THE PROSPECTS FOR LANDFILL GAS-TO-ENERGY PROJECTS IN WEST VIRGINIA

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ABBREVIATIONS

Btu	British thermal unit
CFR	Code of Federal Regulations
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CSR	Code of State Rules
FR	Federal Register
GHG	greenhouse gas
GVW	gross vehicle weight
kWh	kilowatt-hour
LCAP	Landfill Closure Assistance Program
LF	landfill
LFG	landfill gas
LMOP	Landfill Methane Outreach Program
LNG	liquefied natural gas
Mg	megagram
MMT	million metric tons
MW	megawatt
NA	not available
NCIF	Natural Capital Investment Fund
NMOC	non-methane organic compound
scfm	standard cubic feet per minute
SLF	sanitary landfill
SWA	Solid Waste Authority
USEPA	United States Environmental Protection Agency
WVDEP	West Virginia Department of Environmental Protection
WVDO	West Virginia Development Office
WVPSC	West Virginia Public Service Commission
WVSWMB	West Virginia Solid Waste Management Board
yr	year

1. INTRODUCTION

This report explores the prospects in West Virginia to economically turn landfill gas (LFG)—an energy-rich resource now released directly into the atmosphere or flared—into an asset, thereby reducing harmful emissions and providing energy to support local businesses and communities.

As shown in Figure 1, 396 LFG-to-energy projects are in operation across the United States. In many projects, LFG is used directly in boilers or for heat; in others, it is converted into electricity. Large companies such as Ford, Nestlé, and Sunoco have sought out these projects for low-cost energy (USEPA, 2005a). The federal government is also using LFG (USEPA, 2005a). And in yet other projects, small enterprises such as greenhouses use heat generated from LFG (SCS Engineers, 1998). In 2005, LFG projects in 40 states supplied 9 billion kilowatt hours of electricity and 74 billion cubic feet of LFG to end users (USEPA, 2006f). Every LFG project is unique, and reflects the conditions found at the landfill, the desires of local end users, and in many cases the hard work of local champions who bring parties together.

Compared with other states, the use of LFG in West Virginia is lagging. According to Figure 1, West Virginia is one of only ten states with no LFG-to-energy projects.[1] In contrast, 64 projects are operational in West Virginia's five neighboring states. Although West Virginia landfills are small, LFG-to-energy projects have been installed on 33 other small landfills across the country, as shown in Table 1.

Figure 1: Landfill gas-to-energy projects across the United States

Source: USEPA (2006b). No LFG-to-energy projects are in Alaska or Hawaii.

[1] As detailed in Section 3.1, while West Virginia landfills collect and vent or flare LFG, none have installed significant LFG-to-energy projects.

Table 1: Operational landfill gas-to-energy projects on landfills with waste in place of 1 million tons or less

Landfill	State	Landfill owner	Project start year	Project type
Adrian Landfill	MI	Allied Waste Services	1994	Elec., Cogeneration
Ahearn LF	MA	Allied Waste Services	1993	Elec., Recip. engine
Allen County LF	KS	Allen County	NA	Direct, Thermal
Atlantic Co. Utilities Authority LF	NJ	Atlantic County Utilities Authority, NJ	2004	Elec., Recip. engine
Attleboro LF, Inc.	MA	Attleboro Landfill, Inc.	1999	Elec., Recip. engine
Belleville Sanitary LF	IL	Allied Waste Services	1998	Elec., Recip. engine
Braintree LF	MA	Town of Braintree	2000	Elec., Fuel cell
Brattleboro	VT	Vermont Energy Recovery	1982	Elec., Recip. engine
Burlington LF	VT	Biomass Energy Partners	1991	Elec., Recip. engine
Burnsville SLF	MN	Waste Management, Inc.	1994	Elec., Recip. engine
California Street LF	CA	City of Redlands	2003	Elec., Recip. engine
Carleton Farms LF	MI	Republic Services, Inc.	1998	Elec., Recip. engine
City of Keene LF	NH	City of Keene	1995	Elec., Recip. engine
Cranston	RI	NA	1996	Elec., Recip. engine
Crapo Hill LF	MA	Grt. New Bedf. Reg. Ref. Mgt. Dist.	2005	Elec., Recip. engine
E.R.C. LF	IL	Allied Waste Services	1998	Elec., Recip. engine
Fighting Creek Farm LF	ID	County of Kootenai	1999	Direct, Leachate evap.
Greater Lebanon Refuse Auth. LF	PA	Greater Lebanon Refuse Authority	1985	Elec., Recip. engine
Green Valley LF	KY	Allied Waste Services	2003	Elec., Recip. engine
Lynchburg City LF	VA	City of Lynchburg	2002	Direct, Boiler
Lyon Development	MI	Allied Waste Services	1993	Elec., Recip. engine
Redwood SLF	CA	Waste Management, Inc.	1997	Direct, Leachate evap.
Richmond LF	VA	Allied Waste Services	1993	Elec., Recip. engine
Sauk County SLF	WI	Sauk County	2003	Elec., Microturbine
Sauk County SLF	WI	Sauk County	2004	Elec., Microturbine
South Barrington LF	IL	Allied Waste Services	1997	Elec., Recip. engine
State Wide LF	OH	Waste Management, Inc.	1999	Direct, Thermal
Tay Mouth LF	MI	Republic Services, Inc.	1996	Elec., Recip. engine
Union Mine Disposal Site	CA	El Dorado County	2001	Elec., Recip. engine
Vienna Junction Industrial Park LF	MI	Allied Waste Services	1996	Direct, Thermal
Wayne Disposal LF	MI	EQ - The Environmental Quality Co.	1986	Elec., Recip. engine
Wayne Disposal LF	MI	EQ - The Environmental Quality Co.	2002	Elec., Stirling cyc. eng.
Yancey/Mitchell County LF	NC	Yancey County	1999	Direct, Thermal

Source: USEPA (2006e). LF = landfill. SLF = sanitary landfill. NA = not available.

This report focuses on the prospects for installing LFG-to-energy projects at West Virginia's public landfills, although much of the information applies to public and private operators alike. Both public and private landfills will likely install LFG-to-energy projects if they are financially viable and will generate income. But public landfills may also be interested in LFG-to-energy projects that serve community or development purposes. In other words, public landfills may consider a wider range of benefits in addition to finances when deciding on LFG-to-energy projects. The Mountain Institute is committed not only to the financial and environmental benefits of LFG projects, but also to the other potential public and social benefits that can come from LFG projects (See Sections 3 and 5). LFG projects on public landfills are most likely to fulfill the dual objectives of The Mountain Institute.

West Virginia landfills face unique challenges for converting LFG into energy. These challenges can be overcome and projects can be built, given the right mix of financial incentives, local champions, and sound landfill management. Challenges in West Virginia include:

- **Few open landfills.** Only eighteen landfills currently accept waste in West Virginia. Typically, open landfills are the most economical for LFG-to-energy projects because gas generation declines after closure.

- **Small size of landfills.** West Virginia landfills are generally small, and therefore LFG generation rates are generally low, making them less attractive energy sources because of the fixed capital costs of installing LFG-to-energy projects. In addition, West Virginia's small landfills are nearly all exempt from federal regulations that require the capture of LFG. If regulations were to apply, LFG-to-energy project costs would only be those above and beyond mandated costs for wells, vents, and flares.
- **Low price of electricity.** Electricity in West Virginia is the third cheapest of all 50 states (Energy Information Administration, 2006). LFG-to-electricity projects will only stand on their own if the electricity they produce is as cheap as, or cheaper than, what can be bought from utilities.
- **Need for incentives.** Even though LFG wells and vents must be installed when landfill cells close and some landfills are required to collect and flare their LFG, it will be up to the West Virginia Public Service Commission (WVPSC) whether tipping fees and escrow funds could be used to build wells and collection systems that are most compatible with LFG-to-energy projects. It is also not clear whether tipping fees and escrow funds could be used for LFG treatment and conversion systems. Incentives will likely be needed for many West Virginia landfills to implement LFG-to-energy projects.
- **Poor communication of financial incentives.** Many federal and market incentives could be used to spur the development of LFG-to-energy projects; however, these incentives are not widely understood by landfill operators or solid waste authorities.
- **Lack of state and local incentives.** While some states and localities provide incentives for LFG-to-energy projects, few incentives were found in West Virginia that might encourage the construction of LFG-to-energy projects (See Sections 6.10 through 6.13).

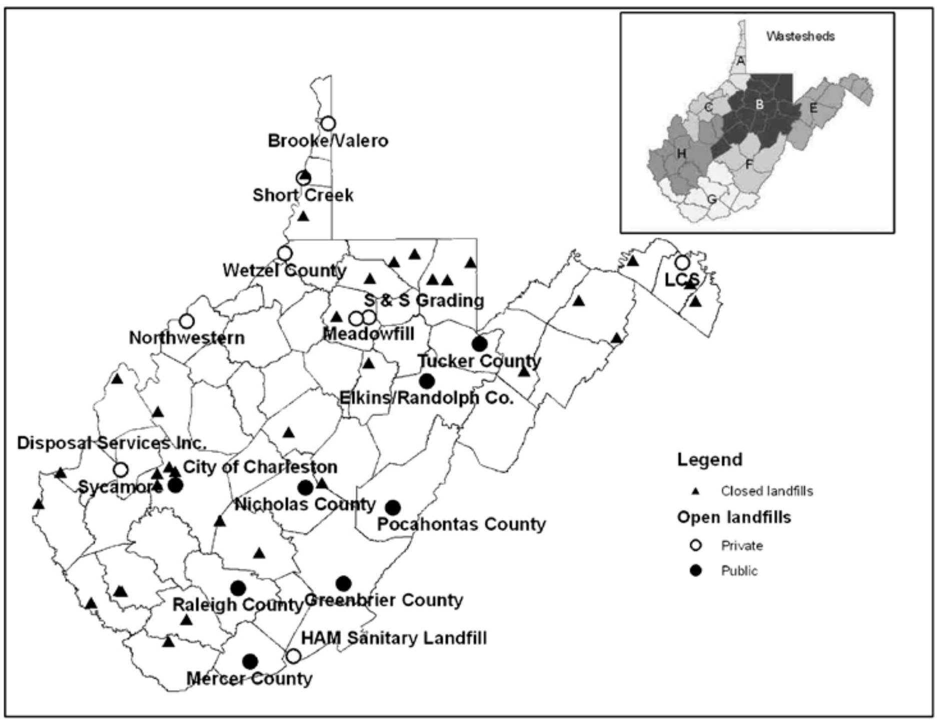
This report considers these challenges as it evaluates the prospects for developing LFG-to-energy projects in West Virginia. Audiences for this report are diverse, and include landfill owners and operators, agency staff, potential end users, and potential project champions.

