Global Methane Initiative

SUCCESSFUL APPLICATIONS OF ANAEROBIC DIGESTION FROM ACROSS THE WORLD

SEPTEMBER 2013

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Methane Mitigation and the Global Methane Initiative

Methane (CH_4) is the second most abundant greenhouse gas (GHG), accounting for 14 percent of global GHG emissions. Manmade as well as naturally occurring, methane has a relatively short lifespan of approximately 12 years in the atmosphere, but its ability to trap heat (global warming potential) is 21 times greater than carbon dioxide (CO_2). As awareness about the negative effects of methane has grown, work has advanced to help reduce emissions around the world. In 2012, the dedicated work of the Global Methane Initiative (GMI) Agriculture Subcommittee (Subcommittee) resulted in actual emission reductions of more than 990,994 Metric Tons of CO_2 equivalent ($MTCO_2E$) across the agriculture sector (with eventual potential emission reductions exceeding 2,211,575 $MTCO_2E$).

Purpose of Document

This document aims to promote the environmental, financial, social, and health benefits of anaerobic digestion projects, while also demonstrating the varied technologies and partners involved in these projects throughout the world. Technology enhancements and social, environmental and economic benefits suggest opportunities for additional growth in anaerobic digestion (AD) projects. Additionally, the GMI Subcommittee has supported several AD projects throughout developing and developed countries that demonstrate the importance of the work. In support of continued growth, the GMI Subcommittee requested case studies and project examples from Partner countries, which are showcased in this document. The Subcommittee received information on nearly 30 projects from 15 countries, which demonstrate the success of AD systems worldwide.

Global Methane Initiative – Introduction

GMI is an international public-private initiative with more than 40 Partner countries (see *Figure 1*) that works to promote global methane emission reductions. Launched in 2004, GMI urges stronger international action to fight climate change while developing clean energy and stronger economies. Specifically, GMI aims to advance cost effective, near-term methane abatement and recovery, and use of methane as a clean energy source. GMI subcommittees focus on five sectors: agriculture, coal mines, municipal solid waste, oil and gas systems, and wastewater.

The GMI Agriculture Subcommittee (the author of this document) aims to build capacity, develop strategies and markets, and remove barriers to methane mitigation project development in order to increase environmental quality, improve rural livelihoods, strengthen economies, and expand opportunities for renewable energy production and use. Additionally, facilitating the development of methane projects will increase energy security, enhance economic growth, improve local air quality, and improve industrial safety. The United States, Argentina and India co-chair this Subcommittee and work closely with delegates from all member countries to achieve its goals.

For more information and links to other websites, please visit the Global Methane Initiative website.

AD at Work!

*The anaerobic digester at the **Tamil Nadu Newsprint and Papers Limited** facility created 25 jobs in Tamil Nadu Pincode, India. Biogas produced replaces around 21 KL / day of furnace oil.*

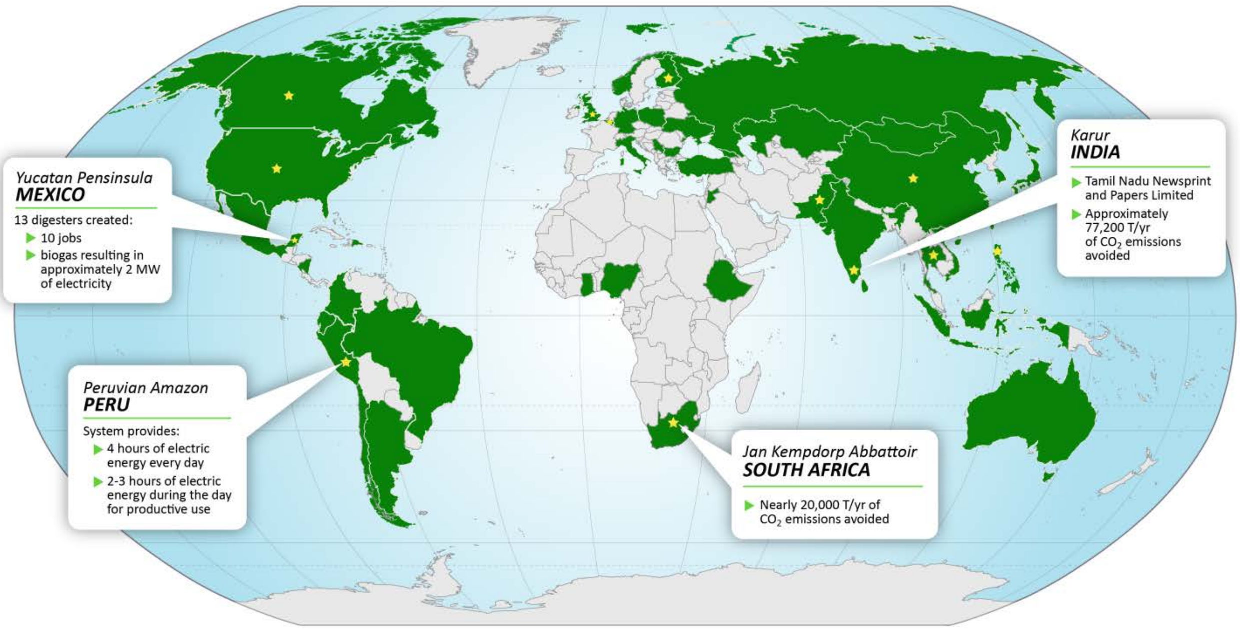

Figure 1: Worldwide Benefits Realized by Methane Mitigation Projects. Global Methane Initiative Partner countries (dark green) and locations of case study projects (gold stars are not placed to represent exact location of project within the country). The four highlighted projects alone will eliminate more than 150,000 Tons of CO_2 per year.

