Nebraska's Potential for Energy Recovery from Animal Manure

Prepared by the Nebraska Methane Workgroup

The purpose of this document is to give the reader an idea of the tremendous energy potential embodied in manure on Nebraska's beef, dairy, pork, and poultry operations that could be recovered by anaerobic digestion. The intended outcomes of producing this document are increased awareness of the opportunity for energy recovery from manure and spurred interest amongst policymakers, producers, financiers, entrepreneurs and the public in realizing this opportunity.

This document was prepared in the summer of 2011 by a subset of the Nebraska Methane Workgroup, which includes participants from the University of Nebraska-Lincoln, Nebraska Public Power District, Nebraska Department of Environmental Quality, Nebraska Organic Waste Energy, Nebraska Cattlemen, and the Nebraska Department of Agriculture. In preparing the document, considerable effort was put into obtaining information from current, credible sources and vetting the information to assure it was realistically accurate and that resulting estimates would be somewhat conservative. As with any assessment like this, it was necessary to make some assumptions; every effort was made to be unbiased and consistent in the application of all assumptions.

Finally, the authors recognize that, while the energy that could be recovered from manure in the state is quite substantial, livestock operations are dispersed and various challenges exist for implementing digesters and recouping costs. This likely means that only some small percentage of the operations considered will pursue anaerobic digestion and the recovery of energy. The extent to which the opportunity is actually realized depends on the level of entrepreneurship, innovation and paradigm-altering change that occurs in the coming years.

BIOGAS ENERGY POTENTIAL FROM LIVESTOCK WASTE IN NEBRASKA

LIVESTOCK	HEAD	BIOGAS (ft3/year)	ELECTRICITY (kWh/year)	DIESEL (DGE/year)	GASOLINE (GGE/year)
Beef	2.300,000	7,008,000,000	366,600,000 (41.8MW)	16,230,000	18,440,000
Dairy	55,000	2,079,000,000	108,800,000 (12.4MW)	4,818,000	5,473,000
Swine	3,050,000	5,007,000,000	261,900,000 (29.9MW)	11,600,000	13,170,000
Poultry	9,351,000	1,843,000,000	96,420,000 (11MW)	4,270,000	4,850,000
TOTALS:	**14,750,000**	**15,930,000,000**	**833,800,000 (95.1MW)**	**36,990,000**	**41,940,000**

There are estimated to be 14.7 million livestock in Nebraska - including beef cattle on- feed, dairy cows, swine, and poultry layers. The manure produced by these animals is a potential source for biogas energy generation, capable of producing approximately 16 billion cubic feet of biogas annually. A renewable form of energy ('natural' gas), the methane in this biogas could supply over 830 million kilowatt-hours (kWh) of electricity annually – an electric capacity of 95 Megawatts (MW). For an average household usage of 1,200 kWh each month, that's enough energy to power 57,000 Nebraska homes – or about 8% of the roughly 725,000 households in the state.

Biogas produced from Nebraska's livestock and poultry manure may also be upgraded or "scrubbed" and either compressed or liquefied for use as an alternative or supplemental vehicle fuel for tractors, trucks, forklifts, front-end loaders, and automobiles. Biogas produced from manure in Nebraska could supply a fuel demand equivalent to 36.9 million gallons of diesel fuel or 41.9 million gallons of gasoline. That's enough fuel to offset the greenhouse gas emissions equivalent of burning 867,000 barrels of oil each year or removing 78,500 passenger vehicles from the road.

BIOGAS ENERGY POTENTIAL FOR BEEF LOT MANURE IN NEBRASKA

LIVESTOCK	HEAD	BIOGAS (ft^3/year)	ELECTRICITY (kWh/year)	DIESEL (DGE/year)	GASOLINE (GGE/year)
Beef	2.300,000	7,008,000,000	366,600,000 (41.8MW)	16,230,000	18,440,000

On any given day, there are an estimated 2.3 million beef cattle on-feed in Nebraska. The manure and feed waste generated by Nebraska's beef cattle are capable of producing approximately 19.2 million cubic feet of biogas every day. This volume of biogas is capable of generating over 1 million kilowatt-hours (kWh) of renewable electricity daily - or an electric capacity of about 40 Megawatts (MW). Given an average household consumption of 1,200 kWh of electricity each month, that's enough energy to power approximately 25,110 homes in Nebraska.