2. LANDFILLS IN WEST VIRGINIA

Fifty-one open and closed solid waste landfills are scattered across West Virginia, as shown in Figure 2. West Virginia is divided into seven wastesheds: areas with common solid waste management problems that are used by agencies for planning solid waste management services.

Eighteen landfills in West Virginia currently accept waste, and are shown as circles in Figure 2. Table 2 provides additional information about these open landfills. With the exception of the City of Charleston Landfill, the open public landfills are all located in a band from southeastern West Virginia northeast through the mountain counties to Tucker County. In the northern panhandle, north-central counties, and the eastern panhandle, all open landfills are privately owned and operated.

Figure 2: Landfills and wastesheds in West Virginia



Source: WVSWMB (2005).

While private landfills are owned and operated by private companies, public landfills are owned and operated by solid waste authorities or cities.[2] Whether public or private, all landfills operate under permits from the West Virginia Department of Environmental Protection (WVDEP). The West Virginia Solid Waste Management Board (WVSWMB) provides services to landfills and issues biannual Solid Waste Management Plans. The most recent plan provides a thorough analysis of landfill operations across the state, and is available online (WVSWMB, 2005).

Public and private landfills are typically operated with different goals, which affects the ability of these landfills to implement LFG-to-energy projects. In general, public landfills are operated

[2] The public City of Charleston landfill is an exception; it is privately operated.

by local governments and their primary purpose is to provide a long-term waste disposal service to the community at the lowest possible cost. Public landfills therefore have an incentive to accept waste primarily from their community. According to tonnage reports provided by permittees, only 11.3% of all waste received by public landfills is generated outside each landfill's designated wasteshed (WVSWMB, 2005). While this practice maximizes the life of the landfill, it limits the amount of trash accepted each year. In general, the smaller size limits total revenues to public landfills from tipping fees; this has a corresponding tendency to lead to increased per-ton tipping fees so that fixed costs are covered. The smaller size also limits the generation of LFG.

In contrast, private landfill operations are profit-driven, with the incentive to maximize the amount of waste taken to these landfills. Therefore, 22.9% of their waste is generated outside of the wasteshed in which they are located—twice the percentage for public landfills (WVSWMB, 2005).

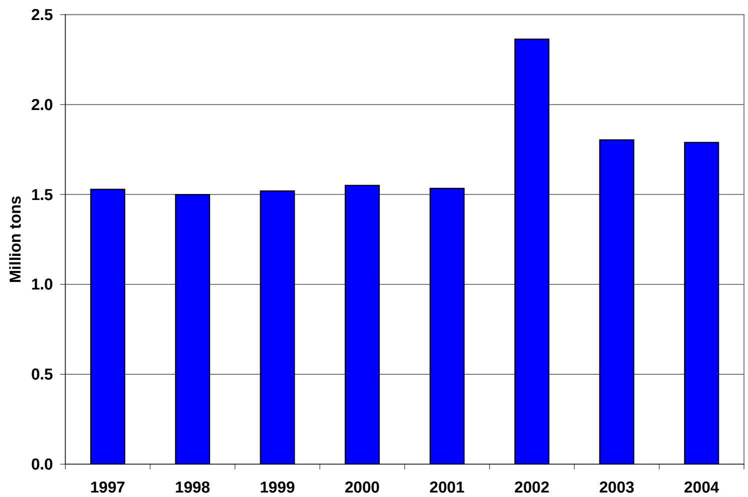
Table 2: Open landfills in West Virginia, with public landfills shaded gray

Name	County	Owner	2004 Waste acceptance rate (tons/mo.)	Out of state waste (tons/mo.)	Permit limit (tons/mo.)
Wasteshed A					
Brooke/Valero	Brooke	JP Mascaro and Sons	3,815	Unknown	22,000
Short Creek	Ohio	Allied Waste Industries	20,336	8,000	24,200
Wetzel County	Wetzel	JP Mascaro and Sons	7,090	Unknown	9,999
Wasteshed B					
Elkins/Randolph Co.	Randolph	City of Elkins	724	0	9,999
Meadowfill	Harrison	Waste Management Inc.	23,943	<6,500	24,200
Tucker County	Tucker	Tucker County SWA	6,111	0	8,000
S&S Grading	Harrison	Waste Management Inc.	5,792	0	9,999
Wasteshed C					
Northwestern	Wood	Waste Management Inc.	18,494	5,785	30,000
Wasteshed E					
LCS	Berkeley	Waste Management Inc.	9,913	<100	9,999
Wasteshed F					
Greenbrier County	Greenbrier	Greenbrier County SWA	3,660	0	9,999
Nicholas County	Nicholas	Nicholas County SWA	1,930	0	9,999
Pocahontas County	Pocahontas	Pocahontas County SWA	706	0	9,999
Wasteshed G					
HAM	Monroe	David Humphreys	1,553	NA	9,999
Mercer County	Mercer	Mercer County SWA	4,418	200	9,999
Raleigh County	Raleigh	Raleigh County SWA	10,661	0	12,500
Wasteshed H					
City of Charleston	Kanawha	City of Charleston	15,584	0	16,500
Disposal Service	Putnam	Waste Management Inc.	3,624	0	20,000
Sycamore	Putnam	Superior Waste Services	8,627	0	20,000

Source: WVSWMB (2005). These commercial solid waste landfills are listed as permitted and operational as of September 2004. SWA = Solid Waste Authority. The City of Charleston Landfill is publicly owned but privately operated. The HAM Landfill was given approval to begin accepting waste on December 1, 2004. The waste acceptance rate for this landfill is based on 2005 figures provided by Bakanas (2006). NA = not available.

As shown in Figure 3, about 1.75 million tons per year of solid waste were disposed of at all open landfills in 2003 and 2004. In recent years, tonnage has varied because of the amount of debris generated by floods and other factors.

Figure 3: Amount of solid waste placed at West Virginia landfills



Source: WVSWMB (2005). Years are fiscal years for collections by the West Virginia Department of Tax and Revenue from July through June.

As shown in Table 3, most of the 33 closed landfills have qualified for the Landfill Closure Assistance Program (LCAP). Through this program, funding is provided from tipping fees at open landfills to pay for proper closure at closed landfills. These measures are designed to protect the environment since old landfills were not built to modern environmental safety standards.

Table 3: Closed landfills in West Virginia

Name	County	Pub. or priv.	Owner	Closure area (acres)	Status
Wasteshed A					
Moundsville	Marshall	Pub.	City of Moundsville	31	LCAP: 2005 interim work
Wheeling	Ohio	Pub.	City of Wheeling	31	LCAP: 2005 interim work
Wasteshed B					
Big Bear	Preston	Priv.	Big Bear Lake	1	LCAP: 2005 interim cap
Buckhannon	Upshur	Pub.	City of Buckhannon	14	LCAP: 2002 cap compl.
Central WV Refuse	Braxton	Priv.	Central W.Va. Refuse Inc.	11	LCAP: 2001 cap compl.
Clarksburg	Harrison	Pub.	City of Clarksburg	20	LCAP: 2005 interim cap
Kingwood	Preston	Pub.	City of Kingwood	12	LCAP: 2005 interim cap
Marion	Marion	Pub.	Marion County SWA	13	LCAP: 2005 interim cap
Monongalia	Monongalia	Pub.	W.Va. SWMB	16	LCAP: 2001 cap compl.
Morgantown	Monongalia	Pub.	City of Morgantown	20	LCAP: 2005 cap compl.
Preston	Preston	Priv.	Hadre Enterprises, Inc.	15	LCAP: 2003 cap compl.
Wasteshed C					
Jackson	Jackson	Pub.	Jackson County SWA	6	LCAP: Under construction
Wasteshed E					
Berkeley	Berkeley	Pub.	Berkeley County SWA	26	LCAP: 2004 cap compl.
Capon Springs	Hampshire	Priv.	Capon Springs & Farms Inc.	1	LCAP: 2005 interim cap
Hampshire	Hampshire	Pub.	Region Eight SWA	9	LCAP: 2005 cap compl.
Jefferson	Jefferson	Pub.	Jefferson County SWA	46	LCAP: 1997 cap compl.
Morgan	Morgan	Pub.	Morgan County SWA	6	LCAP: 2005 interim work
Petersburg	Grant	Pub.	Region Eight SWA	12	LCAP: 2003 cap compl.
Wasteshed F					
Webster	Webster	Pub.	Webster County SWA	NA	Permit revoked, in appeal
Wasteshed G					
Fayette	Fayette	Pub.	Fayette County SWA	11	LCAP: 1999 cap compl.
Midwest Disposal	Summers	Priv.	Midwest Disposal (Bankruptcy)	10	Permit revoked, uncapped
McDowell (Old)	McDowell	Pub.	McDowell County SWA	9	LCAP: 2003 cap compl.
Mingo	Mingo	Pub.	Mingo County SWA	9	LCAP: 2002 cap compl.
Montgomery	Montgomery	Pub.	City of Montgomery	8	LCAP: 1998 cap compl.
Wyoming	Wyoming	Pub.	Wyoming County Commission	10	LCAP: 2005 cap compl.
Wasteshed H					
Don's Disposal	Kanawha	Priv.	Don's Resources Inc.	40	LCAP: 2005 under constr.
ERO	Mason	Priv.	E.R.O Landfill	17	LCAP: 1997 cap compl.
Fleming	Kanawha	Priv.	Fleming Landfill Inc.	20	LCAP: 2002 cap compl.
Huntington	Cabell	Pub.	City of Huntington	30	Closed, uncapped
Kanawha Western	Kanawha	Pub.	Kanawha County SWA	17	LCAP: 1999 cap compl.
Pine Creek/OMAR	Logan	Priv.	Pine Creek Omar Landfill, Inc.	8	Closed: 2005 interim status
Prichard	Wayne	Priv.	Republic Industries	15	Closed: 2000 cap compl.
South Charleston	Kanawha	Pub.	City of South Charleston	5	LCAP: 2005 interim status

Source: WVSWMB (2005). These commercial solid waste landfills are listed as closed as of September 2004. SWA = Solid Waste Authority. LCAP = Landfill Closure Assistance Program. NA = not available.

