Co-Op City CHP Plant Summary Information

Summary Table	Co-Op City CHP System
• Plant Type:	Hybrid Combined Cycle
• Number and Type of Generators:	(2) Combustion Turbines, (1) Backpressure Steam Turbine
• Nameplate Capacity:	40 MW
• Heat Recovery System:	Once-through Steam Generators on Combustion Turbines
• Additional Thermal Generation:	High Pressure Steam Boiler
• Total Steam Output:	279,000 lb/h @ 850 psig
• Primary Fuel Source:	Natural Gas
• Secondary Fuel Source:	No. 2 Fuel Oil
• Construction Period:	2007-2009

Annual Performance:		
• Electricity Produced	126,947	MWh/year
• Thermal Energy Delivered	955,357	MMBtu/year
• Fuel Input	2,112,926	MMBtu/year
• Fuel Conversion Efficiency	65.7%	% HHV

GHG Impact		
• Total Reduction	143,105	metric tons (MT) CO_2e/year
• (%) Reduction	50.6%	

Summary:

The Co-Op City complex is a housing cooperative located in Bronx, NY, originally constructed in 1973. The complex includes 15,372 units located in over 35 buildings, and houses approximately 60,000 residents. The central plant for Co-Op City has been upgraded to a combined heat and power plant meeting the facility's electrical and thermal needs, and allowing for operation independent of the local utility system. It is one of the pioneer micro grid applications in the New York City Metro Area. The CHP plant provides much needed energy generation reliability to the residents, and allowed the complex to recently weather Hurricane Sandy with minimal disruption. In addition to improving energy efficiency and system reliability, the Co-Op City CHP plant has reduced the cooperative's greenhouse gas emissions from purchased electricity and fuel oil consumption by over 50%.

A Unique Site...

The Co-Op City Complex is a housing cooperative located in Bronx, NY, completed in 1973. The complex includes 15,372 units located in over 35 buildings, and houses approximately 60,000 residents. Co-Op City provides many services for its residence in a self-contained community. This "city within a city" also has eight parking garages; three shopping centers; a 25-acre educational park, including a high school, two middle schools and three grade schools; a firehouse; and a central utilities plant. More than 40 offices within the development are rented by doctors, lawyers, and other professionals, and there are houses of worship, nursery schools, and day care centers spread throughout the community. The Co-Op City complex houses and serves enough people to be the 10th largest city in New York State if the complex were a standalone municipality. The complex is managed by the Riverbay Corporation, which is also responsible for operation of the central utility plant.

...With a Unique Utility Plant

Figure 1. Co-Op City Central Utilities Plant

The central utilities plant for Co-Op City, located on the corner of Bartow Ave and Co-Op City Blvd (Figure 1), dates largely from the late 1960's. By 2003, it was clear to the cooperative board that the plant's aging No. 6 fuel oil boilers - and the 1960's era steam distribution system they supported - would need to be upgraded to improve reliability and reduce residents' utility costs. The site's costs to import electricity from the local utility were also rising.

By 2005, a bold design had been formulated: the original, 67% efficient boilers would be replaced by a 40 MW combined cycle combined heat and power (CHP) system. The new plant would include two 12.5 MW Siemens combustion turbines, two once-through steam generators (OTSGs), and a new 850 psig boiler. As shown in Figure 2, either one or both turbines' exhaust gas could be used to generate high pressure steam in parallel with the boiler. Together or individually, this equipment would supply steam to a 15 MW steam turbine generator and two pressure-reducing stations, which would convert the high pressure steam to the 150 psig steam that meets Co-Op City's thermal loads. These include year-round domestic hot water production and winter space heating. During the summer months, the low-pressure steam would drive up to 20,000 tons of steam turbine driven centrifugal chillers.

