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Applications and Potentials for Biogenic Methane Recovery Operations in Nebraska Agriculture, Industry, and Economic Development

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APPLICATIONS AND POTENTIALS FOR BIOGENIC METHANE RECOVERY OPERATIONS IN NEBRASKA AGRICULTURE, INDUSTRY, AND ECONOMIC DEVELOPMENT

by:

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APPLICATIONS AND POTENTIALS FOR BIOGENIC METHANE RECOVERY OPERATIONS IN NEBRASKA AGRICULTURE, INDUSTRY, AND ECONOMIC DEVELOPMENT

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ABSTRACT: This thesis report illustrates the applications and potentials of biogenic methane recovery in Nebraska's agricultural and industrial sectors and as a means for increasing sustainable economic development in the state's rural communities. As the nation moves toward a new green economy, biogenic methane recovery as a waste management strategy and renewable energy resource presents significant opportunities for Nebraska to be a national and world leader in agricultural and industrial innovation, advanced research and development of renewable energy technology, and generation of new product markets. Nebraska's agricultural economy provides a distinct advantage to the state for supporting methane recovery operations that provide long-term economic and environmental partnerships among producers, industry, and communities. These opportunities will serve to protect Nebraska's agricultural producers from volatile energy input markets and as well as creating new markets for Nebraska agricultural products. They will also serve to provide quality education and employment opportunities for Nebraska students and businesses. There are challenges and issues that remain for the state in order to take advantage of its resource potential. There is a need to produce a comprehensive Nebraska biogenic methane potential study and digital mapping system

to identify high-potential producers, co-products, and markets. There is also a need to develop a web-based format of consolidated information specific to Nebraska to aid in connecting producers, service providers, educators, and policy-makers.

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CHAPTER ONE: INTRODUCTION

Methane recovery presents a significant opportunity to add value to Nebraska's agricultural and industrial sectors, increase sustainable economic development opportunities for the state's rural communities, and establish Nebraska as a national and world leader in the new green economy.

Climate change and sustainable development are the most important concepts of the 21st century. Greenhouse gas emissions, sustainable food systems, renewable energy, biofuels, natural resource conservation, rural economic development, social and environmental justice issues are guiding policies and partnerships across industrialized, developed, and developing worlds.

In the U.S., energy efficiency and conservation, renewable energy technologies, and alternative fuels are the mechanisms guiding the nation toward a new green economy based on the vision and intent of reducing greenhouse gas emissions, increasing energy independence, and expanding the nation's role as a world leader in innovation, technology, and new product markets. In Nebraska, these same concepts are a guiding theme in new legislations, policies, and partnerships aimed at securing the "good life" for generations to come.

As a waste management strategy, biogenic methane recovery presents significant opportunities for sustainable development worldwide by reducing greenhouse gas emissions, reducing agricultural and industrial production costs, generating renewable energy, improving air, soil, and water quality, and providing a diverse range of value-added products to market.

As a renewable energy resource, biogenic methane recovery offers a distinct advantage over other renewable resources. Unlike wind and solar technologies that rely on specific climate and weather conditions for optimal production of electricity, biogenic methane recovery operations capture and utilize reliable sources of agricultural and industrial organic waste streams, converting them to electricity, heat, nutrient-rich irrigation resources, and raw materials to enhance existing industries and emerging new green industries.

Nebraska's agricultural economy provides a distinct advantage to the state for supporting biogenic methane recovery applications that develop long-term economic and environmental partnerships among agricultural producers, rural communities, and the state's food processing, manufacturing, and biofuels industries and invites new opportunities for Nebraska products. Development of biogenic methane recovery operations will benefit the state by stabilizing agricultural and industrial production costs, creating new marketable jobs, improving rural economic development, and enhancing advanced research and development opportunities.

The potential for developing Nebraska's biogenic methane recovery resources has never been greater than in 2009 and this trend is projected to continue for the foreseeable future. National legislations such as the Farm Bill and American Recovery and Reinvestment Act are extending and expanding funding and tax credit programs for energy efficiency and conservation, renewable energy, and alternative fuels applications. Nebraska's federal and state agencies are working together and cooperating with top industry developers to identify producers and partners in establishing biogenic methane recovery in the state.

This report illustrates the applications and potentials for developing biogenic methane recovery in Nebraska's agricultural and industrial sectors as a means for adding value to production processes and increasing sustainable economic development in the state's rural communities. This report reviews existing literature from print publications, internet resources, site visits, personal interviews and experiences. Chapter 2 of this report will review the basics of methane science, sources and emissions, recovery methods and processes. Chapter 3 of this report will offer a review of case studies for biogenic methane recovery applications in Nebraska from 1978 – 2009. Chapter 4 will discuss the role, challenges, and state of biogenic methane recovery in Nebraska. Chapter 5 will offer a set of conclusions for advancing biogenic methane recovery operations in Nebraska.

