

# RENEWABLE ENERGY IN THE U.S.

## BIOGAS

Swedish Trade Council, USA  
January, 2008

Co-Sponsors and Collaborating Partners:





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## EXECUTIVE SUMMARY

### - Biogas

- There are currently more than 100 on-farm anaerobic digesters in operation in the U.S. More than 80 new anaerobic digesters are in the planning stage
- Federal programs and state programs in primarily California, Pennsylvania, Wisconsin and New York state have been major drivers for the development of new anaerobic digester systems in the U.S.
- There are more than 420 operating landfill gas recovering plants in the U.S., most of them located in the Midwest and in California. 82 new plants are under construction
- Electricity generation from landfill gas is a well established business in the U.S. Due to strong federal and state incentives two-thirds of the landfill gas goes to electricity production
- While a handful of large well established domestic companies provide the vast majority of equipment and services for landfill gas to energy projects, the market for anaerobic digesters is far less competitive. Foreign companies have a small presence in both sectors
- Due to a lack of economic incentives and important legal, logistical and technological challenges a very limited amount of biogas is upgraded to natural gas quality in the U.S. Only a couple of small domestic companies are present in this market segment
- Areas Swedish companies should look into are anaerobic digestion of multiple waste streams and cost efficient biogas upgrading to CNG and LNG quality



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## SAMMANFATTNING

### - Biogas

- Det finns för närvarande mer än 100 biogasanläggningar baserade på rötning av gödsel i USA och mer än 80 nya anläggningar är i planeringsfasen
- Nya federala och delstatliga program innehållande förmånliga lån och skattelättnader för att bygga och driva biogasanläggningar på boskapsgårdar är den främsta förklaringen till de senaste årens starka tillväxt i branschen
- Kalifornien, Pennsylvania, Wisconsin och New York är de delstater som i första hand satsat på en energipolitik som främjar gårdsbaserade biogasanläggningar
- Utvinning av deponigas är en relativt mogen bransch i USA. Det finns över 420 anläggningar i drift som utvinnet biogas från avfallsdeponier och 82 nya anläggningar är under uppbyggnad
- Det finns starka federala och delstatliga program med incitament för att producera el från deponigasanläggningar, vilket lett till att 2/3 av den utvunna biogasen används i för att producera elektricitet i USA
- Deponigasmarknaden i USA domineras av ett antal väletablerade inhemska företag som projekterar och bygger deponigasanläggningar. Konkurrensen är betydligt mindre intensiv för gödselbaserade rötningsanläggningar. Mycket få utländska företag är aktiva på den amerikanska biogasmarknaden.
- Det saknas idag tillräckliga politiska och ekonomiska incitament i USA för att uppgradering av biogas ska ta fart. Legala och logistiska hinder liksom avsaknaden av en gasstandard i USA innebär andra problem. Endast några få små inhemska företag finns på marknaden
- Svensk teknologi och kompetens när det gäller att blanda olika biogassubstrat (rötningsråvaror utav organiskt lättnedbrytbart material) för att få en större produktion av metangas efterfrågas i USA, liksom teknologier för att uppgradera biogas till fordonsbränsle



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## BACKGROUND

- Sweden is internationally recognized as one of the leading countries when it comes to environmental regulation and a successful private-public partnership. Many Swedish companies decided early on to invest in the development of new technical solutions in order to reduce emissions to air and water. Combined with a strategic approach to environmental issues and many years of experience, Swedish companies have a strong position in a number of environmental sectors
- The U.S. environmental technology market is the world's largest. There is a growing interest in the U.S. for environmental technologies, particularly in the area of renewable energies, among investors, large corporations, policymakers and the public
- The Swedish Embassy in Washington D.C., the Consulates General of Sweden in New York and Los Angeles and the Swedish Energy Agency, have requested the assistance of the Swedish Trade Council (STC) to identify and assess Swedish business opportunities in the renewable energy sector in the U.S. The project should include a comprehensive and concrete analysis of business opportunities for Swedish companies within the areas of waste-to-energy (WTE), biogas, and ethanol
- The direction and outline of this project have been discussed with a number of Swedish organizations, including the Swedish Energy Agency, Swentec and IVL. The project team has taken advantage of this network and the competence and knowledge available in these organizations

## OBJECTIVE AND KEY ISSUES

The objective of the project is to evaluate Swedish business opportunities within the U.S. renewable energy sector with a focus on waste-to-energy (WTE), biogas and ethanol

In order to meet the objective the STC will address the following key issues:

- What does the U.S. market for WTE, biogas and ethanol look like in terms of market size and structure?
- What are the key trends in the U.S. market and what affects the development?
- What are the key regulations affecting the market?
- What types of promotional activities would be beneficial for Swedish companies?



## LIST OF ABBREVIATIONS 1(3)

Abbreviation	Name/ explanation
ACE	American Coalition for Ethanol
APPA	American Public Power Association
BALLE	Business Alliance for Local Living Economies
BR&DI	Biomass Research and Development Initiative
Btu or BTU	British Thermal Unit
CNG	Compressed Natural Gas
CREBs	Clean Renewable Energy Bonds
DOE	Department of Energy
DOE EERE Biomass Program	Department of Energy Efficiency and Renewable Energy Biomass Program
DSIRE	Database of State Incentives for Renewables and Efficiency
EDA	U.S. Department of Commerce Economic Development Administration
EPA	Environmental Protection Agency
EPC-contractor	Engineering, procurement and construction contractor



## LIST OF ABBREVIATIONS 2(3)

Abbreviation	Name/ explanation
IDEA	International District Energy Association
IWSA	International Solid Waste Association
LFG	Landfill Gas
LFGE	Landfill Gas Energy
LMOP	EPA's Landfill Methane Outreach Program
LNG	Liquefied Natural Gas
MGY	Million gallons per year
MSW	Municipal Solid Waste
MTBE	Methyl tertiary-butyl ether
NG	Natural Gas
NGVs	Natural Gas Vehicles
NSWMA	National Solid Wastes Management Association

## LIST OF ABBREVIATIONS 3(3)

Abbreviation	Name/ explanation
REPI Program	Renewable Energy Production Incentive Program
RFA	Renewable Fuels Association
RFS	Renewable Fuels Standard
RPS	Renewable Portfolio Standard
USDA	U.S. Department of Agriculture
VEETC	Volumetric Ethanol Excise Tax Credit
WTE	Waste-To-Energy



## TERMS AND TRANSLATIONS

Term	Translation
Bagasse	Bagass, sockerrörsavfall
Barley	Korn
Biomethane	Uppgraderad och renad biogas med egenskaper som liknar naturgas
Combustible waste	Brännbart avfall - avfall som brinner utan energitillskott efter det att förbränningsprocessen startat
Energy recovery	Energiåtervinning
Grain sorghum	Korndurra
Landfill	Deponi - kontrollerat upplag för avfall som inte avses flyttas
Milo	Milo, durra
Municipal solid waste (MSW)	Hushållsavfall
Waste-to-energy (WTE)	Avfallsförbränning med energiåtervinning
Whey	Vassla
WTE plant	Avfallsförbränningsanläggning

## CONVERSION OF WEIGHTS AND MEASURES

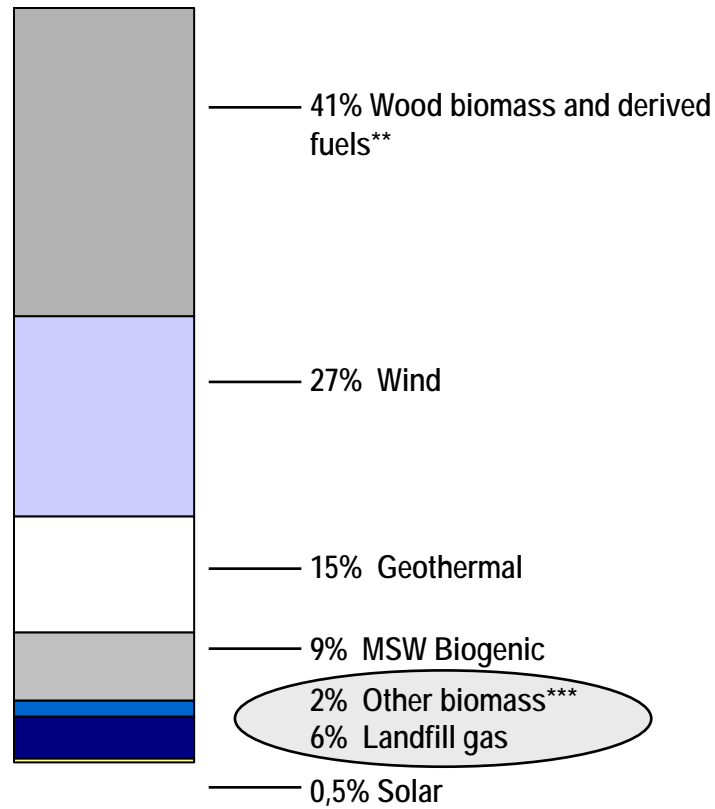
U.S. weights and measures	European conversion
Btu or BTU	1 Btu = 1 055.0559 joule
Bushel	1 bushel = 35,2 liter
Gallon	1 American gallon = 3,785 liter
MBTU = thousand Btu	1 MBTU = 1.055 joule
Miles	1 U.S. mile = 1.609 344 kilometer
MMBTU = million Btu	1 million BTU = 1.055 Giga joule = 28.263682 m <sup>3</sup> of natural gas at defined temperature and pressure
Pounds (lbs)	1 kg = 2,2 pounds

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## BIOGAS ACCOUNTS FOR AROUND 8% OF THE ELECTRICITY PRODUCTION GENERATED FROM RENEWABLE ENERGY SOURCES IN THE U.S.

Electricity Net Generation from Renewable Energy\* (2006)  
100% = 96,7 Billion Kilowatt-hours



- There are about 427 landfills that recover methane gas, which forms as waste decomposes in low-oxygen (anaerobic) conditions in the U.S.
- The methane is burned to produce electricity and heat
- Other biomass consists of methane gas production in anaerobic digesters for heat and electricity generation at municipal sewage treatment plants, livestock operations and dairy farms

# THERE IS STRONG POTENTIAL FOR BIOGAS IN THE U.S.

- Biogas recovery from livestock operations and landfills are the fastest growing biogas markets

## Biogas recovery systems at livestock operations

- Increased financial support from state and federal programs has led to strong increase in demand for anaerobic digesters over the last 3 years
- 100 operational systems and 80 in the planning stages
- Technically feasible at about 7000 dairy and swine operations in the U.S.
- Potential to generate 6 MWh/year

## Landfill gas (LFG)

- About 425 out of 2300 landfills in the U.S. recover methane gas
- According to the EPA, 560 additional MSW landfills have the potential to start economically viable biogas recovery operations and turn their gas into energy
  - There are currently 82 new landfill gas energy projects under construction in the U.S.

## BIOGAS APPLICATIONS

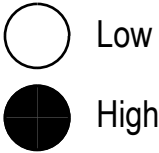
## Biogas recovery from wastewater treatment plants




- There is a trend away from investments in biogas recovery at waste water treatment plants in the U.S.
- This is a result of both technological problems, increasing restrictions from authorities regarding exhaust fumes and poor economic returns

## Biogas production from food residues and other organic waste

- The market for biogas recovery from food residues, woodwaste and garden materials has so far been undeveloped in the U.S.
- There is a trend towards adding foodwaste and other organic waste to on-farm manure digester systems

# THIS STUDY WILL FOCUS ON BIOGAS RECOVERY FROM ANAEROBIC DIGESTERS AND LANDFILL GAS



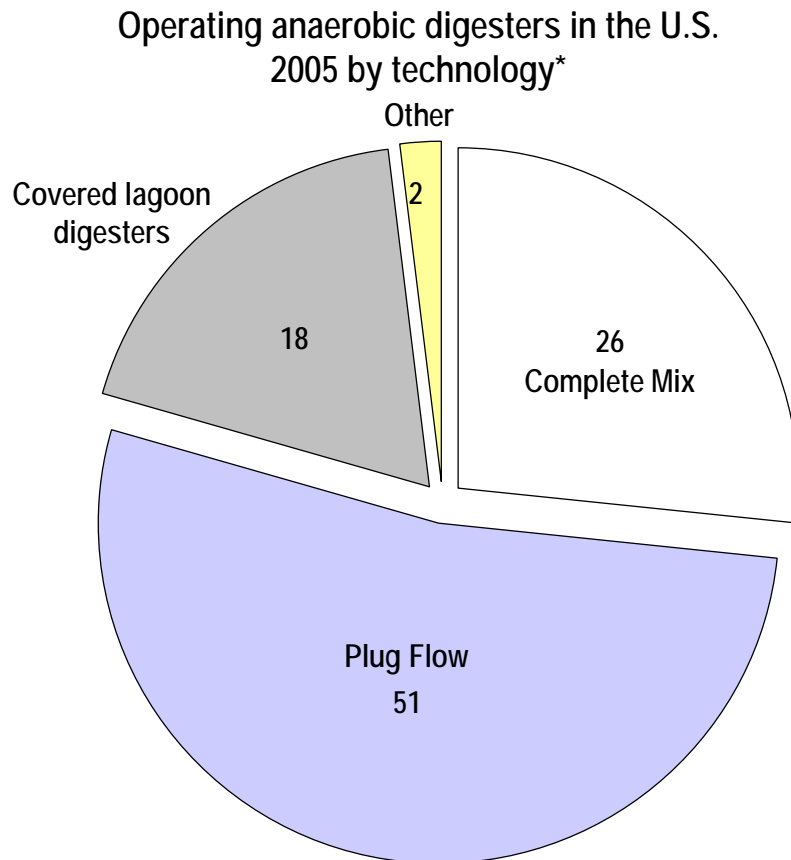
Industry sector	Key observations	Attractiveness
Biogas recovery from livestock operations*	<ul style="list-style-type: none"> <li>• Strong increase the last 5 years. More than 80 new manure digesters will be built in the coming years</li> <li>• There are strong federal and state programs favoring investments in on-farm biogas plants</li> </ul>	
Landfill gas	<ul style="list-style-type: none"> <li>• Well established sector in the U.S. but with a strong potential for further growth</li> <li>• More than 80 new landfill gas energy projects are under construction</li> <li>• New federal and state programs provide financing possibilities</li> </ul>	
Biogas recovery from wastewater treatment plants	<ul style="list-style-type: none"> <li>• Weak interest from industry and authorities in the U.S for biogas recovery from wastewater treatment plants</li> <li>• Fewer programs and incentives than for biogas from manure and landfill gas</li> </ul>	

\* Biogas production from food and other organic waste is largely integrated with on-farm biogas production and will from here on be included in that section

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# PLUG FLOW, COMPLETE MIX AND COVERED LAGOON DIGESTERS ARE THE PREDOMINANT TECHNOLOGIES FOR ON-FARM BIOGAS RECOVERY SYSTEMS IN THE U.S.



## Plug-flow digester

has a long narrow tank with a rigid or flexible cover. The tank is heated and often built partially underground to reduce heat loss. Plug flow digesters are common in the U.S. as it is easy to handle large volumes of manure with the plug-flow system.