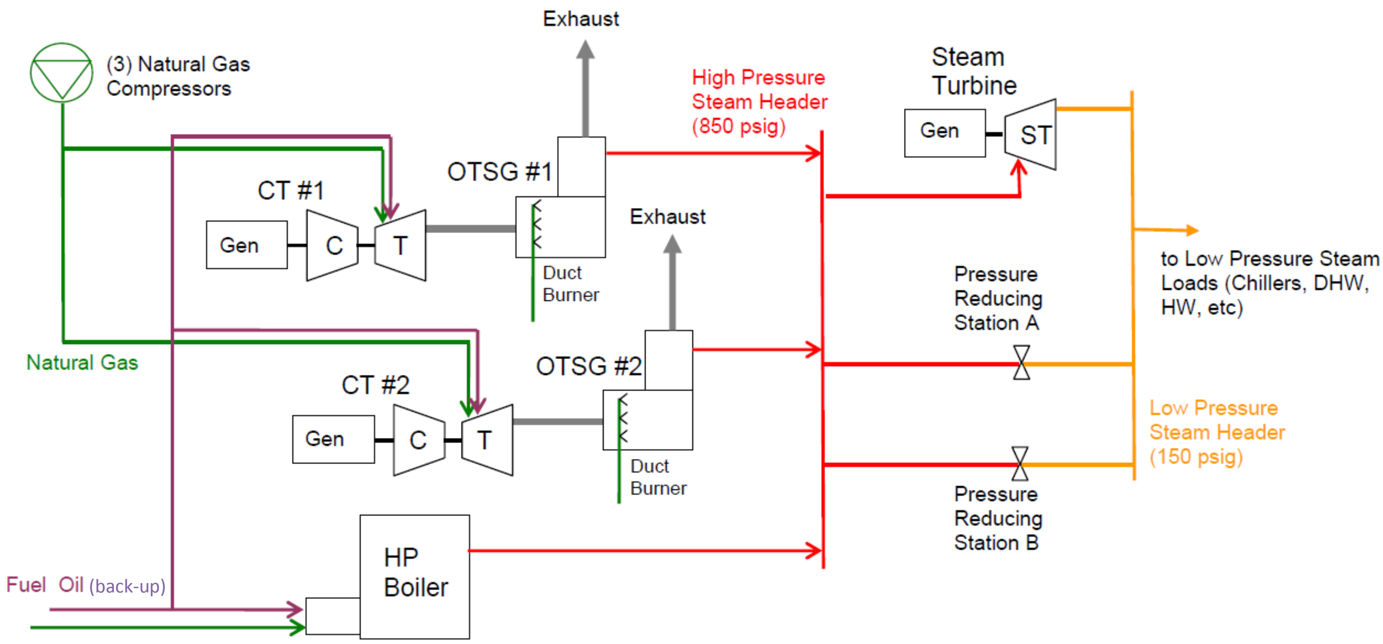

Figure 2. Co-Op City Central Utilities Plant Schematic

The design emphasized flexibility. Different combinations of equipment could be used to supply a wide range of thermal and electric load requirements. Both steam and electricity could be supplied even during major equipment outages. During periods of high fuel pricing or fuel supply outages, the site could choose between fuel types: the two combustion turbines and the boiler would operate on natural gas as a primary fuel but could also use No. 2 fuel oil. Table 1 summarizes the rated power and steam output for each of the major system components. The maximum gross electrical output of the plant would be 40 MW with 1.8 MW of large ancillary equipment necessary for plant operation, resulting in a net output of approximately 38 MW. The OSTGs and high pressure boiler combined would produce a maximum of 279,000 lb/h of 850 psig steam.

The CHP system was constructed over a two-year period from 2007 through 2009. System operation started in May 2010, with full load operation beginning in June 2010. The Co-Op City CHP system qualified for a $2 million performance-based incentive from the New York State

Energy Research and Development Authority (NYSERDA). In order to receive this incentive, the CHP system was subject to a strict design review process and required to pass performance thresholds for both environmental and energy performance over a two-year monitored period. This monitoring period was completed on July 1, 2012, and the CHP plant has now operated successfully for the past 36 months to meet the facility's electricity, thermal, and space cooling needs.

Prior to the central plant upgrade, the complex was one of the largest users of No. 6 fuel oil in the New York City boroughs. With the upgrade, the CHP system allows Co-Op City to meet its energy needs far more efficiently, and with a much lower carbon footprint than the previous operation of importing utility electricity and producing steam via fuel oil boilers.