There is specific information relating to the economics and development processes of the case studies presented here that is currently impossible to report. The contributing factors to this are confidentiality and proprietary rights issues. Another contributing factor is funding. This report has received no outside funding. A future attempt at a comprehensive report on methane recovery operations in Nebraska will need to address this issue in order to provide baseline evaluations and comparisons between projects.

CHAPTER TWO: METHANE AND METHANE RECOVERY BASICS

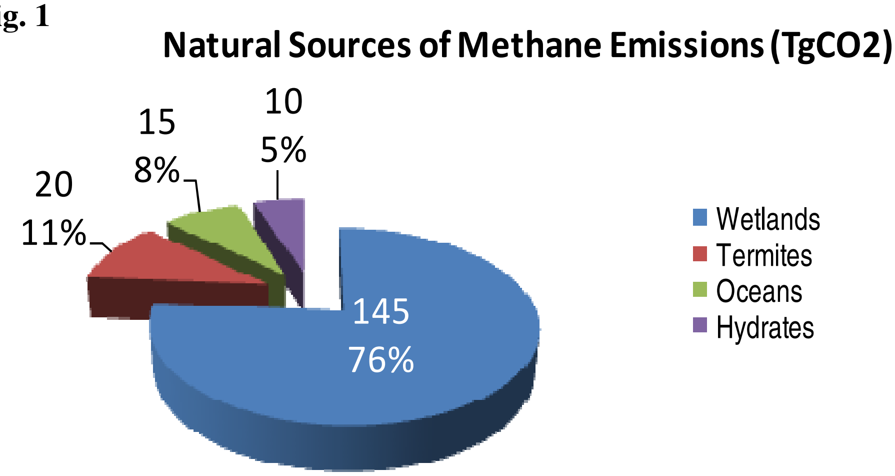
What is Methane?

Methane *(CH_4)* is the simplest saturated hydrocarbon. Methane is a compound gas comprised of one carbon atom and four hydrogen atoms. There are two basic types of methane – *biogenic* and *thermogenic*. Biogenic methane refers to methane that is produced by bacteria during the decomposition of organic matter (EPA, 2004 [4]). Thermogenic methane refers to methane that is produced by organic matter that is exposed to high pressure and temperature environments. Examples of thermogenic methane are coal bed methane and the methane associated with petroleum systems. Agricultural and industrial methane in Nebraska are examples of biogenic methane.

There are anthropogenic as well as natural sources of methane emissions. The Intergovernmental Panel on Climate Change (IPCC) and the U.S. Environmental Protection Agency (EPA) estimate that 60% of total global methane emissions are associated with human activities. Natural sources of methane emissions comprise the remaining 40% (EPA 2009, 2004 [5]).

Natural Sources of Methane Emissions

Fig. 1



Wetlands: provide a conducive environment for *anaerobic* bacteria. As vegetation and wildlife wastes accumulate in the water, oxygen is consumed and reduced at the bottom layers where bacteria breakdown the organic materials, producing methane (EPA, 2004 [5]).

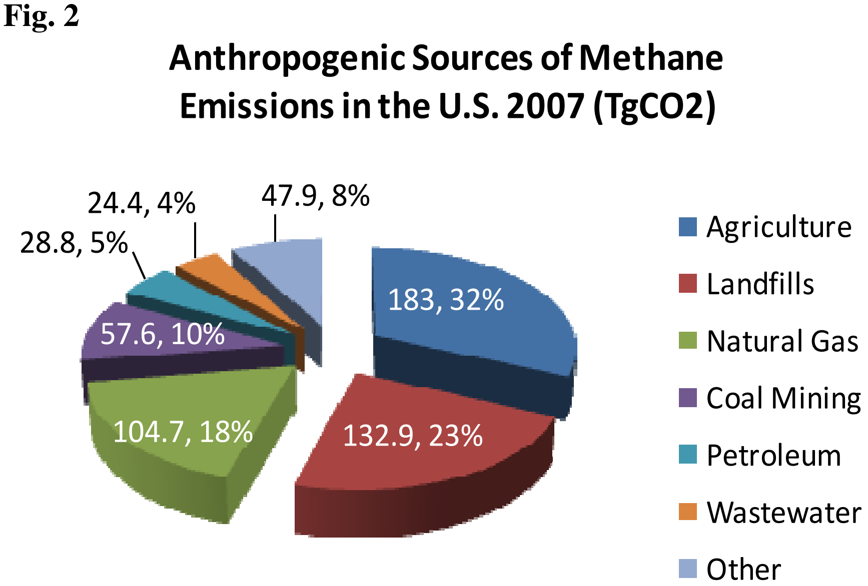
Termites: produce methane as a normal function of digestion. Emissions depend on the specific species and total population (EPA, 2004 [5]).

