

Emerging Manure to Energy Technologies - Are Cost Effective Small Scale Digesters Possible?

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DEPARTMENT OF ENVIRONMENTAL
SCIENCE & TECHNOLOGY
College of Agriculture & Natural Resources

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Anaerobic Digestion Scale



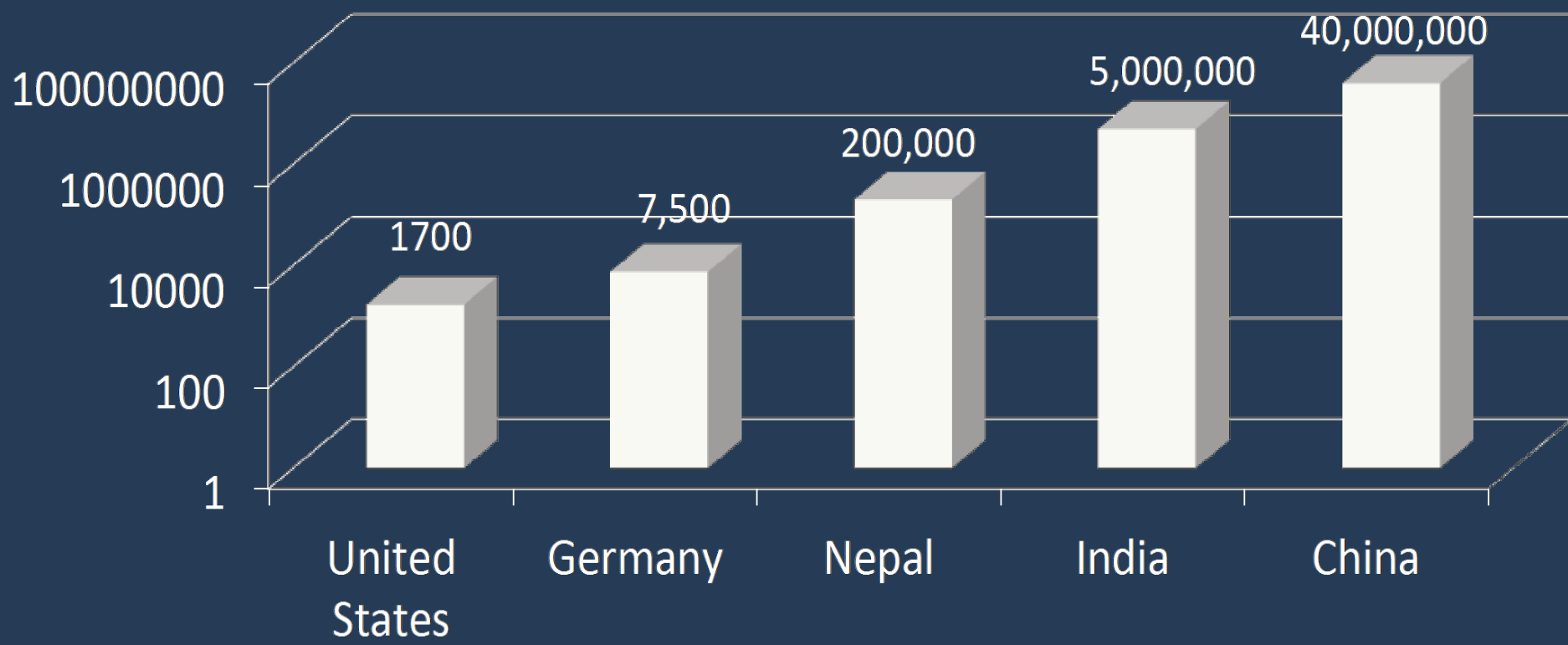
Wastewater Treatment Plant (WWTP)
Digester in Boston MA



Dairy Manure Digester
Guapiles, Costa Rica



Anaerobic Digesters in the World



The majority of US digesters are at WWTP, only 260 on-farm



Chinese Dome - Mortar



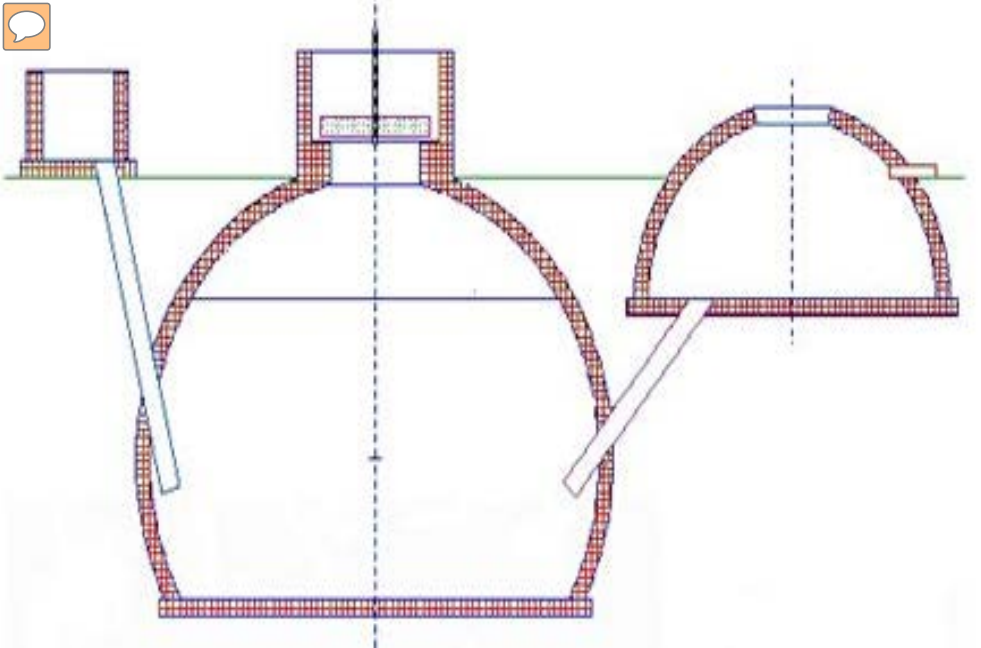
Floating Drum



Taiwanese-Model



Covered Lagoon



Floating Drum



Taiwanese-Model



Covered Lagoon

Anaerobic Digesters (Haiti)



