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Elgin Community College
Site Report for
CHP Applications

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For: Midwest CHP Application Center

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Figure 1: Main Campus of Elgin Community College

1.1. General

Elgin Community College is a community college providing education to the residents of Kane and Cook Counties in Illinois. 25,000 students are enrolled each year at the community college taking credit and noncredit courses. The college has 340 full time employees and over 800 part time employees.

Elgin Community College (ECC) is located in the Community College District 509, a 360 square mile region with a population of 275,000 people. The projected growth of the Community College District by the year 2010 is a population of 400,000. The estimated student population for ECC is 50,000 by 2020. ECC encompasses two campuses – the main campus and the downtown Elgin campus. The ECC main campus, which the case study covers, consists of 12 buildings totaling 672,235 square feet on over 145 acres. The downtown Elgin campus consists of approximately 56,000 square feet.

In 1991, a stand-alone cogeneration building was considered to provide electrical power and heating to the college. The board of trustees decided the project, with a payback over five years (incorporating local funding only) was not acceptable. In 1993 the concept of cogeneration was reconsidered and a 3.2 MWe Cooling, Heating and Power (CHP) Plant was recommended. The CHP Plant would be part of a larger building project. By 1996, the CHP Plant was installed at the main campus to provide building cooling operations in the summer and heating in the winter. The $2.5 million project offered reliability, energy savings and site owner control of power to the campus. In May of 1997, the cogeneration plant was in operation and cogenerating power to over 70% of the campus and its buildings. Today the CHP Plant generates electricity to over 90% of the campus.

Generating their own power, ECC had nearly eliminated any threat to brownouts or total blackouts due to energy shortages. This would ensure that the campus would continue to function during energy shortages. Secondly, when initially installed, the college expected average monthly energy operating savings of $30,000. And finally, the college's engineering department now had control in determining when and how the CHP system would operate to achieve maximum efficiency. Because of the excellent performance and reliability of their system and the faith it will continue to serve them efficiently, ECC plans to install additional equipment in the near future to cover the entire main campus with CHP.

Further general information of Elgin Community College can be found at www.elgin.edu.

1.2. Site Location

The campus is located at 1700 Spartan Drive between McLean Boulevard and Randall Road in southwest Elgin, Illinois. The city of Elgin is a suburb of Chicago located 40 miles northwest of the city.

1.3. Site Characteristics

Elgin Community College was originally built in the early 1970s. After continued expansion, the main campus today includes 12 buildings totaling 672,235 square feet. Today, 11 of the 12 buildings totaling 618,715 square feet are operating under cogeneration. The single building not operating under cogeneration is the newly built Industry Training Center building totaling 53,520 square feet. This building has a cogeneration power feed running to it and will be connected to CHP system later this fiscal year.

Power supply to the campus is an important factor in daily operations. Keeping the central computer mainframe in operation along with over 2,000 campus desktop computers is critical to ECC. Elgin Community College is also required to be a FEMA (Federal Emergency Management Agency) shelter during times of emergency for the local community. With a CHP Plant, the college can be fully functional providing power, heating and cooling during times of emergency while operating on natural gas.

The electricity for the college is provided by the local electric utility Commonwealth Edison Company on Rate 6, a general service time-of-day rate. Rate 6 consists of two different on-peak rate periods: Demand On-Peak and Energy On-Peak. The demand charges occur between the hours of 9 AM and 6 PM non-holiday weekdays, while the energy charges occur between the hours of 9 AM and 10 PM, also on non-holiday weekdays. Because the ComEd off-peak energy charge is so low, the generators are shut down during the off-peak periods. Savings would not occur if the generators were to run during this time.

Figure 2: ECC's Cogenerating Plant

2. Market Segment Evaluation

University and college facilities are generally good candidates for CHP applications because they have extended hours of operation, they operate during the entire year, and probably most importantly, they are often heated and cooled by central district heating and cooling plants.

Because of the cold winters and hot summers in Chicago, it is regionally well suited for CHP applications. Also because it is a metropolitan center, there is a higher expectation for buildings to be comfortably heated or air-conditioned.

3. Technical Description

3.1. Overview of CHP to Baseline/Original Installation

Prior to cogeneration at Elgin Community College, a 25-year-old 600 ton Trane absorption chiller was augmented by a 550 ton Trane centrifugal electric chiller. Both chillers were necessary to cover the total cooling load after building expansion. Then in April of 1999, a York Millenium Absorption Chiller replaced the old absorption chiller. The York chiller was placed in the spot previously occupied by a smaller Burnham boiler that was not used due to its small size. Following the replacement of the York absorption chiller, a smaller Burnham boiler was replaced as well. Boilers provided steam for an expansion tank for domestic hot water. This was later replaced by an on demand semi-instantaneous hot water heater that did not require a tank and operated with greater efficiency.

The construction of Elgin Community College CHP Plant began in the fall of 1996 and by May 1997, the college was operating the CHP Plant. The primary equipment of the CHP Plant consists of four engine-generators with heat recovery systems, boilers, and an absorption chiller. The CHP plant load follows electric load during the electric energy on-peak period of 9 AM to 10 PM on non-holiday weekdays. The engines are turned on 15 minutes prior to the peak period beginning and turned off shortly after the peak period has concluded avoiding the high electric rates during the on-peak period and taking advantage of the lower off-peak electric pricing. In June of 2001, an additional 100,000 square feet were added onto the CHP Plant's service area bringing the total square footage that the CHP Plant served to 618,715 square feet.

3.2. CHP System Design

Charles Equipment Company, the local Waukesha distributor, supplied the total equipment package for the CHP plant to Elgin Community College (greater detail provided in Table 10). Charles Equipment Co. also provided the maintenance and all major repairs for the equipment and presently continues this service to the college. Morse Electric Company of Rockford, Illinois was awarded the installation contract. And KJWW Engineering Consultants, also of Rockford, Illinois provided the feasibility study and design of the CHP system for the college prior to the CHP installation.

3.2.1. Electrical Parameters

3.2.1.1. Overview

The Elgin Community College CHP Plant operates 5 days a week from 9AM to 10PM, except holidays. The majority of the time, the CHP plant generates sufficient electricity to meet the college's demand. At times when site demand exceeds generation, power is purchased from the local electric utility, ComEd. ECC does not generate additional electricity for sale back to the utility.

