

**Assessing the Benefits of On-Site Combined Heat and
Power during the August 14, 2003 Blackout**

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Introduction

On August 14, 2003, large portions of the Midwest and Northeast United States and Ontario, Canada experienced an electric power outage. An estimated 50 million people were affected in the states of Ohio, Michigan, Pennsylvania, New York, New Jersey, and Connecticut, accounting for 61,800 MW of electric load. The outage disrupted businesses and factories, many of which experienced power outages and/or cutbacks for several days as power to the grid was gradually restored. The blackout began a few minutes after 4:00 pm Eastern Daylight Time, and power was not restored for four days in some parts of the United States. Parts of Ontario suffered rolling blackouts for more than a week before full power was restored. During this time, huge economic losses were suffered as businesses lost sales, manufacturers lost goods, and the area ground to a halt. Estimates of total costs in the United States range between \$4 billion and \$10 billion. In Canada, gross domestic product was down 0.7% in August with a net loss of 18.9 million work hours.¹

There were some facilities however in the midst of the blackout that were able to remain operational due to backup generators or distributed generation (DG) resources, including Cooling Heating and Power (CHP). This report summarizes the initial findings of an effort to contact facilities with CHP systems in the blackout area and report how these systems operated during the outage.

Objective and Methodology

This study focused on identifying facilities located in the August 2003 blackout area (United States) that have CHP systems installed and operating on their sites and developing an understanding of how these systems operated during the outage. The objective was to contact a limited number of sites where the CHP systems were able continue operation and document the benefits to the site and/or the local community.

The initial task was to identify facilities within the blackout area that have CHP systems the use of the Energy and Environmental Analysis, Inc (EEA) 2003 CHP database². A preliminary scan of the database indicated about 14,000 MW of CHP capacity is in place at over 650 sites in the six states that were affected by the outage. However, not all areas in these states were without power, so the outage area had to be further defined. In the time immediately following the blackout, there was no public source available that

¹ "Final Report on the August 14, 2004 Blackout in the United States and Canada", U.S.-Canada Power System Outage Task Force, April 2004.

² EEA CHP Database – A database of over 2700 CHP facilities representing 77,700 MW of installed electric capacity. Information included in the database for each facility includes site location, application (e.g., hospital, hotel, food processor, etc.), CHP system type (recip engine, gas turbine, combined cycle, boiler/steam turbine, other), fuel type, and servicing utility.

clearly defined the affected areas beyond the scale of major cities and the large areas in between. Maps of the blackout region from the North American Reliability Council (NERC) website and the U.S.-Canada Power Outage Task Force were used to estimate the approximate regions within each state that were without power. The city and zip code information in the EEA database were used to locate sites within the approximate outage areas through the use of a mapping program. The final estimate of CHP systems installed in the actual areas affected by the blackout is 446 systems representing 9,280 MW of electric capacity. Individual site contact information was gathered for these facilities through the use of the U.S. Department of Energy's Energy Information Administration (EIA) Non-Utility Power database, and internal EEA data. These contacts were used to gather information about CHP systems at the sites.

A team was formed, led by Oak Ridge National Laboratory (ORNL) and supported by EEA and Motor and Generator Institute, to contact a target group of CHP facilities in the blackout region. The team developed a comprehensive interview guide for CHP operations to ensure consistent information collection among multiple interviewers. The interview guide provided a standard format for discussions with facility personnel who are familiar with the site's CHP system. The interview guide sought to confirm the basic system information derived from the EEA 2003 CHP database; it also included questions pertaining to the specific operations on August 14, 2003, as well as the site's opinion of the system and their reason for installing it. The interview guide is located in the appendix.

A targeted list of candidate sites for contact was developed for priority applications where it was determined that on-site CHP systems may have serve as a crucial support system for continued or safe operations during the blackout. The priority applications were identified as hospitals, nursing homes, multifamily housing, food processing, and chemical/pharmaceutical facilities. The table below provides a breakout of the number of sites in the blackout area in each of these applications.

Table 1: Targeted Application Sites

SIC	Application	# Sites	Capacity (MW)
20	Food Processing	26	268
28	Chemicals	46	1,555
6513	Multi-Family Housing	51	91
8051	Nursing Homes	34	3.3
8060	Hospitals/Healthcare	36	184
	Total	193	2,101

Profile of CHP in Blackout Area

As indicated above, there are 446 CHP sites in the EEA CHP database in the area affected by the blackout, representing 9,280 MW of capacity. The following tables profile the entire group of CHP systems located in the blackout area by application, prime-mover, system capacity range and state. New York and New Jersey account for the vast majority of the affected sites because they both have a higher overall number of CHP sites than the other states in the affected regions.

Table 2: CHP Sites by State (Blackout Affected Areas Only)

State	# Sites	Capacity (MW)
Connecticut	18	8
Michigan	34	1,335
New Jersey	146	2,070
New York	209	5,001
Ohio	18	173
Pennsylvania	21	693
Total	446	9,280