## Complete mix digester

is an enclosed heated tank with a mechanical, hydraulic or gas mixing system. Complete mix digesters work best when there is some dilution of the excreted manure with process water

## Covered lagoon digester

is an earthen lagoon fitted with a flexible cover that collects and pipes the methane gas to a combustion device. Covered lagoons are less costly but usually also less efficient than plug-flow and complete mix digesters. They cannot be used for energy applications above the 40<sup>th</sup> parallel

\* Includes digesters in start-up and construction stage

## THERE IS A NEW TREND OF ADDING FOODWASTE AND OTHER WASTE WITH A RICH ORGANIC CONTENT TO MANURE DIGESTERS

- Co-digestions increases the methane level in a manure digester

- More and more swine and dairy farms with biogas operations are starting to add foodwaste and other waste with a rich organic content
- There are two main reasons for this development:
  - Adding foodwaste and other waste with a rich organic content and mixing it with manure increases the methane level and thus the energy that can be produced from the biogas system
  - Profitability is also increased as most organic waste is subject to a tipping fee paid to the owner of the digester for receiving the waste
- In a number of cases it has been difficult for farmers to obtain special permits from authorities that gives them the right to receive and treat special organic waste

*"There is definitely a new trend here. We are starting to see a high percentage of people adding waste rich in organic materials to their biogas recovery systems"*

Chris Voell  
Program Manager, EPA's AgSTAR program

*"Many of our customers are building systems with an over capacity of 20% so that they can add by products from ethanol plants, breweries etc to the digester, that is good business"*

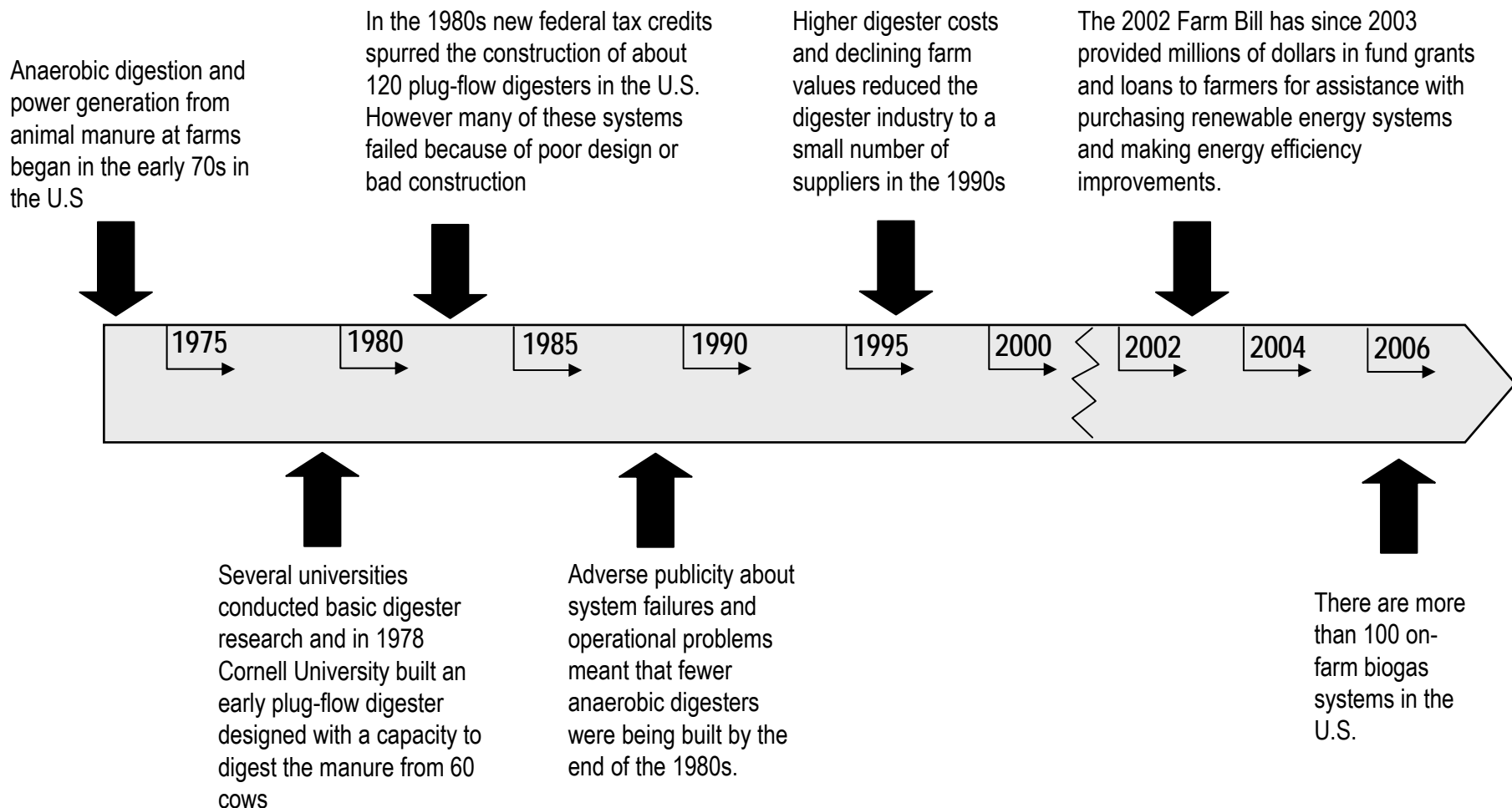
Dan Holst, GHD, Inc

*"What we lack in the U.S. is your know-how and experience from many years of trial and error"*

Kevin Best,  
CEO, Real Energy

# MANURE DIGESTERS HAVE EXISTED IN THE U.S. SINCE THE 1970s

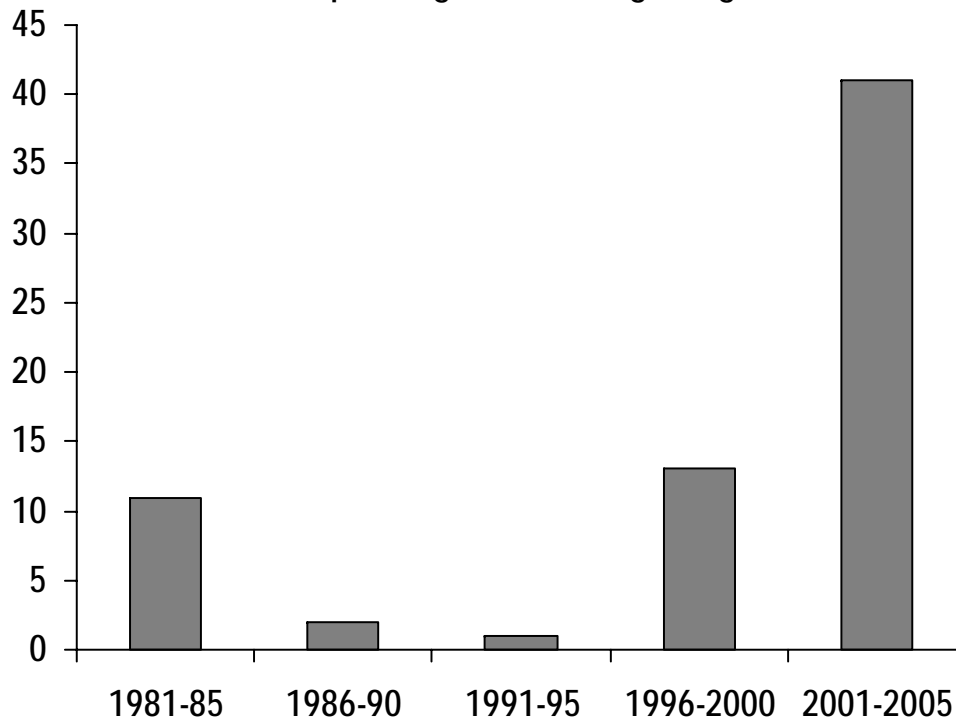
- However, as the technology was not fully developed many systems failed in the 70s and 80s



## THE NUMBER OF OPERATIONAL ON-FARM BIOGAS DIGESTER SYSTEMS HAVE INCREASED SUBSTANTIALLY IN THE U.S. IN THE LAST FIVE YEARS

- Due to increased technical reliability and new federal / state programs and funding

Construction of new operating on-farm biogas digesters in the U.S.\*



- Federal programs like the grants awarded for renewable energy projects under section 9006 of the 2002 Farm Bill have provided beneficial funding for farms installing anaerobic digesters
- State programs in California, Pennsylvania, Wisconsin and New York state have provided important funding opportunities explaining why the majority of the new systems are built in these states
- State Energy legislation such as net metering\*\* has reduced a key market barrier for grid-interconnected independent power producers
- The creation of green power programs by several utilities favoring the use of biogas

\* Counted from the year they became operational \*\* see slide 43

## FARM BILL GRANTS HAVE CONTRIBUTED TO THE SHARP INCREASE IN NEW ON-FARM BIOGAS SYSTEMS IN RECENT YEARS

### The Renewable Energy and Energy Efficiency Program (section 9006 of the 2002 Farm Bill)

Type of Assistance: Grants and loans

Program Description: The Renewable Energy Systems and Energy Efficiency Improvements Program that was part of the 2002 Farm Bill has been providing grants and loan guarantees to agricultural producers and rural small business for assistance with purchasing renewable energy systems and making energy efficiency improvements since 2003.

For the fiscal year 2007 there is approximately \$11.4 million in funding for competitive grants and \$176.5 million for guaranteed loans.

Applications are made through the local USDA State Rural Development Offices

For more info: <http://www.rurdev.usda.gov/rbs/farbill/index.html>

*"The grants made available through the 2002 Farm Bill have been a major driver for the development of new manure digester systems in the United States"*

Chris Voell  
Program Manager, EPA's AgSTAR program

## OTHER IMPORTANT FEDERAL INCENTIVES FOR INVESTMENTS IN ON-FARM PRODUCTION OF BIOGAS ARE THE EQIP AND SARE PROGRAMS

### Environment Quality Incentives Program (EQIP)

Type of Assistance: Grant

Program Description: EQIP was reauthorized and its funding amount significantly expanded under the 2002 Farm Bill that requires that 60% of EQIP funds be spent on animal operations. EQIP funds are distributed primarily in priority areas with serious environmental need and resource concern. EQIP may provide up to 75% of the costs of certain conservation practices. Incentives payments may be provided for up to three years. Local Soil and Water Conservation Districts have discretion over the allocation of the funding within their areas. Applications are usually awarded based on environmental benefit and cost effectiveness

For more info [www.nrcs.usda.gov/programs/eqip](http://www.nrcs.usda.gov/programs/eqip)

### Sustainable Agriculture Research and Education (SARE)

Type of Assistance: Grant

Program Description: The SARE program is administered by the U.S. Department of Agriculture. The goal of the program is to assist farmers in adopting sustainable agricultural practices to improve profits and protect the environment. SARE has three separate grant programs of which two are interesting from a biogas perspective:

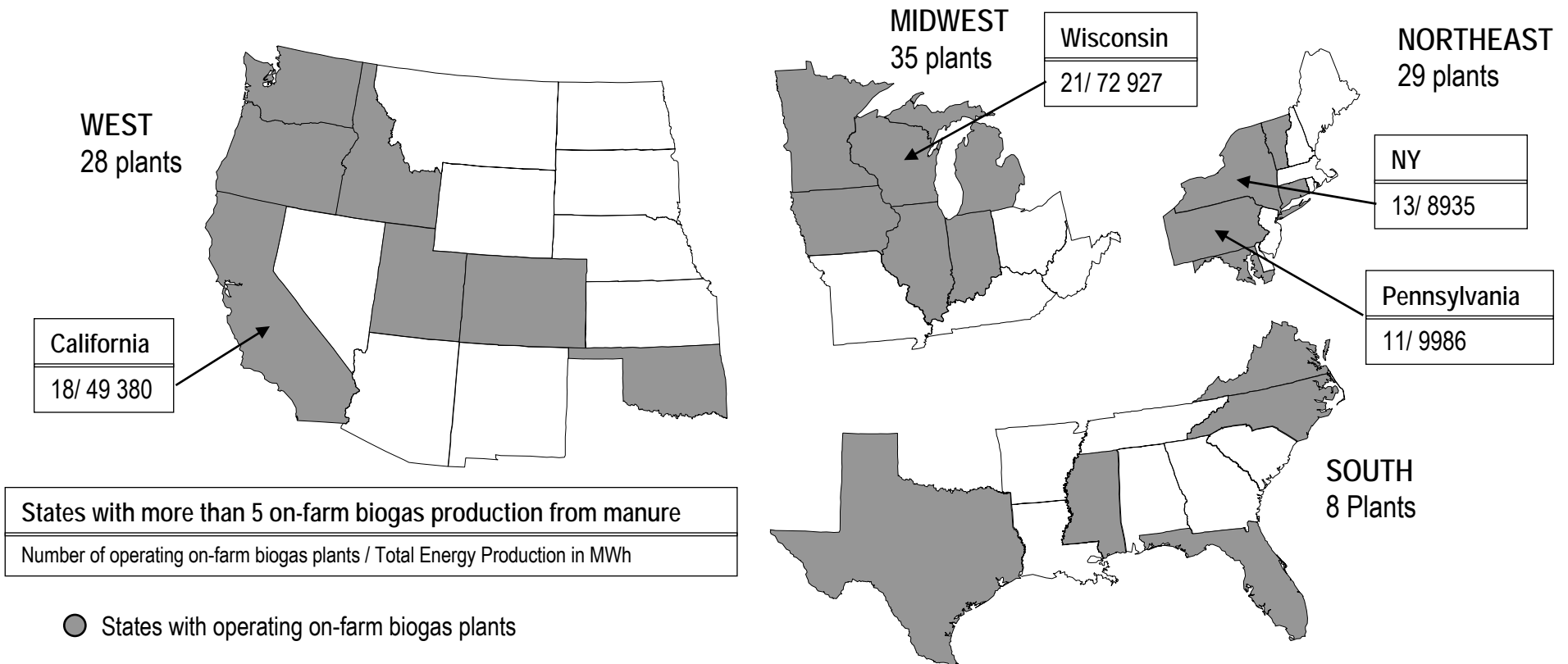
- Producer Grant Projects are conducted by producers. These projects are generally located in one state often on single farms using small grants of up to 15 000 USD
- Professional Development Projects offer educational opportunities about sustainable agriculture techniques

For more info: [www.sare.org](http://www.sare.org)

# THERE ARE MORE THAN 100 ON-FARM BIOGAS MANURE DIGESTERS IN THE U.S.

- Most of them are located in Wisconsin and California

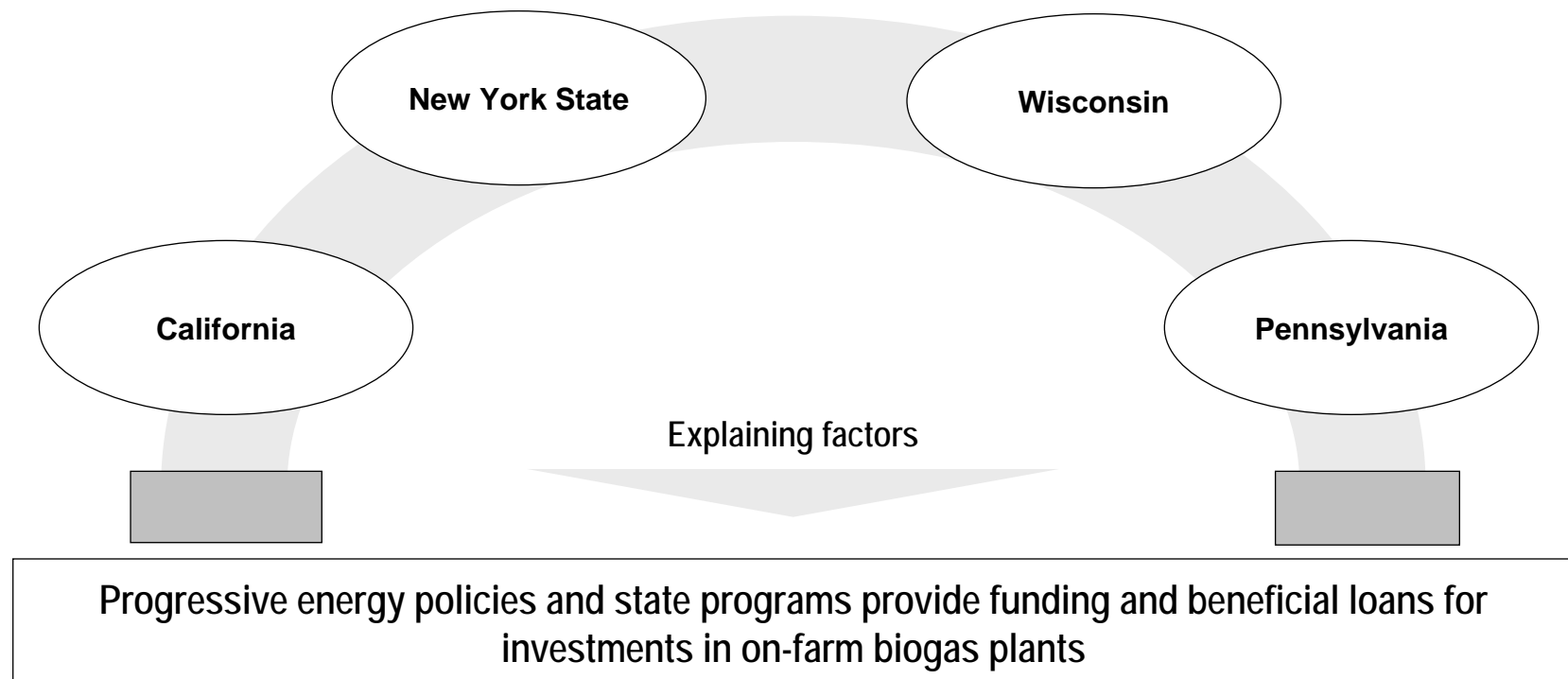
Operating on-farm biogas recovery systems from dairies and swine farms in 2006





## CALIFORNIA, WISCONSIN, NEW YORK STATE AND PENNSYLVANIA HAVE SIGNIFICANTLY MORE OPERATING ON-FARM BIOGAS PLANTS THAN OTHER U.S. STATES

- It is also in those states that most new on-farm biogas plants will be built in the coming years





# CALIFORNIA'S DAIRY PRODUCTION PROGRAM IS AN IMPORTANT INCENTIVE FOR INVESTMENTS IN MANURE DIGESTERS

- The Biomethane for Vehicle fuel project is also interesting to keep an eye on

## Dairy Power Production Program (DPPP)

Type of Assistance: Grants, production credits

Program Description: The purpose of the Dairy Power Production Program, created by the California Energy Commission (CEC) is to encourage the development of electricity generation through anaerobic digestion projects at California dairies.

The USD 10 million program includes both grants and production credits.

A program extension in late 2006 made a second round of funding available for new projects. Nine more methane digester construction projects have been approved through the extended program.

The program is administered through the Western United Resources Development Inc. (WURD).

For more info: [www.wurdco.com](http://www.wurdco.com)

## Biomethane for Vehicle Fuel Project

Type of Assistance: Grant

Program Description: The goal of the five-phase project is to develop a new model to convert biogas (biomethane) from agricultural sources such as food processing and dairy waste into vehicle fuel. Four heavy-duty diesel powered milk trucks will be converted to run on methane.

The Western United Resources Development Inc. (WURD) received in March 2007 a \$400,000 grant from US-EPA Region 10 to run the project. WURD will collaborate with Western United Dairymen, Sustainable Conservation, UC Davis, CalStart, Hilarides Dairy, Hilmar Cheese Company, California Department of Food and Agriculture.

SWENTEC. Project partners will also develop engineering design plans and conduct financial analyses of biomethane upgrading plants in expectation of constructing a biomethane upgrading plant and refueling station at a later date. For more info: [www.wurdco.com](http://www.wurdco.com)

# OTHER FINANCIAL INCENTIVES FOR MANURE DIGESTERS IN CALIFORNIA ARE THE SELF-GENERATION INCENTIVE PROGRAM AND ENERGY IMPROVEMENT LOANS

## Self Generation Incentive Program

Type of Assistance: Production Incentive

Program Description: California Assembly Bill 970 calls for in-state development of new energy resources. As part of its implementation, the California Public Utilities Commission requires utilities (Southern California Gas Company and Pacific Gas & Electric Company) to provide businesses financial incentives to encourage the installation of various electric generation technologies.