3.2.1.2. Electrical Generation Prime Mover

Four Waukesha Enginator® Model VHP5108GL Lean Burn engines are installed at Elgin Community College as prime movers. Each engine weighs approximately 36,000 lbs.

Figure 3: Waukesha engines installed at Elgin Community College

Figure 4: Single Waukesha engine data screen

3.2.1.2.1. Generator (Type/Size)

Each engine is rated at 800 kWe, to be operated 3,400 hours per year. The Waukesha engine model 5108GL is coupled to a Kato Engineering synchronous generator rated 805 kWe at 4160 volt, 3–phase, 60 Hz @ 105°C temperature rise.

3.2.1.2.2. Fuel Type

The Waukesha lean burn engines operate on 900 Btu/ft^2 minimum of commercial quality natural gas at 35 psig.

3.2.1.2.3. Waste Heat Profile

Heat recovered from the engine generators at ECC incorporates an ebullient engine cooling system for low pressure steam (9 to 12 psig) with 250°F jacket water temperature out of the engine. The cooling is achieved by natural convection without the use of a jacket water pump. The fuel consumption and heat recovery rates can be found below in Table 1.

Table 1: Fuel Consumption and Heat Recovery of Waukesha VHP5108GL Enginator®

Fuel Consumption and Heat Recovery					
Generator Power	**Percent Load**	**HHV Fuel Consumption**	**Jacket Water Recovered**	**Exhaust Recovered**	**Steam Production**
kW	*%*	*Btu/hr*	*Btu/hr*	*Btu/hr*	*Lb/Hr*
805	100	8,224,000	1,765,920	1,056,022	2,835
700	87.5	7,334,000	1,657,980	899,353	2,705
603	75	6,509,000	1,530,000	793,258	2,458
564	70	6,165,000	1,477,020	749,712	2,356

- *Manufacturer supplied data*

3.2.1.3. Backup/Standby Power

If the engines should fail, 100% back-up power is available from ComEd until repairs are made and the engines are in operation again. Also, if the power sources at ECC fail, three small emergency generators are available to supply enough power for a black-start in the CHP Plant. These generators supply enough power to supply the control panels, start the engines and restore power to the campus. Emergency power equipment is shown in Figures 5 and 6.

Figure 5: Kohler Emergency Generator

Figure 6: Blackstart® Air Compressor - Controls air compressor that runs continuously, fed by ICT emergency generator.

3.2.1.4. Grid Supply

Power is available from the grid through ComEd's Standard Rate 6 (facilities less than 10,000kW demand) and ComEd's Standby Rate 18. The Waukesha engines generate 4,160 volts of electricity and send it to a transformer (rented by ECC from ComEd) where the voltage is stepped up to 12,470 volts. The electricity is then sent to ComEd's feed, the college draws the needed power, which is then directed to each building transformer by means of switchgear located in the parking lot.

Table 2: ComEd's Standard Rate 6 and Standby Rate 18 Electric Rates

ComEd Electric Rates			
	Rate 6	Rate 6L	Rate 18
Summer Demand ($/kW)	$14.24	$12.85	Varies
Winter Demand ($/kW)	$11.13	$16.41	Varies
On-Peak ($/kWh)	0.05599	0.05022	0.05022
Off-Peak ($/kWh)	0.02341	0.02123	0.02123
Generator Capacity ($/kW)	NA	NA	$2.99

Figure 7: Winter photo of transformers rented from ComEd to step up 4,160 volts of electricity from the generators to ComEd's line of 12,470 volts.

3.2.1.5. Interconnection Requirements

Additional valves and relays were installed at ECC due to interconnection requirements.

3.2.2. Fuel Supply Description

The fuel supplied to the Elgin Community College CHP Plant is primarily natural gas at a nominal 35 psi.

3.2.3. Thermal Recovery Systems

The CHP Plant utilizes an ebullient cooling system to produce steam for heating domestic hot water and low-pressure plant load steam. This type of cooling system is achieved without the use of a jacket water pump through natural convection.

3.2.3.1. Steam

Steam is produced from the water that is supplied to the engines to keep them cool. If the CHP system cannot produce the required amount of steam, the boilers can also produce sufficient amounts of steam to carry the load.

While producing electricity, the exhaust gas is run through a thermal heat recovery package. The recoverec heat is transferred to the water of the boiler tanks through tubes thereby producing steam. The steam is sent through the main header by a one-way check valve and is used for three purposes:

1) Chilled water through an absorption chiller
2) Heat exchangers
3) Instantaneous domestic hot water

When the steam is produced, it is sent to a main steam header for the heat exchangers and the semi-instantaneous hot water heater. Whether steam is produced via cogeneration or boilers, this low-pressure process is tied into the same system, piped into the same header and sent to the converters to heat the hot water loops.

3.2.3.2. Absorption Cooling (Type/Size/Manufacturer)

The steam produced by the engines is recovered for use in the 550 ton York Millennium Single-Stage Li-Br Absorption chiller.

Figure 8: MAC Case study visit with Facility Operators Management Paul Dawson viewing a York 550 Millennium Absorption Chiller

Figure 9: Controls of York Absorption Chiller

3.2.4. Non-Recovery Thermal Systems

3.2.4.1. Area Refrigeration Equipment

3.2.4.1.1. Centrifugal Chiller

When the absorption chiller is not able to cover the entire cooling load, chilled water is also obtained through a Trane 550-ton, 3-stage centrifugal chiller. Recently, the centrifugal chiller was upgraded to R-123 according to EPA regulations.

Figure 10: Trane, 550-ton, 3-stage centrifugal chiller

3.2.4.1.2. Electric Air Conditioning

45 various Trane electric air conditioning units of differing sizes exist on campus and are in operation over the campus, providing approximately 850 tons of total cooling when needed.

Table 3: Cooling Equipment at Elgin Community College

Cooling Equipment				
Type	**Manufacturer**	**Quantity**	**Capacity (Tons)**	**Total Capacity (Tons)**
Electrical Air Conditioners	Trane	45	Various	850
Electric Chiller	Trane	1	550	550
Absorption Chiller	York	1	500	500

3.2.4.1.3. Heating Equipment

Three natural gas-fired Kewanee boilers provide a total capacity of 44,280,000 BTUs. Nine natural gas-fired Patterson-Kelly hot water heaters provide a total capacity of 12,030,000 BTUs to the campus as shown below.

