Designing EHS into Alternative Energy

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There is a paradigm shift in the energy field. Promising new technologies are showing success in research level developments. Others are being commercialized for the first time and struggling through startup and shakedown. Still others are showing their frailties and their limits in the marketplace. And some may yet be a long daydream away.

The mix of energy sources we might see 20 years from now is yet unknown. We know some of the elements, and some of the elements we know well.

Such change brings new challenges as well as new opportunities for improvement. Economic and political seismology impose additional layers of complexity.

This session is intended to reflect on real-time development and early commercialization of thermophilic anaerobic digestion (TAD) in the U.S. and how one team is approaching Environmental Health and Safety concerns relative to such development. It follows last year's session, which compared energy and emissions data from a number of alternative fuels on a well-to-wheel basis using the GREET model from Argonne Labs.[1]

One of the fuels examined at the 2008 PDC was compressed natural gas (CNG) derived from the TAD process. The modeling data reflected considerably better energy and emissions data from CNG than for any of the alternatives to conventional diesel included in the study. This result was magnified for greenhouse gas emissions, where CNG reflected a carbon negative performance on a well-to-wheel basis.

Last year's data revealed the following summary data regarding emissions of CNG from both extracted and renewable feedstocks as compared with low sulfur diesel.

	Btu/mile or grams/mile		
Item	**Low Sulfur Diesel**	**Extracted CNG**	**Renewable CNG**
Total Energy	18,890	23,823	22,626
Fossil Fuels	18,833	23,600	22,410
Coal	583	1,091	1,066
Natural Gas	1,107	22,346	20,973
Petroleum	17,143	162	371
CO2	1,493	1,473	-781
CH4	1.648	5.346	0.471
N2O	0.016	0.016	0.026

[1] Argonne National Labs, GREET, http://www.transportation.anl.gov/modeling_simulation/GREET/

GHGs	1,536	1,601	-763
VOC: Total	0.297	0.365	0.263
CO: Total	0.496	4.06	3.97
NOx: Total	8.865	1.081	0.777
PM10: Total	0.195	0.239	0.237
PM2.5: Total	0.074	0.081	0.082
Sox: Total	0.362	0.582	0.365
VOC: Urban	0.156	0.146	0.145
CO: Urban	0.239	2.408	2.405
NOx: Urban	5.242	0.314	0.307
PM10: Urban	0.055	0.024	0.025
PM2.5: Urban	0.025	0.015	0.014
Sox: Urban	0.122	0.068	0.065

The GREET Well-to-Wheel model provides a full life-cycle assessment of energy and environmental performance of transportation fuels. For fossil fuel natural gas, this includes contributions from extraction and processing, as well as how efficiently and cleanly the fuel burns. For TAD technology, the steps include cultivation and/or collection of biomass and processing.

In its most simple terms, a TAD operates as follows: when organic waste decomposes it gives off methane and carbon dioxide. TAD holds organic matter in an oxygen-free environment until it decomposes and then captures the gases that otherwise would be emitted into the environment.

The installation is planned to process 621 tons per day of organic waste in an oxygen-starved in-vessel system at temperatures from 50^{o}C (122^{o}F) and 58^{o}C (136^{o}F). This compares with mesophilic systems which are more common in the United States and run at temperatures ~98^{o}F.

The four products of the digestion process are: methane, carbon dioxide, water and compost. There are no other by-products from this operation.