Oceans: emit methane from anaerobic digestion in marine zooplankton and fish as well as *methanogenisis* in sediments and drainage areas of coastal regions (EPA 2004 [5]).

Hydrates: are solid deposits of water molecules (ice) that trap methane molecules, which form as organic sediments in the water decay during the formation process. Hydrates form in the shallow subsurface of polar regions and outer continental shelf *(OCS)* regions where high-pressure and low-temperature conditions exist (EPA 2004 [5]).

Anthropogenic Sources of Methane Emissions

Fig. 2



Agriculture: is the leading source of methane emissions in the U.S. Emissions are the result of enteric fermentation and manure management practices. Enteric fermentation – the digestion process of ruminant animals such as cattle, contributes far more emissions than manure management. However, manure management emissions have increased 44.7% since 1990 compared to 4.3% for enteric fermentation. Manure management is a key emphasis in mitigating methane emissions worldwide (EPA 2009, 2004 [2][5]).

Landfills: are the most significant source of methane emissions in the U.S. linked to human activity. Methane is produced in open dumps and landfills as wastes decompose under anaerobic conditions. As waste accumulates, pressure and temperature increase differentially below the surface. This creates pockets of trapped natural gas that ultimately seep to the surface via pore spaces in the ground (EPA 2009, 2004 [5]).

Natural Gas: is comprised of 95% methane. Emissions occur via production, processing, storage, transmission, distribution operations. Natural gas is the most abundant by-product associated with petroleum production, refinement, transportation and storage (EPA 2004 [5]).

Coal Mining: emits methane trapped in coal mines and surrounding geologic strata. Coal is organic carbon. Methane is formed as organic sediments decompose and are exposed to intense temperatures. Methane is emitted via normal underground and surface mining operations (EPA 2004 [5]).

Wastewater: produces methane during the treatment process of municipal and industrial wastes under anaerobic conditions. Emissions are the result of flaring and further treatment of sludge in lagoons. Typically, wastewater treatment facilities use anaerobic digestion to remove pathogens from the water prior to discharge into the hydrologic system. In many cases, wastewater treatment facilities use methane to provide electricity during peak demand hours (EPA 2004 [5]).

Other: sources of methane emissions account for 8% of methane emissions linked to human activity. The greatest of these *(stationary combustion)* contributes 6.6 $TgCO_2$ (EPA 2009, 2004 [5]).

Methane and Climate Change

Methane is a potent greenhouse gas *(GHG).* In the atmosphere, methane molecules absorb infrared radiation emitted from the Earth's surface. This process is a significant contribution to global warming trends via the *greenhouse effect*. The IPCC and EPA estimate methane's global warming potential *(GWP)* to be 21 times greater than carbon dioxide *(CO_2).* By definition, GWP is the ratio of heat trapped by one unit of mass of a given GHG to that of one unit of CO_2. Over 100 years, methane molecules in the atmosphere will trap 21 times more heat than carbon dioxide despite CO_2 being significantly more abundant (EPA 2004 [2]).

Once emitted, methane molecules have an average atmospheric lifespan of 12 years. Data collected from Arctic ice core samples illustrates that atmospheric concentrations of methane have increased 150% during the Industrial Revolution Era *(1750 C.E. – Now).* Recent data results indicate that total global methane emissions continue to increase, but at decreasing rates from historical levels. This current trend is attributed to increased global efforts in mitigating climate change and advancements in processes and technologies in associated sectors (EPA 2009, 2004 [2]).

Measuring specific atmospheric concentrations of reactive GHGs, such as methane and other volatile organic compounds, remains problematic. The IPCC and EPA calculate emissions once they are released into the atmosphere. Meanwhile, NASA researchers are developing advanced modeling techniques to measure GHGs at the point of emission. As a result, methane contributions to global warming trends are estimated between 1/6 and 1/3 of total GHG impacts (EPA 2004 [2]; NASA 2005).

