



Global Leadership Center
U.S.-Ohio to Poland Biogas Initiative
Research and Case Study
Fall 2009

Project Charge: Identify and analyze U.S./Ohio renewable energy initiatives in biogas technology that may help Poland realize renewable energy goals

Client: U.S. Commercial Attaché in Warsaw, Poland; Embassy of Poland in Washington, D.C.

Project Description:

The goals of the project were to conduct research on biogas initiatives in the Midwest United States and their potential for application and/or commercial tie with Poland's growing renewable energy sector. Research was conducted on biogas initiatives in the state of Ohio and was then applied to the development of an individual case study for Rumpke Consolidated Companies, Incorporated. This case study was used as a business model for potential landfill biogas plants in Poland – with an emphasis on business-to-business links and the production chain.



Presenting at the Embassy of Poland, Washington, D.C.

Biogas Initiative Research and Case Study Project Outline

Briefings

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GLC MEMORANDUM

Date: September 28th, 2009

To: Tricia Echeman, Amanda Jones

From: Patrick Henderson

Re: Ben Stuart on Carbon Recycling via Membrane-based Photobioreactor

Presenter Biography:

Dr. Ben Stuart is a professor at Ohio University. He has a dual appointment in the Departments of Civil and Chemical Engineering. His research on developing bioremediation and pollution prevention strategies has gained him support by state agencies and the private sector. He is currently researching the growth of algae in otherwise inhospitable regions to decrease carbon footprint and create a renewable alternative to petroleum fuel. Dr. Stuart has collaborated on six journal articles and presented papers at six conferences in his area of interest.

Presentation Summary:

Dr. Stuart talked a lot about what biofuels are and how they work. He started off by defining biofuels as fuels that come from biological material (carbon based fuels) that were recent in development. He said the only difference between biofuels and fossil fuels is age. He noted that wood is the most common of biofuels and that over 80% of fossil fuels on the earth originate from prehistoric algae. Today, he says most biofuels come from aquatic and terrestrial plants.

He also spoke a lot about controversy surrounding biofuels and talked in depth about different types of ethanols and their pitfalls. One issue is the idea that using plants to create biofuel takes away from the plants people can eat, creating a food shortage. He adamantly denied this myth, citing that maybe 20% of current U.S. corn crop goes to biofuel. He also noted that ethanol fuels are not very efficient and can damage and destroy conventional combustion and diesel engines.

Stuart then offered a solution to all these problems: algae. His research shows that the growth of algae can efficiently reduce carbon emissions, put waste water to use, and create a renewable alternative to petroleum based fuel. He posed several questions to using algae to create biofuels (1) what is the end product? (2) which algae? And (3) what are the culture's optimal environments (what makes the algae grow).

Project Application:

The information provided by Dr. Stuart will be really helpful in moving forward with our project looking into different ways that Ohio and Poland can work together on renewable energy initiatives (specifically biogas) because it shows us a living, breathing example of how technology is being used to develop new energies right here at OU. We can take the ideas and principles he presented and apply them to other types of renewable energy and have a more basic understanding of how renewable energy development occurs.

GLC MEMORANDUM

Date: October 5th 2009
To: Amanda Jones, Tricia Echeman
From: Patrick Henderson
Re: Electrolysis of Ammonia Elements by Samy Palaniappan

Presenter Biography:

Mr. Samy Palaniappan is a PhD student studying in the Department of Chemical and Biomolecular Engineering. He works for Dr. Geri Botte, who is the director of the Electrochemical Engineering Research Laboratory. They have been working together on the development of research to create hydrogen from the electrolysis of ammonia effluents.

Presentation Summary:

Palaniappan talked about the use of electrolysis of ammonia effluents to create hydrogen and oxygen byproducts for use in fuel cell development. He started off by describing what fuel cells are: devices to generate electricity, similar to a battery, that use hydrogen or other energy in order to generate the power. Hydrogen fuel cells create a byproduct of water and are higher efficiency than combustion engines. He hopes that the hydrogen they create can be used for electricity for renewable resources.

Palaniappan talked about several challenges to his research: fuel cell design and parts, the source of hydrogen, and the storage and transportation of the hydrogen they create. He noted that it needs to be safe and clean to keep up with renewable energy standards. He spoke specifically of urea conversion as an option for creating hydrogen. This conversion is very energy and cost efficient and urea is very plentiful.

Project Application:

This presentation showed us how real world scientists are trying to create new renewable energies that can be implemented. It also shows the diversity of energy opportunities out there. This is a technology that could make generating electric almost entirely renewable. It can be applied to home heating and large business buildings to save energy and although it may not be something the Polish clients are interested in – it is a potential for future renewable energy plans.

Polish Attitude Toward Renewable Energy Initiatives

Polish opinion

There is a general awareness that climate change is a fact, but there is still disagreement on the human responsibility for this process and a general doubt prevails in the public and media debates on any other related topics.

In Poland, the existing and potential consequences of climate change are considered a non-issue for the neighboring vicinity. They are rather perceived as a problem of other regions whom we cannot help to any larger extent.

Greenhouse gas emission reduction is seen mostly as a cause for higher energy costs for households and national industry sectors.

In 2008, the Institute for Sustainable Development issued a report on the environmental problem changed from “ozone depletion” to “climate change.”

Incentives for Polish opinion

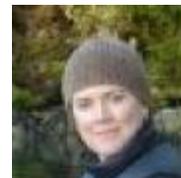
The Polish people are pressured by many different factors. Among them include:

- The pressure of Russian control of natural resources
- People are concerned that making the transition to renewable energy will bring up their energy costs
- In a recent study, 41% said they would be willing to pay more for energy if it came from renewable energy. 45% said no.

The Polish Mentality

Blogger’s voices on renewable energy initiatives:

As long as people have to struggle to make their living, we shouldn’t expect them to follow the basic rules of preserving the natural environment and sources of fuel.



The industrialized nations of the world are almost entirely for the problem of climate change that we now have. It was (and still is) the well educated and powerful of the world that have made (and still make) decisions that harm the global environment and therefore the people and other living things that depend on it.



With sustainable power comes new jobs, new industry ... It’s like the internet. You can say: Internet? Oh, man, that is toooo expensive! But with the internet came new jobs, and we all became more wealthy because of internet.



Politics and Government Actions

Politics of Renewable Energy in Poland

Poland has agreed to the European Climate and Energy Package goals (20x20x20).

The most controversial idea of the agreement is the auctioning of 100% of the CO₂ emission credits through the ETS.

It is seen both by the government and in public opinion as a serious threat to the national economy and as an even more serious threat to a lot of the industry stakeholders and other businesses in Poland.

