

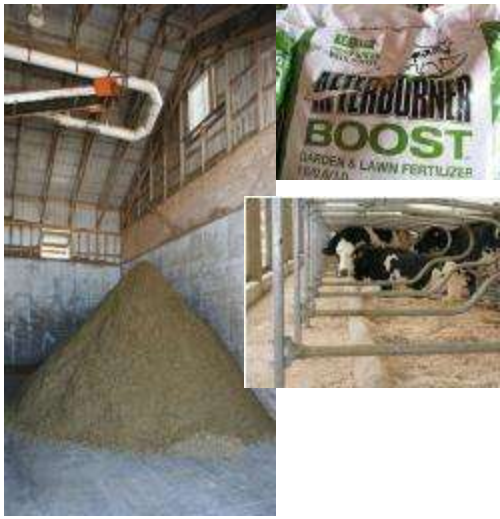




Electricity: biogas may be used to generate electricity using a gas electric generator set or natural gas boiler system. Electricity may either be used on-site or sold to the local utility.

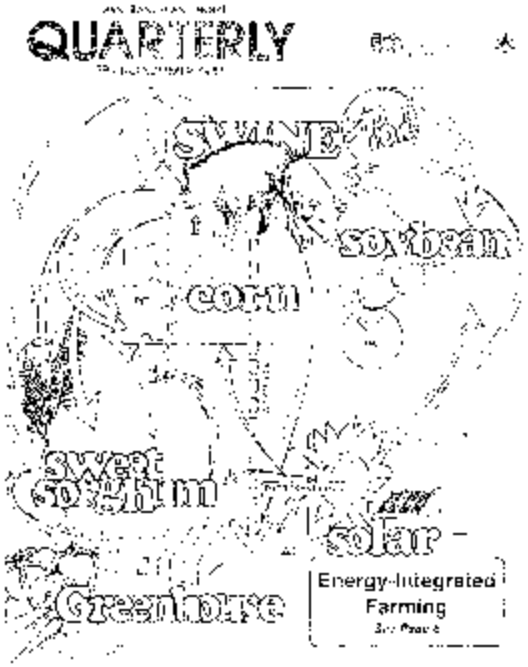
Heat: biogas may be used to produce heat for cooking and space heating applications. It may also be upgraded for injection into existing natural gas pipelines.

Fuel: biogas may be scrubbed and compressed to be used in light and heavy-duty vehicles. With 4 times more hydrogen than carbon, steaming methane also can generate hydrogen for use in fuel cells.



Digested Solids – can be used as livestock bedding, organic compost and fertilizer, or biodegradable, nutrient-rich planters.

Liquid and Slurry Effluent – can be used in land application and irrigation systems.

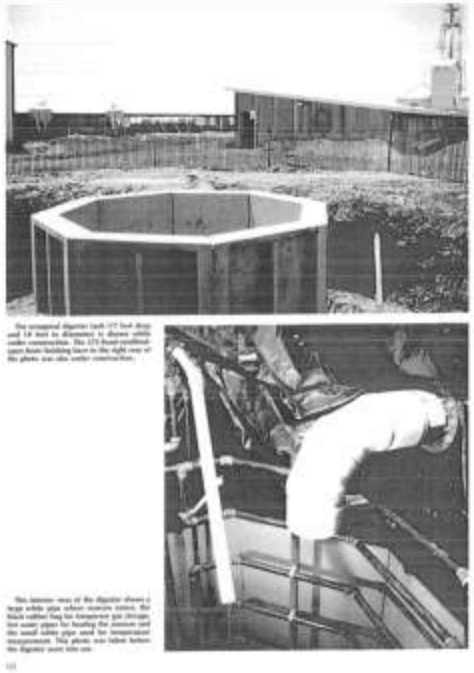


From 1978 – 1984, the University of Nebraska Institute of Agriculture and Natural Resource *(IANR)* partnered to develop an advanced research and demonstration project to determine the economic feasibility of energy-integrated farming for swine and irrigated crop production.

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.

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.

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.



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.

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.

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.

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.




The NRES Farm Energy Project is located on a 10.5 acre homestead north of Lyons, Nebraska. The farm has successfully operated energy self-sufficiently “off-grid” for 6 years by integrating small wind with photovoltaic solar panels, thermal solar hot water and space heating applications, a biodiesel generator, and an on-site biodiesel production facility.

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”.

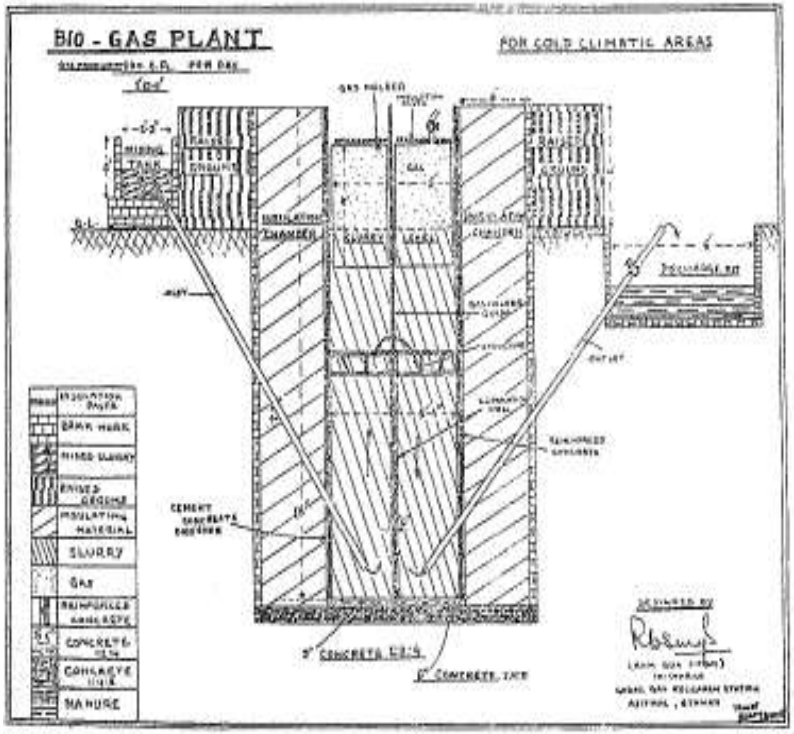
The farm is a place for internships, workshops, and seminars for hands-on training in renewable energy production. In 2004, NRES partnered with Wayne State College to create an internship program combining classroom and real world experiences.

