



The Solutions Network

Rochester, New York

Distributed Generation and Operational Reliability

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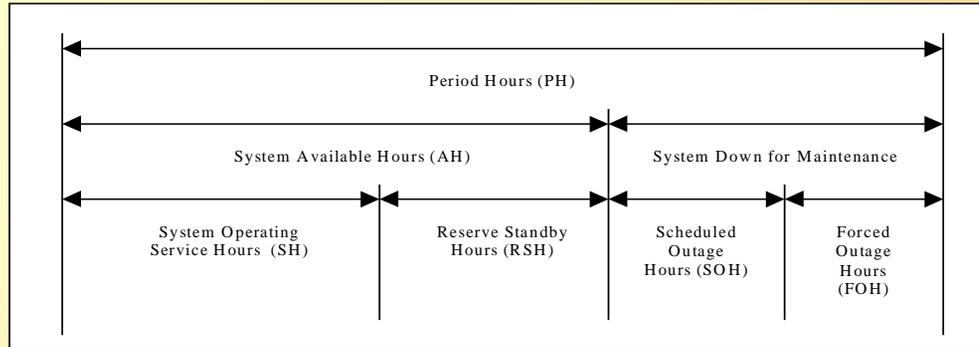
Energy and Environmental Analysis,
Inc.

Operational States



- Operating and producing electricity and/or thermal energy
- Not operating due to planned or unplanned maintenance
- Not operating, but capable of producing electricity or thermal energy

Operational Reliability and Availability Indices



| OR Measure | Formula |
|---|--|
| Period of Demand (POD, hours): Measures the time the unit was planned to operate. | $POD = PH - RSH - SOH$ |
| Availability Factor (AF, %): Measures, on a percent basis, the unit's "could run" capability. Impacted by planned and unplanned maintenance. | $AF = \frac{(PH - SOH - FOH) * 100}{PH}$ |
| Running Availability (RR, %): Measures, on a percent basis, probability of avoidance of forced outages. Accounts for planned, unplanned, and administrative outages. | $RR = \frac{PH - FOH - SOH - AOH * 100}{PH - SOH - AOH}$ |
| Forced Outage Rate (FOR, %): Measures portion of time due to unplanned factors | $FOR = \frac{FOH * 100}{(SH + FOH)}$ |
| Scheduled Outage Factor (SOF, %): Measures percent of time set aside for planned maintenance | $SOF = \frac{SOH * 100}{PH}$ |
| Service Factor (SF, %): Percent of total period hours the unit is on-line. Varies due to site related or economic factors | $SF = \frac{SH * 100}{PH}$ |
| Mean Time Between Force Outages (MTBFO, hours): Measure the nominal time between unscheduled forced outages | $MTBFO = \frac{SH}{\# \text{ Forced Outages}}$ |
| Mean Down Time (MDT, hours): Measures the nominal duration the unit is down during maintenance events | $MDT = \frac{SOH + FOH}{\# \text{ Forced Outages} + \# \text{ Planned Outages}}$ |

Central Station Performance



| OR Measure | Fossil (boiler/steam) | Nuclear | Gas Turbine | Combined Cycle | Hydro |
|--------------------------------|--------------------------|---------|----------------|-------------------|-------|
| Number of Units | 1524 | 128 | 887 | 80 | 823 |
| Availability Factor (%) | 86.66 | 82.87 | 90.31 | 85.85 | 90.62 |
| Forced Outage Rate (%) | 5.16 | 7.83 | 41.40 | 3.24 | 4.68 |
| Scheduled Outage Factor (%) | 9.59 | 10.09 | 6.36 | 7.64 | 6.53 |
| Service Factor (%) | 68.98 | 82.85 | 4.72 | 61.36 | 57.95 |

NERC GAR 1997 – 2001 Summary OR Statistics

DG Operational Database



- >120 units
- 731 MW Capacity
- 1,669,411 unit hours of operation
- 2,991 outage events
- Commercial, industrial, institutional sites

