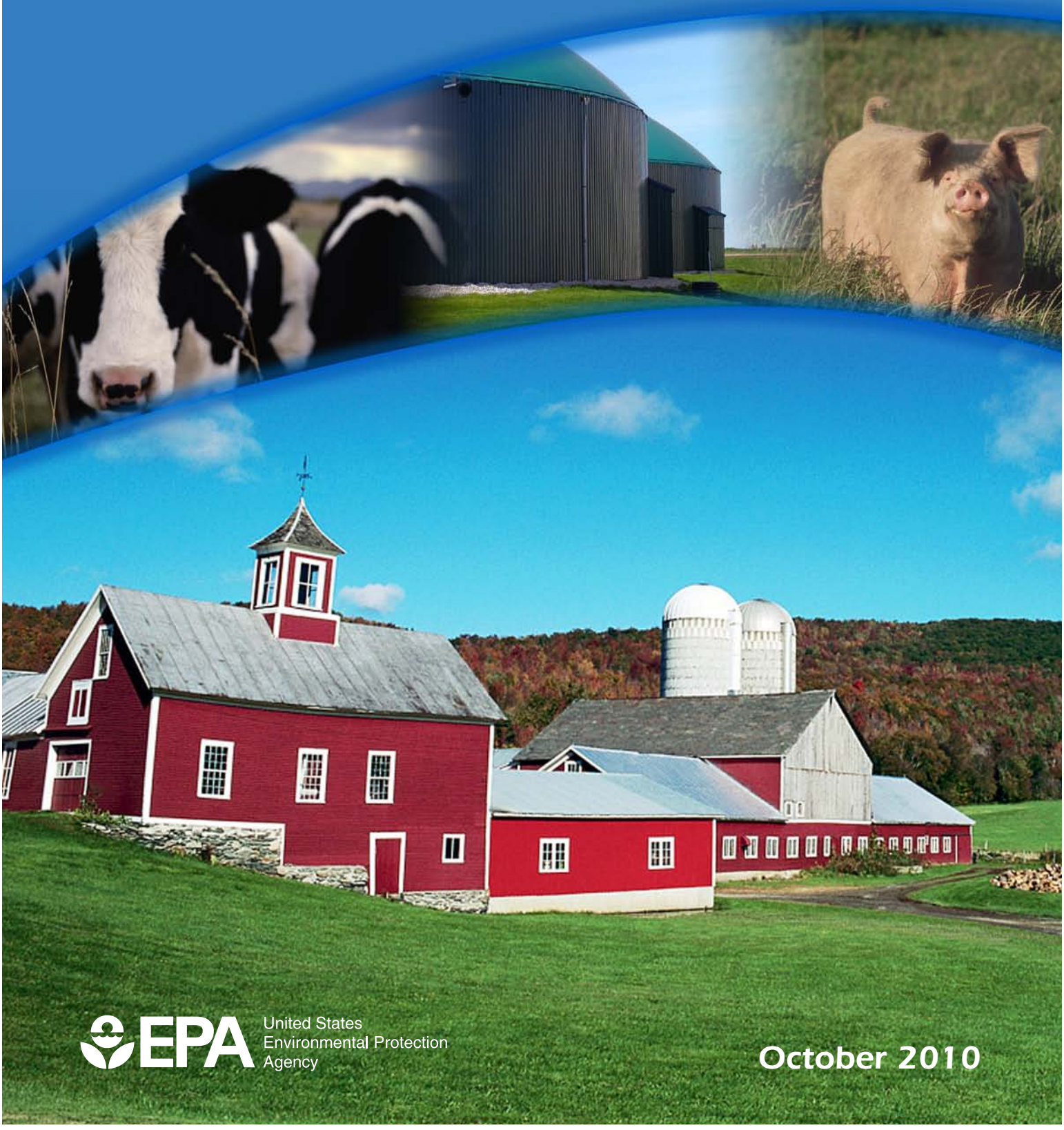
U.S. Anaerobic Digester

Status Report

AgSTAR



EPA United States Environmental Protection Agency

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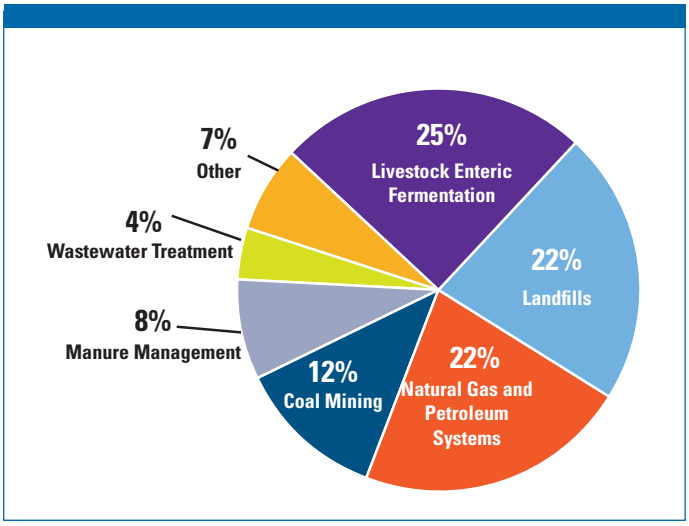
Introduction

Livestock producers face a significant challenge in managing manure and process water in a way that controls odors and protects environmental quality. Additionally, livestock manure management practices in the United States are estimated to emit about 2 million tons of methane and account for approximately 8 percent of U.S. methane emissions from anthropogenic activities annually (Figure 1). Biogas recovery systems can provide a multitude of benefits including odor control, improved air and water quality, improved nutrient management flexibility, and the opportunity to reduce greenhouse gas emissions and capture biogas—a useful source of energy.

Figure 1. Human Related Sources of Methane in the United States (percent of total methane emissions)



Source: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2008*, April 2010.

A biogas recovery system is an anaerobic digester coupled with a device that captures and combusts biogas to produce electricity, heat, or hot water. Biogas is produced when the organic matter in manure decomposes anaerobically (in the absence of oxygen). Biogas typically contains 60 to 70 percent methane, the primary constituent of natural gas, and is a clean burning fuel. Due to facilitation by federal, state, and local programs, the number of operating digester projects has increased from about a dozen in 1990 to over 150 today.