The incentives vary depending on technology and size of the energy production facility. For example electricity production sites using renewable fuel microturbines or small gas turbines get an incentive of \$1.30/Watt

For more info: [www.socalgas.com/business/selfgen](http://www.socalgas.com/business/selfgen)

## Energy Efficiency Improvements Loan Funds

Type of Assistance: Loan

Program Description: Created in 1980, the State Assistance Fund for Enterprise, Business and Industrial Development Corporation (SAFE-BIDCO) administers the Energy Efficiency Improvements Loan Funds which includes provisions for low-interest loans to small businesses in California for renewable energy systems.

Applicant may not have a net worth in excess of \$6 million nor have average net income in excess of \$2 million. The borrower must be the project's owner, operator and beneficiary. The maximum loan amount is \$ 350 000 at a four percent interest with a five year repayment period

For more info: [www.safe-bidco.com](http://www.safe-bidco.com)

**There are strong financial incentives for dairy farmers in California to invest in on-farm biogas recovery systems**



## WISCONSIN'S "FOCUS ON ENERGY" PROGRAM GIVES POWERFUL INCENTIVES FOR INVESTMENTS IN NEW MANURE DIGESTERS

### Focus on Energy

Type of Assistance: Grants

Program Description: The Focus on Energy program aims to promote energy efficiency and renewable energy in the state of Wisconsin. The program offers a variety of incentives:

- **Business & Marketing Grant** provides financial support to businesses that provide renewable energy services for developing their business plans and marketing materials. Up to 50 percent of these project costs, up to a maximum of \$10,000 can be funded by the program
- **Feasibility Study Grant** provides financial support for feasibility studies in order to increase the ability of businesses to make informed decisions about using renewable energy systems by understanding and solving financial and technical uncertainties. Up to 50 percent of these project costs, up to a maximum of \$10,000 can be funded by the program
- **Development Grant** provides financial support for assessing development activities of customer-sited Biogas Digesters or Biomass Combustion Systems of greater than 500 kW capacity. These grants co-fund complex feasibility studies, environmental permitting, financing and other developmental activities. Up to 50 percent of the project costs, up to a maximum of \$50,000 can be funded by the program
- **Dairy Farm Anaerobic Digester Grant** provides financial support for the installation of a commercially available anaerobic digester system at Wisconsin dairy farms to produce any of the following : electricity, thermal energy and biogas

For more information: [www.focusonenergy.com](http://www.focusonenergy.com)

# NEW YORK HAS BEEN VERY ACTIVE IN DEVELOPING A PROGRAM PROMOTING RENEWABLE ENERGIES

## New York State Energy Research and Development Authority

Type of Assistance: Grants

Program Description: The New York State Energy Research and Development Authority (NYSERDA) provides funding for research and development to help businesses in New York solve problems related to energy and the environment.

NYSERDA makes public proposal requests using Program Opportunity Notices (PONs) which are posted year-round on NYSERDA's web site. Approximately \$10 million is available annually to support distributed generation projects such as anaerobic digester projects.

The NYSERDA has co-financed a number of anaerobic digester projects in the latest years through cost-share funds. The average award is around \$ 200 000

More information can be found on: [www.nyserdera.org](http://www.nyserdera.org)

*"New York has a very active state program in the NYSERDA. They have financed a number of digesters"*

Chris Voell  
Program Manager, EPA's AgSTAR program

## PENNSYLVANIA HAS A PROGRESSIVE ENERGY POLICY PROMOTING RENEWABLE ENERGY SOLUTIONS

- The sustainable energy funds and the energy harvest program are encouraging investment in manure digesters

### Sustainable Energy Funds

Type of Assistance: Grants and low-interest loans

Program Description: The Sustainable Energy Funds were created in the end of the 1990s by Pennsylvania's Public Utility Commission.

Four funds exist with each one covering a region within the state of Pennsylvania.

The funds are designed to promote the development of sustainable and renewable energy programs and clean-air technologies on both a regional and statewide basis. The funds have provided more than \$20 million in loans and \$1.8 million in grants to over 100 projects.

For more info: [www.puc.paonline.com](http://www.puc.paonline.com)

### Energy Harvest

Type of Assistance: Grant

Program Description: The Pennsylvania Energy Harvest is designed to assist the state's extensive agricultural community in developing its green power resources. The program provides grants to livestock producers generating power from green and renewable sources. Qualifying projects include solar energy; wind; low-impact hydropower, geothermal, biologically derived methane gas, including landfill gas, biomass and fuel cells. The grant may be used for purchase of equipment, construction and engineering design necessary for construction or installation. The maximum grant is \$ 1000 000 and the average grant approximately \$ 375 000.

For more info: <http://www.depweb.state.pa.us/dep>

## OTHER STATES LIKE IOWA AND VERMONT ARE CATCHING UP

- They have recently started innovative programs promoting investments in new on-farm biogas plants

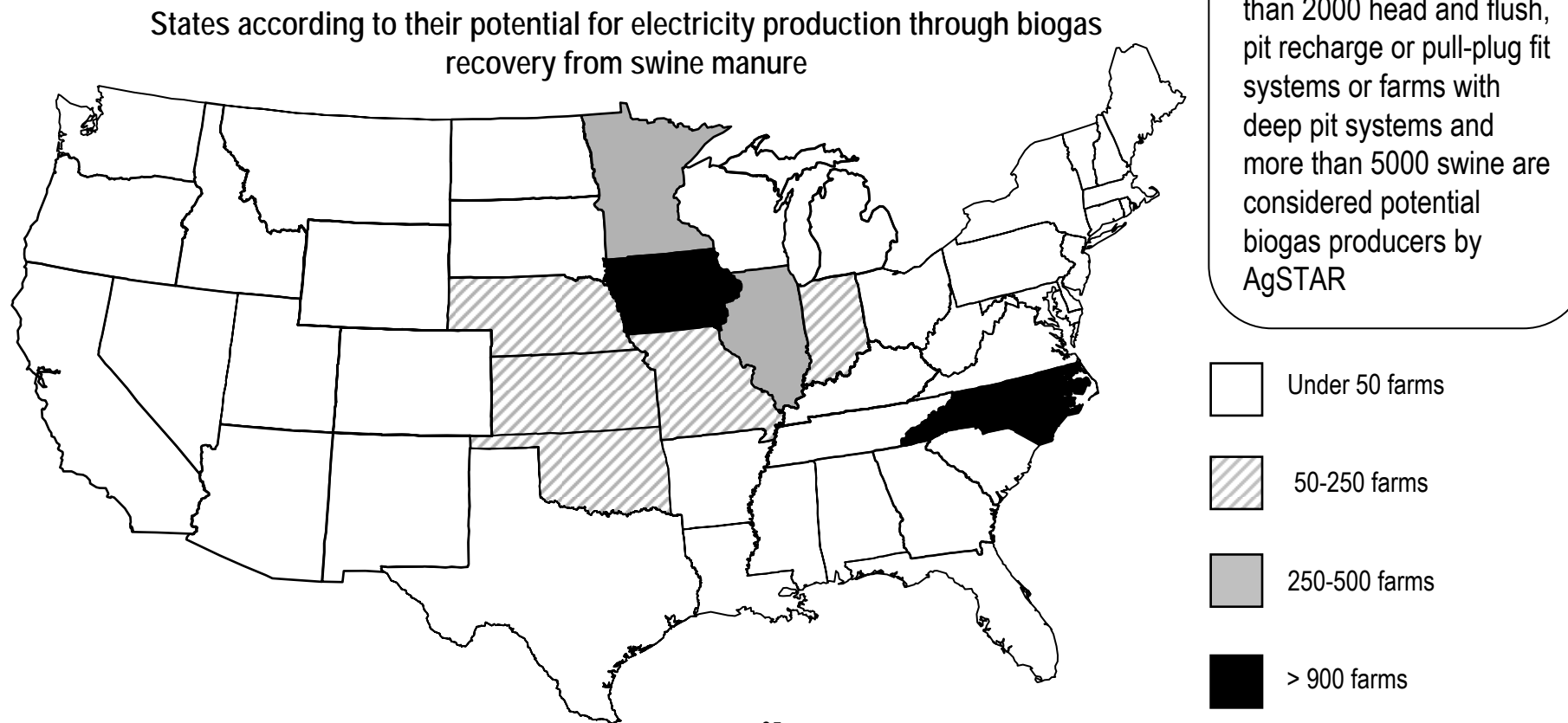
Methane Energy Recovery in Iowa
<p>Type of Assistance: Tax exemptions</p> <p>Program Description: In order to increase the methane recovery at farms and landfills Iowa offers two methane gas tax exemptions</p> <p><b>Methane Gas Conversion Property Tax Exemption</b> Real and personal property used for methane gas collection and conversion into energy in the state of Iowa and connected with a publicly owned sanitary landfill, is exempt from property tax.</p> <p><b>Methane Energy Replacement Generation Tax Exemption</b> All energy generated by methane gas conversion property (including digester gas facilities) is exempt from the replacement generation tax of .06 cents per kWh.</p> <p>More information: <a href="http://www.iowadnr.com/energy/renewable/methane.html">www.iowadnr.com/energy/renewable/methane.html</a></p>

Vermont's Cow Power program
<p>Type of Assistance: Grants</p> <p>Program Description: Central Vermont Public Service (CVPS) Cow Power program is a direct farm-to-consumer renewable energy program that works with dairy farmers to process their cow manure and farm waste to generate electricity through anaerobic digestion.</p> <p>CVPS customers can sign up to get all, half or a quarter of their electrical energy through CVPS Cow Power.</p> <p>Customers pay a premium of 4 cents per kWh for CVPS Cow Power, which goes to participating farm-producers, to purchase renewable energy credits (RECs) when enough farm energy isn't available, or to the CVPS Renewable Development Fund. Farm producers are also paid 95 percent of the market price for the electricity sold to CVPS</p> <p>For more info: <a href="http://www.cvps.com/cowpower/">http://www.cvps.com/cowpower/</a></p>



# NORTH CAROLINA AND IOWA HAVE THE LARGEST POTENTIAL FOR ELECTRICITY PRODUCTION FROM SWINE MANURE IN THE U.S.

- According to AgSTAR calculations, some 4300 swine farms in the U.S. have the potential to produce more than 3 million MWh/year of electricity





## THERE IS ONE MAIN EVENT WHERE A LARGE SHARE OF THE ANAEROBIC DIGESTER INDUSTRY PARTICIPATES EVERY YEAR

### AgSTAR National Conference

- AgSTAR's national conference that takes place once a year is recognized as the leading industry technical conference and trade show focusing on farm based biogas plants
- The conference is attended by livestock producers, project developers, regulators, energy professionals, financiers, and others interested in manure digesters and energy projects
- The conference offers good networking opportunities as well as opportunities to learn more about the U.S. market and identify potential projects

Tradeshows and workshops are important for making business connections within the U.S. biogas industry

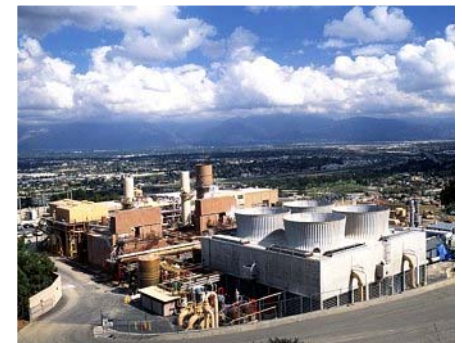
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## ELECTRICITY GENERATION FROM LANDFILL GAS IS WELL ESTABLISHED IN THE U.S.

- Landfills are the largest human-made source of methane emissions in the United States, accounting for about 24% of the total U.S. methane emissions in 2005
- About 427 out of 2300 operating or recently closed landfills recover methane gas in the U.S.
- Landfill gas facilities supplied 10 billion kilowatt-hours of electricity and 75 billion cubic feet of landfill gas to direct use applications in 2006
- According to the EPA's estimations landfill gas powers over 780 000 homes and heats nearly 518 000 while removing emissions equivalent to 14 million vehicles
- There are currently 82 new landfill gas recovery plants under construction in the U.S.
- According to the EPA, 560 additional Municipal Solid Waste (MSW) Landfills could recover methane gas and turn it into energy

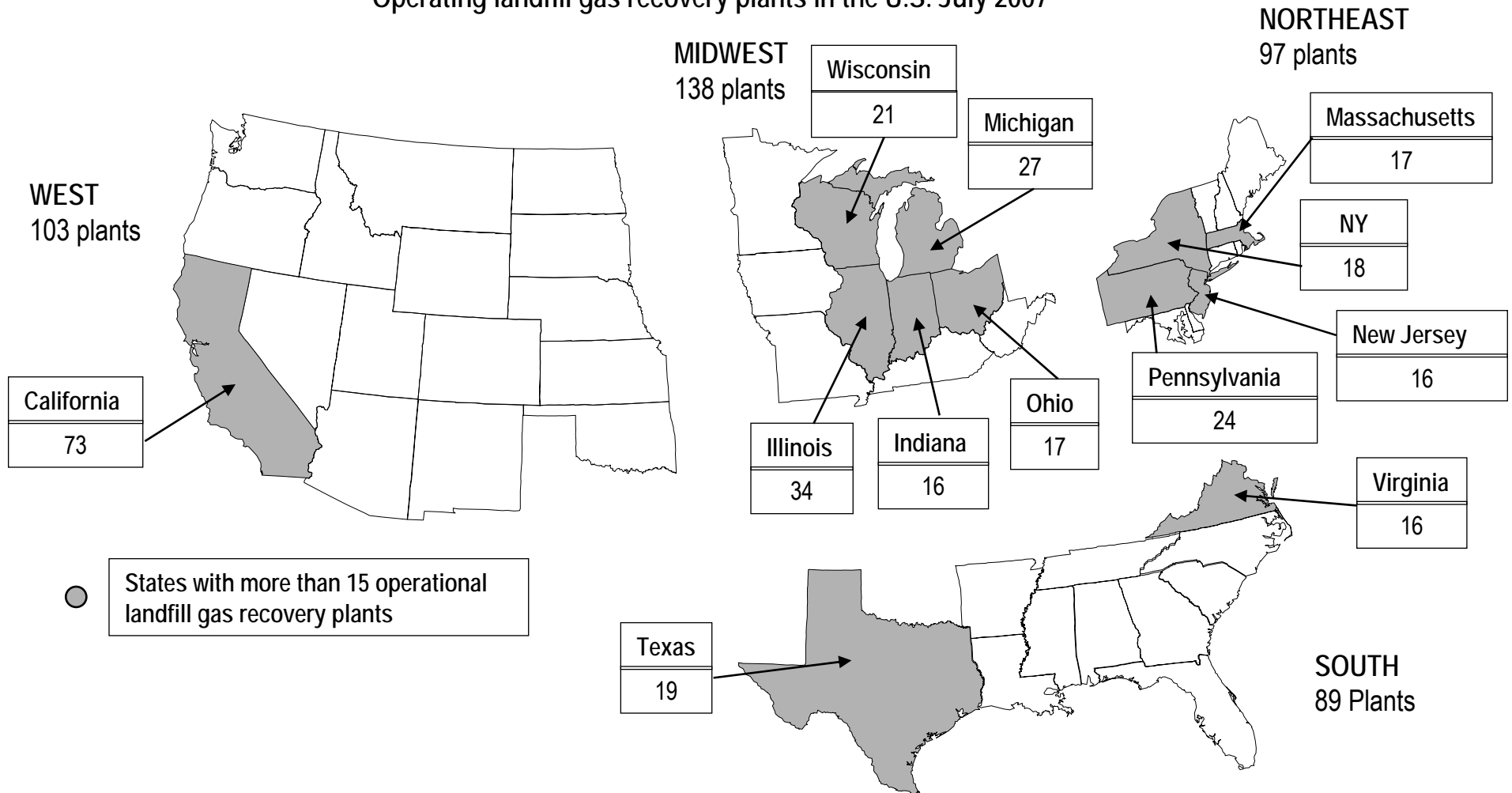


There is a potential for further development of landfill gas to energy plants in the U.S.