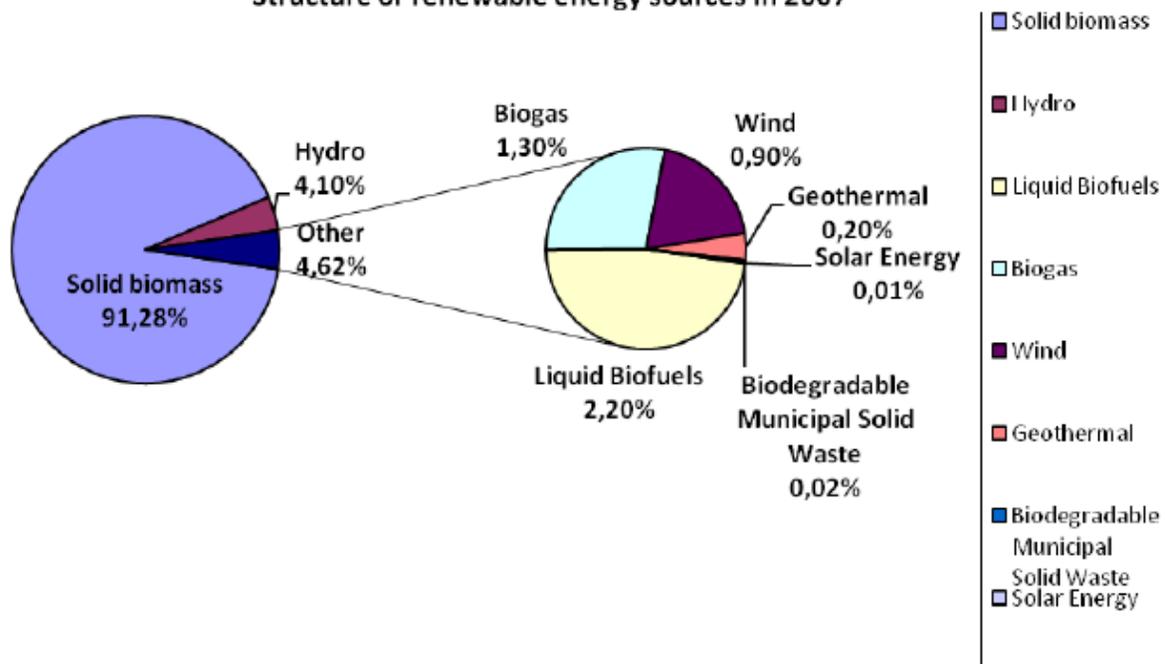
Government Actions up to 2009

Since 2003 Poland has had its Climate Policy act, with the goal of 40% greenhouse gas reduction by 2020, compared to 1988.

Since 1990, the energy intensity of Poland's greenhouse gas production has decreased twice as much as the EU's average.

Poland has made a national commitment in the Development Strategy of Renewable Energy Sector of an amount 7.5% RES in the primary energy balance by 2010 and 14% by 2020.

Structure of renewable energy sources in 2007



NGO Activity

An alliance of Polish NGOs for climate protection, the Climate Coalition, was established in 2002.

There were 10 founding members, mainly environmental, involved in the advocacy for global climate protection.

NGO efforts are often invited to the efforts of governmental expertise such as consideration of the potential of RES use in Poland, the concept of the white certificate energy efficiency for Poland, and many others.

Rumpke Consolidated, Inc.'s Methane Production Process



Rumpke collects trash from consumers



Rumpke transports waste to the landfill and collects gas



Methane gas is then refined by Montauk, Inc.



