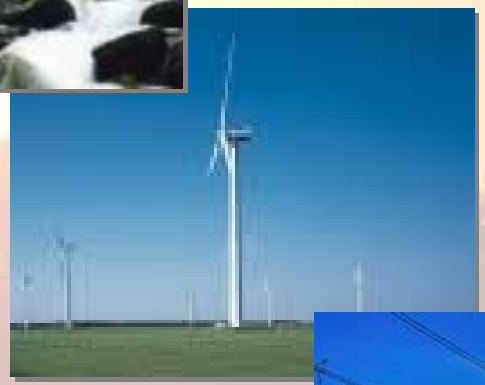


American Case Studies, Costs, Incentives, and Barriers

Jerry Leone

General Manager – Renewable Energy

Companies Directly Using LFG as Fuel

- Ford
- GM
- Georgia Pacific
- Chrysler
- Cone Mills
- Lucent
- Blue Circle Cement
- S.C. Johnson
- Rolls Royce
- Ocean Spray
- Ogden
- International Paper
- BMW
- GE
- Lonza Chemical
- Ashland Chemical
- Ajinomoto
- Malenckrodt
- Georgia Pacific
- Walbridge Castings
- Cargill
- Champion International
- Emory Chemical
- Nestle
- NASA
- Sunoco

BMW Project

Ameresco has a 20-year, multimillion-dollar contract with BMW Manufacturing Corporation to provide energy to their Spartanburg Plant in South Carolina.

- Ameresco designed, built and is now operating a new landfill gas-to-energy plant at the largest landfill in South Carolina.
- Over 1M MMBTU/yr of landfill gas is being filtered, partially treated, dried, compressed, and delivered via a dedicated 10-mile HDPE pipeline to combustion turbines at the BMW Manufacturing Corporation (a facility that comprises over 2 million square feet).
- Dual compressor stations at the landfill and the end user's facility, as well as the 10-mile pipeline are sized for future growth to 1.5M MMBTU/year (boiler or absorption chilling options).