Table 1. Nameplate Capacity for Major CHP Equipment at the Site

Electric Generation Equipment	**Power Output (MW)**
Combustion Turbine #1	12.50
Combustion Turbine #2	12.50
Back-pressure Steam Turbine	15.00
Gas Compressors	-0.66
Feedwater Pumps	-0.79
Draft Fans	-0.37
Gross Generation Total	**40.0**
Ancillary Equipment Load Total	**-1.8**
Net Total	**38.2**

High Pressure Steam Equipment Output	**850 psig Steam Output (lb/h)**
Once-through Steam Generator #1	86,000
Once-through Steam Generator #2	43,000
High Pressure Boiler	150,000
Total	**279,000**

A History of Efficiency

Tables 2 through 4 display generation summaries for the Co-Op City CHP plant during the two-year monitoring period.

Electric Loads

For the period examined, the plant produced over 253,000 MWh totaling over 95% of the entire complex electricity requirements. The plant is controlled to meet the site's thermal loads while matching electrical generation as closely as possible. This typically means operating one combustion turbine at full load and engaging the second combustion turbine as needed, primarily during peak cooling periods in the summer months; the boiler produces any remaining steam required. The steam turbine generator operates when sufficient high pressure steam is available.

Table 2. Electrical Output Summary – Co-Op City July 2010 - June 2012

Year	CHP System		Total Generation (MWh)
	Comb. Turbines (MWh)	Steam Turbine (MWh)	
Jul 2010 – Jun 2011	90,224	42,835	133,060
Jul 2011 – Jun 2012	77,249	43,585	120,834
Total	**167,473**	**86,420**	**253,893**
Avg. Year	**83,736**	**43,210**	**126,947**

Steam Loads

Over the two-year period, the peak facility steam load was typically near 4,000 Mlb/day, with occasional days' steam use as high as 4,900 Mlb/day.[1] The OSTGs operate to provide base load steam, and the high-pressure boiler serves variable loads, including the steam turbine. The CHP system steam output totaled over 1.9 million Mlb for the two year period, with the OSTG units providing 41% of the total steam load and the balance provided by the high pressure boiler.

Table 3. Steam Output Summary – Co-Op City 2010-2012

Year	CHP System Production		
	OSTG (Mlb)	HP Boiler (Mlb)	Total (Mlb)
Jul 2010 – Jun 2011	443,908	586,038	1,029,946
Jul 2011 – Jun 2012	366,575	534,469	901,044
Total	**810,483**	**1,120,507**	**1,930,990**
Avg. Year	**405,242**	**560,253**	**965,495**

[1] 1 Mlb = 1000 lb

Fuel Consumption

Fuel consumption statistics are shown in Table . Over the two-year period the combustion turbines accounted for approximately 60% of the total fuel consumed, with the balance consumed by the high-pressure boiler. While the plant can operate on No. 2 fuel oil, only a nominal amount was used during this period.

Table 4. Fuel Input Summary – Co-Op City 2010-2012

	CHP System		
Year	Comb. Turbine (MMBtu)	HP Boiler (MMBtu)	Total (MMBtu)
Jul 2010 – Jun 2011	1,284,261	864,977	2,149,238
Jul 2011 – Jun 2012	1,144,618	931,998	2,076,615
Total	**2,428,878**	**1,796,975**	**4,225,853**
Avg. Year	**1,214,439**	**898,487**	**2,112,926**

Notes: Energy content of natural gas assumed to be 1,030 Btu/CF HHV.

Table5 presents plant fuel conversion efficiency (FCE) calculations for the entire CHP system, including operation of the high-pressure boiler system and steam turbine generation.