Table 3: CHP Sites in Blackout Area by Application

Application	# Sites	Capacity (MW)	Application	# Sites	Capacity (MW)
SIC 20: Food	26	269	SIC 4000: Ground Transportation	1	10
SIC 22: Textile Products	1	1	SIC 4500: Air Transportation	2	10
SIC 24: Wood Products	2	5	SIC 4800: Communications	2	6
SIC 25: Furniture	1	1	SIC 4939: Utilities	7	85
SIC 26: Paper	32	1,279	SIC 4952: Wastewater Treatment	3	14
SIC 27: Publishing	3	4	SIC 4953: Solid Waste Facilities	10	841
SIC 28: Chemicals	46	1,556	SIC 4961: District Energy	3	94
SIC 29: Petroleum Refining	3	886	SIC 5000: Wholesale/Retail	4	12.
SIC 30: Rubber	6	389	SIC 5411: Food Stores	5	1
SIC 32: Stone, Clay, Glass	2	31	SIC 6512: Comm. Building	9	24
SIC 33: Primary Metals	11	1,555	SIC 6513: Apartments	51	91
SIC 34: Fabricated Metals	5	58	SIC 7011: Hotels	8	1
SIC 35: Machinery	4	9	SIC 7200: Laundries	4	1
SIC 36: Electrical Equipment	1	1	SIC 7990: Amusement/ Rec.	23	103
SIC 37: Transportation Equip	12	1,118	SIC 8051: Nursing Homes	35	4
SIC 38: Technical Instruments	2	56	SIC 8060: Hospital/Healthcare	37	185
SIC 39: Misc Manufacturing	6	182	SIC 8211: Schools	19	3
Total Industrial	163	7,397	SIC 8220: Colleges/Univ.	26	346
SIC 9900: Unknown	3	3	SIC 8300: Comm Services	4	1
SIC 01: Agriculture	3	71	SIC 8400: Zoos/Museums	2	4
SIC 12: Coal Mining	1	33	SIC 8900: Services NEC	12	7
SIC 13: Crude Oil	2	1	SIC 9100: Government Fac.	1	1
Total Other	9	108	SIC 9200: Courts/Prisons	2	5
			SIC 9700: Military	4	389
			Total Commercial	274	1,775
			Grand Total	446	9,280

The CHP profile in the blackout area has a much larger percentage of commercial sites, and subsequently less industrial and other application sites, than the population of CHP sites in the overall country. Over 87% of the CHP systems in the blackout area serve commercial applications, 12% industrial applications, and 1% other applications. The data for the whole country shows that commercial applications make up 50% of existing CHP systems, with industrial applications at 44% and other applications at 6%. There is also a higher percentage of smaller systems in the blackout area given the higher number of commercial sites; CHP systems in commercial facilities tend to be smaller than those servicing industrial facilities. This can be seen in the system size distribution of Table 4.

Table 4: CHP Sites by Prime-Mover and Size Range (Blackout Affected Areas Only)

Prime Mover	0 - 1 MW		1.01 - 5 MW		5.01 - 50 MW		≥50.01 MW		Total	
	Sites	MW	Sites	MW	Sites	MW	Sites	MW	Sites	MW
Boiler/Steam Turbine	5	2	17	53	35	778	11	998	68	1,832
Combined Cycle	0	0	4	11	11	267	36	5,644	51	5,922
Combustion Turbine	2	2	18	61	19	350	2	851	41	1,263
Fuel Cell	5	1	0	0	0	0	0	0	5	1
Recip Engine	226	48	37	79	13	121	0	0	276	247
Other	3	2	0	0	2	13	0	0	5	15
Grand Total	241	55	76	204	80	1,528	49	7,493.5	446	9,280

Interview Results

Detailed information on CHP system performance was obtained from twelve sites out of the 193 targeted facilities. The CHP systems at nine of the facilities continued operation during the blackout, one was undergoing maintenance at the time of the blackout, and two were not designed to continue operations during an outage:

CHP systems remained operating:

- Chemical Plant, Rochester NY – The CHP system at this site continued to operate throughout the blackout, but the facility had to scale back operations because the system does not provide for all the power needs of the site.
- Entenmann’s Bakery, Bayshore NY – The CHP system continued to operate through the entire blackout and the plant was not affected by the blackout.
- Montefiore Medical Center, Bronx NY – This site went down for five minutes when the blackout started, which is expected during an outage, but then came back online to operate throughout the duration of the outage.
- Norwalk Hospital, Norwalk, CT - This site went down for one hour when the blackout started, which is expected during an outage, but then came back online to operate throughout the duration of the outage.

- North Shore Towers (owned by Three Towers Associates), Floral Park NY - This site relies solely on its CHP system, which continued to work normally throughout the blackout, allowing the site to remain fully operational.
- Pharmaceutical Plant, Rochester MI – This site had a short power loss at the beginning of the blackout because the CHP system tripped offline, but system operation was restored shortly thereafter and the CHP system continued to operate throughout the duration of the blackout.
- South Oaks Hospital, Amityville NY – The CHP system operated exactly as planned and the facility never lost power, normal operations were continued throughout the outage.
- Spring Creek Towers, Brooklyn NY – This site relies solely on its CHP system, which continued to work normally throughout the blackout. The site never lost power and was able to provide for some needs of the local community.

CHP systems were non-operational during the blackout:

- Food Processor, Brooklyn NY – Although the CHP system at this site was designed with stand alone capability, it was undergoing maintenance and went down with the outage.
- Pharmaceutical Plant, Nutley NJ – The CHP system did not operate through the blackout because it is not designed to function without power from the grid.
- Pharmaceutical Plant, Union NJ - The CHP system did not operate through the blackout because it is not designed to function without power from the grid.

Facility: Chemical Company

Location: Rochester, NY

Utility: Rochester Gas & Electric Co.