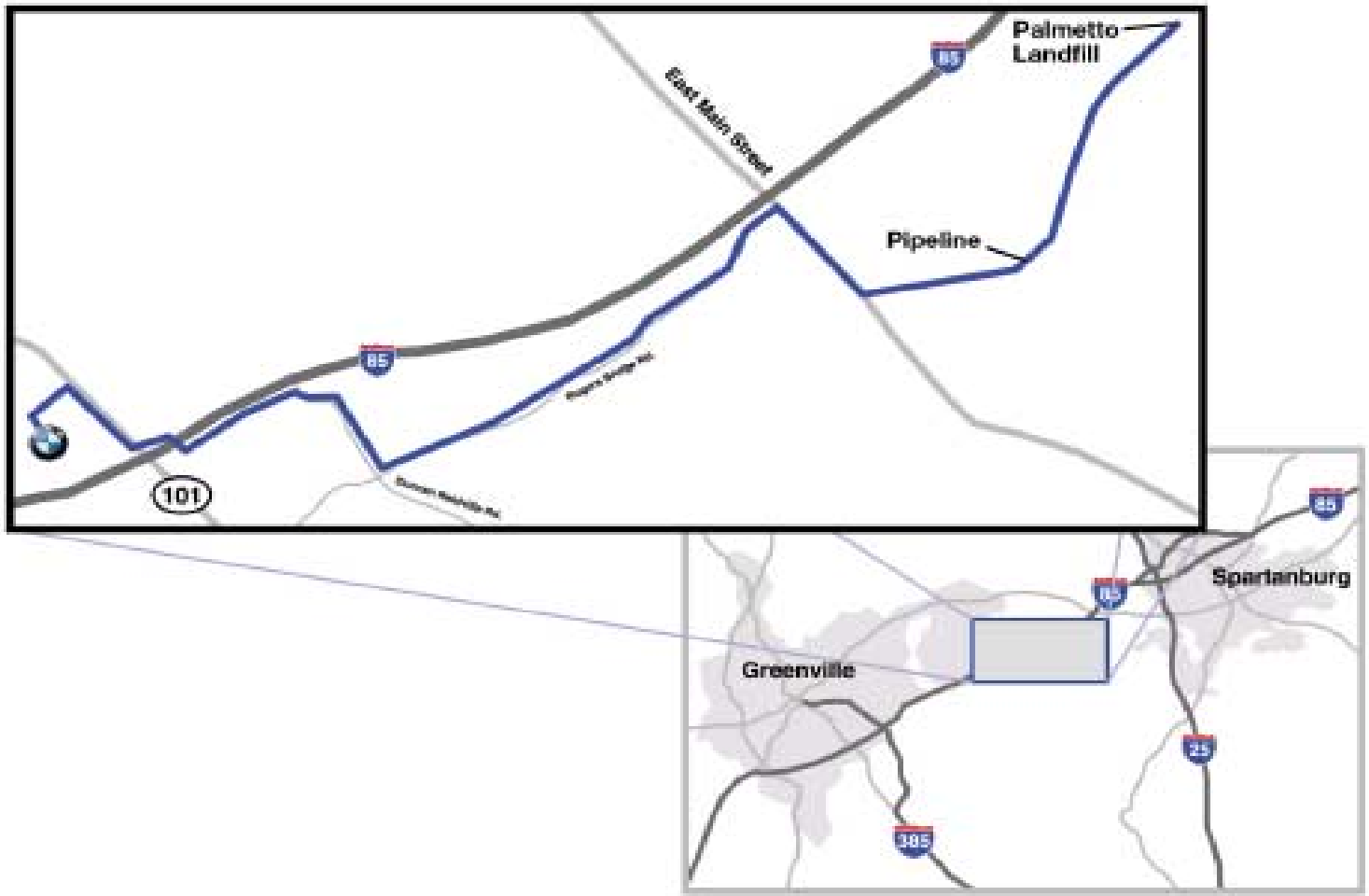
- Construction initiated April 2002, flow test completed December 24, 2002

BMW Project – con't

- Pipeline was installed along rural and urban sections entirely with public right of ways – no cost for easements

BMW Project – con't

- State not only rapidly approved easement request, but suggested a better routing



BMW Project – con't

- Retrofit to allow combustion of LFG
  - ✓ Diesel fuel for turbine start-up
  - ✓ New combustor head with a low Btu/diesel dual fuel nozzles
  - ✓ Addition of controls and software
- Four (4) 1.25 MW gas turbines
  - ✓ 5 MW electricity
  - ✓ 275 deg. high temperature hot water
    - Meets 80% of BMW's Thermal Needs or approximately 500,000 MMBTU per year
    - Each Turbine can generate 18 MMBTUs per hour of Thermal Heat recovery
- LFG supplies approximately 20% of BMW's electric energy requirements
- Future gas flow to be used in package boilers – line sized to handle flow

Grand Central Project

- Waste Management, Inc. designed, built and is now operating this $9.2M gas-to-energy plant at one of the largest landfills in Pennsylvania
- Power plant is owned by non-profit corporation comprised of three (3) townships surrounding the landfill (Green Knight Economic Development Corp.)
  - One put up with noise
  - One put up with traffic
  - One put up with odors and blowing litter
- Plant includes three (3) Solar Centaur combustion turbines with 10 MW total capacity

Grand Central Project – cont'd

- The region know as the Slate Belt is comprised of mostly small towns and farmland
- Historically, the agricultural economy was strongly supplemented by slate quarrying and garment/textile manufacturing
- Today, the quarrying and garment industries are a small fraction of their former size and the textile plants are defunct
- Green power is sold to local utility
- GKEDC does not pay taxes
- GKEDC got very competitive interest rate
- Project eligible to receive Federal funding under DOE's Renewable Energy Production Incentive Payments
- In conclusion, GKEDC's organizational structure puts the local community in charge of its own economic redevelopment

