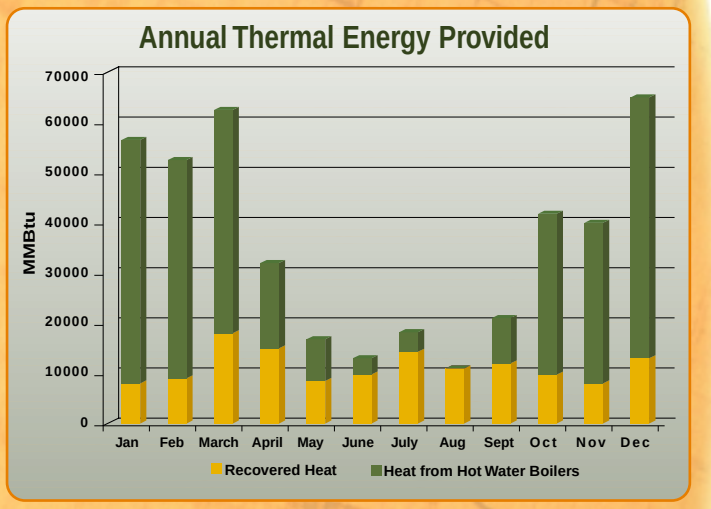
MIDWEST CHP APPLICATION CENTER

University of Illinois at Chicago Cooling, Heating, and Power Plant

Case Study

In the early 1990s, the University of Illinois at Chicago (UIC) considered adding power generation to its central heating and cooling facility as a way to meet the increasing energy demands of a growing university. What began in 1993 as a 12.6-MW cogeneration plant to provide electricity and hot water to service a portion of the East Campus, has become a 20.2-MW cooling, heating, and power (CHP) plant. CHP for Buildings is an integrated system that is located at or near a building that provides a portion of the electrical load, and utilizes the thermal energy from the generation of the electricity to provide cooling, heating, and/or dehumidification. The new CHP plant now provides enough electricity to meet the energy demands of the entire East Campus. The recovered heat from the generation of that electricity supplies 38 MBTU/hr to offset the heating and cooling requirements of more than 3.8 million square feet in 29 campus buildings.



Economic Savings

Based on total costs, CHP on the University of Illinois campus provided approximately $1,931,518 or 18.62% in savings for 2000. These savings, however, are lower than in previous years beca use natural gas costs for much of 2000 were uncharacteristically high. The table above shows the estimated savings after taking into account various average natural gas prices.

Savings for Various Natural Gas Average Prices

Natural Gas Average Price [$/MMBTU]	% of Annual Operating Savings	Projected Annual Savings
2.5	36.18%	$3,349,512
3.0	31.80%	$3,029,657
3.5	27.66%	$2,709,802
4.0	23.74%	$2,389,947
4.5	20.03%	$2,070,093
4.68	18.62%	$1,931,518
5.0	16.50%	$1,750,238

"Our plant is designed to serve our needs at the university with some capacity for redundancy. The project was totally financed by the university without federal, state, or utility subsidies. We believe that future CHP systems that service multiple facilities like universities and district energy systems, will be very bright as the electric utilities continue to restructure"

Ken Buric, Director of Utility Operations for UIC

Improved Emissions Performance

Considering the replacement of electricity and recovered thermal energy, the CHP plant provides an overall source energy reduction of 14.15% (236,856 MMBTU/yr). The CHP plant also represents an estimated 28.5% (29,545 tons/yr) reduction in CO_2, a 52.8% (126 tons/yr) reduction in NO_X, and an 89.1% (551 tons/yr) reduction in SO_2.

Replicating the Success

Based on the success of the East Campus CHP plant, the university is commissioning a second plant on its West Campus, which will be electrically tied to the East Campus through a 69 kV line, and will provide an additional 37.2 MW of electric power. The 360,000 lbs/hr of 150 psi steam recovered from the generators will combine with 300,000 lbs/hr of steam from three boilers. This will provide the steam requirement for the University Medical Center along with the other buildings that comprise the West Campus.

"All engines at the East Campus facility are equipped with high-temperature hot water heat recovery systems.... The East Campus uses 400°F water and distributes it throughout the campus for heating and absorption air conditioning."

John Cuttica, Coordinator of Energy & Environmental Research Projects, UIC

Configuration of the Power Plant

East Campus

The East Campus plant operates with reciprocating engines, supplying the campus with electricity and thermal energy for heating and cooling. The plant is equipped with supplemental-fired hot water generators to meet the energy needs of the university efficiently.

Equipment at the East Campus plant includes:

- 2 Cooper-Bessemer dual-fuel reciprocating engine-generators, each rated at 6.3 MWe
- 2 Wärtsilä 18V-28SG natural gas reciprocating engine generators, each rated at 3.8 MWe
- 4 exhaust gas heat recovery systems, providing a total recovered energy of 30 MMBTU/h (8.8 MWth)
- 2 jacket water heat recovery systems, providing a total recovered energy of 8 MMBTU/h (2.4 MWth)
- Several remote building absorption chillers activated by the hot water loop, for a total of 1,350 RT (4.83 MWth)
- 1 Trane 2-stage absorption chiller, rated at 1,000 RT (3.5 MWth)
- 3 high-temperature hot water generators (HTHWGs) (natural gas/#6 fuel oil)–two rated at 75 MMBTU/h (22 MWth) and one rated at 50 MMBTU/h (15 MWth)
- 3 York International electrical centrifugal chillers, each rated at 2,000 RT (7.0 MWth)

The Cooper-Bessemer units have been running for over 50,000 hours without a major overhaul. While they are operated almost exclusively on natural gas, their ability to operate on #2 diesel fuel provides additional flexibility. The University recently installed catalytic oxidizers on the Cooper Bessemer engine-generators and afterburners on the Wärtsilä engine-generators to receive emission credits.