DG Technologies



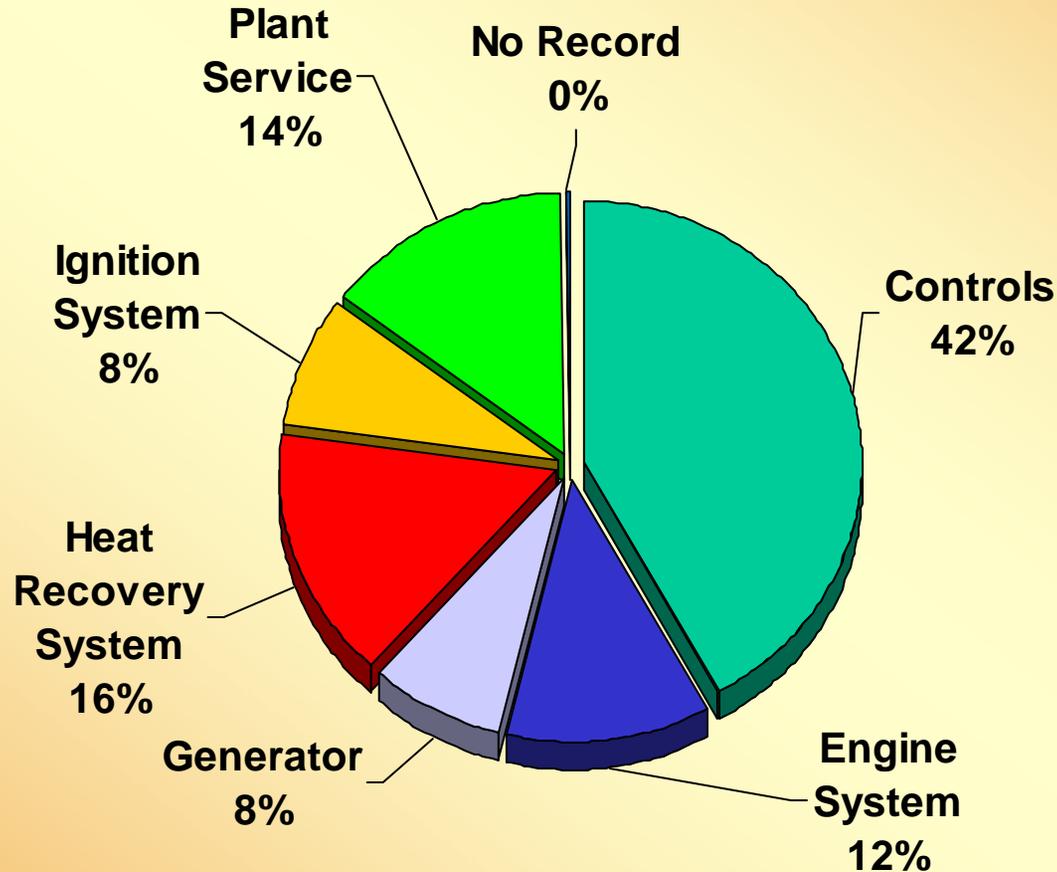
- Reciprocating engines
 - < 100 kW
 - 100 – 800 kW
 - >800 kW
- Gas turbines
 - 500 kW – 3 MW
 - 3 – 20 MW
 - 20 – 100 MW
- Steam turbines
 - <25 MW
- Fuel cells