Grand Central Project – cont'd

- Designed and built to allow for future waste heat recovery, facility just on boarder of industrial park
- Elected EPA's Project of the Year Award in 2001
- Project financed by local bank with backing from WMI
- All members of GKEDC volunteer their time
- Since going on-line in March 2001, GKEDC has provided the funding as follows:
  - Annual $1,000/yr for 4 years – college scholarship
  - $7,500 donation to Community Library
  - $5,000 contribution to school's Families First Program
  - $5,000 contribution to local park (1.2 mile hiking path)
  - $5,000 contribution toward purchase of new ambulance
  - $2,500 contribution to support park concert series
  - $4,300 contribution toward purchase of new firemen suits

Elk River Project

- Waste Management, Inc. designed, built and is now operating this $2.9M gas-to-energy plant in Minnesota
- Power plant is owned by local electric utility
- Plant includes three (3) Caterpillar reciprocating engines with 2.4 MW total capacity with spare bay
- Plant also includes an educational “wing”
- County provided financing using abatement funds collected as waste disposal tax

Rutgers University Project

- The Eco Complex located in New Jersey conducts research associated with using methane as an energy source plant is owned by local electric utility
- Project includes a one (1) acre greenhouse that is a commercial facility using LFG for heating
- Also includes a fish farm for raising tilapia
- Support research associated with ethanol production using locally grown corn, plant biomass, and MSW

Rutgers University Project – cont'd

- Includes 120 kW (four 30 kW microturbines with heat recovery - went into operation in Nov. 2002
- Greenhouse typically grows Poinsettias and/or tomatoes
- Serves as an outlet for hiring and working with handicapped individuals
- Also Includes a state of-the-art gas cleaning skid that removes CO_2 from LFG (funded by DOE)

Edgeboro Project

- The Edgeboro Landfill project includes two unique applications at this single large landfill also located in New Jersey
- Project includes a 10. 2 MW combined cycle steam turbine power plant that uses LFG from ½ of the site
- LFG from the other half of the site is piped 5 miles north where it is used in a separate 10 MW combined cycle turbine plant that supplies power to a sewage treatment plant
- Landfill gas is also collected from two (2) other landfills located along the pipeline route used at the treatment plant

Hackensack Project

- The Kingsland and Balefill landfills project also includes dual applications at a series of three closed landfills also located in New Jersey
- Project includes 3 containerized 3516 CAT engines at Kingsland and 4 tandem 3516 CAT engines using 65% of the gas from Balefill
- LFG from the other portion of the Balefill site is piped 2 miles south where it is combined with LFG for another landfill and injected (untreated) into NG distribution system – blended with tail gas from a refinery

Hackensack Project – cont'd

End use plans call for entire complex to be converted into golf resort using dredge spoils

Ford Project

- The Ford pipeline project in Wayne, MI is also located in a very congested area in Wayne, MI, a Detroit suburb - has been on-line for close to 15 years
- Project includes a 4 mile pipeline that runs along a congested neighborhood to Ford's massive assembly plant
- LFG from this large landfill is compressed and piped to Ford and used in their package boilers to produce steam which previously ran on coal, now LFG and NG
- Ford liked the use of LFG so much that they installed 3 3516 engines

Ash Grove Cement Project

- The Ash Grove Cement Company, a 118-year old company with a plant located just over a mile from the closed St. Johns Landfill
- Ash Grove historically used large volumes of waste oil and natural gas to produce lime in their three (3) kilns
- Project includes a 1.6 mile pipeline with annual production of ~ 880 mmBTU/yr
- Total project cost ~$2.6M
- Reduced emissions by 23,300 MT/yr same as:
  - removing 3,300 cars
  - planting 7,100 acres of trees

Rivergate Industrial District and St. Johns Landfill

Ash Grove Cement Co., where the gas is metered and used in one or more kilns.