Table 4: Heating Equipment at Elgin Community College

Heating Equipment				
Manufacturer	**Fuel Type**	**Quantity**	**Capacity (BTUs)**	**Total Capacity (BTUs)**
Kewanee	natural gas	2	17,710,000	35,420,000
Kewanee	natural gas	1	8,860,000	8,860,000
Patterson-Kelly	natural gas	7	1,500,000	10,500,000
Patterson-Kelly	natural gas	2	765,000	1,530,000

3.3. Baseline System Configuration

This case study compares the operation of the Elgin Community College CHP Plant for the case study year July 2001 to June 2002, referred to as the CHP Plant, against a plant without cogeneration of electricity that can be considered as the more conventional alternative, which will be referred to as the Baseline Plant.

The Baseline Plant will be the same as the CHP Plant, except without the onsite generation of electricity. It will provide steam and chilled water via the central plant to the campus buildings in the same manner as the CHP Plant. The electrical energy from the engine-generators is assumed to be replaced by electricity from the local utility, ComEd under Rate 6L, the large service time-of-day rate. Additional fuel provided to the hot water heaters and boilers will compensate for the loss of the recovered thermal energy from the engine-generators. The electric consumption of the Baseline Plant will remain the same as the CHP Plant. The Peak Demand will be assumed to be the maximum generator load measured by the local utility, ComEd, from the CHP Plant data. The fuel consumption and heat recovery rates of the generator will be calculated for 75% part load. The boiler efficiency will remain the same for both cases at 80% efficiency.

4. Energy Analysis (Baseline versus CHP)

During the case study year, July 2001 to June 2002, the ECC CHP Plant consumed 1,419,139 therms of natural gas and 13,678,805 kWh from ComEd. The CHP Plant also converted 711,080 therms of natural gas into 6,587,510 kWh of net electricity and recovered 25,372 MMBTUs of energy through exhaust heat and jacket hot water. The system achieved a yearly efficiency of 67%; without heat recovery the generator's efficiency would have only been 32%. On the other side, during the same year, the CHP Plant consumed the same amount of electricity as the Baseline Plant but consumed 1,025,209 therms of natural gas, 28% less than the Baseline Plant

4.1. Electrical Parameters

The Elgin Community College CHP Plant has a total electric generating capacity of 3,220 kWe of power and a cooling capacity of 1,900 tons of refrigeration. During the case study year of July 2001 to June 2002 the generators supplied nearly half, 48%, of the total electric load of the campus (Figure 12 and Table 5). The remaining electric load was supplied to ECC by ComEd under Rate 6 and Rate 18. (Case Study analysis does not include electric charges to ITR building since the CHP Plant does not supply it.)

The generators installed at ECC are electric load following. During the on-peak energy hours of the case study year, the generators supplied the campus with 94% of the total electric load (see Figure 11). The generators were turned off during off-peak hours due to the low charge of 2.1 ¢/kWh resulting in zero or minimal savings during this period if the ECC were to operate them. Elgin Community College also does not generate any additional electricity for sale to ComEd for sell-back.