# THERE ARE 427 OPERATIONAL LANDFILL GAS PLANTS IN THE U.S.

- Most of them are located in the Midwest and California

Operating landfill gas recovery plants in the U.S. July 2007



# THERE ARE MANY FEDERAL INCENTIVES STIMULATING LANDFILL GAS ENERGY PROJECTS

- The most important are the incentives coming through the Energy Policy Act of 2005

## The Energy Policy Act of 2005

The Energy Policy Act of 2005 has been significant for landfill gas operations in the U.S. It has extended a number of incentive programs for renewable energies to include landfill gas operations, including:

- Renewable Electricity Production Credits
- Clean Renewable Energy Bonds
- Renewable Energy Production Incentives
- Federal Purchase Requirements
- Rural and Remote Communities Electrification Grants
- Loan Guarantees

More info on: [www.epa.gov/landfill/res/guide/federal.htm#1](http://www.epa.gov/landfill/res/guide/federal.htm#1)

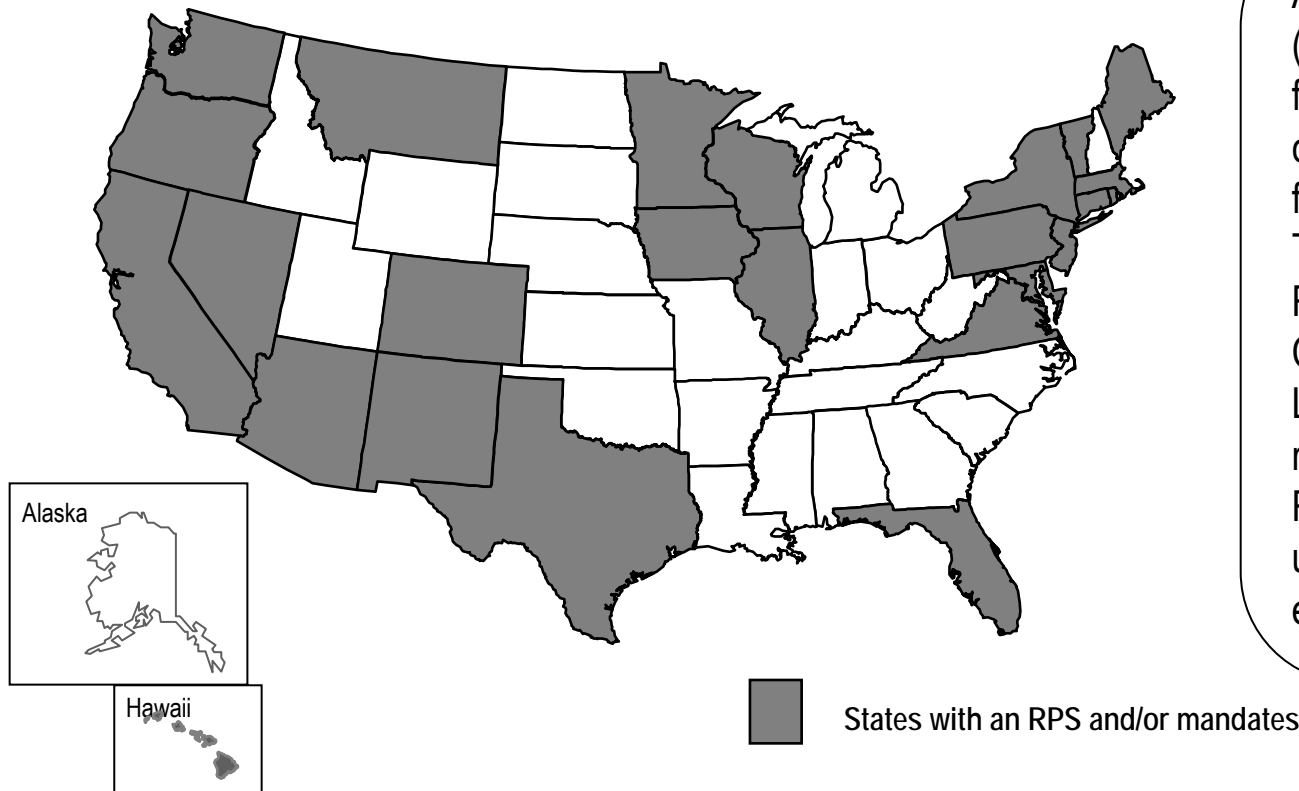
## Other federal programs promoting landfill gas operations

- The USDA's Renewable Energy Loan Program offers low-interest loans to fund renewable energy development in rural areas of the country
- Another USDA program, the Rural Business Opportunity Grants could be applicable to a landfill gas energy project located in a rural area
- The U.S. Department of Commerce's Economic Development Administration (EDA) Public Works Program helps communities in economic decline revitalize and upgrade their facilities. Landfill gas projects are eligible.
- The U.S. Department of Energy's Biomass program promotes landfill gas energy projects through its local offices
- EPA's office of Pollution Prevention and Toxics Pollution Prevention Grants Program has provided funding for landfill gas energy projects

More info on: [www.epa.gov/landfill/res/guide/federal.htm#1](http://www.epa.gov/landfill/res/guide/federal.htm#1)

# AS OF 2007, 26 U.S. STATE POLICIES REQUIRED SOME FORM OF RENEWABLE PORTFOLIO STANDARDS AND/OR HAD MANDATES IN PLACE

- State requirement policies aid and encourage further research and development of renewable energy sources



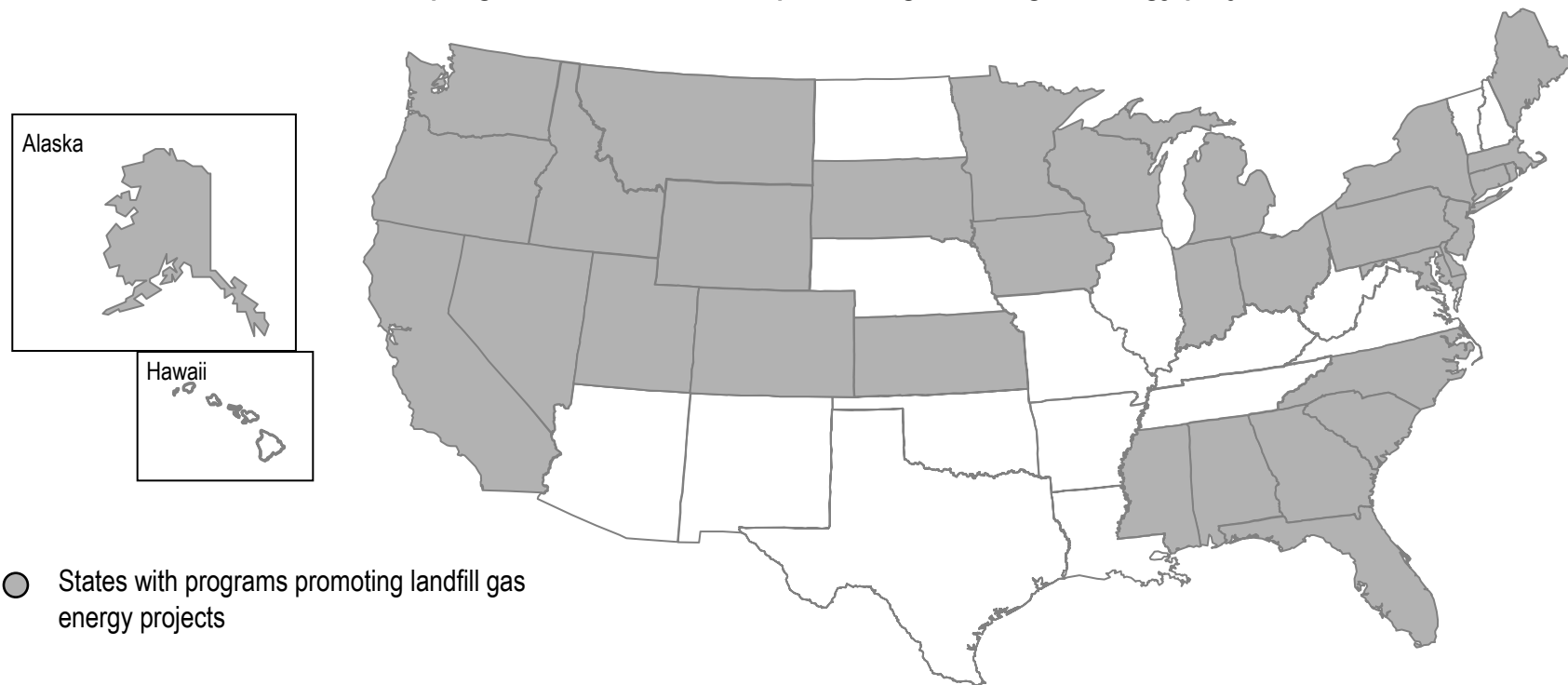
A renewable portfolio standard (RPS) is a legislative requirement for utilities to generate or sell a certain percentage of their electricity from renewable energy sources. The percentage requirements under RPS programs vary widely. Currently all state-wide RPS classify Landfill Gas as a renewable resource. Utilities in states with Renewable Portfolio Standards usually pay a premium for “green” electricity from landfill gas facilities



# 32 STATES HAVE PROGRAMS PROMOTING LANDFILL GAS ENERGY PROJECTS

- They are varying largely in extent and design

States with programs and incentives promoting landfill gas energy projects, 2007

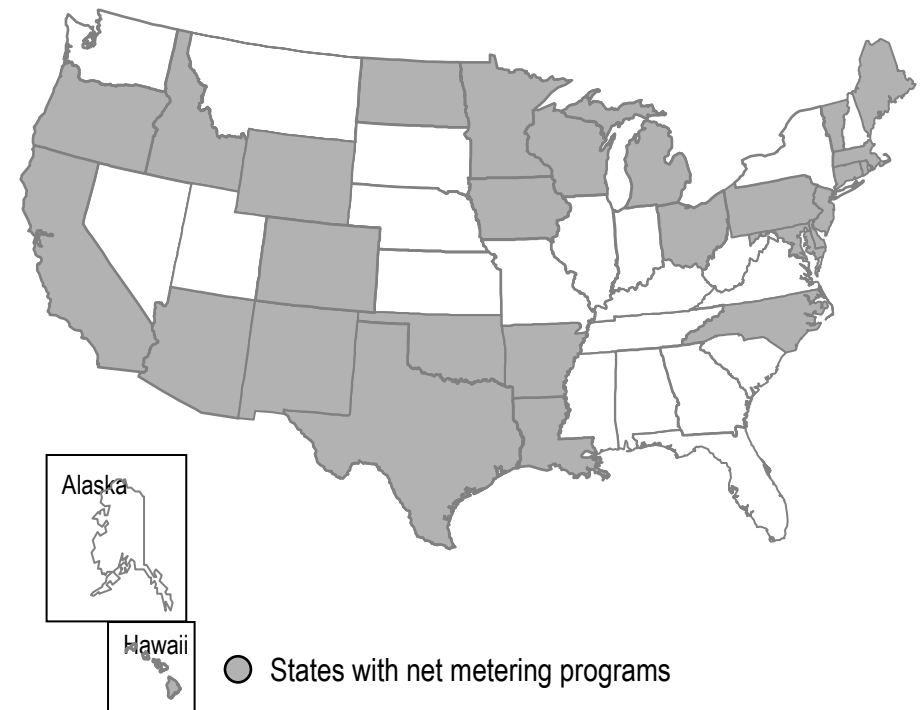


EPA / LMOP lists all state incentives for landfill gas energy projects on the website:  
[http://www.epa.gov/landfill/res/guide/state\\_resources.htm](http://www.epa.gov/landfill/res/guide/state_resources.htm)

## NET METERING PROGRAMS ARE USED AS A TOOL FOR ENCOURAGING INVESTMENTS IN ELECTRICITY PRODUCTION FROM BIOGAS

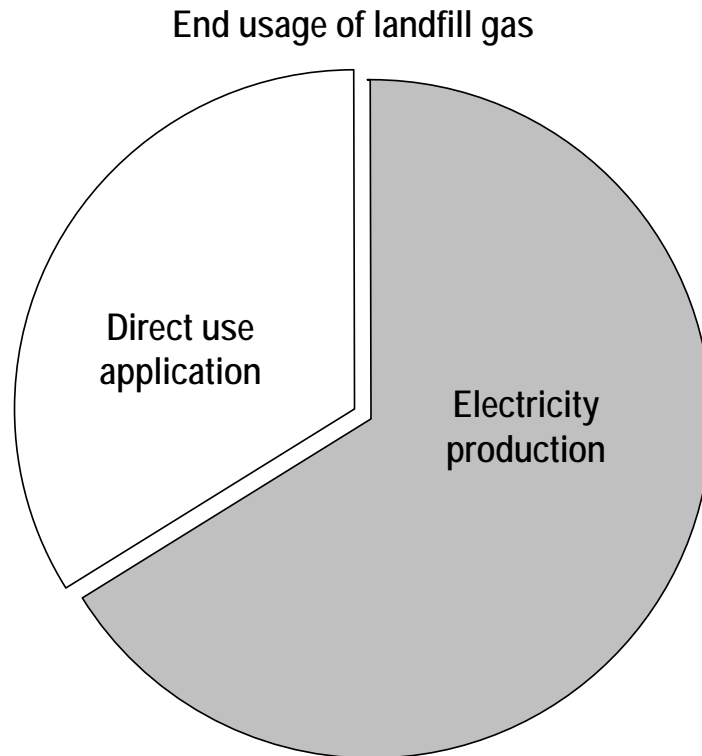
- For farms or landfills generating electricity, net metering allows the farm/landfill's electric meter to turn backwards when the generator is producing electricity in excess of the farm/landfill's demand. Farms / landfills are thus able to use their own generation to offset their purchased electricity over a billing period (e.g., month, year)
- This offset means that the farm / landfill effectively receives retail prices for any electricity they generate and consume because they do not need to purchase it from the utility during the period.
- For farms / landfills with generating facilities in areas that do not allow for net metering, a second meter is usually installed to measure the electricity that flows back to the utility; under this scenario the utility purchases the power at a rate much lower than the retail rate

States with net metering programs in place, 2007



## LANDFILL GAS CAN BE USED FOR ELECTRICITY PRODUCTION OR USED DIRECTLY TO SUPPLEMENT OR REPLACE NATURAL GAS

- Two-thirds goes to electricity production but direct use applications are growing



- Landfill gas consists of about 50% methane and about 50% carbon dioxide and some non-methane organic compounds
- Electricity produced from landfill gas can either be used on-site or sold to the grid
- Landfill gas can also generally be used to supplement or replace natural gas – direct use
- For some applications it must be conditioned first to increase its Btu content or filter out impurities

## INTERNAL COMBUSTION IS BY FAR THE MOST USED TECHNOLOGY IN LANDFILL-TO-ENERGY OPERATIONS IN THE U.S.

- Electricity can be generated from landfill gas using a variety of different technologies:
  - Internal combustions engines (reciprocating engine)
  - Gas turbine
  - Microturbine technology (used at smaller landfills and in niche applications)
  - Stirling engines / external combustion engines (development phase)
  - Organic rankine cycle engines (development phase)
  - Fuel cells (development phase)
- Out of the 250 operational LFG facilities in the U.S. producing electricity, more than 200 use reciprocating engine technology



*Dave Mussell*



## LANDFILL GAS CAN ALSO BE USED DIRECTLY THROUGH A LARGE NUMBER OF APPLICATIONS

- Examples of applications for landfill gas in the U.S. include:
  - Boiler and generator-sets applications designed or modified to operate with biogas
  - Combined heat and power (CHP)
  - Natural gas pipeline injections (after upgrading)
  - Vehicle fuel in the form of liquefied natural gas, LNG and/or compressed natural gas ,CNG (after upgrading)
  - Other applications like Greenhouse and Aquaculture (fish farming)
- Many utilities are still reluctant to let landfill gas into their grid and put very strict requirements on the quality of the biogas they accept

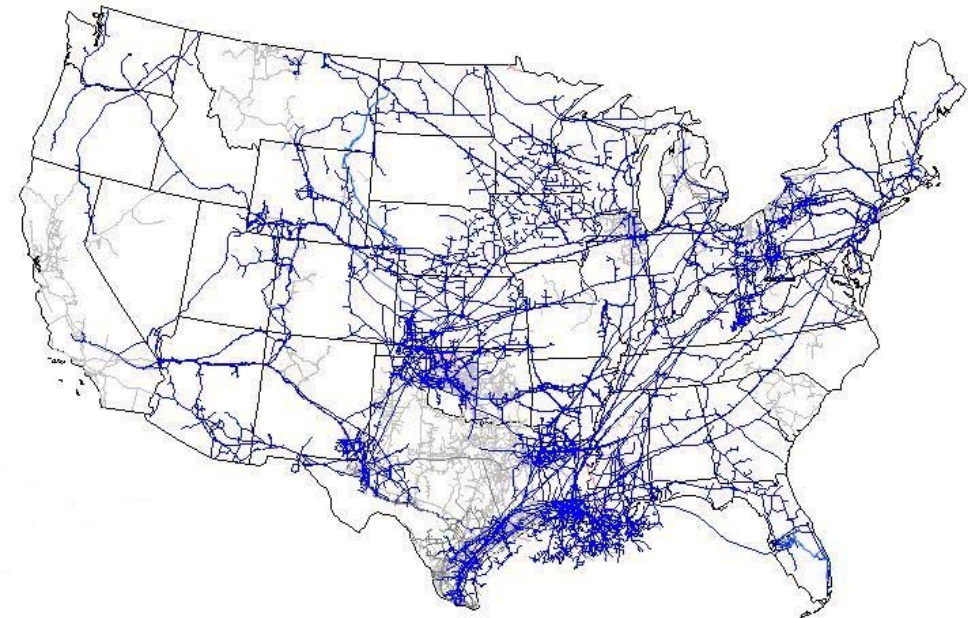
*"The technology is there to upgrade landfill gas to natural gas quality. It is more a matter of consumer preferences. I think that is why some utilities are reluctant to let landfill gas into their grid"*

Brian Guzzone,  
Program Manager, EPA / LMOP

## THERE IS AN EXTENSIVE NATURAL GAS PIPELINE NETWORK IN THE U.S.

- The U.S. natural gas pipeline network is a highly integrated transmission and distribution grid that can transport natural gas to and from the lower 48 States
- The natural gas pipeline grid comprises of more than 210 natural gas pipeline systems and 300,000 miles of interstate and intrastate transmission pipelines
- More than 1,400 compressor stations maintain the pressure on the natural gas pipeline network and assure continuous forward movement of supplies
- Natural gas can be imported/exported via pipelines through 55 locations and through 5 LNG (liquefied natural gas) import facilities

U.S. Natural Gas Pipeline Network, 2007



— Interstate pipelines (pipeline systems that cross States)  
— Intrastate pipelines (pipeline systems that operate within one State)