Recip Engine Performance

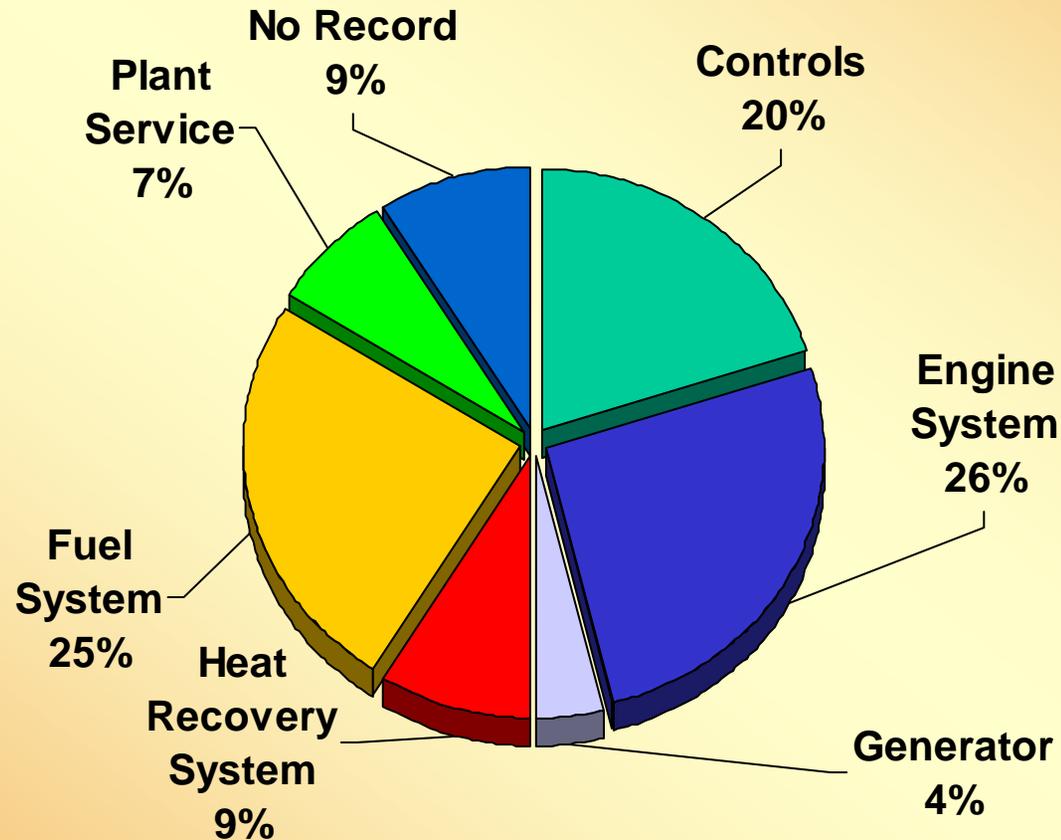


| Reciprocating Engines | <100kW | | | 100-800 kW | | | 800-3000 kW | | |
|--|--------|--------------|-------|------------|--------------|--------|-------------|--------------|--------|
| Number Sampled | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. |
| Availability (%) | 96.27 | 97.93 | 99.00 | 84.55 | 95.99 | 99.93 | 91.14 | 98.22 | 100.00 |
| Forced Outage Rate (%) | 0.86 | 1.76 | 3.07 | 0.00 | 1.98 | 5.05 | 0.00 | 0.85 | 6.63 |
| Scheduled Outage Factor (%) | 0.26 | 0.73 | 1.33 | 0.07 | 2.47 | 14.22 | 0.00 | 1.12 | 3.42 |
| Service Factor (%) | 68.20 | 75.11 | 79.60 | 2.06 | 51.76 | 95.43 | 1.50 | 40.59 | 91.39 |
| Mean Time Between Forced Outages (hrs) | 505 | 784 | 1376 | 361 | 1352 | 4058 | 263 | 3582 | 14,755 |
| Mean Down Time (hrs) | 7.29 | 13.71 | 24.21 | 12.50 | 50.66 | 173.05 | 0.00 | 27.06 | 91.91 |