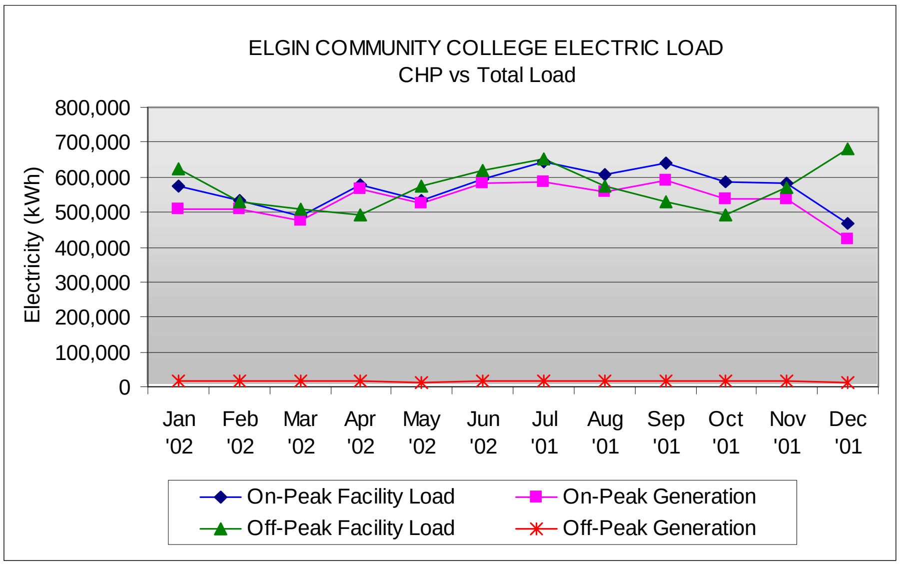

Figure 11: CHP Electric Usage - Generated vs Purchased

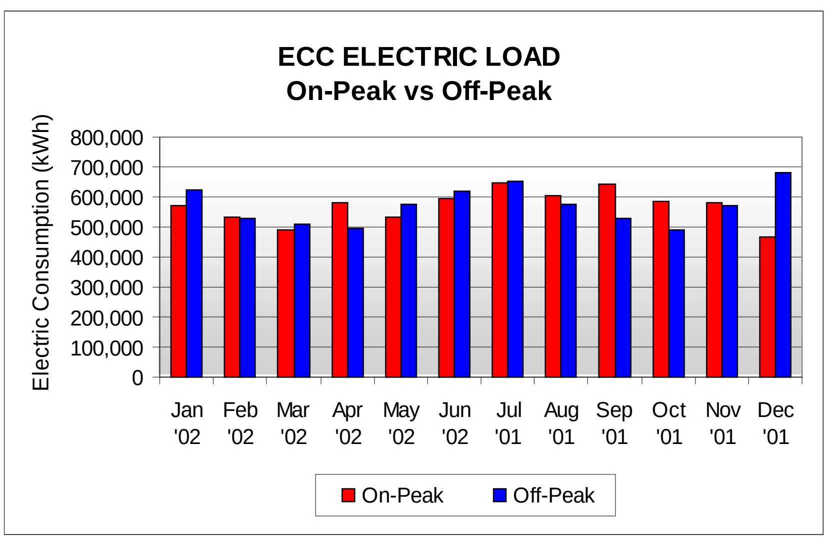

Figure 12: ECC Electric Load - On-Peak vs Off-Peak

Table 5: ECC CHP & Baseline Annual Electric Usage

Annual Electric usage						
	CHP Plant				**Baseline Plant**	
	Peak Demand	Generated	Purchased from Utility	Delivered to ECC	Peak Demand	Purchased from Utility
	kW	*kWh*	*kWh*	*kWh*	*kW*	*kWh*
Jan '02	212	542,685	670,935	1,195,620	2,081	1,195,620
Feb '02	219	521,752	539,881	1,061,633	2,114	1,061,633
Mar '02	15	489,125	508,369	997,494	2,114	997,494
Apr '02	130	585,189	488,399	1,073,588	2,796	1,073,588
May '02	19	536,762	573,412	1,110,174	2,374	1,110,174
Jun '02	11	600,414	614,266	1,214,680	2,629	1,214,680
Jul '01	271	606,745	690,786	1,297,531	2,612	1,297,531
Aug '01	236	573,925	608,081	1,182,006	2,542	1,182,006
Sep '01	287	606,458	563,603	1,170,061	2,681	1,170,061
Oct '01	177	556,834	522,192	1,079,026	2,565	1,079,026
Nov '01	205	550,697	600,504	1,151,201	2,653	1,151,201
Dec '01	199	434,924	710,868	1,145,792	1,956	1,145,792
Total		**6,587,510**	**7,091,296**	**13,678,806**		**13,678,806**

The electric demand profile is drastically different between the CHP and Baseline Plant (Figure 13). The savings realized for the CHP Plant shown in the Financial Analysis, Section 6, are even greater due to ComEd's high electric demand rate structure. The CHP average On-Peak, Off-Peak and maximum electric demand can be seen in Figure 14. Note how closely the average generation follows the average on-peak demand; this is a good example of load following.

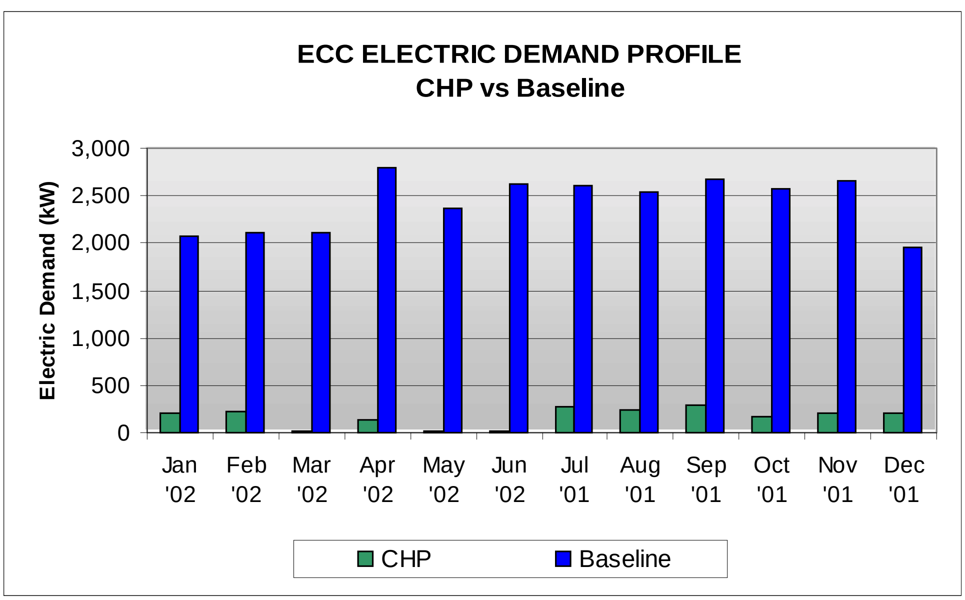

Figure 13: ECC Demand Profile - CHP vs Baseline

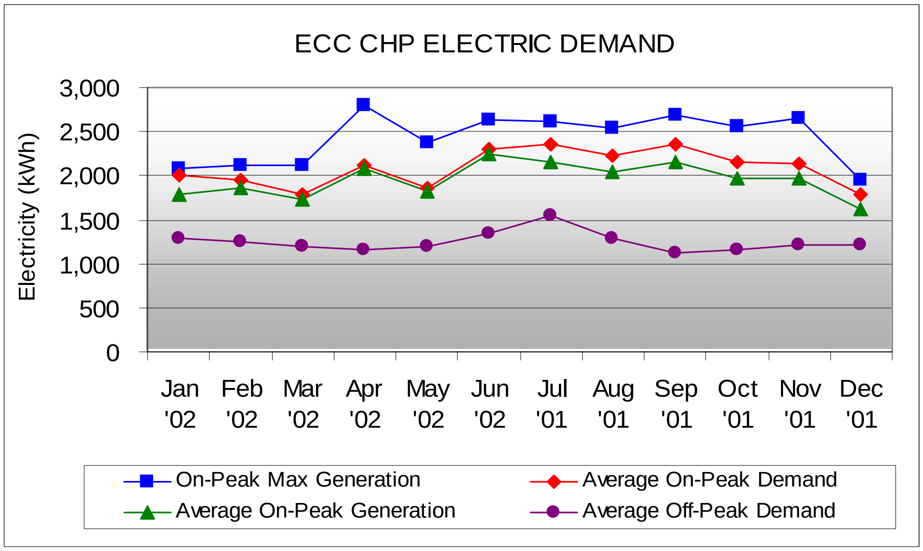

Figure 14: ECC Average Electric Demand

4.2. Thermal Profiles

Elgin Community College imports natural gas from Nicor Gas Company. Table 6 and Figure 15 below show the boiler and CHP system fuel consumption. Analysis of the heat recovery system (ebullient cooling system) accompanied by data from Waukesha, shows that 35.7% of the input energy to the engines is recovered from the jacket hot water and exhaust in the form of steam (Table 6 and Figure 16). The heat recovery provides approximately 35.8% of the ECC's steam load. The steam recovered from the generators is used to operate either the absorption chiller (avoiding electric consumption by the centrifugal chillers) and/or heating of the buildings and/or hot water, avoiding additional natural gas consumption. The heat recovery raised the efficiency of the system during the case study year from 32% to 67%.