2.1 Tipping fees

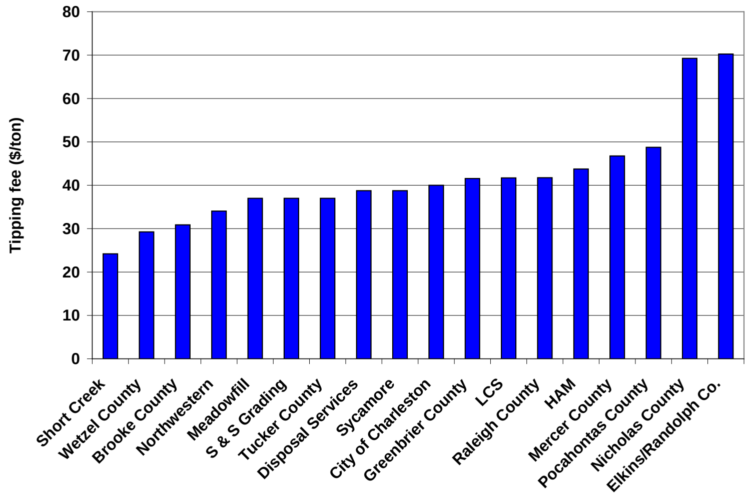
Tipping fees, which haulers pay to landfills to dispose of waste, are the primary source of income for West Virginia landfills. These fees include a base rate, which stays with the landfill, plus per-ton state and local assessments. Table 4 and Figure 4 illustrate the wide range of tipping fees across the state. Most charge around $40 per ton, and fourteen of eighteen charge between $30 and $50 per ton. The six cheapest tipping fees are found at private landfills, while the four most expensive are found at public landfills. Two of these public landfills—Nicholas County and Elkins/Randolph County—charge significantly more than all others: about $70 per ton.

Table 4: Tipping fees at West Virginia landfills ($/ton)

Landfill	Tipping fee
Wasteshed A	
Brooke/Valero	30.88
Short Creek	24.20
Wetzel County	29.25
Wasteshed B	
Elkins/Randolph Co.	70.25
Meadowfill	37.00
S&S Grading	37.00
Tucker County	37.00
Wasteshed C	
Northwestern	34.05
Wasteshed E	
LCS	41.70
Wasteshed F	
Greenbrier County	41.55
Nicholas County	69.25
Pocahontas County	48.75
Wasteshed G	
HAM	43.75
Mercer County	46.75
Raleigh County	41.75
Wasteshed H	
City of Charleston	40.00
Disposal Service	38.75
Sycamore	38.75

Source: Tipping fees are from September 2004 (WVSWMB, 2005) except Brooke/Valero and City of Charleston, which are from March 2006 (Bakanas, 2006). Tipping fees include state and local assessments, which fund all state solid waste management programs and county and regional solid waste authorities. State fees total $8.25 per ton.

Figure 4: Tipping fees at West Virginia landfills



Source: Tipping fees are from Table 4.

These fees are approved by the WVPSC and cover operational costs of the landfill. A portion of tipping fees is also placed into escrow and is saved for closure and post-closure costs. The WVPSC would have to determine whether tipping fees could cover costs solely related to un-mandated LFG-to-energy projects. If a landfill operates efficiently, then surpluses from tipping fees might be available to help pay some of the costs of developing a LFG-to-energy project.

According to WVSWMB (2005), lower tipping fees at a nearby landfill in Kentucky led to the closure of at least one West Virginia landfill: the Prichard Landfill in Wayne County. But this combination of lower tipping fees and nearby out-of-state landfills is not duplicated with existing landfills. As shown in Table 5, tipping fees at landfills within 75 miles of West Virginia that accept out-of-state waste are generally comparable to the tipping fees charged in West Virginia.

While 383 thousand tons of West Virginia waste were exported to neighboring states in 2003, 229 thousand tons were imported to West Virginia from neighboring states (WVSWMB, 2005). This net export of about 154 thousand tons is less than 10% of the amount of waste landfilled in West Virginia in recent years.

Table 5: Tipping fees and West Virginia tonnage at nearby out-of-state landfills

Landfill	Location	Tipping fee ($/ton)	2003 West Virginia disposal (tons)
Green Valley	Greenup County, KY	32.65	114,353
Pike County (Ford Branch)	Pikeville, KY	30.00	4,751
Mountainview	Frostburg, MD	42.50	5,651
Athens-Hocking	Nelsonville, OH	10.00	52,249
AWS American	Waynesburg, OH	29.00	655
AWS Mahoning	New Springfield, OH	25.00	7,665
BFI Carbon Limestone	Poland, OH	30.00	1,120
Galia County (US Waste Service)	Bidwell, OH	32.00	13,455
Pine Grove Regional Facility	Amanda, OH	28.00	771
RWS Beech Hollow	Wellston, OH	25.00	6
WMI Suburban (South)	Glenford, OH	38.00	11,671
Arden	Washington, PA	50.00	2,111
Grand Central	Northampton, PA	60.00	0
Greenridge	Scottdale, PA	48.00	2,855
IESI, Franklin County	Scotland, PA	53.50	87
Imperial	Findlay, PA	NA	29,367
Kelly Run Sanitation	Elizabeth, PA	27.50	0
Modern Landfill	York, PA	54.00	1
Mostoller Landfill	Somerset, PA	40.60	146
Mountain View	Greencastle, PA	38.00	23,844
ONYX Chestnut Valley	Uniontown, PA	43.30	30,721
Sanitary Landfill	Belle Vernon, PA	35.00	13
Southern Allegheny	Davidsville, PA	39.90	6
Valley Landfill	Irwin, PA	63.00	172
City of Bristol	Bristol, VA	18.00	45,725
		Total	**382,975**

Source: WVSWMB (2005) except Cooksey Bros. was removed from the list and the Green Valley tipping fee was adjusted from $34.15 based on Bakanas (2006). West Virginia disposal is for calendar year 2003. NA = not available.

3. LANDFILL GAS-TO-ENERGY PROJECTS

LFG is created when municipal solid waste decomposes anaerobically. Typically, it is assumed to be composed of about 50% methane (CH_4), 50% carbon dioxide (CO_2), and less than 1% non-methane organic compounds (NMOCs), but this varies depending on the waste composition and other factors (USEPA, 2005a).

Methane is the source of energy for LFG-to-energy projects. One million tons of waste will produce about 432 thousand cubic feet per day of LFG, which could produce about 0.8 megawatts (MW) of electricity (USEPA, 2005a). This 0.8 MW of electricity is enough to power more than 10 thousand 75-watt light bulbs. Internal combustion engines, gas turbines, or other technologies are used to convert LFG to electricity. When burned for heat, LFG fuels boilers, dryers, and kilns. Treated LFG can be injected into natural gas pipelines, typically after enrichment into a higher heating value fuel. When compressed, methane can be used as a vehicle fuel for engines specifically designed for compressed natural gas (CNG) (USEPA, 2005a). Cogeneration, in which both heat and electricity are produced, is a particularly efficient alternative.

3.1 Requirements for collecting landfill gas

If a landfill is required by regulation to drill wells and vent or flare its LFG, the costs of the wells, collection system, and flare become required costs, whether or not a LFG-to-energy project is installed. The extra cost of turning the LFG into useable energy will be much smaller than the cost of the entire collection, flaring, and conversion project. In fact, the United States Environmental Protection Agency (USEPA) has generally found that the installation of wells and collection systems comprises approximately 50% of the cost of LFG-to-energy projects. Appropriate design upfront can save significant project costs, increase the system efficiency and gas capture rates, and help recover some of the mandatory costs associated with the installation of vents and collection systems (Simon, 2006).

A large part of the cost of installing gas vents is associated with mobilizing the drill rig and the dangers of drilling in the equivalent of a gas field. Once the rig is mobilized, however, there are only marginal costs for drilling additional, larger, and deeper wells that will improve the quantity and quality of LFG captured. Similarly, if a landfill installs a larger number of wells, then the incremental footage of collection system piping increases as well, but the fixed installation costs for small or large systems remain largely the same (Simon, 2006).

There are two ways that landfills might be required to install wells, passive vents, and flares: federal air quality regulations and state solid waste management rules.

3.1.1 Federal regulations

Large landfills are required to collect—and combust or use—their LFG.[3] Title V of the Clean Air Act defines the threshold over which landfills are considered regulated “stationary sources,” obligating owners or operators to submit gas management plans. The initial Title V threshold is a

[3] Federal regulations on the capture of LFG are at 40 Code of Federal Regulations (CFR) 51, 52, and 60. See also 61 Federal Register (FR) 9905.

design capacity of 2.5 million metric tons (MMT) of waste in place. Facilities can avoid submitting Title V applications and gas management plans by demonstrating that their actual NMOC emissions do not exceed 50 megagrams per year (Mg/yr), referred to as Tier II conditions. Table 6 summarizes the status of the eighteen open landfills with regards to Title V regulations.

Twelve landfills exceed the 2.5 MMT threshold. But based on preliminary data compiled by WVDEP, emissions at only three facilities exceed 50 Mg/yr. These three facilities—Brooke/Valero, Short Creek, and Wetzel County, all private—are required to submit gas management plans.

Four other landfills—the public Raleigh and Nicholas County Landfills and the private LCS and Sycamore Landfills—have submitted voluntary gas management plans because they anticipate falling under the regulations soon, to improve their waste management practices, or for some other reason. LFG flares are in place or are anticipated at all of the seven landfills that are submitting gas management plans.

Table 6: Status of open landfills with regards to Title V regulations

Landfill	Design capacity greater than 2.5 MMT?	Required to submit gas management plan?	Submitted voluntary gas management plan?	Wells, collection system, and flare in place or anticipated?
Wasteshed A				
Brooke/Valero	**Yes**	**Yes**	No	**Yes**
Short Creek	**Yes**	**Yes**	No	**Yes**
Wetzel County	**Yes**	**Yes**	No	**Yes**
Wasteshed B				
Elkins/Randolph Co.	No	No	No	No
Meadowfill	**Yes**	No	No	No
Tucker County	No	No	No	No
S&S Grading	**Yes**	No	No	No
Wasteshed C				
Northwestern	**Yes**	No	No	No
Wasteshed E				
LCS	**Yes**	No	**Yes**	**Yes**
Wasteshed F				
Greenbrier County	No	No	No	No
Nicholas County	**Yes**	No	**Yes**	**Yes**
Pocahontas County	No	No	No	No
Wasteshed G				
HAM	No	No	No	No
Mercer County	No	No	No	No
Raleigh County	**Yes**	No	**Yes**	**Yes**
Wasteshed H				
City of Charleston	**Yes**	No	No	No
Disposal Service	**Yes**	No	No	No
Sycamore	**Yes**	No	**Yes**	**Yes**

Source: Boehm and Woody (2006) except for Meadowfill, S&S Grading, Northwestern, and Disposal Service from Bakanas (2006). MMT = million metric tons.