Duke Energy, Inc. converts refined gas to electricity

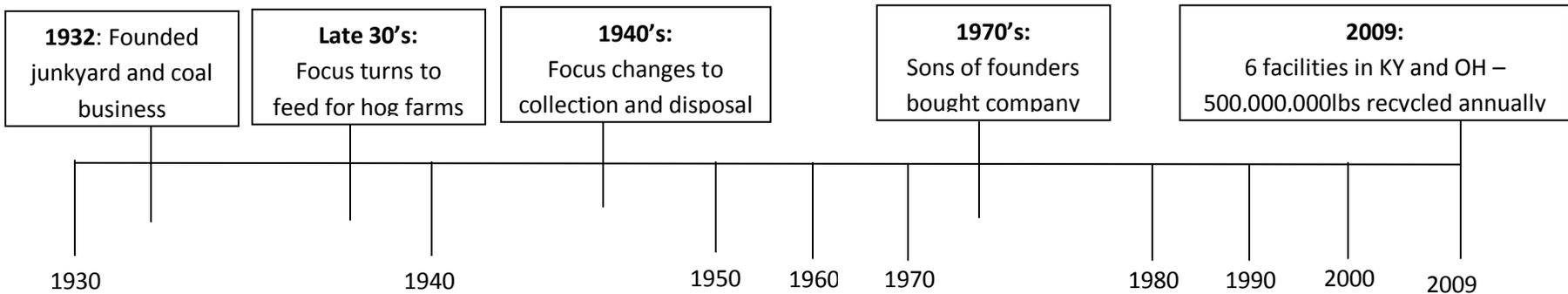


Duke Energy, Inc. distributes electricity



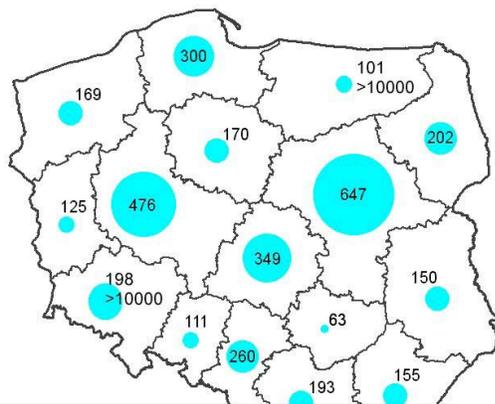
Customers consume RES - electricity

Rumpke Consolidated Companies, Incorporated Business Timeline

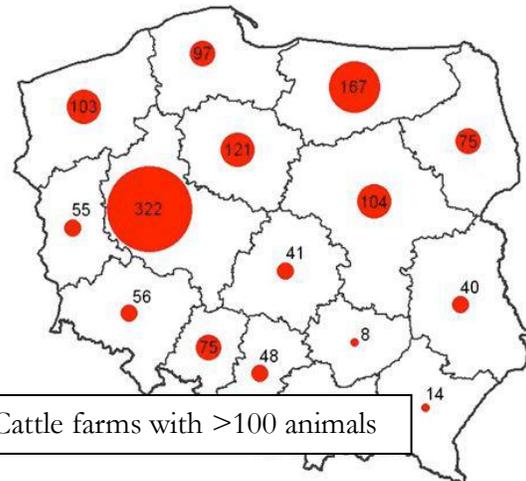


Relevance of Product to Poland's RES Needs/Policy Initiatives

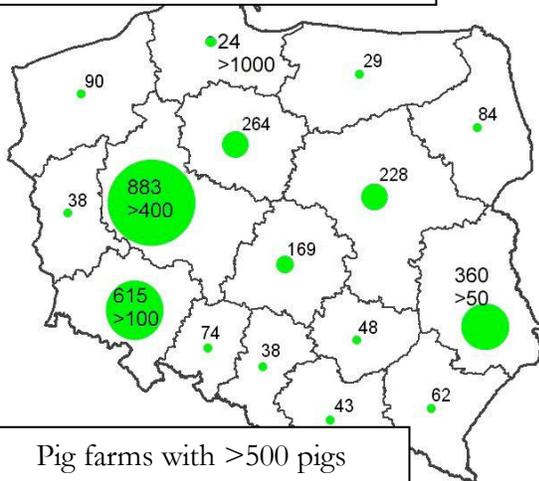
In a report by the Helmut Kaiser Consultancy, they found that over 800 million tons of waste was produced worldwide every year. This waste has the potential for 64 billion cubic meters of biogas. This amount of biogas is equivalent to 32 billion tons of gasoline or diesel fuel. This potential for energy creation is available all over the globe. Poland, in particular, has a specifically optimal environment for biogas development. It is this environment that makes it an ideal partner for Rumpke Consolidated's methods of biogas creation, and biogas creation in general. The following charts map the potential for biogas production in Poland:



Poultry farms with >5000 birds

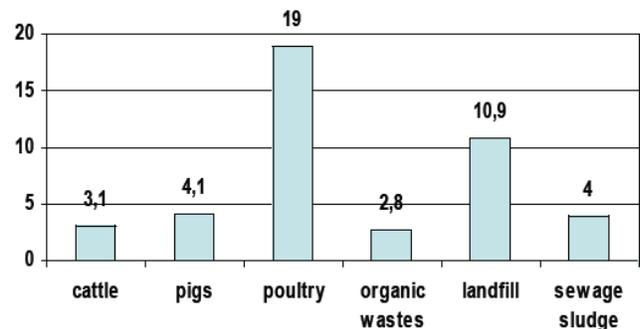


Cattle farms with >100 animals



Pig farms with >500 pigs

Technical biogas potential



Source: ECBREC/IBMER

The European Union has realized the potential and importance of renewable energy sources in creating a cleaner environment and has implemented legislation to regulate and promote the use of

sources of renewable energy. The EU Directive 2009/28/EC promotes the use of renewable energy sources within the EU and sets ambitious goals for Poland. It has set Poland's goals at 15 percent total energy consumption by 2020 from renewable sources. This initiative also states that biogas has significant environmental advantages in terms of heat and power production. Due to their localized nature and regional investment structure, biogas installations have the potential to contribute to sustainable energy development in rural areas and they offer farmers new income opportunities. Polish agriculture alone could potentially generate 5 to 6 billion cubic meters of biogas annually. The biogas created from a football field of corn could power a natural gas powered vehicle for 50,000 kilometers. This is huge energy potential.

Poland is one of the most coal dependent countries in the world, with 90 percent of their electricity and heat coming from coal. Approximately 7 percent of the Polish energy supply comes from renewable energy sources, and 91 percent of that is generated from biomass. The most promising areas of renewable energy in Poland are biomass and biogas initiatives. The promise in energy created from agricultural and livestock sources, landfills and waste water treatment plants is one of Poland's biggest opportunities. The areas with the most advantage for biogas development are locations that mainly use coal as a source of fuel, especially rural areas.

The Polish government is just beginning to put government support mechanisms into place to specifically promote biogas. Subsidies will soon become available for investments in agricultural biogas works through the Program for the Development of Rural Areas and programs stemming from the National Fund for Environmental Protection and Water Management. Plans are underway to introduce preferential taxation for energy produced from renewables and tax breaks for investments in biogas works and users of biogas. To aid construction and development, the Polish government is contemplating making amendments to planning regulations to categorize agricultural biogas works as public-purpose investment projects.

Rumpke Consolidated Companies, Inc.

Rumpke Consolidated Companies, Inc. is one of the largest family owned businesses in the United States that specializes in waste and recycling. The company was founded in 1932 by William Rumpke, who managed a junkyard and coal business that was located in Carthage, Ohio. In the late 1930's the focus of the business turned to producing feed for hog farms, where the company collected trash and then separated edible items from waste to feed hogs on the farm. However, in the 1940's, with William Rumpke's brother Bernard joining the business, the company's focus changed once again. This change completely shifted the focus from farming to the collection, disposal, and recycling of waste (Rumpke Landfill, 2009).

The company has successfully expanded its business and added other divisions including recycling and portable restrooms. They currently employ 2,000 people throughout the Midwest United States and operate approximately 1,600 vehicles for waste removal. Rumpke is also dedicated to supporting the environment by using cutting edge technology, such as the process used for methane gas extraction, and promoting recycling through education as ways to utilize waste and keep the water, air and land clean while protecting natural resources. Recycling has become one of the main initiatives in the business. Rumpke has built six recycling facilities in both Ohio and Kentucky. These facilities are able to process over 500 million pounds of recyclable material annually (Rumpke Landfill, 2009).

