MICROTURBINES UPDATE

7TH ANNUAL LMOP CONFERENCE AND PROJECT EXPO

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Washington, DC

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Distributed Generation Overview

- Often difficult to obtain reasonable contracts for sale of wholesale electric power to utilities, but retail rates are still fairly high
- Retail loads at landfills are relatively small
- Can exploit high retail rates through distributed generation (DG) technology
- Can also use DG technology for small “sale to grid” projects

Candidates for Retail Deferral

- Landfill gas flare station
- Leachate or groundwater treatment plant
- MRF or transfer station
- Office complex
- “Over the Fence” User

Distributed Generation Technologies

- Reciprocating engines
- Microturbines
- Fuel cells
- Stirling cycle engines
- Organic rankine cycle engines

Microturbines Versus Reciprocating Engines -- Advantages

- NO_x emissions are much lower
- Can operate on lower methane content fuels
- Pre-packaged in small incremental capacities
- Lower maintenance costs – but yet to be proven on a long-term basis

Microturbines Versus Reciprocating Engines -- Disadvantages

- Higher heat rate
- Higher capital cost
- Less proven technology

Microturbines

- "Tiny" combustion turbine
- Available in 30 kW, 70 kW, 80 kW and 250 kW capacities
- NO_x emissions one-tenth of reciprocating engines
- High pressure fuel (80 to 100 psig)
- Operates at 30% to 35% methane content
- Net heat rate of 13,900 Btu/kWh to 15,400 Btu/kWh (HHV)

Microturbines (continued)

- Can recover hot water
- Equipment cost = $1,000 to $1,200/kW
- Installed cost = $2,200 to $3,500/kW
- Maintenance cost = $0.01 to $0.015/kWh
- Reasonable amount of field experience

Low-Btu Microturbine Availability As of December 2003

Ingersoll-Rand	70 kW	Low-Btu unit now available.
	250 kW	Low-Btu unit will be available in second quarter 2004.
Capstone	30 kW	Low-Btu unit now available.
	60 kW	Natural gas unit now available. Low-Btu unit not available.
Bowman	80 kW	Natural gas unit now available. Limited European low-Btu experience.

SCS Energy Microturbine Experience Operating Facilities

Project	Size	Microturbine	Start-Up
Jamacha Landfill San Diego, CA	280 kW	Ingersoll-Rand	3-02
Calabasas Landfill Calabasas, CA	300 kW	Capstone	9-02
OII Landfill Monterey Park, CA	420 kW	Ingersoll-Rand	9-02

SCS Energy Microturbine Experience
Facilities in Start-Up

Project	Size	Microturbine
Acme Landfill Martinez, CA	280 kW	Ingersoll-Rand
Butterfield Landfill Mobile, AZ	70 kW	Ingersoll-Rand
Allentown WWTP Allentown, PA	390 kW	Capstone

SCS Energy Microturbine Experience Facilities Under Design or Construction

Project	Size	Microturbine	Start-Up
Mountain View Mountain View, CA	140 kW	Ingersoll-Rand	01-04
Napa American Canyon, CA	210 kW	Ingersoll-Rand	04-04
Toland Road Santa Paula, CA	70 kW	Ingersoll-Rand	01-04
Burbank Landfill Burbank, CA	550 kW	Both	04-04