More than 15 permits from 10 regulatory agencies were needed to clear the way for the pipeline's route along waterways, roadways, railroad tracks and Port of Portland property.

At its deepest point, the 9,400-foot pipeline is buried 20 feet under the Columbia Slough.

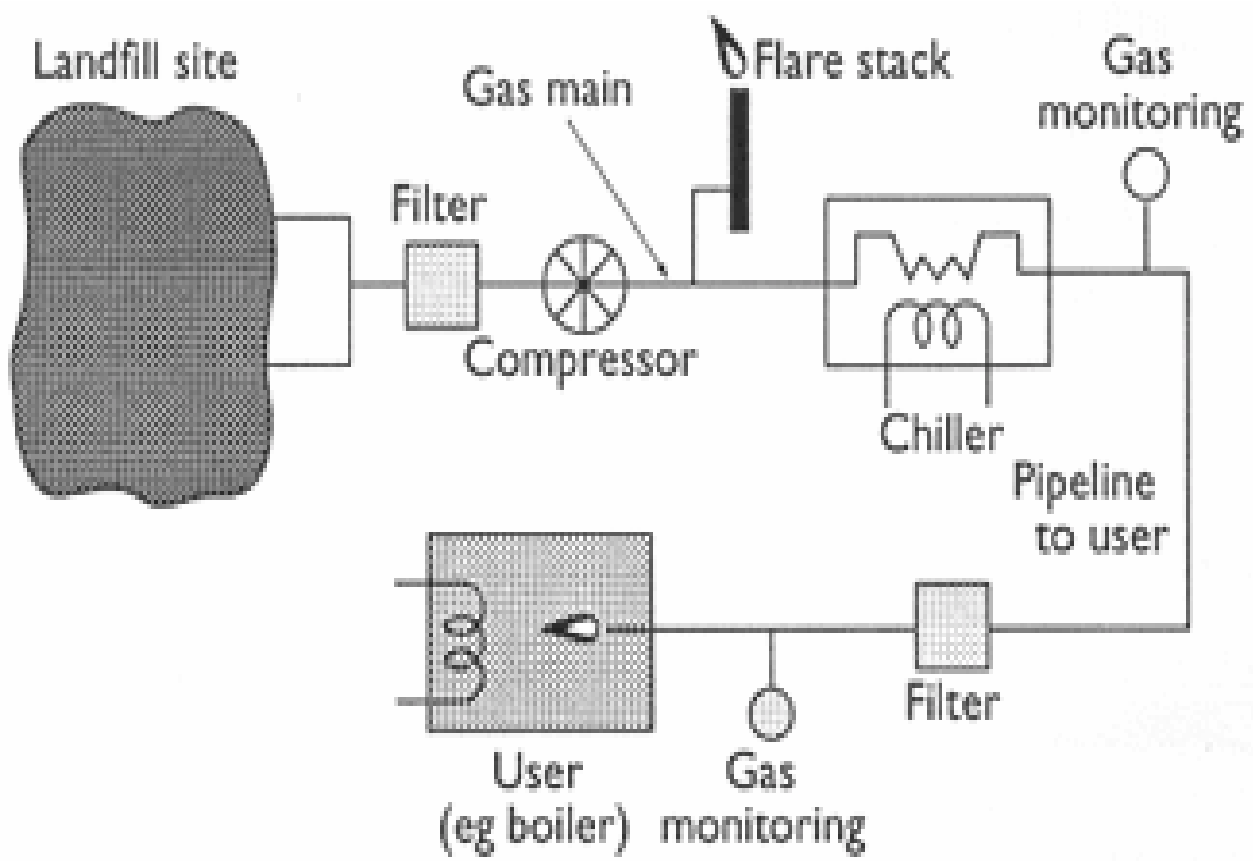
The compressor station sends gas to Ash Grove. Excess gas is combusted by four flares.