3.1.2 State rules

In some situations, the West Virginia Solid Waste Management Rule[4] requires the collection of LFG, but these rules are meant to protect against the migration of explosive gases such as methane from the landfill. The WVDEP Secretary has the authority to require passive LFG vents on disposal areas that have neither received waste in six months nor will receive waste in one year, to control methane and other explosive gases.[5] At least one gas vent per acre would be required. Landfills must monitor for LFG at least quarterly,[6] and when dangerous LFG concentrations are present, they must take steps quickly to remedy the problem.[7]

When landfills or cells within them are closed, operators must install LFG management systems with at least one passive gas vent per acre.[8] Escrow funds—set aside by landfills from tipping fees—are used for closure costs and for post-closure landfill maintenance and repairs. LFG wells and passive gas vents are generally paid for from these escrow funds. It is uncertain whether landfills would be allowed to use escrow funds to cover the extra costs associated with wells, vents, and collection systems most appropriate for energy production, as opposed to being restricted to the minimum costs required by West Virginia rules.[9]

3.2 Environmental benefits

LFG harms the environment in several ways: it contributes to smog and global warming, and may cause health and safety concerns. Of the 40.7 billion tons of CO_2 equivalents of global greenhouse gas (GHG) emissions in 2000, 16% are methane, making it the second most important GHG behind CO_2. Per unit volume, methane is a more potent GHG than CO_2, and landfills are the largest human source of methane in the United States (USEPA, 2005a).

In addition to its global effects as a GHG, LFG emits odors. The capture and use of LFG will therefore benefit the local environment around landfills by removing this source of odors and potentially toxic emissions.

The capture and use of LFG transforms methane and allows other toxic organic compounds to be captured and disposed of properly so that they are not emitted to the atmosphere. In addition, the use of LFG for energy offsets non-renewable resources such as coal, oil, or natural gas, which would have been used, had LFG not been available. Depending on the fuel source, the benefits of these offsets likely include a reduction in sulfur dioxide, nitrogen oxides, particulate matter, and CO_2 emissions (USEPA, 2005a). The benefits of capturing and using LFG are illustrated in Figure 5.

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[4] The West Virginia Solid Waste Management Rule is at 33 Code of State Rules (CSR) 1.
[5] 33 CSR 1-4.10.a.
[6] 33 CSR 1-4.10.b.
[7] 33 CSR 1-4.10.c.
[8] 33 CSR 1-6.1.e.1.B.
[9] In New York, new rules allow the use of escrow funds to promote LFG-to-energy projects. At closure, landfill operators can now request funds to cover the extra costs associated with venting and collection systems for energy production as opposed to being restricted to the minimum costs associated only with regulated venting and flaring regulations (Simon, 2006).

Figure 5: Environmental benefits with increased management of landfill gas

SITUATION
Waste in landfill decomposes. Decomposition generates methane and toxic NMOC emissions with local and global health and environmental impacts.

Strategy 1: No gas management; gas seeps unevenly from landfill.

Strategy 2: Collect and vent gas; gas seeps from pipes.

Strategy 3: Collect and flare gas.

Strategy 4: Collect and develop gas resources (heat, electricity, conversion to CNG).

Result 1:

- GHGs, NMOCs, and trace toxic gases released;
- Foul smells reach community;
- Risk of gas combustion and landfill fire and/or worker injury.

Result 2:

- GHGs, NMOCs, and trace toxic gases released;
- Foul smells reach community;
- Risk of gas combustion and landfill fire and/or worker injury **eliminated**.

Result 3:

- Some new toxins created by burning process;
- **Reduced** GHG, NMOC, and trace toxic gas releases;
- Foul smells **reduced**;
- Risk of gas combustion-related landfill fire and/or worker injury **eliminated**.

Result 4:

- Some new toxins created by burning process;
- **Reduced** GHG, NMOC, and trace toxic gas releases;
- Foul smells **reduced**;
- Risk of gas combustion-related landfill fire and/or worker injury **eliminated**;
- **Additional** GHG emission **reductions**;
- Renewable energy resource developed/coal or natural gas **resources conserved**;
- **Financial savings** opportunities in facility treatment, heating, electricity costs;
- Potential **revenue stream** for facility;
- Positive, **responsible** public education and outreach.
- Potential employment through enterprise.

3.3 Economic benefits

Corporate interest in LFG-to-energy projects is often generated by financial benefits alone. Compared with other energy sources, LFG may be cheaper. With fixed price contracts, LFG can provide a long-term hedge against energy price volatility. For example, General Motors recently brought its fifth LFG project online, and has announced $5 million in savings per year from its projects. The National Aeronautics and Space Administration is saving more than $350 thousand per year (USEPA, 2005a). USEPA's Landfill Methane Outreach Program (LMOP) has fielded requests from more than twenty large companies to identify landfill opportunities (Goldstein, 2005).

There can be additional economic benefits to a community from LFG projects, however. Reduced pollution, production of renewable energy, job creation, and opportunities for public education and microenterprise are among the economic benefits that may not be captured in a simple financial analysis of a project's costs and revenues. These types of benefits may warrant public attention and support for projects.

3.3.1 Opportunity to develop microenterprise in the extraction subsector

New opportunities to develop, install, and operate LFG technologies are other economic benefits that may accrue to a community as a result of a LFG project. For example, at least two small firms in Harrison County are working out the technology for their "Methane Buster," in part because of USEPA support to refine and test the proposed technology. The Methane Buster draws methane out of mines and landfills and uses that same methane to power itself. It then uses additional methane to generate electricity.

Public investment in pollution prevention and pollution reduction can help reduce the cost of technologies available to landfills. High initial costs of technology development may be cost-prohibitive in early phases. But as the technologies in pilot projects are refined and demonstrate consistent financial and environmental benefits, they are more likely to be less expensive and therefore more available to other potential users.

A USEPA-supported pilot project employs the Methane Buster technology at the Meadowfill Landfill. According to project reports, 12 kilowatts of power were generated and supplied to the landfill's leachate aeration pumps, reducing landfill operation costs (Cutlip, 2005). In this project, the landfill benefits and the small businesses designing the new technologies also benefit. Other landfills benefit as well because public financial support at the pilot phase is helping to refine the technology so that it can be more cost-effective elsewhere.

The Methane Buster is specifically tailored for small LFG projects, and is likely appropriate in West Virginia. The cost of electricity generation using Methane Busters is predicted to be small: $60-70 thousand to buy and install a system. Once the technology is refined, the manufacturer expects operations and maintenance costs to be minimal; these costs will include oil, spark plugs, and occasional engine overhauls (Cutlip, 2005).

Projects that convert LFG to electricity typically generate jobs and stimulate local economic activity. According to LMOP's national averages, a typical 3 MW LFG electricity project increases regional output by $3.6 million during construction and $1.1 million during operation, employs 25.3 people during construction and 6 during operation, and generates thousands of dollars in state and local taxes. Direct use projects that convert LFG to heat have similar, but less significant, local economic benefits (Goldstein, 2005).

3.3.2 Economic benefits of pollution prevention and pollution reduction

Important economic benefits are linked to the environmental benefits of LFG production. Among these are the reduction of GHG releases, the potential to shift energy consumption from fossil fuels to renewable energies, and reduced toxic air emissions, among others. Some of these environmental benefits are reflected as financial values via carbon credits or alternative energy supply markets. Others are not yet accounted for in formal markets. Reduced odors and toxic emissions, however, are economically valuable to neighboring communities, where health and property values may be affected.

Also, as noted by the operators of the Raleigh County Sanitary Landfill, the opportunity to demonstrate good environmental stewardship and innovative practices is a valuable educational tool in the community (Allen and Patton, 2006). Such educational opportunities can contribute to more positive and proactive public attitudes and practices toward the environment now and in the future.

3.4 West Virginia's energy plan

The state energy plan prepared in 2002 for West Virginia underscores the state's role in promoting energy sector activities that conserve natural resources and reduce GHG emissions, with the aim of establishing West Virginia as a leader in economically and ecologically sustainable non-traditional energy production. The plan recommends the promotion of clean energy technologies, including renewable energy. State tax incentives are recommended as a tool to promote the development of renewable energy projects in West Virginia (Governor's Energy Task Force, 2002).

> "Within West Virginia, ample opportunities exist to increase resource production, while doing so in an ecologically appropriate manner. For instance, untapped available resources including *methane from coal and waste energy* could serve to power the energy needs of West Virginia and the United States in the coming decades. In order to utilize these resources, however, *government must play a key role as a catalyst to encourage private activities*." (Governor's Energy Task Force, 2002, p. 25, emphasis added)

In an action item, the report recommends "that West Virginia reduce greenhouse gas emissions through the exploration, development, and recovery of methane from coal and waste energy." (Governor's Energy Task Force, 2002, p. 26). The plan also defines related actions that should be taken by the legislature, the executive office, and the private sector. Commercial and civic groups are called upon to increase awareness and to support the development of "appropriate legislation to resolve the ownership and development issues relating to methane from coal and waste energy."

As issues surrounding coalbed methane property rights are clarified, this resource will become more valuable and attract investors and project research and development. Investment oriented toward coalbed methane is likely to generate positive technological and knowledge spill-over benefits for LFG-to-energy work. The development and refinement of the Methane Buster is just one example of coal-LFG cross-sector technological benefits of methane gas production and use.

3.5 Technical constraints and uncertainties

While there are many potential benefits to the collection and development of LFG as an energy source, there are also technical constraints. Constraints and uncertainties should be recognized and integrated into a landfill's project feasibility analysis, project planning, and financing from the beginning. Uncertainties and unexpected problems can lead to additional project expenditures in the LFG production, capture, or conversion phases of a project.

The relatively small size of landfills in West Virginia exacerbates the problem of uncertainty. The same absolute margin of error that could be acceptable for a large project may be relatively much more important for a small landfill, where even a minor margin of error could result in a project being costly rather than profitable.

Constraints faced by project managers can include the following issues, among others: uncertainty in predicting LFG production capacity and timing; costly equipment options that must be tailored according to types of waste and landfill characteristics; uncertainty about equipment operational reliability and productivity; and the requirement to seal landfills to keep rainwater and leachate from reaching groundwater, which decreases decomposition and reduces methane production.

Some technical constraints can be overcome as the LFG utilization sector develops. While technology used for collection systems is well established, equipment used to process LFG and to convert it to electricity is likely to become more predictable and reliable as more LFG projects are implemented and more firms develop institutional experience. Technological lessons learned are continually integrated into improved equipment design and use practices (Anderson, 2006; Nourot, 2006; Johannessen, 1999). As fossil fuel prices rise, the relative cost of developing increasingly reliable equipment for alternative energy sources such as LFG will begin to fall.

Some sources of uncertainty are inherent to the nature of landfills. As shown in Table 7, these include the amount, location, and timing of LFG production. Landfills have non-uniform designs, and varying locations, depths, and content that result in unpredictable spatial and temporal variability of LFG generation. Production rates can even vary based on the quality of the initial landfill construction.