Table 5. Plant Total Efficiency

	Electricity Generation	Thermal Utilization	Fuel Input	FCE	
Year	(MWh)	(MMBtu)	(MMBtu)	(% HHV)	(% LHV)
Jul 2010 – Jun 2011	133,060	1,019,132	2,149,238	68.5%	76.2%
Jul 2011 – Jun 2012	120,834	891,583	2,076,615	62.8%	69.8%
Total	**253,893**	**1,910,715**	**4,225,853**	**65.7%**	**73.0%**
Avg. Year	**126,947**	**955,357**	**2,112,926**	**65.7%**	**73.0%**

Notes: Steam enthalpy gain is 989 Btu/lb.
Natural Gas HHV = 1,030 Btu/CF, LHV = 931 Btu/CF

A Significant Greenhouse Gas Reduction

Operation of the Co-Op City CHP system using the new combustion turbine generators with heat recovery, combined with the conversion of the central utilities plant to burn natural gas instead of No. 6 fuel oil, has had a significant impact on greenhouse gas emissions. Coefficients for greenhouse gas emissions from purchased and displaced electricity, natural gas and fuel oil consumption from the Ecoheat4Cities emissions reduction calculator were used to estimate the CHP plant's impact on Co-Op City's carbon footprint. Table6 displays the impact of the Co-Op

City CHP system on greenhouse gas emissions compared to the baseline of full import of utility electricity and boiler plant operation at 67% efficiency using No. 6 fuel oil for steam production.

Table 6. Impact on Greenhouse Gas Emissions – Two Year Operation July 2010 – June 2012

	Baseline: Import Electricity, 67% Efficient Boiler w/No. 6 Fuel Oil	**Co-Op City CHP Plant**
On-site Generation (MWh)	0	253,893
Net Imported Electricity (MWh)	266,833	12,940
Thermal Load - 150 psig Steam		
MMBtu	1,910,715	1,910,715
MWh	559,998	559,998
Fuel Input - Natural Gas		
MMBtu	0	4,225,853
MWh	0	1,238,527
Fuel Input - No. 6 Fuel Oil		
gallons	18,639,301	0
MMBtu	2,851,813	0
MWh	835,819	0
Total Energy Supplied (MWh)	*826,831*	*826,831*
Carbon Intensity (kg CO_2e/MWh)	*683*	*337*
Total Carbon Emissions (kgCO_2e)	**565,124,883**	**278,915,658**
Carbon Emission Reduction (kgCO_2e)		**286,209,225**
Carbon Emission Reduction (%)		**50.6%**

Notes: Energy content of No. 6 fuel oil assumed to be 153,600 Btu/gal HHV.
Ecoheat4Cities default values were used for both calculations; spreadsheets are available as separate files.

Compared to the baseline configuration, the Co-Op City CHP plant has reduced CO_2 emissions by 50.6%, resulting in a total reduction of 286,209 metric tons of CO_2 equivalent (MTCO_2e) over the two-year period examined.

<u>Stringent Emissions Limits</u>

In order for the facility to receive the incentive offered by NYSERDA, the CHP system was required to pass performance thresholds for environmental performance for a two-year monitored period. This evaluation included passing annual emissions tests for NOx levels and CO levels in the combustion turbine exhaust streams, and meeting any other requirements under the New York State Public Service Commission's definition of Clean Distributed

Generation. CHP Systems meeting these requirements must not exceed a NOx emission limit of 1.6 lb/MWh, or 600 ppm CO. The Co-Op City CHP system easily satisfied these program performance thresholds over the two-year monitoring period.

An Innovative Design

The Co-Op City CHP system represents one of the pioneer large-scale micro grid applications in the New York City Metro Area. The system is designed for flexibility in operation to meet diverse thermal and electrical loading scenarios, as well as fuel switching options based on utility price constraints. The system also represents a major step towards energy resiliency for the Co-Op City residents, allowing for power and thermal production independent of the status of the local utility system. With the recent higher frequency in extreme weather events, these are critical factors in improving the quality of life for the Co-Op City residents.

The Co-Op City CHP system is a well-functioning model for other cooperatives and multifamily facilities facing the same challenges of grid dependence and extreme weather. The load-adaptable nature of the system design, its minimal emissions profile, and its ability to meet both summer cooling and winter heating loads makes it easily replicable at a smaller scale in many large business campuses or multifamily cooperatives.

The project's innovative design has also brought publicity to New York State's energy efficiency efforts. As noted above, the Co-Op City CHP system design and operation qualified the system for a $2 million performance-based incentive from NYSERDA. Strict energy performance evaluation criteria in the NYSERDA incentive program include standards for on-peak demand reduction contributions, annual electricity generation, and fuel conversion efficiency. Co-Op City's CHP plant met all of its contract criteria, making it the first CHP system in the NYSERDA CHP Performance Program to reach the maximum possible $2,000,000 incentive.

