Summary of

Waste to Wheels

BUILDING FOR SUCCESS

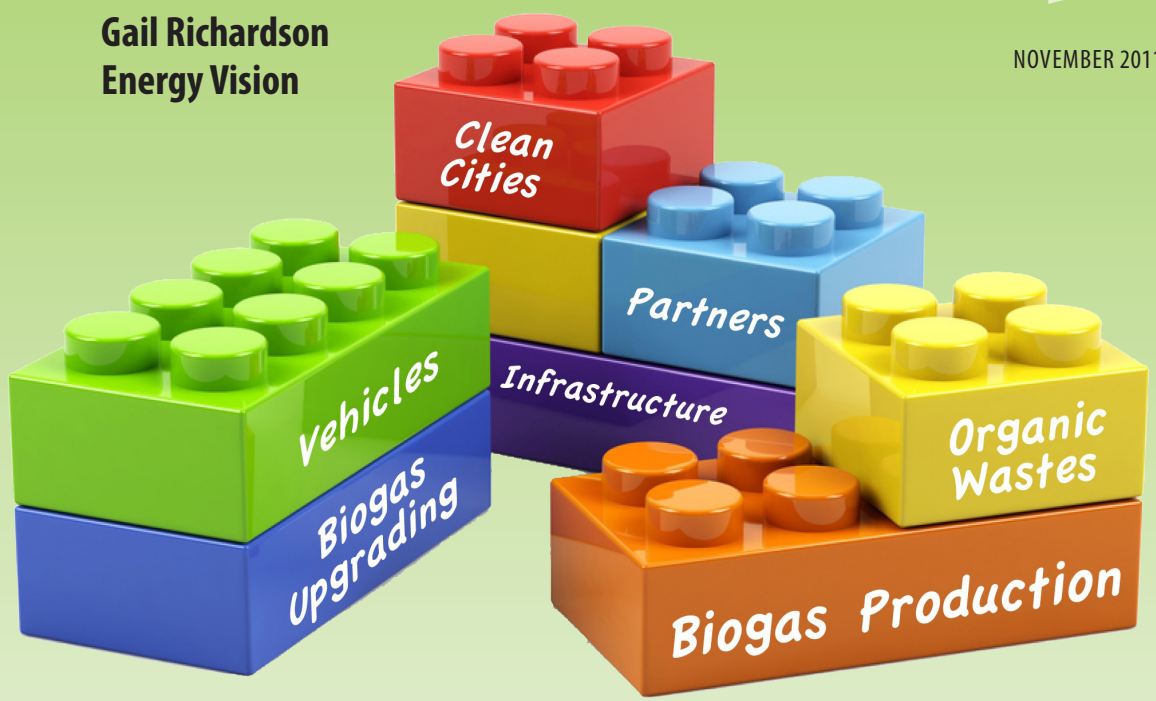
U.S. Department of Energy, Clean Cities Program, December 1, 2010

WORKSHOP

NOVEMBER 2011

prepared by

Gail Richardson
Energy Vision



Argonne NATIONAL LABORATORY

Clean Cities U.S. Department of Energy

CleanFuelsOhio

ENERGY VISION

Argonne National Laboratory seeks solutions to pressing national problems in science and technology. The nation's first national laboratory, Argonne conducts leading-edge basic and applied scientific research in virtually every scientific discipline including specialized assistance on advanced vehicle technologies, alternative fuels, and other petroleum reduction practices for the Office of Energy Efficiency and Renewable Energy's Clean Cities Program. Argonne researchers work closely with researchers from hundreds of companies, universities, and federal, state and municipal agencies to help them solve their specific problems, advance America's scientific leadership and prepare the nation for a better future. With employees from more than 60 nations, Argonne is managed by UChicago Argonne, LLC for the U.S. Department of Energy's Office of Science.

Clean Cities strives to advance the nation's economic, environmental, and energy security by supporting local decisions to adopt practices that contribute to the reduction of petroleum consumption. Clean Cities has a network of nearly 100 volunteer coalitions, which develop partnerships in the public and private sectors to promote alternative and renewable fuels, fuel economy measures, idle reduction technologies, and new technologies as they emerge. Clean Cities is part of the Vehicle Technologies Program in the Office of Energy Efficiency and Renewable Energy.

Clean Fuels Ohio improves air quality and health, reduces environmental pollution, and strengthens Ohio's economy by increasing the use of cleaner, domestic fuels and energy-saving vehicles. As a designated U.S. Department of Energy Clean Cities coalition, Clean Fuels Ohio develops public-private partnerships for fleet deployment projects and a variety of fuel and charging infrastructure while educating businesses, governments, policy-makers and the public.

Energy Vision is a national 501(c)(3) organization based in New York City whose mission is to promote through research and action a swift transition to pollution-free renewable energy sources. Programmatically, Energy Vision informs and engages with policy, business, and environmental leaders, to support the shift of medium- and heavy-duty bus and truck fleets along the path toward sustainable fuel, especially renewable natural gas. Gail Richardson, report author, is Vice President for Programs.

Credits The workshop logo was created by Argonne National Laboratory. Other illustrations were adapted from presentations that can be downloaded at www1.eere.energy.gov/cleancities/waste_to_wheels.html. The design of the report and photography, except where otherwise noted, are by Gail Richardson. Editing was provided by Marianne Mintz and Sana Sandler of Argonne National Laboratory.

Table of Contents

Acknowledgements

1. Workshop Introduction 1

2. The Big Picture 4

3. Waste & Biogas Sources 8

4. Biogas Processing 101 13

5. Vehicles & Fueling 16

6. Partners & Projects 19

7. Making the Case 25

8. Wrap-up 27

The Solid Waste Industry in Transition: 29
Lunch Speeches

- Ron Mills, SWACO
- Chuck White, Waste Management

Field Trips - Photographs

- *Franklin County Landfill* 32
- *Quasar Energy Group* 33
- *Rumpke Landfill* 34

Appendices

- *Workshop Agenda* 36
- *List of Presentations* 37
- *Speaker Bios* 38
- *Speaker Contact Information* 44
- *Field Trip Agenda* 45
- *Resources* 46

Acknowledgements

At Argonne National Laboratory, Marianne Mintz took the lead in organizing *Waste to Wheels: Building for Success*, the first national meeting on renewable natural gas as a vehicle fuel convened by the U.S. Department of Energy (DOE) Clean Cities Program. Dennis Smith, national Clean Cities director, provided overall direction and guidance for this event. Members of the planning committee included Marcy Rood Werpy of Argonne National Laboratory, James Wegrzyn of Brookhaven National Laboratory, Sam Spofforth and Andrew Conley of Clean Fuels Ohio, Erik Neandross and Sean Turner of Gladstein Neandross & Associates, and Gail Richardson of Energy Vision. At Argonne, Ann Murray, Jacque Lebreck, and Sana Sandler assisted in conference planning and materials preparation.

Clean Fuels Ohio, a Clean Cities coalition directed by Sam Spofforth, handled on-site arrangements for workshop sponsors and exhibitors; on-line registration; and site visits for participants. Clean Fuels Ohio staff who contributed to planning and carrying out workshop-related tasks included Andrew Conley, Brad Couch, Katherine Stewart, Jill Herbst, Becky Haltermon, Megan Miller, and Cynthia Maves.

On November 30 and December 1, workshop participants visited four sites in Ohio where the production of renewable vehicle fuel from biogas is underway or is being planned for the future. These sites were the Franklin County Landfill, owned and operated by the Solid Waste Authority of Central Ohio (SWACO); the quasar energy group's demonstration anaerobic digester plant at the Ohio Agricultural Research and Demonstration Center in Wooster; the quasar digester that is under construction in Columbus; and the Rumpke landfill in Cincinnati. Thanks for conducting the tours at each site go to Paul D. Flory, SWACO; Georg Marien, Mark Suchan, and Russ Yoder of quasar energy group; and John R. Butler of Rumpke.

Corporate sponsors of *Waste to Wheels* were Clean Energy, Cummins Westport, Greenlane (Flotech), Linde, quasar energy group, and Waste Management. Special thanks to Dan Huberty of Clean Energy for arranging the dinner at the Elevator Brewery Company on November 30; to Chuck White of Waste Management and Bryan Luftglass of Linde for the luncheon on December 1; and to Mel Kurtz of the quasar energy group, for the reception on December 1. This workshop would not have been possible without the support of these sponsors.

1 Workshop Introduction

Every day U.S. households, institutions, factories, and farms discard vast quantities of garbage, lawn clippings, food processing leftovers, animal manures, and other organic materials, oblivious to their significant value as a source of renewable energy. Of particular importance, these wastes can be turned into vehicle fuel to reduce U.S. dependence on foreign oil, improve urban air quality, slow the pace of global warming, and boost the growth of "green" jobs.

The easiest and least expensive way to turn wastes into fuel begins with a process known as anaerobic digestion: Trapped in airless enclosed spaces such as landfills, wastewater plants, or manure lagoons, under warm and moist conditions, organic wastes break down and emit (primarily) methane and carbon dioxide. These emissions, called biogas, can be purified (or "upgraded") to nearly pure methane. Known as renewable natural gas (RNG) or biomethane, upgraded biogas is virtually pollution-free and carbon-neutral and can replace either gasoline or diesel as fuel for vehicles that are equipped with natural gas engines.

In Europe, RNG powers municipal bus and truck fleets in more than a dozen cities. In the U.S., RNG is also beginning to emerge, but most U.S. communities remain unaware of local opportunities for building this new green industry and enjoying its many advantages.

To expand public awareness of the benefits of developing RNG vehicle fuel projects, and to provide local leaders with some of the tools for launching them, the Clean Cities Program of the U.S. Department of Energy convened a special workshop, *Waste to Wheels: Building for Success*, on December 1, 2010, in Columbus,

Workshop Planning Committee

From left, *Sam Spofforth, Clean Fuels Ohio; Marianne Mintz, Argonne National Laboratory; Dennis Smith, U.S. Department of Energy Clean Cities Program; Marcy Rood Werpy, Argonne National Laboratory; Erik Neandross, Gladstein Neandross & Associates; James Wegrzyn, Brookhaven National Laboratory; Gail Richardson, Energy Vision; and Andrew Conley, Clean Fuels Ohio. (*Not shown: Sean Turner, Gladstein Neandross & Associates)

Photo: Katherine Stewart, Clean Fuels Ohio

Ohio. Attendees were coordinators and members of Clean Cities coalitions – a coast-to-coast network of industry-government partnerships that sponsor and support projects to displace petroleum-derived vehicle fuel by introducing alternative fuels and vehicles and fuel-use efficiency measures (*see map, below, and page 3*).

At the workshop national experts provided information and insight about the benefits, technologies, costs, and challenges related to producing RNG vehicle fuel. Topics ranged from how to spot high-energy waste streams to how to write winning grant proposals. Field trips on November 30 and December 1 introduced workshop attendees to four Ohio sites where RNG vehicle fuel is now, or soon will be, produced.

The aim of this summary is to offer those unable to attend the workshop some of the benefit of the event itself and to encourage local and state leaders to explore the broader development of a precious new green fuel resource. The body of the report adheres closely to points made in the formal presentations, with the exception of additional detail provided on the Clean Cities Program (*page 3*), the Waste to Wheels graphic (*page 7*), and the description of biogas cleanup technologies (page *14-15*). The order of the topics in the summary differs somewhat from that of the agenda. A list of presentations showing the chapter where each is summarized appears on page 37, along with a link for downloading the originals. Illustrations consist largely of presenters' slides and images, and slide authors are identified where applicable. In a few cases, slides have been slightly modified to increase clarity and legibility. Occasionally, an image or photograph closely resembling or related to one used in a presentation is introduced from an outside source. Transcriptions of keynote lunch speeches appear, slightly shortened, on pages 29 to 31. Photographs from the site visits can be found in a special section on pages 32 to 34. Program and field trip agendas, speaker bios and contact information, and a resource list are included in the *Appendices*.

29 Clean Cities Coalitions at *Waste to Wheels* Workshop

ARIZONA – Tucson • CALIFORNIA – Coachella Valley Region, East Bay, Greater Sacramento, Los Angeles, Silicon Valley • CONNECTICUT – Greater New Haven, Southwestern Area • DISTRICT OF COLUMBIA – Greater Washington • GEORGIA – Atlanta • ILLIINOIS – Chicago • MAINE – Maine • NEVADA – Eastern Sierra • NEW JERSEY – New Jersey • NEW YORK – Central New York, Greater Long Island, New York City & Lower Hudson Valley • NORTH CAROLINA – Centralina, Triangle • OHIO – Clean Fuels Ohio, Northeast Ohio • PENNSYLVANIA – Greater Philadelphia, Pittsburgh • TENNESSEE – East Tennessee • UTAH – Utah • V ERMONT – State of Vermont • VIRGINIA – Virginia • WASHINGTON – Puget Sound • WISCONSIN – Southeast Area

Clean Cities Coalitions

Waste to Wheels in the Context of the Clean Cities Program

U.S. Department of Energy

The Clean Cities Program was created in 1993 to "accelerate [the] adoption of alternative fuels, advanced vehicle technologies, and smarter driving practices". To carry out the program, DOE established a network of local coalitions of industry, government, and nonprofits, which now number nearly 100 and are located in 46 states. These coalitions receive technical and financial assistance from DOE. They also raise project funds from a variety of other public and private sources.

Of all the petroleum-reduction measures sponsored through Clean Cities coalitions, those that have achieved the greatest reduction in petroleum use and greenhouse gas emissions involve shifts of public and private fleets to alternative fuels (*see circle graph, below*). And among alternative fuel measures, the greatest petroleum reductions by far have occurred due to the shift of relatively few medium- and heavy-duty vehicles (trucks and buses) to natural gas fuel, either in a compressed or a liquid form (*see bar/line graphs below*).

Included in the Clean Cities alternative fuels portfolio are ethanol E85, biodiesel, electric hybrids, propane, and natural gas.

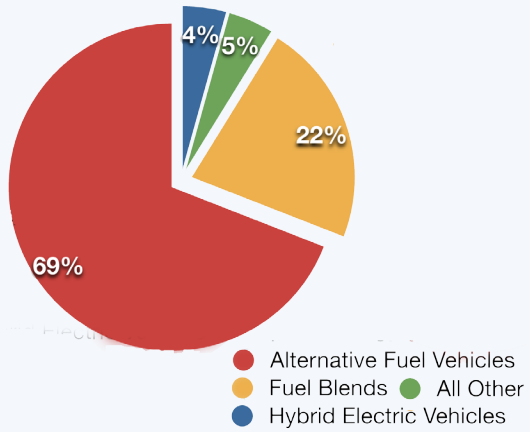
Waste to Wheels marked the introduction of a new alternative fuel into that portfolio – RNG, which is interchangeable with conventional natual gas, but comes from gases emitted by decomposing wastes. The workshop represented the first step in the 3- to 5-year strategic priorities established for RNG (also known as biomethane) within the overall Clean Cities Program. Other steps will include providing assistance to RNG projects as they start up, publicizing the greenhouse gas reduction benefits of RNG, and facilitating initiatives to reduce barriers inhibiting RNG market development. (Strategic priorities also have been established for expanding the use of other alternative fuels, each of which is viewed by the Program as having a valuable role to play in displacing petroleum-derived fuel.)

All Clean Cities coordinators received invitations to the *Waste to Wheels* workshop and 29 of them (and/or their designees) accepted the invitation to receive technical training on how to lay the foundations for mounting RNG projects in their communities. Clean Cities in Atlanta and Puget Sound are already carrying out RNG projects with grants awarded under the 2009 American Recovery and Reinvestment Act.

The Role of Natural Gas Fuels in Initiatives Sponsored by Clean Cities Coalitions

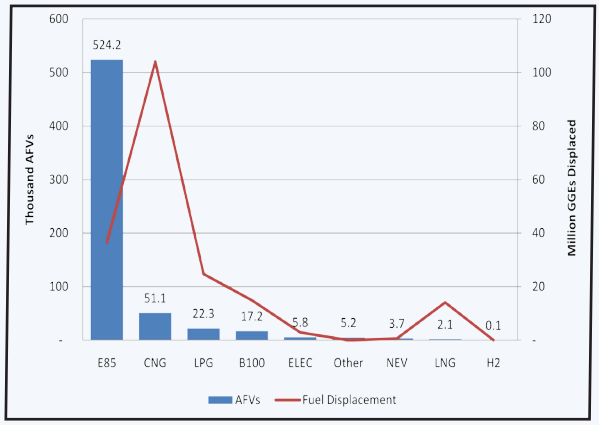
Source: Clean Cities Annual Metrics Report, 2008

% of Total Petroleum Displaced by Each Clean Cities Strategy



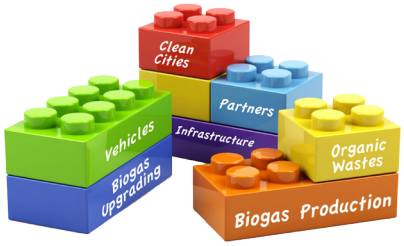
In 2008, 624,000 alternative fuel vehicles operated by Clean Cities-sponsored programs displaced 198 million gasoline gallon equivalents (GGEs) of petroleum-derived fuels, or 69% of the total petroleum displacement reported by Clean Cities coordinators in that year. Fuel blends accounted for another 22% and other measures for the remaining 10%.

CNG and LNG Vehicles - Small Numbers but Large Impact



In 2008, CNG- and LNG-powered vehicles accounted for most of the GGE's of petroleum displaced by the 624,000 alternative fuel vehicles sponsored by Clean Cities programs., even though they constituted only 9% of these vehicles . CNG and LNG vehicles accounted for more than 40% of total reported petroleum displacement by <u>all</u> measures.