Anaerobic Digestion Technology Background

The primary sources of methane emissions from agriculture are livestock enteric fermentation, livestock waste management, rice cultivation, and agricultural waste burning. Of these, livestock waste management, which represents 7 percent of global methane emissions, offers the most viable, near-term opportunity for methane recovery and utilization. When livestock manure and organic components in agro-industrial waste decompose, the process produces and emits methane.[1] Capturing this methane provides an opportunity to lower the amount of methane accumulating in the global atmosphere and harness this renewable energy source.

Anaerobic digestion is a biological process in which bacteria break down organic matter in the absence of oxygen. An AD system (*Figure 2*) utilizes a digester as an airtight chamber where manure, biosolids, food waste, other organic wastewater streams, or combinations of these feedstocks decompose. The process produces biogas—a blend of methane and carbon dioxide—and digestate. For over 30 years these systems have been used commercially, including in the agricultural management sectors, to reduce methane emissions, improve manure disposal, control odors, and produce biogas for energy. Biogas produced through AD systems has proven to be a valuable energy source in Subcommittee Partner countries. As an example, in Peru, 14 percent of primary energy consumed is biogas, primarily in rural areas across the country. There, the use of biogas addresses two problems: providing thermal energy for food preparation and providing electrical energy to homes that have no opportunity to tie into the main electric grid.

[1] U.S. EPA, 2011.

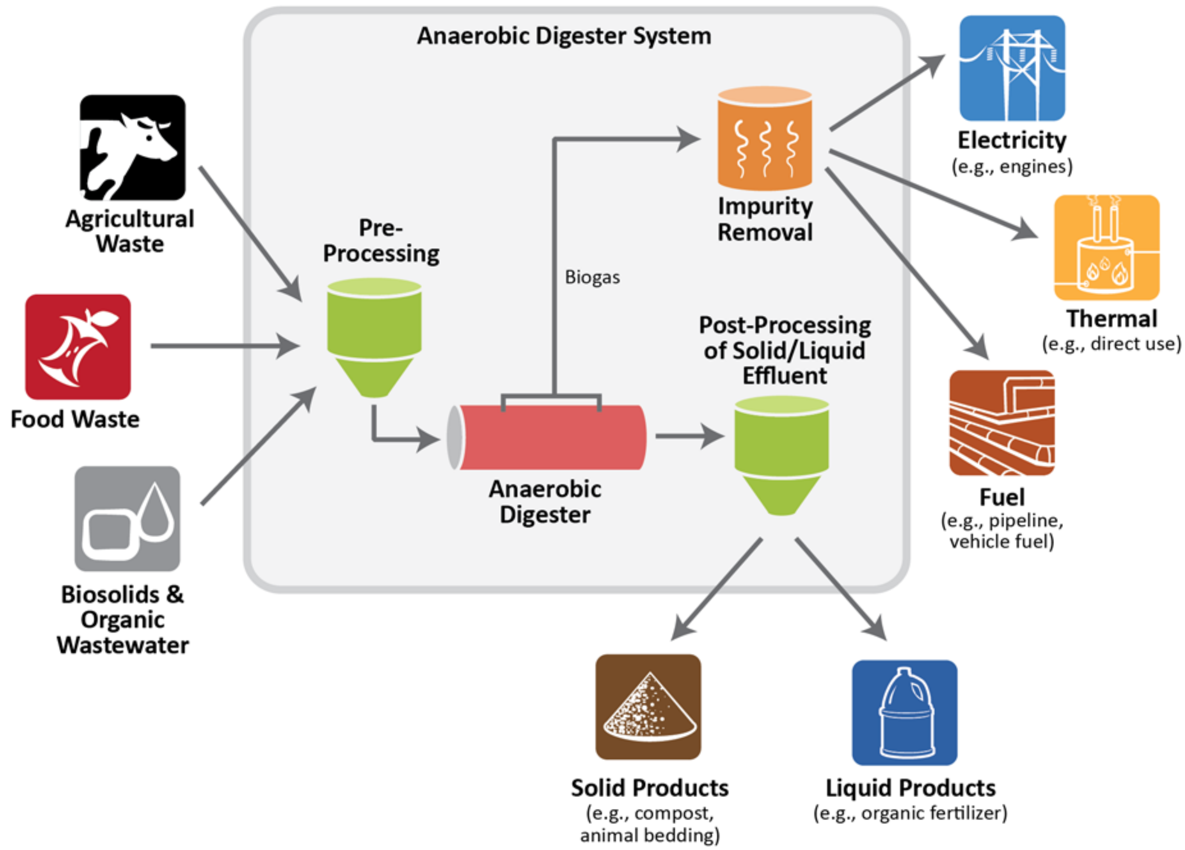

Figure 2: Anaerobic Digestion Process

AD systems range from small-scale digesters to complete mix digesters and other advanced systems. There are multiple designs for AD systems that depend upon the facility's location, feedstock and anticipated outcomes. In South Africa, the Jan Kempdorp Abbatoir site uses a small-scale AD system to address cattle and bovine wastes in order to reduce GHG emissions, improve the elimination of animal by-products, reduce power grid demand by producing energy onsite, and create jobs. While in Ogden, Utah, the Wadeland Dairy installed a complete mix system to handle 330,000 gallons of manure a day. This AD system simplifies the nutrient management plan for the dairy, reduces odor, and produces a product that can both generate income and eliminate manure export costs.

Anaerobic Digestion Technology Evolution

Anaerobic digester system designs continue to evolve with technology enhancements. Currently, there are four main types of digesters used around the world: complete mix, covered lagoon, plug flow, and small fixed dome. This section provides technological highlights of these different types of digesters.

<u>Complete Mix</u>

A 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 water (e.g., milking center wastewater) and manure handled as slurry. The contents of the digester are mixed by motor or pump.