CHP System Description

The CHP system at the chemical facility in Rochester, NY consists of twelve steam turbines utilizing coal as the primary fuel. The system at this chemical manufacturing facility has a potential electrical capacity of 196 MW but is only run at about 100 MW. The system was initially installed in the 1930's and has been continually expanded and upgraded throughout the years. It is grid connected and has stand-alone capabilities. The site does not sell excess power back to the utility because all the power the CHP system generates is used on-site. During normal operations, the CHP system is used for baseload power and provides roughly 75% of the electric needs of the site. The system plays a large role in the energy profile of the facility because it is used as the primary source of power, with the electricity coming from the grid being viewed as supplemental. The thermal output of the system is in the form of steam and provides 100% of the site's needs for process heating. The CHP system is owned by the facility however it is operated and maintained by a third party energy manager.

Operation During the Blackout

The local area where the facility in Rochester, NY, is located was heavily affected by the August 2003 blackout, with power remaining out for about a day and a half. The CHP system at the plant has stand-alone capabilities and is designed to continue running during grid failures. When the blackout occurred the CHP system performed as planned and disconnected from the grid immediately. At the time, the facility was drawing about 30 MW from the grid, therefore requiring some operations at the site to be halted. The CHP system continued to run, however, and plant operations were adjusted to account for the loss of utility power. The system is designed so that non-critical loads that do not heavily affect plant operation can be easily shed if necessary. The site is set up to be totally self reliant at any time by using the CHP system to provide all priority energy needs. The transition from pre to post blackout conditions remained smooth with the exception of some minor computer problems caused by power quality issues resulting from the grid fluctuations prior to full outage conditions. Manufacturing at the plant continued on schedule and all personnel reported to work and continued on a business as usual mode.

The site incurred some minor economic losses as a result of lost production time as the switch was being made from full production to slightly scaled back operations. However, no product was lost and no costly cleanup was needed. The site remained separated from the grid for an additional two weeks after power was restored to give the utility time to stabilize, and to protect the site from any possible reoccurrences. The site's relationship with Rochester Gas & Electric can be characterized as neutral. The utility has neither been especially supportive or prohibitive of the CHP system since the two have developed alongside each other for the last 70 years.

Attitude Toward CHP

The founder of the company believed that the manufacturing facility for his products should be totally self-sufficient and that all operational needs should be met with on-site resources. This started a trend at the facility to own and operate all essential services including the water, power, sanitation and waste disposal systems that are needed at the site. Originally the main reason for installing the CHP system was for independence from the grid and reliability. The site contact said that the decision to install a CHP system has definitely been justified and he cited cost effective power and high reliability as the most significant benefits the facility has derived from the system. The site does not have any other backup power source so the burden is solely on the CHP system. The reliability of the CHP system has been good enough that backup generators are not deemed necessary. The contact feels that the CHP system provides the site with a competitive advantage over others in the same market and would “absolutely” recommend CHP to others.

Facility: Entenmanns Bakery
Location: Bayshore, NY
Utility: Long Island Power Authority (LIPA)

CHP System Description



The CHP system at the Entenmanns Bakery facility in Bayshore, NY, consists of four reciprocating engines utilizing natural gas as the primary fuel. The system has a total electrical capacity of 5100 kW and was installed in 1994. The system remains grid connected even though it has stand-alone capabilities and the plant has almost no need to buy power from the grid. During normal operations the CHP system is used for baseload power and

provides 100% of the electric needs of the site with any excess power being sold back to LIPA. Most of the thermal needs of the plant are also met with the CHP system. Private Energy Partners Inc. is a third party owner of the system and are also responsible for the system's operation and maintenance.

Operation During the Blackout

The local area where the Entenmanns Bakery is located was heavily affected by the August 2003 blackout, with power remaining out for a significant period of time. While other facilities in the area had to shut down, the Entenmanns Bakery stayed fully operational. Since the CHP system was able to service the complete energy needs of the facility independently of the grid, operations "didn't miss a beat" and no product was lost. Processing at the site is impacted by even short power outages; the ability to remain operating without a pause allowed the plant to avoid the costly process of cleaning up wasted material that results with any kind of a shut down.

Operations at the Entenmanns Bakery progressed smoothly through the blackout from start to finish with no problems that affected processing. The site contact, Jack Wolf, commented that they "didn't even miss a donut". Although their site had power throughout the blackout, they were not called upon to provide help or services to other facilities in the area. The Entenmanns site was not requested to assist the utility in reestablishing service after the failure, and there were no mechanical or performance issues with the system when the utility was finally able to bring the grid back online.

Attitude Toward CHP

The site's previous experience with blackouts were short local outages that again did not cause trouble for the facility's operations because of the CHP system. Reliability was cited as the primary reason for installing the system due to the substantial potential losses that are associated with power outages at this kind of facility. The system is highly valued by site management and has proved itself to be extremely beneficial in

maintaining operations, and has performed exactly as designed. In management's view, the decision to install the system has been completely justified and the site contact would "definitely" recommend a CHP system to others. It proved to provide a competitive advantage over other producers that were affected by the outage.

Facility: Montefiore Medical Center

Location: Bronx, NY

Utility: Consolidated Edison

CHP System Description

The CHP system at Montefiore Medical Center located in the Bronx, NY, consists of three dual fuel reciprocating engines running off of a combination of natural gas and diesel fuel, and one gas turbine fueled by natural gas. The CHP system has a total electrical capacity of 10 MW with two standby engines providing an additional 4 MW of capacity. The initial system was installed in 1994 and consisted of three reciprocating engines; the site added the gas turbine in 2002. During normal operations the CHP system is run to provide baseload power. The system provides 100% of the electric and thermal needs of the medical center while providing service to additional buildings on the block. The system provides 80% of the electric needs of the block (including the entire medical center), and 100% of the thermal needs of the block (including cooling). This led to a situation during the blackout where several of the building surrounding the medical center had air conditioning supplied from the CHP system, but did not have electricity normally supplied from the grid. The site is grid connected and is designed to use grid power as a backup in case the CHP system is down. However, the grid connection only supports 4 MW, so the medical center is not able to run at full capacity on grid power. The thermal output of the system is in the form of steam and hot water, and it is used for space heating, domestic hot water, air conditioning, and sterilization purposes. The system is owned by the hospital and maintained by their engineering personnel.

