Ensuring Electric Power for Critical Services After Disasters with Building-Sited Electric Generating Technologies

SYMPOSIUM ON IMPROVING BUILDING SYSTEMS
IN HOT AND HUMID CLIMATES
JULY 24 & 25, 2006
Orlando Florida

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Electric Power Outages After Disasters Contribute to Property Damage and Human Costs

- Hurricane Katrina was a “worst-case” scenario
  - » Health systems
  - » Public safety
  - » Command and control
  - » Shelter
- Power outages after less severe hurricanes and other disaster situations also impose significant costs
  - » Hurricane experience in Florida over previous two seasons
  - » Ice storms and snowstorms
  - » Terrorist-related activities

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Traditional Emergency Generators Provide Limited Post-Disaster Support

- Diesel-fired generators
- Designed for short-term (hours/days) outages
- Limited capacity and functionality
- Questionable reliability
- Limited fuel storage capacity

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Risk Management Analysis Supports the Stats Quo

- Before a disaster – for specific disaster situation

  Invest if Expanding Emergency Generation Cost ($) < Probability of Occurrence * Estimated Benefit ($)

- After even moderate disaster situations,

  Benefit ($) **>>>** Expanded Emergency Generation Cost ($)

- The probability of the future occurrence of moderate disasters within the near term is too small to justify additional investment in emergency generation using traditional risk analysis

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Combined Heat and Power (CHP) Technologies Can Also Provide Emergency Power

- Building-sited electric generation
  - Natural gas reciprocating engines and microturbines
- Onsite use of waste heat
  - Space heating, domestic water heating, air conditioning, desiccant dehumidification, air conditioning , process uses, laundry,etc.
- Remote monitoring, third-party service contracts limit required onsite-engineering expertise
- Meet emissions standards
- Can provide positive economic benefits
  - Onsite electric production may cost more but waste heat is “free” reducing natural gas and other fossil fuel purchases
  - Manufacturers are striving for “plug-and-play” system designs
  - Increasingly active CHP market

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United Technologies Packages 4-6 60 Kw Microturbines With Double-effect Absorption Chiller/Heaters

ISO (59 °F) Cooling Mode Performance of our Trigeneration Systems

PureComfort™ Solution	Number of Microturbines	Net Electric Power (kW_e)	Cooling Power (kW_c)	Supplemental Heating Power (kW_t)	Fuel Utilization (%)
240	4	227	500	70	91%
300	5	284	602	105	91%
360	6	341	696	100	86%

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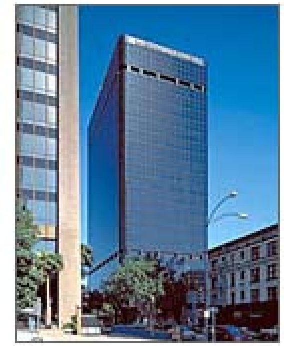
California and New York Are the Two Most Active CHP Markets

Viceroy Hotel
Santa Monica, CA
200 kW

California Bank & Trust
Long Beach, CA
600 kW



Merrill Lynch
San Diego, CA
600 kW

Northwest Community Hospital Central Utility Plant Building. Lower Left: Singe Waukesha Engine.

The Holiday Inn in Fargo, ND, where Capstone solved a hot water shortfall while generating an electricity dividend.

Study Question: Can CHP Economic Benefits Make Expanded Critical Services Emergency Power a Feasible Disaster Preparedness Option?

- CHP System economics
  - Cost
    - Equipment and installation
    - Operating and maintenance
    - Natural gas costs
  - Benefits
    - Avoided electricity costs ($/kWh, $/kW)
    - Avoided natural gas costs
- CHP design varies by facility
  - Hourly electricity use profiles
  - Hourly thermal energy profiles for appropriate end uses
- Analysis results also vary by location
  - Weather-related end uses
  - Electricity and natural gas costs

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Study Framework – Consider Hurricane-Related Disasters

- Select three hurricane-prone locations
- Identify critical service facility requirements for a benchmark population of 100,000 people
- Determine hourly electric and thermal energy use characteristics for each facility type at each location
- Size CHP electric and thermal components as a function of hourly loads and energy prices in each facility at each location
- Evaluate economic costs and benefits of providing emergency electric service for all critical services at each location

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Locations

- Locations

Table 1. Characteristics of Three Study Locations

	Charleston	Houston	Miami
Mean January Temperature °C (°F)	8.8 (47.9)	11.0 (51.8)	20.1 (68.1)
Mean July Temperature °C (°F)	27.6 (81.7)	28.7 (83.6)	28.7 (83.7)

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Critical Service Facilities

- Facilities
  - » Office (public safety, command and control), hospital, nursing home, schools (shelter)
  - » Number and size of facilities benchmarked to 100,000 population
    - – Capacity assumptions: 50% hospital beds, 75% nursing home beds, shelter for 5 % of population
  - » General facility characteristics developed from US DOE Commercial Buildings Energy Consumption Survey data