Covered Lagoon

Covered lagoon systems have two cells, both of which are needed for efficient operation. This type of AD system, consisting of a lagoon that captures biogas under an impermeable cover, has low maintenance requirements. The first cell of a two-cell lagoon is covered and the second cell is usually uncovered. The level of wastewater in the first cell remains constant to promote manure breakdown, while the liquid level in the second cell may vary.

Covered lagoons are not heated and are therefore affected by the ambient temperature. Methane production drops when lagoon temperatures dip below 20 degrees Celsius. A covered lagoon in the tropics will produce gas year-round, while gas production will drop considerably for covered lagoons located in colder climates.

Plug Flow

For a plug flow system, manure flowing into the digester displaces digester volume; an equal amount of material flows out, and the contents are thick enough to keep particles from settling to the bottom. The manure moves through the digester as a plug, hence the name “plug flow." For most plug flow digesters, the total solids content of manure should be at least 10 to 20 percent, so extra biodegradable matter may need to be added. Plug flow digesters are usually five times longer than they are wide and the recommended retention time for their contents is 15 to 20 days.

Small Fixed Dome

Small fixed dome digesters consist of an inlet trough, a lower fermenting reservoir with a rigid, immovable collection dome capping it, and some type of overflow relief. Several different types of fixed dome digesters exist, but the most popular is the Chinese design, which is typically built of gas-sealed brick and mortar or cement. The simple design of a fixed dome digester and its lack of moving parts means that if constructed well, it will last for many years. Most small fixed dome digesters are constructed underground, which means that they are hard to access for cleaning and maintenance. Since methane gas inside the collection chamber is being pushed out only by the pressure of other methane, the gas pressure coming out of the collector is subject to large fluctuations. Therefore, in order to use the biogas for cooking or other applications, a regulating device is commonly added.

Benefits and Successes

Successful applications of anaerobic digesters have proven that these systems provide valuable financial, environmental, social, and health benefits. AD systems help reduce GHG emissions, control water pollution, and manage waste streams. Additionally, the systems lead to the production of alternative and renewable energy, which can improve quality of life in many areas of the world. The added revenue streams and financial savings from the production of biogas and commodities also create social, health and financial benefits for communities. While the benefits are worth promoting and the successes of projects across the world provide learning opportunities, it is important to note that there are barriers to widespread AD system use. These include the potential for high capital and maintenance costs, potential loss of profitability due to declines in biogas prices, variability in the markets (feedstock, byproduct, carbon offset, and other environmental credit markets), and limited education across the world on regulations and installation. However, the work of the GMI Subcommittee promotes the vast opportunities associated with AD systems and the significant financial, environmental and social and health benefits that offset these barriers.

Financial

Many GMI Subcommittee countries recognize financial benefits from AD projects. First, AD systems eliminate the need to transport waste to an established waste disposal facility. Utilizing the waste onsite saves upfront costs of transportation and disposal and also generates financial gains with the byproducts produced. The process creates a viable energy source that can be used for heating and electricity for homes or the facility itself. This biomass energy can be a net zero cost and offset electrical costs; provide new forms of energy to areas that might not have access to traditional electrical energy sources; or generate profit if the energy produced can be sold. At the Ringler Energy site in Ohio, regional businesses are given an opportunity to manage their organic waste at the facility, which expects to generate 800 kW (kilowatt) hours of electricity per day. Plans to upgrade the gas at this facility for use as vehicle fuel would result in the production of the equivalent of 550 gallons of gasoline per day.

Recognized Financial Benefits

- ✓ *Reduces transport and disposal costs*
- ✓ *Reduces energy costs (for equipment, lighting, heating)*
- ✓ *Reduces costs from organic fertilizer use*
- ✓ *Increases income from sale of energy*
- ✓ *Increases income from sale of fertilizer*
- ✓ *Increases revenue from larger crop production (fertilizer use)*

Additionally, the AD systems often generate commodities such as fertilizer, which can be used at the site or sold for additional income. Creating natural, organic fertilizer in itself saves costs for these facilities, which use the fertilizers on their crops. In developing countries the biogas produced by AD systems can also be used to run a cook stove, which saves a family from having to purchase alternative fuels for cooking.

Project Highlight –
Energy Production for Rural Communities

The Agro-Energy Cooperative in the Ajuricaba watershed, Parana, Brazil, is a great demonstration of financial gains from a biodigester demonstration project. Installed in 2009, the biodigester uses cow manure to generate 438 MW (megawatt) hours per year of energy. The 33 small farms that participate in the cooperative receive financial gains from the production of energy and heat and the biogas grain dryer replaces electric or gas powered grain dryers for extra savings. Additionally, the digestate is used as fertilizer on agricultural and grassland areas.

Project Highlight – Combating Rising Costs

At the North Kilworth Community Interest Company AD plant in Leicestershire, United Kingdom, rising costs to transport wastes to treatment facilities provided an opportunity to utilize agricultural waste onsite. The current plan is to utilize a community-led, joint-venture company to run this AD project. The resulting AD system is expected to reduce waste disposal costs, provide low-cost renewable heat, and minimize fertilizer costs by utilizing system byproducts. The project team hopes to begin work in 2013.

Environmental

Some of the most obvious benefits of AD systems are environmental. Using these systems reduces water and air pollution, and improves human health and the environment. The use of "green energy" is a growing trend across nations and the biogas produced by anaerobic digesters can replace the use of fuel gas and oil. Harnessing methane lowers GHG emissions from farm systems, improving air quality. Examples include the Hampton Feed Lot in Missouri, where an Induced Blanket/Bed Reactor was installed to help control pollution from 1,800 beef cows and Tamil Nadu Newsprint and Papers Limited (TNPL) in Karur, India, which installed an upflow anaerobic sludge blanket digester (UASB) to avoid GHG emissions and generate carbon credits for the company.