This report is designed to provide a brief overview of the current status of operating digesters at U.S. livestock operations.

Energy Potential

Biogas from manure can be collected and burned to supply on-farm energy needs for electricity or heating. Biogas recovery systems are technically feasible at more than 8,000 U.S. dairy and swine operations. These systems offer a substantial business opportunity to increase farm income by offsetting energy purchases or through the sale of produced energy back onto the electricity grid. Biogas recovery systems at these facilities (Table 1) have the potential to collectively generate more than 13 million megawatt-hours (MWh) per year, which will displace about 1,670 megawatts (MW) of fossil fuel-fired generation on the electrical grid each year. Biogas recovery systems are also feasible at some poultry operations.



Table 1. Electricity Generation Potential for Biogas Recovery Systems at Animal Feeding Operations

Animal Sector	Candidate Farms	Energy Generating Potential		
		MW	MWh/year	MMBtu/year
Swine	5,596	804	6,341,527	21,643,632
Dairy	2,645	863	6,802,914	23,218,346
Total	8,241	1,667	13,144,441	44,861,978

More information about biogas recovery potential is provided in AgSTAR's 2010 *Market Opportunities for Biogas Recovery Systems* report available at www.epa.gov/agstar.

USDA Collaboration and Support

Cost is one of the primary obstacles encountered by those wishing to install biogas recovery systems at their facilities. Many successfully operating digester projects have been realized with the assistance of federal grants, most commonly U.S. Department of Agriculture Farm Bill awards.