CNG

Bi-Fuel CNGV on CNG **Renewable Natural Gas**

Item	Btu/mile or grams/mile: Feedstock	Fuel	Vehicle Operation	Total	Percentage of each stage: Feedstock	Fuel	Vehicle Operation
Total Energy	375	1,675	20,576	22,626	1.66%	7.40%	90.94%
Fossil Fuels	371	1,463	20,576	22,410	1.66%	6.53%	91.82%
Coal	28	1,038	0	1,066	2.63%	97.37%	0.00%
Natural Gas	45	352	20,576	20,973	0.21%	1.68%	98.11%
Petroleum	298	73	0	371	80.32%	19.68%	0.00%
CO2	-2,143	140	1,222	-781	274.39%	-17.93%	-156.47%
CH4	0.033	0.188	0.25	0.471	7.01%	39.92%	53.08%
N2O	0.012	0.002	0.012	0.026	46.15%	7.69%	46.15%
GHGs	-2,139	145	1,231	-763	280.34%	-19.00%	-161.34%
VOC: Total	0.02	0.013	0.23	0.263	7.60%	4.94%	87.45%
CO: Total	0.081	0.037	3.852	3.970	2.04%	0.93%	97.03%
NOx: Total	0.183	0.152	0.442	0.777	23.55%	19.56%	56.89%
PM10: Total	0.017	0.184	0.036	0.237	7.17%	77.64%	15.19%
PM2.5: Total	0.012	0.049	0.021	0.082	14.63%	59.76%	25.61%
SOx: Total	0.023	0.336	0.006	0.365	6.30%	92.05%	1.64%
VOC: Urban	0.001	0.001	0.143	0.145	0.69%	0.69%	98.62%
CO: Urban	0.002	0.007	2.396	2.405	0.08%	0.29%	99.63%
NOx: Urban	0.006	0.026	0.275	0.307	1.95%	8.47%	89.58%
PM10: Urban	0.001	0.002	0.022	0.025	4.00%	8.00%	88.00%
PM2.5: Urban	0	0.001	0.013	0.014	0.00%	7.14%	92.86%
SOx: Urban	0.003	0.059	0.003	0.065	4.62%	90.77%	4.62%

However, a weakness identified in the study was the use of Argonne’s GREET model to calculate the well-to-wheel emissions of the CNG from renewable sources. The model did not have a component for CNG from renewable sources, and surrogates were required to estimate comparable results. While feedstock and fuel use surrogates could be found, no reliable model was presented for production of CNG from renewable feedstocks. While still encouraging at the feedstock and fuel levels, the resulting lack of reliability of available data regarding CNG production presents an unacceptable gap both for project design and permitting needs.

Vendor emissions data has been shared to form a baseline for how the system can be expected to perform.

GAS TYPE/COMPONENT[2]	Composition - units
BIOGAS	
Water	16%
Methane	60% (dry)
Carbon Dioxide	40% (dry)
Hydrogen Sulfide	220 ppmv
Ammonia	10 ppmv
Heating value	575 Btu/scf
NATURAL GAS MOTOR FUEL	
Methane	92%
Carbon Dioxide	8%
Water	<0.1%
Ammonia	<1 ppmv
Hydrogen Sulfide	<10ppmv
Heating value	925 Btu/scf
CARBON DIOXIDE INDUSTRIAL GAS	
Carbon Dioxide	99.9%
Methane	<0.1%
Oxygen	<1 ppm

Still, we believe that further research is needed to gain better confidence of production-level emission potentials.

We are finding support and guidance available from until recently been unlikely sources. Members of the Society of Petroleum Engineers, at their recent meeting in San Antonio, expressed support for alternative energy in ways that might not have been anticipated a few years ago. We found much common ground when talking about controlling natural gas and that industry's experience with these materials informs our progress without question.

Because we are a model for this technology in the U.S., we draw on Europe's experience. We will benefit from a combined motivation to make the first TAD installation in the U.S. a model for those which will follow.

To this end we now find ourselves planning and designing to minimize worst-case incidents and to handle them if they do occur. We continue to take every opportunity to think about our development from every perspective, assess its risks, consider its engineering hurdles and solutions, and to take advantage of how best to apply best practices.

Our task this year has been to perform a more rigorous exposure assessment specifically related to the operation of the TAD which produces the CNG. Thus, environmental and safety

[2] EcoCorp, http://www.ecocorp.com/

concerns from delivery of feedstock; through the steps of processing; separation, compression and delivery of gases; and storage and distribution must be considered both for the anticipated outputs of the facility (methane, carbon dioxide, water and compost) and also for contaminant by-products which might be present, such as hydrogen sulfides, ammonia, VOCs and chlorinated hydrocarbons.