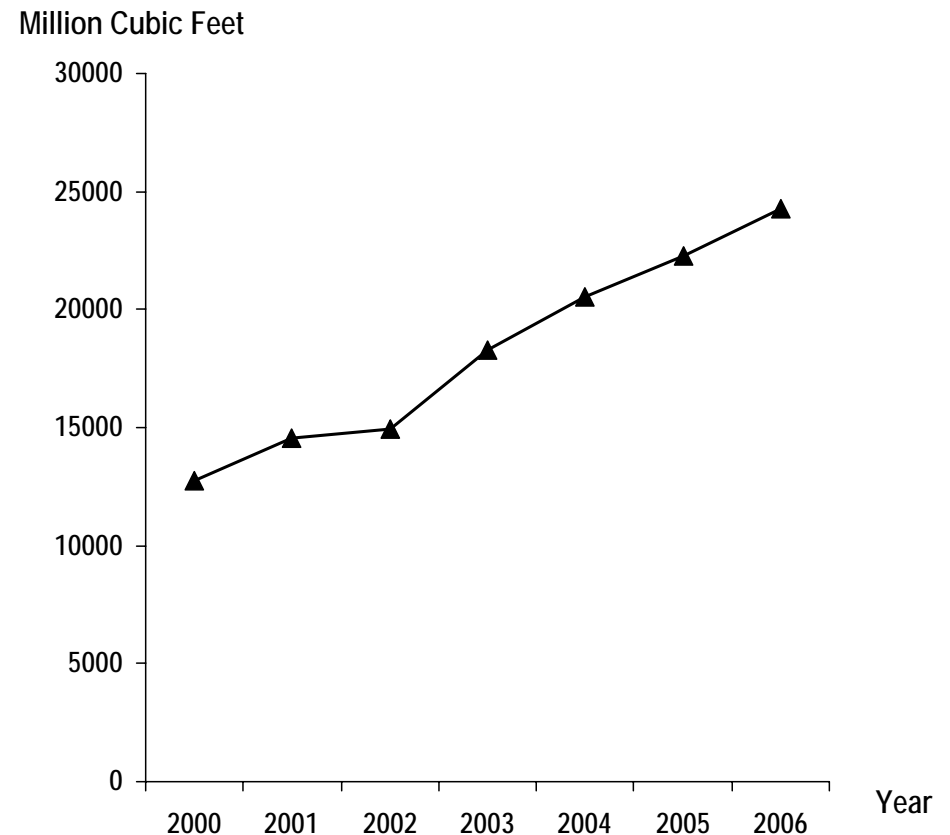
There is potential for biogas upgrading to grid quality in the U.S. as the infrastructure is already largely in place

## THE MARKET FOR NATURAL GAS VEHICLES IS GROWING IN THE U.S.

- California is leading the development when it comes to natural gas vehicle fuel

- There are over 150 000 natural gas vehicles in the United States
- There are over 1500 natural gas fueling stations in the U.S. today and approximately half are available for public use
- Approximately 22% of all new transit bus orders in the U.S. are for natural gas vehicles
- Natural gas costs on average 30% less than conventional gasoline at the pump in the U.S.
- California is leading the development when it comes to natural gas fuel usage. A number of municipalities like Santa Monica and Orange County are running fleets of buses on natural gas
- The fueling infrastructure for natural gas vehicles is growing strongly in California which has over 200 compressed natural gas (CNG) fueling stations and another 50 stations under construction

U.S. Natural Gas Vehicle Fuel Consumption 2000-2006



## THE U.S. IS LACKING A GAS STANDARD

- Making it more difficult for upgraded biogas in the form of biomethane to be accepted as an equivalent to natural gas

- Biogas upgrading implies a process where a significant portion of the carbon dioxide, water, hydrogen sulfide and other impurities are removed from raw biogas
- The major biogas upgrading technologies include:
  - Water scrubbing
  - Membrane separation
  - Pressure swing adsorption (PSA)
  - Mixing with higher quality gases
- Upgraded biogas usually referred to as biomethane is used as an energy source in applications that require pipeline quality or vehicle fuel quality gas
- Unlike Europe the U.S. has not yet developed a gas standard. European standards are being studied

*"We will have to create our own gas standards here in the U.S. otherwise we will run into a lot of trouble in the future"*

Kevin Best  
CEO, Real Energy

*"We are very, very conservative with what kind of gas we let in to somebody's home, so we are not considering letting landfill gas into our grid for the moment."*

Phil Baker  
Director, Southern California Gas Company



## THE DISTRIBUTION OF BIOMETHANE IS PROBLEMATIC IN THE U.S.

- for fuel usage road transportation of liquefied biomethane is the better option

- There are several options of distribution for biomethane:
  - Distribution via special biomethane pipelines
  - Distribution through the natural gas pipeline network
  - Road transportation of compressed biomethane
  - Road transportation of liquefied biomethane
- It is very difficult to obtain the necessary permits to put own gas pipelines in the ground in the U.S. It is also very expensive for other than very short distances
- The local gas utility that typically owns the natural gas pipeline network is usually very reluctant to let biomethane into their grid
- Road transportation of compressed biomethane involves costly investments in capital investment due to sharp safety requirements
- Road transportation of liquefied biomethane is attractive as the infrastructure (traktor towing a LNG tanker) and market (LNG vehicles) already exists in the U.S. However the technology for small-scale liquefaction is expensive and has not yet proved to be commercially mature in the U.S.

*"for distribution purposes  
LNG is a better solution than  
CNG in the U.S."*

Brad Rutledge,  
Senior Project Manger, Weststart-CALSTART

*" I have heard that the company  
Prometheus that are developing  
a LNG plant at the Frank R  
Bowerman landfill in California  
has got important technological  
problems"*

Brad Rutledge,  
Senior Project Manger, Weststart-CALSTART



## THERE IS A LIMITED INTEREST FOR UPGRADING LANDFILL GAS TO BIOMETHANE AMONG COMPANIES RUNNING LANDFILLS

- due to technological and economical constraints

*"If there are companies in Sweden with cost efficient technologies for cleaning the methane from landfill gas to gridline quality we would be interested to discuss it with them. From what we have seen so far, the technologies are not perfected yet."*

Tim Ralston  
Allied Waste Services, Manager Landfill Gas

*"When it comes to biogas cleaning and upgrading to high Btu standard we are watching and waiting for the new technologies to prove themselves in the long term."*

Matt Davies,  
Republic Services, Manager Landfill Gas

*"From what I am aware of, there are very few examples in the United States of landfill gas projects where the gas is upgraded and put into the natural gas grid."*

Kevin Best  
CEO, Real Energy

**New technologies for biogas upgrading have yet to prove themselves both from a technological and from an economic point of view in the U.S.**

# RENEWABLE PORTFOLIO STANDARDS REQUIREMENTS AND OTHER NEW POLICIES COULD INCREASE THE INTEREST FOR BIOMETHANE

- This is especially likely to be the case in California

- According to California's Renewable Portfolio Standard (RPS), 20% of the electricity sold in California has to come from renewable energy source by 2010 and 33% by 2020
- As the first state in the U.S. California has recently established a Low-Carbon Fuel Standard (LCFS). This greenhouse gas (GHG) standard for transportation fuels is expected to increase research and investments in alternatives to oil and reduce GHG emissions.

*"We could be interested in technologies for upgrading and liquefying landfill gas so that we can use it as fuel for part of our fleet."*

Phil Baker  
Director, Southern California Gas Company

## THERE ARE POOR FINANCIAL INCENTIVES FOR UPGRADING BIOGAS TO BIOMETHANE

- The U.S. biomethane industry is limited to a handful of small scale projects
- There are no federal or state programs or incentives in the U.S. directly aiming at increasing investments in biomethane other than general incentives related to natural gas vehicles and renewable energy sources
- The existing tax credits to produce electricity from biogas are not applicable to the production of biogas fuel

*"We are lobbying in order to get the same incentives for the production of biogas fuel as there is currently for electricity production from biogas. Right now the financial incentives aren't entirely there."*

Richard Kolodziej,  
Program Manager, NGV America

*"During 2-3 years we had a compressed biomethane fuelling station in Idaho Falls for public utility vehicles as a part of a clean cities program but when the program financing ended we had to close the fuel station."*

Dennis Keiser  
CEO, Intrepid Technologies and Resources

**Under the current market conditions it appears unlikely that the biomethane industry in the U.S. will experience a strong growth in a near future**



## THERE IS ONE MAIN EVENT WHERE A LARGE SHARE OF THE LANDFILL GAS INDUSTRY PARTICIPATES EVERY YEAR

### Annual LMOP Conference and Project Expo

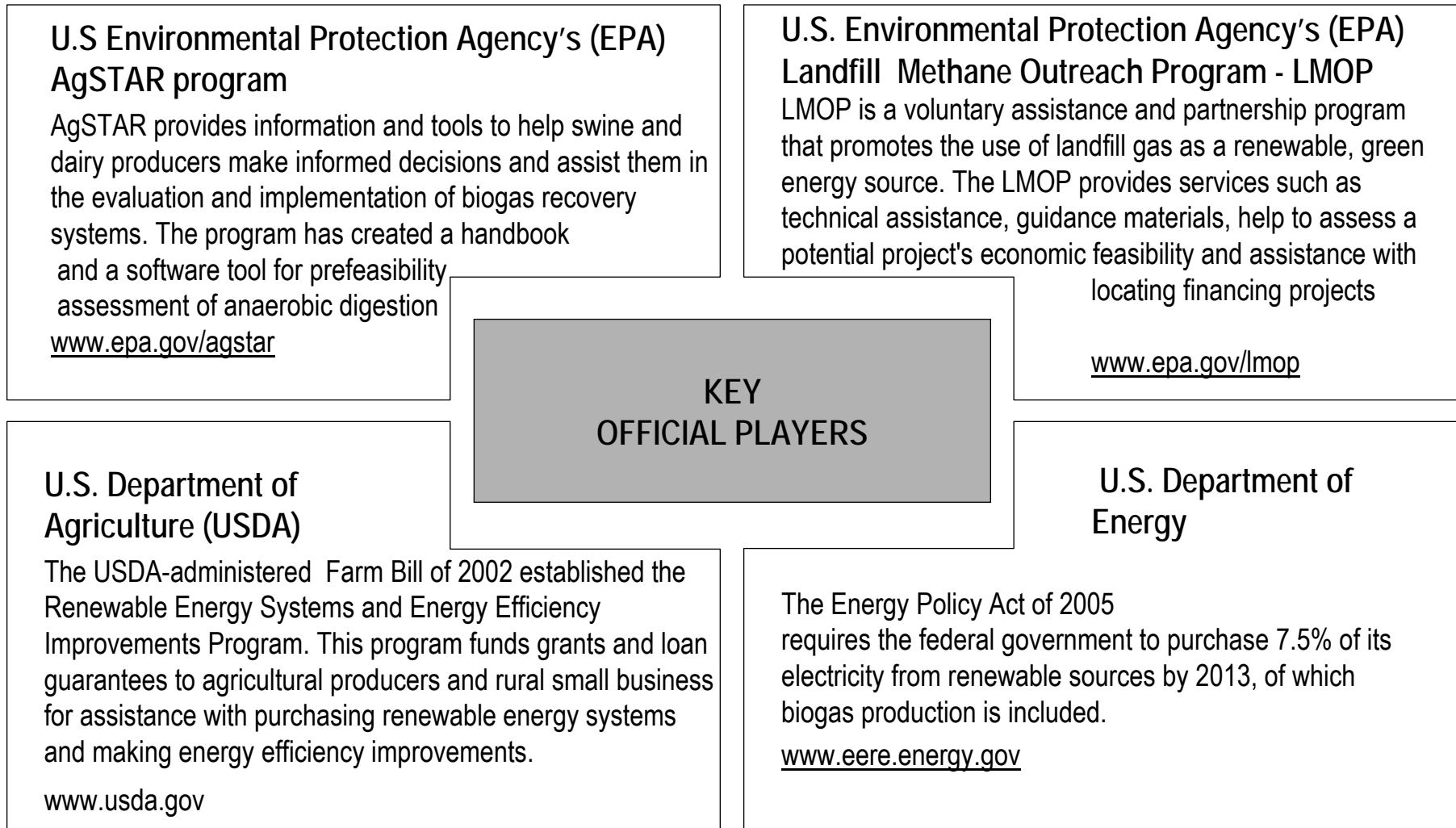
- The Annual LMOP Conference and Project Expo is recognized as the leading industry technical conference and trade show focusing on landfill gas in the U.S.
- The exhibition is attended by many of the leading landfill gas professionals and decision makers, and offers networking opportunities as well as opportunities to showcase products and services
- It is arranged in at the Hyatt Regency, Capitol Hill in Washington DC, January 9-10, 2008

Tradeshows and workshops are important for making business connections within the U.S. biogas industry

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## KEY PLAYERS INFLUENCING THE BIOGAS INDUSTRY



## KEY PLAYERS INFLUENCING THE BIOGAS INDUSTRY

### NGV America

Natural Gas Vehicle for America (NGVAmerica) is an organization dedicated to the development of a growing, sustainable and profitable market for vehicles powered by natural gas or hydrogen. NGVAmerica represents more than 100 companies interested in the promotion and use of natural gas and hydrogen as transportation fuels

[www.ngvamerica.org](http://www.ngvamerica.org)

### Solid Waste Association of North America (SWANA)

SWANA's Landfill Gas Management Division is a widely recognized authority on issues surrounding landfill gas (LFG) recovery, control, management, utilization, & system design, operation, and maintenance. SWANA has taken a leading role in promoting the use of LFG as a sustainable and renewable energy source

[www.swana.org](http://www.swana.org)

### KEY ORGANIZATIONS

### Weststart-CALSTART

WestStart-CALSTART is a non-profit organization that works with the public and private sectors to develop advanced transportation technologies and foster companies that will help clean the air, lessen the U.S. dependence on foreign oil, reduce global warming, and create jobs

[www.calstart.org](http://www.calstart.org)

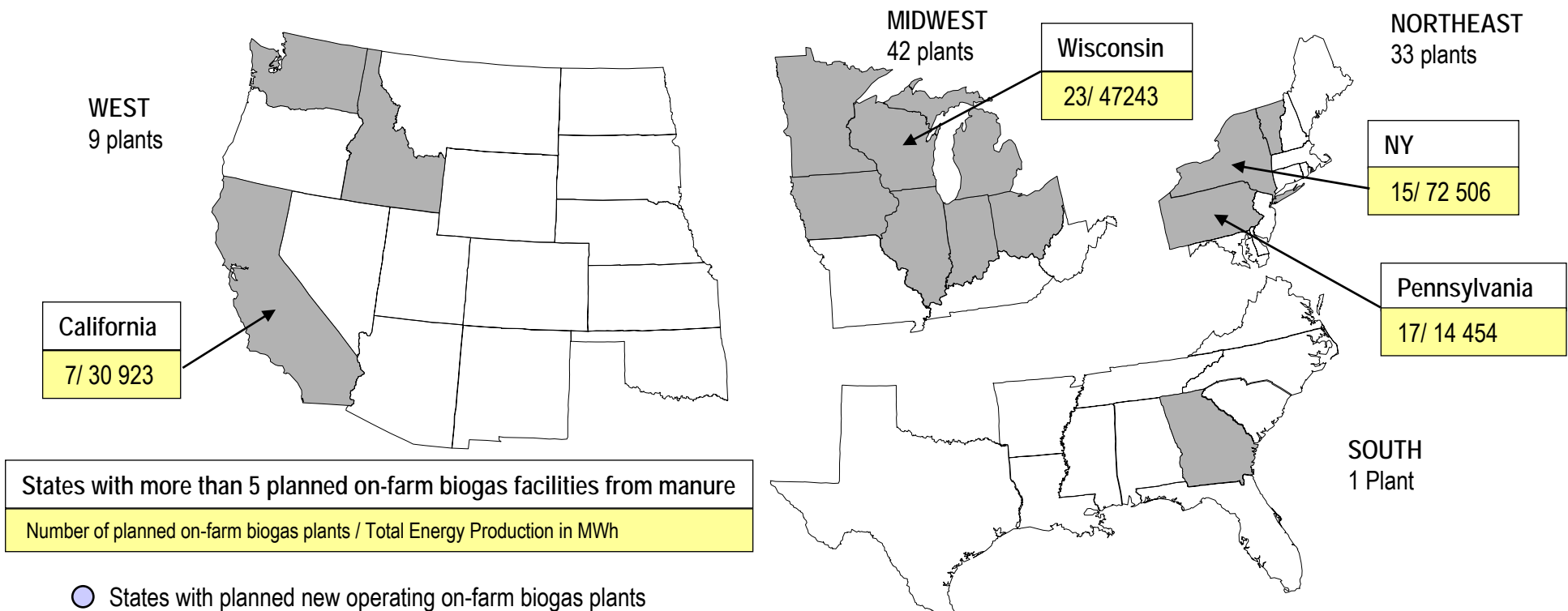
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# MORE THAN 80 NEW ON FARM BIOGAS DIGESTERS ARE PLANNED FOR THE COMING YEARS

- More than 75% of these new plants will be built in Wisconsin, New York State, Pennsylvania and California

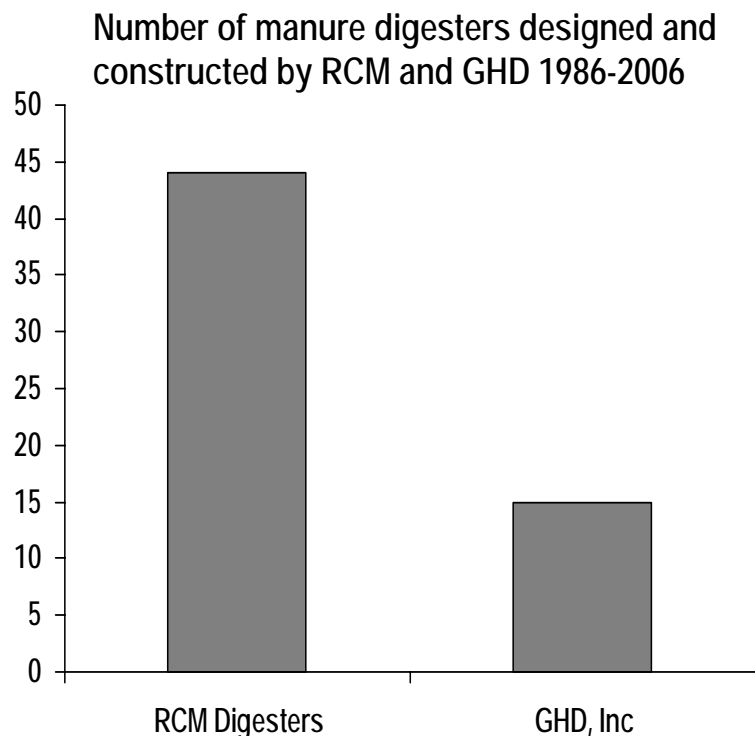
Planned on-farm biogas recovery systems from dairies and swine farms in 2006



The states that already have the most on-farm biogas systems are also the states where the most new plants will be built

## RCM AND GHD ARE MARKET LEADERS WHEN IT COMES TO DESIGN AND CONSTRUCTION OF MANURE DIGESTERS IN THE U.S.

- Together they have constructed more than half of the operational manure digester systems in the U.S.