Table 6: Boiler and Generator Natural Gas Consumption and Heat Recovery Credit

Boiler and Generator Natural Gas Consumption, Heat Recovery Credit				
Month	Boiler Consumption	Electricity Generated	Generator Consumption	Heat Recovery Credit
	therms	*kWh*	*therms*	*therms*
Jan '02	87,239	542,685	56,636	20,208
Feb '02	74,511	521,752	56,320	20,095
Mar '02	79,637	489,125	52,798	18,839
Apr '02	58,801	585,189	63,167	22,539
May '02	65,643	536,762	57,940	20,673
Jun '02	43,742	600,414	64,811	23,125
Jul '01	45,408	606,745	65,494	23,369
Aug '01	62,087	573,925	61,952	22,105
Sep '01	28,603	606,458	65,463	23,358
Oct '01	53,231	556,834	60,107	21,447
Nov '01	50,522	550,697	59,444	21,210
Dec '01	100,144	434,924	46,947	16,751
Totals	**749,567**	**6,587,510**	**711,080**	**253,719**

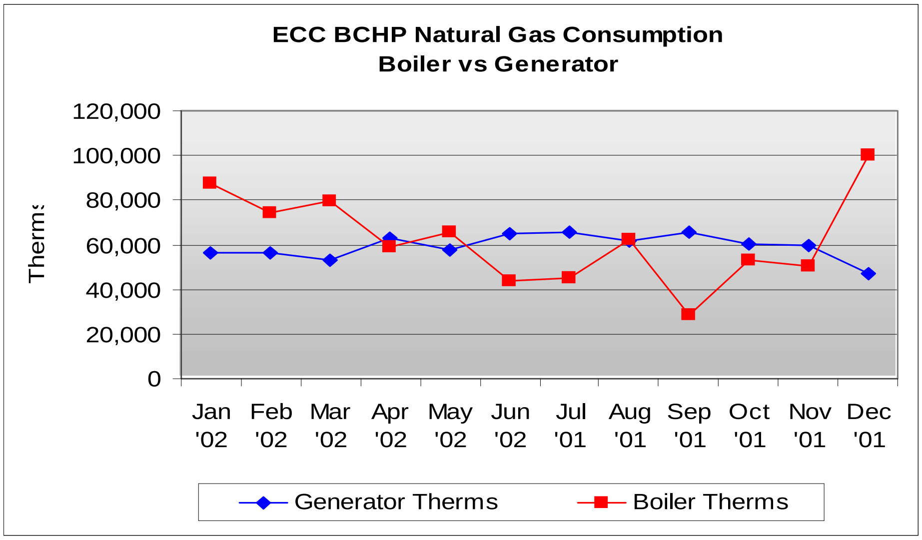

Figure 15: ECC CHP Natural Gas Consumption - Boiler vs Generator

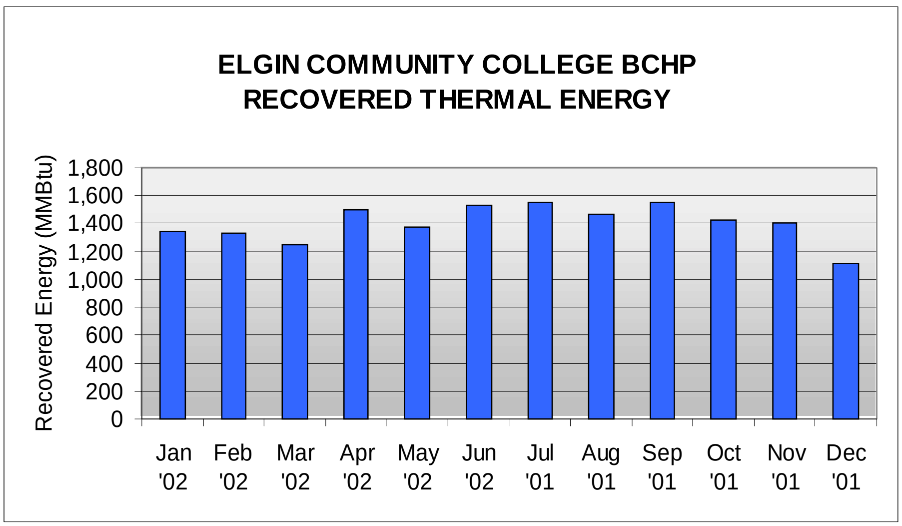

Figure 16: ECC CHP Recovered Thermal Energy

4.3. Fuel Usage

The CHP Plant consumed 1,460,646 therms of natural gas while the Baseline Plant consumed 1,066,824 therms. With power generation, more fuel is consumed by the CHP Plant to operate the generators. This is seen in Figure 17. Note the slight downward trend in natural gas consumption during the summer months and the rise back up during the winter months. This is due to the additional heating requirements during the winter supplied by natural gas consumption.