SCS Energy Aggregated Microturbine Experience

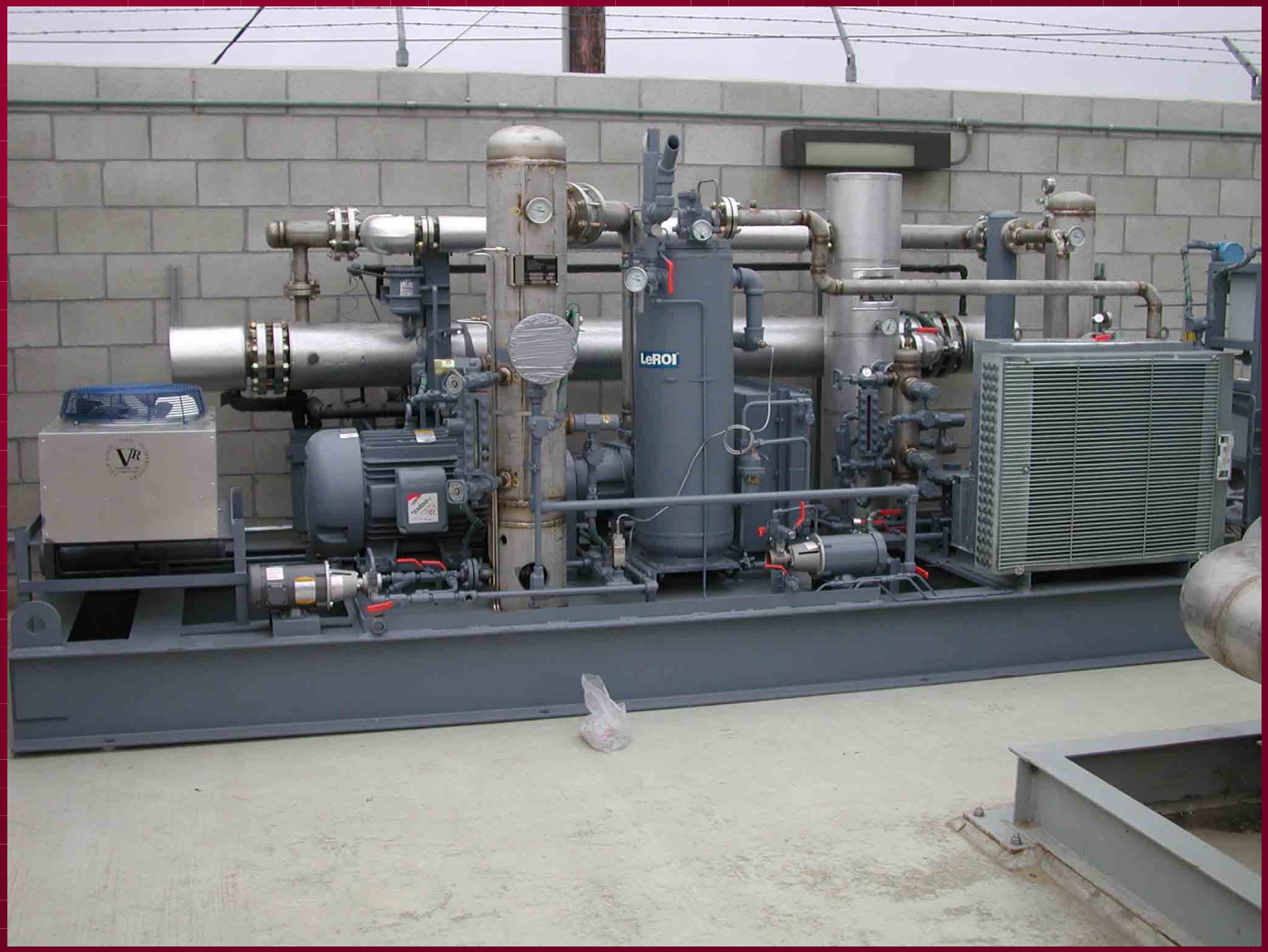
	No. of Projects	No. of Units	kW of Units
Operation	3	20	1,000
Start-Up	3	18	740
Design/Construction	4	17	970
Total	**10**	**55**	**2,710**

Jamacha Landfill

- Four Ingersoll-Rand 70 kW microturbines
- 280 kW (gross) / 235 kW (net)
- Microturbine inlet pressure = 8 psig and 80 psig
- 30% to 45% methane content
- H_2S = 15 ppmv / siloxanes = 232 ppbv
- 80 psig flooded screw compressor / chilling of gas to 40º F / reheat of gas by 20º F / activated carbon on 50% of fuel

Jamacha Landfill

- Capital cost = $700,000 ($2,500/kW)
- O&M cost = 2.2¢/kWh
- Sale to grid at 6¢/kWh
- Interconnection cost = $18,000 ($64/kW)
- Design/construction duration = 4 months
- Simple payback (after grant) = 9.7 years