Biogas End Uses

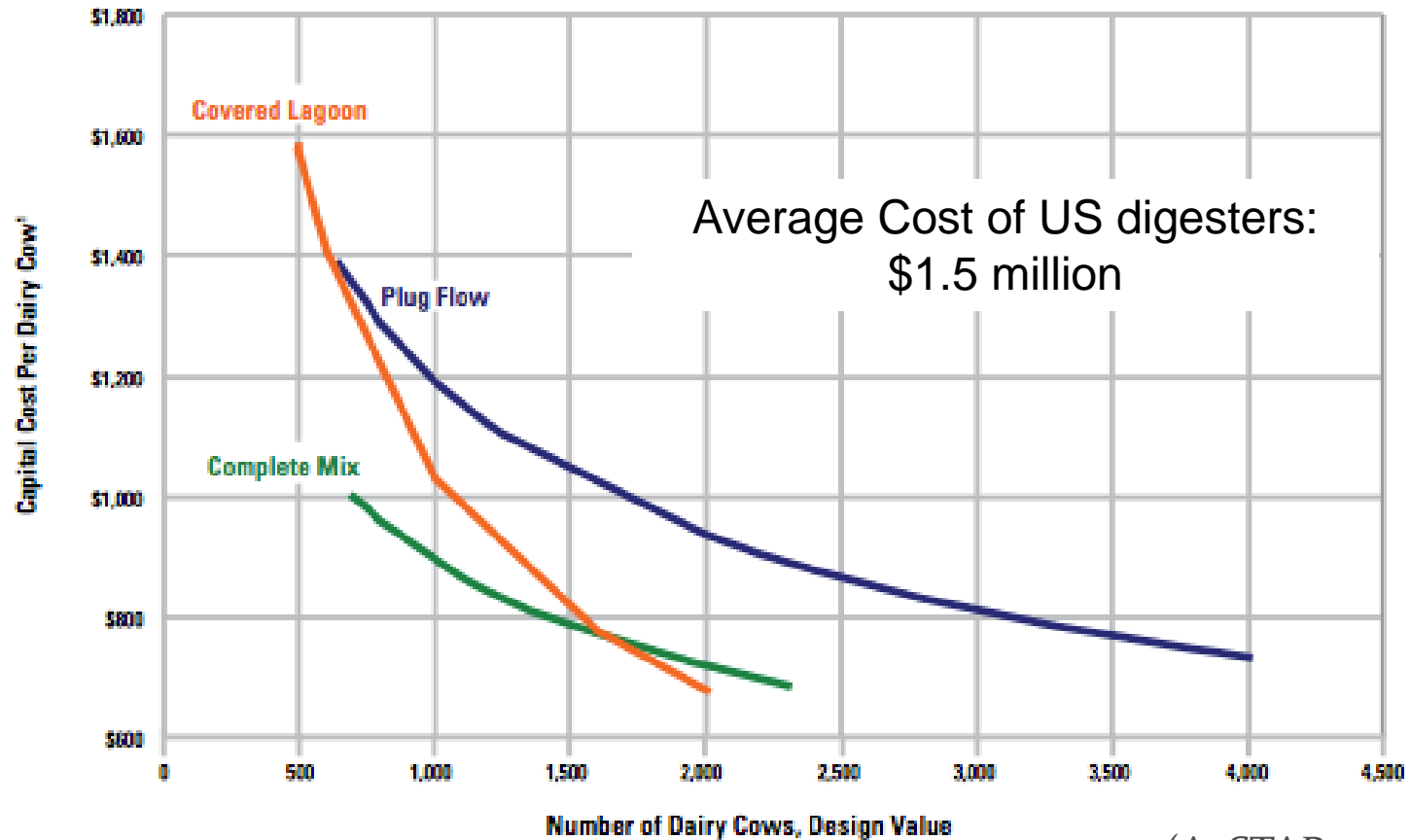


Lack of US Small-scale on-farm Digestion in the US

Of the 260 farm-based US digestion systems only FOUR dairy digesters are on farms with 200 cows or less (87% of dairy farms).

Number of Dairy Cows on-Farm	Number of US Operations (2012)	Percent of Total US Dairies
1-29	18,800	32%
30-49	9,700	17%
50-99	14,500	25%
100-199	7,900	14%
200-499	3,800	7%
500+	3,300	6%

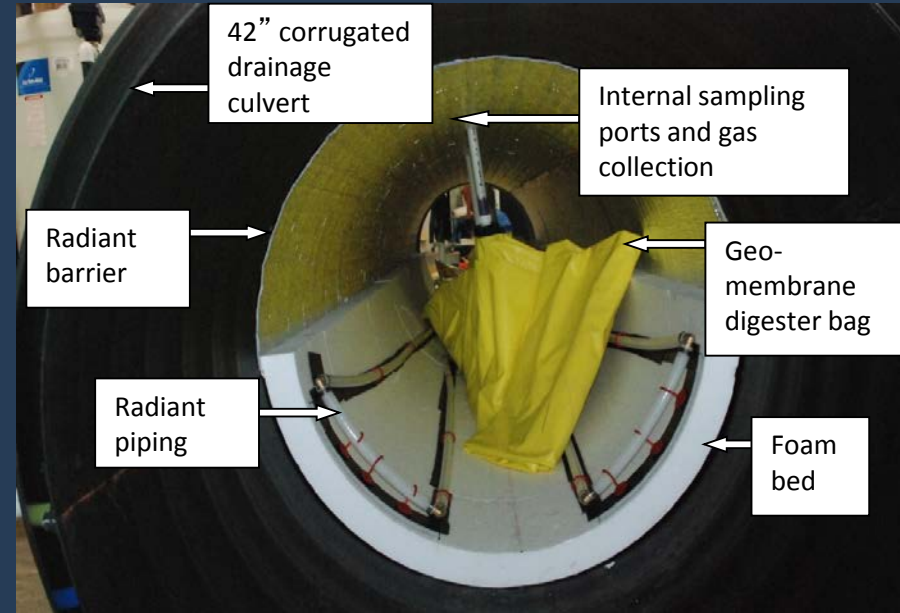
Estimated Capital Cost for US Digesters



¹ Costs are stated in September 2009 dollars.

(AgSTAR, 2010)