Both are focusing on biogas to electricity systems

RCM Digesters, Inc.  
(Berkeley, California)

- RCM Digesters has constructed more than 44 anaerobic digester systems since 1982
- The company is active all over the U.S. and internationally
- RCM services include feasibility studies, design, engineering and construction management, startup & troubleshooting
- RCM constructs both covered lagoons, complete mix and plug flow digesters

GHD, Inc  
(Chilton, Wisconsin)

- GHD, Inc has been very active in the segment of manure digesters since the end of the 90s
- GHD has a patented mixed plug flow technology
- GHD is active all over the U.S. but mostly in the Midwest
- GHD's services includes engineering & design, installation, equipment specification, start-up

## A NUMBER OF NEW SMALLER PLAYERS HAVE ENTERED THE MARKET

- Several are designing, constructing, and operating manure digester systems

### Clear Horizons LLC (Milwaukee, Wisconsin)

- Clear Horizons designs, builds and operates above-ground, complete mix anaerobic digesters
- The business idea is to provide turn key solutions and partnership deals to customers
- Clear Horizons provide technical services, construction services, and the ability to operate and maintain the system for the customer

### Bison Renewable Energy LLC (Mendota Heights, Minnesota)

- The business idea of this new company is to build and operate regional biogas anaerobic digesters in agricultural communities across the U.S.
- Its first plant in Iowa will receive manure from a number of farmers. The remaining 50% of the raw materials for the plant will come from food waste

### E3 BioFuels (Shawnee, Kansas)

- E3 BioFuels has constructed and operates a closed-loop ethanol plant in Mead, Nebraska, fueled in part by methane from cow manure
- The patented system produces energy by combining manure from the adjacent Mead Cattle company's 28 000 head feedlot with stillage, a bi-product of ethanol refining

Like the two market leaders, most companies are focusing on biogas to electricity systems



# REAL ENERGY IS BUILDING A FIRST BIOGAS PLANT USING ENERGY CROPS AS MAIN FEEDSTOCK

- European companies Ros Roca and Envitech are technological partners

RealEnergy LLC  
(Yountville, California)

- RealEnergy is a leading developer of renewable and highly efficient on-site hybrid power systems and microgrids
- The company develops, builds, owns, operates and trades "clean technology" and financially attractive small power projects applied in agricultural, commercial industrial and institutional markets.
- RealEnergy has completed over 43 electric grid interconnections to date
- Real Energy is now looking into building up to 30 biogas plants in the U.S. based on methane recovery from mainly energy crops. A first plant is currently under construction
- European companies Ros Roca and Envitech are technological partners

*"The idea is to have approximately 70% of the methane gas coming from energy crops and the rest from food waste streams that generates income from tipping fees and eventually manure."*

Kevin Best  
CEO, Real Energy

*"We are closely following what is happening in Europe. Ros Roca, a company we are working with, has worked with several biogas plants in Sweden."*

Kevin Best  
CEO, Real Energy

## ITR AND MICROGY ARE FOCUSING ON UPGRADING THE BIOGAS FROM MANURE DIGESTERS AND INSERT IT INTO THE GRID

### Microgy Inc / Environmental Power Corp (Golden, Colorado)

- Microgy provides development, construction, financing and ongoing operation & maintenance of manure anaerobic digesters
- The business model is to build, own and operate the biogas systems
- Microgy has a partnership with a European technology provider

### Intrepid Technology and Resources (Idaho Falls, Idaho)

- ITR has constructed and operates three manure digester biogas plants in Idaho
- The business idea is to clean the methane to consumer standards and insert it to the grid
- ITR provides management and engineering/technology for planning, construction, and operation of biogas production facilities
- ITR is open to cooperation with Swedish companies

*"We are focused on biogas upgrading to grid standard but for the moment we are not dealing with LNG as that technology is more complicated"*

Jeffrey Dasovich  
Microgy

*"We would be very interested in a cooperation with a Swedish company on the technology side"*

Dennis Keiser  
CEO, Intrepid Technologies and Resources



## A FEW FOREIGN COMPANIES HAVE RECENTLY ENTERED THE U.S. MARKET FOR BIOGAS MANURE DIGESTERS

- The two German Biogas leaders Schmack and Biogas Nord are increasing their presence in the U.S.

### Biogas Nord (Bielefeld, Germany)

- Biogas Nord is an engineering firm that has specialized in the development, planning, construction and operation of biogas plants
- The company has 160 employees and can build up to 60 biogas plants a year
- Biogas Nord has built more than 120 biogas plants in Germany and 4 in the U.S. in Michigan and Wisconsin

### Schmack Biogas AB (Schwandorf, Germany)

- Schmack offers a complete range of services for biogas plants, from project development, planning and obtaining a building permit, construction, commissioning and providing technical services to financing and contracting models
- Schmack has built more than 200 biogas plants mainly in Europe. One plant is currently under construction in the U.S.

*"In my way of seeing things European companies have more advanced technologies for biogas digesters than our market leaders here in the U.S."*

Kevin Best  
CEO, Real Energy

Competition is relatively weak in the market for anaerobic digesters in the U.S.

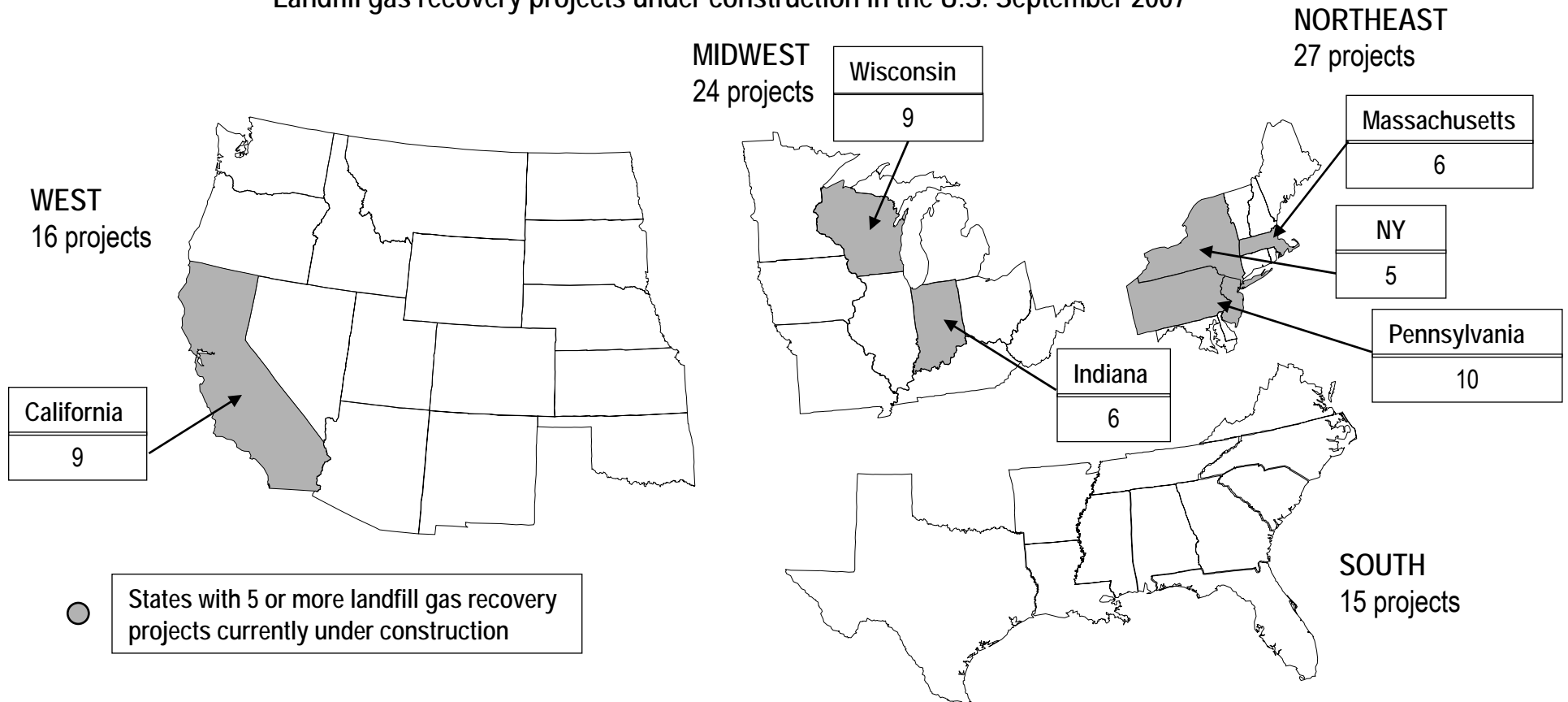
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# 82 NEW LANDFILL GAS PROJECTS ARE UNDER CONSTRUCTION

- Most of them are in Pennsylvania, Wisconsin and California

Landfill gas recovery projects under construction in the U.S. September 2007



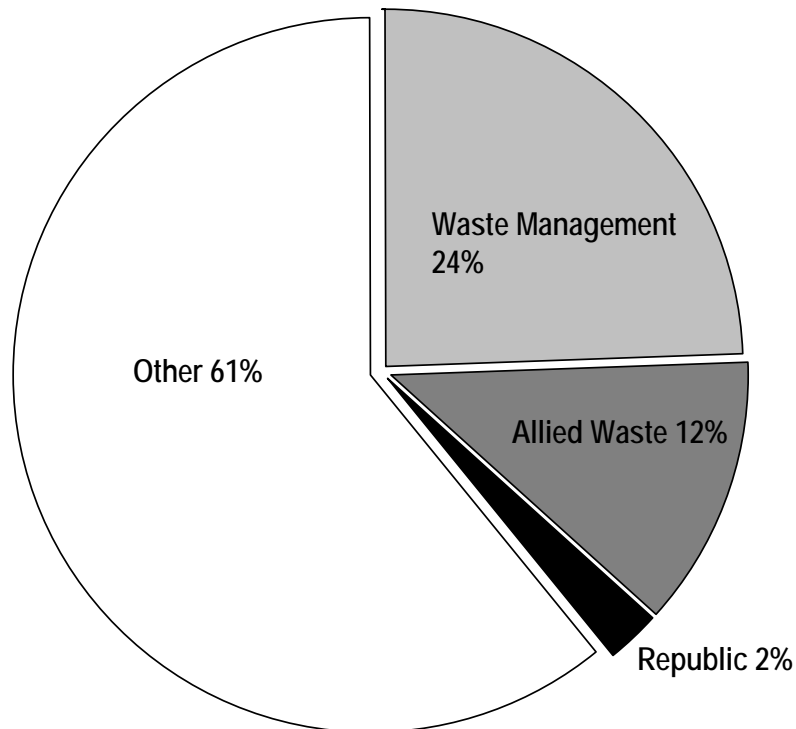
According to the EPA, an additional 570 landfills have a potential to recover enough landfill gas to make it financially and technically feasible. Those are listed on [www.epa.gov/lmop/](http://www.epa.gov/lmop/)



# WASTE MANAGEMENT, ALLIED WASTE AND REPUBLIC ARE THE LARGEST COMPANIES OPERATING LANDFILLS ALL OVER THE U.S.

- They are also the companies operating most of the landfill gas to energy facilities

Operation of landfill gas to energy plants in the U.S.  
(out of a total of 427 plants)



*"I would say that approximately 60% of the landfills in the U.S. are privately owned and 40% owned by municipalities. However of the 40% publicly owned, as many as 75% are operated by private companies. More and more landfills are going over to private companies"*

Brian Guzzone,  
Program Manager, EPA / LMOP

Landfills are to a growing extent privately owned and operated in the U.S.



## WASTE MANAGEMENT OPERATES OVER 100 LANDFILL GAS FACILITIES IN THE U.S. AND PLANS TO BUILD 60 MORE OVER THE NEXT 5 YEARS

- Waste Management Inc. (WM) is Americas' largest landfill-to-gas developer and operator
- The investment for the 60 new facilities is estimated at between 350 and 400 million USD
- According to Paul Parlor, Vice President for renewable energies at WM there are three main reasons for WM's investment in new landfill gas facilities
  - Rising energy prices
  - State incentives
  - Federal tax credits for landfill gas projects
- Waste management has developed a unique business model where the strategy is to finance the landfill-to-gas facilities internally, plan, build and operate the plants themselves and sell the energy
- Unlike its top competitors Allied and Republic, WM is also acting as developer bidding for external projects

*"We are internalizing all the functions in the process from the financing to the construction and the operation of the landfill-to-gas facility. We are also acting as developers and actively bidding for external projects"*

Paul Parlor  
Vice President Renewable Energies,  
Waste Management Inc.



## A NUMBER OF LARGE U.S. COMPANIES PROVIDE EQUIPMENT AND SERVICES FOR LANDFILL GAS TO ENERGY PROJECTS

- Several have offices all over the U.S. and experience from international projects

### Ameresco Inc.lear (Framingham, Massachusetts)

- Ameresco offers a wide range of services to landfills including project design, financing, construction and management of landfill gas to energy systems
- Ameresco has more than 400 employees and own offices throughout the United States and Canada

### Ingenco (Richmond, Virginia)

- Ingenco is designing and manufacturing power generating equipment, developing and constructing power generating facilities and owns and operates power plants
- Ingenco applies new technologies such as dual fuel sources (diesel + LFG) and transportation class compression ignition engines

### SCS Engineers (Long Beach, California)

- Provides engineering, construction, training, operation, maintenance and monitoring services for landfill gas to energy projects
- SCS' more than 40 offices serve public- and private-sector clients throughout the U.S. SCS has also performed work for clients in 40 countries worldwide

### Innovative Energy Systems (IES) (Oaksfield, NY)

- Innovative Energy Systems offers design, engineering, construction, manufacturing and administrative services in all aspects of methane gas recovery for the subsequent use in landfill gas to electricity plants
- IES also owns and manages over 40 MW of capacity in New York State and Vermont.

## THE MARKET FOR ELECTRICITY PRODUCTION FROM LANDFILL GAS IS HIGHLY COMPETITIVE IN THE U.S.

*"I see much more room for competition on the high Btu cleanup side. When it comes to electricity production from landfill gas the field is already very competitive"*

Tim Ralston  
Allied Waste Services, Manager Landfill Gas

*"It is a very competitive market. Recently we won a contract in NY state. We were one of fourteen companies bidding for a fairly small project"*

Paul Parlor  
Vice President, Vice President for Renewable Energies at Waste Management Inc.

It can be difficult for Swedish companies to enter the market for landfill gas to electricity in the U.S.

## FIRMGREEN AND PROMETHEUS ENERGY ARE TWO START-UPS WITH TECHNOLOGIES FOR TRANSFORMING LANDFILL GAS TO CNG AND LNG

### FirmGreen Energy Inc. (Newport Beach, California)

- FirmGreen Energy's patented landfill gas cleanup technology can process landfill gas (LFG) into Compressed Natural Gas (CNG)
- FirmGreen is currently working on a project in Columbus Ohio and negotiating with landfills in Illinois and Missouri.
- FirmGreen has worked with RE projects in Spain, Puerto Rico and Chile

### Prometheus Energy (Mercer Island, Washington State)

- Prometheus Energy is capturing methane from waste or low-quality sources such as landfills, wastewater treatment facilities and agricultural operations to transform the methane into LNG
- Prometheus is currently working with a landfill gas (LFG) to Liquefied Natural Gas (LNG) project on the Frank R. Bowerman Landfill in California

*"Through our technology we can provide biomethane to the market at a price less than the price for petroleum for the same energy content and in the end that is what it all comes down to"*

Steve Wilburn, President  
FirmGreen Energy Inc.

