

Portable Biogas Microturbine Power System Installation

CANMET Energy Technology Centre
& The City of Calgary

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Project Organization

- Funding & Project Support
 - CETC (75%): Microturbine Trailer Operations
 - The City of Calgary (25%): LFG Recovery, Supply & Monitoring
- Project Management
 - CH2M HILL

Installation Summary

- Location: Shepard Landfill, Calgary, AB
- Portable Unit: Trailer-mounted Capstone C30 complete with on-board LFG conditioning system
- Unit initially tested in 2001 (1,051 hours); Re-installed November 2003 with LFG conditioning system upgrades; Operated to November 2004 (6,202 hours)

Installation Summary

- Grid interconnected installation
- Trailer sited on top of completed landfill waste cell; 25kV feeder brought to unit
- CompAir Hydrovane 15 hp compressor used to draw LFG under vacuum from dedicated LFG extraction wells on site
- LFG flow rate ~ 22 m³/h for 30 kW Capstone C30 microturbine

Site Installation

25 kV
Interconnection
Point

Microturbine
Trailer

LFG
Extraction
Well (TYP)

Abovegrade
Gas Lines
(3 LFG Wells
connected)



Project Goals

- Obtain at least 6 months or 4,000 hours of operational experience
- Unattended operation with Web-based monitoring system
- Site visits for routine O&M to be on a monthly basis

Unit Equipment Summary

- Gas processing system
 - Inlet filtration - coalescing filter
 - VanAir deliquescent gas dryer low pressure (Model D-30)
 - Comp Air Hydrovane Model GK707 rotary vane 15 hp compressor – direct-coupled dual-circuit aerial cooler for gas and lube oil cooling
 - Compressor control panel

Unit Equipment Summary

- High pressure water knock-out vessel
- Gas/glycol heat exchanger (plate type) for optional gas chilling system
- Gas/gas heat exchanger (plate type), to re-heat the gas $\sim 10^{\circ}\text{C}$ above dewpoint
- AFT SAG-18 siloxane filtration system
- Automated condensate handling system