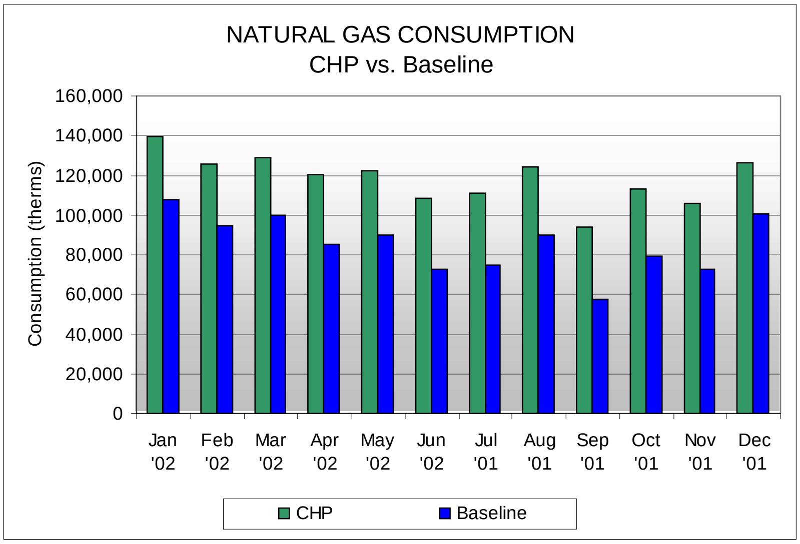

Figure 17: ECC Natural Gas Consumption - CHP vs Baseline

5. Financial Analysis (Baseline versus CHP)

5.1. Assumptions

For the purpose of this case study, assumptions will need to be made to allow for the analysis of the CHP Plant to the Baseline Plant. The CHP Plant purchased electricity from ComEd under Rate 6 and Rate 18. Rate 6 is a general time-of-use service for facilities not incurring a demand over 1,000 kWe. The Baseline Plant will come under ComEd's Rate 6L, a large general time-of-use service charge, since the facility will have a demand greater than 1,000 kW because of the generation not present. The CHP verses Baseline comparisons used the tax rates from the CHP electric utility bills.

5.2. CHP Project Cost

The cost of the ECC CHP Plant including engineering, construction, Capital Development Board (CDB) fees, equipment and change orders, totaled nearly $2.5 million. The cost of the CHP system did not include the structure, gas piping to the room, various plumbing, fire alarm and/or sprinklers.

5.2.1. Equipment

The cost of the equipment supplied by Charles Equipment Company (www.charlesequipment.com) was approximately $1,800,000 (Table 7). It was sold as a package to Morse Electric Company, the project engineers.

Table 7: CHP Equipment Supplied by Charles Equipment Company

CHP EQUIPMENT SUPPLIED BY CHARLES EQUIPMENT COMPANY	
Quantity	**Equipment**
4	800 kW Waukesha Enginators Model VHP5200GL
4	Beaird Heat Recovery Silencers
4	Beaird Exhaust Silencers
4	Fisher 3” Pneumatic Back Pressure Valves with Controls
1	Fisher 6” Pneumatic Excess Steam Valve with Controls
1	Bell & Gossett Shell & Tube Heat Exchanger (excess steam condensing)
2	Amercool Model 1F16-104-1 Horizontal Core Round Tube Radiators (cooling coolant in excess steam condensing heat exchanger)
4	GTI Model HB40Q20-3Pass Horizontal Core Radiators (engine intercooler and lube oil cooling circuits)
1	Set of Redco Switchgear & Engine Controls (parallel between engines and utility)

5.2.2. Absorption Chiller Cost

The cost of the 500 ton York Millenium Absorption chiller, installed in April 1999 was $474,461.

5.3. Annual Costs

5.3.1. Operating Costs

5.3.1.1. Electrical Costs

Actual electric bills were used to calculate the electric costs for the CHP Plant. The applicable rates and riders specified in the ComEd tariff book, “ComEd Tariffs”, in effect for Elgin Community College are as follows:

- Rate 6, General Service – Time-of-Day, which defines monthly, demand and energy charges for a delivery with maximum demand established during on-peak period under 1,000 kW;
- Rate 6L, Large General Service – Time-of-Day, which defines monthly, demand and energy charges for a delivery with maximum demand established during on-peak over 1,000 kW;
- Rate 18, Stand By Service – This rate is applicable to any customer who has installed their own electric generating facility (or uses the output of a third party company) and/or uses ComEd’s electric service as a standby, reserve or auxiliary service;
- Rider 6, Optional/Non-Standard Facility;
- Rider 7, Meter Lease;

5.3.1.2. Fuel Costs

The fuel costs for Elgin Community College case study were calculated from the local gas utility Nicor Gas Company's monthly utility bills. The contracted monthly price of natural gas for the case study year was approximately 46¢ per therm prior to variable commodity charges and delivery utility charges. After variable commodity charges and delivery utility charges, the average price of natural gas delivered to the college was 52¢ per therm used. The latter price was the price used in the calculations for the case study. This price of 52¢ per therm was used in the Baseline Plant calculations. The following year through June 2003, the Elgin Community College's contracted price of natural gas is 31¢ per therm. The CHP Plant operates from 9 AM to 10 PM weekdays (excluding holidays) unless gas prices rise above 43¢ per therm (contracted amount). If gas prices rise above this amount, the schedule of operation is adjusted to achieve optimal economic savings with high gas prices.

The price of natural gas can vary from time to time affecting the operating costs of natural gas using equipment and their savings. The gas price sensitivity was taken into account comparing the CHP Plant and the Baseline Plant and the change in savings shown in Table 8. As seen, even when gas prices do spike and become high, savings are still realized while operating a CHP Plant over a Baseline Plant.

Table 8: ECC Natural Gas Sensitivity of Annual Operating Savings

ECC ANNUAL SAVINGS - GAS PRICE SENSITIVITY			
Natural Gas Average Price (¢/therm)	Annual Savings		Monthly Savings
30	40%	$527,154	$43,930
35	37%	$507,488	$42,291
40	34%	$487,797	$40,650
45	32%	$468,106	$39,009
50	29%	$448,414	$37,368
52	**28%**	**$440,023**	**$36,669**
55	27%	$428,723	$35,727
60	25%	$409,032	$34,086
65	23%	$389,341	$32,445
70	22%	$369,650	$30,804
80	18%	$330,268	$27,515

5.3.1.3. Operator Costs

Because the CHP Plant and the Baseline Plant operate the same equipment with the exception of the generators and the heat recovery equipment, only the maintenance and overhauls of the specific CHP equipment was taken into account. A standard number in the industry of 1.2¢ per kilowatt generated was assumed in the maintenance calculations (Table 9). The additional maintenance cost of the CHP Plant compared to the Baseline Plant during the case study year is $79,050 annually and $6,588 monthly.