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Calabasas Landfill

- Ten Capstone 30 kW microturbines
- 300 kW (gross) / 250 kW (net)
- Microturbine inlet pressure = 80 psig
- 30% to 45% methane content
- H_2S = 75 / siloxanes = 705 ppbv
- 80 psig sliding vane compressor / chilling of gas to 40º F / reheat of gas by 20º F / activated carbon on 100% of fuel

Calabasas Landfill

- Capital cost = $770,000 ($2,570/kW)
- O&M cost = 2.5¢/kWh
- Onsite retail deferral at 15¢/kWh
- Interconnection cost = $5,000 ($16/kW)
- Design/construction duration = 5 months
- Simple payback (after grants) = 1.6 years

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OII Landfill

- Six Ingersoll-Rand 70 kW microturbines
- 420 kW (gross) / 355 kW (net)
- Microturbine inlet pressure = 8 psig
- 30% to 40% methane content
- H_2S = 15 / siloxanes = 690 ppbv
- 8 psig rotary compressor / chilling of gas to 40º F / reheat of gas by 20º F / no activated carbon
- Required dedicated wellfield and thermal destruction of microturbine exhaust

OII Landfill

- Capital cost = $1,300,000 ($3,095/kW)
- O&M cost = 1.9¢/kWh
- On-site retail deferral at 15¢/kWh
- Interconnection cost = $105,000 ($250/kW)
- Design/construction duration = 6 months
- Simple payback (after grants) = 2.0 years

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SCS Distributed Generation SCADA System

- Integration of all plant components into a single control system
- On-site monitoring and operation via touchscreen
- Monitoring and operation via the internet
- Customized reporting and trending

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9/9/2002
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Turbine Summary Screen

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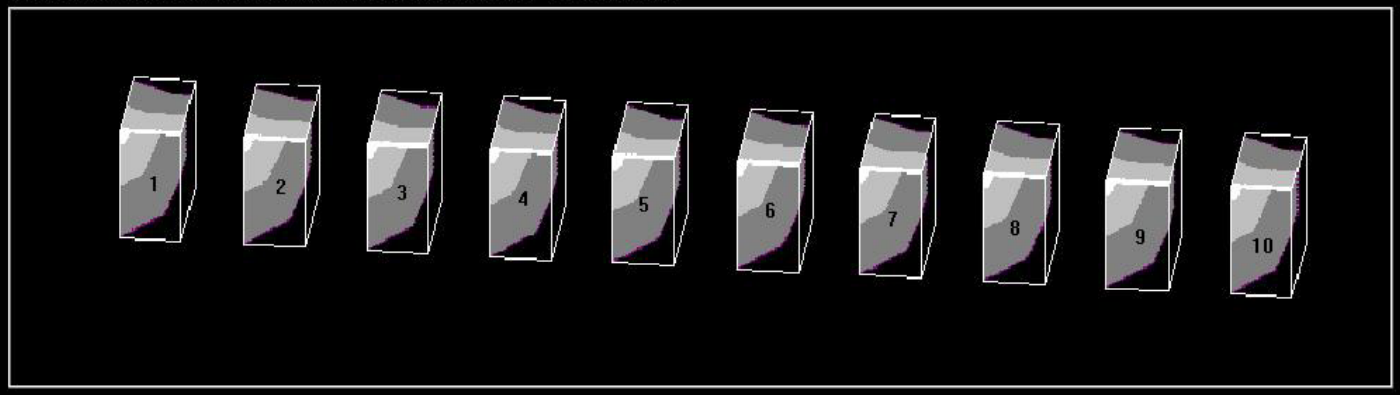
Environmental Energy Solutions