Another constraint is the fact that regulations and design trends are resulting in dry landfills, which reduce decomposition and therefore reduce methane production. At drier landfills, waste does not decompose as fast and space is not freed up by decomposition as quickly. Bioreactors—in which water or leachate are intentionally added to the landfill—can help accelerate LFG production rates and can save air space. This technique, however, requires a high level of operator technical skill and time, and it is not appropriate on all types of soils and terrains (Johannessen, 1999). A proposed bioreactor in the Raleigh County Sanitary Landfill is being considered by DEP now; the plan is driven largely by its promise of speeding up the decomposition process and freeing up airspace, which will allow the disposal of more waste without the expense of new cells.

Of the LFG that is produced from a landfill, the amount that can be captured by a LFG collection system varies. This variation is influenced by the design and construction quality of the landfill—how much might escape in various ways—and the design of the collection system. The EnergyXChange program in North Carolina is discovering that its LFG supply may dwindle years before predicted by the feasibility study (See Section 5.1).

Finally, the productivity and reliability of the equipment designed to clean and utilize LFG is also associated with a certain degree of uncertainty. Siloxanes and other LFG pollutants pose challenges for LFG project operators (Cutlip, 2005; Pierce, 2005). Complications can include permanent damage to equipment components such as boilers, combustion turbines, microturbines, and post-combustion catalysts. Expensive refrigeration equipment may also be needed, and hazardous waste byproducts might need to be carefully disposed of at additional expense (Nourot, 2006).

Table 7: Sources of landfill gas technical uncertainty

Project phase	Some sources of technical uncertainty or constraints
LFG production (timing and quantity)	Variable levels of waste moisture content, availability of oxygen, temperature, microflora, compaction rates. Developing bioreactors can expedite and increase production of LFG.
Capture vs. loss of produced gas	• Loss of gas to atmosphere, lateral gas migration; • Incomplete anaerobic decomposition of near-surface layer (due to air intrusion in gas extraction process); • Washout of organic compound via leachate; • Timing of when collection system is installed relative to infilling of waste cell.
Gas development or utilization system	Choice and performance of equipment given waste type, environment, equipment operation and maintenance practices, and nature of end use.

Source: Compiled from Johannessen (1999).

Understanding that each LFG opportunity carries a significant margin of risk and uncertainty, it is important that project research planning account for this. Uncertainty and risk are project costs. They can, to some degree, be considered fixed costs of project development. By repeating projects and learning from experience, LFG developers can recover some of these high fixed costs and benefit from experience and economies of scale.

4. LANDFILL GAS GENERATION AT WEST VIRGINIA LANDFILLS

To consider the prospects for LFG-to-energy projects at public West Virginia landfills, it is important to first understand how much LFG is produced at these sites. LFG production can be predicted in several ways, from very simple back-of-the-envelope calculations, to computer models, and ultimately to site-specific monitoring.

As a first estimate of the best candidate landfills for LFG-to-energy projects, a basic screening tool is used. USEPA considers the best candidate landfills to have the following characteristics:

- The landfill has at least 1 million tons of waste in place;
- The landfill is still open, or has closed in the last five years; and
- The landfill has a depth of at least 40 feet (USEPA, 1996).

Information on waste in place and depth were not provided by WVDEP or landfill operators for six of the eight public landfills. However, information provided by the Raleigh and Mercer County Landfills is summarized in Table 8. Both landfills pass USEPA's initial screening.

Until waste in place and average depth are compiled for the remaining six public landfills, it will not be known whether they pass USEPA's screening. However, as shown in Table 2, the City of Charleston and Tucker County Landfills accept more waste each year than Mercer County, and would be expected to pass the screening test now or in the near future. The Greenbrier County and Nicholas County Landfills accept less waste, but are also worth investigating to see if they pass. The Elkins/Randolph County and Pocahontas County Landfills accept far less waste each year, and are the least likely to pass.

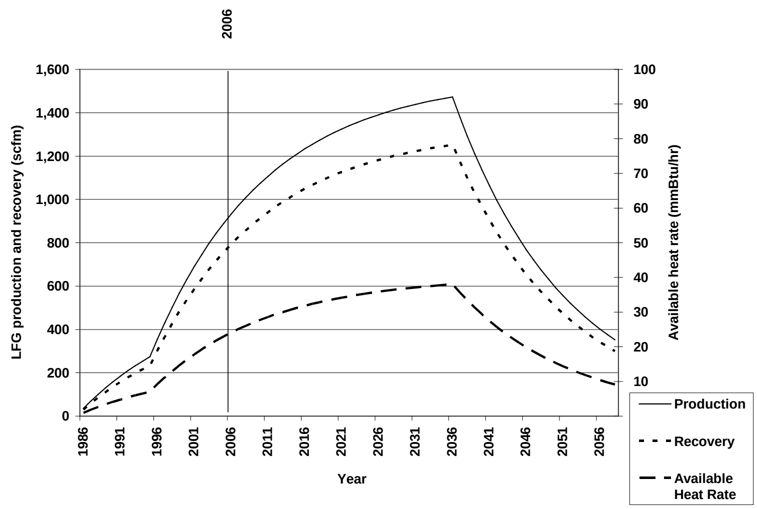
Table 8: Initial screening for landfill gas-to-energy project potential

Landfill	Waste in place (million tons)	Average depth (feet)	Passes initial screening?
Wasteshed B			
Elkins/Randolph Co.	Unknown	Unknown	Unknown
Tucker County	Unknown	Unknown	Unknown
Wasteshed F			
Greenbrier County	Unknown	Unknown	Unknown
Nicholas County	Unknown	Unknown	Unknown
Pocahontas County	Unknown	Unknown	Unknown
Wasteshed G			
Mercer County	1.8	58	Yes
Raleigh County	1.4	100	Yes
Wasteshed H			
City of Charleston	Unknown	Unknown	Unknown

Source: Mercer County Solid Waste Authority (2006), Raleigh County Solid Waste Authority (2005), and Allen (2006).
Mercer County depth calculated as weighted average of Cells 1, 1A, 2, and 3, and does not include the unlined portion closed in 1998.

USEPA's LandGEM computer model estimates LFG production rates based on waste in place, annual acceptance rates, and other factors that affect LFG production. LMOP contractors calculated a landfill gas generation curve for Raleigh County, shown in Figure 6.

Figure 6: Landfill gas production curve for Raleigh County



Source: LandGEM model result from LMOP contractors. Input data from Raleigh County Solid Waste Authority (2005), Allen (2006), and other standard assumptions.

While this curve provides only a preliminary estimate of LFG production and recovery, it suggests that LFG generation will increase year after year for more than three decades, as long as the same amount of waste is placed in the landfill, peaking at more than 1,400 standard cubic feet per minute (scfm). Gas recovery peaks at more than 1,200 scfm.

A comparison with operational projects in USEPA's LMOP database suggests that gas recovery at this scale is enough for a LFG-to-energy project. In fact, 189 operational projects across the country have LFG flows of 1,200 scfm or less (USEPA, 2006e).

5. LANDFILL GAS END USERS

Across the country, a wide variety of end users now benefit from LFG. Some landfills use the gas directly for heat or electricity. Some sell heat or electricity to neighboring industries. In at least one case, LFG will be compressed and used as a vehicle fuel. This chapter highlights several end users across the country and considers what kinds of end users might be most appropriate for public landfills in West Virginia.

As shown in Table 9, end users for heat might include the landfill itself and nearby businesses, greenhouses, or pottery studios. In some cases, however, end users may not demand a constant, year-round heat supply. Production of electricity, while a less efficient use of LFG, may then be the most viable alternative. End users might use electricity to power their buildings or for industrial processes.

When LFG is purified into methane and compressed, end users might also include natural gas companies that accept gas into their pipeline for sale elsewhere, truck fleets that use CNG, or possibly even fleets of school buses.

Table 9: Typical landfill gas end uses

Heat and electricity	Conversion to CNG or LNG
• Landfill leachate evaporation • Landfill building • Nearby industry • Nearby commercial building • Nearby greenhouse • Nearby pottery kiln • Nearby lumber kiln	• Sale of treated LFG to natural gas pipeline • Enrichment to create high Btu fuel for trucks or buses

Note: CNG = compressed natural gas. LNG = liquefied natural gas. Btu = British thermal unit.

A wide variety of end users are possible in West Virginia, given the right landfill size, the ability of appropriate facilities to locate nearby, demand for suitable amounts and kinds of energy, and financial incentives. At this early stage in the development of LFG-to-energy projects in West Virginia, it would be inappropriate to limit the range of possible end users. Financial incentives might make it economical for certain end users to start using LFG. Or a project champion with a particular interest might devote effort toward making a certain LFG-to-energy project succeed. Various potential end users are described here, without considering their financial viability. Financial viability will, of course, have to be considered before a project is planned.

Finding direct users close to the landfill can be important to the financial viability of a project. The financial feasibility of a project also increases if the energy produced can be used to avoid costs of retail-priced energy use. In contrast, if LFG is converted into electricity and sold to the grid, or if it is treated and sold through a natural gas pipeline, income is limited to the electricity or natural gas utility’s purchase price. Still, at this early stage it is worth considering all options for end users in West Virginia.

5.1 Heat and electricity

5.1.1 For landfills

The most obvious end user to consider first is the landfill itself. In some situations, using LFG onsite has the potential to save money, and could conceivably lead to lower tipping fees. For example, LFG can be used to generate heat to evaporate leachate pools, reducing energy and disposal costs. At the private Meadowfill Landfill, a pilot project of the Methane Buster technology generated 12 kilowatts of power, which was used to power the landfill's leachate aeration pumps (Cutlip, 2005).

The Raleigh County Sanitary Landfill is designing a LFG collection system now, for planned installation soon (Allen and Patton, 2006). A permit modification is needed before money can be allocated to retain an engineering firm to design the system (Bakanas, 2006). Landfill managers are considering onsite uses, including heat for the recycling center and shop building, at an estimated energy cost savings of more than $70 thousand annually. Plans are also being considered to produce electricity from LFG to light a public golf course, envisioned for a capped portion of the landfill (Allen and Patton, 2006).

5.1.2 For businesses and artisans

Businesses—particularly manufacturers—often have significant energy needs for heat and electricity, and might be interested in using green energy such as LFG to help their bottom line and to improve their environmental performance. In fact, well known corporations such as Ford, Nestlé, and Sunoco have sought out LFG projects in other states (USEPA, 2005a).