Building Type	Building Size Square Meters	Square Feet	Number of Buildings
Disaster Management and Public Safety	5,000	53,820	1
Hospital	13,000	139,931	1
Nursing Homes	2,900	31,215	5
Shelter (schools)	4,600	49,514	10

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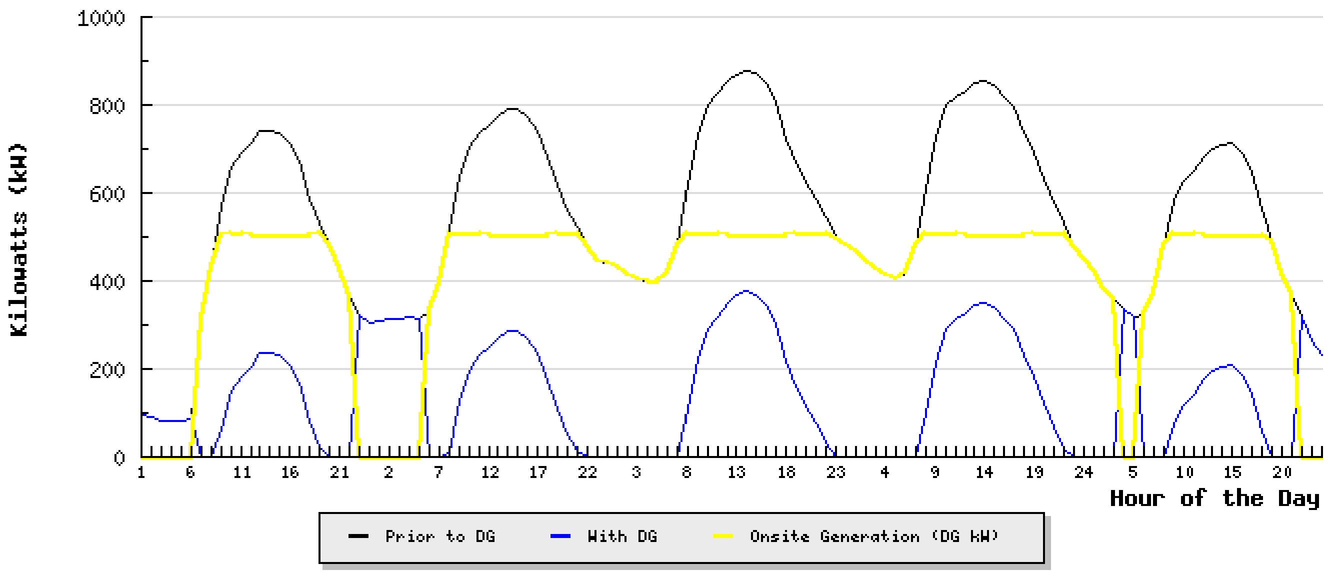
Hourly Loads For CBECS Facilities Developed With Simulations Calibrated to Monthly kWh, Peak kW

Sample of Hourly Loads Used to Size and Calculate DG System Economics
Five Days Beginning August 11, 2003



The chart above provides a sample of this site's hourly loads data used in sizing, designing and evaluating the DG systems in this analysis. All 8,760 hourly loads are used in computing the energy use and cost of each DG system. Hourly loads are applied to Consolidated Edison Co-NY Inc rate structures to determine energy charges and energy bill savings.

The black line shows hourly electricity loads (kW) before DG system installation. The yellow line shows electricity (kW) generated by the onsite DG system and the blue line shows electricity needs which must be purchased from the utility after DG system installation.

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CHP System Costs/Characteristics From: US Department of Energy, 2002. Integrated Energy Systems (IES) for Buildings: A Market Assessment. Oak Ridge National Laboratory, Ornl/Sub/409200

Size	Unit Type	Base Case Current Technologies (1999/2000)				
		Package Cost ($/kW)	Operating& Maintenance ($/kWh)	Efficiency @ Rated Output	Thermal Output (BTU/kWh)	Total Installed Cost ($/kW)
45-75kW	Engine	550	0.0150	31.0%	5.4	1033
	Microturbine	900	0.0100	27.1%	6.7	1383
75-150kW	Engine	522	0.0012	31.7%	5.2	953
	Microturbine	800	0.0100	27.1%	6.7	1231
150-300kW	Engine	506	0.0120	33.5%	4.7	880
	Microturbine	700	0.0090	27.1%	6.7	1074
	Fuel Cell	4500	0.0150	39.6%	3.8	5003
300-600kW	Engine	488	0.0100	35.0%	4.6	800
	Microturbine	703	0.0090	27.1%	6.7	1015
	Fuel Cell	4500	0.0150	39.6%	3.8	4812
.6-1MW	Engine	481	0.008	36.5%	4.5	730
	Turbine	508	0.006	25.0%	8.2	757
1-2.5MW	Engine	473	0.0075	38.0%	4.2	704
	Turbine	473	0.0055	28.0%	7.2	704
2.5-5MW	Engine	467	0.0075	39.0%	4.0	622
	Turbine	437	0.0045	29.0%	6.8	592
5-10MW	Engine	450	0.007	42.0%	3.1	575
	Turbine	425	0.004	31.0%	6.2	550
10-20MW	Engine	450	0.007	42.0%	3.1	563
	Turbine	375	0.004	33.0%	5.6	488