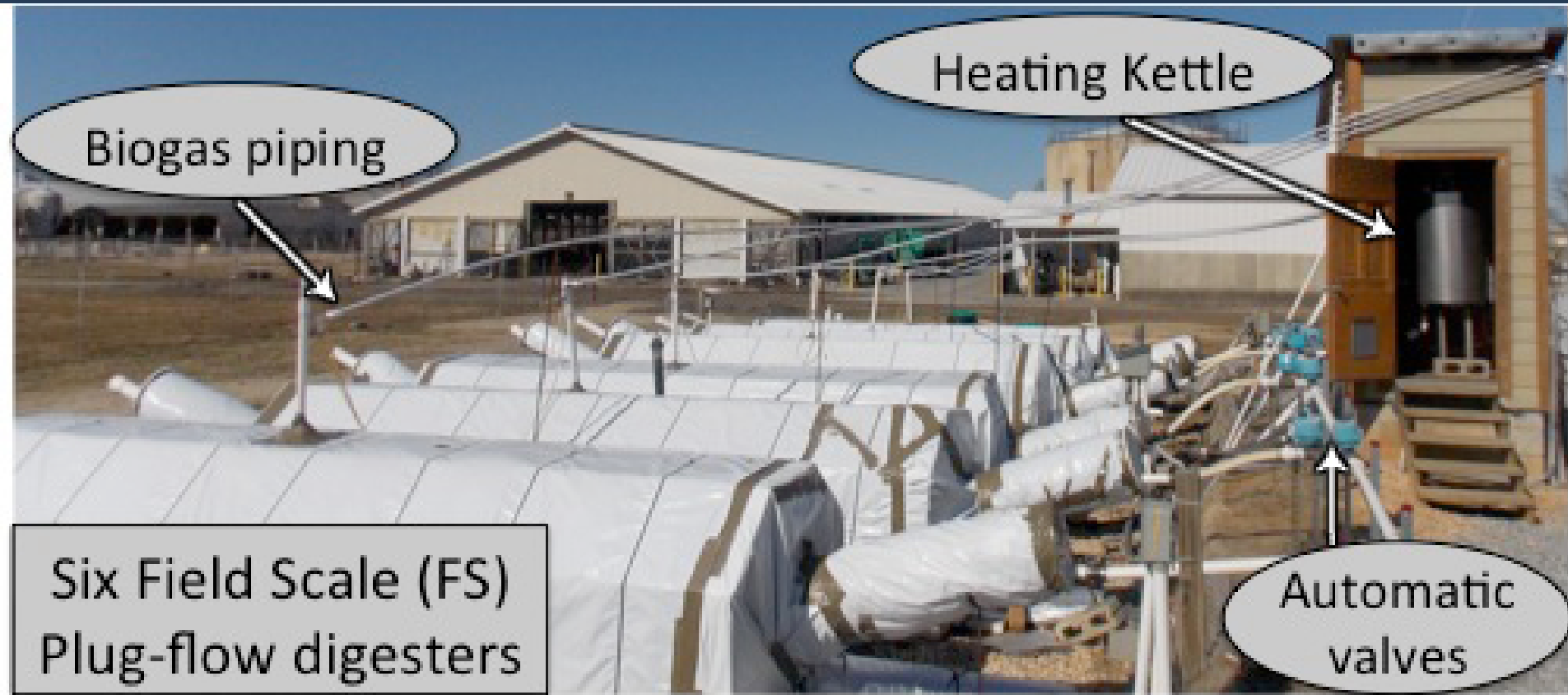
Adaptation of Tropical AD Models



Credit: Aziza Kenya

Credit: Jay Martin -OSU

Small-Scale Digesters for US

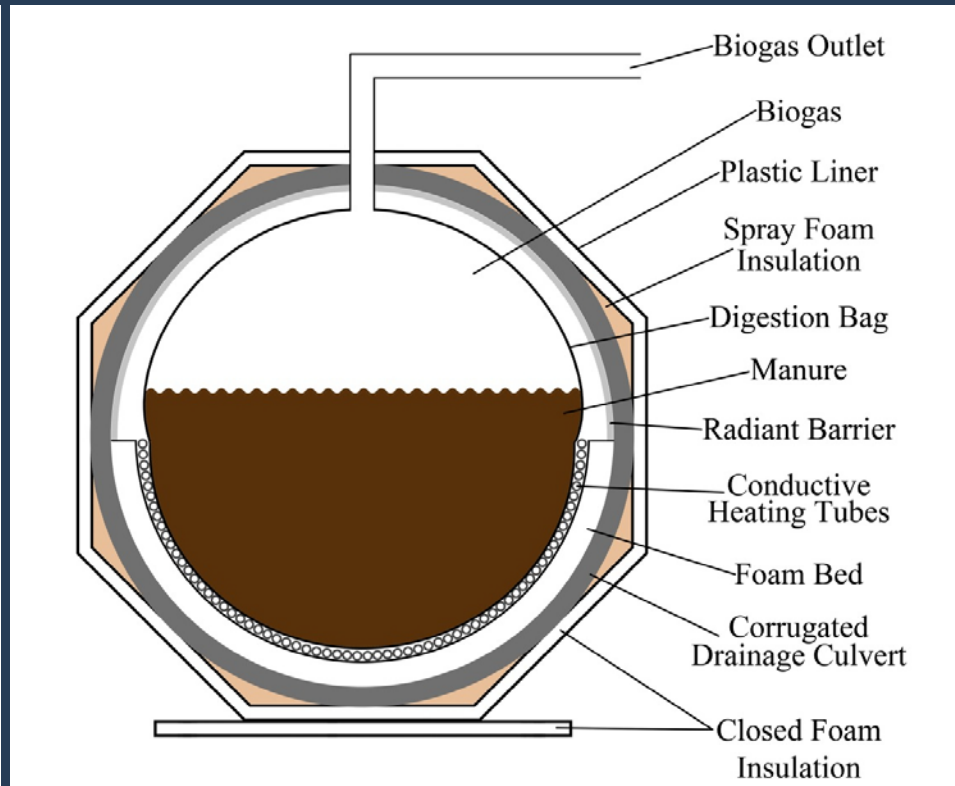
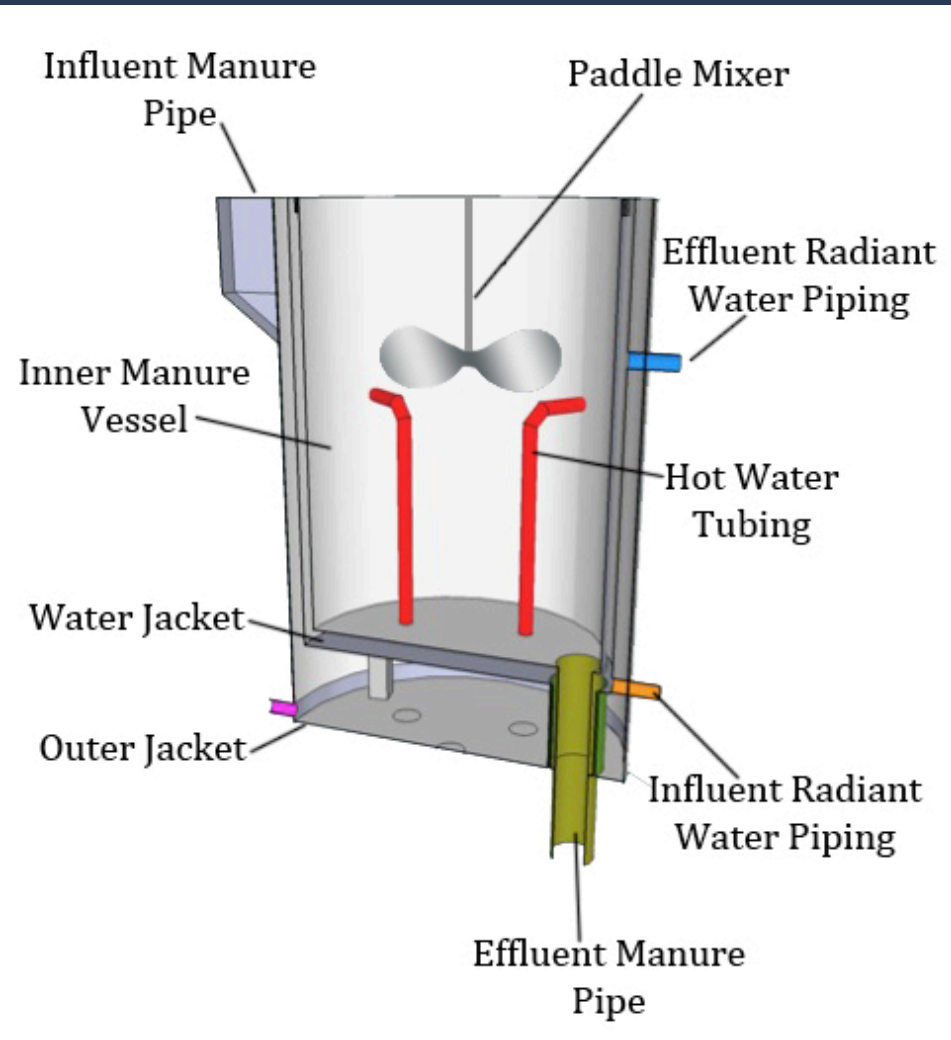