Operation During the Blackout

The local area where the Montefiore Medical Center is located was moderately affected by the August 2003 blackout, with power remaining out for about 20 hours. The normal operations of the site were slightly affected by the blackout because the CHP system went down for about five minutes at the beginning of the blackout and then came back online. This is as designed, the site must be pulled offline when the grid goes down. Once the breaker has been switched, the site can then come back up, island itself and be fully self-reliant. The CHP system did not have any mechanical or performance problems, and once the CHP system was running the center was able to operate normally. The hospital maintained a business as usual approach throughout the blackout by continuing to perform all scheduled operations and medical procedures. The site transitioned smoothly throughout the entire blackout. The site has become proficient at dealing with grid failures because service is typically interrupted at least four or five times a year.

During the blackout, Montefiore was reportedly the only hospital in New York City that continued to admit patients, perform surgeries, and continue normal operations. At the time of the blackout the hospital was fairly full and did not have a large number of open beds, but non-critical patients were discharged to make room for patients from other facilities, including those dependent on life support equipment that required power. The

hospital's lobbies became a refuge for elderly people in the neighborhood who needed to cool off in the air conditioning. The cafeteria also remained open and was able to serve food late into the night to local residents, policemen, and service personnel.

Attitude Toward CHP

The primary reason for installing a CHP system at the hospital was for the reliability benefits that it would provide the site, allowing it to be self-reliant and to reduce the impact of grid interruptions. The system started to provide the site with significant cost benefits after the installation of the gas turbine in 2002. Prior to that time, the three reciprocating engines did not provide sufficient power for the site to operate independently of the grid, and the site was therefore subject to significant demand charges from Consolidated Edison. The site contact described the utility as unsupportive of the installation of the CHP system. The increased reliability of the CHP system is considered the most significant benefit from the system. Management considers the decision to install a CHP system as justified and it is believed by the site contact that the system gives the hospital a competitive advantage over others, especially as demonstrated during the August blackout. The site contact would recommend a CHP system to others depending on their needs and if they had enough redundancy in the system to be able to take single units offline for maintenance.

Facility: Norwalk Hospital

Location: Norwalk, CT

Utility: Northeast Utilities

CHP System Description

The CHP system at Norwalk Hospital located in Norwalk, CT consists of two gas turbines operating on natural gas as the primary fuel and No. 2 fuel oil as the secondary fuel. The CHP system has a total electrical capacity of 2 MW and was initially installed in 1991. Norwalk Hospital is a community teaching hospital licensed for 366 beds, however during typical operation 225 to 270 beds are usually occupied. The hospital facility is 700,000 square feet and has a 156,000 square foot parking structure. The CHP system provides for the primary electrical and thermal demand of the facility and runs constantly throughout the year. The system is grid connected however it does not sell excess power back to the grid. Around 70 - 80% of the needs of the facility are met with the CHP system; winter demand is entirely met however there is a need to purchase supplemental power from the grid during the summer months. The thermal output of the system is in the form of steam, providing for a winter peak of 23,000 lbs. per hour and a summer load of 16,000 lbs. per hour. The steam is used primarily for space heating however a small amount is used for cooling and steam sterilization. The system is owned and operated by facility personnel.

Operation During the Blackout

The local area where the Norwalk Hospital is located was moderately affected by the blackout, with power remaining out for about 7 hours. Normal operations of the site were affected by the blackout because the CHP system went down for about one hour at the beginning of the outage and then came back online. The CHP system performed as expected, it automatically goes offline when there is a power outage and then takes approximately one hour to bring back on-line. Once the breaker has been switched, the site can then come back up, island itself and be fully operational. The CHP system did not have any mechanical or performance problems, and once it came back online the hospital was able to operate at 95% capacity. During the interim time when both the grid and CHP system were down, backup generators at the hospital were run to provide for all necessary systems at the site. The hospital maintained a business as usual approach throughout the blackout by continuing to perform all scheduled operations and medical procedures. The site transitioned smoothly throughout the entire blackout since the cooling system was operational in enough time to maintain the schedule for various functions. There was no mechanical or performance problems with the CHP system and normal blackout procedures were followed. The hospital did not provide power or services to any other facilities and there was no need to take on any additional patients from other service providers.

Attitude Toward CHP

The primary reasons for installing a CHP system at the hospital were for power quality and reliability issues and for operating cost savings. The site contact described the utility as supportive of their decision to install the CHP system. The installation of the system is deemed as completely justified by site personnel. The hospital has a Facility Master Plan that outlines facility and infrastructure upgrades that will allow the hospital to maximize the usefulness of the system. The site contact believes that the reliable power and cost efficient production of electricity gives the site a competitive advantage because they can use the energy savings for additional program funding. A CHP system would be recommended to others as long as any new sites have studied and understood all of the issues such as cost of fuel, thermal demand vs. output, and maintenance.