2 The Big Picture



On the eve of the 21st century, a study prepared for the U.S. Department of Energy pegged at 10 billion gasoline gallon equivalents (close to 9 billion diesel gallon equivalents) the amount of renewable natural gas (RNG) that could be made from organic wastes at landfills, at wastewater plants, and on farms. The report, *Biogas for Transportation: A 1998 Perspective*, by the QSS firm, was cited by Erik Neandross of Gladstein Neandross & Associates in his overview of the benefits and challenges of RNG vehicle fuel, which is summarized in this chapter.

Benefits of RNG

Displacing 10 billion gasoline gallons of road fuel with RNG, according to the QSS report, would not only lessen U.S. dependence on imported oil but also prevent, every year, 580 million tons of carbon dioxide "equivalent" from entering and heating up the global atmosphere. In contrast to fossil fuel combustion, which unlocks buried carbon from ages past, RNG recycles carbon active in the biosphere today – carbon that is taken out of the air by plants when they grow and put back when they decay. For this reason, RNG has negligible impact on global warming. In fact, according to research in the U.S. and Europe, including a recent report by Argonne National Laboratory, RNG is the fuel with the lowest carbon content of any fuels currently available (*see page 26*).

*Rob Adams (*left*), Marathon Technical Services, and Ronald Flowers, Greater Washington Region Clean Cities.*

Another advantage of RNG fuel, if used to displace older diesel trucks and buses, is that it reduces emissions of fine particulates (soot) and nitrogen oxides, air pollutants that are closely linked with respiratory and cardiovascular diseases and cancer.

Green jobs are a further benefit. Organic wastes are widely distributed across rural and urban regions, so virtually every community can develop local green jobs and energy by converting its wastes to fuel on some workable scale.

Yet, in spite of the demonstrable benefits of turning the nation's plentiful organic wastes into vehicle fuel, only a tiny fraction of this potential is currently being tapped. Of the nation's 1754 large sanitary landfills that receive mixed solid wastes, more than two-thirds simply flare off their biogas. Of the 541 landfills that convert biogas to energy, the overwhelming majority produce either local heat and power or electricity

to sell into the grid, or both. Only 24 U.S. landfills upgrade biogas to pipeline quality and, of these, only 3 use RNG to fuel vehicles (*see map on page 9*). The largest of the biogas-to-RNG plants, located at the Altamont Landfill in California, makes enough fuel for hundreds of trucks (*see pages 19-20, 31*).

Similarly, at the more than 16,000 wastewater treatment plants nationwide, only 544 digest sludges to produce biogas for making electricity and/or local heat and power. And only two plants, East Bay Municipal Utility District *(see page 10)* in California and the municipal wastewater plant in Flint, Michigan (*see pages 20-21)*, plan to make a transportation fuel out of biogas in the future.

The same picture emerges when one looks at farms. Of the 7,000 large-scale dairy, poultry, beef, and swine farms in the U.S., fewer than 160 have facilities for digesting animal wastes and extracting biogas, and only one, Hilarides Dairy in California, uses the recovered biogas for transportation. A second dairy, Vander Haak in Lynden, Washington, plans to make vehicle fuel in the near future (*see page 22*).

Chuck White, of Waste Management, foreground*, was one of more than 120 people who traveled to Columbus, Ohio, to attend the* Waste to Wheels *workshop.*

Challenges to Resolve

Topping the list of challenges that confront prospective developers of RNG fuel is the small size of natural gas vehicle (NGV) markets in the U.S., which have only 110,000 of the world's nearly 13 million NGVs. This very small number of NGVs results in relatively high vehicle prices and also restricts the potential markets for producers of RNG.

Due to the small size of the NGV population, there are fewer natural gas fueling stations in the U.S. And even though this country has by far the largest pipeline delivery grid in the world – including 1.5 million miles of supply arteries, interstate pipelines, and local delivery lines, along with numerous compression stations, storage facilities, and other infrastructure – RNG producers often cannot gain access to the grid due to restrictions imposed by pipeline companies or state policies, which will take time to modify.
Yet widespread pipeline access for RNG, when it arrives, will not, by itself, resolve a serious pricing quandary: At present, RNG costs more to produce than the price it can command when sold through the grid at wholesale gas commodity prices. Needed is some way for RNG producers to turn the "green" value of their gas into a stream of revenue to reward their investments. The most likely scenario – assuming the eventual regulation of carbon emissions – would be the evolution of a strong carbon market that would enable RNG producers to sell green "credits" to buyers seeking to offset their carbon emissions.

A different type of obstacle arises as an unintended effect of federal and state policies that reward companies for producing electricity from biogas but provide no comparable incentives for companies that produce vehicle fuel from biogas. The main examples here are the federal production tax credits that make it economic to produce electricity for landfills but not vehicle fuel; and the state-level Renewable Portfolio Standards that result in higher-than-market prices for renewable electricity made from biogas, but provide no such market incentives for renewable vehicle fuel made from the same source.

Finally, RNG projects, although not technically complex, involve the juggling and balancing of diverse interests and components. Owners and managers of waste streams, vendors of anaerobic digesters and biogas upgrading systems, installers of fueling stations, local gas utilities, fleet owners, funding and permitting agencies, private investors, and others – must figure out how to join forces to carry out a unified and successful business venture. This challenge requires collaborative skills of a high order. Engendering such skills, community by community, is at the heart of the Clean Cities mission.

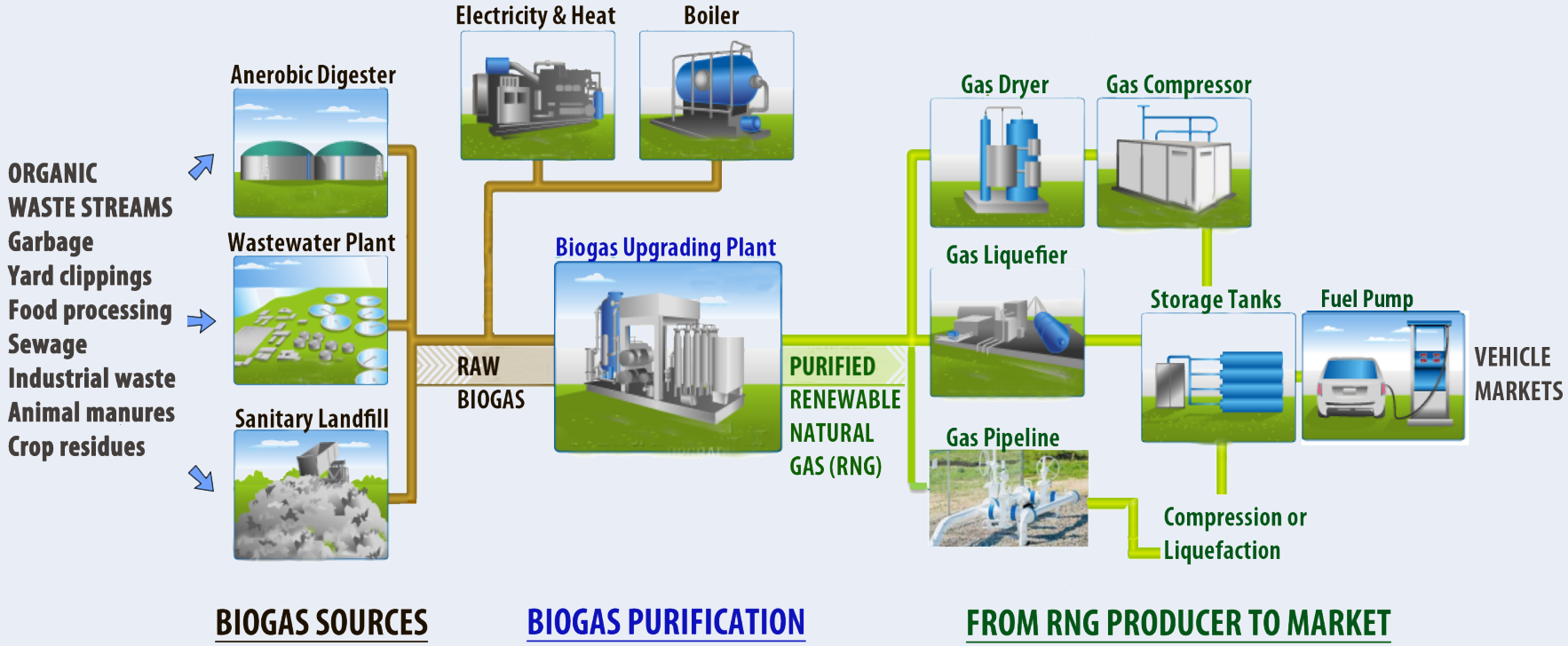
Anna Brynås, Swedish Biogas International, and Nolan McCann, Kettering University.

Waste to Wheels

How to Turn Biogas Emitted by Organic Wastes into Renewable Transportation Fuel

All organic wastes emit "biogas" when they decompose in oxygen-deprived environments that are also warm and moist. Landfills and anaerobic digesters – either free-standing or located at wastewater treatment plants – are the most common sites for collecting biogas. Landfills (essentially "natural" digesters) have the advantage of being able to process organics in mixed waste streams in spite of the presence of many materials that do not break down. Digesters have the advantage of greater efficiency in extracting biogas from a given volume of waste over a shorter time period, but they can handle only concentrated and usually pre-treated organic wastes.

Raw biogas collected at landfills or digesters can be used to cogenerate electricity and heat or to run boilers. To make vehicle fuel, raw biogas must be upgraded, using one or more of several commercial technologies to remove carbon dioxide, sulfur, nitrogen oxides and other gases, siloxanes, and trace contaminants. Purified "renewable natural gas" (RNG or "biomethane") is interchangeable with conventional natural gas and can be mixed with it in any proportion. It can be dispensed to vehicles at the production site, liquefied for truck transport to fueling stations, or injected into the gas pipeline grid and then compressed or liquefied on site at a fueling station.



Graphic: Adapted by Erik Neandross, Gail Richardson and Marianne Mintz from K. Sorchek, Xebec, Inc. – *Biocycle USA*, October 2010. From Erik Neandross, *Promise and Challenge of Renewable Natural Gas as a Vehicle Fuel*

3 Waste & Biogas Sources

The pros and cons of siting RNG production facilities at diverse sites, and the sources of wastes for processing at these sites, were the broad topics of the first workshop panel. The presenters were Robert W. Simkins, Burlington County (N.J.) Resource Recovery Complex; Michael Wardell, Mid-Atlantic Bio-Solids Association (through 12/31/10); Craig Coker, Coker Composting and Consulting; and Clemens Halene, quasar energy group. Erik Neandross facilitated this panel as he did the other workshop sessions.

Sites that already manage large quantities of decomposing wastes – landfills, sewage treatment plants, livestock farms – are likely locations for producing RNG fuel. Another type of site – compost facilities – may also find it economic at times to invest in an anaerobic digester and produce fuel. Free-standing digesters that do not "piggyback" on existing waste-management facilities but are expressly sited to capture and process energy-rich organic wastes are likely to play an increasing role in RNG fuel production in the future.

Sanitary Landfills

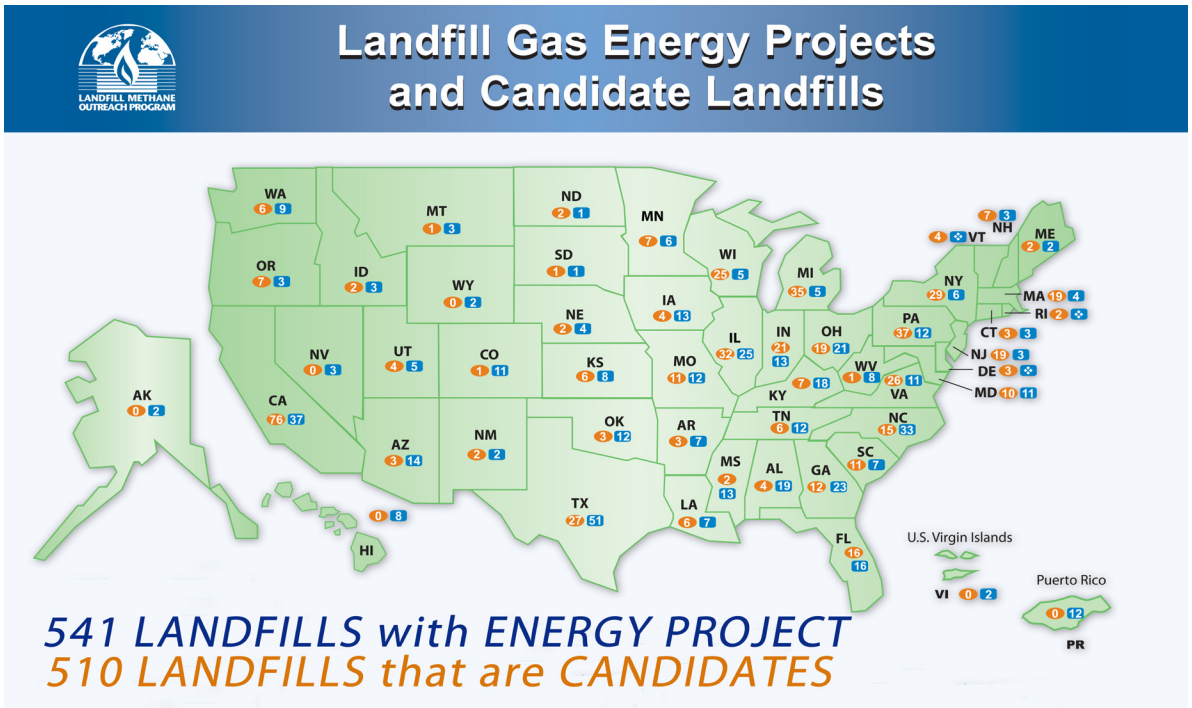
Landfills are, in effect, anaerobic digesters. They are constructed as a series of earth-enclosed cells – airless spaces where moist organic wastes intermixed with non-degradable materials are entombed, and where over time the organics break down and emit biogas. Federal and state laws require landfills to collect and dispose of biogas emissions, both to control odor and reduce unhealthful emissions.

No one advocates building new landfills as fuel production sites. Yet several features of existing landfills, many of which are likely to be in operation for some time, create attractive opportunities for producing RNG as transport fuel.

First, are the large tonnages of organic wastes that go to landfills. In 2008, according to the annual *Biocycle*/Columbia University survey of state data on solid waste management, 270 out of 389 million tons of mixed solid waste generated were deposited in landfills. Between 50% and 60% of this amount

The Workshop Begins

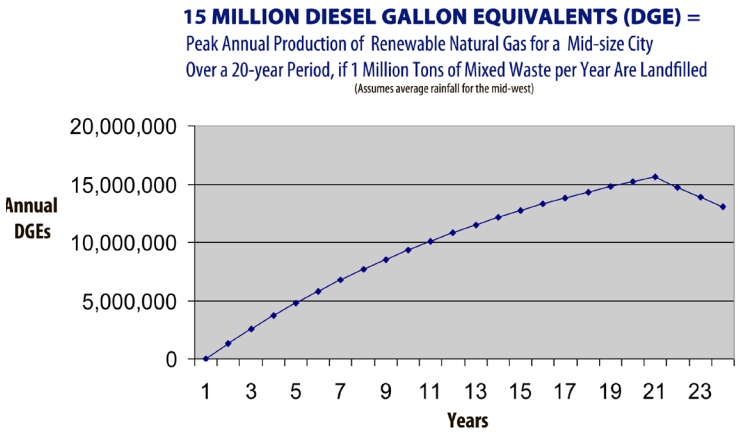
Speakers and presenters prepare for the first workshop panel. From left, *Clemens Halene, quasar energy group; Robert Simkins, Burlington County Resource Recovery Complex; Erik Neandross, Gladstein Neandross & Associates; Marianne Mintz, Argonne National Laboratory; and Craig Coker, Coker Composting and Consulting.*



Source: http://www.epa.gov/lmop

Historically, landfills have flared biogas to control methane emissions and odor. Now, often with the assistance of the Landfill Methane Outreach Program of the U.S. Environmental Protection Agency, 541 landfills have developed energy projects, but only 3 so far convert biogas to vehicle fuel. Another 510 landfills generate enough biogas to be considered as candidates for energy projects. The remaining 703 landfills flare their gas.

consisted of organic materials. If just 1 million tons of these mixed wastes – a typical amount for a mid-sized city in a region having average rainfall – were deposited in the same landfill over a 20-year period, these wastes would emit, at peak yield, enough biogas annually to make the equivalent of 15 million diesel gallons *(see graph below)*. This quantity of fuel could run 2,500 refuse and recycling trucks for a full year.



Source: Robert W. Simkins, Burlington County (N.J.) Resource Recovery Complex, *Sanitary Landfills: Source of Organic Materials and Biomethane Transport Fuel*

A second factor that favors landfills as sites for RNG development is their built-in biogas collection systems and infrastructure. The latter includes a power source (sometimes on site), storm and wastewater drains, access roads, truck scales, and a security system. In addition, landfills are fully permitted for waste management. The primary extra expense for producing RNG is the purchase of cleanup technology and possibly a fueling station. In general, for a given quantity of biogas, it costs less to make fuel than electricity at a landfill (not counting subsidies). Moreover, RNG production has two big advantages over power generation: Vehicle fuel sells for two or three times as much as electricity on an energy-content basis; and no internal combustion engines are required at the landfill site, so the increasingly difficult and costly task of meeting air quality emissions standards for these sources is avoided.

A third advantage of landfills as sites for RNG production is their continuous truck traffic, which offers a practical solution to one of the most difficult problems confronting alternative fuel developers – finding vehicle markets. The trucks that drive daily to and from a landfill can, if equipped with natural gas engines, conveniently tank up with RNG made from the very wastes they haul. They are a "captive" market.

Although removing organics from landfill-bound wastes is rising on the agenda of states, localities, and environmental groups, landfills may actually turn out to be part of the solution to the huge challenge of recycling organics on a broad scale. One example of how this might work is illustrated by a system recently piloted at Yolo County Central Landfill in California. There, organic materials were placed in a specially constructed earthen cell in order to produce electricity, create high-quality compost, and reduce air emissions associated with composting.