The Farm Security and Rural Investment Act of 2002 (the 2002 Farm Bill) established the Renewable Energy Systems and Energy Efficiency Improvements Program under Title IX, Section 9006. Under this program, the Secretary of Agriculture provides loans, loan guarantees, and grants to farmers, ranchers, and rural small businesses to purchase renewable energy systems and make energy efficiency improvements. On June 18, 2008, the Food, Conservation, and Energy Act of 2008 (the 2008 Farm Bill) was enacted into law. The 2008 version of the Bill includes Section 9007: Rural Energy for America Program (REAP), which expanded and renamed the program. USDA has pledged to continue financial support of anaerobic digestion systems through REAP grants and loans. Through 2009, USDA has awarded a total of approximately $37.2 million for anaerobic digestion systems.

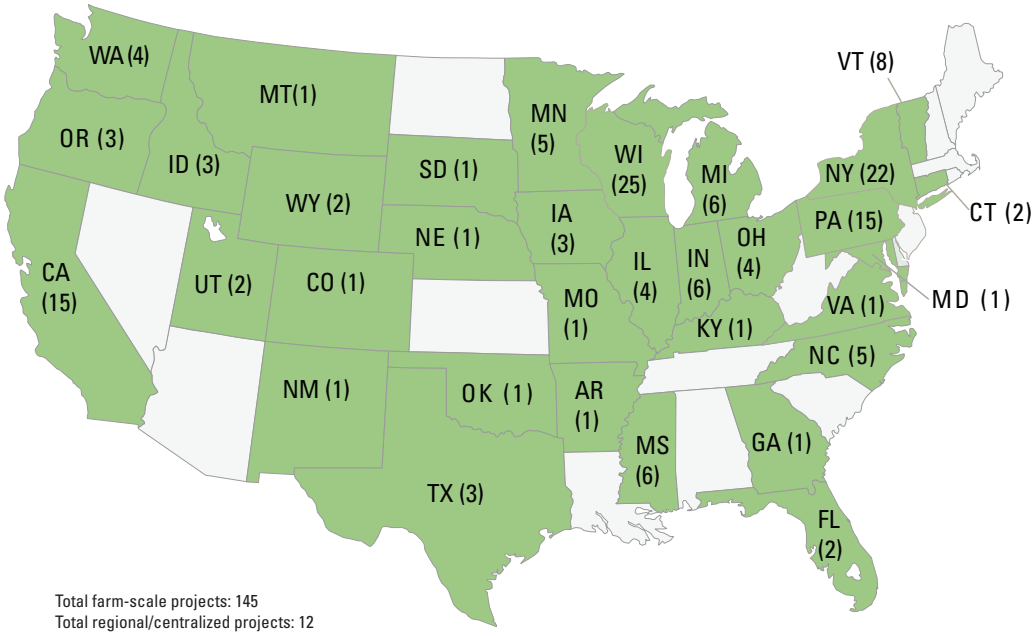
Secretary Tom Vilsack, USDA and Administrator Lisa P. Jackson, U.S. EPA signing the interagency agreement on May 3, 2010.

On May 3, 2010, USDA and EPA announced a new interagency agreement promoting renewable energy generation and slashing greenhouse gas emissions from livestock operations. The purpose of the agreement is to leverage and utilize each other's expertise and resources to advance deployment of commercially ready anaerobic digestion and biogas use technologies that reduce investment and operational risk to farm owners. With this agreement, USDA's Office of Rural Development and the Natural Resources Conservation Service will work together with EPA to increase the number of biogas systems by finding ways to allow more farmers to tap into this too often neglected resource. The AgSTAR Program has an excellent track record of promoting biogas systems on farms through technical assistance, project assessment, and other collaborative approaches.

Profile of Anaerobic Digesters

As of July 2010, EPA estimates that 157 digester projects are operating on commercial scale livestock facilities nationwide (Figure 2). This number, as well as all other data provided in this section, is based on AgSTAR's Anaerobic Digester Database, which comprises information collected from project developers, farm owners, press releases, and a variety of other sources.