You Are Logged OFF

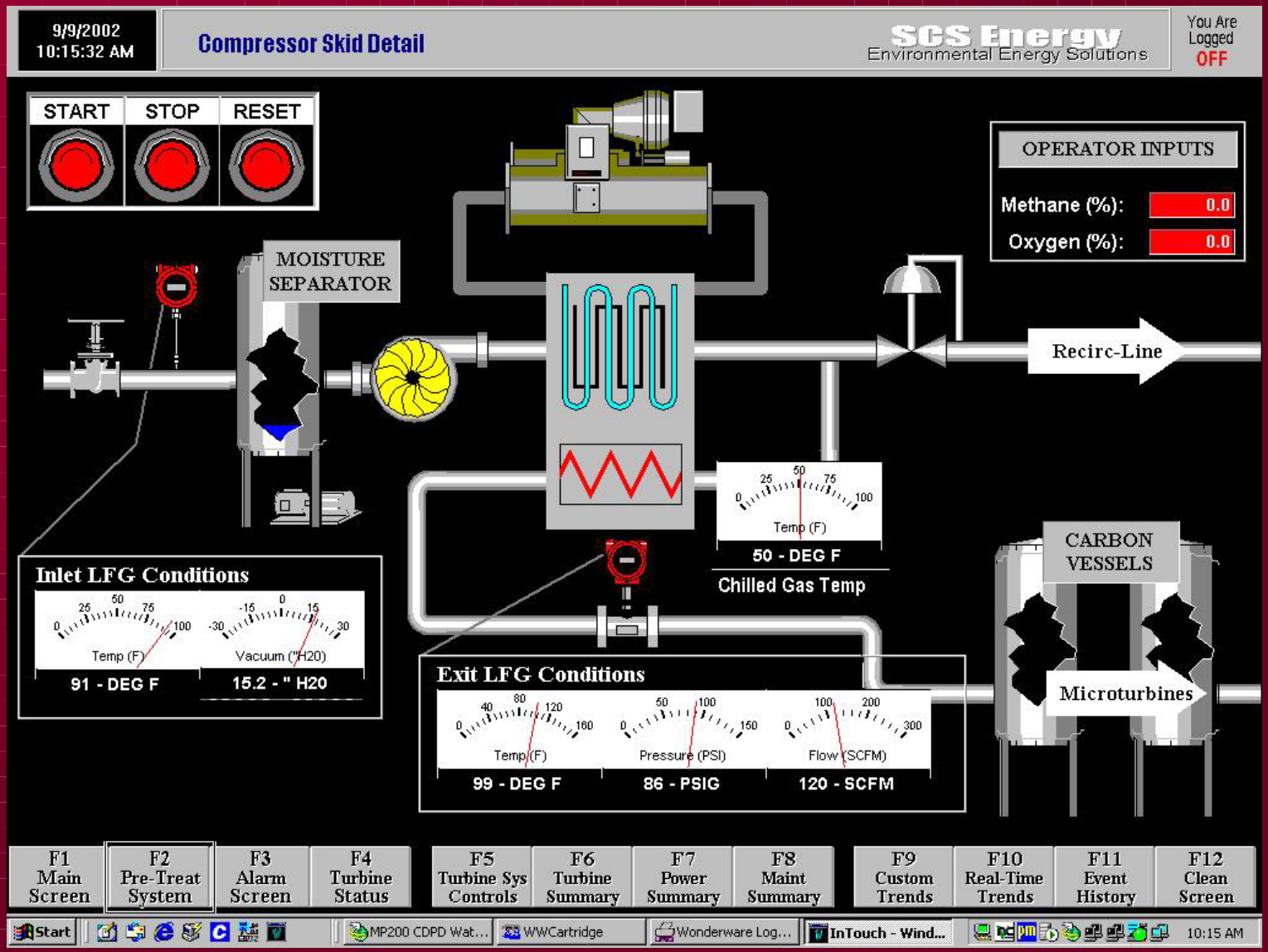
Turbine Number:	1	2	3	4	5	6	7	8	9	10
Turbine Enabled:	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Runtime (hrs):	347	347	347	347	347	347	347	347	347	347
Power Output (kW):	27	26	24	24	25	24	25	26	26	26
Current (A):	850	88	81	81	84	81	85	86	86	86
Ambient Air Pressure (psia):	13	14	14	14	13	13	14	13	14	14
Compressor Inlet Temp (F)	98	98	98	98	98	98	98	98	98	98
Engine Speed (RPM):	96,300	96,090	95,798	95,612	95,862	95,654	95,612	95,924	96,048	96,028
Exhaust Temperature (F):	938	938	938	941	941	939	939	939	938	938