Another possibility, which would be more expensive, would be to construct mechanical digesters at the landfill site. These plants (which would get the benefits of the existing landfill infrastructure) could process organic wastes pulled out of the mixed waste stream either before being brought to the landfill or after arriving there. Similarly, transfer stations, where trucks load up on their way to landfills, could prove good sites for digesters and fuel production.

Wastewater Treatment Plants

Of the more than 17,000 wastewater treatment plants in the U.S., approximately 1,500 of the largest already have anaerobic digesters on site, along with the expertise needed to operate them. The primary functions of these digesters are to reduce the volume of sludges by 40% to 60% (which makes their final disposal less costly) and to control pathogens and odor in compliance with regulations.

About half of these digesters produce gas that is too low in energy content to convert to heat, power, or fuel; so the gas is simply burned off. Plants seeking to increase the energy content of digester gas can "co-digest" additional organic wastes along with the sludges – typically fats, oil, and grease (FOG) and food processing wastes – following the example of the East Bay Municipal Utility District (*see below*). This strategy can increase gas production by up to 40% with as little as a 10% increase in feedstock volume.

Biogas that is recovered at wastewater plants can be used to run a boiler for on-site heating; to power internal combustion engines (or microturbines) to generate local heat and power; to run engines or turbines to make electricity for sale into the grid; and/or (after upgrading the biogas) to sell into the pipeline grid or use to fuel vehicles. The costs of these options vary significantly, as illustrated at the Klamath

From Food Waste to Fuel at a Wastewater Plant

The East Bay Municipal Utility District in northern California produces biogas by processing 100 tons per day of food wastes along with sludges. The biogas is used to make electricity now, and fuel production is planned in the future. (Digesters are the 12 tan and grey circles in the middle of the photo, but only six of them are currently in use.)

Photo: East Bay Municipal Utility District. From Michael Wardell, Mid-Atlantic Biosolids Association, R*NG and Wastewater Treatment: Curent Practice and Potential Benefits*

Falls wastewater plant in Oregon, which recently estimated the initial capital cost of installing a biogas boiler at $730,000; that of cogeneration plant to produce heat and power at $1,770,000; and that of an RNG facility to make fuel for 66 vehicles at $2,940,000. Additional economic analysis determined that the payback period for the RNG facility would be greater than 20 years compared to a 12-to-15-year payback period for the cogeneration alternative.

The higher intial costs and longer payback periods for for fuel production at wastewater plants, compared to heat and power, explains why many U.S. and Europe produce electricity but very few produce vehicle fuel. Plants in Sweden are exceptions. They develop a range of products to sell into all energy markets, including vehicle fuel. The Swedish model is now being tried out for the first time in the U.S. at the Flint, Michigan, wastewater plant (*see pages 20-21*).

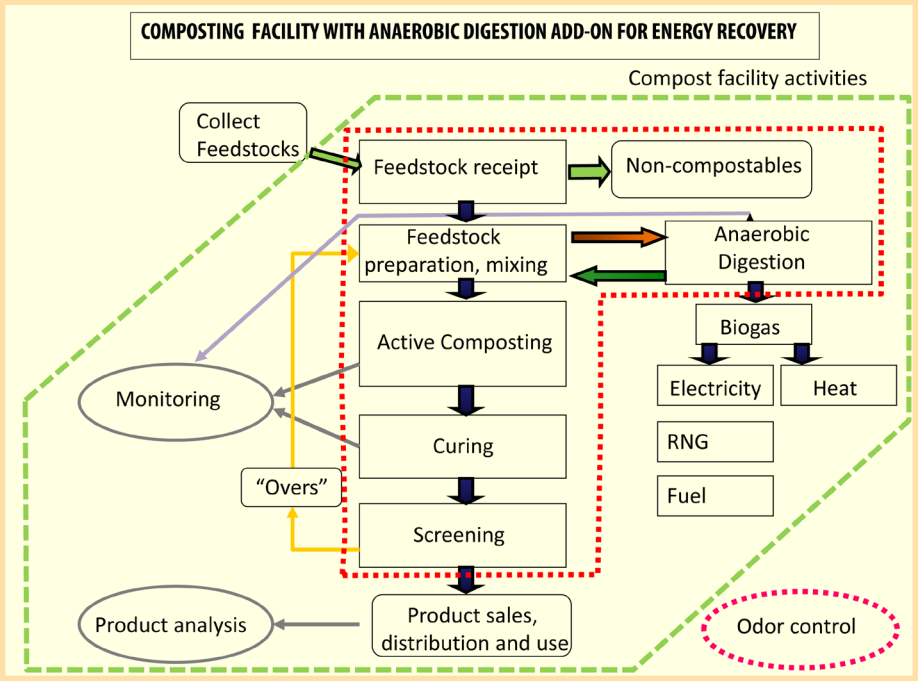


Chart: U.S. Composting Council *Photos:* Craig Coker , Coker Composting and Consulting. From Craig Coker, *.Integrating Organics: Sourcing, Digesting, Composting*

Compost Facilities

Composting, like anaerobic digestion, is a biological system that makes use of microbes to decompose wastes and turn them into useful products. Unlike anaerobic digestion, composting is an open-air process. However, an existing facility can sometimes benefit by integrating a digester into its operations to extract biogas for energy production from part of its waste feedstocks. Digestion, which encloses wastes in a sealed vessel, helps a composter reduce the odor of decomposing organics. It also brings a new source of revenue from existing feedstocks. Moreover the solids left behind after biogas is extracted from part of the compost stream retain their nutrient value and can be

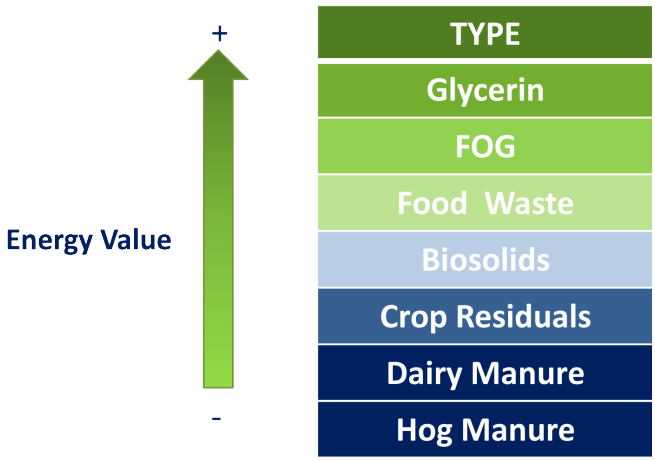
Adding a Digester to a Compost Facility Can Make Sense, Especially if It is a "Dry Fermenter"

The typical stages of organic waste management in a composting facility are depicted on the chart: Feedstock receipt and preparation, active composting, curing, screening, and product sales and distribution. Anaerobic digestion could provide an extra source of revenue by processing some of the waste feedstocks for energy while leaving the nutrient value of the "digestate" intact to be added to the larger compost stream.

Dry fermenters, like the one pictured here, located in Germany, are the most efficient choice for extracting energy from relatively dry organic waste streams. In dry fermentation, organic matter is loaded into a gas- and liquid-tight shed, sprayed with microbe-containing "percolate" to start the digestion, and retained for the required number of weeks. After the biogas is extracted, the remaining solids can be composted along with fresh organic waste.

added to the fresh wastes for composting and preparation as soil amendments and fertilizer (*see diagram, below*).

One big challenge in combining anaerobic digestion and composting in the U.S. concerns the different moisture levels typical of these processes. Composters work with relatively dry feedstocks – yard, farm, food, and other solid organic wastes – whereas anaerobic digesters process wastes in liquid or slurry states. To marry a "dry" composting system with a "wet" anaerobic system requires watering down some of the compost stream for digestion and biogas production, and then drying out the digestate before composting it. Every time a watering-down or drying-out process is used, processing costs go up, but the producer cannot charge any more for the product. One way of getting around this problem would be to use a "dry fermenter" of European design, which processes feedstocks having a moisture content similar to that of the wastes that are composted (*see chart and photo below*).



Source: Clemens Halene, Quasar Energy Group, *Feedstock Streams for Anaerobic Digesters*

Different Wastes Produce Different Amounts of Energy

The chart above lists seven common types of organic waste by relative energy content. In general, two or more waste streams must be combined in an anaerobic digester to optimize biogas output.

Free-standing Digesters

The production of RNG at landfills, wastewater plants, and composting facilities involves the use of sites originally built for purposes other than power or vehicle fuel production. However, a business that sets out to maximize biogas yield and the value of energy products made from identifiable waste streams may choose to build free-standing anaerobic digesters that process pre-tested feedstock mixes. This is the route being taken by quasar energy group in Ohio, a company that is using German technology to launch what it hopes will be a new anaerobic digestion industry in the U.S.

Quasar is in various stages of siting, constructing, and operating 14 plants in Ohio and another two dozen plants in several other states including 5 in Massachusetts.

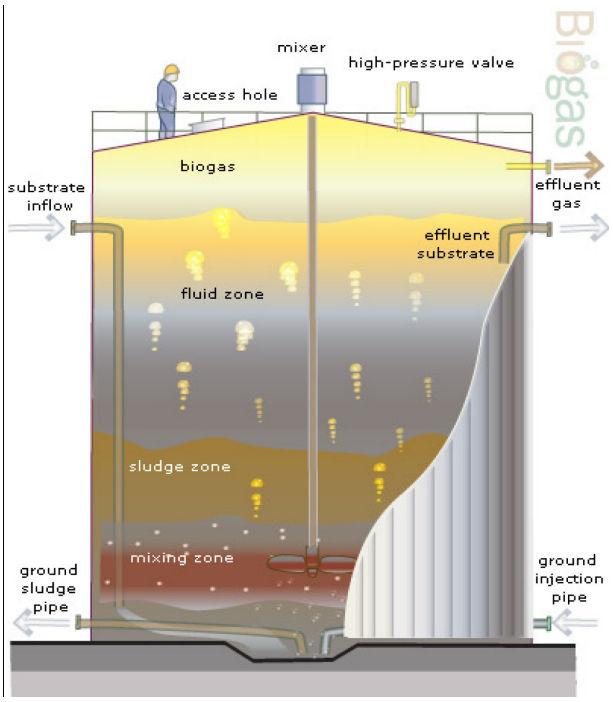
The stages involved in developing the business plan for each quasar plant are as follows:

- "Prospect" to identify one or more waste streams having high enough energy content to make a project economic.
- Review current costs of disposing of the targeted waste stream. Often, generators of wastes that are rich biogas sources, such as food waste, must pay more for disposal services than do generators of wastes having lower energy content, such as manures. Higher "tipping fees" bring more revenue to an anaerobic digester project.
- Determine the quality and volume of the waste stream and the means of acquiring it.
- Lab-test the waste stream to determine with precision how much gas it can produce.
- Determine the tip fee to be offered to producers of the waste stream.

4 Biogas Processing 101

Organic wastes are converted to biogas by the process of anaerobic digestion. Biogas can then be purified to make vehicle fuel using one of several processes. Kelsi Bracmort, Congressional Research Service, discussed anaerobic digestion and Jeffrey Cook, Acrion Technologies, summarized commercial upgrading technologies.

The illustration below depicts the formation of biogas bubbles in an anaerobic digester where wastes are agitated by a large mixer-blade to speed up the process of decomposition. Biogas collected at the top of the digester is drawn off for processing or disposal. By contrast, biogas percolating through landfilled wastes is drawn by a vacuum pump system into "extraction wells" and removed by pipelines for processing or disposal.



Source: Renewable Energy Association. Included in Bracmort, Kelsi, *Anaerobic Digestion: Greenhouse Gas Emission Reduction and Energy Generation,* Congressional Research Service, 7-5700 May 2010, p.5.

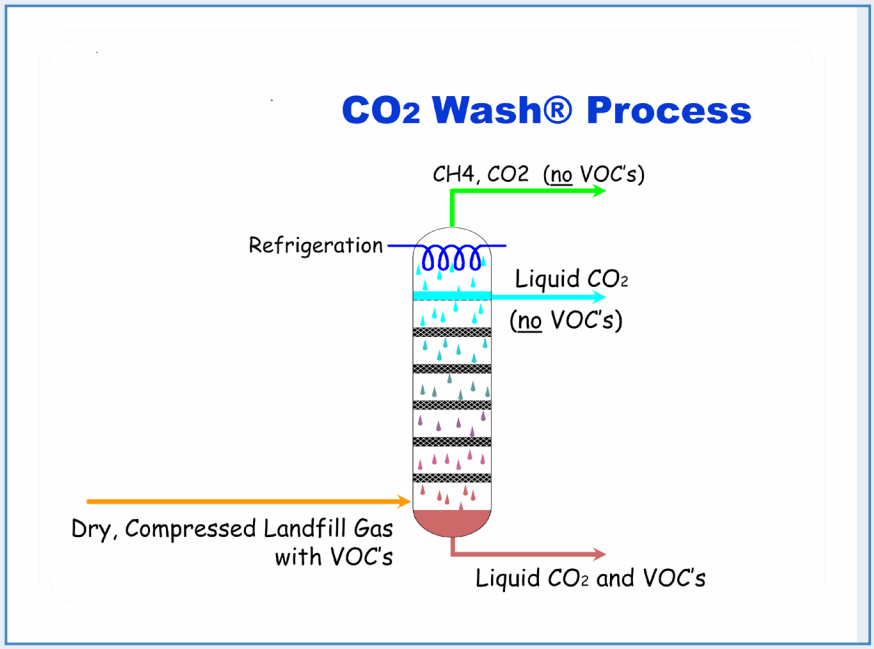
ABC's of Upgrading Biogas to RNG

Raw biogas is typically 45% to 60% methane. To increase the methane concentration to 95% or more, several off-the shelf technologies make use of the properties of different gases, such as their solubility, to cleanse the biogas of impurities and remove carbon dioxide, nitrogen and other intermixed gases and trace contaminants. Four commonly used biogas upgrading technologies are summarized on the following pages.

Anaerobic Digestion

In airless chambers such as landfills, digester plants (shown here), or manure lagoons, under warm and moist conditions, four different microbes, each requiring a different diet, eat their way through a feast of carbohydrates such as food scraps, yard trimmings, fats and grease, soiled paper, animal manure, and so forth. Waste products left behind by one type of microbe become food for another, until virtually all the carbon atoms have been "rotted" into molecules of carbon dioxide (CO_2) or methane (CH_4). This mix, known as "biogas," also contains other gases and impurities depending on the initial feedstock. The methane content of biogas ranges from 45% to 60%, and this concentration can be raised to 95% or higher by using one or more of several gas-separation processes. The resulting product is called "renewable natural gas," "RNG," or "biomethane" and is fully interchangeable with conventional natural gas.

CO_2 Wash is the trade name for a low-temperature process that uses refrigeration to separate methane from a biogas mixture and to remove contaminants.

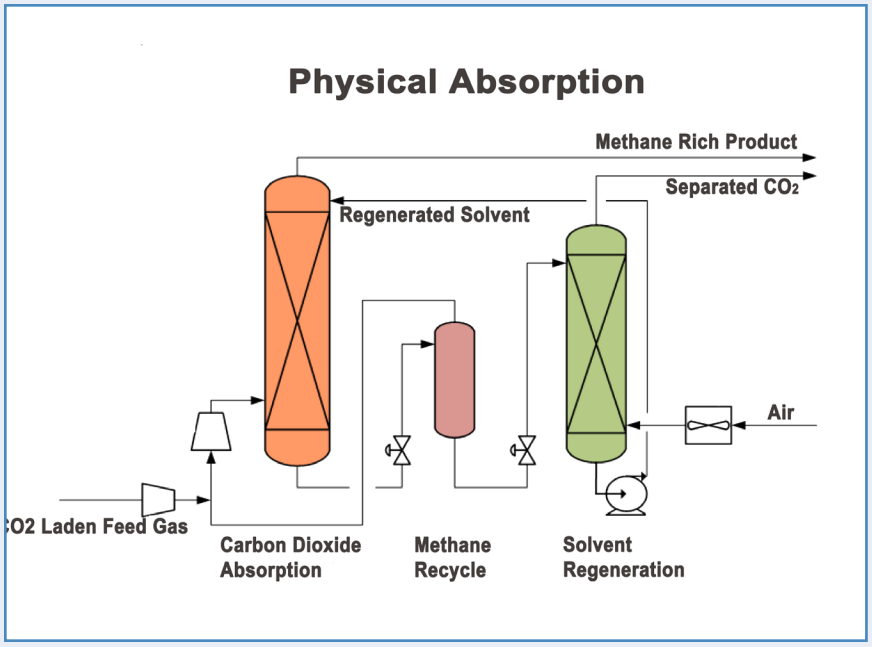


As illustrated here, dry, compressed landfill gas (containing volatile organic carbons -VOCs - such as ethelyne) is fed into a mesh-packed column where it rises to the top. There, a cooling unit lowers the temperature of the gas to the point where about 30% of the CO_2 condenses out of the mixture and is mostly drawn off to make a clean liquid CO_2 product.

The central feature of this process, however, is that part of the liquid CO_2 remains in the column and drips downward through the mesh. As it meets the rising raw landfill gas, the liquid CO_2 absorbs VOCs and other contaminants from it, including siloxanes, hydrocarbons containing sulfur, and hydrocarbons containing halogens (e.g., chlorine). By the time the rising gas reaches the cooling chamber, it consists of contaminant-free CO_2 and CH_4. Further separation of these two gases is accomplished by one or more CO_2 removal processes, like those described in this section.