In order to validate last year's findings and also for the practical step of submitting a permit request to the State of Illinois, it became necessary for us to have much more understanding of the emissions from the TAD facility itself. The lack of operating experience in the U.S. has created the greatest challenge to obtaining such information.

While this technology has a number of installations in Europe and some in Asia, there are currently only bench scale operations in the U.S. Further, the largest municipalities presently being served by TAD technology, to our knowledge, are in Spain. These elements create unique challenges to bringing such a development to market in Chicago.

In Chicago, organic waste feedstocks can be residential, commercial, and institutional landscape and food waste, industrial food processing wastes, POTW biosolids or imported agricultural wastes. Even harvested invasive species and cultivated algae may be appropriate and are being investigated at the research level.

After separation from the CO_2, the resulting biogas is mostly methane, usually 92 – 95% depending on user specifications and considered pipeline quality. Methane is essentially natural gas and can be used for anything natural gas can be used for. Natural gas consists typically of 93% methane, 3% ethane and 2% propane, with the remainder being nitrogen and carbon dioxide.[3]

The gas is cleaner than the same gases drawn from a landfill. In Europe, biogas is being compressed and/or liquefied into CNG/LNG and used as a transportation fuel. Extracted natural gas is already being used extensively in the United States.

In permitting, we can better quantify and control what we know will be generated in the process than what might be. Once identified, the risk of the occurrence of each of these "what if's" must be considered and appropriate engineering controls offered as a part of the permit to assure their implementation.

Regulatory Framework and Constituents of Concern

In 2008, we examined the regulatory framework hurdles facing compressed natural gas (CNG) as a transportation fuel covering two general areas of the Clean Air Act's regulatory framework: Criteria Pollutants and Hazardous Air Pollutants (HAPS). Both of these regulations also have application to the facility itself. In addition, new legislation related to Greenhouse Gases has been introduced[4] which will also have significant impacts on how this facility operates.

Clean Air Act (CAA)

The Clean Air Act provides the regulatory structure for much of the consideration of air emissions.

[3] Dr. John Ingersoll, conversation September, 2007, March, 2009.
[4] As of the date of this writing

National Ambient Air Quality Standards (NAAQS) (Criteria Pollutants)

The Clean Air Act (Title I) requires EPA to set National Ambient Air Quality Standards (NAAQS)[5] for pollutants considered harmful to public health and the environment; Primary Standards to protect public health, including the health of sensitive populations such as asthmatics and children and Secondary Standards to protect against decreased visibility, damage to animals, crops, vegetation, and buildings. NAAQSs are set for six Criteria Pollutants.

Where cities, counties and states are deficient in their control of any of these Criteria Pollutants, US EPA can, and does impose stricter enforcement on that area until compliance can be assured. A non-attainment designation given an area in violation of the most stringent standards for each of these six pollutants means restrictions on permits for new sources and monitoring of those industries which have been in operation for some time.

Cook County, which includes Chicago and some of its suburbs, is “non-attainment” for 8-Hr Ozone and PM-2.5 and has had trouble meeting the requirements for PM-10 and VOCs.

National Ambient Air Quality Standards[6]

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm ($10\ mg/m^3$)	8-hour (1)	None	
	35 ppm ($40\ mg/m^3$)	1-hour (1)		
Lead	$0.15\ \mu g/m^3$ (2)	Rolling 3-Month Average	Same as Primary	
	$1.5\ \mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm ($100\ \mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM_{10})	$150\ \mu g/m^3$	24-hour (3)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	$15.0\ \mu g/m^3$	Annual (4) (Arithmetic Mean)	Same as Primary	
	$35\ \mu g/m^3$	24-hour (5)	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour (6)	Same as Primary	
	0.08 ppm (1997 std)	8-hour (7)	Same as Primary	
	0.12 ppm	1-hour (8) (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm ($1300\ \mu g/m^3$)	3-hour (1)
	0.14 ppm	24-hour (1)		

[5] Clean Air Act, 40CFR50
[6] U.S.EPA, http://www.epa.gov/air/criteria.html

The contribution of renewable CNG to the quality of the air in the Chicago environment might give some regulators a positive dispensation to the permit application of a TAD. However, when it comes to the permit to operate the TAD, its environmental profile must stand alone in that process.