Select the turbine information you would like to highlight



F1 Main Screen	F2 Pre-Treat System	F3 Alarm Screen	F4 Turbine Status	F5 Turbine Sys Controls	F6 Turbine Summary	F7 Power Summary	F8 Maint Summary	F9 Custom Trends	F10 Real-Time Trends	F11 Event History	F12 Clean Screen

Start | MP200 CDPD Wat... | WWCartridge | Wonderware Log... | InTouch - Wind... | 10:17 AM


9/9/2002
10:15:32 AM
Compressor Skid Detail
SCS Energy
Environmental Energy Solutions
You Are Logged OFF
START
STOP
RESET
OPERATOR INPUTS
Methane (%): 0.0
Oxygen (%): 0.0
MOISTURE SEPARATOR
Recirc-Line
Temp (F)
50 - DEG F
Chilled Gas Temp
CARBON VESSELS
Microturbines
Inlet LFG Conditions
Temp (F)
Vacuum ("H20)
91 - DEG F
15.2 - " H20
Exit LFG Conditions
Temp (F)
Pressure (PSI)
Flow (SCFM)
99 - DEG F
86 - PSIG
120 - SCFM
F1 Main Screen
F2 Pre-Treat System
F3 Alarm Screen
F4 Turbine Status
F5 Turbine Sys Controls
F6 Turbine Summary
F7 Power Summary
F8 Maint Summary
F9 Custom Trends
F10 Real-Time Trends
F11 Event History
F12 Clean Screen
Start
MP200 CDPD Wat...
WWCartridge
Wonderware Log...