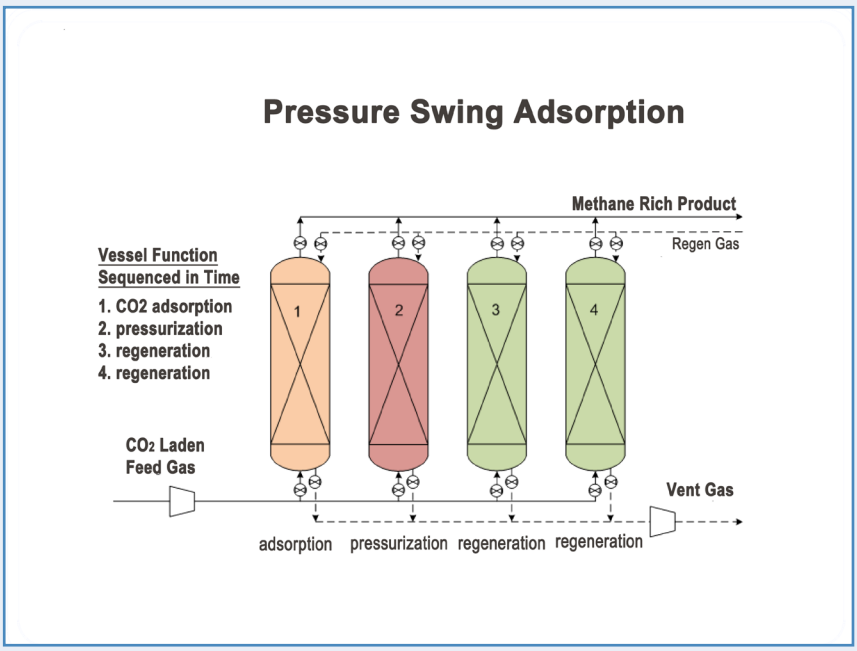
Physical Absorption

employs solvents to dissolve carbon dioxide (CO_2) and other impurities at high pressure (*orange vessel*) and release them again at low pressure (*rose and green vessels*). Solvents commonly used to extract methane from landfill gas are water, "Selexol" (a brand name for dimethyl ether of polyethelene glycol), and methanol.



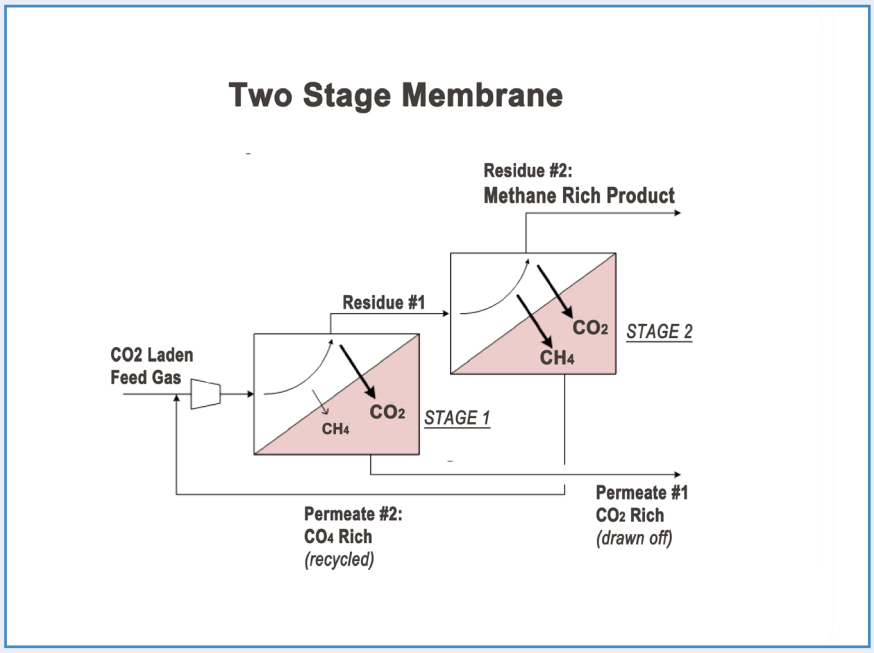
Water, commonly used in European plants, has the lowest CO_2 solubility of the three, but is also the least expensive. Selexol, in use at a number of U.S. landfills including Fresh Kills on Staten Island, removes contaminants in a pre-wash that also partially dries the gas before a second wash removes the CO_2. Methanol is used in two separate streams in the "Kryosol" process, a first absorption to preferentially absorb hydrogen sulfide and trace landfill gas contaminants; and a second absorption to remove CO_2 from the remaining gas. mixture.

Pressure Swing Adsorption systems use "beds" of highly adsorbent materials (e.g., activated carbon) to selectively bind and release one or more gases from a mixed gas stream, as the stream is subjected to "swings" from high to low pressure.



Each one of several vessels processes a different batch of gas in four stages. Vessels shown in this illustration are each timed to be at a different phase in the process so as to ensure a continuous flow of nearly pure methane from the system. 1) Under high pressure, adsorbents strip carbon dioxide and other impurities from raw biogas. 2) Under low pressure, the adsorbents release the contaminants back into the gas phase for removal. 3-4 The adsorbent material is purged of contaminants and regenerated. A full cycle of adsorption and regeneration takes a matter of minutes, or even seconds.

Membranes are barriers (like extremely thin walls) having microscopic pores. Membranes are configured as flat sheets or hollow fibers whose typical thickness is 0.15 millimeters, about the size of a thick human hair.



Different gases permeate at different rates through a membrane, from a higher-pressure area on one side to a lower-pressure area on the other side. These different permeability rates permit the separation of one or more gases from a mixed gas stream.

In the case of biogas, which is mostly CO_2 and CH_4, a two-step process can be used, as illustrated here, to create a stream of nearly pure methane gas. In the first stage, most of the carbon dioxide permeates the membrane and is drawn off ("*Permeate #1*") for disposal. In the second stage, most of the remaining non-methane gases are removed (*Permeate #2*), leaving nearly pure methane gas (*Residue #2*) that is captured for use as vehicle fuel. To separate out additional amounts of methane from *Permeate #2*, this gas stream is fed back through the entire process by being added into the main flow of "feed gas" from the landfill or anaerobic digester.

5 Vehicles & Fueling

Two workshop presenters spoke about NGVs and fueling: Sean Turner of Gladstein Neandross & Associates gave an overview of available models of natural gas cars and trucks; and Rob Adams of Marathon Technical Services described alternative designs for CNG fueling stations, which account for nearly all of the stations built in the U.S. to date.

Renewable natural gas (RNG) is interchangeable with conventional natural gas. These "twin" fuels can be mixed in any proportions. They can be stored and transported in either compressed (CNG) or liquefied (LNG) form, dispensed by the same pumps, and used in the same engines. Thus, the requirements for expanding vehicle markets for RNG fuel are identical with those for expanding markets for conventional natural gas fuel. The major obstacles to overcome in both cases are the small size of the markets for natural gas vehicles (NGVs) and the related lack of fueling infrastructure.

The Availability of Natural Gas Vehicles (NGVs)

NGVs are available as light-, medium- and heavy-duty vehicles in one of three ways: as original equipment from the factory floor; as conversions of gasoline or diesel engines to run on CNG; or as "repowers" of heavy-duty diesel engines to run on either CNG or LNG. Because heavy-duty buses and trucks are by far the largest per-vehicle consumers of petroleum-derived fuels, a shift of these vehicles to CNG or LNG can achieve sizable reductions in fuel consumption, air pollution, and greenhouse gas emissions.

Source: Sean Turner, Gladstein Neandross & Associates, *Natural Gas Vehicles: What's Here and What's Coming*

Cummins Westport, the manufacturer of the ISL-G natural gas engine, has led the way since the late 1980s in opening up heavy-duty natural gas vehicle markets in the U.S. and Canada. Recognized as the cleanest heavy-duty engine available, the ISL-G (8.9 liter, inline six-cylinder design) has been certified to the 2010 EPA/CARB diesel emission standard since 2007. The engine has ratings of up to 320 horsepower per 1000 pound-foot using either CNG or LNG. Trucks and buses pictured here illustrate the engine's diverse applications. There are more than 6,000 units on the road in the U.S.

In the U.S., the only factory-produced light-duty vehicle made to operate solely on natural gas fuel is the Honda Civic GX sedan. Several models of Ford and Chevrolet vans and pickups can be converted to NGVs, a service that is provided by a number of companies. Engine conversions must meet certification requirements established by the U.S. Environmental Protection Agency or the California Air Resources Board to ensure safe emissions performance and to protect the integrity of the base vehicle.

Heavy-duty NGVs come in a number of models and use engines supplied by Cummins Westport, Westport Innovations, Emission Solutions Inc., and Doosan. Cummins Westport's ISL-G engine, which runs on CNG, has led the way in developing the heavy-duty NGV engine market since the late 1980s (*see illustration on page 16*). All vehicles using this engine have been built by combining engines and body parts from different manufacturers, which can be complex and costly.

Recently, Cummins Westport received funding from several government agencies to develop its 11.9 liter ISX engine that will run on CNG and have a peak rating of 400 horsepower. The anticipated launch date is 2013. Westport's new GX engine is now available in factory-built trucks from both Kenworth and Peterbilt. This 15-liter high-pressure direct injection engine uses LNG fuel and has ratings of up to 475 horsepower. It is designed for long-haul tractors pulling very heavy loads.

CNG Station Design Primer

The vast majority of NGV vehicles use CNG dispensed at specially built stations having the following equipment:

- A dryer to remove moisture from the fuel
- A compressor (or more than one), to raise the pressure of the gas delivered by a utility pipeline from about 3600 pounds per square inch (psi) to 4500 to 5500 psi
- For "fast fill" stations, storage tanks or spheres that hold gas at pressures between 4500 and 5500 psi
- Fuel dispensing pumps

CNG stations are designed as "time fill" or "fast fill." A "time fill" system can refuel an entire fleet from a single compressor over a period of hours. This design often works well for fleets that return to the same garage or lot at the end of the workday and are parked there overnight.

Source of illustrations: Rob Adams, Marathon Technical Services, *Station Design Primer*

A "fast fill" station comes in two varieties, each of which can refuel a vehicle in 5 to 20 minutes. A "cascade" system is used for fleets that need to refuel during very short periods and whose need can be supplied by gas stored on site. A "buffer" system, which often makes use of several compressors, is required for a fleet of many large vehicles that fill up back to back over a period of several hours.

Buffer

- *For large vehicles (e.g. buses) that refill back to back, for several hours*
- *5 to 20 minutes per fill, from compressors*
- *Requires large equipment*

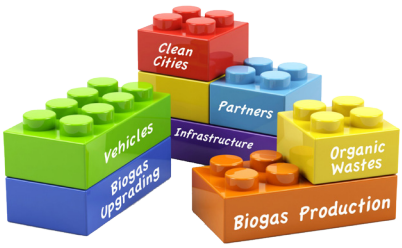
When designing a fueling facility, a prospective station owner needs to meet with the local gas utility to determine how to match the minimum, maximum, and typical pressure in the service area to the needs of the CNG station. In addition, it is essential to know the exact composition of the natural gas supply (which can vary from one location to another) and in particular, the moisture content, which typically must be reduced through the use of dryer equipment.

Most garages that house CNG buses or trucks or other fleet vehicles require some upgrading. These buildings can contain no open flame or heaters that burn at temperatures greater than 750 degrees Farenheit. There must be continuous exhaust, makeup air, and ventilation to prevent accumulation of gaseous fumes; and a gas detection system having "interlocks" to alarms, exhaust fans, doors, and other emergency response features.

A number of permits are required for constructing a fueling facility. Among the applicable codes are 52 and 70 NFPA (National Fire Protection Association) which govern vehicular gaseous fuel and electrical systems, and NFPA 30A which regulates motor fuel dispensing facilities. Also applicable are guidelines of The American Society of Mechanical Engineers (ASME) for process piping and unfired pressure vessels; the International Building, Fire, and Mechanical codes; and state and local codes and regulations.
Contracts for constructing a fueling station can follow one of several common approaches:

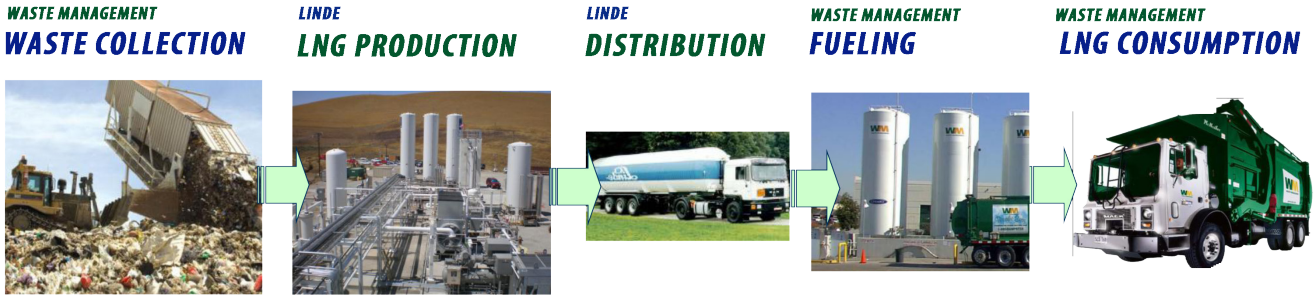
- *Split Contract* – Equipment and construction are purchased under separate contracts.
- *Design Build* – Design, equipment, permitting, and installation are purchased under a single contract.
- *Throughput Contract* (also known as *Lease to Own)* – Like Design Build, except that payments are made over time based on the amount of fuel sold, measured on a per-Therm basis. (One Therm equals 100,000 Btus, or about 73% of the energy contained in a diesel equivalent gallon.)
- *Maintenance* can be covered in the construction contract or bid separately. A warranty for parts is not usually included in a maintenance contract.

6 Partners & Projects



The projects to develop renewable natural gas (RNG) fuel that are beginning to emerge in the U.S. vary widely with regard to their location, cost, waste feedstocks, access to the pipeline grid, vehicle markets, financing, and regulation. These variations reflect the highly site-specific nature of each project. They also give rise to the need for cooperation among partners, as is shown in the experience of the RNG fuel plants at Altamont landfill in California, the Flint wastewater treatment plant, and the Vander Haak Dairy in Washington State, as described in presentations by Bryan Luftglass of Linde, Anna Brynås of Swedish Biogas International, and Stephanie Meyn of Puget Sound Clean Air Agency, respectively. Mel Kurtz of quasar energy group summarized his company's approach to building anaerobic digesters.

All of these speakers and others emphasized the importance of assembling a dedicated project team representing a range of interests and expertise, which can provide access to diverse constituencies and funding sources. Christopher Cavanagh of National Grid talked about the "sustainable gas" vision of his natural gas utility company. Ralph Hirshberg, an Ohio consultant, described how Clean Cities coalitions are well positioned to play a critical role in bringing partners to the table and developing new revenue streams. Evan Williams of Cambrian Energy analyzed the production-cost challenge of an RNG project. Ted Barnes of Gas Technology Institute discussed funding sources.



Source: Bryan Luftglass. Linde, *Partnering on the Altamont Landfill Gas to LNG Plant*

Closing the Loop at Altamont Landfill in California

At the Altamont Landfill outside San Francisco, project partners Waste Management (WM) and Linde manage the supply chain "loop" for the production and use of renewable liquefied natural gas (LNG) made from mixed solid wastes. These wastes are collected from Bay Area communities by WM refuse fleets and are deposited in the landfill, where the organic components decompose and emit biogas. A plant designed by Linde upgrades the biogas to nearly pure methane gas. This fuel product is then hauled by Linde tankers to WM fueling stations for dispensing to between 300 and 400 WM trucks that provide services in both the Bay Area and Southern California.

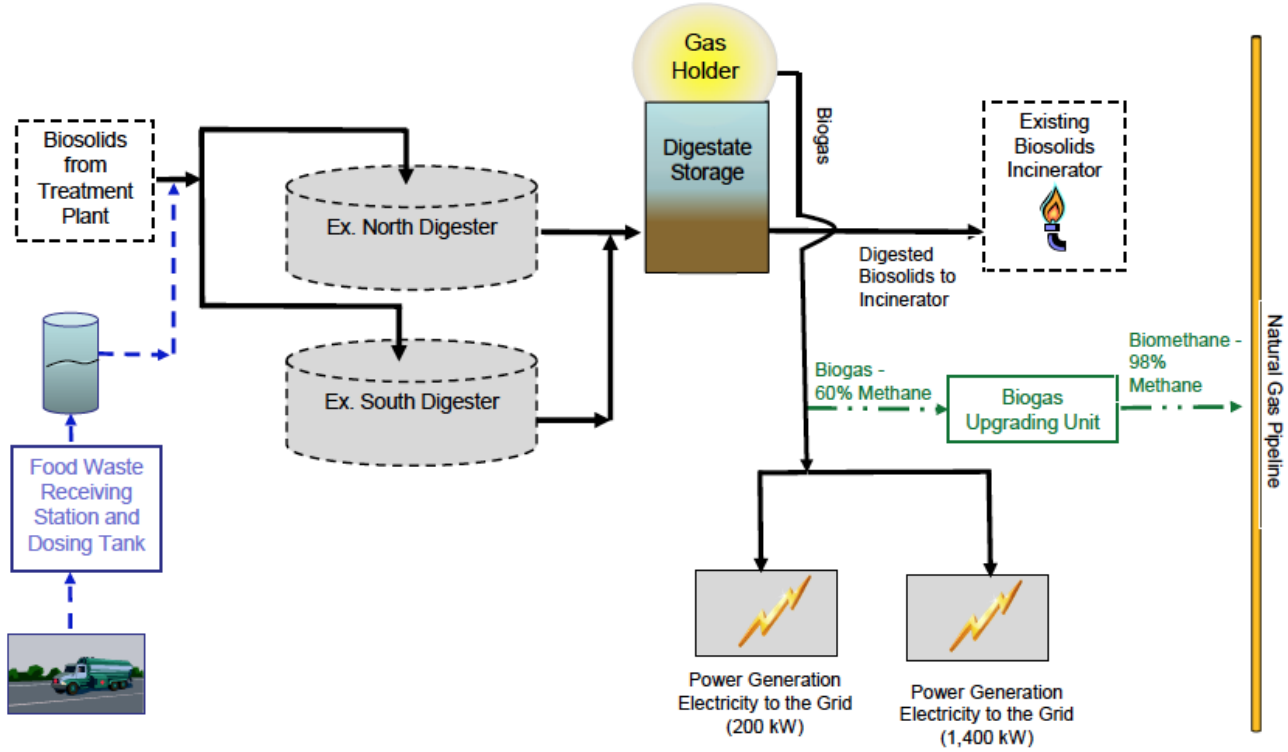
Waste Management and Linde Close the Loop at the Altamont Landfill in California

At the Altamont Landfill in northern California, Waste Management (WM), the largest waste management company in the U.S., and Linde, an international industrial gas supplier, recently formed a 50-50 joint venture to build the world's largest plant for upgrading landfill gas to renewable natural gas vehicle fuel. A third entity, the Gas Technology Institute, provided the gas liquefaction and storage technology for the treated bio-LNG. The plant, which cost $15.5 million, was financed in part by $2 million in grants from several California agencies. It is designed to produce 13,000 diesel gallon equivalents daily from wastes decomposing at a landfill that receives 7,000 tons of refuse daily from the Bay Area. The plant went on line in 2010 and has received numerous awards including recognition as a Project of the Year by the Landfill Methane Outreach Program of the U.S. Environmental Protection Agency.