Facility: North Shore Towers Apartments

Location: Queens, NY

Utility: Consolidated Edison Company's service territory

CHP System Description

The CHP system at the North Shore Towers high-rise co-op apartment complex of three buildings in Floral Park, NY consists of six reciprocating engines operating on natural gas as the primary fuel. They can also be fired with # 2 fuel oil. The system has a total electrical capacity of 7,500 kW, but the building's load of 3,000 to 4,000 kW is normally maintained with three engines. The units were installed during construction of the building in 1974 to provide both reduced operating costs and increased reliability. The system is completely isolated from the grid. There are 1,846 apartments with approximately 2,500 residents in the building. During normal operations, the CHP system provides 100% of the electric demand of the site. The CHP system provides 25% of the site's year round thermal needs (including cooling through absorption chillers) in the form of low-pressure steam. The balance of the thermal load is provided by one of four auxiliary boilers with a capacity of 750 hp each, operating on natural gas as the primary fuel. They can also be fired with # 2 fuel oil. The CHP system is owned by the facility and is maintained by facility personnel.

Operation During the Blackout

The local New York City metropolitan area was heavily affected by the August 2003 blackout, with power remaining out for over 48 hours. However, operations at the apartment building were not affected at all due to its normal isolation from the utility grid.

Attitude Toward CHP

The primary purpose for installing the CHP system at the high-rise was for energy conservation and reduced energy costs. Additionally, it was a good match for the residential hot water and steam load. The building's chief engineer described their relationship with Consolidated Edison as "fractured." They briefly considered connecting their system to the grid as a result of the state of New York's phasing in of stringent NOx emissions regulations for existing generating equipment. However, the utility intended to charge them over \$2 million dollars to implement the connection. As a result, the decision was made to invest in emission control retrofits, which are currently being evaluated. The cost of the retrofit will be passed onto the residents and the chief engineer felt that the blackout would be a helpful justification. He felt that the system provides a competitive advantage over other apartment buildings without CHP. In fact, management promotes the site's reliable CHP system to prospective cooperative apartment purchasers. He would recommend a CHP system to others.

Facility: Pharmaceutical Company.

Location: Rochester, MI

Utility: Detroit Edison Co.

CHP System Description

The CHP system at the pharmaceutical plant in Rochester, MI, consists of one combustion turbine utilizing natural gas as the primary fuel. The system has a total electrical capacity of 3,100 kW and was initially installed in 1986 to provide both cost advantages and increased reliability. The system is grid connected and has stand-alone capabilities. The site has the capability to sell excess power back to the utility however there is almost never a need to do so. During normal operations, the CHP system is used for baseload power and provides 40-60% of the electric demand of the site. The system plays a large role in the energy profile of the site because it is tied to all critical processes such as ventilation systems, which require high reliability. The other portion of the site's electric needs are provided by Detroit Edison and cost the facility around \$1 million a year. During the summer, the CHP system provides 100% of the site's thermal needs, however during the winter months two extra boilers are called on to supplement the CHP system. The thermal output is in the form of steam and is used for process heating. The CHP system is owned by the facility and is maintained by facility personnel.

Operation During the Blackout

The local area where the plant in Rochester, MI, is located was heavily affected by the August 2003 blackout, with power remaining out for over 48 hours. The CHP system at the plant has stand-alone capabilities and is designed to continue running during grid failures. At the time that the blackout occurred, the plant was receiving electricity through two feeders, one feeder had electricity coming from the utility and the other had electricity coming from a combination of the CHP system and the utility. When the utility went down the site was able to completely disconnect from the utility, however since the plant load on the feeder connected to the CHP system was too great for the on-site system to handle alone, it was overloaded and went down as well. The CHP system needs to be provided some power to be able restart and since the grid was down, the site had to use a generator from a neighboring facility to restart their system. It took close to 6 hours to get the CHP system up and running again. Once back in operation, the system proceeded to run through the duration of the blackout while the local area was still without power.

There was a significant disturbance in production at the plant due to the loss of power for six hours causing an entire batch of product to be lost. This was an extremely expensive loss for the site and there was a substantial amount of clean-up that needed to be done as well after power was restored by the CHP system. Despite the losses, the site contact was very positive about the CHP system and how it helped them recover while the blackout was still in effect. The initial failure to operate was not a failure of the CHP system itself but due to an overload on the circuit it was serving. The system was able to keep the site running at partial load, and maintained normal function of the administrative offices. The

site was not called upon to provide any power or assistance to nearby facilities or help the utility reestablish service. The site contact characterized the utility as being “very unsupportive” of the site’s decision to install the CHP system.

Attitude Toward CHP

The primary purposes for installing the CHP system was for enhanced power reliability and for reduced energy costs. The decision to install the system has been completely justified, with the most significant benefit coming from the long term economic benefits of reduced operating costs. The contact felt that the system provided a competitive advantage over other sites without CHP systems. He would recommend a CHP system to others depending on their needs.

Facility: South Oaks Hospital
Location: Amityville, NY
Utility: Long Island Power Authority

CHP System Description

South Oaks Hospital complex in Amityville, NY, consists of a 234 bed psychiatric hospital, a 320 bed nursing home and a 70 bed assisted living facility. The CHP system consists of two reciprocating engines utilizing natural gas as the primary fuel and diesel oil as a secondary fuel. The system has a total electrical capacity of 1,300 kW and was installed in 1990 to provide operating cost savings. During normal site operations, the CHP system is run to provide baseload power, with the only exception to this being when the cost of fuel is high enough to make buying electricity from the utility less expensive. The site is grid connected and is able to sell excess power back to the utility, however this is only done when the price of electricity makes it very profitable. The thermal output of the system is in the form of steam and it is used for space heating and domestic hot water purposes, as well as in the laundry and kitchen of the hospital. The CHP system can provide 100% of the site's electric and thermal needs. There are two backup boilers that can be used when needed and electricity is purchased from the grid when the CHP system is down for maintenance or repair. The system is owned by the hospital and maintained by their engineering personnel.