InTouch - Wind...
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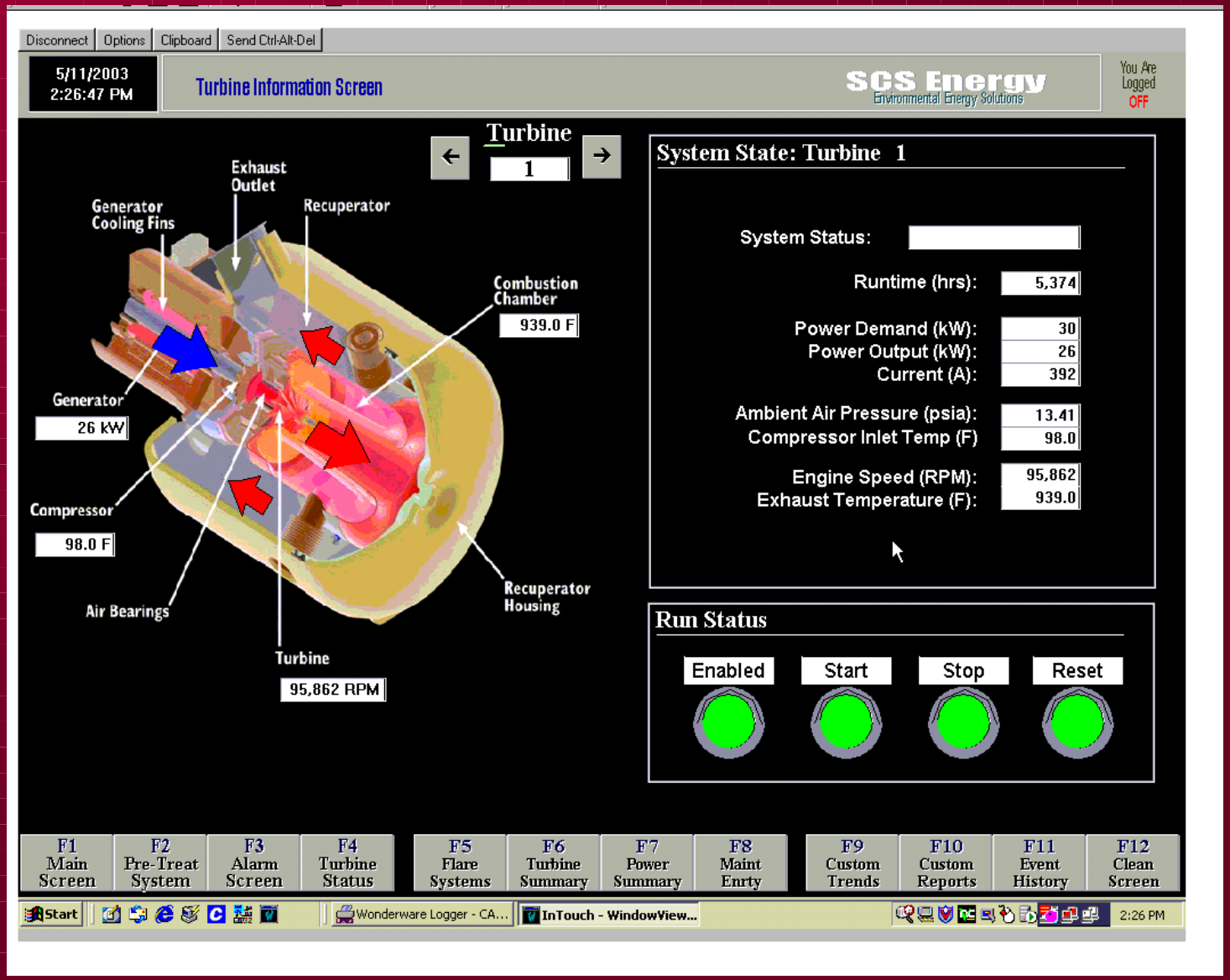
Disconnect
Options
Clipboard
Send Ctrl-Alt-Del
5/11/2003
2:26:47 PM
Turbine Information Screen
SCS Energy
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You Are Logged OFF
Turbine
1
Exhaust Outlet
Generator Cooling Fins
Recuperator
Combustion Chamber
939.0 F
Generator
26 kW
Compressor
98.0 F
Air Bearings
Turbine
95,862 RPM
Recuperator Housing
System State: Turbine 1
System Status:
Runtime (hrs): 5,374
Power Demand (kW): 30
Power Output (kW): 26
Current (A): 392
Ambient Air Pressure (psia): 13.41
Compressor Inlet Temp (F) 98.0
Engine Speed (RPM): 95,862
Exhaust Temperature (F): 939.0
Run Status
Enabled
Start
Stop
Reset
F1 Main Screen
F2 Pre-Treat System
F3 Alarm Screen
F4 Turbine Status
F5 Flare Systems
F6 Turbine Summary
F7 Power Summary
F8 Maint Enrty
F9 Custom Trends
F10 Custom Reports
F11 Event History
F12 Clean Screen
Start
Wonderware Logger - CA...
InTouch - WindowView...
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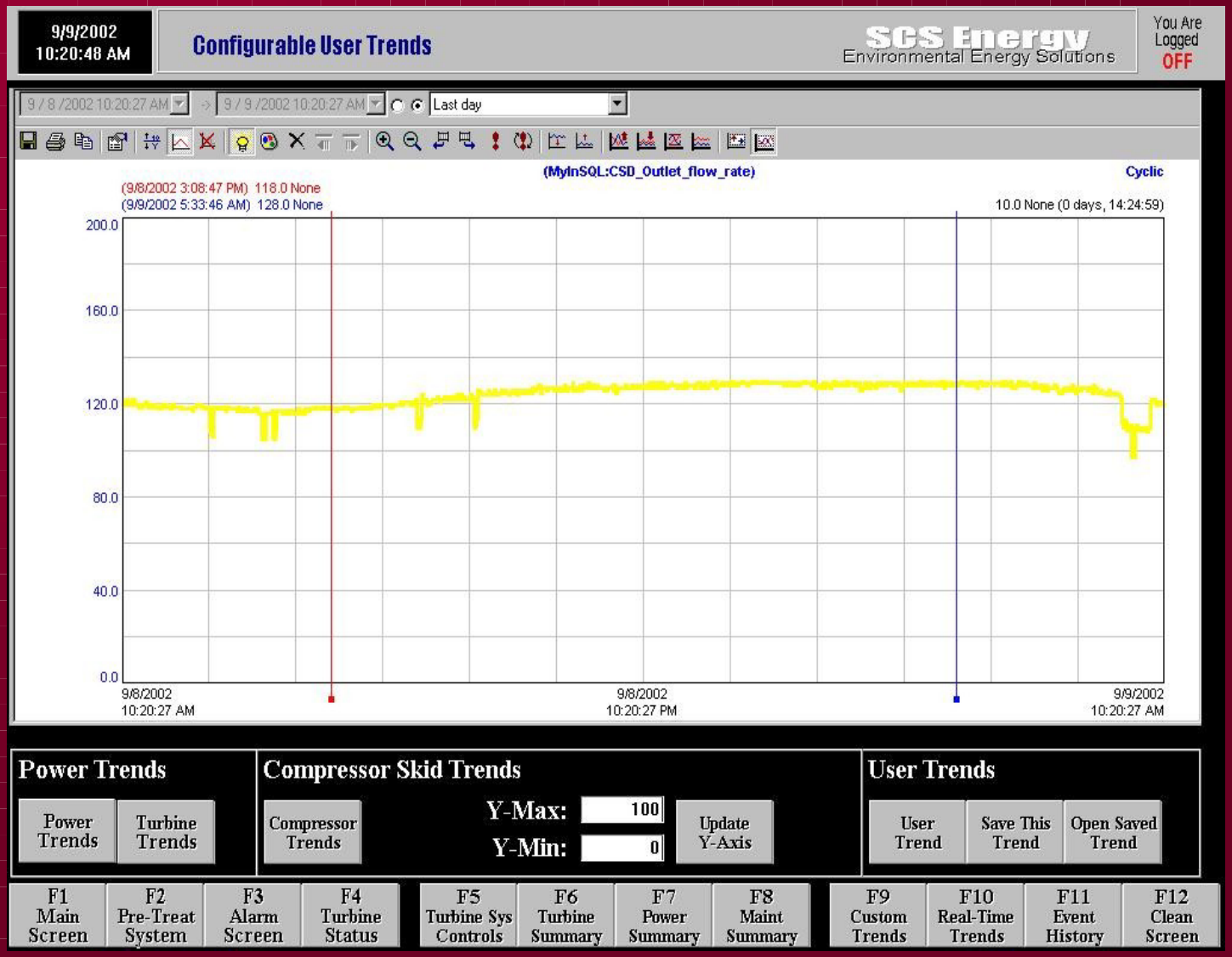