Due primarily to WM's large presence in California's solid waste management business, the joint venture with Linde is able to "close the loop": Wastes hauled by WM trucks to the Altamont landfill are the source of the fuel that powers these trucks, as well as others belonging to WM in other parts of the state (*see illustration, page 19 and Chuck White, page 31*).

The City of Flint and Swedish Biogas International Revamp a Wastewater Plant in Michigan

An unusual U.S.-Swedish partnership unfolding in the city of Flint, Michigan, is streamlining sludge processing at a municipal wastewater treatment plant in order to produce electricity, heat, and eventually pipeline grade gas and vehicle fuel. The principal partners are the city of Flint and Swedish Biogas International, whose representatives signed a 21-year contract in fall 2009. Other partners, include the State of Michigan's Economic Development Corporation, Kettering University, U.S. federal agencies, the city of



Source: Anna Brynas, Swedish Biogas International, *Wastewater Plant Biogas to RNG*

Components of Flint's Initial Wastewater-to-Energy Project

This drawing depicts the Swedish Biogas plan for processing food wastes along with sewage in order to produce electricity and renewable natural gas. Plans after 2011 call for the production of vehicle fuel.

Linkoping, and the Swedish government. The total project cost is expected to be $8 to $10-million, and savings to the city of Flint in reduced electricity costs alone will amount to $3.5 million within seven years.

In order to boost biogas and energy yield at the redesigned plant, food processing wastes are being mixed with sludges. A Kettering University lab tests the potential biogas yields of specific waste streams to assure that they meet the plant's biogas yield criteria before these wastes are accepted for processing. The lab also measures and analyzes other aspects of the anaerobic digestion process to confirm the high quality both of energy products made at the Flint plant and of the digestate that is left behind. The digestate can be sold for use in conditioning and enriching soils.

Flint's refurbished wastewater plant will begin producing electricity in spring 2011. And, even though significant fuel production will not occur for at least a year, Flint – a home town of the U.S. auto industry – is announcing its future plans in the form of an eye-catching paint job on the side of one of its pickup trucks *(below)*.

Flint's international partner; Swedish Biogas, is a prominent player in Sweden, where more than a dozen cities power municipal buses and trucks with RNG made from wastes. Swedish Biogas alone owns 6 biomethane production plants, 16 public fueling stations, and 2 bus depots. The company now has long-term plans to invest in the U.S. biomethane market and is already pursuing a second Michigan project, in Reed City.

Source: Flint Wastewater Treatment Plant

When this pickup truck drives through the streets of Flint, Michigan, it educates the public about the potential for producing energy, including vehicle fuel, at the city's wastewater treatment plant

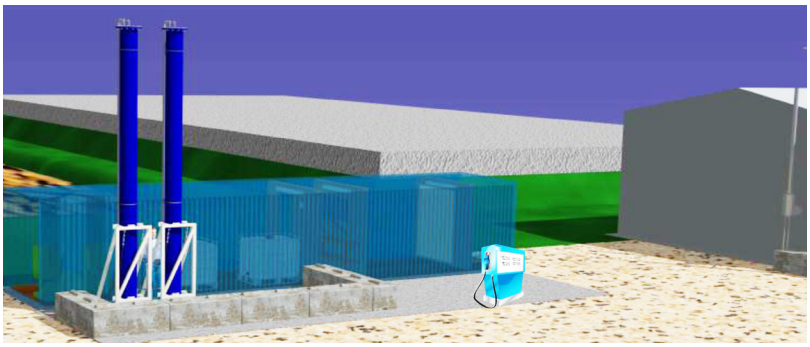
Vander Haak Dairy Builds a Digester, Makes Electricity – and Targets a Fuel Market – in Washington State

In 2004, the Vander Haak family, owners of a dairy in Lynden, Washington, located north of Seattle, worked with a number of public and private sector partners ranging from a local family foundation to an international oil company and federal agencies, to build the first commercial anaerobic digester in the state. Costing $1.2 million and measuring 73 feet wide, 150 feet long, and 16 feet high, this digester currently processes manures from three dairy farms (about 1200 cows) along with fish trimmings and other organic material.

Biogas drawn off the digester runs an engine that generates enough electricity for sale into the power grid to serve approximately 180 homes. The solids left behind after biogas is removed are used on the farm as soil amendments and animal bedding, and the liquid stream is applied as a largely pathogen-free fertilizer. Yet even taking into account all these valuable products, the payback period of ten years remains uncomfortably long for the modest 8% annual return the investment is earning.

Seeking to improve its bottom line, the Vander Haak family is exploring an exciting new market for biogas – vehicle fuel. If a sizable portion of the dairy's biogas production can be sold as vehicle fuel instead of electricity, revenues will increase significantly because profit on a given amount of biogas is two to four times higher if sold as vehicle fuel than if sold as electricity. If the dairy can capture this higher value without incurring excessive new debt, the Vander Haak family may find the crucial missing link needed to make the digester robustly economic.

Working through the Puget Sound



Source: Stephanie Meyn, Puget Sound Clean Air Agency, *Finding Key Partners – Puget Sound Clean Cities Experience with a Dairy Digester Biogas Project*

*The Vander Haak Dairy in Lynden, Washington (*top*) has built an anaerobic digester (*middle*) to turn biogas from manure into electricity. Soon it will add a biogas cleanup component (*bottom "prototype" drawing*) to turn some of the biogas into vehicle fuel for use by a local fleet owner.*

Clean Air Agency, the home of a Clean Cities coalition, a project team including the Research Vehicle Institute at Western Washington University wrote a proposal for federal funding to help finance an RNG fuel project at the Vander Haak Dairy. The team succeeded in winning an award of $500,000 in 2009. A crucial partner in this initiative, which is now under way, is the Bellair Airporter Shuttle, an operator of shuttle and charter services in Seattle and Puget Sound area. The company expects that RNG fuel from the Vander Haak digester will the cut oil consumption and carbon footprint of its fleets.

If the Vander Haak model were adopted by nearby dairy farms, the transportation sector in Whatcom County could greatly reduce its carbon footprint. A rule of thumb used by the Vehicle Research Institute is that each cow produces approximately 120 pounds of manure per day, which generates close to 60 cubic feet of methane, or about the energy content of one-half gallon of gasoline. Whatcom's 50,000 cows produce about 25,000 gasoline gallon equivalents daily, over 9 million gallons in a year, which is seven times the amount used by all of the county's major government fleets combined.

Gas Utilities as Pivotal Players

In general, the easiest way for Vander Haak Dairy and Flint's wastewater plant – and many similar projects in the future – to get RNG to vehicle markets is by pipeline because a vast interconnected system of national and local pipelines already exists. This grid includes gas compression facilities, storage tanks, and other features required to move gas from producers to 24 hubs or market centers where local delivery companies (LDCs) carry it to end-users.

National Grid, one of these LDCs, serves consumer and power generation markets in Massachusetts, New Hampshire, New York, and Rhode Island. Emphasizing the near carbon-neutrality of RNG, National Grid promotes idea that a blend of RNG with conventional gas can achieve significant overall reduction in greenhouse gas emissions of the nation's natural gas supplies. National Grid encourages future producers of RNG to distribute their fuel through its pipelines and the broader grid (*see illustration on page 26*).

On the policy level, National Grid seeks to "level the playing field" so that producers of renewable gas have the same federal and state policy incentives as producers of renewable electricity.

Transportation markets for RNG are not a current priority for National Grid although the company is well positioned to pursue these markets in the future. Its 40 natural gas fueling stations, primarily in New York State, are managed by Clean Energy to fuel 4,000 vehicles, primarily in public fleets.

Clean Cities Coalitions and RNG Projects

Clean Cities Coalitions can provide the same kinds of help to RNG developers as they provide at present to other alternative fuel projects. This help includes finding vehicle fuel consumers by outreach to government agencies and private fleets; promoting the development of local fueling capacity; and helping to identify and pursue opportunities for grants, tax credits, and low-cost bonds or other low-cost debt as part of a project's financing package. Another potential role for Clean Cities is that of a green fuel "broker," as envisaged by Ralph Hirshberg (*see illustration on page 27*).

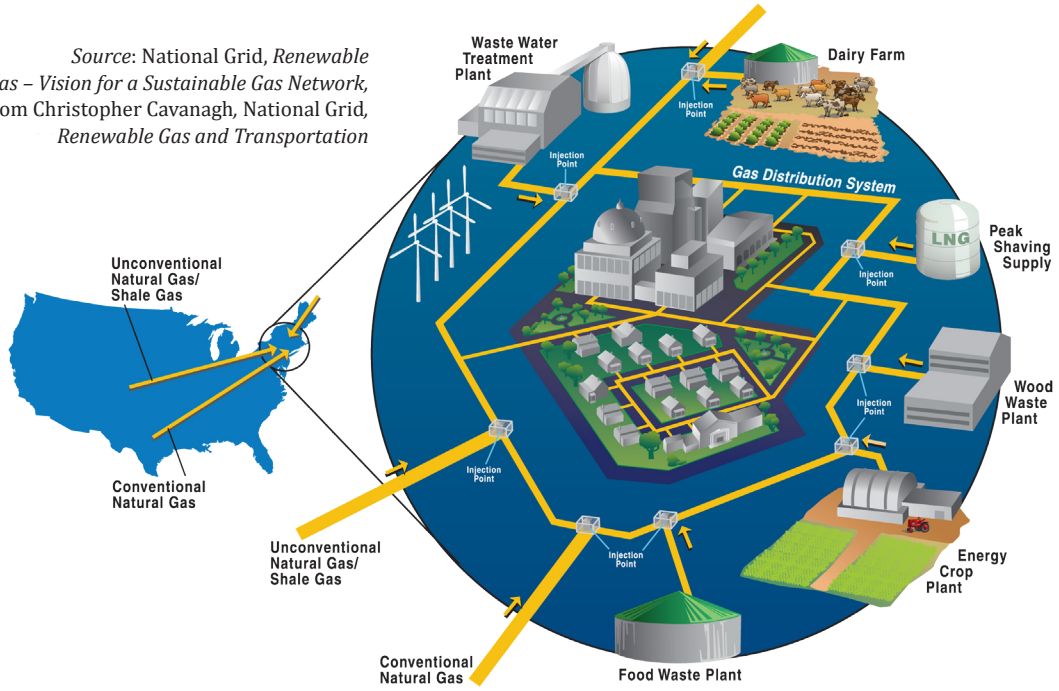
More broadly, Clean Cities coalitions can educate the public about the potential role of RNG vehicle fuel. And they can provide important links between RNG projects and federal and state agencies, to ensure good information flow and collaboration where possible.

Funding Sources

External funding, primarily grants from public agencies, was recognized as an essential component of every project described by presenters at the *Waste to Wheels* workshop. Some of the most likely sources of funding for future RNG projects, as noted by Ted Barnes of the Gas Technology Institute, are the following:

At the federal level – the U.S. Departments of Energy, Environmental Protection, Defense, and Transportation.

Source: National Grid, *Renewable Gas – Vision for a Sustainable Gas Network,* from Christopher Cavanagh, National Grid, *Renewable Gas and Transportation*



Bringing "Sustainable" Gas into the Pipeline Grid

*National Grid, encourages the development of small-scale producers of RNG within its Northeast service territory (*circle insert*), for example, on farms and at foodwaste processors, as discussed during the workshop. The injection of RNG into the company's pipeline distribution system (along with gas from other sources in the U.S.) would the lower the carbon footprint of the company's overall gas supply while also stimulating local economic activity and the creation of new green jobs.*

At the state level – energy authorities and boards, waste reduction boards, air quality agencies, and environmental protection agencies. Some of these agencies play national leadership roles, including the California Energy Commission, the California Air Resources Board, the New York State Energy Research and Development Authority, the Texas Commission on Environmental Quality, and the Illinois Clean Coal Institute.

Local utilities - natural gas and electric utilities at times offer incentives to small-scale energy producers.

The Gas Technology Institute (GTI) is a potential project partner having the capacity to leverage resources for the commercialization of technologies developed in its labs. GTI is currently involved in three projects to turn biogas into energy: the Gills Onion project in California to make electricity from wastes at the nation's largest onion processing plant; the Altamont Landfill project *(see pages 19-20)*; and the Fort Lewis Army Base project to produce hydrogen at a wastewater plant located at the base, near Seattle.

Costs for LFG to Pipeline Quality Renewable Natural Gas Project

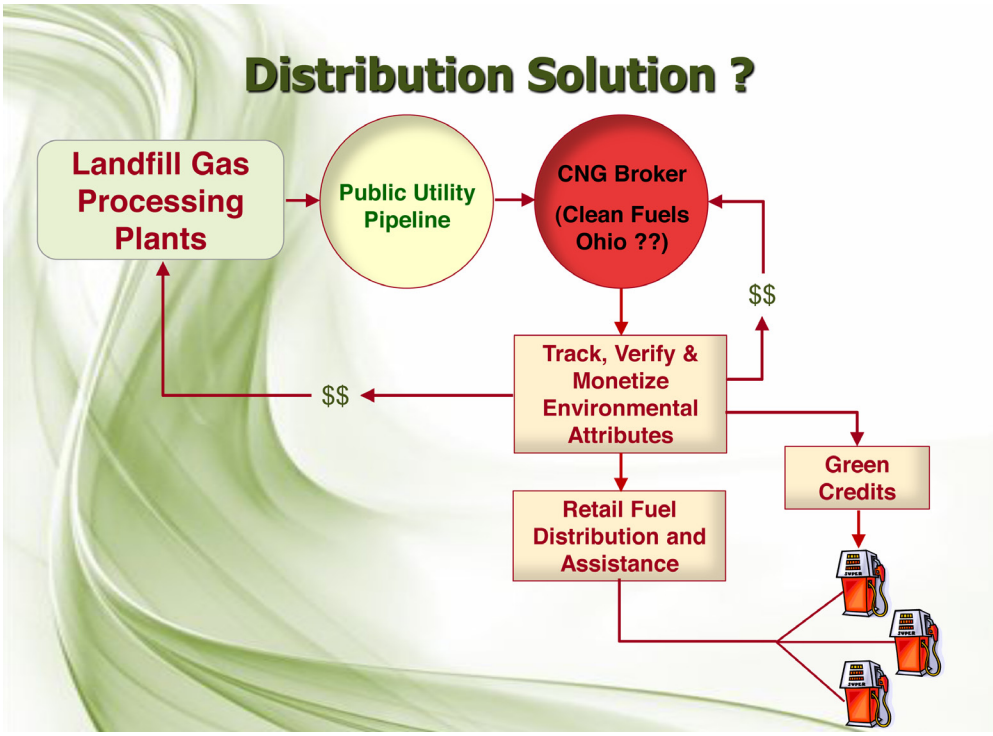
Gas Processing Cost For 2 million Feet/Day Inlet in $/MMBtu	
$1.80	Plant Capital Amortization
$2.20	O&M for Processing Plant
$0.38	Collection System Expansion Per Year
$0.61	Collection System O&M Per Year
$0.49	Initial Collection System and Flare Capital Amortization
$0.78	12.5% Royalty
$5.48	Total Cost Per MMBtu

Source: Evan Williams, Cambrian Energy,, *An RNG Developer's Perspective: It's a Numbers Game*

The cost of upgrading biogas at landfills (where it is already being collected) is about $5.50 per million Btu's (MMBtu), as shown on the table above. Wholesale gas prices at the time of the workshop were about $4.00 per MMBtu. No federal or state incentives exist to offset the low wholesale price of pipeline gas for producers of RNG seeking to deliver this green fuel to vehicle markets.

One possible approach to increasing the revenue stream to producers and retailers of RNG vehicle fuel, as illustrated here, would be for Clean Cities organizations to serve as RNG brokers. They could, for example, manage the distribution of RNG in such a way as to track, verify, and market its low-carbon "green" features. This system would need to be financed by some form of green credits, like carbon markets. Clean Cities, landfill gas producers, and fuel providers would all receive a share of the monetary value of the credits.

Source: Ralph Hirshberg, Civil and Environmental Consultants, Inc.