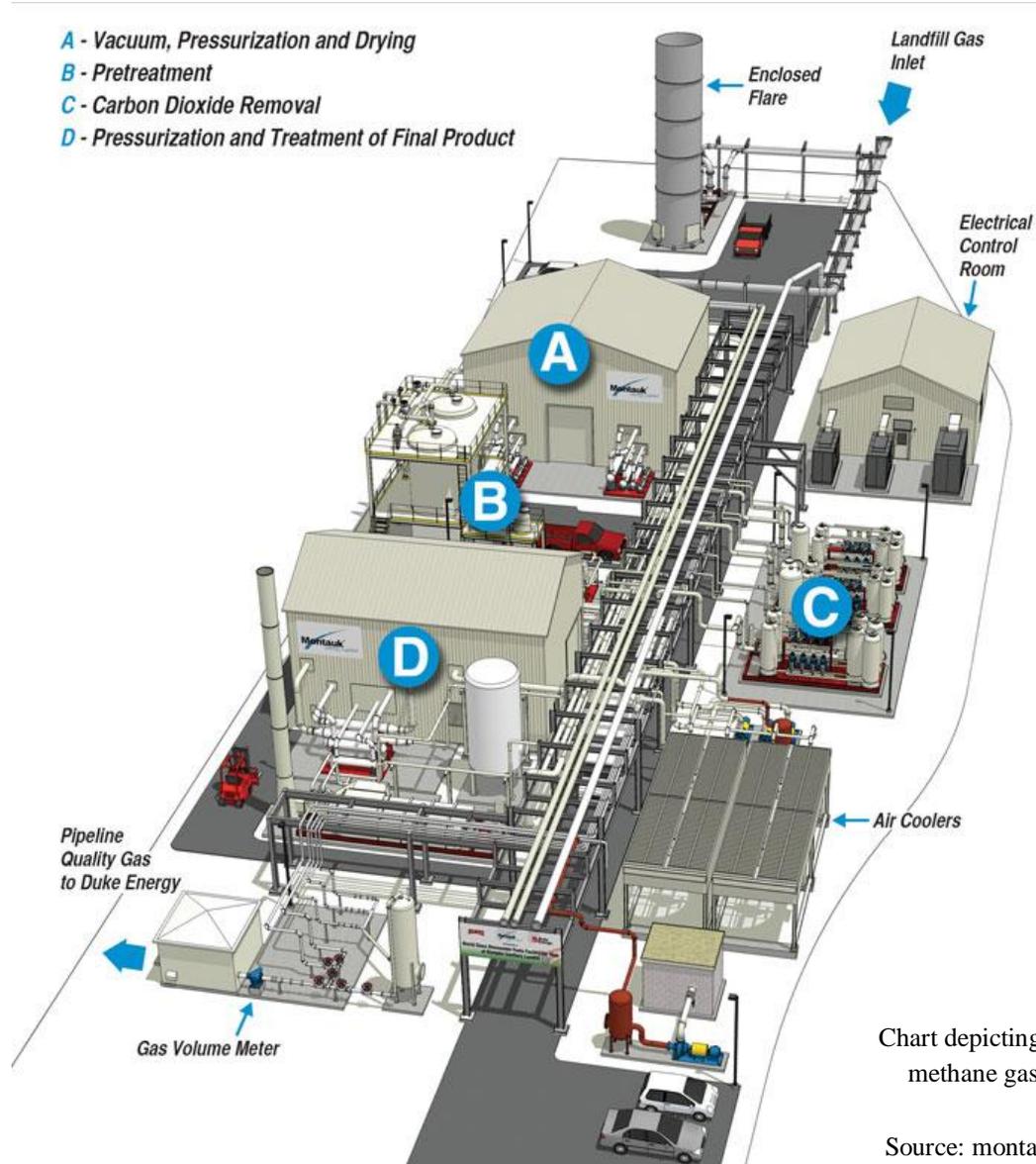
Technology Utilized

One way in which Rumpke helps to promote clean energy is by using innovative technology to generate renewable energy. Rumpke extracts methane gas from its landfills which then goes through a chain of production until it is distributed to consumers as electricity. First, Rumpke transports trash to the landfill. Once the waste in the landfill begins to decompose, it creates methane gas and water. The methane byproduct is taken through a vacuum pump system and sent

to on-site gas plants where it is refined into a more pure form of methane gas. This form of gas can be distributed to and utilized by consumers. The gas obtained from this process at Rumpke is used to heat nearly 20,000 homes daily.

At the Rumpke Sanitary Landfill in Cincinnati, Ohio, trash is reused to create a commercial renewable energy product. In a typical landfill, microorganisms consume the waste material and landfill gas is produced. The landfill gas consists of 50 to 60 percent methane and 40 to 50 percent carbon dioxide. In a facility like Rumpke, methane gas collected is used to fuel nearby turbines which then generate electricity for surrounding neighborhoods. The Rumpke facility is a closed facility, which means that it prevents odors and hazardous gases from being emitted to neighborhoods within the area. In the case of an emergency at the plant, workers would burn the methane gas in a flare tower to prevent it from seeping into the atmosphere.

Turning methane gas into renewable energy starts when methane gas is recovered through wells drilled in the landfill, which are all connected through a common pipeline. The lateral part of the pipeline produces a vacuum and transfers the gas to a compression building close in proximity. Next, the methane gas is de-watered and cooled to 30 degrees Fahrenheit in order to remove dirt and other substances to purify it. Afterwards, the gas is then reheated in a micron filter. Finally, the gas will be pumped into combustion engines which produce the electricity sold to Duke Energy Corporation. Duke Energy is one of the largest electric power companies in the United States and supplies electricity to business and residential consumers in its service area.



Rumpke is able to provide a source of renewable energy to 25,000 Duke Energy customers. The Rumpke Sanitary Landfill uses Xebec’s M-3100 system to purify their biogas. Xebec is a company that specializes in the design and manufacture of cost-effective, environmentally responsible processing equipment for gases and compressed air. Montauk Energy Capital LLC, a company in partnership with Rumpke Consolidated, invested in the M-3100 system when building their third on site gas purification system at Rumpke Sanitary Landfill in Cincinnati, Ohio. The M-3100 system is a compact, skid-mounted processing system for operating feed flows that extract

from 300 to 3,000 normal cubic meters of gas per hour. This new technology's operation time is much faster than conventional systems and enables Montauk to process landfill gas more quickly. After the purification process, the natural gas is 96 percent pure. The purified gas is then sent to Duke Energy Corporation and distributed to customers. Through the use of this system, Rumpke is able to effectively reduce greenhouse gas emissions by the equivalent of approximately 135.9 million gallons of gasoline.

Commercial Application

There is a huge potential for commercial application of this technology. Companies like Rumpke are already capitalizing on their development of biogas extraction, refinement and distribution in their area of coverage. They are applying the methane gas extraction and refinement technology in a commercial setting by collecting landfill gas, purifying it and then selling it to customers. Montauk Capital LLC refines the gas collected from Rumpke Sanitary Landfill to meet the pipeline standards of Duke Energy Corporation and then sends the purified gas through the corporation's distribution system. The Montauk plants at Rumpke Sanitary Landfill have the capacity to process 15 million cubic feet of gas daily. This accounts for approximately 7 percent of Duke Energy's local natural gas distribution.

By using systems like the Xebec M-3100, waste management companies can utilize a by-product of everyday work to produce biogas for profit. Similar technology can be implemented in on-farm and feedstock biogas operations because both involve the creation and collection of methane gas from decomposing materials. A potential barrier to entry into this sector of renewable energy is the initial start-up cost of installation and initial production; however, the company's ability to capitalize on the processing of materials they already have access to increases their chances for profit. Waste being collected in landfills releases landfill gas that can be collected, refined and then

sold to customers, as is done at Rumpke Sanitary Landfill in Cincinnati, Ohio. This is a profit motive for the company and an incentive for investing in renewable energy.

There is a positive market base for profit in the biogas industry in Ohio. There are several government support mechanisms within Ohio that make it easier for companies that are producing renewable energy. One of these is the option of tax exemptions for building conversion facilities within Ohio. To receive the exemption, a business must apply for an energy conversion certificate from the state tax commissioner. The application includes a narrative description of the facility and a descriptive list of component parts and materials incorporated or to be incorporated into the facility. Ohio's office of Energy Efficiency operates an Energy Loan Fund to help support businesses that are conducting renewable and efficient energy production. This is particularly applicable to companies in the development of biogas. The Energy Loan Fund offers four categories of loan assistance, including the Renewable Energy Assistance Program. Residential customers can receive loans ranging from \$500 to \$25,000, while business loans are in the range of \$5,000 to \$500,000. In the current financial market, borrowers pay approximately half the standard interest rate.