A Benefit to the Community

In its short operating history, the Co-Op City CHP system has proven invaluable for the residents of the complex. On October 29, 2012, Hurricane Sandy struck the New York City Metro area, knocking out power for over 8 million people. One exception to the widespread utility disruption was the residents of Co-Op City, who continued to receive electric power and heat from the CHP system through the storm, and into the days and weeks of recovery afterward. The CHP system allowed Co-Op City to operate nearly as normal through the storm period. Monitored data during the storm period displayed the CHP system providing between 11.1 and 14.9 MW during the storm event. For a two-hour period during the storm on October 29, the operating combustion turbine #1 generator was knocked offline and only the steam turbine generator operated to provide 3.3 MW of power to the facility.

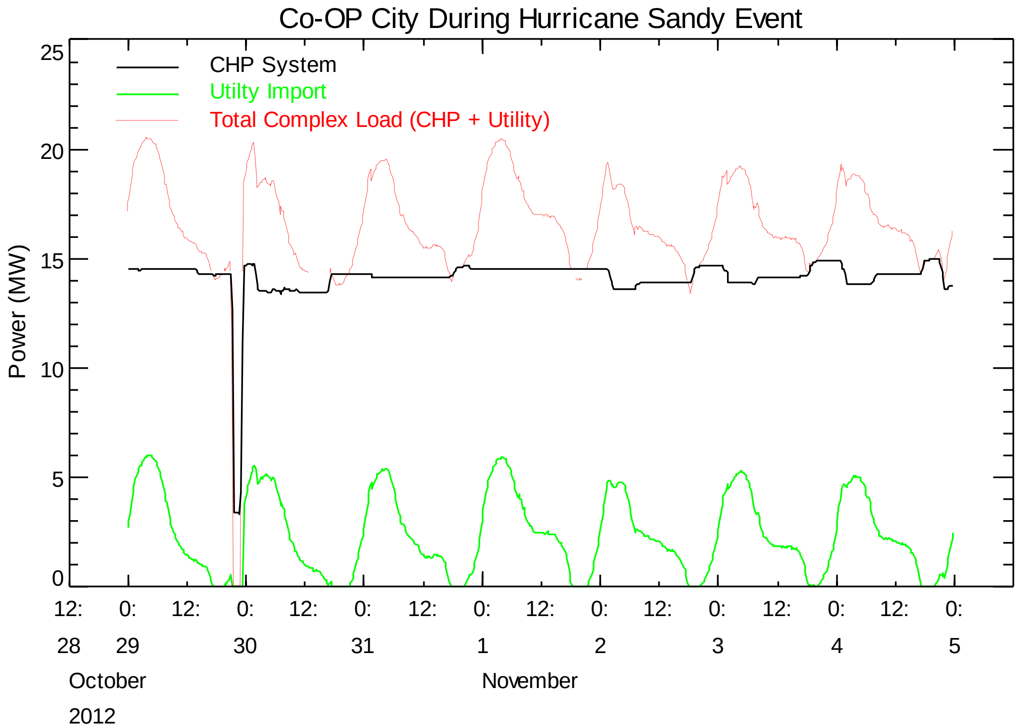

Figure 3. CHP System Output and Utility Import During and After Hurricane Sandy

Over this critical seven-day period, the CHP system provided 2,368 MWh (86%) of the 2,742 MWh of electricity needed by the complex. Operating the CHP system concurrently with the strained utility grid removed critical load from the utility during this recovery period, reducing the potential for further disruptions.

According to Herb Freedman, a principal of Marion Real Estate Inc., which manages Co-Op City for the Riverbay Corporation, "We decided to invest in an onsite cogeneration plant because we wanted to save money by producing our own electricity and capturing the waste heat to provide our residents with hot water and space cooling. We have certainly saved money, but we are also really happy to provide our residents with the added benefit of independence from the power grid."[2]

[2] http://www.forbes.com/sites/williampentland/2012/10/31/where-the-lights-stayed-on-during-hurricane-sandy/