Ralph Hirschberg, Civil & Environmental Consultants, Inc., *Sustainable Transportation Solutions for the 21st Century: Landfill Gas to Vehicle Fuel Development Perspectives*

7 Making the Case

Clean Cities coalitions are eligible to apply for a variety of federal, state, and local funding awards as well as private sector grants. Primary sources for most applicants are the U.S. Department of Energy (Clean Cites Program) and the U.S. Environmental Protection Agency (Diesel Emission Reduction Program). The larger the grants, in general, the more intense the competition, and the more important it is for an applicant to meet four general criteria, as described below. These were emphasized by Dennis Smith, director of the Clean Cities Program at the U.S. Department of Energy, in his opening remarks, as well as by Erik Neandross later in the program. Marianne Mintz discussed two Clean Cities-supported tools, "GREET Fleet," which enables users to estimate greenhouse gas savings and petrolium reduction achievable through specific vehicle replacement programs; and GREET, which estimates general reductions in petroleum, regulated air pollutants, and greenhouse gas emissions associated with various alternative fuels. Four general criteria include:

GREET Fleet is a user-friendly tool for estimating the fuel, emissions and greenhouse gas savings of replacing conventionally fueled vehicles with alternatively fueled options, including RNG. The GREET Fleet calculator is available at http://www1.eere.energy.gov/cleancities/national_partnership.html.

Team expertise and prior experience: A granting agency considers the expertise and experience of the project partners in seeking answers to questions like these: How qualified are individual team members to carry out the tasks they propose? Does the team as a whole combine expertise and experience that are well-matched to project requirements? Have individual team members or the team as a whole done any other projects like this one? What is their track record?

Technical strategy and work plan*:* A convincing technical strategy and carefully developed work plan are usually essential ingredients of a winning proposal. Applicants need to exhibit a thorough understanding of the technologies they propose to employ and show that they have the capacity to implement them on time and within budget.

Targeted benefits: Most grant programs require applicants to quantify the benefits that their projects will achieve, such as improving air quality, reducing petroleum use, lowering greenhouse gas emissions, and creating "green" jobs. Greenhouse gas reductions, in particular, are increasingly important to demonstrate. These are now measured at each step along a fuel's entire journey from extraction (or production) through refining, transport, storage, and end-use. Then the results from each step are totaled. Calculations of these life-cycle carbon emissions for RNG and other fuels, both conventional and alternative, have been developed from mathematical models by researchers in the U.S. and Europe, including those at Argonne National Laboratory (*see page 26*). See the name of your paper.

Cost effectiveness**:** Finally, a team seeking grant funding must show that its project is a good investment. This means, in part, a grant will attract,

or be combined with, additional financial and in-kind resources from elsewhere. Most funders also look for evidence that a project initiated with grant funding will be able to sustain itself after grant funds run out.

How to Prepare a Winning Proposal

Writing a successful proposal is harder than it looks, and some of the stumbling blocks have nothing to do with the substance of the proposal itself. Advice from veteran proposal writers at Gladstein Neandross & Associates includes the following points:

Study and respond to the selection criteria. Read the entire application to be sure your project is eligible. Understand what the funding agency is looking for and carefully screen your project plans to ensure a good fit with the funder's priorities.

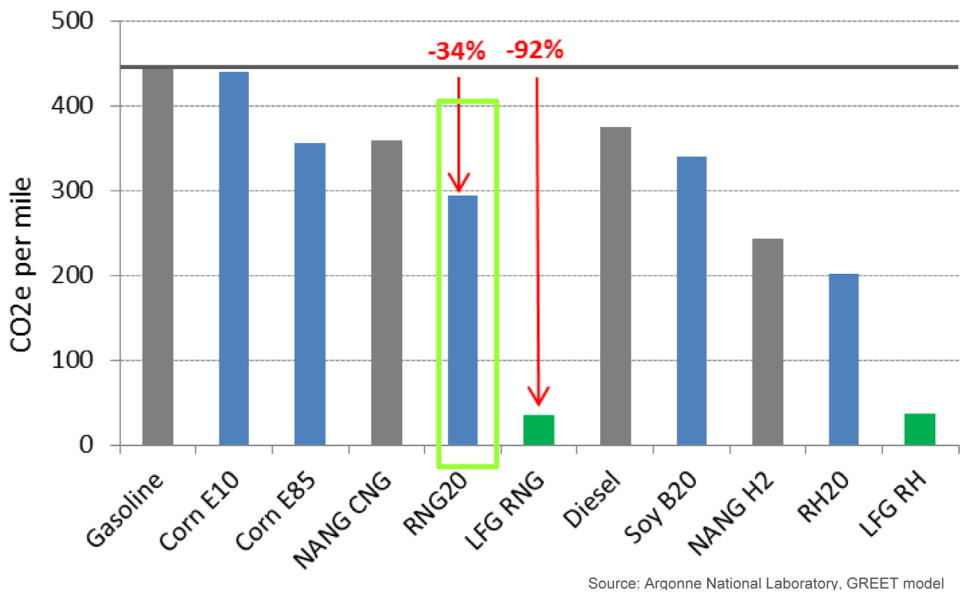
Request information such as the following at the beginning of the process: budget quotes; anything requiring a signature: e.g. site and permit information; letters of commitment and support. Sometimes it takes longer to get a few signatures than to write an entire proposal.

Manage time efficiently. Set and meet time lines in gathering information and writing the proposal. Plan to submit the proposal 24 hours before it is due, especially if an electronic submission process is involved, because a high volume of submissions at the last moment is typical and can jam the system. It is important to work with an electronic submission specialist.

More generally, it is important for Clean Cities coalitions to build relationships and explore project ideas among public agencies, waste generators and managers, vehicle providers, fleet managers, infrastructure and fuel providers, and other prospective RNG partners before a grant solicitation is announced. In this way they can be better prepared to respond to grant opportunities when these arise.

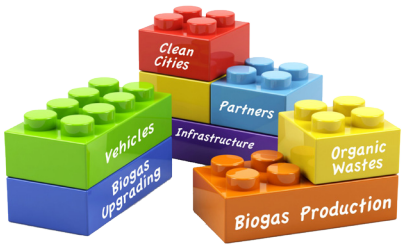
Scientists at Argonne National Laboratory have recently calculated the "lifecycle" greenhouse gas emissions (GHG) of renewable natural gas made from landfill gas (LFGRNG) and compared them with those of other fuels, including conventional gasoline and diesel, North American natural gas (NANG), ethanol blends from corn (E10 and 85), biodiesel blends from soy beans (B20), and renewable hydrogen made from landfill gas (LFG-RH). The GHG benefit achieved by using RNG made from landfill gas is greater by far than that of any available alternative fuel – and is about equal to the benefit of renewable hydrogen. (which is not yet commercial).

Lifecycle Greenhouse Gas Benefits of Conventional and Alternative Vehicle Fuels



Source: Marianne Mintz & Andrew Burnham, Argonne National Laboratory, *Demonstrating Energy and Greenhouse Gas Benefits of Renewable Natural Gas*

8 Wrap-up



The *Waste-to-Wheels* Workshop provided training to representatives of 29 Clean Cities coalitions concerning a promising new alternative fuel: renewable natural gas (RNG), also called biomethane. During the course of six panels, two luncheon speeches, and four site visits, workshop participants heard about the basic components of RNG fuel projects. Important points were summarized by Erik Neandross.

Vast amounts of organic wastes, the feedstocks for RNG, are churned out daily by households, institutions, factories, and farms in every state in the country. In total, if these wastes were converted to vehicle fuel, they could replace 25% of the annual consumption of diesel fuel by highway vehicles. Yet the energy value of these wastes remains largely untapped.

Sites where organic wastes are already being aggregated and where biogas is produced and collected include landfills, wastewater treatment plants, and farm-based anaerobic digesters and manure lagoons. By investing in technology to upgrade the raw biogas to nearly pure methane, these sites can become producers of RNG vehicle fuel.

The many benefits of converting organic wastes into RNG vehicle fuel – which make this fuel sustainable – include the following:

- Reduction of global warming both through the capture of methane emissions from wastes and the displacement of carbon dioxide emissions from the burning of petroleum fuel
- Reduction of U.S. dependence on foreign oil, which increases national economic security
- Reduction of air pollution from tailpipe emissions
- Creation of green jobs

At landfills, wastewater plants, and on farms, biogas-to-energy projects produce primarily electricity for sale into the grid and/or local heat and power. Very little biogas is currently being upgraded for vehicle fuel use because RNG is expensive to produce (relative to the wholesale price of conventional natural gas), fuel markets are still small, and RNG production is actually discouraged by current federal and state renewable energy policies that reward the use of biogas to make only electricity, not vehicle fuel.

Nonetheless, projects to develop RNG as a vehicle fuel are beginning to emerge in the U.S. A number of examples were presented at the workshop; others were observed on field trips.

- Linde and Waste Management have built the world's largest landfill gas to liquefied natural gas (LNG) plant at Altamont, California.
- Flint and Swedish Biogas are turning a municipal wastewater treatment plant into a producer of electricity, pipeline gas, and vehicle fuel.

- The Vander Haak dairy in Washington State is preparing to make vehicle fuel at a digester that turns wastes from 1200 dairy cows into biogas.
- quasar energy group is building anaerobic digesters in Ohio and several other states to convert farm and food processing wastes to electricity now, and vehicle fuel in the future.
- Franklin County Landfill, owned by the Solid Waste Authority of Central Ohio, has a biogas cleanup plant and uses the RNG it produces for fueling some of its own vehicles.
- The Rumpke company's Cincinnati landfill has the nation's largest biogas upgrading plant for sale of RNG into the pipeline grid, which is owned and operated by Montauk Energy. This plant will soon make RNG fuel for some of Rumpke's trucks.

A crucial key to success in an RNG fuel project is to get a firm commitment from end-users of the RNG vehicle fuel. This commitment provides predictability of income, which is needed for project financing. Grants from public agencies are nearly always needed to help cover the up-front investment costs.

Most Clean Cities coordinators are not experts on RNG, but they don't need to be in order to launch RNG projects in their communities. Their best role is to facilitate and coordinate project teams – to bring key partners to the table including project developers, generators of organic wastes, technology consultants and providers, end-user fleets, fuel station builders, local gas utilities, public agencies, financial institutions, public agencies, and others.

Project development takes a long time, so it is important to begin early to identify possible RNG production sites, talk with prospective partners, and identify grant, loan, and equity sources for financing. Where project opportunities are already under consideration, as is often the case, Clean Cities coalitions should become involved in those discussions, making the case for utilizing RNG in vehicles where it can achieve significant reducations in greenhouse gases and other pollutants; displace largely imported petroleum; and boost local economic development, job growth, and local energy resources. By starting now with public education programs and outreach to prospective partners, Clean Cities coordinators will be prepared to respond to RNG-targeted funding opportunities, as these evolve in the future.

RON MILLS, EXECUTIVE DIRECTOR
SOLID WASTE AUTHORITY OF CENTRAL OHIO (SWACO)

In my 35 years in the solid waste sector, the single most important change that I have witnessed is a change in attitude. We no longer look at waste as something to get rid of at the cheapest price, but as a resource from which we need to extract valuable commodities, including energy. This approach has led to competition in developing alternatives to traditional landfilling, and competition is a wonderful thing. It leads to innovation. It leads to economies of scale. And it leads to entrepreneurship.

But competition has to be considered within the context of the overall business climate and what will be sustainable not only environmentally but economically. A great environmental idea that isn't economic won't be around very long.

In late 2000, SWACO actually rewrote our mission statement to treat solid waste as a resource in terms of yielding commodities. We also underscored the need to reduce reliance on landfills in the future, using sound and viable alternative technologies.

SWACO owns and operates the Franklin County Landfill. We take in almost 4 thousand tons every day that we're open, with almost 950,000 tons total intake projected for 2011. Our landfill is the eighth largest publicly owned and operated landfill in the country. But SWACO does more than just landfilling. We operate the largest recycling-drop off facility in the U.S., with 225 locations scattered around the Columbus area and about 1000 containers. We are also partners with Kurtz Brothers and quasar energy group to build an anaerobic digestion facility within the city of Columbus to produce electricity or to make methane gas that we can turn into other fuels.

Photo: SWACO, John Remy

Ron Mills,
Executive Director, SWACO

At the landfill, we are very proud of our green energy center that converts our landfill gas into compressed natural gas using Acrion CO_2 Wash technology. When fully built out, this project can generate 10 million gasoline gallon equivalents of CNG per year. That's enough fuel to power the entire refuse collection fleet of 12 American cities about the size of Columbus.

CNG from landfill gas is a green renewable fuel. It burns cleaner in vehicles than does traditional gasoline and certainly than diesel fuel. It serves as an economic engine. It creates jobs. It stimulates the economy. And it reduces reliance on foreign oil.

Let's look at that last point – the potential of this application to reduce our reliance on foreign oil. Based on the SWACO experience, if the largest of our country's landfills converted biogas to vehicle fuel, we could produce billions of gasoline gallon equivalents per year and reduce our need for imports.

Sounds great. Are there any issues related to using landfill gas to make vehicle fuel? There certainly are. Here in Ohio, the state has established goals for solid waste districts like SWACO to reduce reliance on landfills as their principal disposal option. The state is also starting to create incentives for companies that keep energy-rich materials out of the mixed solid waste stream and convert these materials into electricity and fuel.

One week ago today [*i.e., on November 23, 2010*], Ohio issued a draft policy that would deregulate facilities using thermal and biological conversion technologies "such as pyrolysis, gasification, and anaerobic digestion, to convert solid waste to fuel". This policy aims to accelerate investment in engineered systems for converting waste to energy and eliminate some of the bureaucracy that will be involved.

A second part of this policy would lighten the regulatiion of companies making energy from wastes by excluding from the definition of "solid waste" those materials, such as foodwastes, that can be used to produce energy, if three conditions are met:

- They are handled as a valuable commodity.
- They have meaningful heating value.
- They do not contain contaminants significantly higher in concentration than traditional fuel products.

What these conditions might mean in practice is anyone's guess because they not yet precisely defined. But the growth of incentives to keep organics out of landfills raises the interesting question: Is landfilling an obsolete technology? I think it is. But let's draw a distinction between technical obsolescence and functional obsolescence.

Here in Central Ohio, we look at waste disposal costs in the range of $45 to $55 per ton. The engineered systems for producing biofuels that I've seen around the country are much more expensive. How long will it take for those systems to come on board? Ten years? Fifteen years? No one knows.

The CO_2 Wash technology by Acrion is used to make fuel at SWACO's Franklin County Landfill.

Yet for our landfills to utilize the kind of biogas-to-energy system that we already have in place at SWACO, we have to accept the fact that from a business point of view, SWACO and its business partner need to commit to landfill gas-to-energy technology for a 10- to 20-year time period to earn back our investment and returns on that investment. So where does SWACO go with its landfill gas-to-energy project? I am not suggesting that SWACO would be in opposition to the state's new solid waste policy directions. But I go back to the word "transition." We have to be wise about how we transition. It can't happen without regard to collateral impacts.

So a business plan needs to be developed in my shop. We need to plan for a transition that advances the new engineering systems while also achieving our goal of biomethane fuel production, so as to avoid negative financial and economic consequences. As the landfill owner and operator, SWACO needs to maximize its return on investment in as short a time frame as possible. We need to explore structuring terms like "price floors" for sale of gas to a private partner to limit our risk; and we need to negotiate a higher rate of return based on the higher quality of gas we produce at our site. SWACO has invested a lot of resources to operate that landfill as well as we can to generate as high quality gas as we can. And I want to be rewarded for that in revenue.

A private partner also needs to maximize return on investment in as short a time as possible. Instead of price floors for the gas, this partner needs to have price ceilings for the purchase of the biogas from the landfill. Finally, from the point of view of the private investor, a long-term commitment is needed that is not based solely on landfill gas but is based on integrating and transitioning into advanced engineering systems.

I want to look at a transition strategy that should include an orderly plan for transition with a private partner. Perhaps that includes the private partner investing in the advanced engineering system right at the landfill.

Most of the prospective private partners I have discussed this with hope to explore the generation of gas from other sources in addition to the landfill. They want to arrange long-term takeoff agreements for buyers of the landfill gas to set the stage for their investment, in a follow-up stage, in the types of engineering systems we have been talking about.

CHUCK WHITE, CALIFORNIA LEGISLATIVE DIRECTOR WASTE MANAGEMENT

Waste Management is really turning our attention to the production of low-carbon and renewable transportation fuels. We have about 19,000 heavy-duty vehicles nationwide. About 1000 of them, slightly more than 5% of the fleet, are natural gas vehicles, 800 of which are located in California. Half of the California-based trucks use liquefied natural gas (LNG) and half use compressed natural gas (CNG).

Waste Management is really focused on the natural gas platform moving forward. In good economic times, we have been buying as many as 1200 new trucks per year, and in the future many of these trucks will be natural gas vehicles.

The low-hanging fruit for Waste Management is clearly landfill gas because we own many landfills as well as the fleets that can use fuel made from landfill gas. At the Altamont landfill in the Bay Area, we have created a partnership with Linde, one of the largest industrial gas suppliers, to build the world's first commercial-scale LNG plant for natural gas. Linde is a great partner. We also work with the Gas Technology Institute and other partners.

At Altamont, we are technically producing up to 13,000 diesel-equivalent gallons per day and using it to fuel our LNG fleets around California. Over 400 refuse trucks are running on low-carbon LNG.

The main challenge we have right now is that carbon markets are not fully developed. This is true even in California. This month the California Air Resources Board (CARB) is launching the first cap and trade system in the U.S. Two years ago CARB adopted the Low Carbon Fuel Standard. But the revenues that may be generated through these programs will take a number of years to develop. So before such systems come into play, we need to bridge a financial gap to make renewable fuel projects a reality – because they are expensive.

Waste Management and Linde are hoping to build a second landfill gas-to-LNG plant in southern California. The California Energy Commission has offered us $11 million out of a $22 million capital cost. That public investment is absolutely essential if we are going to build plants like these. We need to have assistance until the true value of bio-LNG is recognized. We also need to have tax credits for renewable natural gas. We need to work with public partners who are trying to make these projects a reality. And I can tell you that Waste Management stands ready to do this.