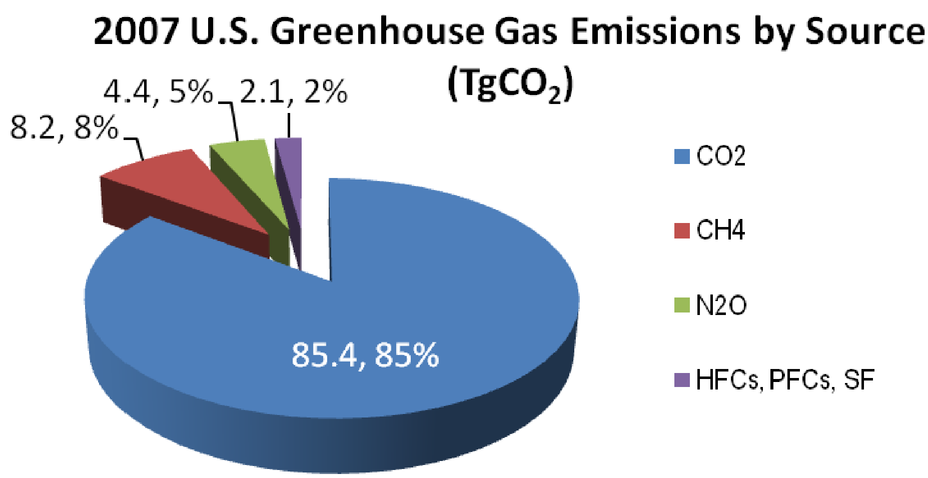
The significant difference between the two sets of measurements is attributed to NASA's inclusion of the impacts of methane on tropospheric ozone. Tropospheric ozone refers to ozone levels in the troposphere. The troposphere is the level of the atmosphere humans live in and it contains 75% of the Earth's atmospheric mass and 99% of its water vapor. Photosynthetic reactions in tropospheric ozone are a leading cause of smog along with other air quality and human health issues (EPA 2004 [2]; NASA 2005).

Tropospheric ozone is the result of chemical reactions from GHGs such as methane, carbon monoxide *(CO),* nitrogen oxides *(NO_x),* and other volatile organic compounds *(VOC)* emitted into the atmosphere. CO and NO_x are largely anthropogenic contributions to tropospheric ozone whose effects are generally local and regional in scale. Conversely, due to its potency and atmospheric lifespan the effects of methane emissions on tropospheric ozone production are realized on a global scale (NASA 2005).

Methane's impacts on climate change and human development make it a key emphasis in pending climate change legislations and renewable energy standards worldwide.

In 2007, methane comprised 8% of total U.S. greenhouse gas emissions. Second only to carbon dioxide with 85% of total U.S. GHG emissions. In spite of this significant difference in percentage of total emissions, methane will trap 21 times more heat in the atmosphere than CO_2 (EPA 2009).

Fig. 3



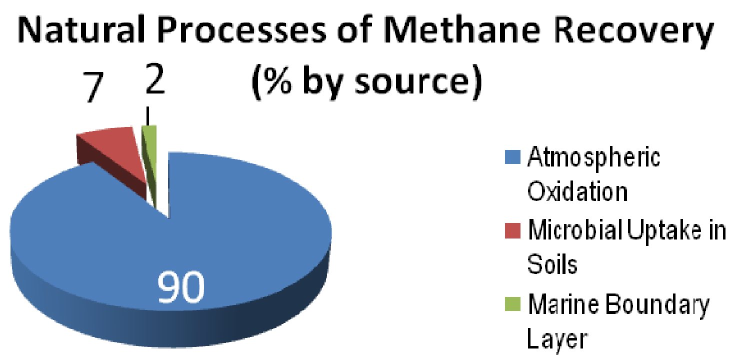
What is Methane Recovery?

Methane recovery refers to the processes by which methane is captured, sequestered, and/or removed from the atmosphere. There are anthropogenic methods and natural processes of methane recovery.

Natural Processes of Methane Recovery

Atmospheric Oxidation: is the process by which gases are broken down and released into space. This process accounts for 91% of total methane removal. The production of tropospheric ozone is a significant limiting factor to the efficiency of Earth's oxidation system (EPA 2004 [5]).

Fig. 4



Microbial Uptake in Soils: accounts for 7% of total methane removal (EPA 2004 [5]).

Chlorine Reactions in the Marine Boundary Layer: account for 2% of total methane removal (EPA 2004 [5]).

Anthropogenic Methods of Methane Recovery

All anthropogenic methods of biogenic methane recovery are based on a process known as *anaerobic digestion (AD).* Anaerobic digestion refers to the process by which bacteria digest organic materials in an oxygen-free *(anaerobic)* environment (EPA 2004

[4]). Specific methane operations will vary according to local environments and economies of scale.