2008 Modeling Data for Priority Pollutants from Production of CNG

Bi-Fuel CNGV on CNG **Renewable Natural Gas**

	Btu/mile or grams/mile				Percentage of each stage		
Item	**Feedstock**	**Fuel**	**Vehicle Operation**	**Total**	**Feedstock**	**Fuel**	**Vehicle Operation**
N2O	0.012	0.002	0.012	0.026	46.15%	7.69%	46.15%
VOC: Total	0.02	0.013	0.23	0.263	7.60%	4.94%	87.45%
CO: Total	0.081	0.037	3.852	3.970	2.04%	0.93%	97.03%
NOx: Total	0.183	0.152	0.442	0.777	23.55%	19.56%	56.89%
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SOx: Total	0.023	0.336	0.006	0.365	6.30%	92.05%	1.64%
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SOx: Urban	0.003	0.059	0.003	0.065	4.62%	90.77%	4.62%

<u>Nitrous Oxides (NOx)</u>
As a precursor to ozone, NOx has received significant attention. As a primary contributor to Greenhouse Gas Emissions, NOx will receive even greater attention as new legislation is created to monitor and report its release. Despite the scrutiny, TAD operations do not appear to significantly contribute to NOx emissions at any point in its life cycle.

<u>Sulfur Dioxide (SOx)</u>
There appear to be no significant contributions of SOx from either the Feedstock or Fuel use cycles. At the point of TAD operations, some consideration must be given to its generation as a by-product of treatment for Hydrogen Sulfide as described below. This is not expected to be a significant source if that system is operating properly.

<u>Particulates</u>
Compressed natural gas from renewable sources reflected less emission of both PM2.5 and PM10 than did any other of the fuels studied in 2008 and should be considered inconsequential in both facility operations and vehicle operations.

<u>Carbon Monoxide</u>
As a fuel on a well-to-wheel basis, the 2008 modeling data compared favorably with all other types of fuel tested in every constituent examined with the exception of carbon monoxide. In vehicle fuels, this poor performance is caused by an incomplete burn of the methane. For the purposes of the current focus on the plant operations, this is of less concern since the contribution of carbon monoxide is mostly made (97.03%) in burning the fuel in vehicle operations and less than 1% of

the CO contributions being made during fuel production. Still, as the project develops, this element must be re-visited and control measures sought to better manage this pollutant.

Ozone

Metro Chicago currently does not meet the national ambient air quality standard for ground-level ozone (smog) and is classified by USEPA as a "severe" non-attainment area. Ozone is formed by the reaction of NOx and VOCs in the presence of heat and sunlight. Thus, the IEPA will likely pay particular attention to the potential for this plant to emit VOCs. VOCs are present in the operation in the form of methane.

Volatile Organic Compounds

As reported in last year’s presentation, Chicago operates under a “cap and trade” program designed to reduce emissions of volatile organic compounds (VOCs) in the Chicago metropolitan ground-level ozone non-attainment area by 12%. The program is mandatory for major VOC sources in the Chicago metropolitan area and each source has a VOC emissions cap. Where VOC sources fall below the caps, they may trade emission allowances with firms which are less successful, or new sources whose potential emissions were not included in the original cap. This program is administered by the Illinois Environmental Protection Agency (IEPA) and is an important element of the state’s implementation plan (SIP) for meeting the ozone standard in the Chicago metropolitan area.[7]

Because of the operating temperatures of TAD, the potential for release of VOCs is of primary concern. Constituents with a boiling point below 58^{o}C are considered a major concern for compost operations. Anaerobic systems, because they operate in-vessel, have much better control over volatile emissions.