EnergyXChange, Yancey-Mitchell Landfill, North Carolina

Greenhouse, pottery kiln, glass workshop

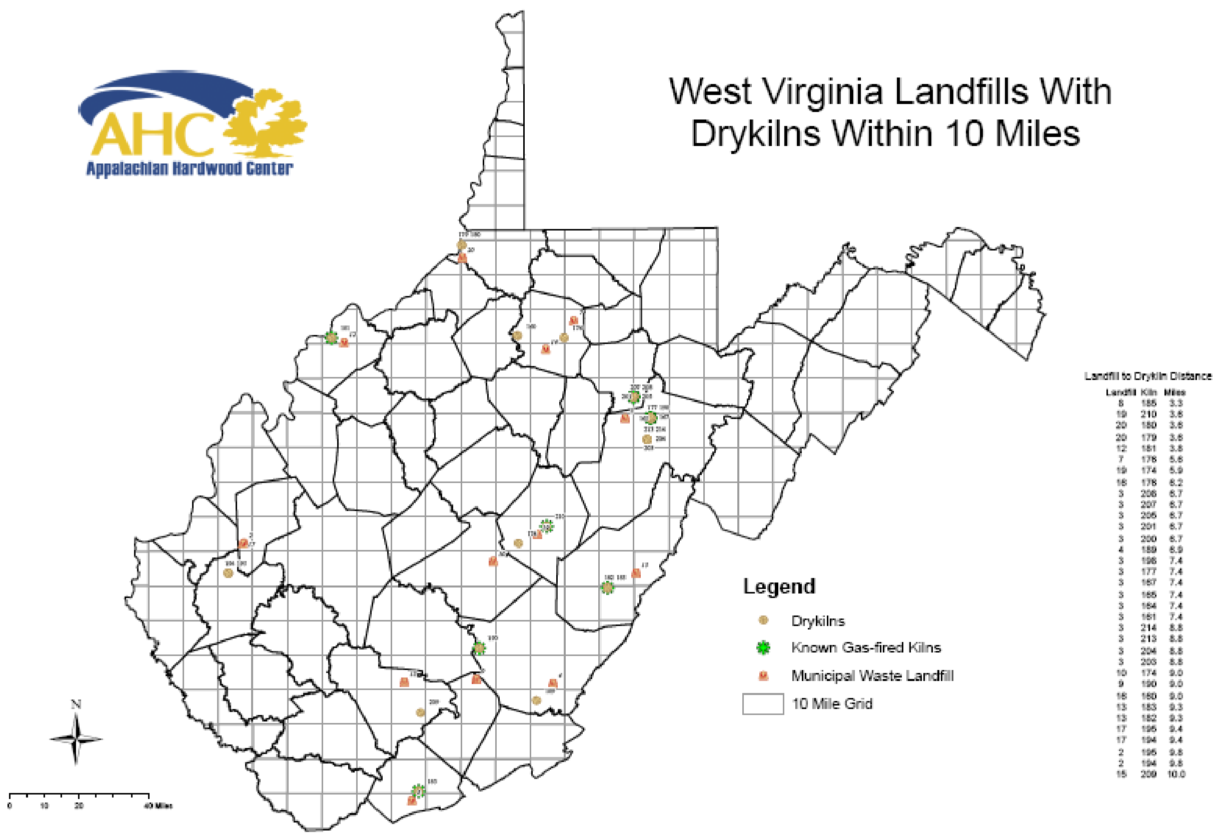
EnergyXChange, located at a closed North Carolina landfill, is an interesting example of a LFG-to-energy project. Dozens of community stakeholders collaborated with state and federal agencies to turn a capped and passively vented landfill into a LFG-to-energy site that provides heat and energy to greenhouses, pottery kilns, and glass workshops developed just for the project. The native plant nursery and artisan incubator programs benefit from the relatively low cost of heat and electricity from LFG. The long-term financial viability of this project, however, is questionable given the substantial federal subsidies it received and the significantly reduced real lifetime of the gas supply relative to its expected lifetime (SCS Engineers, 1998).

While multinational corporations may not seek out LFG-to-energy projects at West Virginia's relatively small landfills, the EnergyXChange project in North Carolina is instructive for West Virginia. Small businesses and artisans play important roles in West Virginia's economy, and might be well suited to use LFG from the state's public landfills. West Virginia is home to a wide variety of artisans that sell their goods at craft fairs and artisan galleries like Tamarack and Mountainmade. Artisans such as potters could use LFG to generate heat for kilns. Greenhouses could use LFG to generate heat, and possibly for CO_2 enrichment. Aquaculture operations might also benefit from heat from LFG.

Heat generated from LFG at the Raleigh County Sanitary Landfill, in addition to being used onsite, may also be sold to local businesses. Landfill operators have already had preliminary discussions with businesses that might be interested in energy from the facility's LFG (Allen and Patton, 2006).

Finally, the West Virginia Division of Forestry (2006) lists 49 lumber companies in the state with dry kilns. Most dry kilns now use natural gas (Grushecky, 2006). As shown in Figure 7, many of these companies are located near open landfills; LFG might provide a new renewable energy source for these kilns.

Figure 7: Dry kilns in the vicinity of landfills



Source: Appalachian Hardwood Center (2006).

5.1.3 For municipal and county uses

Local governments might be able to use heat and electricity from LFG for community buildings, government buildings, wastewater treatment facilities, schools, maintenance shops at prisons and local colleges, or other public uses. In Mercer County, for example, a juvenile detention facility is located about one mile away from the landfill (Haynes, 2005).

5.1.4 *For biodiesel production for school buses and other vehicles*

LFG, when burned to create heat, can be used to produce biodiesel, another alternative fuel. This process is already being used in Denton, Texas. Biodiesel, in turn, can be used to run school buses or other vehicles.

Denton Sanitary Landfill, Texas

Biodiesel production facility

Until recently, LFG from the City of Denton's Sanitary Landfill in Texas was not being collected. Because of its low NMOC emissions, it was not required to install a collection system. Now, LFG is used to run a 30 horsepower boiler, producing process water that, in turn, is used to produce B20 biodiesel fuel (Fiedler and Stewart, 2006).

To produce the biodiesel, the Denton landfill uses soybean and vegetable oil collected from farmers who grow oil-bearing crops. In addition, oil is collected from Dallas-Fort Worth area restaurants. Biodiesel produced from LFG is used to fuel the city's fleet of garbage trucks, as well as other utility vehicles. A total of 3 million gallons of biodiesel will be produced each year. This project was designated a USEPA LMOP award winner in 2005 (USEPA, 2006d).

In West Virginia, five county school systems have used biodiesel: Berkeley, Jefferson, Marion, Monongalia, and Upshur Counties. Biodiesel can be used without converting engines, and results in cleaner emissions. The state provides an incentive for the use of biodiesel: a higher reimbursement of fuel costs (See Section 6.12) (Burnside, 2005). A synergy might exist between the use of biodiesel to clean up school bus emissions and the production of biodiesel using heat from LFG.

5.1.5 *Electricity for sale to the grid*

Currently, it would be difficult for West Virginia landfills to sell electricity to the grid, because net metering is not allowed. Net metering would allow landfills to sell excess supply, turning the meter backward and reducing the facility's electricity costs. Forty states already allow some form of net metering (Interstate Renewable Energy Council, 2006). While net metering is usually discussed in relation to solar or wind power generation at homes, it can also apply to the generation of electricity from LFG at landfills.

In 2002, the WVPSC initiated a proceeding to determine the feasibility of implementing a pilot net metering program for the largest electric utilities in West Virginia. In February 2006, this proceeding was dismissed, due to new requirements stemming from the federal Energy Policy Act of 2005. The WVPSC will now undertake a comprehensive review of net metering (WVPSC, 2006). A key point that will affect the usefulness of net metering for LFG-to-energy projects is the price that is set for energy sold into the grid: the higher the price, the greater the benefit to landfills.

Other current actions may affect the net metering debate in West Virginia. The West Virginia Public Energy Authority passed a resolution in February 2006 to encourage the WVPSC to implement net metering. Net metering and promotion of renewable energy development and use would be advanced under the proposed West Virginia Division of Energy. In the 2006 state legislative session, Senate Bill 567 would have established the Division of Energy within the Department of Commerce. This division would then have created an energy policy and annual energy development plans, and may have helped implement the state's first net metering program. This bill, however, did not ultimately succeed. The outcome of the WVPSC proceeding and the fate of future bills similar to Senate Bill 567 will affect the viability of LFG-to-electricity projects in West Virginia.

5.1.6 Electricity for federal government buildings

The federal government—including the National Aeronautics and Space Administration and the Hill Air Force base in Utah—already uses LFG in other states (USEPA, 2005a). As new federal regulations increase the amount of renewable energy that must be used to generate electricity for federal facilities, even more demand for LFG might be generated.

As discussed in Section 6.4, this requirement can be met if the federal government purchases renewable energy credits. Other federal facilities, however, might be ideally located to make direct use of a LFG-to-energy project. For example, the Federal Bureau of Investigation property in Clarksburg is located less than one mile from the Meadowfill Landfill.[10] A United States Postal Service facility is located close to the public Raleigh County Sanitary Landfill in Beckley; this facility may be ideally located to make use of electricity produced from LFG.

5.1.7 Rural electric cooperatives

Rural electric cooperatives are another potential end user of LFG, because many cooperatives across the nation are looking for local sources of renewable energy for at least part of their energy portfolios.

For example, three plants operated by the East Kentucky Power Cooperative produce electricity from LFG. Its Bavarian Landfill Plant was installed in 2003, and includes four units with a production capacity of 3.2 MW (East Kentucky Power Cooperative, 2006).

Vermont's Washington Electric Cooperative has been under contract with Vermont Yankee Nuclear Power Corporation to supply 30% of their power needs from a nuclear power plant. With the expiration of that contract, the cooperative searched for a renewable source of energy as a replacement, and found that a LFG-to-energy project would be competitive. A financing plan is being developed with assistance from the Rural Utilities Service (Thompson, 2002).

In West Virginia, the only rural electric cooperative is the Harrison Rural Electrification Association in Harrison County. Publicly-funded efforts at the Meadowfill Landfill in Harrison County to develop a LFG-to-energy project may consider this local cooperative as a viable market for future production.

[10] Meadowfill is a private landfill and not the focus of this report, but the proximity of a federal office demonstrates how certain facilities might be ideally located to make use of LFG.

5.2 Conversion to compressed natural gas or liquefied natural gas

5.2.1 For trucks, buses, and other vehicles

LFG, when cleaned and compressed, can be used to power trucks, buses, and other vehicles. In Sonoma County, California, for example, LFG will be used to fuel a passenger bus fleet. Refuse disposal trucks would be another logical fleet to fuel with CNG from LFG, as they already visit landfills to drop off their waste and could refill their trucks at the landfills.