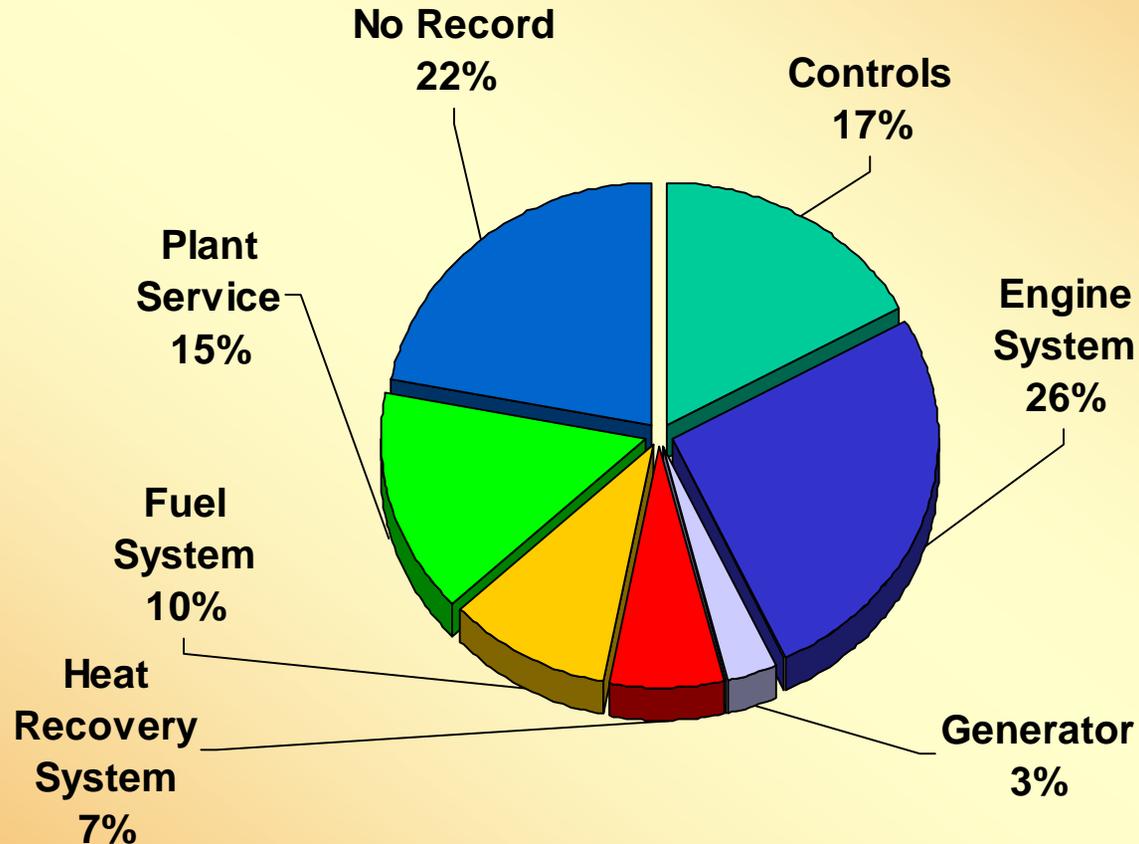
Forced Outage Causes Recip Engines < 100 kW