New sources of VOCs are subjected to a New Source Review by the IEPA as a part of the permit process which looks first at the potential to emit before the actual expected emissions. The subject TAD will likely be required to participate in such a review.

The compost industry is anticipating near term a shift in regulatory requirements to control VOC emissions from compost operations.

Methane

Methane is an odorless, colorless gas, or a colorless, odorless gas or liquid. Both the liquid and the gas pose a serious fire hazard when accidentally released. The liquid will rapidly boil to the gas at standard temperatures and pressures. As a gas, it will act as a simple asphyxiant and present a significant health hazard by displacing the oxygen in the atmosphere.

The gas is lighter than air and may spread long distances. Distant ignition and flashback are possible. The liquefied gas can cause frostbite to any contaminated tissue. Flame or high temperature impinging on a localized area of a cylinder of methane can cause the cylinder to rupture without activating the cylinder’s relief devices.[8] Handling explosive gases is a specialized

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[7] US EPA, “Approval and Promulgation of Implementation Plans; Illinois Trading Program”, http://www.epa.gov/EPA-AIR/2000/December/Day-27/a32945.htm

[8] OSHA, http://www.osha.gov/dts/chemicalsampling/data/CH_250700.html

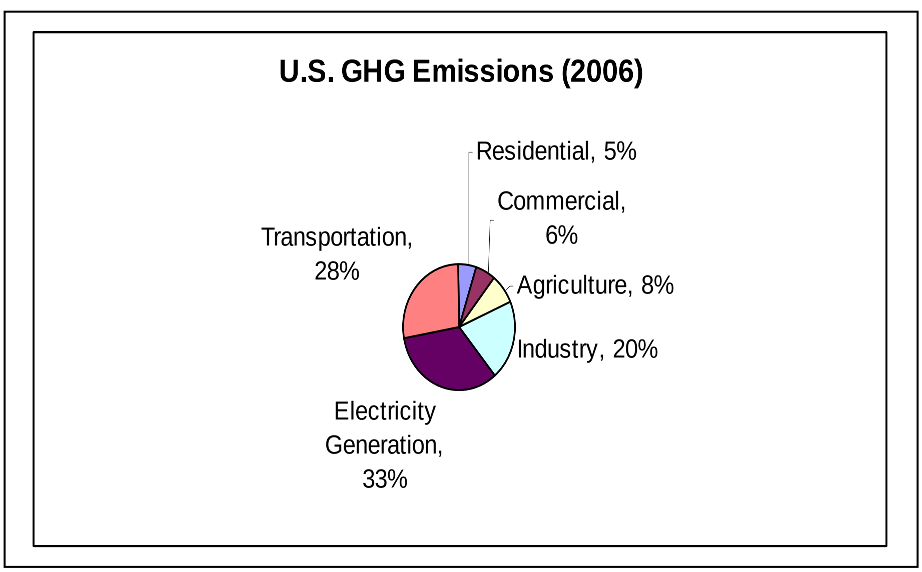
skill. Safety issues related to handling methane have not been thoroughly covered in this document.

As a natural element escaping a landfill or a pile of leaves, methane is unregulated. As a by-product of organic waste production and capture, methane is a volatile organic gas capable of producing emissions which would contribute to Chicago's VOC cap. As a fuel, it can serve to significantly reduce VOCs in the City's air and thus, ultimately improve its regulatory profile as well. However, despite its overall benefits, the facility must stand alone when quantifying potential or actual emissions, correctly estimating that potential for purposes of applying for the permit, and then accurately reporting such emissions should they occur in processing. Thus, as noted, the TAD may be subject to "New Source Review" by the IEPA. It will also be regulated as a greenhouse gas.