The main form of methane recovery in the agricultural and industrial sectors involves waste management practices, which include livestock manures as well as other organic wastes such as carcasses, fats, milks, crop residues, lawn clippings, and food wastes. These wastes are processed in what are known as anaerobic digesters, which are also commonly referred to as methane digesters or bio-digesters.

Anaerobic digesters are manmade oxygen-free environments designed to expedite and facilitate the AD process. Digester designs can range in scale from inner-tubes and 55-gallon drum barrels to concrete and steel containers and structures. The main product of the AD process is referred to as *biogas*. On average, biogas is comprised of 60% methane and 40% carbon dioxide with some trace elements such as hydrogen sulfide (EPA 2004 [4]; NEO 2009). The process also generates solids, liquids, or slurry waste streams.

Biogas is most commonly used for *combined heat and power (CHP)* operations. CHPs are biogas operations that generate and utilize electricity and heat. In some cases, biogas is used in flaring operations that do not capture the energy produced. Flaring methane, a practice that exists in agriculture, industry, landfills, and fossil fuels production results in *reduced carbon emissions.* When CH_4 is burned, it produces CO_2. Since methane is 21 times more potent than CO_2, this results in a 21% reduction in GHG emissions (EPA 2004 [4]).

The anaerobic digestion of organic materials results in a reduction of pathogens in effluent waste streams, and increases retention of nutrients such as nitrogen that are otherwise lost to oxidation and run-off during conventional land application practices (Powers 2007; EPA 2004 [5]; WRBEP 1994). In Nebraska, this adds value to the production process by reducing fertilizer input costs and improves air, soil, and water quality.

Anaerobic digesters increase energy independence by reducing greenhouse gas emissions and producing reliable renewable energy resources. In Nebraska, this adds value to the production process by generating new revenue streams in carbon credit markets and production tax credits, as well as reducing fossil fuel energy input costs.

The anaerobic decomposition of agricultural and industrial organic wastes eliminates odors associated with waste management practices (Powers 2007; Kluthe 2005). In Nebraska, odor reduction is a valuable tool in promoting rural economic development opportunities.

In cases where wastes are not directly applied or there is an excess supply, solids, liquids, and slurries can become raw materials for bio-products ranging from biofuels to cosmetics to cleaners to fertilizers to plastics and beyond.

There are four main anaerobic digester designs: *covered lagoons, plug flow, complete mix, and fixed film.* The different designs reflect adaptations to a variety of environmental and operational considerations.

Environmental considerations are operating temperature, types and availability of feedstocks, and the amount of available land. Bio-digesters can operate in a wide range of temperatures from below freezing *(0°C/32°F)* to above 57°C/134.6°F. Most agricultural and industrial methane digester operations in the U.S. operate under *mesophilic* conditions, which are temperatures around 38°C/100°F (Powers, 2007).

Fig. 5: Bio-digester Design and Performance

Type of Digester:	COVERED LAGOON	PLUG FLOW	COMPLETE MIX	FIXED FILM
Vessel:	Deep Lagoon	In-Ground Tank	In/Above Ground Tank	Above-Ground Tank
Level of Technology:	Low	Low	Medium	Medium
Additional Heat	No	Yes	Yes	No
Total Solids	0.5% - 1.5%	11% - 13%	3% - 11%	3%
Hydraulic Retention Time (HRT)	40 - 60 days	15 days	15 days	2-3 days
Farm Type:	Cattle/Hog/ Poultry	Cattle Only	Cattle/Hog/ Poultry	Cattle/Hog/ Poultry
Climate:	Temperate/Warm	All	All	Temperate

Covered Lagoons: are the most basic digester design. In a covered lagoon system, an impermeable cover is placed over an anaerobic waste lagoon. Covered lagoons are the lowest cost option in materials, particularly for existing lagoons. Covered lagoon systems are designed for cattle or hog operations. The system requires the largest land area, lowest concentration of solids (which translates to higher water use), and the slowest rate of production among designs (Powers 2007).

Plug Flow: digesters are the next level of complexity in system design. Plug flow systems are engineered as in-ground concrete tanks with a flexible cover for biogas collection. The system is designed for dairy cattle only. The system increases the amount of total solids concentration (reducing water use) and reduces the *hydraulic retention time* – the amount of time it takes to produce gas. The plug flow design also takes advantage of heat produced in the electric generation process to maintain operating temperature, making it optimal for use in all climates (Powers 2007).

Complete Mix: digester systems are engineered of concrete or steel and can be located above or below ground and offer similar benefits as plug flow digesters to non-dairy cattle and hog operations. Complete mix digesters have a wider range of total solids concentrations and a comparable hydraulic retention time. The design also takes advantage of system heat to maintain operating temperature, making it optimal for use in all climates as well (Powers 2007).