Recognized Environmental Benefits

- ✓ *Reduces GHG emissions and improves air quality*
- ✓ *Improves water quality by lowering eutrophication effects*
- ✓ *Decreases odor*
- ✓ *Lessens pest issues*
- ✓ *Replaces chemical fertilizer with organic fertilizer*
- ✓ *Decreases use of firewood, helping to combat deforestation*

The removal of manure from these facilities also improves water quality by reducing runoff and controlling pests. Runoff from the land leaches phosphorous, increasing eutrophication (nutrient loading) and the potential for water pollution in local waterways. A secondary benefit of AD systems is that there is less runoff from farms due to the containment of the manure and therefore, less runoff polluting waterways. Additionally, utilizing manure decreases the time it sits at the farm contributing to odor and pest issues (e.g., as a breeding ground for pests and disease vectors). Another benefit is from the use of the final digestate product (both liquid and solid), which is used as fertilizer at many of the facilities. This organic fertilizer reduces waste byproducts and the need for chemically-enhanced fertilizer, as well as helps improve crop production.

Several countries that use AD systems report a reduction in the use of firewood for heating and cooking. The replacement of firewood with biogas-powered electricity and heating helps prevent deforestation, especially in remote populations that count on forestry as a source of exports.

**Project Highlight –
Reforestation, Water Quality, and Methane Reduction**

In 2009, the Yucatan Peninsula, Mexico, embarked on a first-of-a-kind project that merges water treatment and methane reduction, while promoting reforestation. This project installed 13 wastewater management systems for 44 swine farms. Each system includes an anaerobic digester, enclosed flare, solid separator, storage lagoon, and forest plantation. The systems utilize the effluent as a source of water and nutrients for the forest plantations. Additionally, these systems capture and produce biogas energy , which is used to supply electricity to all the farms, minimizing or eliminating the need for electricity from the municipal electric company.

Project Highlight – Water Quality Improvement

The St-Hilaire Farm project was the second patented low temperature AD system installed in Canada. The technology was installed on the St-Odilon de Cranbourne, Quebec farm to solve a phosphorus surplus problem. The system is stable and easy to operate, offers superior performance, and generates a net energy balance. This was the first AD system in the province of Quebec to produce and send electricity to the external grid.

Social and Health

An additional, indirect benefit from the use of AD systems is a product of the biogas generated and captured from these systems. Several communities that utilize AD and capture biogas do not have access to the main electric grid due to remoteness or expense. The electricity produced from biogas becomes a tremendous social benefit to communities as it can change the way communities interact. AD systems can give farmers energy independence and make them self-sufficient. In Finland, small remote farms often lose access to the electrical grid during strong storms; providing an independent energy source gives farmers more reliable access to electricity, improves quality of life, and promotes economic growth.

Recognized Social Benefits

- ✓ *Provides access to electricity and heating source*
- ✓ *Creates jobs*
- ✓ *Increases skilled labor force*
- ✓ *Improves sanitation and public health*

AD systems can also change the way communities heat their homes, providing a constant heat source so people do not have to look for wood or other fuels. Another social benefit is the creation of jobs. While farms or mills utilize workers for day-to-day operations, the addition of an AD system can create new jobs. Learning how to operate an AD system and perform routine operations and maintenance checks also improves laborer skills and can help establish the local expertise needed for additional biomass electricity systems.

AD systems also provide health benefits. Utilizing byproducts from the system, indoor air quality is improved with enhanced cooking and sanitation opportunities. Additionally, these systems reduce or eliminate nitrates in groundwater and ozone released into the air, improving health conditions for the community.

Project Highlight – Community Socialization

The BioSynergy site in Huimbayoc, San Martin, Peru, is located far from the main electric grid and the local community had no prior access to electricity. Today, the capture of methane and generation of biogas at the BioSynergy site serves as an alternative energy source. The system generates between 8.74 and 11.65 cubic meters of biogas a day, which provides 16kW of power. The installation of public lighting from the electricity generated makes it possible for local residents to engage in activities after dark and has changed the way the community socializes.

Project Highlight – 500,000 AD Systems

SNV, an international not-for-profit development organization, recently reached an implementation milestone by installing more than 500,000 anaerobic digesters in 17 countries in Asia and Africa. The Biogas Support Program in Nepal and the Biogas Program in Vietnam are the longest running programs, accounting for more than 80 percent of this total production. The biogas programs in Africa have achieved a total of 24,000 biodigesters in the past three years. Since 1992, 2.9 million people benefited from clean cooking energy and smoke-free kitchens. They have seen reduced workloads and improved health of women and children. Additionally, effluent from the biodigesters has proven to be a potent organic fertilizer, which has increased agricultural productivity.

Advancing AD Projects

The GMI Subcommittee work demonstrates that AD projects are successfully implemented and also vary in construction, implementation, and use around the world. Without a doubt, each AD project provides numerous benefits to communities and businesses. Advancements in technology, implementation, understanding, and by-products have made AD projects more feasible in varied locations. While the economic feasibility based on return on investment varies by location, support from financial incentives and partnerships can make these projects viable. Government incentives (e.g., federal, state, local) will continue to increase the number and success of these projects in the future. Additionally, advanced work completed by such projects as the Fair Oaks Farm in Indiana, where biogas is converted to vehicle fuel, will help improve opportunities, stimulate new interest in research and application, and bridge existing gaps. Finally, as trends such as co-digestion grow, the value added by digestate products (e.g., liquid products for organic fertilizer; solid products for compost or animal bedding) further improves the return on investment by decreasing farm operational costs. The continued investment in these projects, and spreading the word about the benefits achieved around the world, will improve the ability to implement AD projects in years to come.