Relevance to Poland

In a report by the Helmut Kaiser Consultancy, they found that over 800 million tons of waste was produced worldwide every year. This waste has the potential for 64 billion cubic meters of biogas. This amount of biogas is equivalent to 32 billion tons of gasoline or diesel fuel. This potential for energy creation is available all over the globe. Poland, in particular, has a specifically optimal environment for biogas development. It is this environment that makes it an ideal partner for Rumpke Consolidated's methods of biogas creation, and biogas creation in general.

The EU Directive 2009/28/EC promotes the use of renewable energy sources within the EU and sets ambitious goals for Poland. It has set Poland's goals at 15 percent total energy consumption by 2020 from renewable sources. This initiative also states that biogas has significant

environmental advantages in terms of heat and power production. Due to their localized nature and regional investment structure, biogas installations have the potential to contribute to sustainable energy development in rural areas and they offer new income opportunities.

Poland is one of the most coal dependent countries in the world, with 90 percent of their electricity and heat coming from coal. Approximately 7 percent of the Polish energy supply comes from renewable energy sources, and 91 percent of that is generated from biomass. The most promising areas of renewable energy in Poland are biomass and biogas initiatives. The promise in energy created from agricultural and livestock sources, landfills and waste water treatment plants is one of Poland's biggest opportunities. The areas with the most advantage for biogas development are locations that mainly use coal as a source of fuel, especially rural areas.

The Polish government is just beginning to put government support mechanisms into place to specifically promote biogas. Subsidies will soon become available for investments in agricultural biogas works through the Program for the Development of Rural Areas and programs stemming from the National Fund for Environmental Protection and Water Management. Plans are underway to introduce preferential taxation for energy produced from renewables and tax breaks for investments in biogas works and users of biogas. To aid construction and development, the Polish government is contemplating making amendments to planning regulations to categorize agricultural biogas works as public-purpose investment projects.

Industry Competitors and Collaborators

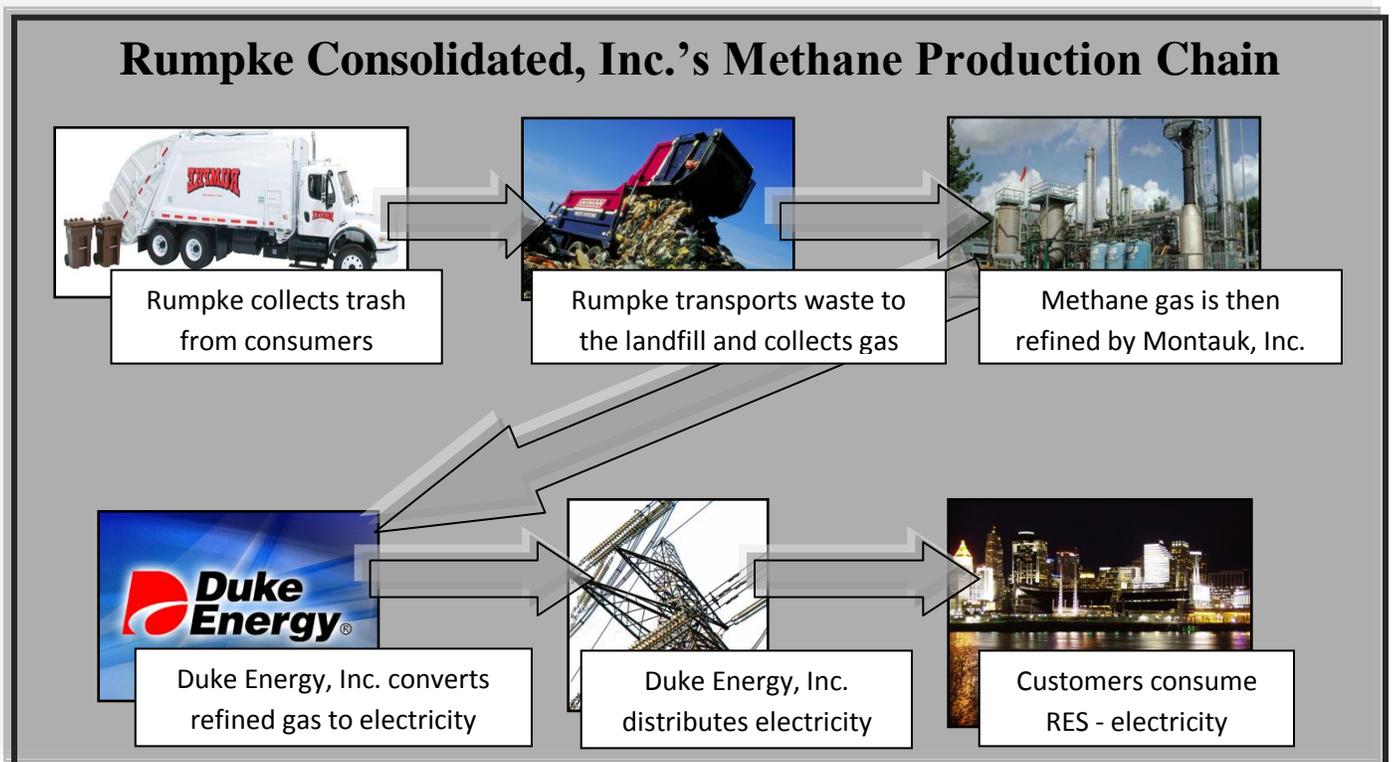
Competitors:

A big competitor to the Rumpke Company is Waste Management, Inc. It is ranked number one in waste and environmental services in the United States. They provide many services including creating energy to supply power to over one million homes a year across North America. Waste Management operates 273 landfill sites and 355 transfer stations where waste is converted to energy. Within their renewable energy program, they can provide energy from 16 waste-to-energy sites

available in the United States. Waste Management's goal by 2020 is to triple the amount of recyclable materials from 8 million to 20 million tons and increase their output of energy to over 2 million homes. They are currently in the process of constructing 22 new plants in the next upcoming years so they can produce more energy to supply more customers.

Another competitor to Rumpke Consolidated Inc. is Republic Services Inc. It is located in the Cincinnati, Ohio area and is one of Rumpke's biggest competitors. Services included are waste disposal and recycling. They operate over 400 collection agencies in 40 states. Republic Services, Inc. serves to residential, industrial, municipal and commercial client. They have 213 landfills and 242 transfer stations. They focus on depositing the waste at transfer stations where compaction and recycling takes place. This company is devoted to protecting the environment with cost-effective programs.