CompAir Hydrovane
GK707 Compressor
Gas Aftercooler



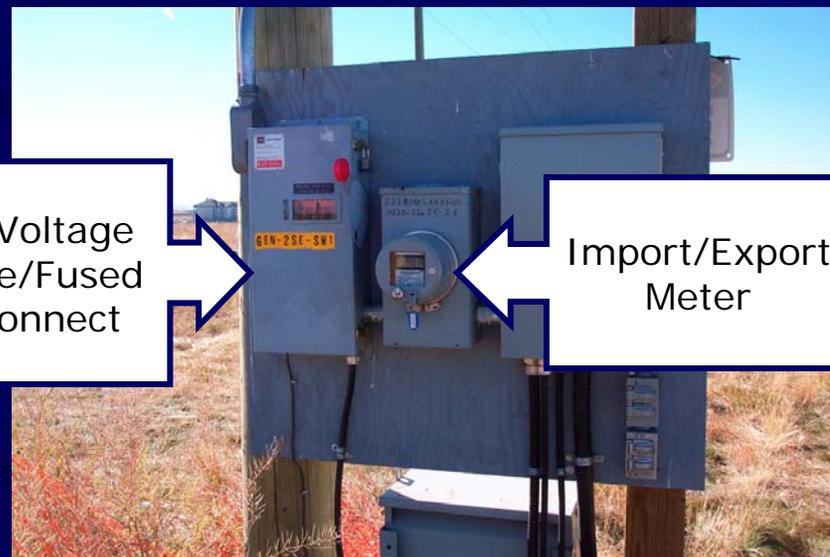
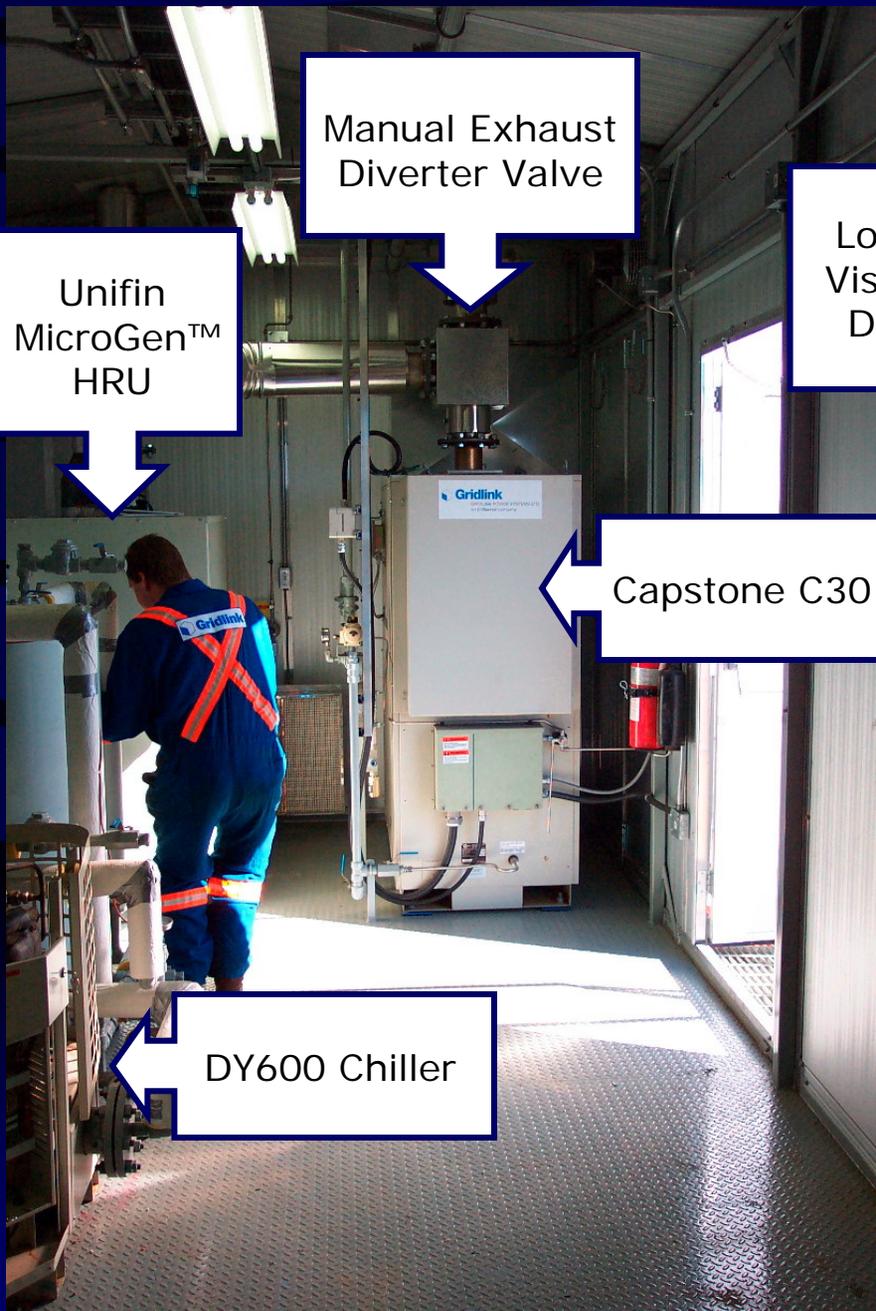
AFT-SAG-18
Siloxane Filter

Condensate K.O.