- 🌐 Six flexible biogas bags digesters situated in insulated, heated culverts
- 🌐 Influent can be pre-heated and radiant piping used for in-vessel heating
- 🌐 Automatic loading and temperature control at 30° C

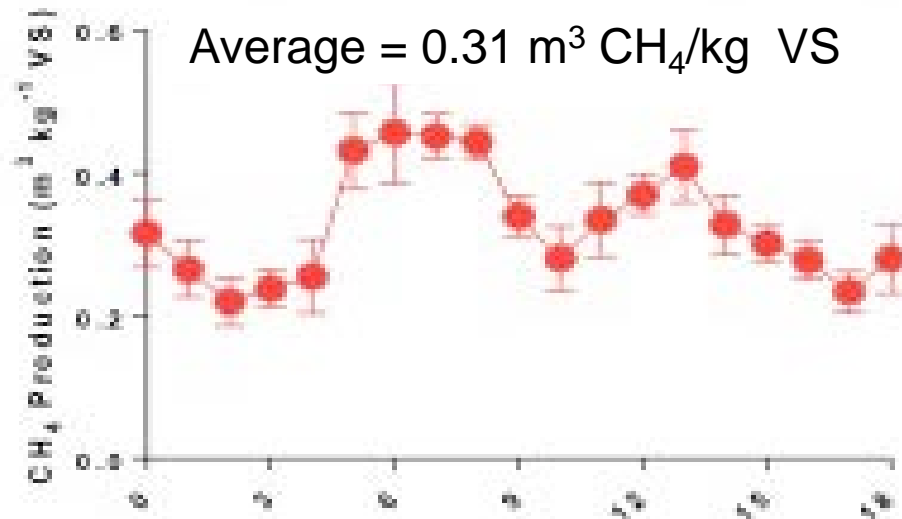
UMD Digester Design Construction



UMD Small-Scale Plug Flow Digesters



Small-scale Digestion Performance

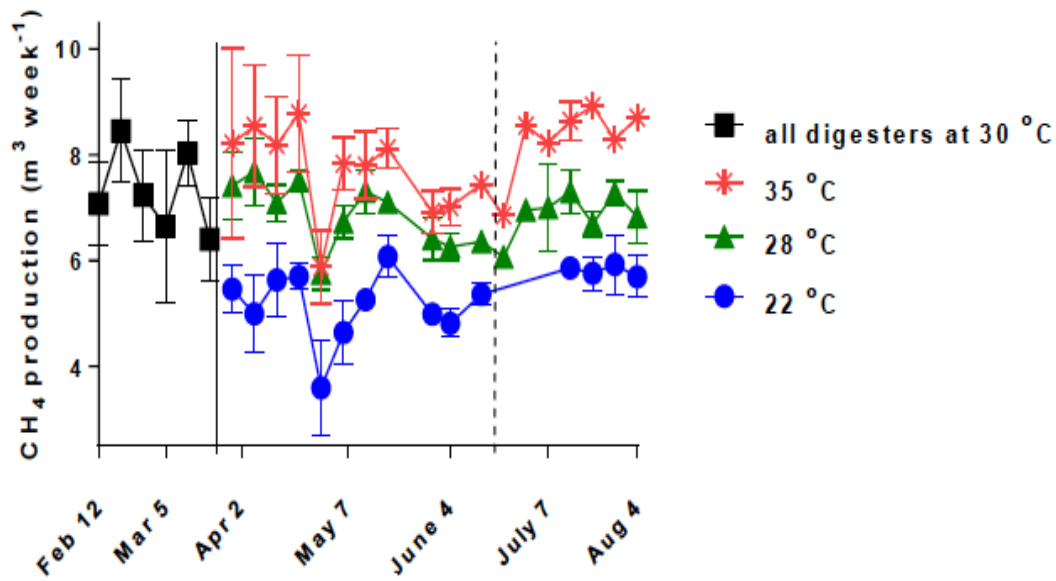


High methane production (67.2% CH₄). Solids reduced by 43.3%.

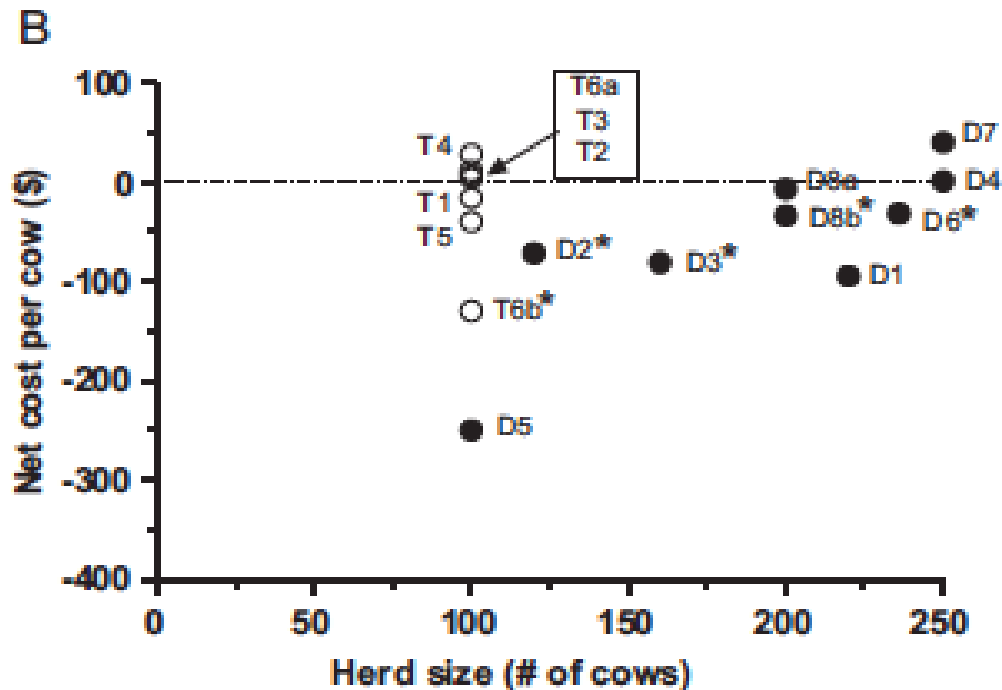
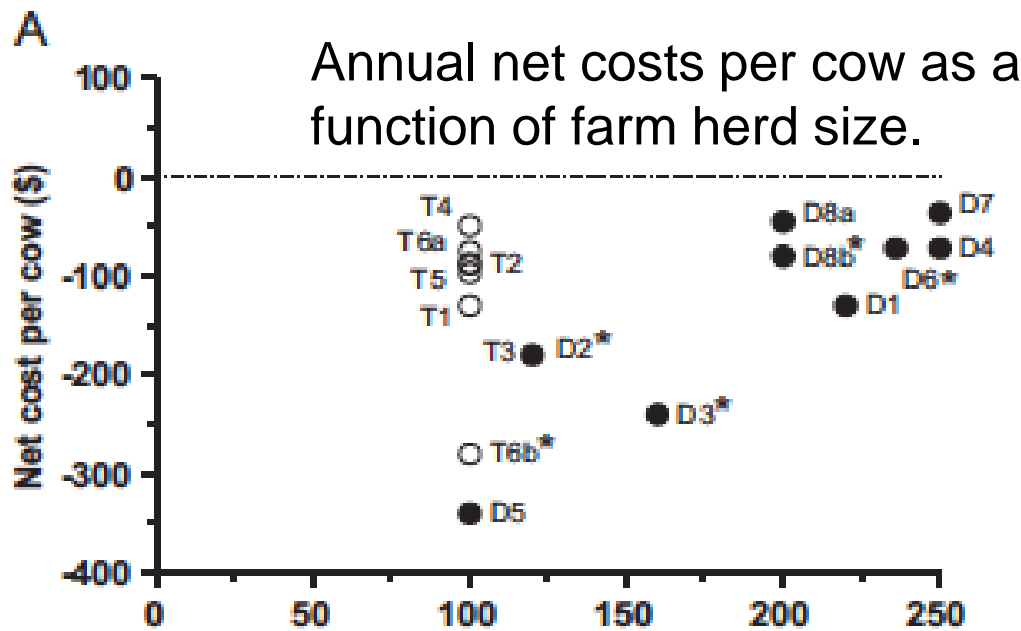
13% less CH₄ production at 28° C compared to 35° C, and 30% less at 22° C.