Operation During the Blackout

The local area where the South Oaks Hospital is located was moderately affected by the August 2003 blackout, with power remaining out for about 14 hours. The normal operations of the site were not affected at all by the blackout because the CHP system operated as designed and disconnected from the grid when the blackout occurred. The employees at the facility were not even aware of the blackout at first because they did not see any disturbance in power. The hospital found out about the power failure when the local police station called to see how they were doing, followed by numerous calls from people checking on patients. The hospital maintained a business as usual approach throughout the blackout by continuing without any interruption to daily procedures. The CHP system saved the site from having to go on backup power, which would have only allowed them to maintain certain critical operations.

The hospital offered to provide service to the community by helping the local police station and fire department, however these services were not needed. The site was not asked to provide assistance to other service providers although offers were made. South Oaks has a contract with a nearby nursing home to take a portion of their patients in the event of an emergency that would prevent the nursing home from providing adequate service for the residents, however that agreement was not called upon.

Attitude Toward CHP

The primary reason for installing a CHP system at the hospital was for the reduced operating costs, enabling the hospital to use the savings to supplement other programs. The increased reliability of the CHP system is considered an added benefit, which although significant, is far out-paced by the financial savings of the system. The decision to install a CHP system has absolutely been justified in management's view, and it is believed by the site contact that the system gives the hospital a competitive advantage over others, especially after the experience of the August blackout. The site contact would recommend a CHP system to others depending on their needs and the cost of electricity from the utility.

Facility: Starrett City Inc./ Spring Creek Towers

Location: Brooklyn, NY

Utility: Consolidated Edison Co. service territory

CHP System Description

Spring Creek Towers is a high-rise apartment community comprised of 5,881 apartments, housing over 20,000 people. There is a supermarket and laundry on-site as well as other features that make the complex very similar to a miniature city. The CHP system at the complex located in Brooklyn, NY, consists of two steam turbine driven generators supported by four 110,000 pounds per hour, high pressure steam boilers capable of burning either natural gas or No. 6 fuel oil. There are also three reciprocating engines running on diesel as the primary fuel. The extraction steam by-product from the turbine generators is used to support the thermal needs of the complex. The system is completely modular, and redundant capacity gives it the flexibility to operate different generators when one unit is down for service or maintenance. The system has a potential electrical capacity of 18 MW, but is normally run at 11 MW, leaving sufficient capacity to handle any increases in electric demand. The system was installed in 1974 when the complex was built and has never been connected to the grid due to the high cost of connection and standby charges. Therefore, the CHP system provides most of the energy that is used at the site including 100% of the electric load and most of the thermal load. There are backup boilers that contribute to the thermal needs of the complex depending on the time of year. The thermal output of the CHP system is used for space heating, domestic hot water, cooling and other needs. The system is owned and operated solely by the facility.

Operation During the Blackout

The local area where the Spring Creek Towers apartment complex is located was moderately affected by the August 2003 blackout, with power remaining out between 12 to 24 hours. The normal operations of the complex were not affected at all by the blackout since the site is totally independent from the grid. The CHP system continued as designed and provided the complete energy needs of the site even as the city around the complex was dark. The site contact referred to the site as “a lit Christmas tree standing in the dark”. The transition through the blackout was non-eventful with no mechanical problems occurring and nothing to disturb normal operations at the site. Since it is not connected to the grid, the complex was not able to provide excess power to other nearby facilities, however there was a large influx of people to the site. Many relatives of residents came to stay with them and enjoy the air conditioning as well as other benefits of having electricity. Also, the on-site supermarket experienced a large rush of consumers when people from the surrounding community arrived to get food and supplies. There were so many people coming to store that additional security was brought in to control the crowd flow.

Attitude Toward CHP

The primary reasons for installing a CHP system at Spring Creek Towers were a lack of adequate utility infrastructure and for reduced energy costs. The facility was not near the grid at the time of construction and it would have cost an extra \$5 million to interconnect with the utility in addition to over a half million dollars in standby charges each year. Since the complex would be a large user of both electric and thermal energy, the CHP system was the least expensive option to provide the site's energy needs. The decision to install the CHP system has been entirely justified with significant economic savings over the operating years. The CHP system at the complex provides a competitive advantage over others in the same market because of the lower energy costs and higher reliability. Even before the blackout, the Spring Creek Towers were in high demand as a place to live, with every apartment filled and a waiting list to get in. Management is expecting interest to increase even more in the aftermath of the blackout. The site contact would recommend a CHP system to others and he is a strong believer in the benefits of CHP.

Facility: Food Processing Plant

Location: Brooklyn, NY

Utility: Consolidated Edison

CHP System Description

The CHP system at the facility in Brooklyn, NY, consists of three steam turbines operating off of natural gas boilers. The system has a total electrical capacity of 10 MW and was initially installed in 1966 to provide cost advantages in the production of thermal energy. The system is grid connected and has stand-alone capabilities. The site has little need to buy power from the grid although it does not sell excess power back to the utility. During normal operations the CHP system is used for baseload power and provides 100% of the electric and thermal needs of the site. The thermal output is in the form of steam and is used in various processes involved in sugar production. The CHP system is owned by the facility and is maintained by facility personnel. This plant was scheduled to be shutdown in January of 2004 as part of an ongoing consolidation of the companies processing facilities.