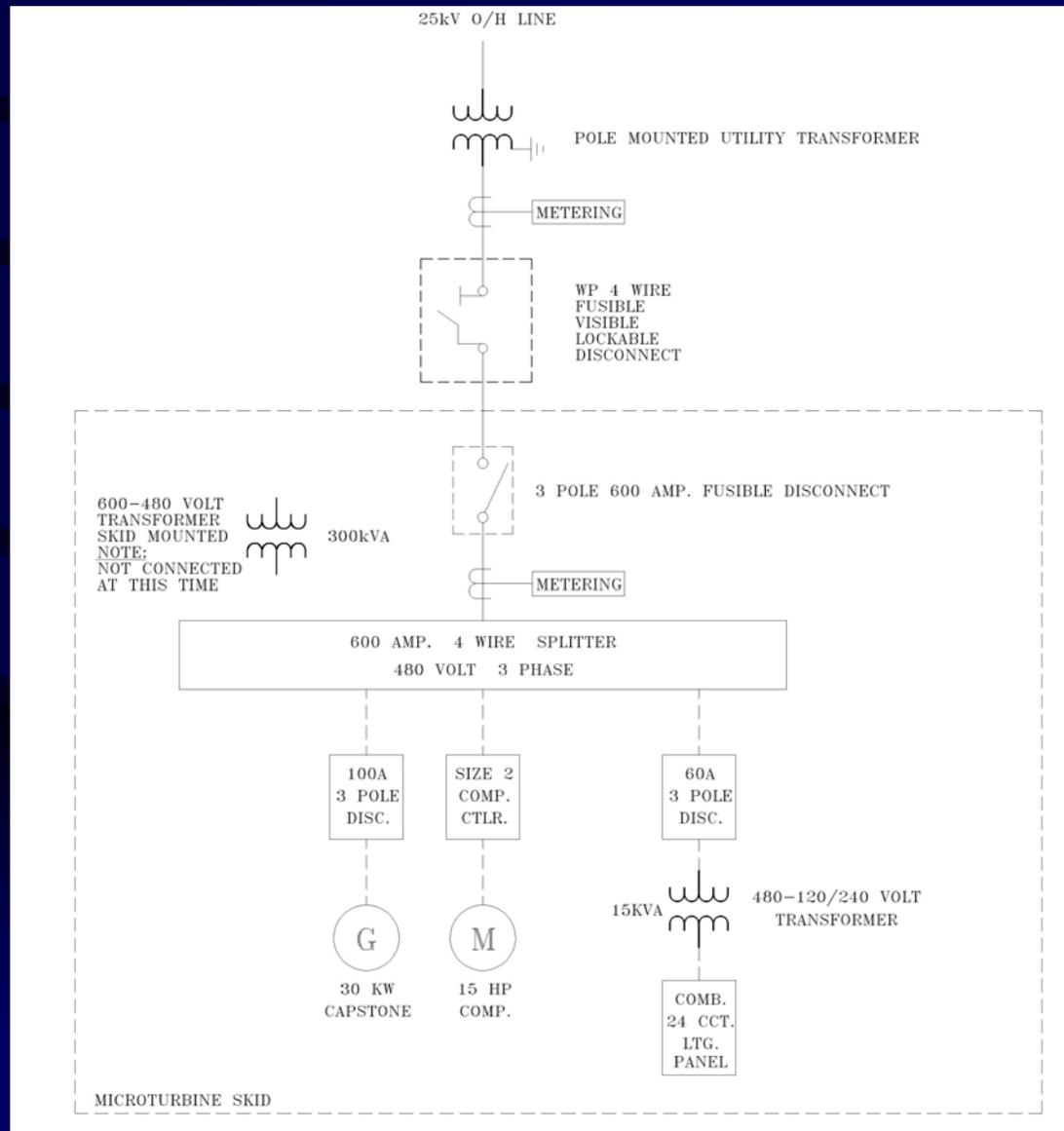
Gas/Glycol
Heat Exchanger
(optional Chilling Loop
available)

Unit Equipment Summary

- Power generation system
 - Capstone 30 kW microturbine
 - Unifin Microgen Heat Recovery unit
 - DY600 heat-driven adsorption chiller initially installed and tested for gas chilling application; removed due to limitations of the DY unit capacity and system component failures
 - Electrical room (power output 480V or 600V)
 - Net-Flow Web-based monitoring system



Electrical Single Line Diagram



LFG Conditioning System Performance

- LFG conditioning system operated as designed; only minor maintenance issues
- Downtime associated with fuel gas system:
 - Condensate dump valve malfunction on air delivery side (two separate occasions)
 - Fuel gas PCV upstream of microturbine not seating properly. Deposits found on valve seat
- Total Siloxanes measured:
 - Raw LFG from the wellfield: 5.13 ug/l
 - Treated LFG to Microturbine: 0.05 ug/l