Fixed Film: digester systems are engineered above ground for agricultural and industrial operations with less available land area. In a fixed film system, bacteria attach to layers of film within the digester unit. The film layers increase the available surface area for bacteria to grow. As a result, fixed film digesters produce the highest composition of methane and have the shortest retention time. Fixed film digesters require a low total solids concentration (more water) to avoid clogging, and are optimal for use in warm climates (Powers 2007).

There are other opportunities for biogenic methane recovery operations in Nebraska.

Co-Digestion: of organic materials presents opportunities to develop business partnerships or cooperatives, improve system efficiencies, and increase biogas production and quality. Additional materials such as food wastes, crop residues, and lawn clippings improve biogas quality by reducing hydrogen sulfide, a trace element that is corrosive on generator equipment. In Nebraska, co-digestion presents an opportunity for increasing landfill space and adding value for the producer (Powers 2007).

Landfills: produce methane as anaerobic digestion occurs naturally as wastes decompose under intense pressures and temperatures. Landfill gas *(LFG)* is comprised of 50% CH_4 and 50% CO_2 on average. Specific results vary by quantity and moisture content of the wastes. In Nebraska, landfill gas from rural communities presents opportunities for economic development (Powers 2007; EPA 2004 [2]).

CHAPTER THREE: CASE STUDIES IN NEBRASKA

Overview

Methane recovery is not new to Nebraska. Nebraska farmers and pioneers have captured methane to produce biofuels, heat, and electricity since the 1800s. However, demand for methane recovery operations has been historically cyclical relative to the cost of oil since the internal combustion engine came to prominence on the farm. Most recently, methane recovery in Nebraska boomed during the 1970s in response to the 1973 OPEC oil embargo and the 1979 Iran Revolution. In the 1980s, the combination of the Midwest farm crisis and the return of cheap oil brought the methane boom in Nebraska to an end.

In the 1990s and early 2000s, growing concerns over climate change and energy independence have renewed interest in methane recovery as a viable component to agricultural production, sustainable economic development for rural communities, and renewable energy standards *(RES)* for electric utilities.

University of Nebraska Energy-Integrated Research and Demonstration Farm Project

From 1978 – 1984, the University of Nebraska Institute of Agriculture and Natural Resource *(IANR)* partnered to develop an advanced research and demonstration project to determine the economic feasibility of energy-integrated farming for swine and irrigated crop production (Schulte 1983, 2009).

The project was located on 157 acres of the Agricultural Research and Development Field Laboratory near Mead, Nebraska. The goal of the project was to demonstrate that by integrating renewable energy sources with energy conservation methods it is theoretically possible to produce 750 head of swine to market per year using zero direct and little indirect petroleum inputs. To do this, university engineers designed the project elements to create a closed-loop farm production system (Schulte 1983, 2009).

82 acres of irrigated corn was grown to feed the swine. 48 acres of soybeans were planted to produce oil for biodiesel research and a protein supplement for the swine. 20 acres of sweet sorghum were harvested to produce 190-proof alcohol *(ethanol)* for use in farm equipment (Schulte 1983, 2009).

Energy efficiency and conservation was achieved through soil testing, conservation tillage, modified center pivot irrigation systems, computer-aided scheduling and management. Solar energy was used to heat buildings and provide electricity. Wind energy was used to conduct electrolysis for calcium nitrate fertilizer production (Schulte 1983, 2009).

The production of biogas was used to provide heat for hot water to maintain a 95°F operating temperature, supplement in-floor heating system in offices, laboratories, swine buildings, and for electricity (Schulte 1983, 2009).

Biogas production was facilitated through a 10,000 gallon anaerobic digester utilizing manure from 275 finishing head. The system produced the equivalent of 8.5 gallons of propane per day. The biogas was converted to electricity and hot water using an electric generator set. The recovered biogas was used to produce 65 kilowatt hours *(kWh)* of electricity and 285 gallons of hot water for heating applications per day (Schulte 1983).

The project did successfully achieve its goal and several aspects of the system were proven to be economically feasible. Among renewable energy systems employed at the farm, methane recovery proved 2nd in terms of economic feasibility behind solar heating for buildings (Schulte 1983).

Ultimately, the 1980s farm crisis and shifting research attentions among project partners sealed the project's fate. It would take another decade for methane recovery and energy-integrated farming to re-emerge in Nebraska's agricultural vision.

Nebraska Renewable Energy Systems Farm Energy Project

The NRES Farm Energy Project, owned and operated by Robert Byrnes, is located on a 10.5 acre homestead north of Lyons, Nebraska. The farm has successfully operated energy self-sufficiently "off-grid" for 5 years by integrating a small 1 kW wind turbine with 500 kW of photovoltaic solar panels, thermal solar hot water and space heating applications, a biodiesel generator, and an on-site biodiesel production facility (Byrnes 2004).