Produced 3x the energy needed to counteract digester heat loss

Cost = \$16,800, higher than tropical systems (\$400): high impact of heating and insulation



Economic Analysis of US Small-scale Digesters



•A: Calculated without cost sharing included

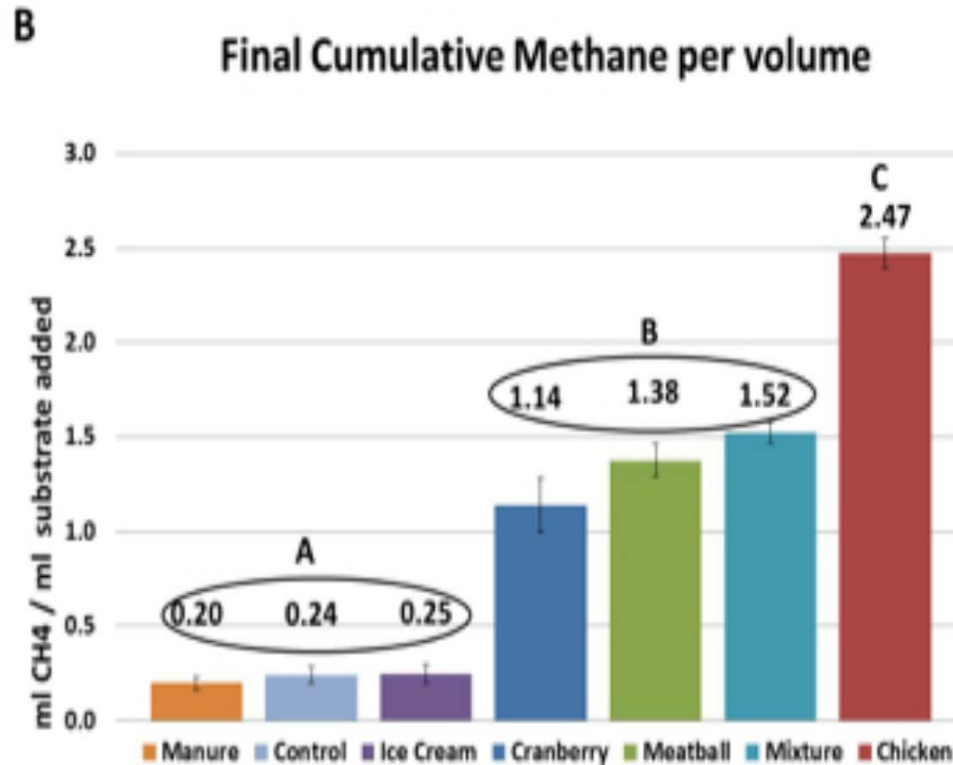
•B: Calculated using 50% cost sharing

•Solids Circles: Existing Digestion System.

•Open Circles: Proposed Digestion Systems (Minnesota Project and UMD)

* Systems with Gen-sets

Food Waste Co-digestion at Kilby Farm



Covered lagoon dairy manure digester – currently unheated – in Colora, MD

- Food processing waste from manufacturing of Cranberry, Ice cream, Chicken and Meatballs and manure from 600 cows.

- Digester input consists of 96.8% (by volume) dairy manure and the remaining is the food waste.

Digestion Opportunities

- Livestock operations have consistent biomass collected in one spot and with digesters could produce non-intermittent renewable energy with a small land footprint.
- Small-scale farms are >50% of market. If a US small-scale dairy operations had digesters, there would be 25% less U.S. natural gas consumption and 5% less methane emissions (34.5 million tons of CO₂ eq)
- In Germany, with ag-based 8,000 digesters, the overwhelming majority incorporate co-digestion. Co-digestion of food waste, with tipping fees (more \$\$ to farmers) can greatly increase energy production, assuming the nutrients from the food waste can be incorporated into nutrient management plans.
- EPA has identified more than 11,000 viable agricultural AD systems using current technology, which could power 3 million homes and could reduce methane emissions by 54 million metric tons of CO_{2(eq)}, equal to emissions from 11 million passenger vehicles.

Digestion Challenges (\$ \$ \$ \$)

- 🌐 Understanding dairy industry pressures and low economic return from manure-only waste digestion and infancy of poultry litter based digesters (3 in US)
- 🌐 Importance of scrubbing H₂S from biogas, especially for electric generation and reducing frequency of generator malfunction
- 🌐 Dependent on electricity price for large-scale systems and year-round demand for direct use of biogas
- 🌐 Net metering not available in most states
- 🌐 Combined heat and power systems are expensive, but provide excessive heat – hard to justify cost at the small-scale
- 🌐 Difficulties and time to obtain financing and operate, especially at the small-scale.



Some Existing Small-Scale Systems

- Minnesota Project's Jer-Lindy (160 cows)

 - \$460,000

- Universities

- Private Dairies

 - \$152,000 - \$266,000

- Commercial

 - Avatar

 - (>100 cows)

 - Bioprocess

 - (250 cows)

 - Agreen Energy/Quasar

 - (250 - 400 cows)

 - BioFerm



Case Study: Butler Farms

Butler Farms applied for and received multiple grants, a cost-share agreement, and a cash reimbursement to fund its covered lagoon anaerobic digestion system.

Capital costs

The total capital cost for the anaerobic digester was \$550,000 to \$650,000.

The farm operator received the following:

- A combined grant of \$373,780 from the North Carolina State Energy Office and the North Carolina Green Business Fund. (Note: Both grants were administered at the state level, but ultimately, the funds were derived from the ARRA.)
- A \$116,480 cost-share agreement from the USDA's NRCS EQIP.
- A \$20,000 grant from the North Carolina Farm Bureau Federation's Farm Energy Efficiency Program (FEETP).
- A grant for 30 percent of eligible project cost from the ARRA Section 1603 Program.