Figure 2. Operating Manure Digester Systems by State (July 2010)



Most digester projects (79 percent) are located at dairy farms, which are largely concentrated in the Midwest, West, and Northeast. Digesters have also been constructed at swine farms (15 percent), beef farms (2 percent), and at poultry farms (3 percent). The poultry farm digester projects are located on 3 broiler farms, 1 layer farm, and 1 duck farm. Table 2 lists the number of projects operating by animal sector.

Table 2. Number of Operating Anaerobic Digester Projects by Animal Type

Farm Type	Total Digester Projects	Plug Flow Projects	Complete Mix Projects	Covered Lagoon Projects	Other Projects
Dairy	126	74	27	16	9
Swine	24	2	5	15	2
Poultry	5	1	4	0	0
Beef	2	2	0	0	0

About half of operating digester projects in the United States use plug flow digesters (Figure 3). Complete mix systems are the second most common digester type, at about 23 percent, followed closely by covered lagoons, at 19 percent. Plug flow digesters are prevalent because this technology is commonly used for scraped manure systems at dairies, and dairy farms currently represent almost 80 percent of the digester projects in the United States.

Energy Production and Biogas Use

Since 2000, there has been almost a 25-fold increase in the annual electricity generation from digester projects, from about 14 million kilowatt-hours (kWh) to an estimated 331 million kWh per year (Figure 4). Many of the projects that generate electricity also capture engine-generator set waste heat for various on-farm uses in addition to digester heating. Some operations use the biogas as a boiler fuel, process it for injection into natural gas pipeline as renewable natural gas, or flare it for odor control. The percentage of digester projects using the captured biogas for purposes other than generating electricity has increased from nearly zero in 2000 to about 17 percent in 2009. Non-electric energy capture from anaerobic digestion has increased from less than 1 million kWh equivalent in 2000 to about 54 million kWh equivalent of useable energy in 2009.

Figure 3. Number of Operating Anaerobic Digester Systems by Technology

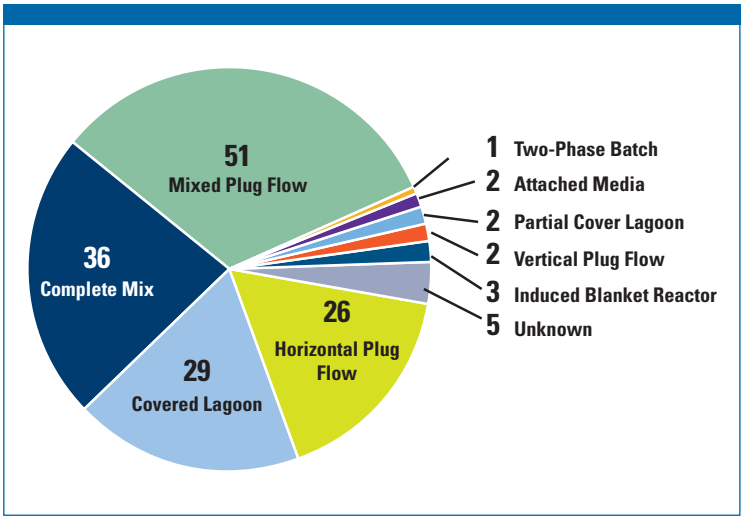
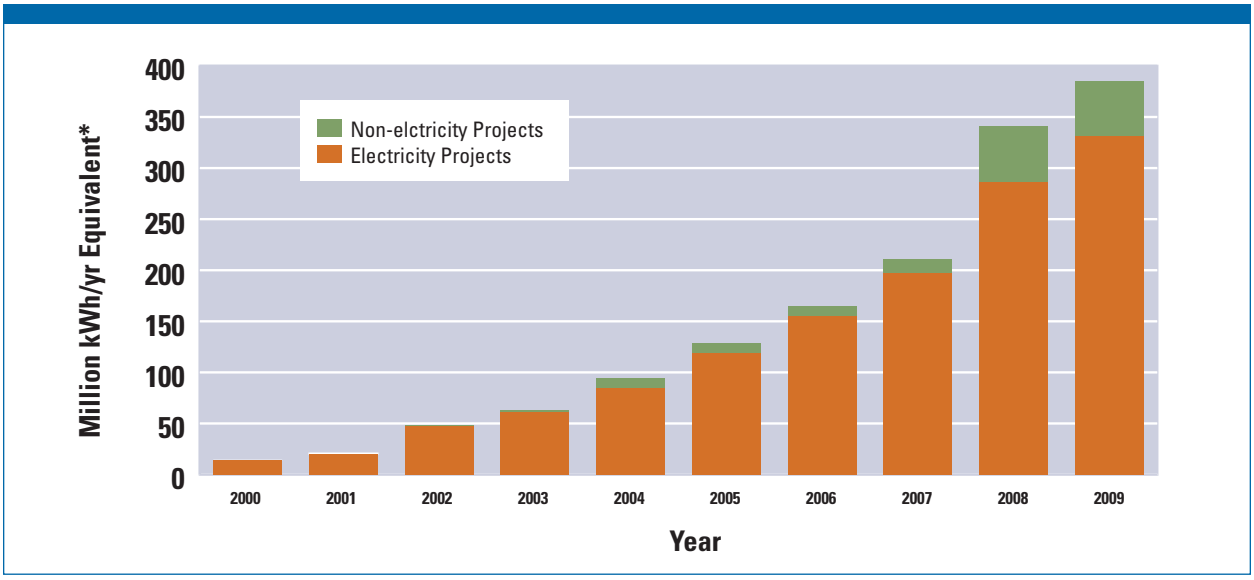