The goal of the project is to establish a functional demonstration of the synergies created when multiple renewable energies are applied together. The project illustrates how farms can be an exporter of energy instead of "buying energy to grow energy" (Byrnes 2004).

The farm is a place for internships, workshops, and seminars for hands-on training in renewable energy production. In 2004, NRES partnered with Wayne State College to create an internship program combining classroom and real world experiences (Byrnes, 2004).

In 2005, efforts began to integrate biogas production into the farm energy project. The source for the biogas would come from 200 poultry and 5 swine (Byrnes 2005; Dingman 2005).

An adaptation of a Gobar Gas design from India, the NRES digester is constructed of a 10,000 gallon cinderblock tank placed in a housing unit constructed of recycled materials. Construction of the digester is scheduled for completion in summer 2009 and production is slated for spring 2010 (Byrnes 2009).

Although the NRES digester is not yet online, the project is already demonstrating the potential for educational opportunities with methane recovery and energy-integrated farming. Since 2005, the internship program has managed to employ 6-10 students per year from all across the country in all areas of interest.

OLean Energy

In 2003, Danny Kluthe began taking the necessary steps to implement a complete mix digester at his 8,000 head swine facility near Dodge, Nebraska. The digester came online in 2004 as OLean Energy. The Olean Energy methane recovery system is the only operating farm scale digester selling electricity back to the utility in the state.

The system consists of a mixing tank, a concrete in-ground digester, and an effluent lagoon. Gravity transports waste from 6 swine buildings to the mixer, where sludge is mixed with water to form slurry. The slurry is fed into the digester, where bacteria begin to breakdown the organic material and produce biogas. Effluent is transported via pipeline to a waste lagoon for use in land application and irrigation. The biogas is fed into an electric generator set, which produces 85 kW of electricity and heat to maintain a 95°F operating temperature (Kluthe 2005, 2009).

The OLean Energy operation represents the leading edge of farm scale digesters in Nebraska. Its construction forged partnerships among the federal and state agencies responsible for feasibility, funding, permitting and development, and demonstrates commercial potential of technologies for future methane producers.

Douglas County Landfill Gas Operation

In April 2002, the Douglas County Landfill near Elk City, Nebraska became the state's first landfill gas operation. The project is owned and operated by Waste Management in partnership with Omaha Public Power District *(OPPD)*, which purchases the electricity. At a cost of $4 million, the project generates 3.2 MW of electricity, enough to power an estimated 4,000 homes (Waste Management 2002).

The Douglas County Landfill Gas Operation demonstrates the potential for electricity generation from landfill gas in Nebraska. However, LFGs have the potential to fuel industry and rural economic development as well.

Butler County Landfill Gas Operation

In November 2008, the Butler County landfill near David City, Nebraska in partnership with Timberline Energy of Denver, Colorado, began producing pipeline quality natural gas for use in the steam boiler system at Henningsen Foods, a poultry processor in David City and the county's largest employer (NPPD 2009).

The 63 acre landfill generates 1.3 MW of biogas energy from 19 wells. The success of the project has the partners interested in doubling the output to 2.6 MW to accommodate for Henningsen Foods planned growth. The energy produced would be enough to satisfy David City's current electrical demand (NPPD 2009).

CHAPTER FOUR: DISCUSSION OF THE POTETNIALS FOR BIOGENIC METHANE RECOVERY IN NEBRASKA

Western Regional Biomass Energy Program (WRBEP)

In 1994, the Western Regional Biomass Energy Program, a partnership between Western Area Power Administration and U.S. Department of Energy, released a final report on *Energy Conversion of Animal Manures: Resource Inventory and Feasibility Analysis for Thirteen Western States*.

The report compiled data from agricultural and census statistics dating from 1987 – 1991. The data was evaluated according to source, on state and county levels for each of the 13 states. In the report, Nebraska ranks #1 overall in manure resource potential and #1 in both feedlot cattle and swine categories. Nebraska is #4 for dairy cattle and #6 for turkey (WRBEP 1994).

The report also evaluated 5 case studies – a plug flow system in South Dakota, a complete mix system in Nebraska, covered lagoons in Texas and California, and a combustion plant in California. In the report, Nebraska's complete mix system proved 2^{nd} in feasibility at $0.069/kWh behind South Dakota (WRBEP 1994).