The balance of the capital costs (approximately \$50,000) were paid out of pocket by the farm operator.

Operating costs

The annual operating and maintenance costs for the digester and end-use equipment are approximately \$25,000. End uses for the methane gas produced include electricity generation, which is sold to the local utility, and use of waste heat to heat the digester. The farm estimates that revenue from electricity sales will be approximately \$56,000 per year, without codigestion. (Butler Farms estimates that with the planned codigestion, electricity sales could be \$130,600 per year.) The project vendor estimated that the simple payback period is 8 to 10 years; however, the farm operator hopes to shorten the payback period with increased biogas from a planned codigestion project.



USDA Energy Financing for Digesters

Deb Yocum

Northeast Regional Energy Coordinator
USDA Rural Development-Energy Division

June 1, 2016

USDA Energy Financing Programs

- What is the Rural Energy For America Program (REAP)?
- How can I leverage Federal Programs?



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of rural communities.



- Where can I go for State specific financial and technical assistance?

REAP - Eligible Applicants

Agricultural Producer



- **Individual or entity that receives 51 percent or more of their gross income from agricultural production** – crops, livestock, aquaculture, forestry operations, nurseries, dairies

Rural Small Business



- **For-profit small business** - as defined by the Small Business Administration (SBA)
- **Rural area or non-metro community of $\leq 50,000$**

REAP Summary 2003 to 2015















Year	Sum of number	Grant Amount	Loan Amount	Leverage Amount	Corrected Total Project Cost	Energy Saved/Generated (MWH)	Gallons of Biofuel	Reduced GHG Emissions (MT CO ₂ e)
2003	114	21,707,373	0	545,381,487	567,088,860	260,423	49,719,421	155,380
2004	167	22,812,049	0	136,984,587	159,796,636	355,368	58,957,934	270,499
2005	156	22,237,268	10,100,000	193,511,453	225,848,721	379,443	6,255,313	175,413
2006	395	21,209,435	24,158,862	190,332,768	235,701,065	371,997	232,446,498	794,759
2007	436	19,123,191	57,270,743	243,396,339	319,790,273	373,536	95,240,196	713,402
2008	764	34,239,666	15,566,169	158,032,939	207,838,774	755,272	115,852,839	1,265,423
2009	1,559	54,409,524	57,522,141	166,702,708	278,634,372	1,324,092	36,701,160	2,156,213
2010	2,404	86,332,404	73,664,775	299,373,011	459,424,426	3,013,027	69,812,157	2,632,031
2011	2,012	62,519,999	34,072,816	331,529,788	428,122,603	1,581,963	221,892,403	2,343,788
2012	872	21,634,127	14,278,112	126,650,908	160,225,146	139,855	4,268,425	410,708
2013	1,422	39,589,998	32,557,550	250,715,746	322,863,294	245,580	61,628,552	1,023,824
2014	540	12,374,278	56,449,244	255,237,838	324,031,098	241,464	517,611	361,347
2015	1,906	82,979,098	161,265,520	660,573,049	916,682,551	1,098,419	19,044,800	557,806
Total	12,747	501,168,409	536,905,932	3,558,422,621	3,689,365,268	10,140,440	972,337,308	12,860,594

REAP Biogas Projects Funded in 2015

2015 Rural Energy for America Program, Biogas System Investments by State

State	Number of Projects	Grant Amount	Guaranteed Amount	Leverage Amount	Total Development Cost	Projected Renewable Energy Generation (MW hours)
CALIFORNIA	7	\$2,595,968	\$0	\$25,049,373	\$27,645,341	39,206
MAINE	1	\$500,000	\$0	\$4,649,000	\$5,149,000	7,884
MASSACHUSETTS	3	\$1,019,912	\$0	\$3,337,959	\$4,357,871	5,655
MICHIGAN	1	\$480,251	\$0	\$3,319,505	\$3,799,756	1,577
NEW YORK	1	\$500,000	\$0	\$2,253,322	\$2,753,322	4,494
NORTH CAROLINA	1	\$500,000	\$6,500,000	\$3,836,994	\$20,673,988	103,799
OHIO	1	\$311,354	\$0	\$5,324,626	\$5,635,980	1,351
WASHINGTON	2	\$49,666	\$0	\$148,998	\$198,664	3,796
Total	17	\$5,957,151	\$6,500,000	\$47,919,777	\$70,213,922	167,761

Eligible Projects

Energy Efficiency		Renewable Energy	
	Lighting		Solar
	Heating		Wind
	Cooling		Small Hydroelectric
	Ventilation		Anaerobic Digesters
	Fans		Biomass
	Automated Controls		Geothermal
	Insulation		Wave/Ocean Power

The technology must be commercially available. Research and development projects do not qualify.

Eligible Projects

DIGESTERS

- Energy for self-use
- Replacement for existing energy
- Energy for sale to the utility
- Scrubbed biogas for sale into pipeline
- Scrubbed biogas to compressed natural gas
- Retrofits to existing digesters

**Eligible Project Costs**

- **Equipment:**
 - Purchase & installation
 - New or refurbished
- **Post-application construction & facility improvements**
- **Retrofitting**
- **Professional service fees**
- **Permits & license fees**
- **Working capital, land acquisition (Guaranteed loan ONLY with restrictions)**



**Ineligible Project Costs**

- **Residential energy projects**
- **Equipment:**
 - Farm tillage equipment
 - Used equipment
 - Vehicles
- **Pre-application construction & facility improvements**
- **Application preparation or grant writer fees**
- **Line of credit**
- **Lease payments**
- **Payment to the applicant/business owner, beneficiary, or relative**

REAP Grant Assistance

Up to 25%

of Eligible Project Costs

 Renewable Energy Systems		 Energy Efficiency Improvements	
Minimum Grant Request	\$2,500 Total eligible project costs \geq \$10,000	Minimum Grant Request	\$1,500 Total eligible project costs \geq \$6,000
Maximum Grant Request	\$500,000 Total eligible project costs \geq \$2 million	Maximum Grant Request	\$250,000 Total eligible project costs \geq \$1 million

REAP Guaranteed Loan Assistance

Up to 75%
of Eligible Project Costs

Minimum Loan Amount	\$5,000 Total eligible project costs \geq \$6,667
Maximum Loan Amount	\$25 million Total eligible project costs \geq \$33.4 million
Details	<ul style="list-style-type: none">• USDA guarantees a commercial loan; applicant must have a willing lender.• Terms are negotiated between the lender and borrower.• Fees, appraisals, equity & collateral requirements apply.

REAP Application Window Closing Deadlines

Grants October 31	<ul style="list-style-type: none">➤ Set Aside Fund Competition-Grant Request \$20,000 or less➤ Combination Guaranteed Loan/ Grant Request \$20,000 or less
Grants April 30	<ul style="list-style-type: none">➤ Grant Request \$20,000 or less not competing for set aside➤ Grant Request > \$20,000➤ Combination Guaranteed Loan/ Grant Request
Guaranteed Loans	<ul style="list-style-type: none">➤ Continuous Application Cycle➤ Monthly Competitions for funds throughout the year➤ Loan must score a minimum of 50 to compete monthly

How Can I Leverage Federal Programs?