Collaborators:



One company that collaborates with Rumpke is Duke Energy Corporation. Duke Energy is one of the largest electric power companies in the United States. They supply and distribute energy to four million customers annually. The company has its headquarters in North Carolina; however, they supply natural gas in other areas including Ohio and Kentucky. This company is significant to Rumpke's business because they distribute the energy created from the biogas Rumpke produces (Duke Energy, 2009).

Montauk Energy Capital LLC is another company that collaborates with Rumpke. They are based in Pittsburgh, and are one of the largest landfill gas developers in the United States. According to Pratt (2008), this company is important to Rumpke's business because after the methane gas is recovered from Rumpke's landfill it is then processed by Montauk Energy Capital LLC before being transferred to Duke Energy Corporation pipelines that provide natural gas (see analysis on p. 1).

Contact information for collaborators:

Montauk Energy Capital LLC

Chris Davis
Site located on Rumpke Sanitary Landfill in
Cincinnati, Ohio
(412)-747-8719
<http://www.montaukenergy.com/default.asp>

Duke Energy

526 South Church Street
Charlotte, NC 28202
(800)-544-6900
<http://www.duke-energy.com/company.asp>

Competitor Contact Information:

Republic Services

832 Langsdale Avenue
Indianapolis, IN 46202
(317)-921-1667
www.republicservices.com

Waste Management

28 Johnson Rd
Chester, WV 26034
(304) 387-0020
www.wm.com

Rumpke Contact Information:

Corporate Headquarters

10795 Hughes Road
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(513)851-0122
1-800-582-3107

Southeastern and Central Ohio Market:

Contact: Christine Myers
centralohio.market@rumpke.com

Counties covered in Southeast Ohio:

Ohio: 1-888-786-7531

Athens, Delaware, Fayette, Fairfield, Franklin, Gallia, Highland, Hocking, Jackson, Lawrence, Licking, Madison, Meigs, Pickaway, Pike, Ross, Scioto, Union, Vinton, Washington

Counties covered in Kentucky:

Kentucky: 1-888-786-7531

Boyd, Carter, Elliott, Greenup, Lawrence

Counties covered in West Virginia:

West Virginia: 1-888-786-7531

Cabell, Jackson, Mason, Putnam, Wayne, Wood

Cincinnati Market:

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1-800-582-3107
Cincinnati.market@rumpke.com

Counties covered in Ohio:

Butler, Hamilton, Warren

Counties covered in Indiana:

Switzerland, Ohio, Dearborn, Ripley, Franklin, Union, Decatur, Fayette

Northwest Market

Contact: Janice Konkel
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northwest.market@rumpke.com

Counties covered in Ohio:

Auglaize, Clark, Darke, Greene, Mercer, Miami, Montgomery, Preble, Shelby

Counties covered in Indiana:

Delaware, Henry, Jay, Randolph, Wayne

Southeast Market:

1-(877)-RUMPKE-7
(1-877-786-7537)
southeast.market@rumpke.com

Counties covered in Ohio:

Adams, Brown, Clermont, Clinton, Highland

Counties covered in Kentucky:

Bath, Boone, Bourbon, Bracken, Campbell, Clark, Estill, Fayette, Fleming, Franklin, Harrison, Jessamine, Kenton, Knott, Lee, Leslie, Lewis, Madison, Magoffin, Mason, Montgomery, Nicholas, Pendleton, Powell, Robertson, Scott, Woodford

Southern Market:

Contact: Carol Lanning

1-(800)-678-6753

southern.market@rumpke.com

Counties covered in Kentucky:

Bullitt, Carroll, Grayson, Hardin, Hart, Henry, Jefferson, Larue, Meade, Nelson, Oldham, Owen, Shelby, Spencer, Trimble, Washington

Counties covered in Indiana:

Bartholomew, Brown, Clark, Floyd, Harrison, Jackson, Jefferson, Jennings, Johnson, Scott, Washington

Works Cited and Referenced

- (2009). About Republic. Retrieved from <http://www.republicservices.com/aboutRepublic.asp>
- (2009). About Us Corporate Profile. Retrieved from http://www.wm.com/wm/about/corporate_profile.asp
- Duke Energy. (2009). *About Us*. Retrieved from <http://www.duke-energy.com/about-us/default.asp>
- (2008). *Landfill (Methane) Gas -- Turning Waste in to Usable Energy*. Retrieved from http://www.cpsenergy.com/Services/Generate_Deliver_Energy/landfill_gas.asp
- (2009). *XEBEC powers an energy evolution*. Retrieved from <http://www.ascension-publishing.com/BIZ/XebecRump.pdf>
- EPA, Initials. (n.d.). *Funding On-Farm: Biogas Recovery Systems: A Guide to Federal and State Resources*. Retrieved from http://www.epa.gov/agstar/pdf/ag_fund_doc.pdf
- Galitzine, G. (2007, June 28). *Green technology -waste management: turning landfills into renewable energy* . Retrieved from <http://green.tmcnet.com/topics/green/articles/8044-waste-management-turning-landfills-into-renewable-energy.htm>
- Helmut Kaiser Consultancy. "Biogas Plant Markets Worldwide: 2009 High Growth Expected." *Helmut Kaiser* 2008. n. pag. Web. 19 Oct 2009.
- Kunikowski, G., Rogulska, M. (2009). Biogas production in Poland – drivers and barriers. *Proceedings of the European conference on biomethane fuel*, http://www.biogasmax.fr/media/1t1_biogas_production_in_poland__050402600_0649_30092009.pdf
- Lukasz Liese, L. (2009, October 13). *Renewable Energy in Poland – A Bright Future*. Retrieved from http://discoverpl.polacy.co.uk/art,renewable_energy_in_poland_8211_a_bright_future,3577.html
- Montauk Energy Capital. (2008). Entire Website. Retrieved from <http://www.montaukenegy.com/default.asp>
- Pratt, A. (2008). *Rumpke Sanitary Landfill*. Retrieved from <http://www.rumpke.com/pdfs/Rumpke%20Sanitary%20Landfill%20General%20Updates-Fall%202008.doc-2.pdf>
- (2009). *Rumpke Landfill*. Retrieved from <http://rumpke.com/>
- Szydlowski, J. (2007, June 12). Rumpke recovering methane. *The Cincinnati Post*,

TheBioenergySite News Desk. (2009, September 16). Biogas: New Income Opportunities in Rural Areas. *The Bioenergy Site*, Retrieved from <http://www.thebioenergysite.com/news/4539/biogas-new-income-opportunities-in-rural-areas>