This volume of biogas could also be upgraded and either compressed or liquefied for use as a cleaner-burning alternative or supplemental vehicle fuel in tractors, trucks, forklifts, front-end loaders and automobiles. If converted for use as a vehicle fuel, biogas produced from Nebraska's beef cattle manure could support a diesel fuel demand of approximately 44,000 gallons per day - or about 16.2 million gallons annually. That's enough diesel fuel to displace the greenhouse gas emissions from burning 920 barrels of oil every single day (EPA). If converted for use as a gasoline alternative, biogas produced from Nebraska's beef cattle manure could support a fuel demand of approximately 50,500 gallons per day – or about 18.4 million gallons annually. That's enough gasoline to displace the greenhouse gas emissions from burning 1,045 barrels of oil every single day or the equivalent of removing about 95 passenger vehicles from our roadways.

BIOGAS ENERGY POTENTIAL FROM DAIRY MANURE IN NEBRASKA

LIVESTOCK	HEAD	BIOGAS (ft^3/year)	ELECTRICITY (kWh/year)	DIESEL (DGE/year)	GASOLINE (GGE/year)
Dairy	55,000	2,079,000,000	108,700,000 (12.4MW)	4,818,000	5,473,000

There are estimated to be 55,000 dairy cows in Nebraska. If captured, the manure and feed waste generated by Nebraska's dairy cows is capable of producing approximately 5.6 million cubic feet of biogas per day. A renewable form of methane energy (natural gas), this volume of biogas is capable of generating nearly 300,000 kWh of renewable electricity every day - an electric capacity of about 12MW. Given an average household consumption of 1,200 kWh of electricity each month, that's enough energy to power about 7,452 homes in Nebraska.

Conversely, this volume of biogas may be upgraded and either compressed or liquefied for use as an alternative or supplemental vehicle fuel. Biogas produced from Nebraska's dairy cattle manure could support a fuel demand of approximately 13,000 diesel gallons equivalent (DGE) or nearly 15,000 gasoline gallons equivalent (GGE) every day. Capable of producing the equivalent of around 4.8 million to 5.4 million gallons of vehicle fuel annually, capturing biogas from Nebraska dairy cattle manure could displace the greenhouse gas emissions from burning 273 barrels of oil every single day or the equivalent of removing 24 passenger vehicles from our roadways.

BIOGAS ENERGY FROM SWINE MANURE IN NEBRASKA

LIVESTOCK	HEAD	BIOGAS (ft^3/year)	ELECTRICITY (kWh/year)	DIESEL (DGE/year)	GASOLINE (GGE/year)
Swine	3,050,000	5,007,000,000	261,900,000 (29.9MW)	11,600,000	13,170,000

There are estimated to be 3,050,000 swine in Nebraska. If captured, the manure and feed waste from Nebraska's hogs and pigs can produce approximately 13.7 million cubic feet of biogas every day. A renewable form of methane energy (natural gas), this volume of biogas is capable of generating nearly 718,000 kWh of renewable electricity daily - an electric capacity of about 30MW. Given an average household consumption of 1,200 kWh of electricity each month, this is enough energy to power approximately 17,944 homes in Nebraska.

Conversely, this volume of biogas may be upgraded and either compressed or liquefied for use as an alternative or supplemental vehicle fuel. Biogas produced from Nebraska's swine operations could support a fuel demand of approximately 11.6 million gallons of diesel fuel or 13.1 million gallons of gasoline annually. That's enough fuel for Nebraska's swine to displace the greenhouse gas emissions equivalent of burning 746 barrels of oil every single day or removing about 67 passenger vehicles from our daily commutes.

Since 2005, Danny Kluthe's swine operation near Dodge, Nebraska has had a reliably operating anaerobic digester system. The farm has an 8,000 head capacity which generates 85 kW of electricity daily. The electricity produced by his operation annually is enough to power about 50 homes for a year. Kluthe has also expanded into using compressed methane from the digester to power his farm vehicles.

BIOGAS ENERGY POTENTIAL FROM POULTRY IN NEBRASKA

LIVESTOCK	HEAD	BIOGAS (ft^3/year)	ELECTRICITY (kWh/year)	DIESEL (DGE/year)	GASOLINE (GGE/year)
Poultry	9,351,000	1,843,200,000	96,420,000 (11MW)	4,270,000	4,850,000

There are estimated to be 9.3 million poultry layers in Nebraska. If captured, the litter produced by Nebraska's layers is capable of producing approximately 5 million cubic feet of biogas every day. A renewable form of methane energy (natural gas), this volume of biogas is capable of generating over 264,000 kWh of renewable electricity daily - an electric capacity of about 11MW. Given an average household consumption of 1,200 kWh of electricity each month, that's enough energy to power 6,604 homes in Nebraska.