Project Summary Case Studies

FAIR OAKS, INDIANA, UNITED STATES OF AMERICA

Site Name: Fair Oaks Farm

Site Type: Cow (dairy) farm (35,000)
Digester Type: Mixed plug flow anaerobic digester, including gas upgrading and gas drying operations
Biogas Generation: 865 MMbtu of compressed natural gas (CNG) per day
Biogas Use: Fuel for entire farm operation and milk-hauling truck fleet
Contact: www.fofarms.com

PROJECT BACKGROUND

The Fair Oaks Farm milk-hauling fleet started with a meeting a couple of years ago between John Ruan III, chairman of Ruan Transportation Management, a project partner; and Dr. Mike McCloskey, owner and president of Fair Oaks Farms. They discussed the potential for using methane produced from dairy cow manure to fuel the trucks hauling milk to processing plants. Twelve dairy farms in northwestern Indiana make up Fair Oaks Farms and each dairy has a herd of approximately 3,000 milk cows. Fair Oaks Farms divisions include Windy Oaks Biofuels, which is leasing the 42 tractor trailers and is operating four manure digesters that generate methane gas; and Renewable Dairy Fuels, which oversees the CNG refueling station near the main Fair Oaks Farms facility.

Fair Oaks spent over $12 million on the investment and had help from a government subsidy ($2.75 million), the state ($2 million), and the federal Greater Indiana Clean Cities Coalition ($750,000). Fair Oaks is thought to have the largest manure-powered fleet in the nation, transporting 53 loads of milk per day to Kroger dairy processing plants, which adds up to 7.5 million gallons of milk per month and 90 million gallons per year.

In addition to being a working farm, Fair Oaks has become a tourist attraction. It features a restaurant that sells homemade cheese, ice cream, and yogurt, plus a climbing wall, a 4D movie theater, an outdoor playground called Mooville, and a gift shop.

KEY ACCOMPLISHMENTS

- ✓ Saves millions of dollars annually in fuel costs, displacing more than 1.5 million gallons of diesel fuel
- ✓ Lowers their tractor trailer fleet emissions by 60 percent
- ✓ Reduces the farm's carbon footprint by recovering 98 percent of the methane produced by livestock
- ✓ Capitalizes from excess energy revenue (they plan to sell surplus natural gas to the local utility)
- ✓ Generates income and public education/awareness from tourist attractions

SHANGDONGKUO VILLAGE, CHANGPING DISTRICT, BEIJING, CHINA

Site Name: Large-scale Centralized Biogas Supply Project

Site Type: Chicken (5,000 – 6,000) and swine farm (3,000)
Digester Type: Upflow Solids Reactor (USR); 2x300 m^3 volume
Biogas Generation: 207,000 m^3 biogas produced each year
Biogas Use: Cooking fuel for 540 households in village

PROJECT BACKGROUND

Before the installation of an anaerobic digestion system, chicken and swine manure was collected manually at the farm and transported to the biogas plant every day. The installation of an anaerobic digester improved manure management, decreased odors through the village, and provided a cost-effective alternative energy source for local households. Energy and Environmental Development Engineering Limited utilized grants from Beijing Municipality and began construction of the anaerobic digester in 2007. Operation of the system started in January 2008.

The project now provides cooking fuel for 540 households in Shangdongkuo Village with a total output of 207,000 cubic meters (m^3) biogas and a disposal capacity of 10,000 tons manure each year. It is the largest central biogas supply project of Changping District.

KEY ACCOMPLISHMENTS

- ✓ Reduces odors and pathogens (improving human health)
- ✓ Reduces nutrient runoff
- ✓ Generates and uses organic fertilizer from digestate
- ✓ Capitalizes from excess energy revenue

SANTA ROSILLO VILLAGE, HUIMBAYOC, SAN MARTIN, PERU

Site Name: BioSynergy, Santa Rosillo Village

Site Type: Small, communal village farm (67 animals)
Digester Type: Trapezoidal lake type with a PVC-reinforced geo-membrane; 289.6 m^3 (two digesters total volume of liquid and gas)
Biogas Generation: Between 8.74 and 11.65 m^3 of biogas are produced per day. The equipment used to generate electrical energy is two generators that have a total combined power of 16kW (10 kW + 6 kW).
Biogas Use: Electrical energy via combustion in electrical generators
Contact Information: Fernando Acosta
facosta@snvworld.org

PROJECT BACKGROUND

Santa Rosillo is a small, isolated community (224 people) with approximately 67 head of livestock. At night, these animals stay in a pen for 12 hours, accumulating 160 kilograms (kg) of manure during that time alone. Prior to this project, the manure built up in the village and had no productive use or disposal pathway. The development of this AD project was executed by SNV in alliance with Practical Action and local partners. The installation of two biodigesters (each of 93 m^3, giving a total capacity of 186 m^3) produces 16 kW of electricity for domestic and productive uses. The biodigester was built in two months and began operating in December 2012. Cattle manure is added in daily loads of 270-360 kg.

The project focuses on an innovative model for electricity generation in isolated communities, taking advantage of biomass waste that is locally available. This is a stand-alone project and does not produce energy for an interconnected system. The slurry is used as fertilizer to increase yields of crops such as cacao, coffee and others. This project aims to contribute to a reduction in poverty levels in dispersed and isolated communities in the Peruvian Amazon, by demonstrating the technical, social, economic, and environmental feasibility of an integrated and self-sufficient renewable energy access model, while contributing to the consolidation of the Jatropha value chain. Due to the distance, the costs of connection to the grid, and the number of inhabitants, this community is not being considered for connection to the grid. Therefore, an alternative way of generating energy was sought. Electricity for domestic, social and productive use is generated based on local production of biogas from cow dung and biomass residues.