Operation During the Blackout

The local area where the plant in Brooklyn is located was heavily affected by the August 2003 blackout, with power remaining out for over 24 hours. Although the CHP system at the site has stand alone capability, the governor controls were connected with the grid at the time of blackout causing the system to go down. This configuration is not normal operating procedure and was in place for maintenance reasons. The operations at the site were totally disrupted and production was halted for the entire length of the blackout because the site could not get the system back up. There was no loss of product due to the outage, because all of the sugar could be salvaged from any point in the production process. However, the plant experienced high clean-up costs, paying for overtime labor to remove hardened sugar from the processing machinery subsequent to the blackout.

The site was able to get the system running again shortly after the grid came back online. However the site incurred a substantial penalty charge from Consolidated Edison for using electricity from the grid during peak hours.

Attitude Toward CHP

Reduced energy costs was the primary reason for installing the CHP system, since sugar production is an extremely steam intensive process. The site contact would recommend a CHP system to others based on cost effectiveness. He made the comment that in his experience CHP systems are only reliable if they are properly maintained.

Facility: Pharmaceutical Plant

Location: Nutley, NJ

Utility: Public Service Electric & Gas

CHP System Description

The CHP system at the facility in Nutley, NJ, consists of three combustion turbines utilizing natural gas as the primary fuel. The system has a total electrical capacity of 11.5MW and was installed in the late 1980s. The system is grid connected but sells no power back to the grid. It provides a baseload service of about 50% of the site's power requirements. The thermal output is in the form of steam and is used for various types of chemical processes. The facility owns the CHP system, however a third party maintains and operates the system.

Operation During the Blackout

The local area where the plant is located was mildly affected by the August 2003 blackout, with power going out for slightly less than two hours. The CHP system was not designed to operate without power from the grid, and did not operate during the blackout causing the plant to be down for the entire time the grid was down. The shut down in operations at the plant did cause a large disruption in production. However, emergency generators protected critical processes and provided enough power to maintain limited processing and prevent loss of sensitive materials. Once power from the grid was restored to the plant, the plant and utility worked together, using the CHP system to reduce load and assist the utility in restoring power to others in the region.

Attitude Toward CHP

The primary reason for installing the CHP system at the facility was for reduced operating costs, which is the reason why the stand-alone capability was never implemented. The site contact was very enthusiastic about the system and said that he would absolutely recommend CHP to others. There are plans at the site for an expansion of the CHP system.

Facility: Pharmaceutical Plant.
Location: Union, NJ
Utility: Public Service Electric & Gas

CHP System Description

The CHP system consists of two combustion turbines running on natural gas as the primary fuel. The system has a total electrical capacity of 7,600 kW and was installed in the early 1990s. The system is grid connected and sometimes sells a small amount of power back to the utility. During normal operations the system provides 100 % of the electricity used at the site. Whether the site buys from the grid or sells back depends on the time of year and other operational circumstances. The thermal output is in the form of steam and accounts for most of the thermal requirements of the plant. The facility owns the CHP system, however it is maintained by Solar Turbines.

Operation During the Blackout

The local area where the plant is located was only slightly affected by the blackout, with power going out for 15 minutes. The CHP system at the plant did not operate during the blackout causing the plant to be down for the duration the grid was offline. The system was not designed to operate without power from the grid so there was no malfunction in the system that caused interruption. The shut down, although short in duration, apparently caused significant disruptions in production. The site contact works for Solar Turbines and while familiar with the operation of the site, he did not have quantitative information on the impact of the outage on production. The site was able to transition through the blackout relatively smoothly and come back on line without incident once the grid was back in operations. The site was not called upon to help reestablish the grid.

Attitude Toward CHP

The main purpose for installing the CHP system was for reduced operating costs, which is why the investment was never made in the stand-alone capability. The system runs 24 hours a day, seven days a week all year round and saves the company a significant amount of money in energy costs. The site contact would recommend CHP to others and he believes site management feels the CHP installation at this site was justified.

Conclusions

The overriding conclusion from the twelve interviews is that the CHP systems, in general, operated as designed during the blackout. Those systems designed with stand alone capability operated as planned except for one case where the CHP system was undergoing maintenance and the control system was temporarily dependent on the grid. A few sites experienced temporary outages as they shifted from grid connected to stand alone operation. Cost-effective control systems that would improve the ability to make this shift quickly and without disruption may be an area for technology development.

Several sites contacted were not designed to run during grid failures because they made an economic decision at the time of installation not to invest in stand-alone capability. These sites rely on backup power generators to provide protection to critical or sensitive processes and operate the CHP system solely for operating cost savings. Although not contacted in this effort, stand alone capability is also not the norm with many small CHP users using reciprocating engines systems with induction generators. These systems rely on excitation from the grid to operate and provide no stand alone capability.

One result of the August 2003 blackout may be a re-evaluation by new users of the value of stand alone capability. The incremental costs for larger users (estimated to be between \$100 and 200/kW) for ride through capability may be looked at as a wise investment given the experience of the August blackout. For smaller users, the incremental costs include the difference in costs between an induction generator and a synchronous generator, and the increased costs of interconnecting a synchronous generator which can be significant depending on individual utility requirements. Such requirements would need to be standardized and costs controlled if policymakers want to promote CHP as grid support on a wide basis.

The overall impression from users about CHP and their individual experiences was positive. Even sites that did not stay operational throughout the blackout expressed satisfaction with their systems. The primary reason for installing CHP systems at the majority of sites was for the operating cost savings that the systems provide. Enhanced power reliability was usually mentioned as a secondary benefit that was far outweighed by the operating savings. Most of the site contacts said that they considered the CHP system a competitive advantage and they would recommend a system to others depending on their needs.