Electrical Performance

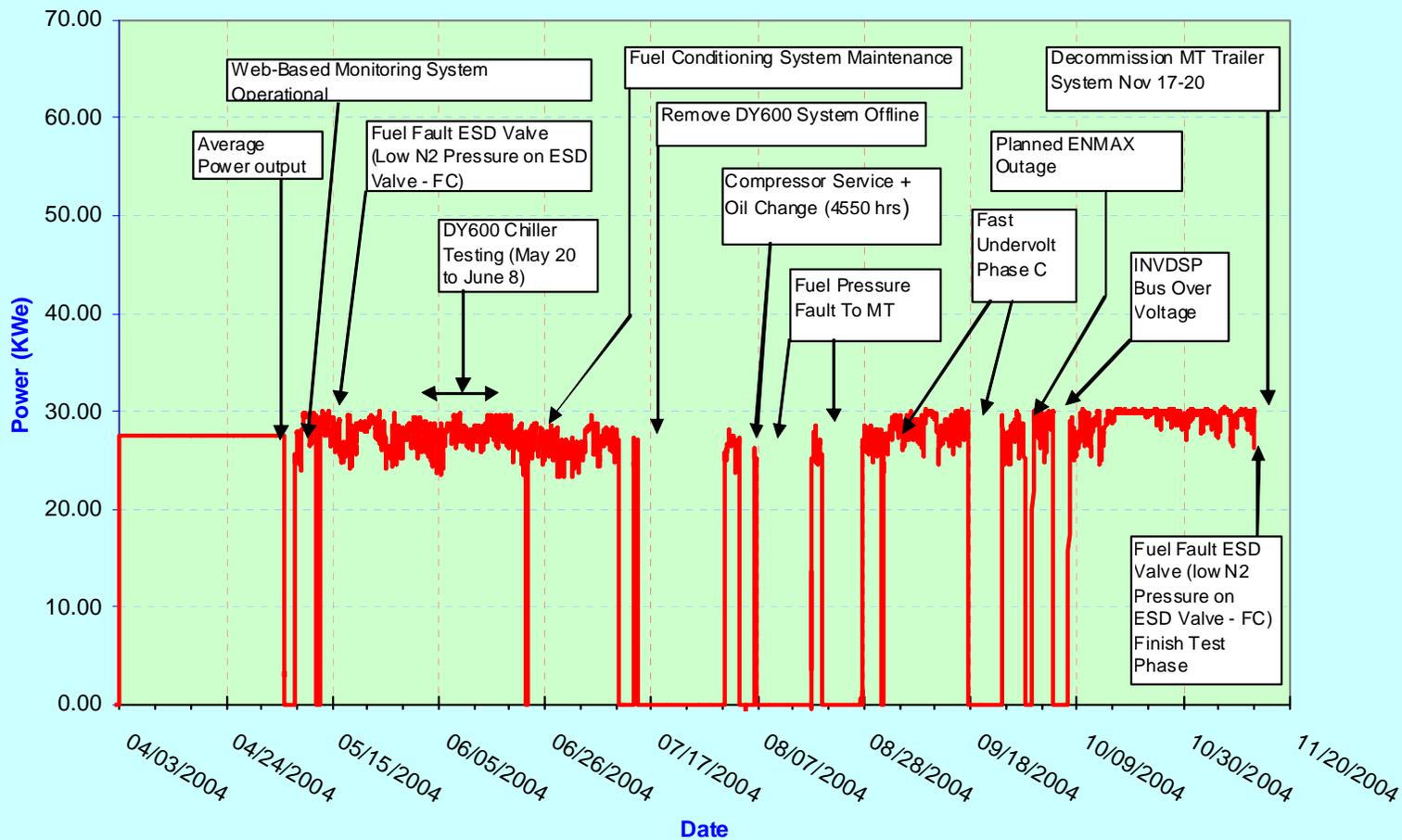
Operation Interval	April 3 – November 13, 2004
Max. Turbine Output (kWe)	30
Min. Turbine Output (kWe)	25
Average Power Output (kWe)	27
Total Estimated Power Generated during interval (kWh)	111,000
Total Microturbine Online Hours	4,425
Total Power Exported to Grid (kWh)	83,067
Total Power Imported from Grid (kWh)	1,278
Average Net Power Output to Grid (kW)	20
Average Parasitic Power (kW) (compressor, pumps, fans, lighting, etc.)	7
Average Onsite Parasitic Power (as a % of total)	25%
System Online Availability during interval	84%