Methane 101
- What is it?
- Where does it come from?
- Why is it important?

Methane Recovery Basics
- What is it?
- Anaerobic Digestion
- Methane Recovery Systems
- Anaerobic Digesters
- End Uses and Markets

Methane Recovery in Nebraska
- Case studies in Agriculture
- Case studies in Municipalities
- Case studies in Industry

Developing a Methane Recovery Project in Nebraska
-The Process
- Project Resources
- Challenges and Opportunities



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.

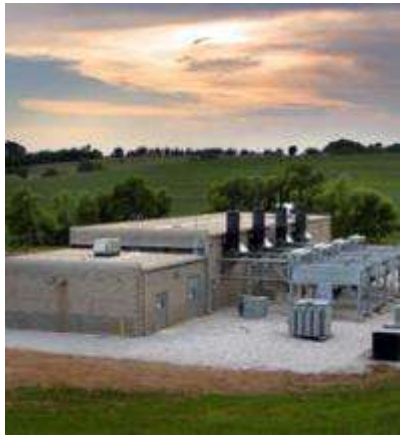
An adaptation of a Gobar Gas design from India, the NRES digester is constructed of a cinderblock tank placed in a housing unit constructed of recycled materials. Construction of the digester is scheduled for completion in summer 2009 and production is slated for spring 2010.

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.

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.

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.



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. The project has the capacity to generate 6 Megawatts (MW) of electricity, enough to power more than 4,000 homes.

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.

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.

The 63 acre landfill generates 1.3 MW of biogas energy from 19 wells. The success of the project has the partners interested in increasing the output to accommodate for Henningsen Foods planned growth and provide power to the city.

Landfill gas operations can also provide opportunity to smaller privately-owned landfills across the state. In 2007, the L.P. Gill Landfill Gas Recovery Project near Jackson began delivering natural gas energy to Siouxland Ethanol near Sioux City.

Municipal wastewater treatment plants in Lincoln and Omaha use anaerobic digestion in the treatment process to stabilize organic solids and remove pathogens prior to discharge back into the hydrologic system. The methane generated is used to provide power to the plant and city. The digested solids – *biosolids* – are delivered to local farmers and city-owned properties for land application.

Anaerobic digesters are also an emerging alternative power option for smaller municipal wastewater treatment plants with capacities of 1 MGY or more.

E3 Biofuels – In 2007, E3 Biofuels, based in Kansas City, opened the world's first commercial-scale closed-loop ethanol plant in Mead, NE. The E3 Genesis Plant was fueled using biogas produced by an adjacent feedlot of 30,000 cattle.

Perform a Feasibility Study to determine the technical and economic feasibility of the project. Evaluate multiple options.

Design the Project based on an analysis of the feasibility study.

Secure Project Financing and Permitting using the details of the feasibility study and the specific project design. Lenders, investors and permitting agencies require specific details on performance and capital costs.

Build the Project!

Nebraska Methane Working Group – a one stop shop for biogas in Nebraska

USDA Rural Development – *feasibility and project financing*

Nebraska Dept. of Environmental Quality – *permitting*

Nebraska Energy Office – *consulting and project financing**

Nebraska Public Power District – *power purchase agreements and connecting to grid*

Advocates, citizens and producers – *public education, venture capital, research and policy*

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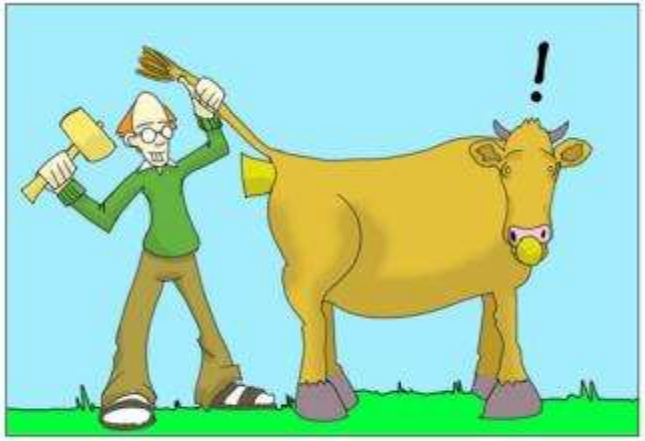

WHEN HE HEARD THAT METHANE WAS RESPONSIBLE FOR AROUND 18% OF THE GREENHOUSE EFFECT, ED DECIDED TO TAKE ACTION.

http://www.epa.gov/agstar/

Western Regional Biomass Energy Program

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.

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 2nd in feasibility at $0.069/kWh behind South Dakota.

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.

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.

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.

End-use opportunities are also problematic for many potential producers. 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.

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.