<u>Greenhouse Gases</u>

The regulatory framework relative to energy and environment is shifting. A Greenhouse Gas Inventory has recently been released. Several new pieces of legislation are currently under consideration in Congress, including the **American Clean Energy and Security Act of 2009.**

According to the Greenhouse Gas Inventory, waste management and treatment activities are sources of greenhouse gas emissions. Landfills accounted for approximately 23 percent of total U.S. anthropogenic methane (CH4) emissions in 2007, the second largest contribution of any CH4 source in the United States. Additionally, wastewater treatment and composting of organic waste accounted for approximately 4 percent and less than 1 percent of U.S. CH4 emissions, respectively. Nitrous oxide (N2O) emissions from the discharge of wastewater treatment effluents into aquatic environments were estimated, as were N2O emissions from the treatment process itself. N2O emissions from composting were also estimated. Together, these waste activities account for approximately 2 percent of total U.S. N2O emissions. Nitrogen oxide (NOx), carbon monoxide (CO), and non-CH4 volatile organic compounds (NMVOCs) are emitted by waste activities.[9]



[9] U.S. EPA, http://www.epa.gov/climatechange/emissions/downloads09/Waste.pdf

Methane will also be regulated as a greenhouse gas. As noted, new rules will regulate greenhouse gases as pollutants. As a greenhouse gas, methane contributes 23 times more per molecule than does carbon dioxide. Thus, its control as it is created and moves through the facility and how it will be contained particularly during storage and discharge will be the subject of great scrutiny.

But the current driver is global climate change with new rules evolving as we write.

Global Warming Potentials of Greenhouse Gases: relative to CO2

CO2	1
CH4	23
N2O	296
VOC	0
CO	0
NO2	0

<u>Carbon Dioxide</u>

As noted, CO_2 is 40% of the output of the facility. In addition to being the original "Greenhouse Gas" (CO_2e) it is the most used industrial gas.[10] Once captured, it can be reused. There are economic benefits to an adjacent greenhouse with a need for hot CO_2 to boost plant production. The petroleum industry is seeking sources of CO_2 for sequestration and well enhancement.

Thus, both the methane and the carbon dioxide are put to beneficial reuse.

<u>Hydrogen Sulfide</u>

Hydrogen sulfide is produced naturally by decaying organic matter and is released from sewage sludge, liquid manure, sulfur hot springs, and natural gas. Hydrogen sulfide is an extremely rapidly acting, highly toxic, colorless gas with a rotten-egg odor. [11]

The technology vendor of choice controls hydrogen sulfide by releasing oxygen in the ppm range into the digestion chamber to convert hydrogen sulfide to sulfur dioxide.

Hydrogen sulfide must be continually monitored with both area monitors (particularly confined spaces) and personal monitors using real time instruments. A flare has been anticipated in the design to burn off any unexpected puffs.

<u>Chlorinated Hydrocarbons</u>

The potential for the formation of chlorinated hydrocarbons must be addressed. The most obvious candidate would be methyl chloride (chloromethane). Chlorine could be introduced into this

[10] U.E. EPA web site: http://www.epa.gov/climatechange/emissions/downloads09/07Waste.pdf
[11] ATSDR, http://www.atsdr.cdc.gov/mhmi/mmg114.html

methane-rich environment from MWRD bio-solids or other sources. Under certain conditions, methane and chlorine produce methyl chloride. This occurs at low levels in nature.[12]

However, methyl chloride forms in direct contact of methane and chlorine in temperatures between 100^o and 300^o C. Even spikes in temperature should remain far below this threshold. This makes its formation unlikely. However, further investigation here is warranted and will be sought in additional scrutiny of European performance records.

Ammonia

Small amounts of ammonia will enter the system. They are expected to pass through into the water and be treated in the wastewater treatment process. Water issues are not thoroughly documented in this document.

Other Constituents Examined

Most of the operations of the facility will be conducted outside of the vessels. Workers load and unload the vessel, but usually work outside of it. Entry is limited to scheduled downtime for maintenance or if a serious system upset required it to be cleared and restarted. Thus indoor air quality concerns are limited to pipe leaks and exposures as organic wastes are processed, fed into the system, and discharged from the system. Once environmental permitting has been completed, process operations and equipment and facility maintenance guidelines must be written.