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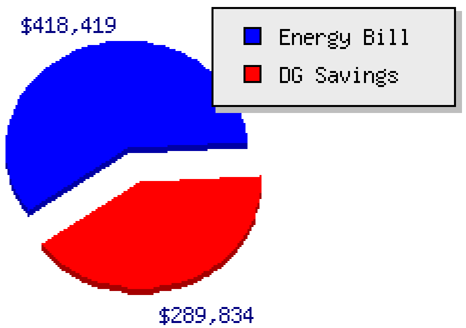
Analysis of Alternative System Designs Identified Most Economical System

Summary Results For
200,000 Square Foot office activity at ZIP 10023 for Engine-Based Systems

DG Energy Bill Savings and
New Energy Bill With DG System



Summary of Annual Energy Use and Bill Savings
Bill Savings: $289,834 Payback: 1.57 Years

	Before DG	After DG	Savings
1. kWh Use	3,373,854	1,244,933	2,128,922
2. Peak kW	992	488	504
3. Electric Bills	$675,443	$274,208	$401,235
4. Natural Gas/Oil Use (Mill Btu)	4,451	21,619	-17,168
5. Natural Gas/Oil Bills	$32,810	$144,211	$-111,400
Energy Bill and Savings With DG System (Add items 3 and 5)		$418,419	$289,834

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Individual Cost/Savings Components Are Determined for Each Facility in Each Location

Analysis Results for Engine-Based DG Systems

Analysis is based on all 8760 hourly loads, Consolidated Edison Co-NY Inc rate structures, equipment manufacturer information and site characteristics provided in the online session forms

Technology	Engine	Electric Bill Savings	$ 401,235
Waste Heat Applications*	Space Heat, Water Heat, Air Cond	Avoided Fossil Fuel Bills	$ 18,767
Generator Size	450 kW	Generator Fuel Costs	$ 130,167
Gen Operating Hours	4,807 Hours	DG O&M Costs	$ 25,217
Generated kWh	2,131,843 kWh	Net Annual Savings	$ 264,618
Installation Cost	$416,333	Payback	1.57 Years
Typical Standby (SB) Charges[1]	$61,028	Payback With Typical SB Charges[1]	2.04 Years

[1] Some utilities impose extra charges on DG customers called standby or backup charges. Standby charges are typically complicated and depend on how much and when onsite generation is down. The estimated standby charges shown above reflect "typcial standby charges." Actual standby charges may differ depending on system design and other issues; some utilities do not assess standby charges. Standby charges can be avoided by "islanding" the load served by a DG system. See DG Installation Guide for more information on standby charges. (ny94728)

* Waste heat-related equipment (i.e., heat exchangers, absorption air conditioners) are sized based on waste heat availability. That is, waste heat may supply only a portion of end use energy. Extended report capabilities provide waste heat and equipment sizing information. See Products and Services.

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Results For All Critical Service Facilities by Location

	Total (Including Multiple Buildings Within Categories)		
	Charleston	Houston	Miami
Annual kWh Use Before CHP	24,377,814	28,163,992	32,649,455
Savings - kWh	13,245,669	17,296,858	19,932,919
System size (kW)	2,360	2,770	2,825
Annual Operating Benefits			
Avoided kWh Costs ($)	961,829	1,759,704	1,651,911
Avoided Natural Gas Costs ($)	355,055	256,728	518,398
Annual Operating Costs			
Generator Fuel Costs ($)	1,172,444	1,094,560	1,595,261
O&M Costs ($)	148,401	205,697	213,557
Total Net Annual Operating Benefits	-3,961	716,175	361,491
System Installation Cost	2,099,480	2,813,890	2,598,085
Benefit/Cost Analysis			
Net Present Value (3% rate, 10 years, $)	-2,133,771	3,386,187	531,419
Simple Payback (years)	N/A	3.9	7.2
Marginal energy prices			
Electricity ($/kWh)	0.073	0.102	0.083
Natural gas ($/MMBtu)	8.68	6.32	8.11

Note: Electric and Nat Gas Prices and Results Will be Updated Prior to Senate Hearing

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Conclusions

Combined heat and power systems (CHP) should be considered as an option for providing critical services power in the aftermath of disasters.

Depending on facility hourly energy use profiles, electric and natural gas prices, these programs can pay for themselves over time. In these applications, a preemptive critical services emergency preparedness program based on CHP systems can actually generating revenue for local municipalities.

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