We've got a number of projects in addition to bio-LNG. We are looking at gasification technologies. We're looking at anaerobic digestion technologies. We're looking at green gasoline technologies and even at green chemistry technologies.

For us, the first low-hanging fruit in the conversion of waste to energy and other valuable products, has been in the production of electricity from landfill gas, in part because of the federal and state incentives that reward these investments. Now we are transitioning into the production of renewable fuels, and then we are going to be transitioning into biochemicals in the future. There is a whole new world opening up for the waste management industry, and I like to think that Waste Management is taking the lead.

Source: Linde and Waste Management

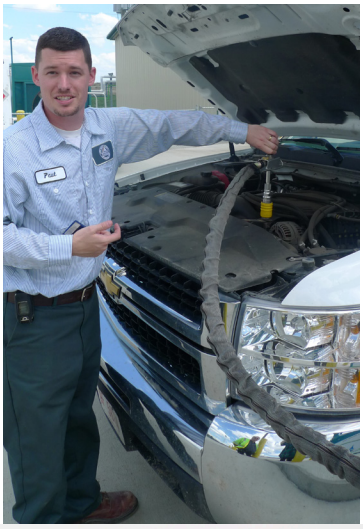
The landfill gas-to-renewable natural gas plant, a joint project of Linde and Waste Management , went into operation in 2010 at the Altamont Landfill in California.

Field Trips - November 30 & December 1, 2010

Organized by Clean Fuels Ohio

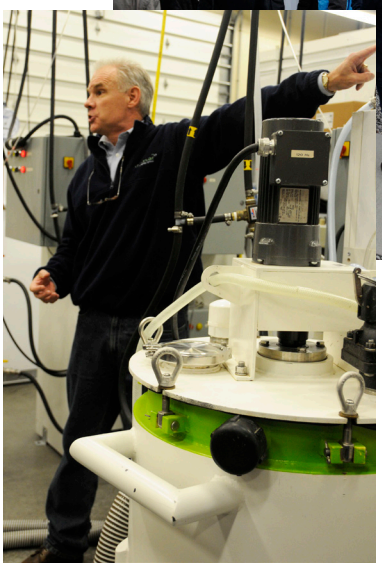
The Franklin County landfill, owned by the Solid Waste Authority of Central Ohio (SWACO), makes compressed natural gas vehicle fuel from landfill gas, using the Acrion CO_2 Wash technology. Clockwise from bottom right: *workshop participants during their visit to the landfill on November 30. Bill Brown (left) of Acrion, and Dennis Smith, of the U.S. Department of Energy's Clean Cities Program; gas collection pump on a closed section of the landfill; Paul Flory of SWACO describing the CO_2 Wash "skid," where the landfill gas impurities are removed; Flory filling up the tank of a pickup truck with CNG.*

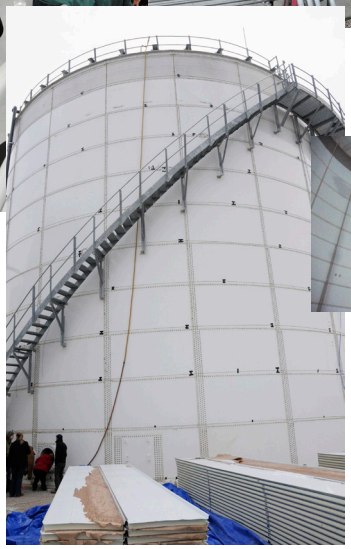
SWACO 11/30

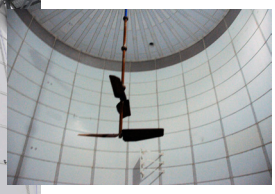


quasar 11/30 & 12/1

Quasar energy group introduced workshop participants to two of its plant sites - a demonstration plant located on the campus of the Ohio Agriculture Research and Demonstration Center (OARDC) of Ohio State University, at Wooster; and a plant under construction in Columbus. Clockwise from top left: *the Wooster digester; Mel Kurtz, quasar president; workshop participants at the Wooster plant (center); biogas cleanup technology at the Wooster plant; the processor and processor blade at quasar's digester in Columbus, which is still under construction; Marianne Mintz of Argonne and Georg Merion of quasar at the Columbus plant site; and Russ Yoder showing off OARDC lab equipment where tests are performed on prospective feedstocks for quasar plants.*







Rumpke 12/1

Rumpke's family-owned waste management business includes a large landfill in Cincinnati. Clockwise from top left: *trucks traveling to and from the landfill; a gas collection pipeline; the gas upgrading plant located at the landfill and owned by Montauk Energy, which has been injecting pipeline grade gas into the grid for many years; Rumpke vehicles, some of which will soon be fueled by renewable natural gas made on site.*

APPENDICES

Workshop Agenda

Workshop Presentations

Speaker Bios

Speaker Contact Information

Field Trip Agenda

Web Resources Suggested by Presenters

December 1st 2010

Waste-to-Wheels Workshop Agenda

7:00	***Registration and continental breakfast***	
8:00	***Introduction and overview***	
	Workshop overview, schedule and introductions	Sam Spofforth, Clean Fuels Ohio
	The role of RNG in the Clean Cities' portfolio	Dennis Smith, U.S. Department of Energy (DOE)
	Promise and challenge of RNG as a vehicle fuel	Erik Neandross, Gladstein-Neandross Assoc. (GNA)
8:45	***Sourcing organic material***	
	Landfills: sources of organic material & RNG fuel	Bob Simkins, Burlington Co. Resource Recovery Co
	Integrating organic wastes: sourcing, digesting and composting	Craig Coker, Coker Composting & Consulting
	RNG & WWT: current practice & potential benefits	Michael Wardell, Mid-Atlantic Biosolids Associatio
	Alternative feedstock streams: finding the best fit	Clemens Halene, Quasar energy group
10:15	***BREAK***	
10:30	***Processing 101***	
	Anaerobic digestion	Kelsi Bracmort, U.S. Congressional Research Servic
	Gas cleanup	Jeff Cook, Acrion Technologies
11:20	***Vehicles and infrastructure***	
	Natural gas vehicles: what's here & what's coming	Sean Turner, GNA
	Natural gas stations: a primer to design	Rob Adams, Marathon Technical Services
12:00	***LUNCH: Sponsored by the Linde group and Waste Management (WM)***	
	From refuse to refueling	Chuck White, WM and Bryan Luftglass, Linde
	Resource competition & tradeoffs	Ron Mills, Solid Waste Association of Central Ohio
1:15	***Assembling the pieces (Panel discussions)***	
	Evaluating supply, demand and regulatory hurdles	Evan Williams, Cambrian Energy Mel Kurtz, Quasar energy group Chris Cavanaugh, National Grid
	Finding key partners: capitalizing on champions and opportunities	Stephanie Meyn, Puget Sound Clean Cities Eric Leonhardt, Western Washington University Anna Brynas, Swedish Biogas Bryan Luftglass, Linde
3:00	***BREAK***	
3:15	***Making the case***	Dennis Smith, DOE
	Elements of a winning proposal	Erik Neandross, GNA
	Demonstrating energy and greenhouse gas benefits	Marianne Mintz, Argonne National Laboratory
	Leveraging financial incentives and programs	Ted Barnes, Gas Technology Institute
	Practical routes to incentivizing biogas production	Ralph Hirshberg, Civil and Environmental Consulta
4:30	***Summary and conclusions***	Erik Neandross, GNA
5:30	***Reception: Sponsored by Quasar energy group and Clean Fuels Ohio***	

PRESENTATIONS

Listed by the Chapter that Draws on Each One

DOWNLOADS: http://www1.eere.energy.gov/cleancities/waste_to_wheels.html

1. WORKSHOP INTRODUCTION

Renewable Natural Gas: The Role of RNG in the Clean Cities Portfolio - *Dennis Smith, U.S. Department of Energy, Clean Cities Program*

2. THE BIG PICTURE

Promise and Challenge of Renewable Natural Gas as a Vehicle Fuel
Erik Neandross, Gladstein, Neandross and Associates

3. WASTE & BIOGAS SOURCES

Sanitary Landfills: Source of Organic Materials and Biomethane Transport Fuel
Robert Simkins, County of Burlington, NJ

RNG and Wastewater Treatment: Current Practice and Potential Benefits
Michael Wardell, Mid-Atlantic Biosolids Association

Integrating Organics: Sourcing, Digesting, Composting
Craig Coker, Coker Composting & Consulting

Feedstock Streams for Anaerobic Digesters
Clemens Halene, quasar energy group

4. BIOGAS PROCESSING 101

Anaerobic Digestion
Kelsi Bracmort, Congressional Research Service

Processing 101: Gas Cleanup
Jeffrey Cook, Acrion Technologies

6. VEHICLES AND FUELING

Natural Gas Vehicles: What's Here & What's Coming
Sean Turner, Gladstein, Neandross & Associates

Station Design Primer
Rob Adams, Marathon Technical Services

7. PARTNERS & PROJECTS

Partnering on the Altamont Landfill Gas to LNG Plant
Bryan Luftglass, Linde

Wastewater Plant Biogas to RNG
Anna Brynås, Swedish Biogas International

Leveraging Financial Incentives and Programs
Ted Barnes, Gas Technology Institutel

Finding Key Partners—Puget Sound Clean Cities Experience with a Dairy Digester Biogas Project
Stephanie Meyn, Puget Sound Clean Cities; and Eric Leonhardt, Western Washington University

Anaerobic Digesters Across Ohio
Mel Kurtz, quasar energy group

Renewable Gas and Transportation
Christopher Cavanagh, National Grid

An RNG Developer's Perspective: It's a Numbers Game!
Evan Williams, Cambrian Energy

Sustainable Transportation Solutions for the 21st Century: Landfill Gas to Vehicle Fuel Development Perspectives
Ralph Hirshberg, Civil & Environmental Consultants, Inc.

8. MAKING THE CASE

Elements of a Winning Grant Proposal
Erik Neandross, Gladstein, Neandross & Associates

Demonstrating Energy and Greenhouse Gas Benefits of Renewable Natural Gas
Marianne Mintz and Andrew Burnham, Argonne National Laboratory

9. WRAP-UP

Erik Neandross—Gladstein, Neandross & Associates

SPEAKER BIOS

Rob Adams

Rob Adams is a Professional Engineer and Accountant with over 26 years of continuous experience in the Compressed Natural Gas (CNG) market. He is a hands-on consultant who is nationally recognized for CNG station design and project management, natural gas vehicle building upgrade design, and CNG education, training and business consulting.

Mr. Adams began his career as a Staff Engineer at a large gas utility where he helped establish CNG station design and operation standards. He then co-founded and operated a major CNG station equipment manufacturer and contractor. Mr. Adams is now the Principal Engineer for Marathon Technical Services, a leader in the North American natural gas vehicle consulting market with an emphasis on infrastructure design. Mr. Adams and Marathon are known as experts in the design of larger and more technically challenging natural gas facilities.

Ted Barnes

As Principal Engineer for Advanced Energy Systems Ted Barnes manages advanced fuel technology projects for the Gas Technology Institute (GTI). He is currently the project manager for GTI on the US DOE Clean Cities ARRA funded grant that is deploying alternative fueled vehicles and fueling stations across the Chicago area. Other projects that Mr. Barnes is managing involve renewable natural gas clean-up for use in fuel cell systems, landfill gas clean-up and liquefaction for use as a vehicle fuel, and hydrogen production from biogas. His past work experiences have included design engineering in a contract manufacturing environment and electro-mechanical systems design in the defense industry. Mr. Barnes is a Registered P.E. and has a BS in Mechanical Engineering and Materials Science from Duke University and a MS in Mechanical Engineering from Yale University.

Kelsi Bracmort

Kelsi Bracmort is a policy analyst for agricultural conservation and natural resources policy for the Congressional Research Service (CRS). CRS serves the Congress throughout the legislative process by providing comprehensive and reliable legislative research and analysis. She covers biomass energy, including cellulosic ethanol and anaerobic digestion. Prior to joining CRS, Dr. Bracmort worked as an agricultural engineer at the U.S. Department of Agriculture Natural Resources Conservation Service and the Department's Global Change Program Office. Her international experience includes working as an Embassy Science Fellow in the Philippines to provide technical expertise concerning methane capture from agricultural sources and promoting the Methane to Markets Partnership. She received a B.S. degree in agricultural and biosystems engineering from North Carolina A&T State University, and a M.S. and Ph.D. degree in agricultural and biological engineering from Purdue University.

Anna Brynas

Anna Brynas is the Lab Manager and Process Engineer at Swedish Biogas International LLC in Flint, MI. Before taking the opportunity to come the U.S she had been working as a Biogas Process Engineer at the Swedish Biogas mother company in Linköping, Sweden. She previously worked at Tekniska Verken as a part of their advanced biogas research team. Before that she worked as a process engineer at Siemens Industrial Turbo machinery. Ms. Brynas received her Ms. Sc in Chemical Engineering from Chalmers University of Technology in Gothenburg, Sweden, with the orientation Energy and Environment.

Chris Cavanaugh

Mr. Cavanagh is a principal engineer in the New Products/Energy Services team at National Grid. He has 29 years of experience in the energy industry after six years at Gibbs & Hill Inc., a large Architecture-Engineering firm. Mr. Cavanagh has led programs that support the technology development and market deployment of new technologies including fuel cells, alternative fuel vehicles, efficient HVAC equipment and (most recently) renewable pipeline gas. Mr. Cavanagh holds BS, MS and MBA degrees and is a registered professional engineer in NY and NJ.

Craig Coker

Craig Coker is a Sanitary Engineer with over 30 years of experience in the planning, permitting, design, construction and operation of organics recycling facilities that process a wide variety of feedstocks using several composting and digestion technologies, as well as in the marketing and sales of compost and compost-amended horticultural products. Mr. Coker is a licensed Waste Management Facility Operator and a certified Nutrient Management Planner and holds an undergraduate degree in Environmental Science from the University of Virginia and a graduate degree in Sanitary Engineering from George Washington University. He serves on the Boards of Directors of the U.S. Composting Council and the North Carolina Composting Council, and is a Contributing Editor to Biocycle magazine.

W. Jeff Cook

Jeff Cook is Vice President of Acrion Technologies and is the co-inventor of the patented CO2 Wash® process for landfill gas cleanup. He is currently involved in commercializing the process to produce renewable transportation fuels from landfill gas. Mr. Cook has worked as a chemical engineer in the area of gas processing for the past 20 years. He holds a B.S. and M.S. in chemical engineering from Case Western Reserve University and is a registered professional engineer in the state of Ohio.

Clemens Halene

Vice-President of Engineering at quasar energy group, Clemens Halene is a German citizen and has been in the United States since 1999. He has held positions of Vice President of Engineering and Marketing to President. He formerly held the position of President of Tekfor USA, which is a subsidiary of the worldwide Neumayer Group, a German-based global supplier of precision machined steel forgings with 2,200 employees worldwide. The U.S. operation and manufacturing plant was started in 2001 to serve U.S. automotive customers. Halene left the automotive industry specifically to seek a new start in energy. Halene holds an M.S. in Mechanical Engineering, from the Technical University of Karlsruhe, Germany.

Ralph Hirshberg

Mr. Hirshberg is a Principal with Civil & Environmental Consultants, Inc. (Cincinnati). With over 24 years of experience in the solid and hazardous waste industries, he has extensive experience in the permitting, design, construction and operation of a wide range of waste disposal and environmental facilities. Following 10 years of work on conventional solid and hazardous waste facility design, Mr. Hirshberg shifted his focus to landfill gas, specifically remediation of landfill gas impacts to soil, water and air, migration control, and the use of collected landfill gas for beneficial re-use with a focus on high-Btu utilization. Most recently, Mr. Hirshberg's efforts have been concentrated on advanced methods of landfill gas treatment, including technology platforms capable of producing vehicle fuel as well as pipeline quality natural gas, and integrated nitrogen removal systems which facilitate processing of landfill gas to typical high Btu pipeline standards without intensive well field control or loss of production capacity.

Looking forward, Mr. Hirshberg anticipates the expanded use of processed landfill gas as a vehicle fuel to require continued testing and advancement of processing technologies. These efforts include evaluation of technologies which also facilitate cross-over application to various biogas sources including digesters and similar methane generating units.

Mel Kurtz

Since 1971, Mel Kurtz has founded, directed, and operated several businesses from start up to millions in annual sales through effective business planning, creative sales techniques, and innovative marketing. His accomplishments also include initiating well planned and executed acquisitions and mergers. Kurtz is currently the chief executive advisor for several corporations and leads the US industry for quasar energy group.

Bryan Luftglass

Bryan Luftglass joined Linde, then BOC Gases, in 2003 as Manager of New Business Development. He is currently the Head of Chemistry, Energy and Environmental Solutions for Linde in North America. Prior to joining Linde, Mr. Luftglass worked for energy and environmental technology start-up companies and as a business consultant. He has a background in the physical sciences and holds a bachelors degree in geology from Colgate University and a masters in earth sciences from the Scripps Institution of Oceanography.

Stephanie Meyn

Stephanie Meyn is the Coordinator for the Puget Sound Clean Cities Coalition. Since joining the Coalition in November 2008, she has successfully secured $15 million from the U.S. Department of Energy to support a suite of alternative fuel and advanced technology projects. These projects include a pilot test of biomethane in tour buses; the purchase of alternative fuel vehicles and supporting infrastructure; and electrification of ground support equipment at Seattle-Tacoma International Airport. Stephanie also plays an integral role in administering and promoting the Evergreen Fleets program. Evergreen Fleets offers efficient and budget-friendly best practices to help fleets conserve fuel, reduce emissions and ultimately achieve certification as a 'green' fleet. Stephanie holds a Master's degree in atmospheric science, with a diverse set of experiences in air quality management planning, government regulation development, numerical modeling, and measuring energy efficiency in buildings.