KEY ACCOMPLISHMENTS

- ✓ Improves community access to energy
- ✓ Provides electricity to communal centre, school, clinic, and church; as well as public lighting for evening activities
- ✓ Utilizes fertilizer for improved crop production and cost savings

PROVINCE OF PUNJAB, PAKISTAN

Site Name: Electricity Generation from Dairy Farm Biogas

Site Type: Dairy farm (4 farms total)
Digester Type: Fixed dome biodigester
Biogas Use: On-farm electricity generation
Contact Information: Qamaruddin, Project Director
Clean Energy & Environment Group (Pakistan)
Phone: 92.51.2827050-1
E-mail: quddin@winrockpk.org

PROJECT BACKGROUND

Many farms in Pakistan face electricity shortages. Under this project, biogas plant construction companies and dairy farmers mobilized to use cow manure for biogas production and meet on-farm electricity requirements. The project increased the capacity of private biogas companies to install medium-sized biogas plants. During the project, biogas construction companies were trained to design, construct and monitor quality construction of biogas plants. Local dairy farmers were trained to use biogas for electricity generation, identify the farm's load management for using the biogas efficiently, and operate and maintain the biogas plant and power generators. Farmers were also trained to monitor the overall system performance to maintain a record of gas production, electricity generation, and thermal use of biogas.

Several biogas plants located at the Nestle Training Centre and at private dairy farms in the area participated in the project. During the project period, 15 prefeasibility and 8 feasibility studies were completed, 5 biogas plants were installed on 4 dairy farms, and a sixth one is under construction. This project has a huge potential to scale up, help Pakistan meet most on-farm electricity requirements from biogas produced by anaerobic digestion of cow manure, and provide a cost effective solution to meet the dairy farms' energy needs.

KEY ACCOMPLISHMENTS

- ✓ Manages animal manure with anaerobic digestion
- ✓ Generates nutrient-rich fertilizer as a byproduct of biogas generation
- ✓ Meets on-farm electricity requirements costs effectively and locally
- ✓ Serves as a multiplier for propagation of the concept

ELAVAMPADAM MODEL RUBBER PRODUCER'S SOCIETY, INDIA

Site Name: Large-scale Centralized Biogas Supply Project

Site Type: Natural rubber latex processing unit
Digester Type: Below ground cylindrical tank in RCC with hopper bottom, fitted with bio-media and a floating dome for gas collection
Biogas Generation: 10-12 m^3/day
Biogas Use: Heat generation by burning biogas in smokehouse to dry rubber sheets; biogas utilization in smokehouse could reduce firewood use by 35 percent
Contact Information: Dr. Jacob Mathew (System Designer)
Deputy Director, Rubber Research Institute of India

PROJECT BACKGROUND

More than 72 percent of the natural rubber produced in India is processed as Ribbed Smoked Sheets (RSS). For every kg of dry RSS made, about 8-12 L of wastewater is generated. The quantity of wastewater generated from a group processing center producing an average of 500 kg of dry rubber per day is about 5000 liters. This effluent, having high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), warrants judicious and efficient management practices in view of their deleterious influence on environment.

Before the organization of group processing centers—a co-operative society of individual growers—the wastewater generated during the processing of latex by individual growers was disposed of without treatment. After the formation of group processing centers, the wastewater, now generated in large quantities, was treated anaerobically in specially designed digesters – anaerobic immobilized growth digesters. Later, through research and development, a highly efficient and quick biomethanation technology was designed and developed through which the COD could be reduced by 95 percent within a day with substantially good production of biogas (10-12 m^3/day).

KEY ACCOMPLISHMENTS

- ✓ Reclaims water
- ✓ Reduces or replaces firewood
- ✓ Abates pollution
- ✓ Encourages other rubber processing units to install biomethanation systems for treatment of wastewater and generation of biogas

BIOMETHANATION PLANT, PUNJAB, INDIA

Site Name: One-Megawatt, High-Rate Biomethanation Plant

Site Type: Dairy complex (80,000 cattle)
Digester Type: Intermittently stirred tank reactors based on biogas inducing mixing arrangement; 2 x 5,000 m^3
Biogas Generation: 10,000 m^3/day; 6 million kWh/year
Biogas Use: Electricity for feeding into the national grid; the waste heat recovered from the engine provides heat to the digesters for maintaining a constant temperature of 37 C (+/- 2 C)

Contact Information: Anil Dhussa, Adviser, Ministry of New and Renewable Energy
Phone: 91 11 24364188, 91 8826247248
E-mail: akdhussa@nic.in
www.mnre.gov.in

PROJECT BACKGROUND

Over the past 30 years, more than 4.5 million household biogas plants using cattle manure have been installed in India. A few small- and medium-size biogas plants with capacities of up to 100 kW have also been installed. The project at the Haebowal dairy complex was set up as the first project to demonstrate large-scale power generation from cattle manure. The project proves the technical feasibility of developing such projects for energy recovery as well as producing large quantities of enriched organic fertilizer and reducing GHG emissions.

DIGESTER AND GAS HOLDER

GAS ENGINE AND WASTE HEAT RECOVERY UNIT

KEY ACCOMPLISHMENTS

- ✓ Generates electricity for feeding into the national grid
- ✓ Serves as potential revenue from sale of excess energy
- ✓ Reduces greenhouse gas emissions
- ✓ Manages manure properly through reduced risk of run-off and leaching of nutrients
- ✓ Converts nutrients from organic to inorganic form, allowing digestate use as a natural fertilizer

OREGON, UNITED STATES OF AMERICA

Site Name: Electricity Generation from Dairy Farm Biogas

Site Type: Dairy farm (3 farms)
Digester Type: Low Temperature Sequencing Batch Reactors (SBR)
Biogas Generation: 190kWe; 370kWe
Biogas Use: Electricity generation and heat recovery
Contact: Dan Bansen, owner, Forest Glen Oaks LLC
Buzz and Jock Gibson, owners, Lochmead Farms, Inc.
Timothy Bielenberg, owner, Oak Lea Dairy Farm

PROJECT BACKGROUND

The *Lochmead Dairy Farm* , *Oak Lea Dairy Farm* and *Forest Glen Oaks* projects are the first three patented low temperature AD systems installed in the United States.