*"For the moment our projects are fully funded by private equity"*

Kehaw Kancaid,  
Prometheus Energy

Competition is weak in this market segment, leaving room for Swedish companies

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  - Customers and Competition landfill gas
  - **Summary biogas**
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## SUMMARY BIOGAS 1(3)

### Biogas recovery from anaerobic digesters

- There are currently more than 100 on-farm anaerobic digesters in operation in the U.S. of which almost half have been built during the last five years. More than 80 new anaerobic digesters are in the planning stage
- The 2002 Farm Bill grants and other federal programs have been major drivers for the development of new anaerobic digesters systems in the U.S.
- Progressive energy policies and state programs providing funding and beneficial loans in California, Pennsylvania, Wisconsin and New York state are explaining factors behind the concentration of anaerobic digester plants in those states. Other states like Iowa are catching up
- California has by far the largest potential for biogas production from cow manure while North Carolina and Iowa has the largest potential for biogas production from swine manure
- Plug-flow is the predominant technology for anaerobic digesters in the U.S. There is a new trend of adding waste with rich organic content to manure digesters to increase methane output and profitability
- The two U.S. companies RCM Digesters and GHD Inc. dominates the market for anaerobic digesters in the U.S. Neither is large in an international comparison A handful of small companies have recently entered the market. Foreign companies have until now hardly been present on the U.S. market

The market for anaerobic digesters is growing fast and competition is limited

## SUMMARY BIOGAS 2(3)

### Biogas recovery from landfills

- There are more than 420 operating landfill gas recovering plants in the U.S, most of them located in the Midwest and in California. 82 new plants are under construction. Most of them in California, the Midwest and the Northeast
- Electricity generation from landfill gas is a well established business in the U.S. Two thirds of the landfill gas goes to electricity production
- There are strong federal and state incentives favoring electricity production from landfill gas operations in the U.S.
- Landfill operations is largely a private business in the U.S. dominated by a handful of large companies. Those companies are also operating most landfill gas to energy facilities
- A number of large domestic companies provide equipment and services for landfill gas to energy projects – the market is highly competitive

The market for biogas recovery from landfills is well established and competition is intense

## SUMMARY BIOGAS 3(3)

### Biogas upgrading to biomethane

- The market for natural gas vehicles is growing in the U.S. especially in California
- There are no direct federal or state incentives in the U.S. encouraging investments in the production or consumption of biomethane other than indirect incentives such as incentives to convert vehicles to natural gas vehicles or general incentives related to renewable energy sources
- There are important challenges to overcome concerning the distribution of biomethane in the U.S.
- There are very few examples of landfill gas projects where the gas is upgraded and inserted to the natural gas grid due to technological and economical constraints
- Economies of scale makes it difficult for individual farms producing biogas to upgrade the biogas to biomethane and distribute it in a cost efficient way
- There is a "wait and see" attitude among companies operating landfills regarding biogas upgrading to biomethane. There is a consensus view in the sector that new technologies have to prove themselves in the long term
- Competition is weak in this segment as the few existing domestic players are small and recently entered the market

The market for biogas upgrading to biomethane is undeveloped in the U.S. New companies and technologies will have to prove themselves

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## SAMMANFATTNING BIOGAS 1(3)

### Biogasutvinning ur rötning av gödsel

- Det finns för närvarande mer än 100 biogasanläggningar baserade på rötning av gödsel i USA varav nästan hälften har byggts under de sista fem åren. Mer än 80 nya anläggningar är i planeringsfasen
- Nya federala anslag i form av förmånliga lån och skattelättnader för att bygga och driva biogasanläggningar på boskapsgårdar är den främsta förklaringen till de senaste årens starka tillväxt i branschen
- Kalifornien, Pennsylvania, Wisconsin och New York är de delstater som i första hand satsat på en energipolitik som främjar förnybara energikällor, däribland gårdsbaserade biogasanläggningar. De flesta gårdsbaserade biogasanläggningar i USA ligger i dessa delstater
- Kalifornien har den största potentialen för biogasutvinning genom rötning av kogödsel medan North Carolina och Iowa har den största potentialen för rötning av svingödsel
- En ny trend är att man bygger nya anläggningar med överkapacitet för att kunna ta emot rikt organiskt avfall (organiskt avfall från bryggerier, livsmedelsindustrin etc.) för att öka metanproduktionen och därmed lönsamheten för anläggningen
- De inhemska företagen RCM Digesters och GHD Inc. är de största aktörerna på USA-marknaden. Båda är små mätt med internationella mått. Utländska företag har fram till nu haft en mycket liten närvaro

Marknaden för biogasanläggningar på boskapsgårdar växer kraftigt och konkurrensen är begränsad



## SAMMANFATTNING BIOGAS 2(3)

### Utvinning av deponigas från avfallsdeponier

- Utvinning av deponigas är en relativt mogen bransch i USA. Det finns över 420 anläggningar i drift som utvinna biogas från avfallsdeponier och 82 nya anläggningar är under uppbyggnad
- Det amerikanska miljödepartementet EPA uppskattar att ytterligare 570 avfallsdeponier har potential att tekniskt och ekonomiskt utvinna biogas i USA
- Kalifornien har absolut flest deponigasanläggningar i USA. Delstaterna runt Lake Michigan har relativt många liksom ett antal delstater i nordöstra USA. Det är också i dessa regioner som flest nya anläggningar kommer att byggas under de kommande åren
- Det finns starka federala och delstatliga program med incitament för att bygga och driva deponigasanläggningar i USA
- 2/3 av den utvunna biogasen används i för att producera elektricitet
- Cirka 60% av alla avfallsdeponier i USA är i privat ägo. Privata företag driver dessutom ett allt större antal av de kommunalt ägda anläggningarna. Företagen Waste Management och Allied Waste dominerar avfallsbranschen och driver de flesta deponigasanläggningarna
- Waste Management och en handfull stora väletablerade inhemska företag projekterar och bygger de flesta deponigasanläggningarna i USA

**Branschen för projektering och byggande av deponigasanläggningar i USA är hårt konkurrensutsatt**



## SAMMANFATTNING BIOGAS 3(3)

### Uppgradering av biogas till naturgaskvalitet

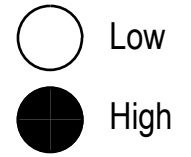
- Mer än 150 000 fordon i USA drivs av naturgas och marknaden växer i första hand i Kalifornien
- Det saknas idag starka politiska och ekonomiska incitament för att uppgradera biogas till sådan kvalitet att det kan användas som drivmedel i naturgasfordon
- Ett problem som lyfts fram av många experter är att man i USA saknar standarder för gas
- Distribution av biogas är en annan utmaning i USA pga. restriktiv lagstiftning och en ovilja från många gasbolag att släppa in biogas i naturgasnätet
- Det är svårt för enskilda gårdar att uppnå tillräckliga produktionsvolymerna av biogas för att det ska vara intressant att uppgradera gasen. Det finns också väldigt få exempel i USA idag på deponigasanläggningar som uppgraderar deponigasen till en högre kvalitet
- Det finns en avvaktande mentalitet bland företagen som driver deponigasanläggningar i USA. Man vill få bevisat att en ny teknologi fungerar på lång sikt både ur ett tekniskt och ett ekonomiskt perspektiv innan man är beredd att investera
- Det finns endast ett fåtal små inhemska företag som sysslar med uppgradering av biogas

**Marknaden för uppgradering av biogas är underutvecklad i USA pga svaga incitament och legala hinder. Nya teknologier måste upp till bevis**

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# CONCLUSIONS BIOGAS



Biogas segments	Key observations	Attractiveness
Biogas recovery from anaerobic digesters	<ul style="list-style-type: none"> <li>• Strong growth in the last five years and an expected strong growth in the coming years</li> <li>• Numerous federal and state programs favoring investments in on-farm biogas plants</li> <li>• Competition is limited</li> </ul>	
Landfill gas to electricity generation	<ul style="list-style-type: none"> <li>• Well established sector in the U.S. but with a strong potential for further growth</li> <li>• New federal and state programs provide financing possibilities</li> <li>• Very competitive market with large domestic players</li> </ul>	
Biogas upgrading to biomethane	<ul style="list-style-type: none"> <li>• Sweden is world leader in production and usage of biomethane</li> <li>• The U.S. market for biomethane is undeveloped due to important challenges and weak financial incentives</li> <li>• Competition is very limited</li> </ul>	

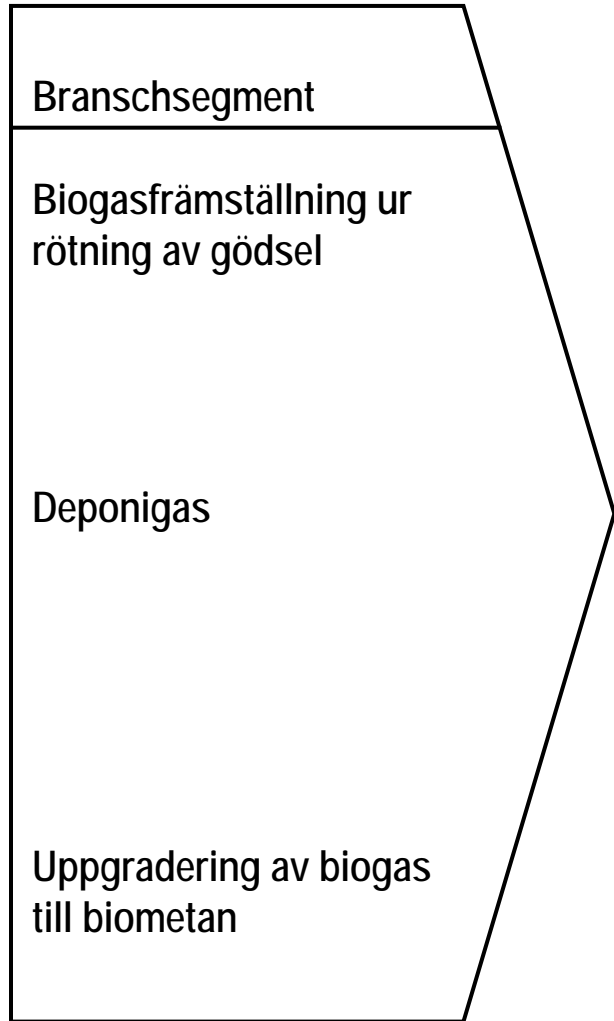
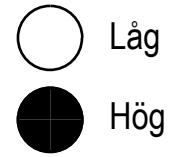
## RECOMMENDATIONS - BIOGAS

- ➔ The market for anaerobic digesters is growing strongly in the U.S. but competition is still limited. Co-digestion is a relatively new technology in the U.S. Swedish companies with experience and expertise regarding co-digestion of multiple waste streams should have a comparative advantage in the U.S.
- ➔ The market for landfill gas operations is growing but well established and highly competitive. Swedish companies should consider partnering with or sub-supply to U.S. companies
- ➔ The market for biogas upgrading to biomethane is largely undeveloped in the U.S. Many failures have created a skepticism towards new technologies. Swedish companies should consider partnering with a U.S. landfill in setting up a small pilot facility in order to prove the functionality of the technology to American clients
- ➔ Swedish companies should focus their sales efforts on California, New York State, Wisconsin and Pennsylvania since they offer the most promising business opportunities both for anaerobic digesters and landfill gas operations

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# SLUTSATSER BIOGAS



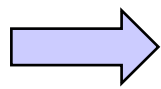
## Nyckelobservationer

## Marknadspotential

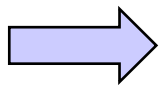
- Stark tillväxt under de senaste åren och en förväntad stark tillväxt under de närmsta åren
- Många program och ekonomiska incitament gör det intressant att investera i nya biogasanläggningar
- Konkurrensen i branschen är begränsad
- Branschen är väletablerad i USA
- Ett stort antal nya anläggningar är under konstruktion eller i planeringsfasen
- Nya federala och delstatliga program och lagar främjar investeringar i nya deponigasanläggningar i USA
- Konkurrensen är hård då branschen domineras av stora väletablerade inhemska aktörer
- Sverige är världsledande inom uppgradering av biogas
- Det saknas i dagsläget tillräckliga incitament för att uppgradera biogas till naturgaskvalitet i USA
- Några få små inhemska aktörer finns på marknaden



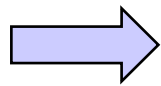
## REKOMMENDATIONER - BIOGAS



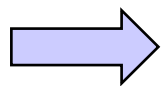
Marknaden för rötningsanläggningar för gödsel är under stark tillväxt i USA men konkurrensen är fortfarande begränsad. Svensk teknologi och kompetens när det gäller att blanda olika biogassubstrat (rötningsråvaror utav organiskt lättnedbrytbart material) för att få en större produktion av metangas efterfrågas i USA



Marknaden för att projektera och bygga deponigasanläggningar växer i USA men konkurrensen är hård. Svenska företag bör överväga att ta sig in på marknaden som underleverantörer till de väletablerade amerikanska bolagen i branschen



Svaga incitament och ett antal legala hinder gör att marknaden för att uppgradera biogas till naturgaskvalitet är underutvecklad i USA. Det finns en skepsis mot nya teknologier i branschen. Svenska företag bör överväga att tillsammans med en amerikansk partner sätta upp en demonstrationsanläggning i USA.



Svenska företag bör fokusera på Kalifornien, Midwest och delstaterna i nordöstra USA då dessa regioner har den största tillväxten av nya deponigasanläggningar och nya rötningsanläggningar för gödsel

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## LIST OF INTERVIEWED PEOPLE 1(2)

Company/Organization	Contact	Title
EPA – Landfill Methane Outreach Program	Brian Guzzone	LMOP territory manager west
Rosenblum Environmental Engineering	John Rosenblum	Owner and Manager
Real Energy	Kevin Best	CEO
EPA – AgSTAR	Chris Voell	Program Manager
Southern California Gas Company	Phil Baker	Director, Commercial and Industrial Services
Borlänge Energi	Ronny Arnberg	Head of International Projects
Scandinavian Biogas Fuels AB	Per Ewers	CEO and President
WestStart-CALSTART, Florida Office	Brad Rutledge	Senior Project Manager
GDH Inc.	Steve Dvorak	Chief Engineer
GDH Inc.	Dan Holst	Manager
Republic Services Inc.	Matt Davies	Manager Landfill Gas

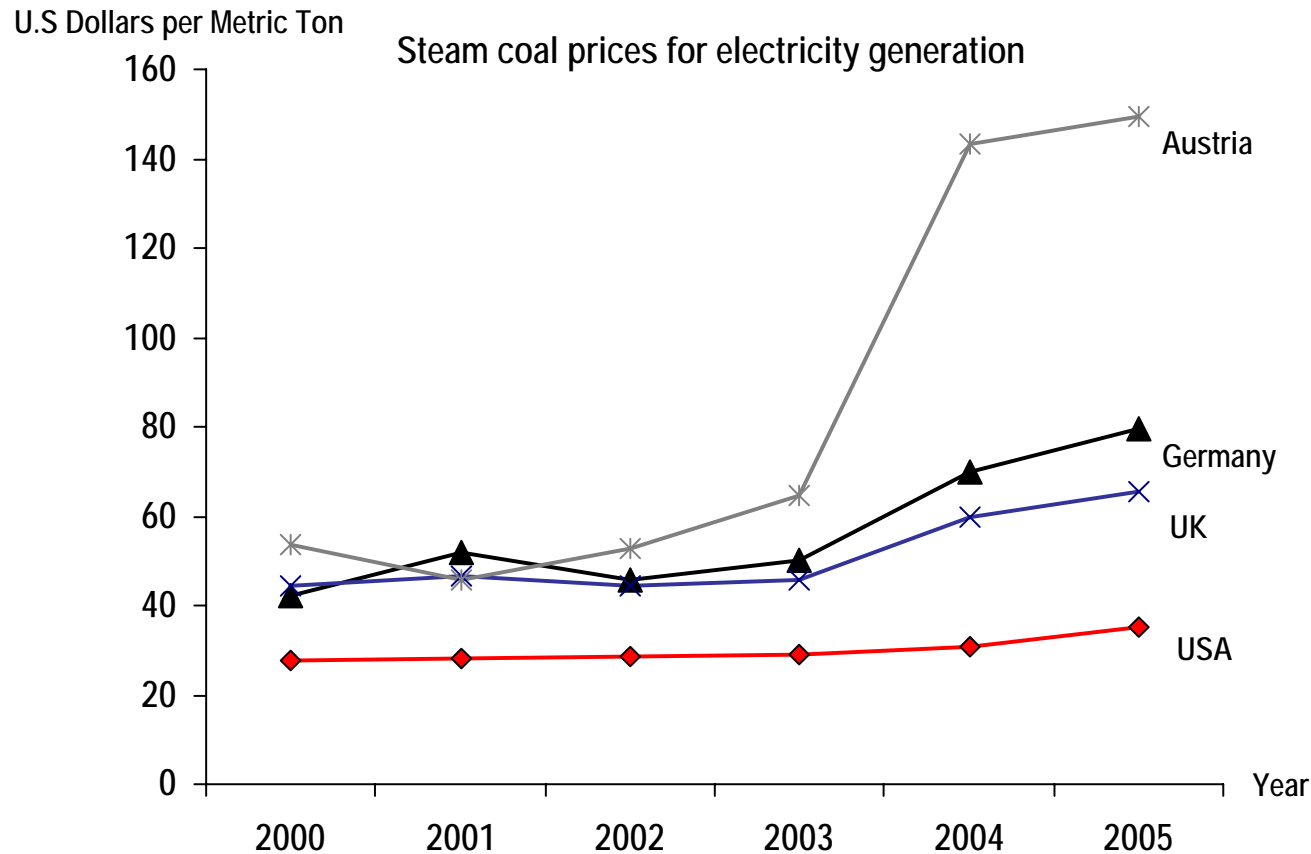
## LIST OF INTERVIEWED PEOPLE 2(2)

Company/Organization	Contact	Title
NGV America	Richard Kolodziej	Program Manager
Allied Waste Services	Tim Ralston	Manager Landfill Gas
Waste Management Inc.	Paul Parlor	Vice President, Renewable Energies
Intrepid Technology and Resources (ITR)	Dennis Keiser	CEO
Firm Green Energy Inc	Steve Wilburn	President
Prometheus Energy	Kehau Kincaid	Business Development Associate
Republic Services Inc.	Matt Davies	Manager Landfill Gas

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# VERY LOW COAL PRICES MAKES IT DIFFICULT FOR RENEWABLE ENERGIES TO BE COST EFFICIENT IN THE U.S.