Ron Mills

As Executive Director of the Solid Waste Authority of Central Ohio (SWACO) Ron Mills oversees all SWACO operations including the Green Energy Center (which turns landfill methane into vehicle fuel), the Franklin County Sanitary Landfill, three municipal solid waste transfer stations and associated transfer fleet, oversight of a county wide yard waste diversion program, the nation's largest residential drop-off recycling program, (225 locations), and a household hazardous waste collection and recycling program. Before his appointment in 2007 to the Executive Director's position, Mills served as Assistant Executive Director of SWACO. During his career, he has also worked as a Senior Associate for Malcolm Pirnie Engineers, a Compliance Officer for the Illinois EPA and a Field Enforcement Officer for the U.S. EPA. Mr. Mills holds a B.A. and M.S. from Southern Illinois University.

Mr. Mills believes in building strong public-private partnerships that benefit the community and bring economic development from what society has in the past considered trash. He sees his role as the leader of one of the top solid waste management districts as an opportunity to ensure an orderly transition from traditional disposal and land-filling to new material processing/recovery methods.

Marianne Mintz

Marianne Mintz specializes in transportation energy forecasting and policy analysis for Argonne National Laboratory's Center for Transportation Research. She has over 30 years' experience in transportation and energy analysis and has authored over 100 publications in the field. Her recent work centers on infrastructure requirements of alternative fuel pathways, hydrogen delivery, fuel transitions and the energy and greenhouse gas emissions associated with hydrogen and renewable natural gas. Mintz is an active member of the Transportation Research Board (TRB), past chair of TRB's Transportation Energy Committee and a current member of the Special Task Force on Transportation and Climate Change. She holds a masters degree from UCLA and has completed post-graduate work at the University of Illinois at Chicago.

Erik Neandross

Erik Neandross is the CEO of Gladstein, Neandross & Associates (GNA), an environmental consulting firm with offices in Santa Monica, California and New York City. Specializing in emission reduction, energy and transportation policy, and market development for alternative fuel vehicles, GNA specializes in heavy-duty natural gas vehicle projects, including biomethane project development. The company is actively involved in several biomethane project development efforts including wastewater treatment plants, landfills, and food waste digestion projects. GNA publishes BioMethane Buzz, and regularly hosts and speaks at biogas and biomethane conferences around the world.

With 17 years of experience, GNA has assisted in a large number of the LNG vehicle fuel projects in the United States. Mr. Neandross has more than a decade of experience in the development of advanced transportation and alternative fuel vehicle and refueling infrastructure projects throughout the nation, with a significant focus on both LNG and CNG for heavy-duty fleet applications. GNA has overseen the development of some of the world's largest and most cutting edge NGV vehicle, infrastructure and biomethane development projects. Mr. Neandross and his company provide NGV consulting services to the NGV industry including heavy-duty truck and engine manufacturers, fuel suppliers, and other participants, as well as to leading national fleet operators including United Parcel Service, Waste Management, Ryder Truck, City of Los Angeles, Sysco Food Services, Kroger, California Cartage Company, Nestle, Aramark, and others.

Robert Simkins

Robert Simkins has worked in the field of solid waste management and resource recovery for the County of Burlington, NJ for the past thirty-five years. During this time he has been instrumental in the preparation of the County's Solid Waste Management Plans, the siting of its 525-acre Resource Recovery Complex, and the design, permitting, operation and maintenance of multiple facilities located therein for the treatment, processing, recovery and disposal of municipal solid waste and biosolids.

He has extensive knowledge in landfill gas management, including gas cleanup technologies for the production of biomethane transportation fuel. He participated in the first US commercial demonstration project to produce liquid biomethane transport fuel from landfill gas in 2005. The fuel was successfully used in two LNG powered refuse trucks during the five-month demonstration period. He is currently participating in a feasibility study to process landfill gas for use in a stationary fuel cell for heat and power production with co-products of biomethane, liquid food-grade carbon dioxide, hydrogen, and Hythane.

Mr. Simkins is an active advocate for policies and waste management practices to optimize the use of organic waste for the production and use of biomethane as a clean, renewable transportation fuel in the heavy duty vehicle sector.

Dennis Smith

Dennis Smith is the technology deployment manager for the Department of Energy's (DOE) Office of Vehicle Technologies in Washington, D.C. He also serves as the national Clean Cities director. His duties include working closely with truck and auto manufacturers, fuel providers, state and regional governments, national laboratories, public safety officials, and other key stakeholders to expand the use of alternative fuels and other petroleum reduction technologies and practices in the transportation sector. Other DOE duties have included managing a research and development portfolio related to renewable and alternative fuels, and engine and vehicle development. Smith is a registered professional engineer and a certified energy manager and has been working in the energy and environmental industry for nearly 30 years.

Prior to DOE, Smith served as Director of Energy Services at Atlanta Gas Light Company (AGLC), a large Atlanta-based utility. During his 20 years at AGLC, he specialized in introducing new energy and environmental technologies to private industry and the general marketplace. From 1992 to 1996, Smith served as president of the American Gas Association's Olympic Clean Air Team, which was responsible for all logistics and operations associated with the fleet of 600 natural gas vehicles used to support the 1996 Atlanta Summer Olympics.

Sam Spofforth

Sam Spofforth has served as Executive Director of Clean Fuels Ohio since the organization's founding in 2002. Under Spofforth's leadership, Clean Fuels Ohio has become the "go to" resource in Ohio for cleaner fuels, vehicles and energy-saving transportation technologies that reduce climate change, increase American energy security and strengthen Ohio's economy. He plays a leadership role in Ohio and nationally in the field of transportation energy deployment. Spofforth was appointed to Columbus Mayor Coleman's Green Team and Chairs the Mayor's Green Transportation Committee. In 2007, Spofforth was named the U.S. Department of Energy's national Clean Cities Coordinator of the Year. The DOE selected him as Midwest Clean Cities Coordinator of the Year in 2004. In 2008 General Motors selected Clean Fuels Ohio as top coalition for their Clean Cities Rewards program. Spofforth holds a Bachelor's degree from Hiram College and a Masters in Public Administration from the University of Pennsylvania.

Sean H. Turner

As Senior Vice President of Operations at Gladstein Neandross & Associates (GNA) Sean Turner provides technical oversight on alternative fuel initiatives, air quality improvement, and vehicular technology for several clients. He has worked in international engineering consulting and government affairs on automotive emissions, alternative fuels, and air quality issues for the past 17 years. Mr. Turner previously served as president of the California Natural Gas Vehicle Coalition (CNGVC). His work there established a new regulatory and legislative presence in California. Before managing the CNGVC, Mr. Turner spent two years working in Cairo, Egypt as a compressed natural gas specialist on the Cairo Air Improvement Project (CAIP). From 1995 until 1998, Mr. Turner was director of technology for the National Natural Gas Vehicle Coalition (NGVC) in Washington, DC. In this capacity Mr. Turner managed all technology-related issues for the organization, as well as the development of national safety standards for natural gas vehicles and fueling infrastructure. Mr. Turner has a Bachelor of Science degree in Mechanical Engineering from Washington University in St. Louis, Missouri and a Master of Business Administration degree from UCLA.

Michael Wardell

Michael Wardell has been active in the environmental field since 1974, working in public health as well as municipal planning. In 1984 he became involved in the wastewater industry, primarily with the permitting and operation of biosolids management facilities. In 1989 his company, Land Resource Recycling Management began contract operation of the largest municipally owned biosolids management facility located in Vineland, NJ.
In 2001 Michael moved to upstate NY, and in 2004 became one of the first auditors for the National Biosolids Partnership, a joint venture of the Water Environment Federation and USEPA. This program, based on the ISO 14001 Environmental Management Systems standard, certifies biosolids programs at approximately 30 facilities throughout the US.

Mr. Wardell is currently the Executive Director of the Mid-Atlantic Biosolids Association, an outreach and education organization operating in the mid-Atlantic region since 1998. He is also a certified Environmental and Quality Systems auditor, and the Director of Quality of a contract manufacturing firm located in Saugerties, NY. Michael has a BA in General Science and a MS in Biology, both from Rutgers University.

Evan Williams

Evan Williams is the son of a motion picture character actor, Rhys Williams, and was raised in Southern California. He was educated at UCLA where he received his Bachelor of Arts in film followed by a Juris Doctorate degree from the UCLA School of Law. He is a practicing attorney with the law firm of Poindexter & Doutre, in Los Angeles, California.

Williams is a co-founder and President of Cambrian Energy Development LLC where he has developed more than 50 landfill gas-to-energy and digester gas-to-energy projects since 1980, including three landfill gas-to-pipeline quality Renewable Natural Gas projects. As an owner and manager of Cambrian Energy and as legal counsel to lending institutions and to a European wind turbine supplier, Williams has participated in more than $1 billion in financings for U.S. renewable energy projects.

Contact Information – *Waste to Wheels* Presenters

Name	*Company*	*Work Phone*	*Email*
Barnes Ted	Gas Technology Institute	847-544-3405	ted.barnes@gastechnology.org
Bracmort Kelsi	Congressional Research Service	202-707-5700	kbracmort@crs.loc.gov
Brynas Anna	Swedish Biogas International LLC	734-680-6015	anna.brynas@swedishbiogas.com
Cavanagh Christopher	National Grid		christopher.cavanagh@us.ngrid.com
Coker Craig	Coker Composting & Consulting	540-890-1086	cscoker@verizon.net
Cook W Jeffrey	Acrion Technologies, Inc	216-901-4848	acrion@acrion.com
Halene Clemens	quasar energy group	216-986-9999	hclemens@quasarenergygroup.com
Hirshberg Ralph	Civil & Environmental Consultants, Inc.	513-985-0226	rhirshberg@cecinc.com
Kurt z Mel	quasar energy group	216-986-9999	mkurtz@quasarenergygroup.com
Luftglass Bryan	Linde North America	908-771-6449	bryan.luftglass@linde.com
Meyn Stephanie	Puget Sound Clean Air Agency	206-689-4055	StephanieM@pscleanair.org
Mills Ron	Solid Waste Authority of Central Ohio		info@swaco.org
Mintz Marianne	Argonne National Lab	630-252-5627	mmintz@anl.gov
Neandross Erik	Gladstein,Neandross & Associates	310-314-1934	erik.neandross@gladstein.org
Rood Werpy Marcy	Argonne National Laboratory	217-362-9844	mroodwerpy@anl.gov
Simkins Robert	Burlington Co.(NJ) Resource Recovery	609-499-1001	rsimkins@co.burlington.nj.us
Smith Dennis	Clean Cities Program, U.S. DOE	202-586-1791	dennis.a.smith@ee.doe.gov
Spofforth Sam	Clean Fuels Ohio	614-884-7336	sam@cleanfuelsohio.org
Turner Sean	Gladstein Neandross & Associates	310-894-1534	sean.turner@gladstein.org
Wardell Michael	Mid-Atlantic Biosolids Association	845-633-3811	mrwardell@gmail.com
White Charles	Waste Management	916-552-5859	crwhite1@wm.com
Williams Evan	Cambrian Energy	213-628-8312	evan@cambrianenergy.com

Waste-to-Wheels: *Building for Success*
Site Visit Agendas

Nov 30, 2010 – SWACO Landfill & Buckeye Biogas Anaerobic Digester Visits

SWACO Landfill Green Energy Center Visit:

- Crowne Plaza Hotel
  - 33 E Nationwide Blvd, Columbus, OH 43215
- SWACO Green Energy Center
  - 4065 London Groveport Rd, Groveport Ohio
  - ***21 min travel from hotel to SWACO Landfill***

Buckeye Biogas Site Visit:

- SWACO Green Energy Center
  - 4065 London Groveport Rd, Groveport Ohio
- Buckeye Biogas (quasar energy group)
  - 2072 Secrest Rd, Wooster, OH 44691
  - ***1 hr 51 min travel from SWACO Landfill to Buckeye Biogas***
- Crowne Plaza Hotel
  - 33 E Nationwide Blvd, Columbus, OH 43215
  - ***1 hr 40 min travel from Buckeye Biogas to Crowne Plaza***

Timeline:

- 12:00 pm – Leave Crowne Plaza
- 12:30 pm - 1:30 pm – SWACO GEC Site Visit
- 1:30 pm – 3:30 pm – Travel to Buckeye Biogas (*Boxed Lunch available during travel*)
- 3:30 pm - 4:30 pm – Buckeye Biogas Site Visit
- 4:30 pm - 6:30 pm – Return Travel to Hotel

Dec 2, 2010 – quasar energy group & Rumpke Landfill Site Visits

quasar energy group Visit:

- Crowne Plaza Hotel
  - 33 E Nationwide Blvd, Columbus, OH 43215
- quasar energy group
  - 2500 Jackson Pike Columbus, OH 43223
  - ***10 min travel from hotel to quasar energy group***

Rumpke Sanitary Landfill Visit:

- quasar energy group
  - 2500 Jackson Pike Columbus, OH 43223
- Rumpke Sanitary Landfill
  - 10795 Hughes Road. *Cincinnati*, *Ohio* 45251
  - ***1 hr 45 min travel from quasar energy group to Rumpke Landfill***
- Crowne Plaza Hotel
  - 33 E Nationwide Blvd, Columbus, OH 43215
  - ***2 hours travel from Rumpke Landfill to Crowne Plaza***

Timeline:

- 8:00 am – Leave Crowne Plaza
- 8:15 am - 9:15 am – quasar energy group Site Visit
- 9:30 am - 11:30 am – Travel to Rumpke Landfill
- 11:30 am - 12:30 pm – Rumpke Landfill Site Visit
- 12:45 pm - 2:45 pm – Return Travel to Hotel (*Boxed Lunch available during travel*)

Resources

Websites and Contact Information

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Clean Cities Website
www.cleancities.energy.gov

Clean Cities Coordinator Toolbox
www.cleancities.energy.gov/toolbox

Alternative Fuels & Advanced Vehicles Data Center
www.AFDC.energy.gov

DOE EERE Information Center and Technical Response Service
www.eere.energy.gov/afdc/informationcenter.html

Phone: 1-800-EERE-INF (1-877-337-3463)
E-mail: technicalresponse@icfi.com
Hours: 9:00 a.m. – 6:00 p.m. EST

Dennis Smith
Director DOE Clean Cities
Office: 202-586-1791
Email: Dennis.a.smith@ee.doe.gov

Linda Bluestein
Co-Director DOE Clean Cities
Office: (202) 586-6116
Fax: (202) 586-3000
Email: Linda.Bluestein@ee.doe.gov

Marianne Mintz
Argonne National Laboratory
630-252-5627
Email: mmintz@anl.gov

Marcy Rood Werpy
Argonne National Laboratory
217-362-9844
Email: mroodwerpy@anl.gov

Jim Wegrzyn
Brookhaven National Laboratory
Email: jimtheweg@bnl.gov

CO2 Removal Processes (Jeff Cook)

www.exxonmobil.com/corporate/news_features_20081101_cfz_process.aspx
www.acrion.com
www.medal.airliquide.com
www.uop.com/objects/separex_membrane_sys.pdf
www.northamerica.ube.com/content.php?pageid=135
www.xebecinc.com
www.moleculargate.com
www.uop.com/objects/97%20Selexol.pdf
www.uop.com/adsorbents/7070.html

Landfills & Transfer Stations (Bob Simkins)

USEPA Landfill Methane Outreach Program (LMOP)

www.epa.gov/lmop/index.html

– Identifies
- Landfills with existing LFGE projects
- Landfills that are candidate sites for projects
- Landfill gas project developers
- Landfill gas consulting firms
- Landfill gas cleanup companies

– Project Development Handbook
– Publications and tools, including models and calculators
– Workshops and conferences

State Departments of Environmental Protection/Division of Solid Waste Management

www.epa.gov/osw/wyl/stateprograms.htm

– May suggest candidate landfills based on site specific knowledge
– Can provide inventory and contact information for active landfills and transfer stations
– Can provide information on which hauling companies are using natural gas trucks

County, city and municipal divisions of solid waste and sustainability organizations

Solid Waste Management Association of North America (SWANA), State Chapter

swana.org

– Generally, public sector facilities.

National Solid Waste Management Association (NSWMA), State Chapter

www.nswma.org

– Generally, private facilities

Waste & Recycling News

www.wasterecyclingnews.com

– National lists of landfills, transfer stations, and collection companies.

Natural gas companies

Contact the state Board of Public Utilities, Energy Commission or similar agency that regulates natural gas sales and distribution.

100 Land Grant Universities

www.csrees.usda.gov/qlinks/partners/state_partners.html

Some involved with AD and biogas cleanup systems.

National Business Incubator Association

www.nbia.org/links_to_member_incubators
www.nbia.org

Some incubators work with ADs and biogas cleanup companies.

Landfill Gas Consulting Engineers

SCS Engineers – **www.scsengineers.com**
Cornerstone Environmental – **www.cornerstoneeng.com**
Many others

Wastewater Treatment (Michael Wardell)

U.S. Environmental Protection Agency

www.epa.gov

Mid-Atlantic Biosolids Association

www.mabiosolids.org

Northeast Biosolids Association

www.nebiosolids.org

Northwest Biosolids Management Association

www.nwbiosolids.org

Water Environment Federation

www.wef.org

Anaerobic Digestion

USEPA Agstar Program
www.epa.gov/agstar

Clean Fuels Ohio Videotapes of Workshop Speakers

www.cleanfuelsohio.org/index.php?option=com_content&view=article&id=274:waste-to-wheels-nov-30-dec-2-2010&catid=99:events&Itemid=270

Energy Vision

www.energy-vision.org

Joanna Underwood, President
138 East 13th Street
New York, N.Y. 10003
212-228-0225
underwood@energy-vision.org

Gail Richardson, VP for Programs
200 Clinton Street 5E
Brooklyn, NY 11201
718-222-5575
richardson@energy-vision.org