The technology can easily fit into the farmer’s current manure management system and can be standardized. This system is very stable, includes a high level of automation, offers superior performance, and generates a net energy balance.

KEY ACCOMPLISHMENTS

- ✓ Ensures energy efficient valorisation of biogas
- ✓ Produces high-quality, safe odourless liquid fertilizer
- ✓ Produces high-quality, organic, concentrated, stabilized, and odourless solid fertilizer
- ✓ Reduces greenhouse gas emissions

Appendix A: Global Methane Initiative Project Successes

Since 2004, the GMI Subcommittee countries have worked together to reduce global methane emissions and to advance the abatement, recovery and use of methane as a valuable clean energy source[2] through the implementation of agriculture projects. The following is a snapshot of projects that successfully implemented anaerobic digesters to manage waste and produce positive financial, environmental, and social outcomes for the communities.

Project Need	*Country* Year	Site Type	*System Type* Feedstock	CO_2/yr Avoided	Additional Information and Benefits
Agro-Energy Cooperative for Family Farming	*Brazil* 2009	Dairy Farm Co-op	Cow Manure	2,650 T/yr	Installation cost: $1,500,000 US
Alfonso Tecpa – Household Farm Bovine waste management, energy production, fertilizer production	*Mexico* 2012	Maize & Alfalfa Farm (with small number of livestock)	*LLDPE Geomembrane Tube Digester* Bovine Manure Mixed at 1:3 Ratio with Municipal Water (Slurry)	Not Provided	Reduces monthly expenditure on LPG by 29%. Reduces annual expenditure on chemical fertilizer by 80%. Cost savings: Estimated MX$2,400/year ($200 USD/year) in chemical fertilizers Amount of biogas produced: Around 12 hours of thermal energy provided between the stove burner and the boiler burner.
Biomethanation Plant (1-MW, High-Rate) Demonstration project to recover energy, reduce GHG emissions, and improve environment	*India* 2004	Dairy Farm	*Intermittently Biogas-Stirred Tank Reactors* Cow Manure	5,291 T/yr	
Biotech Farms, Inc. Control effluent from swine farm	*Philippines* 2009		*Ferrocement Biodigester with HDPE Cover and Liner* Swine Manure / Wastewater	4,800 T/yr	
Clovermead Farms	*Canada* 2012		*Anaerobic Digester* Dairy Cow Manure	Not Provided	Installation cost: $2,000,000 US

[2] www.globalmethane.org/

Project Need	*Country* Year	Site Type	*System Type* Feedstock	CO_2/yr Avoided	Additional Information and Benefits
Elavampadam Model Rubber Producers' Society Efficient and economic treatment of the effluent and augmented biogas production	*India* 2009	Natural Rubber Latex Processing Unit	*Upflow Anaerobic Sludge Blanket* Natural Rubber Latex Processing Effluent	Not Provided	
Forest Glen Oaks LLC	*USA* 2012	Dairy Farm	*Low Temp SBR* Dairy Cow Manure + Off Farm Material	Not Provided	
Hampton Feed Lot Pollution control and added income	*USA* 2010	Feedlot	*Induced Blanket/Bed Reactor* Cattle Manure	Not Provided	
Hertog Jan Heat and electricity produced run the restaurant	*Belgium* Under constructio n (2013)	Restaurant (with own vegetable garden)	*Metal Basin Digester* Food Waste from Restaurant	Not Provided	Certificates for heat and electricity production from cogeneration unit Amount of biogas produced: About 20 MWe/year and about 39 MW_{th}/year
Hooibeekhoeve Heat and electricity produced run the farm and offices	*Belgium* 2014	Cattle Farm	*Microdigester* Cattle Manure	Not Provided	Certificates for heat and electricity production from cogeneration unit Amount of biogas produced: About 78 MWe/year and about 172 MW_{th}/year Financial benefits: Balance about +20,000 €/10year
IVACO Heat and electricity produced run the farm	*Belgium* 2013 (in start-up phase)	Swine Farm, Compost Manure Processing	*Concrete Basin Digester* Swine Manure & Energy Crops	Not Provided	Certificates for heat and electricity production from cogeneration unit Jobs created: 0.2 Amount of biogas produced: About 1100 MWe/year and about 1700 MW_{th}/year Financial benefits: Balance about +20,000 €/year
Jan Kempdorp Abbatoir Green and economically viable proposal to improve the elimination of animal by-products	*South Africa* 2012	Abattoir	*Anaerobic Digestion System* Abattoir Wastes	19,899 T/yr	Installation cost: $1,000,000 US