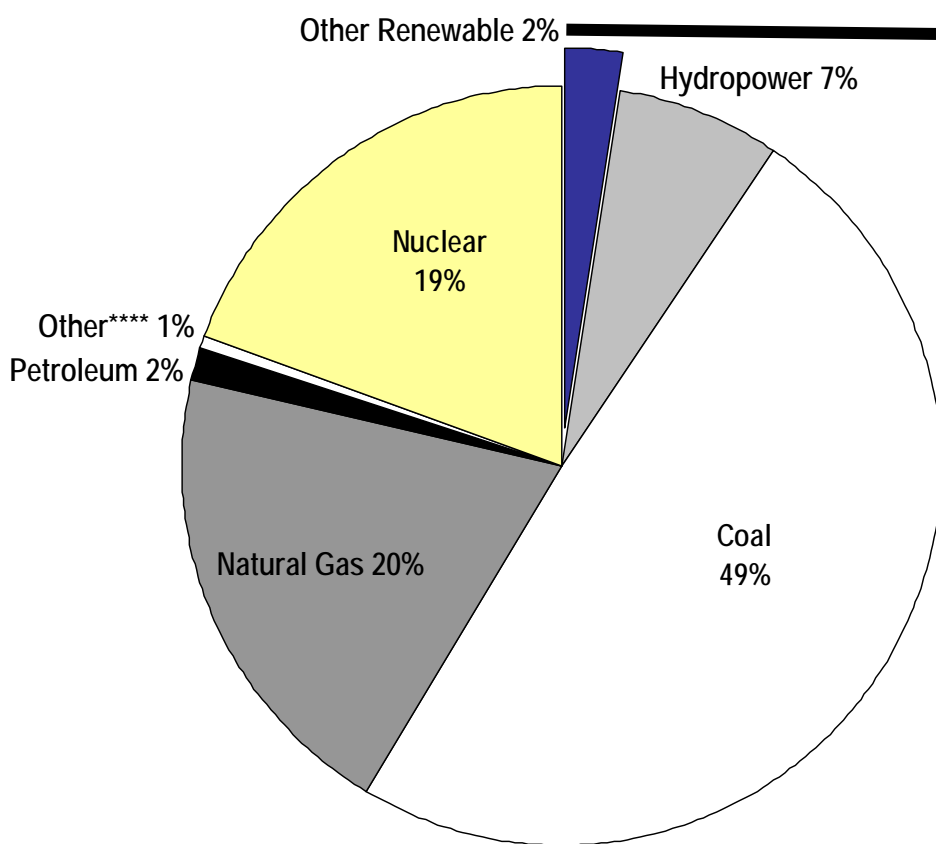


Coal is a very cheap energy source in the U.S. compared to most European countries

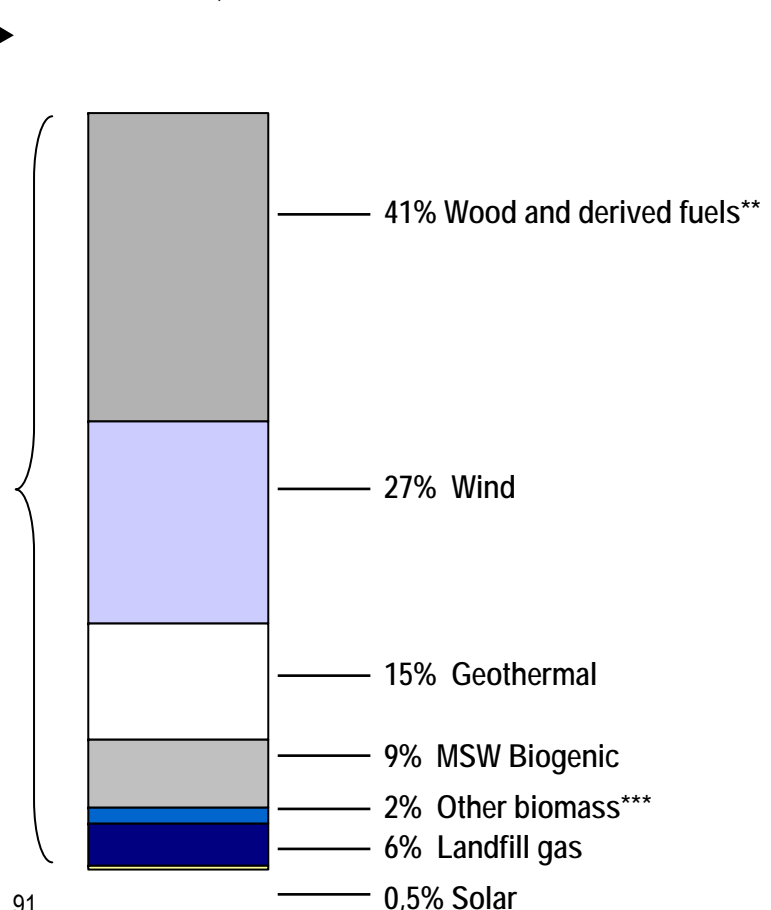
# ONLY 2% OF THE ELECTRICITY PRODUCED IN THE U.S. COME FROM RENEWABLE ENERGY SOURCES OTHER THAN HYDROPOWER

- Coal represent 49% of the total electricity generation in the U.S.

Electricity Net Generation in the U.S (2006)  
100% = 4053 Billion Kilowatt-hours



Electricity net Generation from Renewable Energy\* (2006)  
100% = 96,7 Billion Kilowatt-hours



\*\*\*\* Non-biogenic municipal solid waste, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, tire-derived fuels and miscellaneous technologies.

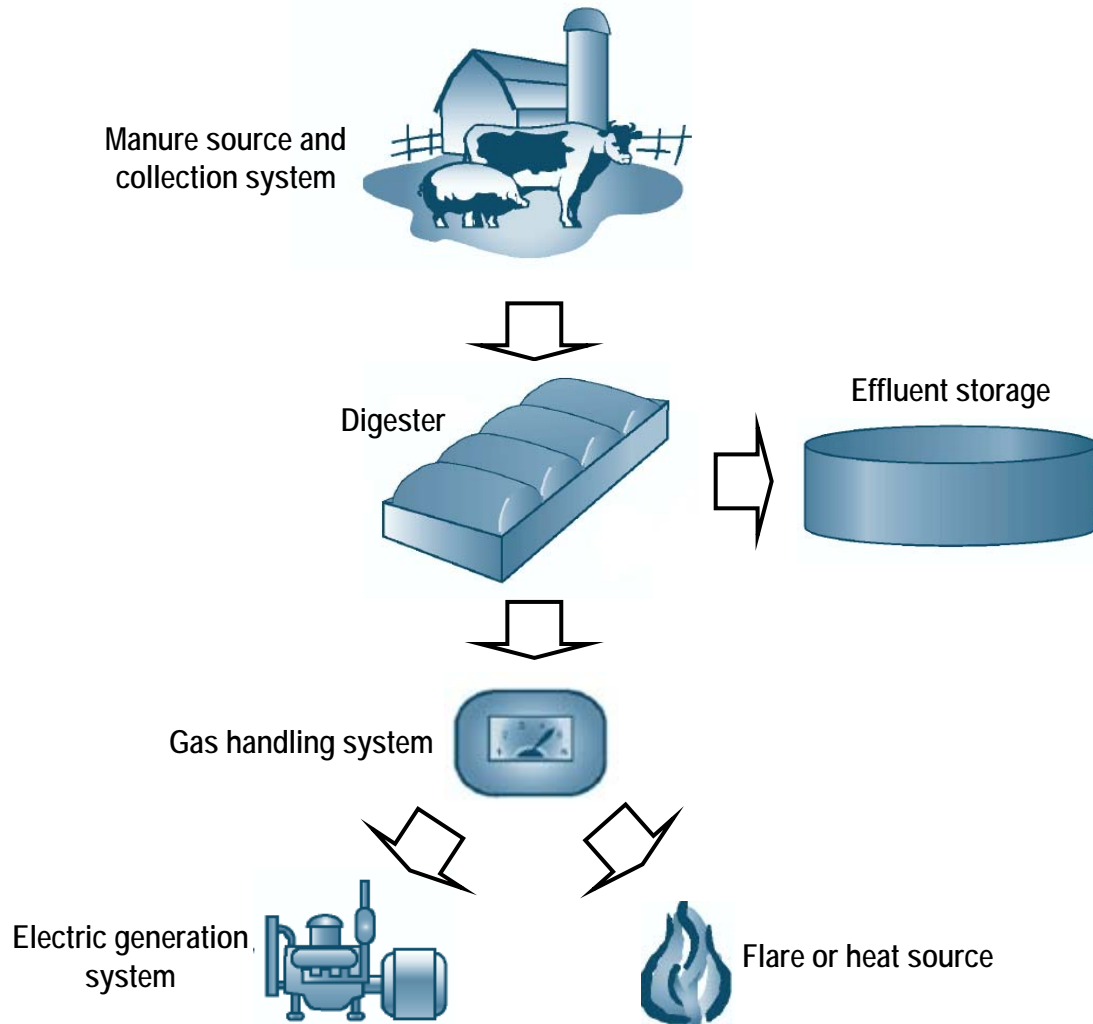
\* Excluding conventional hydroelectric power \*\* black liquor and wood/woodwaste solids and liquids \*\*\* agricultural bioproducts, sludge waste and other biomass solids, liquids and gases

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# ANIMAL MANURE IS SUITABLE FOR THE PRODUCTION OF BIOGAS

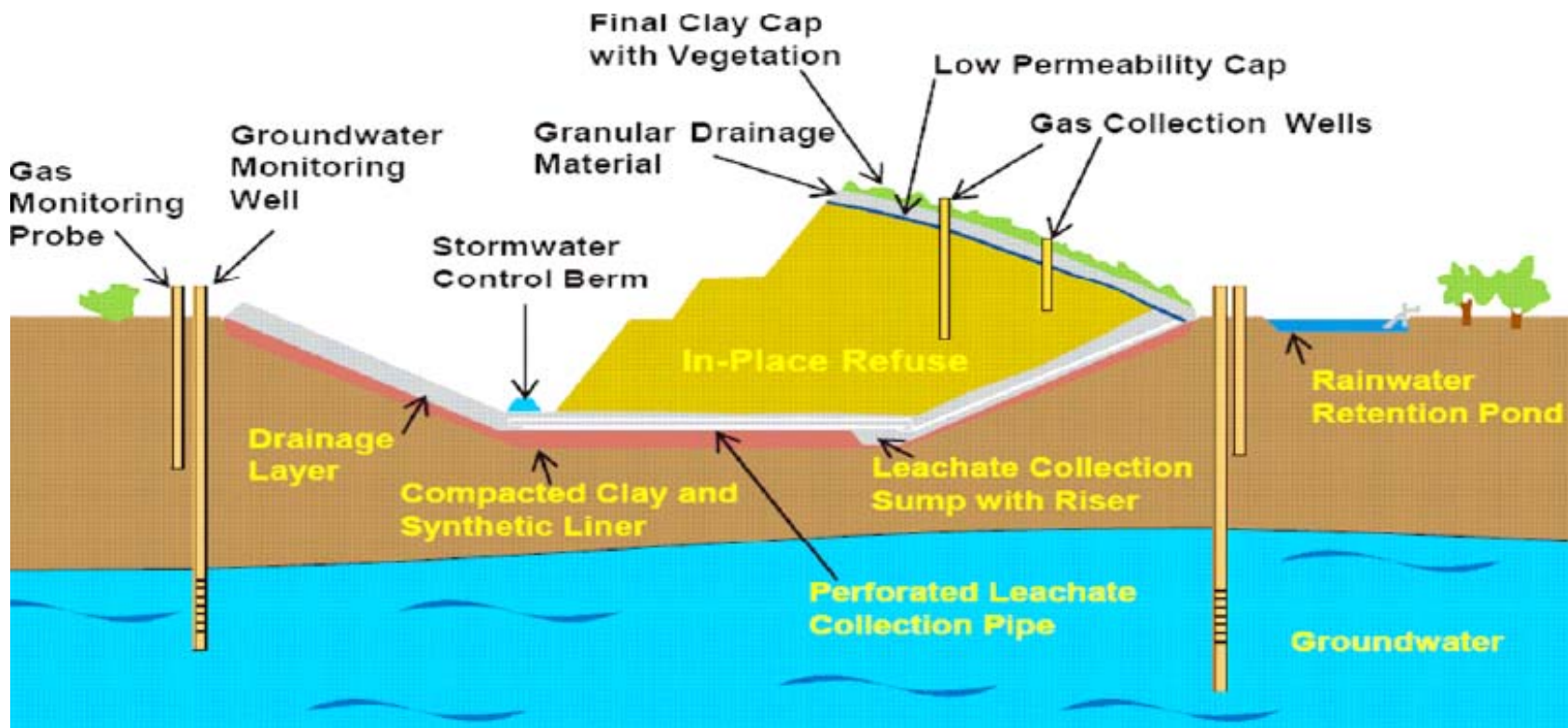
Components and products of a biogas recovery system



- Biomass that is high in moisture content, such as animal manure and food-processing wastes, is suitable for producing biogas using anaerobic digester technology
- Anaerobic digestion is a biochemical process in which particular kinds of bacteria digest biomass in an oxygen-free environment. The bacteria break down organic wastes in stages resulting in the production of biogas
- Controlled anaerobic digestion requires an airtight chamber called a digester. The biogas produced in a digester is a mixture of gases with methane and carbon dioxide making up more than 90%
- Methane is a combustible gas. The energy content of digester gas depends on the amount of methane it contains, typically varying between 55 to 80%

# LANDFILL GAS IS EXTRACTED FROM LANDFILLS USING A SERIES OF WELLS AND A VACUUM SYSTEM

Landfill gas is collected using perforated vertical (wells) and horizontal pipes to prevent methane and other trace organic gases from escaping. The gas is extracted under vacuum and pumped to a destruction device such as a flare or energy utilization facility



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## IT IS IMPORTANT TO CONSIDER LEGAL MATTERS WHEN DOING BUSINESS ON THE U.S. MARKET

Legal concerns are common among Swedish companies considering the U.S. market. However, these are risks that any company active on the U.S. market are exposed to and that can be accounted for. Nevertheless, it is important to address legal matters in an appropriate way

- ➡ Find a U.S. lawyer that know the industry well and can assist you in addressing necessary issues
- ➡ Establish a U.S. subsidiary will facilitate doing business with U.S. companies and can also limit liability for the Swedish aktiebolag
- ➡ Have a U.S. lawyer review contracts in order to make sure that protection is really protective of your company
- ➡ Get insurance that is adequate to cover the risk and project

More information is also available online [www.swedishtrade.se/usa](http://www.swedishtrade.se/usa) and by contacting the Swedish Trade Council in the U.S.

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## EXAMPLES OF U.S. VENTURE CAPITAL FIRMS INVESTING IN RENEWABLE ENERGY 1(2)

Company	Web address
3i	<a href="http://www.3i.com">www.3i.com</a>
Blue Hill Partners	<a href="http://www.bluehillpartners.com">www.bluehillpartners.com</a>
Chrysalix Energy	<a href="http://www.chrysalix.com">www.chrysalix.com</a>
Citigroup Venture Capital International	<a href="https://www.citigroupai.com">https://www.citigroupai.com</a>
Cleantech Group	<a href="http://www.cleantech.com">www.cleantech.com</a>
Enertech Capital	<a href="http://www.enertechcapital.com">www.enertechcapital.com</a>
Environmental Capital ECP	<a href="http://www.ecpcapital.com">www.ecpcapital.com</a>
Expansion Capital Partners	<a href="http://www.expansioncapital.com">www.expansioncapital.com</a>
Global Environmental Fund	<a href="http://www.globalenvironmentfund.com">www.globalenvironmentfund.com</a>

## EXAMPLES OF U.S. VENTURE CAPITAL FIRMS INVESTING IN RENEWABLE ENERGY 2(2)

Company	Web address
Kleiner Perkins Caufield & Byers	<a href="http://www.kpcb.com">www.kpcb.com</a>
Mohr Davidow Ventures	<a href="http://www.mdv.com">www.mdv.com</a>
Morgan Stanley	<a href="http://www.morganstanley.com">www.morganstanley.com</a>
NGEN Partners LLC	<a href="http://www.ngenpartners.com">www.ngenpartners.com</a>
Nth Power LLC	<a href="http://www.nthpower.com">www.nthpower.com</a>
Rockport Capital Partners	<a href="http://www.rockportcap.com">www.rockportcap.com</a>
Sequoia	<a href="http://www.sequoiacap.com/us">www.sequoiacap.com/us</a>
Silicon Valley Bank	<a href="http://www.svb.com">www.svb.com</a>
Technology Partners	<a href="http://www.technologypartners.com">www.technologypartners.com</a>
Vantage Point Venture Partners	<a href="http://www.vpvp.com">www.vpvp.com</a>

## EXAMPLES OF SWEDISH VENTURE CAPITAL FIRMS INVESTING IN RENEWABLE ENERGY

Company	Web address
Sustainable Technology Fund	<a href="http://www.stechfund.com">www.stechfund.com</a>
Borevind	<a href="http://www.borevind.se">www.borevind.se</a>
Industrifonden	<a href="http://www.industrifonden.se">www.industrifonden.se</a>
Provider Venture Partner	<a href="http://www.providerventure.com">www.providerventure.com</a>
Greencap Cleantech Venture Partner	<a href="http://www.dealflower.com">www.dealflower.com</a>