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of rural communities.



Duplication is unauthorized assistance

- Duplication can occur intentionally or unintentionally
- The Government is responsible to avoid making duplicate payments
- Programs may not be used to pay a recipient twice for the same project
- Different programs can pay for different parts of a whole project
- We're obligated to review and monitor our programs to avoid paying for the same thing twice

Kane's Cow Power, LLC

- 225 kWh Anaerobic digester system
- Generates electricity & produces on farm bedding
 - 1,451,336 kWh/year = 133 homes
- Feedstock is dairy waste

- REAP Award: \$575,000 Loan
\$444,737 Grant
- NRCS EQIP: \$863,700
- Vermont Public Service: \$150,000
- Clean Energy Development Fund: \$150,000

Payments via Advanced Biofuel Payment Program

Renewable Energy



Small Energy Company & Dairy Farmers



1 MW Anaerobic digester

- \$4.15 Million Total Cost
- \$100,000 REAP Grant
- \$2.65 Million REAP Guarantee

Powers an equivalent of
700 homes/year



Fennville, MI

- Complete mix, two-stage Anaerobic Digester System
- 2,300 head dairy operation
- Energy produced has made farm self-sufficient
- Excess energy sold to local utility





Rutland AD 1 LLC

- Added a 300 kw generator set to existing digester
 - REAP Award: \$289,996
 - Jordan Farm, Rutland, MA
 - Feedstock is dairy waste & food waste
- 1,752,000 kWh/year = 161 homes

Lakeshore Dairy, LLC

- Mesophilic, complete mix digester
- Guascor 570 kW engine & generator set
- Feedstock is manure from approx. 2,680 cows, heifers and young stock at Lamb Lakeshore Dairy in New York
- REAP Award: \$500,000
- TPC: \$2,753,322
- Savings of 75% of farm demand (\$269,844/year), waste heat and recovered solids
- 4,498,880 kWh/year = 415 homes



VGBLADS, LLC

- Anaerobic Digester at the end of an airport tarmac now called Brunswick Landing (Brunswick, ME)
- Digest 51,684 wet tons of organic material annually
- 7,884,000 kWh/year = 727 homes

- \$500,000 REAP Grant
- \$4,649,000 Bank Loan
- \$5,149,000 TPC



INDIANA

From Farm Waste to Natural Gas



Fair Oaks Dairy Digester/Renewable Dairy Fuels



<http://www.dsireusa.org/>

Database of State Incentives for Renewables & Efficiency[®]

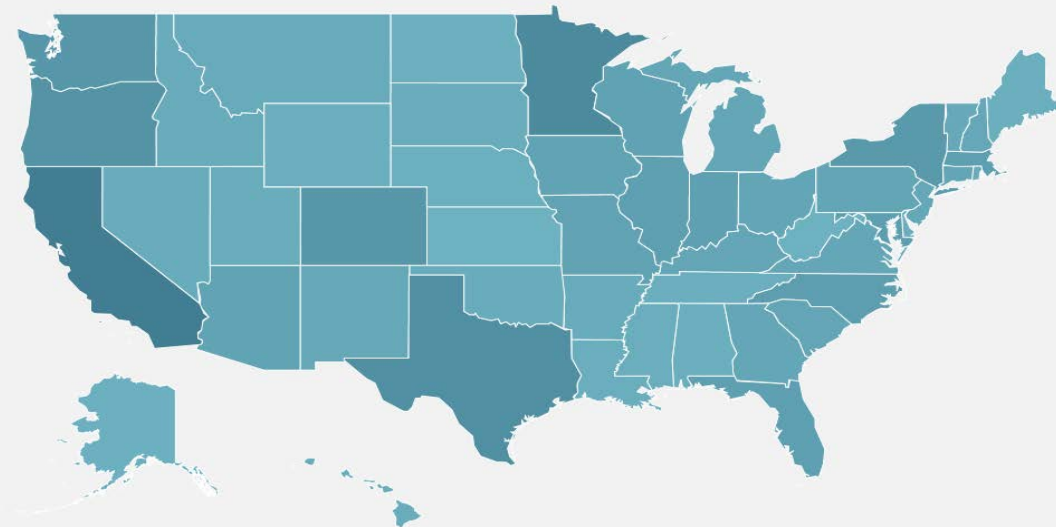
Find Policies & Incentives Near You

Zip Code



Search

Find Policies & Incentives by State



The screenshot shows the DSIRE website interface. On the left, a map of the United States highlights Vermont with a red circle. The main navigation bar includes 'Home', 'Programs', 'Resources', and 'Help/Support'. A secondary navigation bar contains 'Overview', 'Summary Maps' (circled in red), and 'Summary Tables'. Below this is a red banner stating 'We've found 68 programs that match your filters'. A 'Filter Options' button is circled in red. A dropdown menu on the right lists filter categories: Technology, Date, Categories, Program Type, Implementing Sector, State, Coverage Area, and Eligible Sector. At the bottom, there is a search bar, a 'Subscribe' button, a 'Show 50 entries' dropdown, and an 'Apply Filter' button circled in red.

- Click on State
- Click on Summary Maps
- Filter Options
 - Technology
 - Renewable Energy
 - Biomass
 - Anaerobic Digestion
- Apply Filter

Results are all applicable policies & incentives for AD in VT

Rural Business-Cooperative Service

We've found 17 programs that match your filters

➤ Additional Filters

Name	State/ Territory	Category	Policy/Incentive Type	Created	Last Updated
Net Metering	VT	Regulatory Policy	Net Metering	01/01/2000	08/04/2015
Renewable Energy Systems Sales Tax Exemption	VT	Financial Incentive	Sales Tax Incentive	01/01/2000	10/14/2015
Local Option - Property Tax Exemption	VT	Financial Incentive	Property Tax Incentive	01/01/2000	05/12/2016
Interconnection Standards	VT	Regulatory Policy	Interconnection	07/16/2002	12/01/2015
GMP Cow Power	VT	Financial Incentive	Performance-Based Incentive	08/12/2004	05/19/2016
Clean Energy Development Fund	VT	Regulatory Policy	Public Benefits Fund	07/27/2006	08/04/2015
Small Business Energy Loan Program	VT	Financial Incentive	Loan Program	08/07/2014	10/07/2015
Commercial Energy Loan Program	VT	Financial Incentive	Loan Program	08/07/2014	10/07/2015
Agricultural Energy Loan Program	VT	Financial Incentive	Loan Program	08/07/2014	10/07/2015
Standard Offer Program	VT	Financial Incentive	Feed-in Tariff	02/17/2015	05/19/2016

<https://www.epa.gov/agstar>

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AgSTAR: Biogas Recovery in the Agriculture Sector

Contact Us | Share

Biogas Opportunities Roadmap Progress Report
 NEW! The [Biogas Opportunities Roadmap Progress Report](#) highlights the U.S.'s progress in promoting cost-effective biogas strategies to reduce emissions of methane, a potent greenhouse gas.

- Events
- Learn About Biogas Recovery
- Project Database
- Codigestion Guidelines
- How AgSTAR Works
- Frequent Questions

AgSTAR promotes the use of biogas recovery systems to reduce methane emissions from livestock waste. In addition to producing biogas, anaerobic digestion systems can also help achieve other social, environmental, agricultural and economic benefits.