Annual Electric Generation and Use in MWhrs (Based on 2000)

Month	Generated On-Site	Sold to Utility	Purchased from Utility	Total Delivered to Campus
Jan	4,303		3,408	7,711
Feb	4,442		2,412	6,854
Mar	3,991		3,871	7,862
Apr	6,050		1,191	7,241
May	2,337		7,126	9,463
Jun	7,626	-2,048		5,578
Jul	10,512		2,301	12,813
Aug	10,043	-1,924		8,119
Sep	9,917	-2,935		6,982
Oct	8,214	-454		7,760
Nov	8,432	-1,335		7,097
Dec	7,428	-359		7,069
Total	**83,295**	**-9,055**	**20,309**	**94,549**

Annual Total Fuel Usage (Based on 2000)

	CHP Plant	Baseline Plant
Natural Gas	1,176,356 MMBtu	538,645 MMBtu
#2 Fuel Gas	169,517 gallons	0

Economic Comparison Details Between Baseline and CHP Plant for 2000

	CHP Plant	Baseline
Income		
Sold Electricity	$135,858	N/A
St. Ignatius School	$70,827	N/A
General Expenses		
Salaries	$204,619	N/A
Electrical Expenses		
Electricity Wages	$481,400	N/A
Electricity Fuel Oil	$177,477	N/A
Electricity Gas	$3,804,833	N/A
ComEd Electricity	$1,131,845	$6,710,545
Electricity Water/Sewer (a)	$57,723	N/A
Maintenance	$120,000	N/A
Heating and Cooling Expenses		
Heating and Cooling Wages	$886,600	$886,600
Heating and Cooling Fuel Oil	—	—
Heating and Cooling Gas	$1,674,764	$2,463,380
Heating and Cooling Water/Sewer	$52,437	$52,437
Maintenance	$58,200	$58,200
TOTAL	**$8,443,263**	**$10,374,782**

Financial Analysis

In 2001, a UIC graduate student conducted an energy and financial analysis of the East Campus facility as part of his Master's thesis. The study examined actual operation of the East plant for 2000. Following are highlights of his efforts:

- The parameters of the analysis were that the plant operates 24 hours a day and 7 days a week.
- Most of the time, the plant generates sufficient electricity to meet East Campus demands.
- When site demand exceeds generation, power is purchased from the utility. When generation exceeds demand, excess can be sold back to the utility.
- The 7.6-MWe addition provided by the Wärtsilä engine-generators began operation in July 2000. Therefore, the analysis assumed 6 months of plant operation at 12.6 MWe and 6 months at 20.2 MWe.
- Since the 1,000 RT absorption chiller was not commissioned until May 2001, it was not included in the analysis.
- The East Campus CHP plant was compared to a baseline plant that purchases all of its electricity from the utility and provides heating and cooling through the heating boilers and electrical chillers.
- The same thermal loads are assumed for the baseline plant and the CHP plant. The load is supplied by the HTHWGs in the baseline plant.
- For the CHP plant, annual costs are based on actual monthly expenditures paid by the university. For the baseline plant, estimates have been made for the annual cost of electricity and natural gas.

Newly installed 3.8-MW Wärtsilä engine-generator in the central plant at UIC. These lean-burn engines are characterized by high electrical efficiency, dependable operation, and low maintenance costs.

New 1,000RT Trane Double Effect Absorber high-temperature hot-water-activated water chiller

Financial Statistics

UIC Campus Results	Original (baseline) 12.6-MW East Campus Plant (Operational in 1993)	Additional 7.6-MW East Campus Plant with 1000-Ton Absorption Chiller (Operational in mid-2000)
TOTAL COST:	$15M	$10.7M
ORIGINAL GOAL:	Payback in 10 years	Designed for a payback of 10 years
ACTUAL PERFORMANCE:	Payback in 7.5 years	First full year of operation will be 2001
OPERATING SAVINGS	Approximately $2M/yr	Year 2000 (With only 6 months of operation with the additional 7.6 MW and no absorption chiller.) –$1.9M savings even with all time high gas prices

Midwest CHP Application Center:

A Partnership between the U.S. DOE and the Energy Resources Center at University of Illinois-Chicago

The DOE believes that integrating new energy-efficient technologies, such as CHP, requires education of the engineering community, the building trades, real estate developers, and building owners. As part of this goal, The DOE's Office of Distributed Energy Resources has partnered with UIC's Energy Resources Center at its Chicago campus and Gas Technology Institute to form the first of several Regional Application Centers. The purpose of the Midwest CHP Application Center is to:

- Assess the Midwest region for CHP opportunities
- Manage a "SWAT Team" of technical experts that can be dispatched anywhere in the nation to evaluate strategic CHP projects
- Provide communication between state agencies, Public Utility Commissions, legislatures, the Environmental Protection Agency, ASHRAE, etc. to promote CHP for buildings
- Maintain an installation and contact database for the Midwest region
- Develop pertinent educational materials, including regional case studies, presentation materials, and workshops

For more information on the Midwest CHP Application Center visit:

www.CHPCenterMW.org

For further information contact:

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