Central Disposal Landfill, California

Conversion to CNG for passenger bus fleet

In Sonoma County, California, LFG from the Central Disposal Landfill will be used in a two-year pilot project to fuel part of its passenger bus fleet. This project will use LFG not already being converted to electricity in the landfill's existing 7.5 MW LFG generation system (USEPA, 2006a).

Before LFG can be used as vehicle fuel, it must be filtered and compressed. Financing for these systems is provided by a $480 thousand grant from the Federal Transit Administration and $120 thousand in matching funds from Sonoma County (USEPA, 2006a).

It is predicted that this large up-front cost will be offset by annual savings of $200 thousand. In addition, the County will have access to a vehicle fuel with a predictable price. Pending the successful outcome of the pilot project, Sonoma County will apply for additional grants to expand the project, and is considering building a pipeline from the landfill to its bus-fueling facility (USEPA, 2006a).

In West Virginia, tax credits are available to convert trucks to CNG. While this tax credit is not available for the collection, cleaning, and compression of LFG, it still might help make a LFG-to-CNG project economically attractive (See Section 6.10 for details on the West Virginia Alternative Fuel Motor Vehicle Tax Credit).

West Virginia school buses might also be converted to CNG generated from LFG. Because school buses are typically not owned by corporations, the West Virginia Alternative Fuel Motor Vehicle Tax Credit would not be appropriate because it could not offset a state tax burden. However, the West Virginia Alternate Fuels Grant Program is available to government entities (See Section 6.11).

5.2.2 For pipelines

Public landfills might also be able to clean and compress LFG, and sell the resulting CNG through nearby pipelines. Revenues could then be used at the landfill or for other public programs that benefit the local community. In Mercer County, for example, a natural gas pipeline runs close to the landfill (Haynes, 2005).

6. FINANCIAL INCENTIVES FOR LANDFILL GAS-TO-ENERGY PROJECTS

Some West Virginia landfills might be interested in LFG-to-energy projects, but may not have the financial resources to invest in gas capture and energy conversion systems that are not required by regulation. Due to past management issues, some landfills are paying off old debts, which adds a financial burden. It is unclear whether the WVPSC would approve tipping fee increases to pay for un-mandated LFG projects. Even if approval were granted, increased fees might encourage haulers to divert waste to other landfills. Therefore, while all successful LFG projects need a sufficient supply of gas and a compatible end user, financial incentives will often determine whether a project will be built.

In evaluating the prospects for LFG use in West Virginia, it is important to distinguish between projects that are financially viable and those that need subsidies. Projects that generate sufficient revenues to pay off initial investments might need loans to install LFG projects, but would not need incentives. Projects that do not generate enough revenue to pay off the initial investments, however, would need incentives. This chapter introduces various government and market programs that could help make such projects profitable in West Virginia.

6.1 Section 45 federal tax credit for electricity generation

Section 45 of the Internal Revenue Service Code provides for a production tax credit for electricity generation from renewable energy sources, and dates back to the Energy Policy Act of 1992. In 2004, Section 45 was modified so that electricity produced from LFG qualifies for a tax credit, and in 2005 the qualification date was extended until January 1, 2008.[11]

Under Section 45, a tax credit of 0.9 cents/kilowatt-hour (kWh) will be paid over ten years. This can be a substantial sum. For example, a 1 MW project that is online 90% of the time would generate a tax credit of $709,560.[12]

With no federal tax liability, Section 45 tax credits cannot be used directly by public landfills. To take advantage of Section 45, a third party with a tax liability would have to be involved.

6.2 Renewable Energy Production Incentive program

The Renewable Energy Production Incentive program[13] provides payments of 1.5 cents/kWh, adjusted for inflation, for renewable energy power projects owned by a state or local government. LFG is now one of the renewable fuel types included in this program. However, 60% of any appropriated funds are allocated to Tier 1 projects, and only 40% are allocated to Tier 2 projects, which include LFG. These payments are also somewhat of a gamble because

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[11] A second type of tax credit, from Section 29 of Internal Revenue Service Code, applies to the sale of LFG to an unrelated party (USEPA, 1996). Section 45 tax credits cannot be taken for the same project for which Section 29 tax credits were taken. No West Virginia projects have taken advantage of Section 29 tax credits, and these credits cannot apply to new projects. Therefore, Section 29 will not interfere with Section 45 credits for new projects in West Virginia.

[12] 1 MW * 1,000 kW/MW * 8,760 hours/year * 90% * 10 years * $0.009/kWh = $709,560.

[13] Details on the Renewable Energy Production Incentive program are at 10 CFR 451.

they rely on annual federal appropriations. When available, payments are made over ten years. To be eligible, projects must be operational by October 1, 2016 (Jones, 2006).

Because of the reliance on annual appropriations, and because LFG is in Tier 2, it would not be appropriate to base a new project's financial viability on this program alone. However, payments through this program would be an added bonus and could help make a new project more attractive.

6.3 Clean renewable energy bonds

Public landfills that need to borrow money for LFG projects may be able to take advantage of federal clean renewable energy bonds. Owners of these bonds receive federal tax credits instead of tax-free interest payments from the bond issuers (Goldstein, 2006).

A total of $800 million in clean renewable energy bonds can be issued for all projects, and at least $300 million is reserved for electric cooperatives. All bonds must be issued in 2006 and 2007, and applications must be filed with the Internal Revenue Service by April 26, 2006 (Goldstein, 2006).

With this short deadline, it is not likely that public landfills in West Virginia will be able to take advantage of these bonds. However, landfills that would benefit from similar bonds would be advised to stay apprised of developments regarding future funding of new clean renewable energy bonds.

6.4 Federal purchase requirement

The 2005 Energy Policy Act requires that the federal government purchase an increasing amount of its electricity from renewable energy sources. LFG qualifies as a source for generating renewable electricity. The percentage starts at 3% between 2007 and 2009, and increases to 7.5% by 2013.[14]

Several federal agencies have already started using LFG (USEPA, 2005a and 2005b). When a federal agency is located close to a landfill, it might be interested in entering into an agreement to use electricity generated from LFG.

Federal energy managers have other options for meeting this requirement. They can purchase renewable energy credits (RECs), purchase renewable power through competitive electricity procurements in states with competitive energy markets, or sign up to purchase a local utility's renewable energy (United States Department of Energy, 2006).

6.5 Rural and Remote Communities Electrification grants

The 2005 Energy Policy Act also provides for $20 million of Rural and Remote Communities Electrification grants each year from fiscal year 2006 through 2012. These grants aim, among other things, to provide electric generation facilities that serve rural areas. Preference will be

[14] Federal purchase requirements are at Section 203 of the Energy Policy Act of 2005.

given to renewable energy facilities, which include LFG-to-energy projects (Jones, 2006). These grants are a potential source of funding for LFG-to-energy projects in West Virginia.

6.6 Loan guarantees

The 2005 Energy Policy Act also provides for loan guarantees of up to 80% of the cost of certain projects, including renewable energy systems, that reduce air pollutants or GHGs and that employ new or significantly improved technologies (Jones, 2006).[15] These loan guarantees would help make it more attractive to secure private sector loans for LFG-to-energy projects.

6.7 Renewable energy credits and renewable portfolio standards

Renewable energy credits are created when electricity is generated from renewable sources. Certified credits can be bought and sold in markets. The sale of renewable energy credits from the generation of electricity from LFG would provide an added income stream to West Virginia landfills.

Sixteen states have renewable portfolio standards, and include LFG as a renewable energy source (USEPA, 2005a). These states typically create renewable energy credit markets, and might allow the purchase of renewable energy credits from out-of-state.

West Virginia does not have a renewable energy portfolio. Senate Bill 567, introduced in the 2006 legislative session but not passed, would have created a Division of Energy to develop an energy policy and annual energy development plans. The policy and plans were to address a wide range of energy issues, including the development and implementation of renewable energy projects. LFG is specifically listed in this bill. A future bill similar to Senate Bill 567, if it were to pass, might lead to the development of a renewable energy portfolio in West Virginia.

Another potential purchaser of renewable energy credits would be the federal government, which might buy credits to offset fossil fuel use as a way to help meet more stringent federal purchase requirements (See Section 6.4).

6.8 Greenhouse gas credits

Methane is a potent GHG. Although GHG emissions are not regulated in the United States, voluntary GHG credit markets have emerged in the private sector, generating financial value for GHG reductions.

For example, the Chicago Climate Exchange is a nationwide market for the purchase and sale of credits for all six GHGs. And the Regional Greenhouse Gas Initiative, which includes several New England states, provides another opportunity for selling GHG credits.[16]

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[15] These loan guarantees are at Section 1701 of the 2005 Energy Policy Act.

[16] Because they are not within the Regional Greenhouse Gas Initiative states, credits generated at West Virginia landfills would only be worth one-half of the amount compared with credits generated within the region.

These markets provide a potential source of income for LFG-to-energy projects in West Virginia. In fact, small West Virginia landfills have an advantage compared with larger landfills in other states because GHG credits are usually only generated when methane reductions are made that are not required by regulation. Methane reductions are less likely to be required at West Virginia's small landfills, and GHG credits may therefore be generated (See Section 3.1). When combined with other incentives and project revenue streams, these credits could help make a West Virginia project profitable.

One specific opportunity can be found through the Conservation Fund's e-BlueHorizons program, which is currently exploring opportunities for LFG projects in West Virginia. The program helps fund projects that reduce GHG emissions, reducing future emissions by retiring the valuable "offsets" or credits earned through the efforts rather than using them as "a regulatory and financial currency that allow businesses to pollute" (e-BlueHorizons, 2006).

Third party GHG credit certifiers, in general, must establish emissions baselines: estimates of GHG releases that would have occurred without the implementation of GHG reduction projects. Dry landfills, therefore, that create bioreactors by injecting leachate into the solid waste to increase methane gas production, may not be eligible for GHG reduction credits above and beyond their methane production levels as dry landfills (Willey, 2006). Note, however, that the baseline would not preclude them from acquiring renewable energy credits for the use of a renewable energy that supplants the use of non-renewable fossil fuels.

6.9 Clean School Bus grants

In February 2006, USEPA awarded $7.5 million in grants to reduce children's exposure to harmful exhaust from school buses. The grants will help fund the cleanup of more than 500 tons of diesel emissions from 4 thousand school buses nationwide. USEPA's Clean School Bus USA program encourages, among other things, replacement of the oldest buses with CNG-powered buses. For example, the Tucson Unified School District in Arizona is matching its $500 thousand USEPA grant with $6.5 million it raised towards the purchase of more than 60 new CNG buses (USEPA, 2006c). These grants, perhaps combined with other incentives, might make it viable to convert LFG to CNG for use as a school bus fuel.