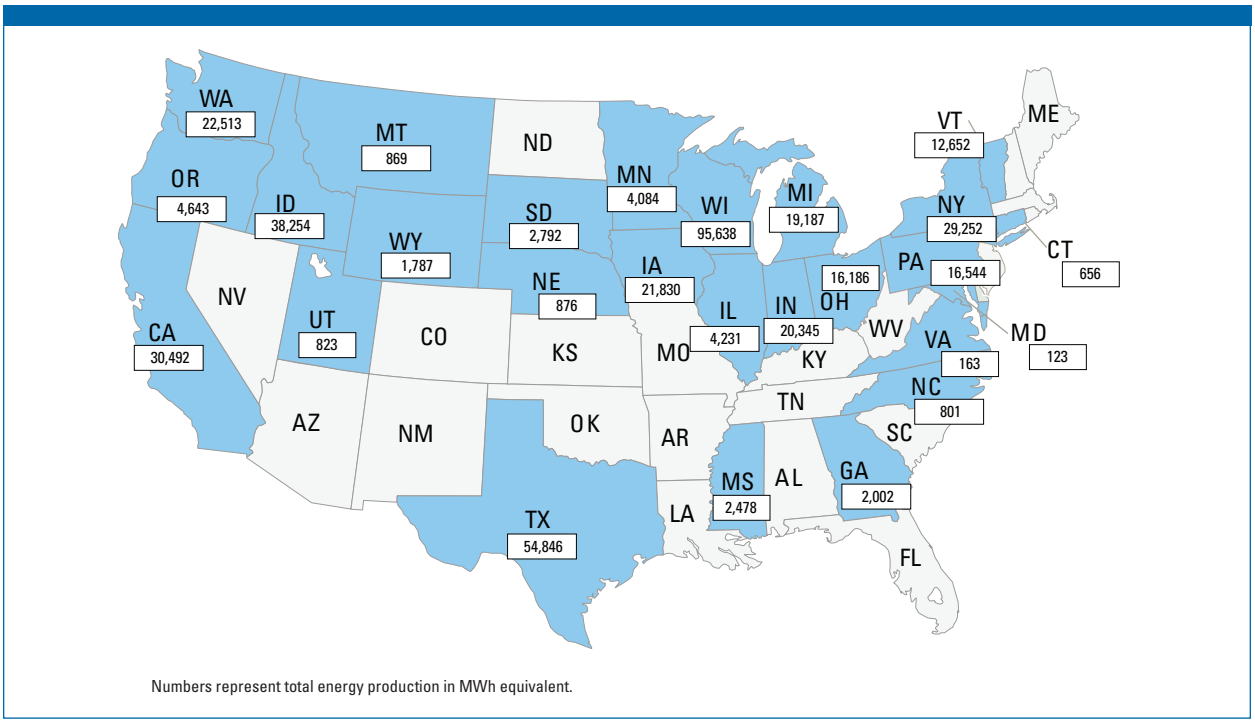
Figure 4. Energy Production by Anaerobic Digester Systems: 2000 through 2009