Forced Outage Causes Recip Engines 100 - 800 kW



Forced Outage Causes Recip Engines 800 - 3000 kW

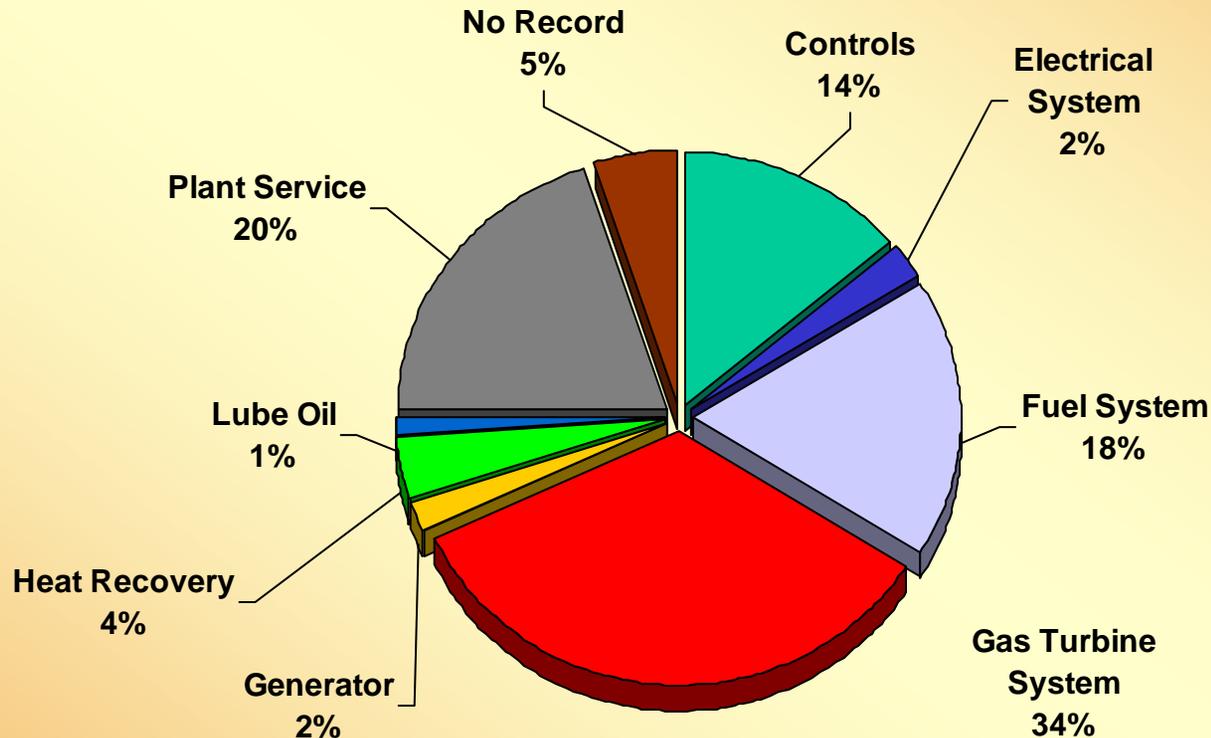


Gas Turbine Performance

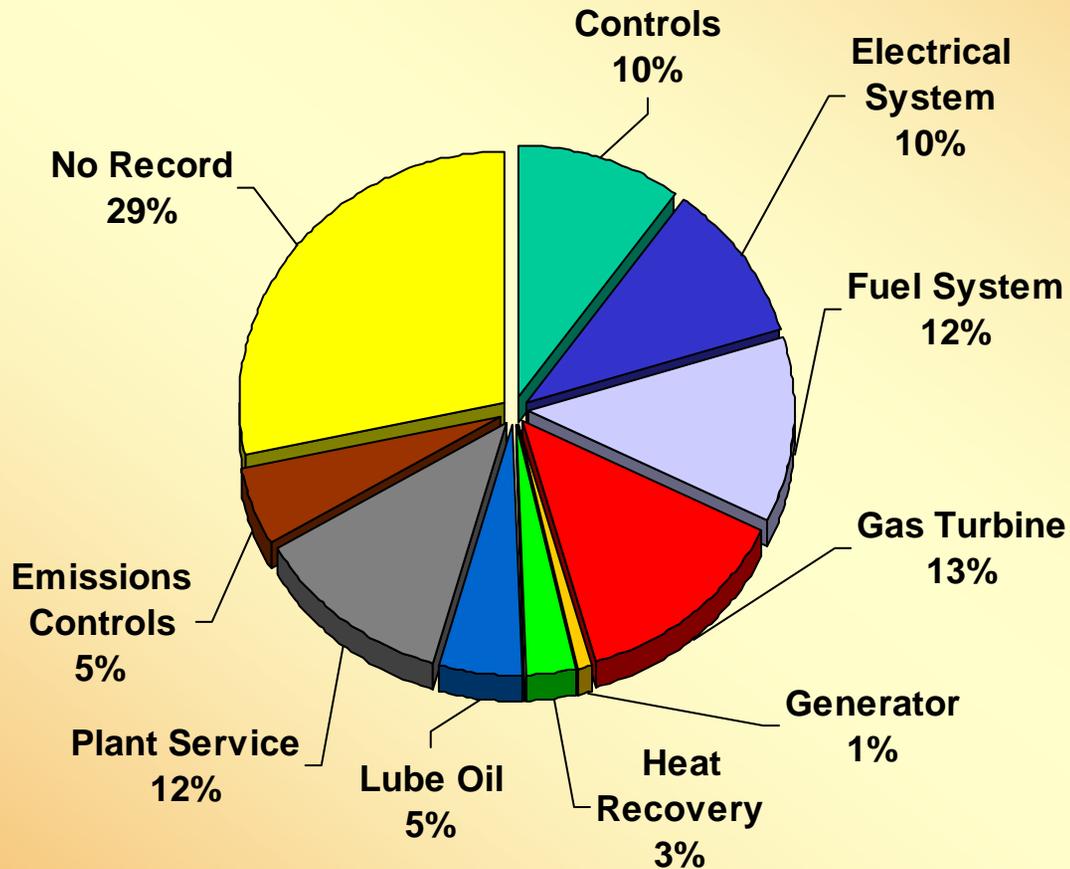


| Gas Turbines | 0.5-3 MW | | | 3-20 MW | | | 20-100 MW | | |
|--|----------|--------------|--------|---------|--------------|--------|-----------|--------------|--------|
| | Min. | Avg. | Max. | Min. | Avg. | Max. | Min. | Avg. | Max. |
| Number Sampled | | 11 | | | 21 | | | 9 | |
| Availability (%) | 88.88 | 97.13 | 100.00 | 88.56 | 94.97 | 99.60 | 86.33 | 93.53 | 99.45 |
| Forced Outage Rate (%) | 0.00 | 2.89 | 18.84 | 0.00 | 2.88 | 9.07 | 0.00 | 1.37 | 6.63 |
| Scheduled Outage Factor (%) | 0.00 | 0.99 | 4.57 | 0.00 | 2.39 | 11.44 | 0.00 | 5.14 | 13.50 |
| Service Factor (%) | 5.33 | 57.93 | 97.27 | 6.26 | 82.24 | 99.01 | 70.27 | 88.74 | 99.45 |
| Mean Time Between Forced Outages (hrs) | 765 | 2219 | 4318 | 216 | 1956 | 15,298 | 536 | 3604 | 17,424 |
| Mean Down Time (hrs) | 0.17 | 65.38 | 325.09 | 2.77 | 68.63 | 501.75 | 21.29 | 75.30 | 288.50 |