Appendix

Standardized Interview Guide Draft

Introduction

This is a study for the U.S. Department of Energy through Oak Ridge National Laboratory on the performance of Combined Heat and Power (also known as cogeneration). We are interested in the performance of Combined Heat and Power equipment generally, and specifically during the August 2003 blackout. We'd like to ask you a series of questions about your cogeneration system, which may take about 20 to 30 minutes of your time. The results will be useful in determining how well cogeneration functions and the role it might play in future energy policy.

We are seeking information that you feel comfortable sharing about the operation of your facility and CHP system. We are not asking you to provide confidential or proprietary information. Before we get started, I'd like to verify some of the basic information we have listed about your site and its existing CHP equipment.

(The below data entries mirror the information found in the EEA CHP database. *(Note: Not all fields will have information for each CHP application)*)

Organization Name:

Facility Name:

Location

Facility City:

Facility State:

Facility Zip:

Servicing Utility:

CHP System Description

Prime Mover Type: (recip engine, gas turbine, boiler/steam turbine, microturbine, fuel cell, other)

Number of Units:

Electrical Capacity – total or per unit (kW):

Primary Fuel:

Secondary Fuel:

Year of Initial Operation:

Section I: Facility Background and CHP System Information

1. I'd like to begin by getting a better sense about your facility. Please provide me with a brief profile of your facility
 - a. **For commercial/industrial facilities:** type of business, number of employees, approx. yearly sales or production.
 - b. **For multifamily residential facility:** number of apartments/condominiums, approx. number of residents.
 - c. **For medical/nursing care facility:** number of beds/apartments; number of patients/residents; approx. square footage of building space.
2. What role does the CHP system play in providing power to your facility?
 - a. e.g. hours per year, hours per day, baseload, peaking?
3. What is the thermal output of the system?
 - a. hot water, steam, cooling or direct heat
4. What is the thermal output used for?
 - a. space heating, process heating (specifics if available), domestic hot water, other
5. How much of the facility's power and thermal needs does the CHP system supply (percentage or kW's and MMBtus)
6. Is your unit 3rd party owned and operated or facility owned and operated?
7. Is your unit 3rd party maintained or self maintained?
8. Is the CHP system Grid connected?
9. Does your facility sell any excess power back to the Grid?
10. Has the local utility been supportive or prohibitive of your decision to install (and interconnect) a CHP system?
11. Is your CHP system designed to operate apart from the grid during blackout conditions?

Section II: CHP Operations During the Blackout

Now I'd like to turn your attention to the August 2003 Blackout across the northeast, and ask you some questions about how your CHP system performed during the blackout.

1. To what extent were your facility's operations affected by the Blackout?
 - a. In what ways were your facility's operations affected?
 - b. For how long were your facility's operations affected?
 - c. *Commercial and Industrial Facilities:* What economic losses did your facility experience as a result of lost product or overtime labor costs?
2. To what extent did your facility's CHP system perform as planned during the blackout?

If the CHP system CONTINUED TO RUN through the blackout:

3. To what extent did the CHP system allow you to maintain business as usual operation during the blackout?
 - a. *For multifamily residential facilities:* To what extent were the residents able to go about their daily routines during the blackout?
 - b. *For commercial and industrial facilities:* To what extent was service or production able to continue?
 - c. *For medical/nursing care facilities:* To what extent did the CHP system allow your facility to maintain "normal" versus "critical" (e.g., emergency or intensive care) operations?
 - d. *If partial, but not all load needs were met:*
 - What partial load needs did the CHP system meet? (electrical and thermal)
 - Why did the CHP system meet only partial load needs?
 - problems internal to your facility's CHP system (e.g., malfunctioning equipment, lack of skilled operating staff?)
 - problems external to your facility's CHP system (e.g., limitation on fuel availability)
4. How long did the CHP system operate during the blackout conditions?
5. Describe the transition from pre- to post-blackout?
 - a. To what extent was the transition smooth versus problematic?
 - b. What are some specific example(s) of how the transition proceeded?
6. Did you experience any problems with the CHP system? (mechanical or performance)
7. Was your system able to provide service to others?

- a. To provide excess power to nearby critical facilities.
 - b. To assist the local utility in reestablishing service after the grid failure.
8. *Medical/Nursing Facilities:* Were you able to take on patients from other facilities?
9. *For Commercial or Industrial facilities:* To what extent did the CHP system save product during the blackout? Or eliminate the need for cleanup after the blackout? Approximate economic value.

If the CHP system DID NOT RUN through the blackout:

- 3. What were the reasons your CHP system did not run during the blackout?
 - a. [Mechanical reasons] Did the CHP system, itself, fail? Specifically, what failed?
 - b. [System design] To what extent is your facility's CHP system designed to rely on an outside source of electricity to maintain operations?
 - c. If the CUP system itself did not fail, did the utility force you to take the system offline as part of your interconnection agreement?
 - d. Other
- 4. How did the blackout affect your facility's operations?
 - a. What were your approximate economic losses as a result of the Blackout (only answer to the extent comfortable)?

Section III: Site Opinion of CHP System

- 1. What was the primary reason for the installation of your CHP system? (cost benefit, reliability)
- 2. What is the most significant benefit your facility has derived from the CHP system?
- 3. To what extent do you think your facility's decision to install the CHP system was justified?
- 4. To what extent do you think that your facility's CHP system provides a competitive advantage over others in the same market without CHP?
- 5. Would you recommend a CHP system to others?

END

Thank you for helping in this effort. Would you be agreeable to public release of this information in the form of a brief "case study"? Would you be available for further contacts?