Learn about Biogas Recovery

- [How does anaerobic digestion \(AD\) work?](#)
- [Explore stories from the farm](#)
- [Realize the benefits of biogas](#)

Implement AD Projects

- [Is AD right for you?](#)
- [Determine financing options](#)
- [Review guidelines for AD systems](#)
- [Browse the vendor directory](#)

Connect through AgSTAR

- [Want to get regular updates?](#)
- [Meet our Partners](#)
- [See AD projects around the world](#)



Resources

➤ State Energy Offices:

<https://www.naseo.org>

➤ State Departments of Agriculture

➤ Extension Offices/Universities

➤ RD State Energy Coordinators:

http://www.rd.usda.gov/files/RBS_StateEnergyCoordinators.pdf



Quick Links

- › About MDA
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- › Horse Industry Board
- › Marketing Services
- › Nutrient Management
- › Proposed Regulations for Public Comments
- › PMT
- › Spay and Neuter Program
- › State Chemist
- › Weights & Measures
- › Contact MDA

Welcome to Maryland's Manure Resources Page



For centuries, farmers have recognized the value of manure as a natural crop fertilizer and soil conditioner. Today, the value of manure as an alternative energy source continues to gain momentum, even as more and more farmers are realizing the benefits of recycling manure vs. purchasing commercial fertilizer products. This page contains valuable information for:

Contact Information

Hans Schmidt
Assistant Secretary
Resource Conservation

Telephone: 410.841.5865
Fax: 410.841.5736

Office Address
50 Harry S. Truman Parkway
Annapolis, MD 21401



Watch Bill Brown discuss how poultry farmers manage manure resources

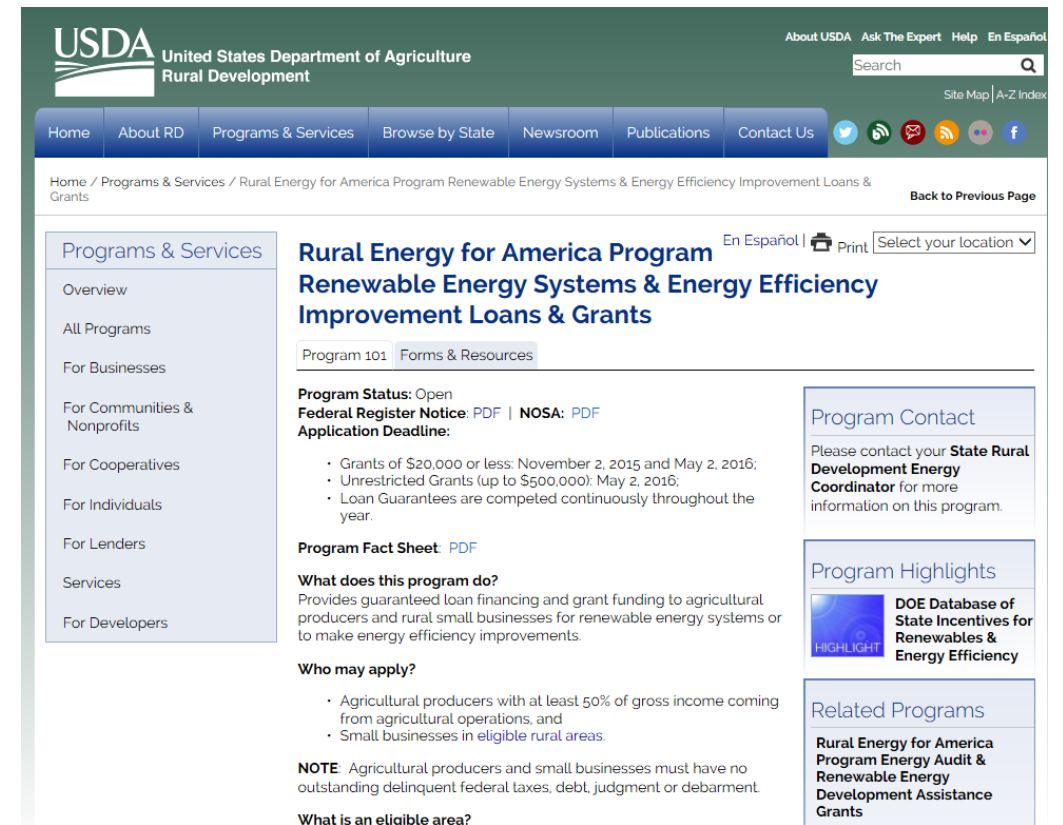
PDFs of Manure Ads

- It's No Bull - Manure Happens
- Follow Me, Girls
- Pardon Me
- Looks Can Be Deceiving

Contact Rural Development:

➤ RD State Energy Coordinators:
[http://www.rd.usda.gov/files/
RBS_StateEnergyCoordinators.
pdf](http://www.rd.usda.gov/files/RBS_StateEnergyCoordinators.pdf)

Deb Yocum
Regional Energy Coordinator
Energy Division
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The screenshot shows the USDA Rural Development website. The main heading is "Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants". The page includes a navigation menu with "Home", "About RD", "Programs & Services", "Browse by State", "Newsroom", "Publications", and "Contact Us". A sidebar on the left lists "Programs & Services" with sub-links for Overview, All Programs, For Businesses, For Communities & Nonprofits, For Cooperatives, For Individuals, For Lenders, Services, and For Developers. The main content area provides details about the program status, application deadline, and who may apply. A "Program Contact" box on the right encourages users to contact their State Rural Development Energy Coordinator. A "Program Highlights" box features a "DOE Database of State Incentives for Renewables & Energy Efficiency". A "Related Programs" box lists "Rural Energy for America Program Energy Audit & Renewable Energy Development Assistance Grants".

USDA United States Department of Agriculture Rural Development

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Overview

All Programs

For Businesses

For Communities & Nonprofits

For Cooperatives

For Individuals

For Lenders

Services

For Developers

Rural Energy for America Program En Español | Print | Select your location

Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants

Program 101 Forms & Resources

Program Status: Open
Federal Register Notice: PDF | **NOSA:** PDF
Application Deadline:

- Grants of \$20,000 or less: November 2, 2015 and May 2, 2016;
- Unrestricted Grants (up to \$500,000): May 2, 2016;
- Loan Guarantees are competed continuously throughout the year.

Program Fact Sheet: PDF

What does this program do?
Provides guaranteed loan financing and grant funding to agricultural producers and rural small businesses for renewable energy systems or to make energy efficiency improvements.

Who may apply?

- Agricultural producers with at least 50% of gross income coming from agricultural operations, and
- Small businesses in eligible rural areas.

NOTE: Agricultural producers and small businesses must have no outstanding delinquent federal taxes, debt, judgment or debarment.

What is an eligible area?

Program Contact

Please contact your **State Rural Development Energy Coordinator** for more information on this program.

Program Highlights

HIGHLIGHT DOE Database of State Incentives for Renewables & Energy Efficiency

Related Programs

Rural Energy for America Program Energy Audit & Renewable Energy Development Assistance Grants