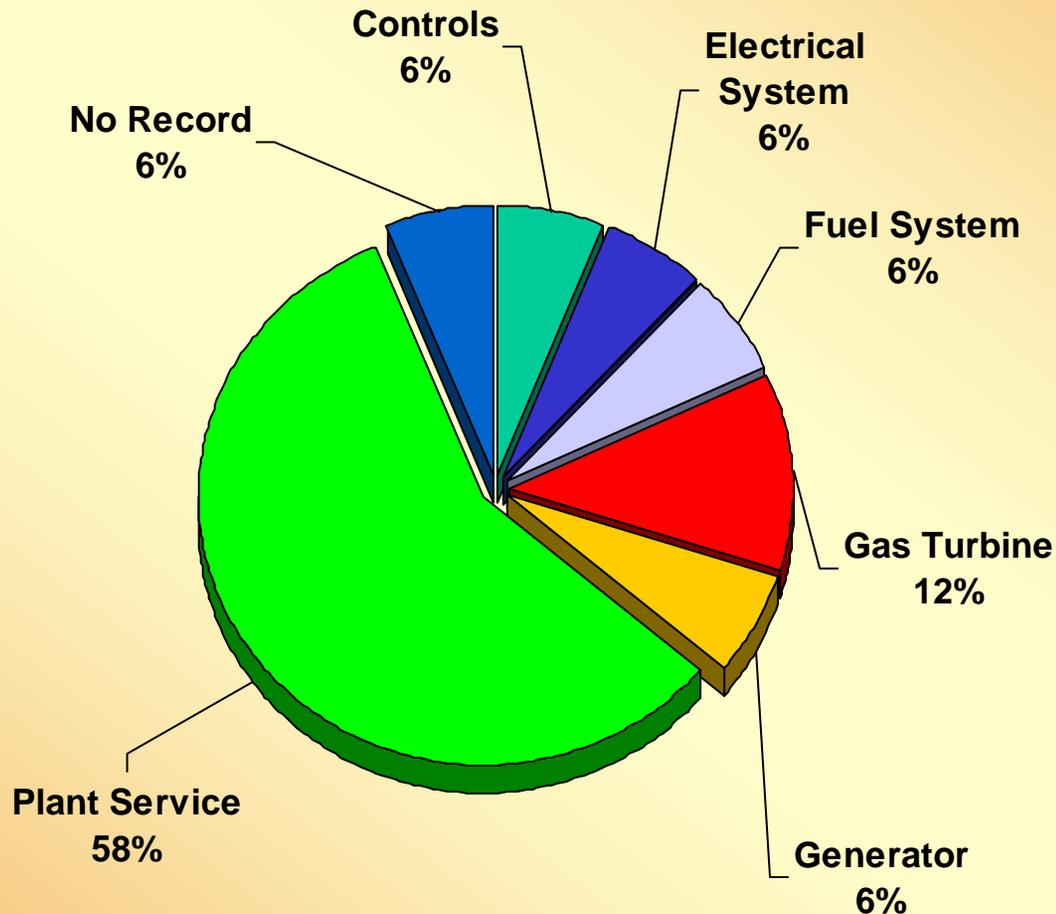
Forced Outage Causes Gas Turbines 0.5 – 3 MW



Forced Outage Causes Gas Turbines 3 – 20 MW



Forced Outage Causes Gas Turbines 20 - 100 MW



Steam Turbine Performance



| Steam Turbine | <25 MW | | |
|--|--------|--------------|---------|
| | Min. | Avg. | Max. |
| Number Sampled | | 25 | |
| Availability (%) | 72.37 | 92.02 | 99.82 |
| Forced Outage Rate (%) | 0.00 | 2.34 | 16.41 |
| Scheduled Outage Factor (%) | 0.00 | 6.01 | 27.63 |
| Service Factor (%) | 3.37 | 81.12 | 99.65 |
| Mean Time Between Forced Outages (hrs) | 120 | 5318 | 29,585 |
| Mean Down Time (hrs) | 5.51 | 292.06 | 4848.00 |

Fuel Cell Performance



| Fuel Cells | <200kW | | |
|--|--------|--------------|---------|
| | Min. | Avg. | Max. |
| Number Sampled | | 15 | |
| Availability (%) | 42.31 | 76.84 | 95.04 |
| Forced Outage Rate (%) | 4.31 | 22.94 | 57.51 |
| Scheduled Outage Factor (%) | 0.48 | 0.92 | 1.23 |
| Service Factor (%) | 42.27 | 74.01 | 92.21 |
| Mean Time Between Forced Outages (hrs) | 1416 | 2004 | 2696 |
| Mean Down Time (hrs) | 66.92 | 369.24 | 1686.83 |