Rumpke, W.J. (2009, October 18). *Rumpke*. Retrieved from www.rumpke.com

Poland's RES Needs and Policy Initiatives

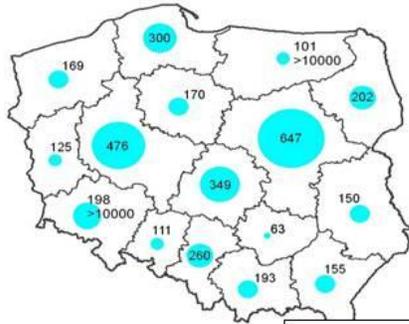


World RES Potential

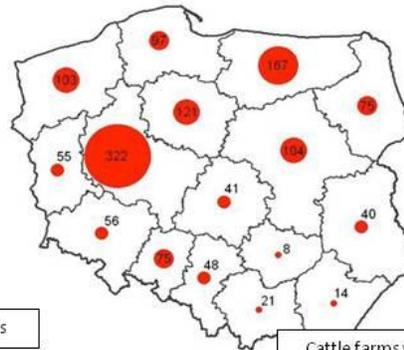
- 800 million tons of waste worldwide per year
 - Potential of 64 billion cubic meters of biogas
 - Equivalent to 32 billion tons of gasoline



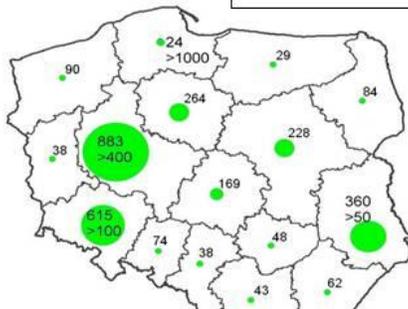
Potential for Biogas in Poland



Poultry farms with >5000 birds

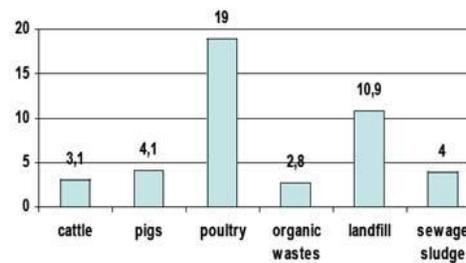


Cattle farms with >100 animals



Pig farms with >500 pigs

Technical biogas potential



Source: ECBREC/IBMER 2003

Policy to Support Biogas

- EU Directive 2009/28/EC
 - 15% energy consumption by 2020
 - Polish Agriculture – 5 to 6 billion cubic meters of biogas
- Polish government subsidies
- Preferential taxation
- Classifying biogas works as “public-purpose investment projects”

Rumpke Consolidated Companies Inc.

A case study conducted by:
Tricia Echemann, Patrick Henderson and Amanda Jones
Global Leadership Center