Conversely, this volume of biogas may also be upgraded and either compressed or liquefied for use as an alternative or supplemental vehicle fuel. If converted into vehicle fuel, biogas produced by Nebraska's poultry layers could support a fuel demand equal to 4.2 million gallons of diesel fuel or about 4.8 million gallons of gasoline. That's enough fuel to displace the greenhouse gas emissions from burning 275 barrels of oil every single day or removing 25 passenger vehicles from our daily commutes.

CONCLUSION AND PATHS FORWARD

Nebraska is a top producer in the country in terms of beef and also has significant production of pork, dairy and poultry. The combined energy potential of anaerobic digestion of the manure on these operations could provide power equivalent to a 95-Megawatt coal-fired power plant – enough electricity to meet the needs of 57,000 homes! Looking at the opportunity another way, if the energy potential of the manure was converted to transportation fuel, it would be the equivalent of almost 42 million gallons of gasoline each year. Livestock and poultry 'waste' does indeed represent a substantial potential energy resource in Nebraska.

Realizing that potential is, of course, a challenge and an opportunity. First and foremost, capital costs for installing anaerobic digesters are significant. Centralized digesters offer some potential to leverage advantages of scale in reducing unit costs and consolidating management requirements, while increasing the productivity and profitability of producing usable energy. What level of opportunity exists for multiple producers to cooperate in constructing and operating a centralized system in Nebraska? What impediments exist and can they be removed or reduced?

Co-digestion of materials other than livestock manure can help offset capital costs. For example, food waste from processing plants is generally problematic and expensive to dispose of, yet often is an ideal material to be fed to an anaerobic digester and may generate substantial revenue from receipt of tipping fees. Combining manure from a confined animal feeding operation and food-processing waste can significantly improve the total gas potential and provide an economy of scale to a facility.

Other opportunities for entrepreneurship certainly exist. Co-locating a digester and an energy-demanding processing operation offers the opportunity to greatly reduce outside energy purchases and value the energy produced closer to its commercial market value. Innovations in generating 'storable energy', especially for markets like transportation fuels, could have significant favorable impacts.

Anaerobic digesters should benefit from offset payments from carbon markets and other applicable renewable energy incentives that may be developed in the future.

The Nebraska Methane Workgroup is committed to monitoring the continued development of technologies, policies and issues associated with anaerobic digestion and animal manure management. We welcome the reader's thoughts and questions. Information related to this document is available at manure.unl.edu.

The Environmental Protection Agency AgSTAR program, which the Nebraska Methane Workgroup interacts with frequently, maintains a website with much useful information www.epa.gov/agstar. Following is a list of other websites that may be of interest.

- Livestock & Poultry Environmental Learning Center: http://www.extension.org/animal_manure_management
- Cornell Dairy Environmental Systems: http://www.manuremanagement.cornell.edu/
- Michigan State University Anaerobic Digestion Research and Education: http://www.egr.msu.edu/bae/adrec/

About the Nebraska Methane Workgroup:

The Nebraska Methane Workgroup is a group of public and private organizations interested in capturing the potential energy from livestock and poultry manure in Nebraska. The Nebraska Methane Workgroup was formed subsequent to a Methane Workshop sponsored by Nebraska Public Power District and the Nebraska Department of Environmental Quality in York, NE, in June of 2002. Current members of the Workgroup are from: Nebraska Public Power District, Nebraska Department of Environmental Quality, University of Nebraska, USDA – Rural Development, Nebraska State Dairy Association, US EPA Region VII, O'Lean Energy, Nebraska Organic Waste Energy, Prairieland Dairy, Nebraska Department of Agriculture, Nebraska Pork Producers, Nebraska Department of Natural Resources and the Nebraska Energy Office.

Members of the Nebraska Methane Workgroup recognize the substantial environmental benefits that can be realized from well designed and operated anaerobic digestion systems. Those benefits include renewable energy production, reduced odor, pathogen destruction, greenhouse gas and hydrogen sulfide emission reductions, and increased nitrogen [nutrient] availability for crop growth. O'Lean Energy's digester on a medium-size pork operation in Colfax County is currently the only operating anaerobic digester on a livestock operation in the state. The owner-operator, Danny Kluthe, has operated the digester since 2005 and indicates great satisfaction with the performance of the facility. He and the rest of the Nebraska Workgroup are seeking ways to realize much more of the opportunity represented by the energy potential in manure.

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