Table 9: Operating Savings with CHP Plant installed at ECC

OPERATING SAVINGS				
	Utility and O&M Costs		**Annual Energy Consumption**	
Item	**Baseline**	**CHP**	**Baseline**	**CHP**
Electricity				
Utility Electricity	$989,285	$264,910	13,678,806 kWh	7,091,296 kWh
Generated Electric	---	---	---	6,587,510 kWh
			Total	13,678,806 kWh
Natural Gas				
Boilers	$538,462	$371,849	1,025,317 therms	708,060 therms
Engines	---	$373,435	---	711,080 therms
Total	$539,981	$745,284	1,025,317 therms	1,419,139 therms
Maintenance (1.2¢/kWh)	---	$79,050		
Total	$1,529,267	$1,089,244		
Annual Savings		**$440,023**		

5.3.2. Total Costs

The total monthly operating costs of the CHP and Baseline Plants can be noted in Figure 18. The graphs depict the rise in operating costs during the summer due to high electric demands of cooling. This is more apparent for the Baseline Case. The total yearly operating expenses for the CHP and Baseline Plants are respectively $1,112,756 and $1,552,778 at 52¢/therm during the case study year of July 2001 to June 2002. The total annual savings realized by the CHP Plant versus the Baseline Plant is $440,023.

Table 10 breaks down the cost of electricity on a rate of ¢ per kilowatt-hour used by the facility. The Baseline Case takes into account only the electric costs charged by the electric utility while the CHP Case needs to also factor in the additional cost of maintenance of the engines and of natural gas to operate the engines to generate electricity. The on-peak average cost of electricity is much greater than the off-peak cost of electricity in all cases due to the electric rate structure as well due to the higher summer costs over the winter costs. The CHP Plant averaged on-peak savings of 4.64¢/kWh during the Case Study Year.

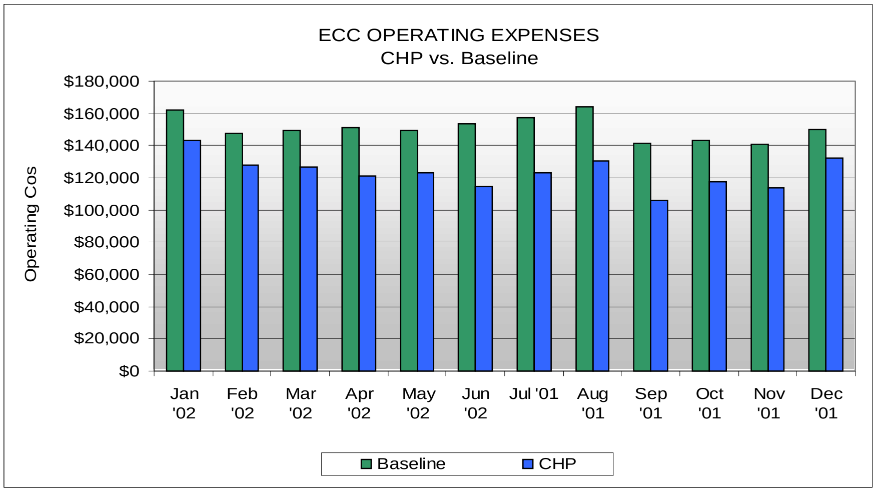

Figure 18: ECC Operating Expenses - CHP vs Baseline

Table 10: ECC Average Cost of Electricity - CHP vs Baseline

AVERAGE COST OF ELECTRICITY (¢/kWh)			
	Yearly	Summer	Winter
Baseline	7.22	7.81	6.91
On-Peak	12.09	13.05	11.61
Off-Peak	2.33	2.33	2.34
CHP	5.19	5.10	5.24
On-Peak	7.45	7.16	7.59
Off-Peak	2.95	2.94	2.96

6. Financial Considerations

The Elgin Community College CHP Plant experienced a payback between 6 and 7 years. A great benefit to Elgin Community College was the funding provided to ECC and the low cost ECC actually had to contribute to the purchase and installation of the CHP Plant equipment and installation. The investment of the CHP Plant was an excellent financial decision on the behalf of ECC, realizing the exceptional savings and payback period. (The total CHP installation cost provided in this case study, does not reflect the cost of the absorption chiller that was purchased and installed later in April of 1999.)

6.1. Actual Payback Period of Total CHP Cost

When first installed, the CHP Plant realized operating savings between $360,000 and $400,000 annually. The payback period on the total cost of the CHP Plant project would have been between 6.25 and 7 years.

6.2. Actual Payback Period of ECC Cost of CHP

The payback on the CHP Plant for Elgin Community College was realized in 4 years. This was due to the fact that ECC only needed to pay $1.5 million of the $2.5 million for the CHP Plant because of previous credits and outside funding (for more detail see Section 10.2). As noted in Section 10.2, if the percentage of the total $15.8 million project cost had been accounted for, then the CHP Plant would actually have been paid off in only 2 years. The CHP Plant was then basically paid off in no time at all compared to other CHP projects.

6.3. Calculated Payback Period

The CHP Plant realized an annual operating savings of $439,966 for the case study year. A simple payback calculated on the total $2.5 million installed cost of the CHP Plant, with the case study savings, would have resulted in 5.7 years. The savings during the case study year were greater than first estimated when the CHP Plant was installed.

6.4. Internal Rate of Return

An Internal Rate of Return of 17.0% was calculated for the Elgin Community College CHP Plant over a 20-year life period for the equipment. The maintenance costs of $79,050 were broken down over the 20-year period including major overhauls every 5 years.

7. Operability Analysis

Not only from a financial point of view, but also operationally, the CHP Plant has served Elgin Community College efficiently and reliably. The increased energy efficiency and increased reliability of supplied power and the quality of power to the campus has been an excellent example of cogeneration practices. And even with the increased maintenance time and costs, the CHP Plant still is able to be a benefit to ECC.

7.1. Efficiency

With the addition of heat recovery, the engines increased their generator efficiency from 32% to 67%, comparing the amount of energy going in to the amount of usable energy. The ECC staff also takes regular inventory and status of equipment and operates maintenance at regular intervals making sure their equipment is always working efficiently. Staff from Charles Equipment Company provides maintenance service regularly to the CHP Plant.

7.2. Reliability

Generating their own electricity, the reliability of providing energy to their facility is greatly increased over the standard power plants. By not relying on the grid for all their power, the college is able to remain unaffected by the occasional blackouts and brownouts suffered each year.