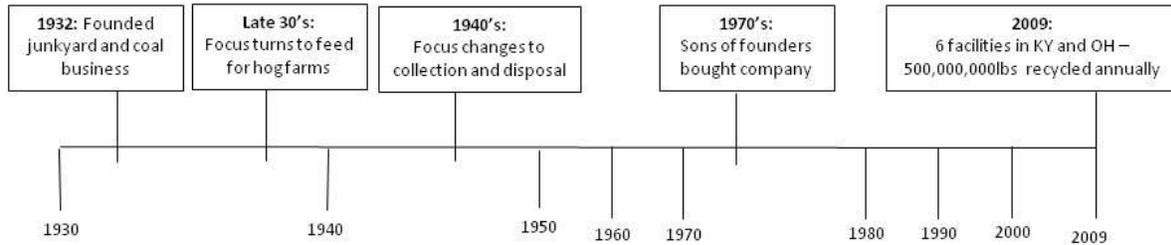


Company Overview

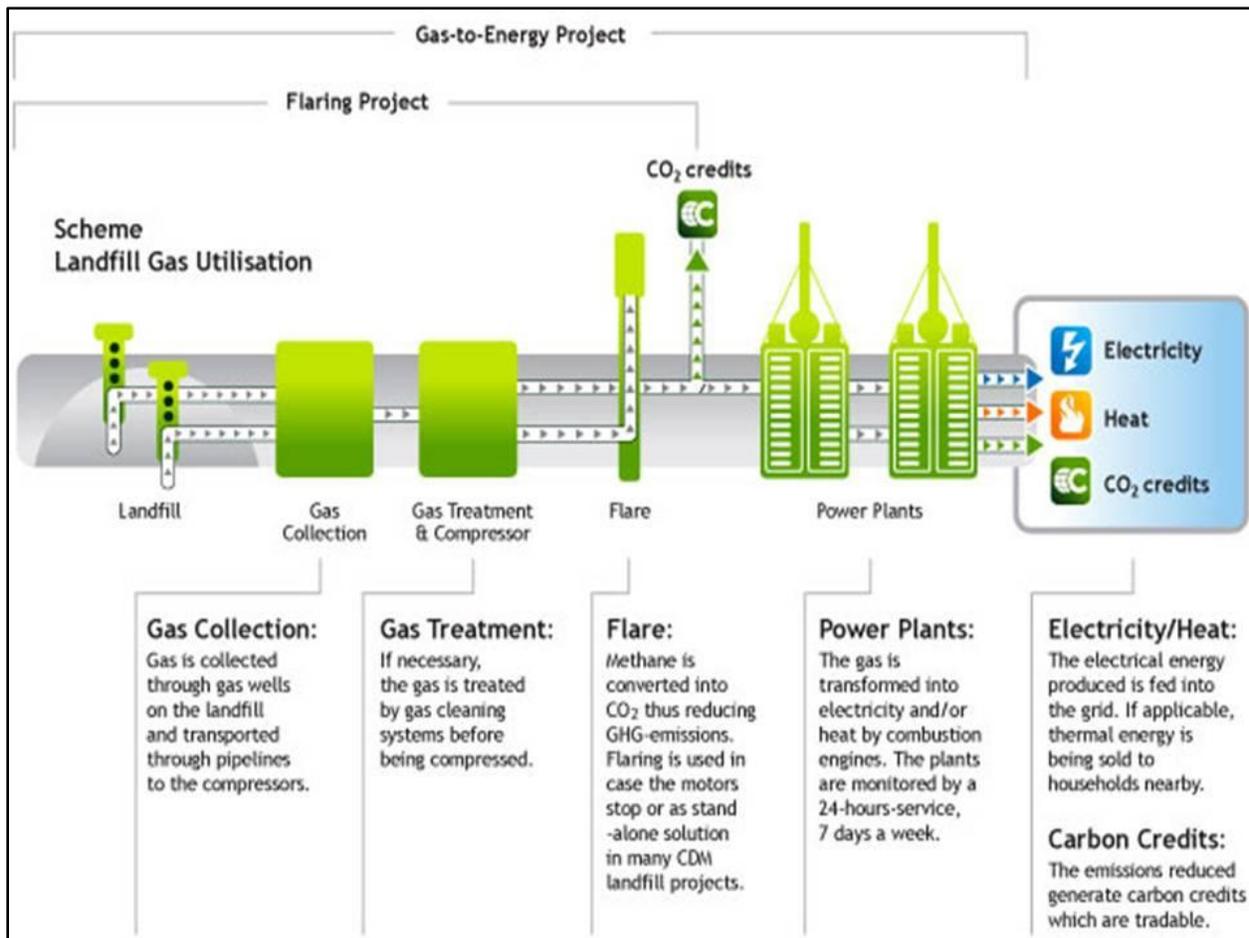


Company Overview

- Rumpke Consolidated History



Products and Technology Utilized

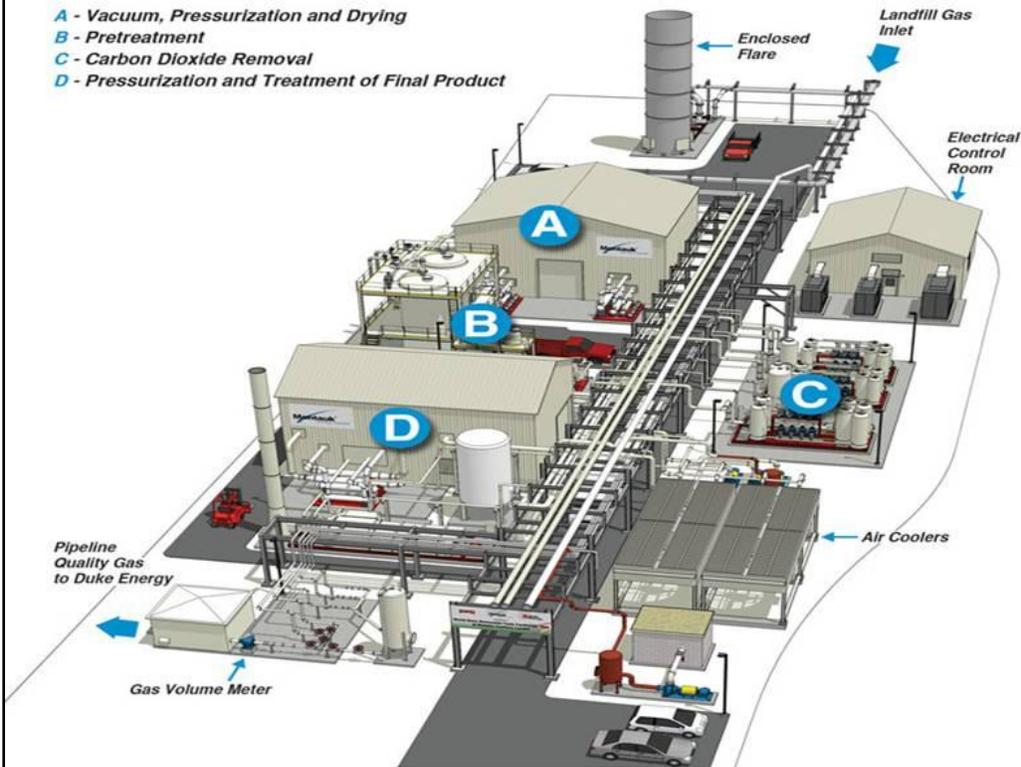


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Technology Utilized

- Montauk processing
- XEBEC M-3100

- A - Vacuum, Pressurization and Drying
- B - Pretreatment
- C - Carbon Dioxide Removal
- D - Pressurization and Treatment of Final Product



Xebec M-3100

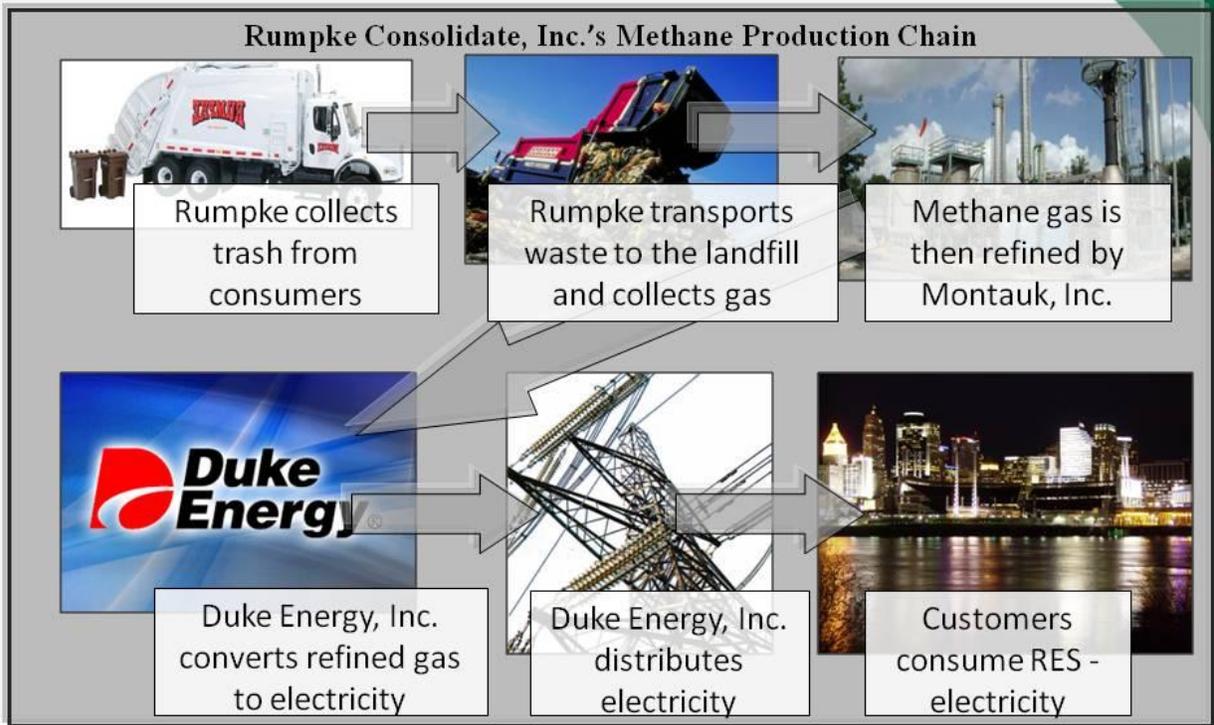


- Purification system
- Extracts 300 to 3,000 NCMH
- ↑ Speed of processing

Business-to-Business Links

Business-to-Business Links

Rumpke Consolidate, Inc.'s Methane Production Chain



Montauk

- On-site processing plant
- Refines raw biogas to useable form
- Send useable gas to Duke Energy



Xebec

- Developed technology used by Montauk for biogas processing
- Montauk purchased this system from Xebec



Source: Xebecinc.com

Duke Energy

- Receives refined biogas from Montauk
- Distribute natural gas to consumers
- Convert gas to electric and distribute



Conclusion