O&M Performance

- Availability Nov. 2003 - Nov. 2004 = 59%
 - Delays in DY600 installation/modifications
 - DPC failure and delays in repair (1,428 hours)
 - Microturbine generator shaft failure (1,527 hours)
- Availability Apr. 2004 - Nov. 2004 = 84%
- Projected annual O&M costs = \$28,000
 - Microturbine and HRU ~ 3.7 cents/kWh
 - Gas Conditioning System ~ 9.0 cents/kWh
 - Above costs based on quarterly inspection for the microturbine and PM on gas compressor

Capstone C30 On-line Output

April - November 2004



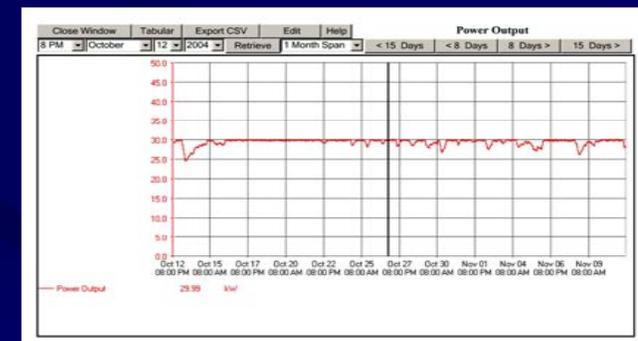
Web-Based Monitoring

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CETC MICROTURBINE TRAILER - SHEPARD LANDFILL, CALGARY, AB

Process Information	
Phase A Power Average	10 kW
Phase B Power Average	9.88 kW
Phase C Power Average	10.04 kW
Power Output	30.11 kW
Phase A Current	33.9 A
Phase B Current	33.99 A
Phase C Current	33.99 A
Neutral Current	0 A
Total Phase Current	101.5 A
Phase A Output Voltage	289.82 V
Phase B Output Voltage	288.56 V
Phase C Output Voltage	290.34 V
Frequency	60.21
Supply Voltage	13.94 V
Ambient Pressure	89 kPa
Exhaust Temperature	11.02 C
Engine Speed	95744 RPM
Exhaust Temperature	579.36 C
Run Time	5979 Hrs
Microturbine Alarm Status	
RPM Alarm Status	
CO Alarm Status	
DY-Chiller Alarm Status - Currently Offline	
Landfill Gas Parameters	
Flow Rate	20.5 m3/h
Methane	58.5 %
Oxygen	0.35 %

Gas Temperatures	
Heat Exchange Temperature 1	22.7 C
Heat Exchange Temperature 2	22.5 C
Heat Exchange Temperature 3	50.76 C
Heat Exchange Temperature 4	32.65 C
Heat Exchange Temperature 5	0 C
Heat Exchange Temperature 6	0 C
Heat Exchange Temperature 7	0 C
Heat Exchange Temperature 8	0 C
Other Temperatures	
MicroTurbine Room Temperature	6.31 C
Compressor Room Temperature	4.94 C
Outside Ambient Temperature	4.81 C
DY Chiller Parameters	
Energy Flow Rate 1	-1.29 MJ/hour
Cooler Temperature 1	27.75 C
Energy Flow Rate 2	-1.28 MJ/hour
Cooler Temperature 2	27.75 C
Export Power Meter	
Power Plus	0 kW
Power Minus	0 kW
Power Plus Var	0 kVar
Power Minus Var	0 kVar



System Component Failures

- Major
 - DPC components failure (1,428 hours)
 - IPM Module burn-out
 - Pre-charge board Phase C resistor
 - Inverter IGBT open
 - Microturbine shaft failure (1,527 hours)
- Minor
 - Gas Compressor - motor coupling failure (4,550 hours)

General Experience

- Areas for Improvement
 - Reduce O&M costs through local mechanical service company and trained local technician
- Future Market Opportunities
 - Smaller remote landfill sites, or small-scale digester gas operations
- Development / R&D Opportunities
 - Field testing new micro-power generation systems - e.g. Stirling engines

Overall Experience

- After replacement of microturbine hot-section, the system operated at over 80% on-line availability; down-time associated with grid faults and fuel faults
- Adjustments in protective relay settings and with fuel delivery system maintenance, on-line availability increased to over 90%
- High projected O&M costs associated with biogas compression and treatment, resulting from:
 - Lack of local service
 - Oversized capacity for future power generation
- Web-based system effective for system monitoring and data storage