Project **Need**	*Country* **Year**	**Site Type**	*System Type* **Feedstock**	CO_2/yr **Avoided**	**Additional Information and Benefits**
K.O.S. Farm Waste to energy by converting open anaerobic lagoons to continuous flow closed anaerobic treatment digesters	*Thailand* 2009		*Channel Digester Plus (CDP)* Swine Manure	3,394 T/yr	Installation cost: $267,262 US
Kalmari Farm Manure treatment; energy self-sufficiency, fuel, fertilizer used on farm	*Finland* 1998 (capacity increased in 2008)	Dairy Farm	*Continuous Stirred-Tank Reactor (CSTR)* Cow Slurry, Plant Based Waste, Animal byproducts	Not Provided	Jobs created: 0.25 Amount of biogas produced: Heat – 230 MWh; Electricity – 105 MWh; Traffic fuel and tractor fuel – 1000 MWh
Large-scale Centralized Biogas Supply Project of Shangdongkuo Village in Changping District Control odor, improve manure management, and supply energy for homes	*China* 2008	Chicken & Swine Farm	*Upflow Solids Reactor*	Not Provided	Generates 207,000 m^3 biogas/yr
Lochmead Dairy Farm	*USA* 2010	Dairy Farm	*Low Temp SBR* Dairy Cow Manure + DAF Sludge	Not Provided	
North Kilworth Community Interest Company AD Plant Investigate joint-venture for regional anaerobic digester	*UK* (2013)	Regional Agriculture and Organics	Various Wastes (Biodegradable Municipal, Agricultural, Abattoir, Commercial/Industrial Organics)	Not Provided	
Oak Lea Dairy Farm	*USA* 2012	Dairy Farm	*Low Temp SBR* Dairy Cow Manure + Off Farm Material	Not Provided	
Peruvian Amazon Demonstrate feasibility of self-sufficient energy based on local biogas	*Peru* 2012	Communal farm	*Lake Digesters w/Membrane* Cattle & Horse Manure	Not Provided	Jobs created: 2 System provides 4 hours of electric energy every day and 2 - 3 hours of electric energy during the day for productive use
Punjab, Pakistan Build the capacity of private biogas companies for installing medium-sized biogas plants	*Pakistan* 2012	Dairy Farm	*Fixed Dome Digester* Cow Manure	294 T/yr	Installation cost: $39,000 US Payback period: 2-3 yrs

Project Need	*Country* Year	Site Type	*System Type* Feedstock	CO_2/yr Avoided	Additional Information and Benefits
Ringler Energy Enables responsible manure management, provide radiant heat and electricity	*USA* 2013	Livestock Farm	*Anaerobic tank* Livestock Manure and Regional Organic Residuals	4,691 T/yr	Produces 800 kW of renewable electric energy per hour Installation cost: $5,000,000 US
Soderal Biogas Project Replace current open anaerobic lagoons with anaerobic digestion, biogas recovery and combustion	*Ecuador* 2012	Vinasse Treatment Facility	Vinasse	30,000 T/yr	
Sociedad de Destilación de Alcoholes S.A Capture methane, produce alternative energy to be utilized for producing alcohol	*Ecuador*	Alcohol Distillery	*Open Lagoon* Wastewater	Not Provided	Jobs created: 10
St-Hilaire Farm Manure management to reduce phosphorous	*Canada* 2004	Swine Farm	*Low Temp SBR* Swine Manure	Not Provided	
Tamil Nadu Newsprint and Papers Limited Generate in-house renewable energy and carbon credits, reduce GHG emissions	*India* 2003	Pulp and Paper Mill	*Upflow Anaerobic Sludge Blanket (UASB)* Bagasse Wash Wastewater	77,162 T/yr	Install cost: INR 110 million Project receives carbon credits Jobs created: 25 Around 35000 m^3± 1000 m^3/day of biogas is produced, replacing around 21 KL/day of furnace oil in lime kilns
Verduyn Heat and electricity produced process the digestate	*Belgium* 2014	Vegetable Processor	*Pocket Digester* Vegetable Waste (Carrots)	Not Provided	Certificates for heat and electricity production from cogeneration unit Amount of biogas produced: About 650 MWe/year and about 960 MW_{th}/year Financial benefits: Balance about +120 000 €/10year
Wadeland Dairy Develop the induced blanket/bed reactor at commercial scale	*USA* 2004	Dairy Farm	*Induced Blanket/Bed Reactor* Cattle Manure	Not Provided	
Wattanakorn Farm Environmental conservation; production of renewable energy; production of a high quality organic fertilizer for crop plantation and as soil amendment	*Thailand* 2011	Swine Farm	*Channel Digester Plus (CDP)* Swine Manure	Not Provided	Farmer can save 4,100 Baht/day or 1,352,505 Baht/year Electricity for farm produced by biogas: 11.7 hrs/day Farmer can gain income from dry sludge which costs 2 Baht/kg Price of energy sold to the grid: 3.80 Baht/unit

Project Need	*Country* Year	Site Type	*System Type* Feedstock	CO_2/yr Avoided	Additional Information and Benefits
Yucatan Peninsula Anaerobic Biodigesters Capture and destroy biogas, use effluent as source of water and nutrients for forest plantations, supply electricity to the farms, produce fertilizer	*Mexico* 2009	44 Swine Farms (Community)	*Anaerobic Biodigester* Swine Manure	62,000 T/yr	Installation cost: $11,000,000 US Jobs created: 10 Biogas produces around 2 Megawatts of electricity

Acronyms

AD	Anaerobic Digestion
BOD	Biochemical Oxygen Demand
CDP	Channel Digester Plus
CH_4	Methane
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
CSTR	Continuous Stirred-Tank Reactor
GHG	Greenhouse Gas
GMI	Global Methane Initiative
kg	Kilogram
kW	Kilowatt
kWh	Kilowatt Hour
LLPDE	Linear Low-Density Polyethylene
m^3	Cubic Meters
MMbtu	Million Metric British Thermal Units
$MTCO_2E$	Metric Tons of CO2 Equivalent
MW	Megawatt
MW_{th}	Megawatt Thermal
RSS	Ribbed Smoked Sheets
SBR	Sequencing Batch Reactor
T/yr	Tons Per Year
TNPL	Tamil Nadu Newsprint and Papers Limited
UASB	Upflow Anaerobic Sludge Blanket
USR	Upflow Solids Reactor