9/9/2002
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Configurable User Trends
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You Are Logged OFF
9 / 8 /2002 10:20:27 AM
9 / 9 /2002 10:20:27 AM
Last day
(MyInSQL:CSD_Outlet_flow_rate)
Cyclic
(9/8/2002 3:08:47 PM) 118.0 None
(9/9/2002 5:33:46 AM) 128.0 None
10.0 None (0 days, 14:24:59)
200.0
160.0
120.0
80.0
40.0
0.0
9/8/2002 10:20:27 AM
9/8/2002 10:20:27 PM
9/9/2002 10:20:27 AM
Power Trends
Power Trends
Turbine Trends
Compressor Skid Trends
Compressor Trends
Y-Max: 100
Y-Min: 0
Update Y-Axis
User Trends
User Trend
Save This Trend
Open Saved Trend
F1 Main Screen
F2 Pre-Treat System
F3 Alarm Screen
F4 Turbine Status
F5 Turbine Sys Controls
F6 Turbine Summary
F7 Power Summary
F8 Maint Summary
F9 Custom Trends
F10 Real-Time Trends
F11 Event History
F12 Clean Screen

Conclusions

- Microturbines are a relatively proven technology for low-Btu fuel
- They are applicable to distributed generation projects
- High retail power costs and financial incentives can result in economically feasible projects