*Output estimated includes a calculated equivalent kWH/yr output for the energy generation of direct thermal, pipeline injection, or other non-electricity-producing projects.

In 2009, farm digester systems produced an estimated total of 385 million kWh equivalent of useable energy. As of July 2010, total energy production from operating digester projects is estimated to be approximately 404 million kWh/yr, an increase of 19 million kWh over estimates from the end of 2009. This energy production is broken down by state in Figure 5.

Figure 5. Total Annualized Energy Production of Operating Digesters as of July 2010



Numbers represent total energy production in MWh equivalent.

Table 3 shows the breakdown of biogas use among operational digester projects in the United States. Cogeneration projects, which are electricity projects that capture waste heat from electricity generation equipment for on-farm use, are the most common type of digester project. Electricity without cogeneration is the next most popular biogas use, followed by direct use in a boiler or furnace. Less common uses include pipeline injection, vehicle fuel, and methanol production.

Table 3. Biogas Use Technologies for Operational Projects

Use	Number of Digester Projects*	Percent of Digester Projects (%)
Cogeneration	78	49.7
Electricity	48	30.6
Boiler/Furnace Fuel	20	12.7
Flared Full Time	15	9.6
Unknown Use	7	4.5
Pipeline Gas	4	2.5
Vehicle Fuel	1	0.6
Methanol	1	0.6

*Project totals sum to more than the total number of operating projects because some farms have multiple uses for recovered biogas.

Although the majority of systems are farm-owned and operated, using only livestock manure, other approaches are emerging. A dozen centralized systems handling manure from multiple farms are currently operating. Table 4 shows the number of farm scale, multiple farm, and centralized projects. A multiple farm project refers to a digester system located on one farm that receives influent from a neighboring farm or farms, in addition to influent originating on site. Centralized systems also receive influent from multiple locations but are not located on farms and are typically much larger than farm scale or multiple farm projects. Codigestion, digesting manure with other high strength organic wastes (normally food processing wastes), may significantly increase biogas production per unit volume of reactor. About 22 percent of the currently operating projects codigest other substrates with livestock manure to increase biogas production and revenue.