DG OR Performance



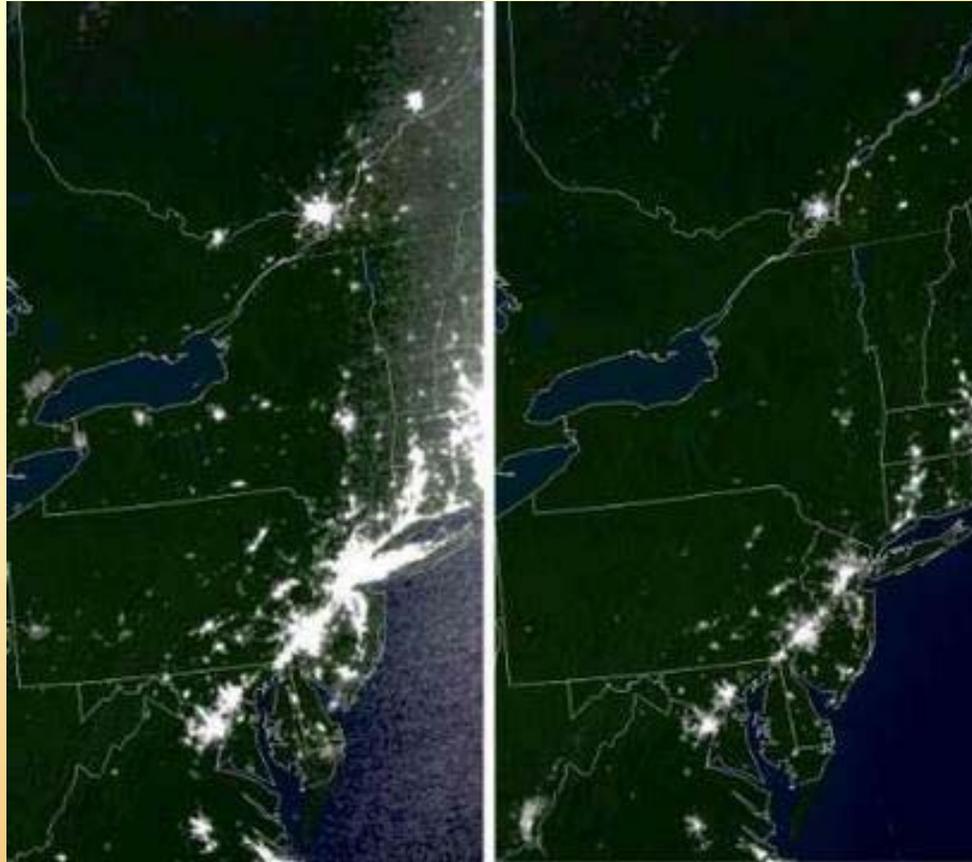
- High unit availability
- Forced outages primarily due to subsystems
- No systematic problems identified
- Emerging technologies need different measure

User Reliability



- High DG unit availability is a plus
- Overall reliability increased with multiple units
- Overall reliability increased with connection to the grid

The August 2003 Blackout



Healthcare



Botsford Health
System Kidney Center
(Livonia, MI)

South Oaks Hospital
(Amityville, NY)

Elderwood Healthcare -
Oakwood Nursing Home
(Williamsville, NY)

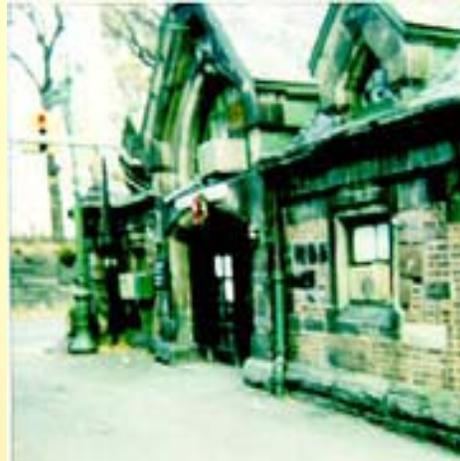
Wyoming County
Community Hospital
(Wyoming County, NY)

The lights stayed on.....

Public Services...



Central
Park Police
Station,
NY



Britannia Water
Treatment Plant
Ottawa, Canada



Water kept flowing...

The lights stayed on.....

Residential

Laurel Homes
Housing
Development
(Long Island, NY)



Family Housing
Quarters
(Sarasota Springs, NY)

Westpoint Military
Academy
Residential Officer
Housing
(NY)

The lights stayed on.....

Manufacturing



Frito Lay
Queens,
NY



Oak Tree Farm Dairy
(Northport Shore, NY)

Smoked Fish MFG.
(Manhattan, NY)
Saved > \$300K



Entenmann's Bakery
(Bay Shore, NY)



Maple Lodge Farms
Canada

Power stayed on !

Questions



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