Dust

Dust control measures will be installed in organic waste delivery and processing areas to control indoor and outdoor air quality. Organic dust filters can be fed back into organic waste processing units. Dust exposures will also be minimized because organic waste will be delivered robotically.

During dry periods, organic waste material can become a combustible dust hazard. Storage of such materials in silos raises those concerns as well. Material must be maintained under conditions that minimize the potential for such an incident to occur.

Mold

Many molds are formed in digestion activities. Their control will be subject to the ANSI ASSE Z-690 Standard for Mold Remediation Workers, as it evolves.

Pathogens

Remote robotic operation of tipping areas will minimize exposures to pathogens in the food waste supply. As material passes into the processing area from the tip floor, it is size reduced and fed into a rotary steam autoclave which further reduces its size. The temperature of this operation will be sufficient to kill pathogens. From here the material is fed into the digesters where it is subjected to thermophilic temperatures and an anaerobic environment. The resulting compost is expected to be pathogen-free.

Permitting Considerations

[12] U.S. EPA web site: http://www.epa.gov/ttn/atw/hlthef/methylch.html

The facility is expected to require a Solid Waste Facility Permit and Air Permits: Construction and then Operating. More detailed performance data will be required to complete the permit application.

The City of Chicago, the county and/or the Illinois Pollution Control Board might all require hearings. Additional sampling and monitoring may be required. While environmental permits are required, safety permits are not. Still, safety concerns are, in fact, environmental concerns, and what affects the workers in the facility has the potential to affect the environment and the neighbors.

The site is on Lake Calumet, an inland lake in Chicago connected to Lake Michigan by the Little Calumet River. There is a city ordinance prohibiting solid waste facility siting along Chicago waterways. A zoning variance will be required,so hearings may also be required.

Siting on Lake Calumet raises immediately obvious community and environmental questions and concerns.

The community of southeast Chicago is steeped in NIMBY folklore. This is the tough, hard- scrabble steel community that witnessed sudden economic decline when the mills closed. People here grew up among acres of wetlands and steel slag. These are folks who have fought labor battles, inter-racial gang warfare, and poor public health outcomes. Who stopped the building of new landfills in the City of Chicago? Who successfully stopped the expansion of one of the country's largest landfills at its last 30 acres, the O'Brien Locks?

When this project started, over two years ago, our first contacts were with the local alderman and the Southeast Environmental Task Force and Calumet Stewardship Initiative, a small but mighty group led by a tenacious advocate for the environment by the name of Marian Byrnes. Their support has helped to catalyze this project into reality.

They know, not because we have told them, but because we have forged relationships over decades and they trust us, that we are constructing a project that will be beneficial to the community and the environment. This trust, hard won, must not be relinquished.

Clean Water Act, Resource Conservation and Recovery Act

In a multi-media approach, it is also necessary to examine the contribution of pollutants from transportation fuels to water and soils. It is expected that the facility will require a **National Pollution Discharge Elimination (NPDES) Permit**, and also a Discharge Permit to the Metropolitan Water Reclamation District of Greater Chicago.

he eco-system of Lake Calumet has seriously suffered from industrialization. Long term, anaerobic technology shows promise for treating the water of Lake Calumet. Short term, our goal is to convince the City of Chicago Zoning Board of Appeals, the community and ultimately the State, that our facility will not cause further harm to Lake Calumet. To do this, we must design, engineer and re-build the buildings and the shoreline so that we can assure containment in the event of a release. Current structures have not been well maintained. They must be re-built to assure structural integrity, and the feasibility of their reuse is still being considered.

As our understanding of this technology grows, we refine our knowledge. Utilizing Process Safety Management tools, we consider each step of turning organic waste into energy. We perform risk assessment outside of the familiar, coupling “what if” scenarios regarding environmental health and safety with a variety of “what if” scenarios regarding final decisions of what specific feedstocks the plant will handle, and how they will be delivered and received, stored, processed, and transported through the system.