Metro's 238-acre St. Johns Landfill is covered with nearly 100 gas wells.

Adapting Boilers to Run on LFG

- **Replacement of burner tip – allow twice the flow of gas**
- **Use of a larger fuel valve orifice can mean additional cost savings since the larger orifice reduces compression requirements**
- **Controls upgrade**
- **Dual fuel consideration for back up supply and stabilization**
  - Use of a UV sensor
- **Typically less than a $60K conversion**
- **Can be done with fuel oil or NG (or propane)**
- **Does require dewatering of LFG**
- **Sulfur trioxide formed from sulfur content in LFG raises the dew point in boiler exhaust and can lead to corrosion**
  - Insulation or preheating combustion air

Direct Sale Overview



LFG Direct Use

- **Advantages**
  - Simplest technology
  - Generally, minimal processing requirements
  - Able to use gas as it becomes available
  - Most cost effective
  - Two party agreement
  - Higher priced commodity

- **Disadvantages**
  - Requires locating an end user
  - Could require utility status classification
  - Easements may need to run through urban areas

Electricity Generation

- **Advantages**
  - No local end user needed
  - Power could be used on-site
  - Allows waste heat recovery

- **Disadvantages**
  - Higher capital and costs
  - Utilities can be difficult to deal with
  - Long term agreement necessary
  - Some markets not competitive enough

LFG Direct Use

- **Advantages**
  - Simplest technology
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  - Able to use gas as it becomes available
  - Most cost effective
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  - Higher priced commodity

- **Disadvantages**
  - Requires locating an end user
  - Could require utility status classification
  - Easements may need to run through urban areas

Microturbines

- **Advantages**
  - Low emissions
  - Multiple fuel capacity
  - Light weight/small size
  - Requires a lower degree of pretreatment than high BTU or fuel cell systems
  - Lower maintenance costs
  - Modules can be linked to increase in gas flow
- **Disadvantages**
  - Low efficiencies
  - Has been tested mostly for natural gas applications
  - Limited track record of performance
  - Requires gas cleaning

Fuel Cells

- **Advantages**
  - High efficiency
  - Minimal emissions
  - Modular
  - Mature technology when used with natural gas
- **Disadvantages**
  - Limited track record of performance on LFG
  - Extensive pretreatment required for LFG
  - High Cost

Project Costs

- **Gas to electric**

  ~$1,100/kW to construct an LFG power plant using engines

  ~$0.03 – 0.04/kWhr to operate

- **Direct Sale**

  - will depend on distance to end user
  - typically $2M - $4M upfront
  - O&M costs ~$200K/yr (mostly compression and labor costs)
  - Pipeline costs ~$30/ft.

Development Barriers

- **Lack of Deregulation/Existence of Regulation**
- **Low Cost of Utility Default Service/Lack of Incentives**
- **Emission Credit Market – Slowly Maturing**
- **Standby Electric Service/Rates**
- **Unreasonable Utility Interconnection Requirements**
- **Inability to Obtain Long-Term Contracts (necessary to finance LFG projects)**
- **Lack of Education**
  - General public
  - Consumers (regarding benefits of green power)

Legislative Issues

- **Public Utility Regulatory Policy Act (PURPA) which governs the sale of electric power generated by LFG-to-energy plants**
- **Federal tax credits and state regulations which provide financial assistance and incentives to recover and reuse LFG**

RCRA Subtitle D

- **RCRA, Subtitle D and Chapter 17-701, FAC, with respect to LFG monitoring, control, and recovery for reuse**
- **Concentration of methane cannot exceed 25% of the lower explosive limit in on-site structures**

NSPS and Emission Guidelines

- **Promulgated under the Clean Air Act**
- **New and existing landfills**
- **Capacities equal to or greater than 2.75 million tons**
- **Regulates methane, carbon dioxide and NMOCs**
- **Require**
  - Well designed/operated collection system
  - Control device capable of reducing NMOCs by 98%