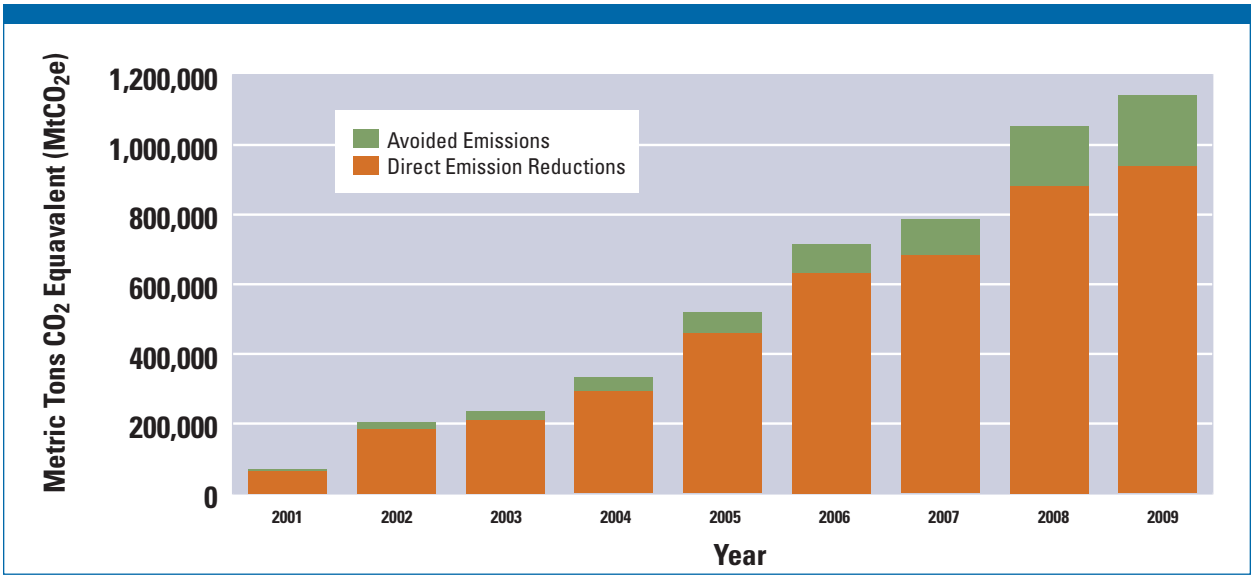
Table 4. Farm Scale, Multiple Farm, and Centralized Projects

Project Type	Number of Operating Projects
Farm Scale	143
Multiple Farm	2
Centralized/Regional	12

Emission Reductions

Anaerobic digesters reduce greenhouse gas emissions in two ways. The first is direct methane emission reduction from the capture and burning of biogas that otherwise would escape into the atmosphere from the waste management system. For projects that generate energy, a second benefit is the avoided emissions of greenhouse gases (carbon dioxide, methane, and nitrous oxide) and other pollutants by the use of biogas to displace fossil fuels that otherwise would be used to generate energy. Figure 6 shows the annual emission reductions, including both direct reductions and avoided emissions, resulting from anaerobic digesters since 2001.

Figure 6. Estimated Annual Emission Reductions from Anaerobic Digester Projects*



*Avoided emissions calculated based on EPA eGRID national average emission rates for electricity projects and EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006* for non-electricity projects. EPA eGRID data was unavailable for 2001, 2002, and 2003, so values were extrapolated based on a linear decrease from 2000 to 2004. EPA eGRID data for 2005 and EPA greenhouse gas inventory data for 2006 were assumed for subsequent years as these are the most recent data available.

In 2009, operating digester projects reduced greenhouse gas emissions by over 1.1 million metric tons of carbon dioxide equivalent. These emission reductions are equivalent[1] to any one of the following annual environmental benefits:

- Removing about 218,000 passenger vehicles from the road.
- Reducing oil consumption by almost 2.7 million barrels.
- Reducing gasoline consumption by over 128 million gallons.

In addition to the benefits of providing an energy source and reduction in greenhouse gas emissions, biogas recovery systems offer a number of air and water quality benefits, including odor control and water quality protection. The primary source of odors from volatile organics and hydrogen sulfide are reduced to methane and carbon dioxide, or contained in the digester and destroyed with the recovered gas. Relative to water quality, anaerobic digestion destroys disease-causing bacteria, and reduces the chemical oxygen demand of the waste that could otherwise result in additional loading on natural waters.

Given the significant benefits recognized from the implementation of anaerobic digestion on agricultural operations and the number of operations that can use these systems across the United States, continued expansion of digester systems is a valuable opportunity for energy and environmental growth.

[1] Emission reduction equivalencies were calculated using EPA's Greenhouse Gas Equivalencies Calculator (March 2010 version) available at www.epa.gov/cleanenergy.



AgSTAR is an outreach program jointly sponsored by the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and the U.S. Department of Energy. The program encourages the use of biogas recovery technologies at confined animal feeding operations that manage manure as liquids or slurries. These technologies reduce emissions of methane (a potent greenhouse gas), generate clean energy, and achieve other environmental benefits. For additional information, please visit our website at www.epa.gov/agstar.