195 kW or Bust:
Watauga County, NC Landfill Gas Project

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PROJECT INTRODUCTION
Watauga County Landfill Timeline

- ‘72-’94 accepted 546,000 tons of waste
- ‘96 passive solar flares installed on 22 vents
- ‘05 active LFG collection system, voluntary
- ‘06-’11 flared >100,000 mmBtu, +/- $600,000
Landfill Gas Project Basics

- 2.6 mmBtu/hour
- 186 kW combined nameplate capacity
  - 2x GM Vortec engines from KSD Enterprises
- 950,000 kWh/year (est.) generation
- 130 kW effective capacity output
8.1 L GM Vortec Engines from KSD Enterprises

Mar. 20, 2012 start of electricity generation
Other Accomplishments & Benefits

• Watauga County: use waste heat from engines
  – Savings on propane and heating energy
  – Drying paint for disposal

• Research: Appalachian State programs
  – Generator testing on 3rd pad
  – Development of real-time monitoring technology
  – Biofuels and horticulture in greenhouses

• Community Leadership: project being replicated in at least 4 other counties at present

• Industry: product and business model development
  – PowerSecure, Inc. now offers 100kW-scale turnkey generator package in partnership with KSD Enterprises at price near $1,000/kW price
  – Concepts for component improvement
PROJECT DEVELOPMENT
Phase I: Gas Collection System

- ## Extraction well
- # Condensate sump
- ⚡ Blower/Flare unit
- Green: Gas collection piping
Historical energy available from LFG (mmBtu/hour)
Electricity Accounts: Landfill Facility
Electricity Use at the Landfill

- 6 separate accounts
- 4 rate schedules
- 262,365 kWh/year
- 145 kW ave. billing demand
- $38,000 annual electricity expense
Demand-based Inverted Block Rate

- Block size = 200 kWh * 145 kW billing demand = 29,000 kWh block
- 21,860 kWh/month ave.
  - All in first block @ 8.65¢/kWh = $1,891
- 70 kW billing demand = 14,000 kWh block
  - 14,000 kWh * 8.65¢
  - 7,860 kWh * 5.95¢
  - Total $1,679 = 7.68¢/kWh = 11.2% savings

Billing Demand (kW)

- Baler 117.3 kW
- Maintenance Shop 18.1 kW
- General Service Accts., 9.8 kW

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On-site Electric Use Challenges

• No single account would maximize on-site use of generator output and project value

• Negotiate with Blue Ridge Electric to combine accounts behind single meter on one rate
  – Aggregated electricity use = 27% kWh generation
  – Aggregated peak billing demand = 165 kW, about 30% more than maximum generator output

• Coordinate large equipment use with generator operation and peak hours
  – Maximize value for selling excess generation
  – Reduce billing demand -> reduce average $/kWh price for purchased electricity
Project Revenue from Sales

• Interconnection to LSE Blue Ridge Electric (BRE)
• Duke Energy (BRE’s all-req. supplier) purchases electricity delivered to grid (i.e., not consumed on-site) and instantaneously re-sells electricity to Blue Ridge Electric
• Originally considered selling to BRE at avoided cost rate of ~4.5¢/kWh, but negotiated deal with Duke for sale at ~5.53¢/kWh (23% gain)
• For electricity delivered to grid, RECs sold to N.C. Green Power for more than 1¢/kWh – County retains RECs for electricity used on-site
OPERATIONAL RESULTS
Daily Project Output, kW

Engine 1
Engine 2

Est. Average Daily kW

4-Apr, 4-May, 4-Jun, 4-Jul, 4-Aug, 4-Sep, 4-Oct, 4-Nov, 4-Dec

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Uptime Percent per day, by engine

Engine 1

Engine 2
Engine Operating Stats

- 272 days between 4/4/12 - 12/31/12
- Days engines down: Engine 1 - 73 days, Engine 2 – 85 days, Both – 28 days (10%)
- Median kW output (operating): Engine 1 – 54.5 kW, Engine 2 – 48 kW, Combined – 70 kW
- Max kW output when operating: Engine 1 – 70 kW, Engine 2 – 69 kW, Combined – 129 kW
Operating Issues

- **Exhaust System:**
  - Siloxanes plugged catalytic converter – recently tested within NSPS limits w/out catalytic converter
- **Electrical Controls:**
  - Heat damage and reverse power flow
- **LFG System:**
  - Loose belts, pipeline pressure, N₂ auto-shutoff
- **Result:** Future uptime projected at 87.5%

**Causes of Downtime**

- Electrical Controls: 33%
- LFG System: 27%
- Exhaust System: 35%
- Grid: 5%
Using Automotive Engines for LFG-fueled Electricity Generation

- **Cost & Size**
  - Low-cost per kW of capacity
  - Easily fit within shipping container enclosure
  - Highly adjustable output over wide range (<30kW – 80kW+)

- **Maintenance – a blessing and a curse**
  - High number of operating hours under load relative to typical vehicle use -> oil changes/consumption, alternator
  - Landfill staff can perform most regular maintenance with a bit of training

- **Development of “genset” product**
  - Incorporating remote-start capability
  - Lightening storms can disrupt monitoring equipment and/or knock generators off grid
  - Placement of electronic controls and components away from high-heat areas
Electricity Purchases Pre- and Post-Project

67% reduction in kWh purchased (Mar-Dec ‘12)

Historical Monthly Average
Project Period Average
Disposition of Generated kWh

1/3 portion of kWh consumed on-site

Grid Sale  On-Site

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<th>Month</th>
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<th>On-Site</th>
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<tr>
<td>Nov</td>
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</tbody>
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OUTCOMES & CONCLUSIONS
Project Outcomes (Apr-Dec ‘12)

• 70% reduction in kWh purchased
• 48% reduction in electricity expenditures
• $17,800 in revenue from sales of electricity and green power
• $1.48 in revenue per $1 of electricity bill
• $31,250 total benefit over 9 month operating period = $41,665 annualized
• IRR = 7% with NO tax credits, subsidized financing, or other incentives available to private developers (based on past year’s performance)
Project Future

• Improve uptime ratio -> increased generation, higher sales revenue

• Continue to reduce billing demand -> reduce electric bill and electricity purchase price

• Capture waste heat to displace electricity and propane used for heating [space and water] ->~$6,500/year in additional savings

• Implement real-time wellhead monitoring and continue innovating small-scale LFG electricity generation systems technology
Future Performance Targets

• Project uptime of >87.5%
• Net capacity output of 120 kW
• Net generation of >900,000 kWh/year
• Billing demand <65 kW
• Electric bills of ~$7,500/year (81% savings)
• Savings + Sales = $74,000/year (no CHP)
• 10-yr IRR = 19%; NPV (3%) = $304,842
Thank You!

QUESTIONS?

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