Nebraska's total biogas potential from animal manures is estimated to be 31,432,811 MMBtu/year. The annual energy potential in Nebraska is equivalent to 6.2 million barrels of oil, or one day of U.S. production in 1994 (WRBEP 1994).

The Role of Biogenic Methane Recovery in Nebraska

The use of anaerobic digestion in Nebraska agriculture and industry will serve to reduce pathogens and nitrates found in discharge streams, improving soil and water quality. Pathogens and nitrates are a leading source of surface and groundwater pollution associated with human health issues in the state.

Pending climate change legislations and renewable energy standards pose significant challenges for Nebraska. Emissions standards on coal production and generation will increase electrical rates from $238 million per year in 2012 to $1.32 billion per year in 2030 (OPPD 2009). Renewable energy standards and emissions regulations place further economic burdens from high capital investment projects on individual agricultural producers. As a result, agricultural production expenditures will increase substantially and Nebraska's feed, grains, biofuels and fertilizer industries, which comprise approximately 60% of the state's total economy, will be negatively impacted.

Nebraska's agricultural economy provides a distinct advantage to the state for supporting methane recovery operations that provide long-term economic and environmental partnerships among producers, industry, and communities.

Methane recovery presents significant opportunities to add value to Nebraska's agricultural and industrial sectors, increase sustainable economic development in the state's rural communities, and establish Nebraska a national and world leader in the new green economy.

Energy-integrated farming, such as demonstrated by the NRES Farm Energy Project, presents opportunities for value-added processes and products in the agricultural sector and enhanced educational opportunities for the state's K-12 schools, and advanced research and development opportunities for the University of Nebraska and Nebraska's State Colleges.

Methane recovery as a waste management strategy presents economically viable opportunities for Nebraska's large farming, feeding, food processing, and landfill operations to produce reliable and renewable natural gas and electricity resources to enhance private production values or in partnership with industry and utilities to enhance economic development.

These opportunities will serve to protect Nebraska's agricultural producers from volatile energy input markets and as well as creating new markets for Nebraska agricultural products. They will also serve to provide quality education and employment opportunities for Nebraska students and businesses.

The Challenges of Biogenic Methane Recovery in Nebraska

At the producer level, capital costs, operational and maintenance demands and end-use are the greatest obstacles to overcome.

Capital costs are estimated at 36% of total project costs and are being addressed through increased federal and state grant and loan programs via the Farm Bill and American Recovery and Reinvestment Act, as well as increased interests from third-party investors and developers. In 2009, more than $10 million in qualified funding is available for methane recovery projects in Nebraska (NMWG 2009).

Operational and maintenance demands are estimated at 20 – 30 minutes per day and 1 – 10 hours for occasional system maintenance. Access to reliable maintenance personnel on a per project basis can be difficult for private producers (NMWG 2009).

End-use opportunities are also problematic for many potential producers. Nebraska net-metering laws do not cover systems rated over 25 kW. Most agricultural producers will operate between 30 kW – 100+kW. It is not economically feasible for many producers to implement projects based solely on electricity generation and carbon credits. To aid in feasibility, partnerships for value-added products must be established.

The State of Biogenic Methane Recovery in Nebraska

Nebraska's existing methane recovery applications have developed working partnerships among federal and state agencies, agricultural producers, rural communities, industry-leading private developers and mangers, creating a cohesive network of organizations capable of providing assistance in all aspects of methane recovery project feasibility, funding, permitting, policy, and development on all scales.

These partnerships are essential for responsible development of methane recovery in Nebraska and have already resulted in collaboration on one methane project, two methane workshops, and one webinar event. Increased public awareness and producer education opportunities are needed.

CHAPTER FIVE: CONCLUSIONS

This thesis report illustrates the applications and potentials of biogenic methane recovery in Nebraska's agricultural and industrial sectors and as a means for increasing sustainable economic development in the state's rural communities. As the nation moves toward a new green economy, biogenic methane recovery as a waste management strategy and renewable energy resource presents significant opportunities for Nebraska to be a national and world leader in agricultural and industrial innovation, advanced research and development of renewable energy technology, and generation of new product markets.

There are challenges and issues that remain for the state in order to take advantage of its resource potential. There are at least two steps Nebraska may choose to take that will further address the issues associated with biogenic methane recovery in the state.

There is a need to produce a comprehensive Nebraska methane potential study and digital mapping system that will identify high-potential producers and industry partners. Understanding methane potential in the state will aid in guiding responsible policies and spending for encouraging recovery opportunities.

There is also a need to develop a web-based format of consolidated information specific to Nebraska. This will further aid in connecting producers to the necessary agencies and service providers as well as create a support network of producers and professionals for producers, educators, and policy-makers.

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