6.10 West Virginia Alternative Fuel Motor Vehicle Tax Credit

The West Virginia Alternative Fuel Motor Vehicles Tax Credit is available to convert, retrofit, or buy alternative-fuel motor vehicles.[17] CNG, liquefied natural gas (LNG), and other alternative fuels qualify for this credit. Methane from LFG can be cleaned and compressed and used as a vehicle fuel as CNG. According to the West Virginia State Tax Department, LFG converted to CNG would probably qualify for this tax credit (Cox, 2006). Tax credits vary by vehicle type, as shown in Table 10.

[17] See West Virginia Code 11-6D.

Table 10: West Virginia tax credits available for alternative-fuel motor vehicles

Vehicle type	Maximum credit
GVW of 10,000 lbs. or less	$3,750
GVW of 10,001 lbs. to 26,000 lbs.	$9,250
Truck or van with GVW of 26,001 lbs. or more	$50,000
Bus seating at least 20 adults	$50,000

Source: West Virginia State Tax Department (1997). GVW = gross vehicle weight.

This tax credit could only be claimed by an entity subject to state corporation net income taxes or personal income taxes (West Virginia State Tax Department, 1997). If LFG were used by a corporate fleet, such an incentive might be valuable. But if LFG were used by a county school bus fleet, it would not be valuable. Another consideration is that this credit expires in 2007, limiting its use unless the credit is renewed.[18]

6.11 West Virginia Alternate Fuels Grant Program

The West Virginia Alternate Fuels Grant Program provides up to $20 thousand to government entities to convert fleet vehicles to alternate fuels or to pay for incremental costs associated with the purchase of alternate-fueled vehicles. Alternate-fueled vehicles include dual fuel or dedicated CNG vehicles. Only county governments, incorporated municipalities, transit authorities, public colleges and universities, and school boards are eligible for this program. The West Virginia Development Office's (WVDO's) Energy Efficiency Program coordinates this program. Grants must show at least a 50% local cash match (WVDO, 2006).

This grant program could help a local school board purchase buses that run on CNG produced from LFG. It could also help counties and cities purchase CNG-fueled vehicles for their fleets. Although $20 thousand is small compared with the total cost of LFG-to-energy projects, this grant program could be one piece of a larger financing package that would make a project financially feasible.

6.12 West Virginia higher reimbursements to county school systems using biodiesel

Biodiesel is not produced directly from LFG; however, LFG has been used successfully in Texas as a source of heat for biodiesel production (See Section 5.1.4). West Virginia provides an incentive for county school systems to convert to biodiesel: a reimbursement rate increase from 85 to 95% of fuel costs. Only five West Virginia counties have taken advantage of the program so far. But in Monongalia County alone, conversion to B20 biodiesel has saved the school system $50 thousand per year, on average, over two-and-a-half years (Burnside, 2005).

This incentive, while not directly related to LFG-to-energy projects, could play a role in the economic viability of such a project. County school systems that convert to biodiesel will realize cost savings, and a broader package that uses LFG to produce biodiesel for school buses might, as a whole, be economically viable due at least in part to these higher reimbursement rates.

[18] See West Virginia Code 11-6D-7.

6.13 Solid Waste Management Board and recycling grant programs

The WVSWMB offers grants to help solid waste authorities properly manage waste.[19] In fiscal year 2006, $320 thousand was provided to solid waste authorities across the state (WVSWMB, 2006). It is possible that these grants might be able to help finance LFG-to-energy projects.

A different grant program—the Recycling Assistance Grant Program[20]—awards grants of up to $100 thousand to solid waste authorities in West Virginia. This funding source focuses on recycling programs, but it is instructive nonetheless as an example of how state assessments on tipping fees are directed back to landfills to promote programs that the state deems important. If LFG-to-energy projects were to become a state priority, these grant programs—modified as necessary—might help spur investments.

6.14 The Natural Capital Investment Fund

Finding private financing for LFG-to-energy projects may be difficult due to the lack of information about such projects in the private banking and finance sector. An alternative source of financial assistance for LFG-to-energy projects is West Virginia's Natural Capital Investment Fund (NCIF). For years, the non-profit NCIF has been working under the mission "to provide debt and equity financing to small and emerging natural resource-based businesses that will advance sustainable economic development throughout West Virginia" (NCIF, 2006). NCIF invests in "projects that promote sustainable development and have a positive impact on human health and the natural environment" (NCIF, 2006). NCIF specifically identifies integrated waste management as a top priority for funding. Funding awards and agreements vary by project type and scale (NCIF, 2006).

[19] 54 CSR 5 provides interpretation and guidance on the WVSWMB grant program.
[20] 58 CSR 5 provides interpretation and guidance on the Recycling Assistance Grant Program.

7. MAKING IT WORK IN WEST VIRGINIA: CONCLUSIONS AND RECOMMENDATIONS

Across the United States, 396 LFG-to-energy projects are now in operation. While 64 of these projects are found in West Virginia's five neighboring states, none are found in West Virginia. Clearly, West Virginia faces constraints in the development of such projects.

West Virginia is home to only eighteen open landfills, and in comparison to landfills across the country, these landfills are small and LFG generation rates are low. Because of their small size, most are not required to collect and flare their LFG. While all landfills must eventually install LFG wells and vents when cells close, these systems are not exactly the same as what would be installed for LFG-to-energy projects. Cheap electricity already available in West Virginia makes it difficult for LFG-to-electricity projects to compete. Incentives will likely be needed to fund LFG-to-energy projects in West Virginia. Although a range of incentives exist, they are generally not communicated effectively to landfill owners, and state and local incentives for LFG-to-energy projects are not as strong as in other states.

Despite these constraints, LFG-to-energy projects can succeed at public landfills in West Virginia with the proper combination of incentives, education, and support. Several steps can be taken to overcome these constraints.

7.1 Developing landfill-gas-to energy projects

- **Combine financial incentives together to make LFG-to-energy projects profitable.** Multiple incentives are likely to be necessary to tip the scale in favor of LFG-to-energy projects at public landfills. Fortunately, a wide range of incentives are available. While a single incentive may not be enough, the combination of production credits, grants, and renewable energy credits, for example, might make such projects viable.
- **Information sharing and education is necessary to communicate these incentives.** While many incentives are available, public landfill operators are likely not aware of them all. A concerted effort to compile and communicate these incentives would be valuable. The most appropriate entity for such an effort would likely be a statewide agency or organization that is already known and respected by public landfill operators, such as the WVSWMB.
- **Local project champions are needed.** Effective local advocates for LFG-to-energy projects have often turned ideas into actual projects. No single advocate is likely to succeed across the state. Project champions could be landfill operators, government agency or nonprofit organization staff, or private citizens. Local government or community leaders may also be able to pull together the various required incentives and communicate the benefits of projects to local residents.
- **Public-private partnerships may help.** Private landfills that have implemented successful projects might share expertise with small public landfills, which have fewer resources available to research un-mandated projects such as LFG-to-energy projects.
- **Technology transfer from coalbed methane will be valuable.** As coalbed methane projects are developed, new more cost-effective technologies are likely to be developed, and these technologies are likely to be transferable to LFG-to-energy projects.

7.2 Making the climate more favorable for landfill gas-to-energy projects

- **Integrate LFG into a new state energy plan.** Of and when a new state energy plan is developed, integrating LFG-to-energy projects into this plan will help spur interest in the development of such projects.
- **Initiate a state renewable energy portfolio.** West Virginia currently does not have a renewable energy portfolio with requirements for a certain amount of electricity to be generated from renewable sources such as LFG. Approval of such a portfolio would provide a significant incentive for the construction of LFG-to-energy projects.
- **Allow net metering.** Net metering allows small independent power producers—such as landfills with LFG-to-energy projects—to sell electricity back to the grid. West Virginia does not allow net metering, but the WVPSC is now considering the issue. Allowing net metering would help make electricity generated from LFG more valuable, as surplus electricity not used by local end users could be sold back to the grid.
- **Integrate the current requirements for LFG collection with LFG-to-energy projects.** Currently, the largest landfills are required to collect and flare LFG to meet air quality regulations. Landfills with high concentrations of methane, which presents an explosion risk, and landfills that cause odor problems for neighbors, must collect LFG. On all landfills, LFG wells and vents are required when cells close. Escrow funds are generally used to fulfill these requirements. Extra costs will likely be encountered if gas is collected for energy production. Allowing the use of escrow funds to cover these extra costs would make LFG-to-energy projects more attractive, as additional funding would only be needed for LFG treatment and conversion systems.

7.3 The path forward

The Raleigh County Sanitary Landfill situation is instructive on how a LFG-to-energy project might be developed on a public landfill. This landfill is moving toward installing a bioreactor, in which leachate is returned to the landfill to add moisture. Bioreactors help landfills reclaim air space as old waste decomposes, and delay the need for new, expensive cells. A byproduct of this process is that LFG generation rates will increase, although it will result in a sharper dropoff of gas generation rates in future years. A permit modification will be required before such a system can be installed.

In Raleigh County, plans to install a LFG collection system are proceeding, even though the landfill is exempt from federal gas capture and flaring regulations. This decision is based on a recognition that methane generation is already affecting landfill operations, and that regulations will kick in soon.

End users are not set yet, but the landfill itself may use LFG to heat its recycling center and shop building, and is likely to generate electricity to light its golf course at night. Nearby businesses may also be interested in energy from LFG.

Depending on the final configuration of the project, various incentives may make the project more economically viable. For example, the landfill might qualify for Renewable Energy Production Incentive program payments of 1.5 cents/kWh for electricity generated from LFG.

They might qualify for clean renewable energy bonds if funds are needed up-front to install the LFG system. The United States Postal Service facility located nearby might be interested in purchasing electricity to help satisfy the federal government's renewable energy purchase requirement.

Renewable energy credits or GHG credits might be sold to generate additional revenues. If the landfill decides to invest in a system to convert LFG to CNG for use as a vehicle fuel, or to use LFG as a heat source to produce biodiesel, other government programs might make money available for vehicles or for the LFG-to-energy system itself.

While it is unlikely that every one of these incentives would be used at a single landfill, multiple incentives can clearly be stacked, potentially turning a LFG-to-energy project from a money-losing into a money-making project.

LFG-to-energy projects are also likely to be feasible at other public landfills, given the right end-users and the right mix of financial incentives. Larger financial incentives might be needed at smaller landfills.

The benefits of installing LFG-to-energy projects, however, go beyond the standard financial benefits that show up on landfill balance sheets. These projects can improve landfill safety, reduce emissions of a potent GHG, and decrease odor problems for landfill neighbors. While LFG in West Virginia will never rival coal or natural gas, LFG-to-energy projects can provide a key renewable energy source to help diversify the state's energy mix and provide low-cost energy to nurture local businesses and communities.

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