The college, also a FEMA shelter, is not only able to provide shelter but can provide energy to the community of Elgin in case of an emergency where no electricity would be provided. These reliability factors provide great assistance and a sense of surety and safety to the community.

7.3. Downtime

There are minimal times when the CHP Plant is shut down for maintenance and repairs during the year. The ECC CHP Plant has never had significant downtimes in its 5+ years of operation since 1997. Only once, one engine had some major repairs, but the CHP Plant was still in operation with three engines handling the load.

During the summer, the Elgin Community College campus is shut down 10 Fridays beginning at 11 PM on Thursdays. The only buildings that might be used on these Fridays is the Business Conference

Center and the Theater, if they are rented out. Even though the campus is closed on the Fridays, the CHP Plant stays in operation on these days, as the Building Engineer's contract is Monday through Friday. Maintenance on these Fridays is optimal with a less demanding electric load due to minimal occupation of the campus.

One of the regularly scheduled maintenance activities of the CHP Plant includes changing the oil of the Bronsky oil tanks every 10 weeks (every 720 hours). The two 500 gallon oil tanks, one tank for new oil and one for old oil, were designed by Broncosky Oil to function with the Waukesha engines using the pumps shown in Figure 20.

Figure 19: Broncosky Oil Tank

Figure 20: Engine Crankcase Oil Pump for oil changes

8. Installation Analysis

The time of installation for the CHP Plant was approximately nine months from beginning of installation to completion and operation. At that time the college was not as large as it is today, nor did the CHP Plant provide power, heating and cooling to as much of the campus as it does today. Two factors contributed to the delay of installation of the CHP Plant. Firstly, the delay was due to problems with the piping contractor and second, a faulty battery charger fried all 120-volt relays that took 70 days to receive new relays. The Capital Development Board later rewarded the contractor with $45,000 change order for installation of the Waukesha engines in lieu of another manufacturer's equipment. Also, during installation, problems with exhaust air resulted with two revisions to the building exhaust stacks.

As shown in Table 11, there was a delay in bringing cogeneration to the college. The initial attempt in 1991, presented a weak case to incorporate cogeneration to the campus as explained in Section 10.3.2. The concept was then reintroduced and acted upon with a feasibility study in 1993. After the CHP Plant design was completed, the bids opened up and were awarded in October of 1995. The installation began in the fall of 1996 and completed in May of 1997.

Table 11: ECC CHP Project Timeline

Project Timeline	
Initial Attempt Denied	1991
Feasibility Study	Nov 1993
Bid Awarded	Oct 1995
Contractor Began	July 1996
Installation Started	Fall 1996
Installation Completed	May 1997

9. Environmental Considerations

Elgin Community College has an allowance of 35.93 tons per year of annual emissions. The college has experienced emissions significantly under their permitted allowance, producing a total of 4.106 tons per year of annual emissions. Generating their own electricity on-site, the emissions are lower compared to coal or other such power generating plants that would normally provide electricity to the college.

Table 12: Annual Emissions of ECC CHP Equipment

Annual Emissions		
	CHP Plant	**Baseline**
NO_x	2.0 tons/yr	tons/yr
SO_x	0.012 tons/yr	tons/yr
CO_2	0 tons/yr	tons/yr
CO	1.68 tons/yr	tons/yr
Total	**4.106 tons/yr**	**tons/yr**

10. Miscellaneous/Lessons Learned/Future

The completion of the CHP Plant at Elgin Community College did not arrive hassle free. Regulatory issues had to be overcome from the electric utility, certain guidelines had to be followed and fees paid. Additional equipment had to be purchased and installed to handle the new equipment. The project funding is explained in greater detail below. The future of cogeneration looks bright at Elgin Community College. The staff plans to install additional cogenerating equipment on the campus within the next couple of years.

10.1. Operations Budget

The total main campus budget for Elgin Community College in the year 2003 is $4,957,775 based on a tax rate of $0.0694. The operations budget for the main campus totals $764,510 on a tax rate of $0.0142. The CHP Plant has helped keep the operating expenses below the operations budget.

10.2. Project Funding

A classroom and lab addition project was in the plans at ECC totaling $15.8 million. Bids came in under the allowable budget for the classroom/lab addition and the $2.5 million CHP Plant was considered using the remaining money available from this budget.

Typically, Illinois community colleges are required to contribute 25% towards a state funded project. The Illinois Community College Board (ICCB - *www.iccb.state.il.us*) supports the remaining 75% of project costs for community colleges. Under normal circumstances, the contribution by ECC would have been near $4 million but ECC had credits (leftover cash) of $2.5 million from previous projects. These credits could be used towards this project to reduce the ECC's funding contribution as shown in Table 13.

The final cost for the lab and classroom additions and the CHP Plant for Elgin Community College came to only $1.5 million. Local funding mainly through local taxes paid for this amount.

Table 13: ECC CHP Project Cost and Funding

PROJECT COST AND FUNDING	
Project Cost	
Classroom/Lab Addition	$13.3 M
CHP System	$2.5 M
Total	**$15.8 M**
Project Funding	
Funding by ICCB (75%)	$11.8 M
Credits from Previous Projects	$2.5 M
ECC Local Funding/Contribution	$1.5 M
Total	**$15.8 M**

In almost two years, ECC had already saved the cogeneration portion of the local funding contribution and anticipated saving the total local contribution for the entire project in four years. By not having to contribute any additional funds for the cogeneration project due to bidding savings on the original project, ECC felt they received the cogeneration system for free.

10.2.1. Initial Attempt at Cogeneration

In 1991, Elgin Community College made a failed attempt to build a stand-alone cogeneration building using local funds. The payback, including the cost of the interest on the funds, was projected at over 5 years. The Board of Trustees rejected this project, deciding it was not acceptable.

10.2.2. Classroom and Lab Addition

In 1989, ECC approached the Illinois Community College Board (ICCB) to build a new classroom building. The Illinois Board of Higher Education (IBHE) funded this project in the fiscal year 1992. The Facilities Management Office quickly requested cogeneration equipment for the project. By the fiscal year 1996 (July 1995), the cogeneration project was at the top of the IBHE funding list with a budget of $2,174,300. However, the project was not funded by the legislature that year.

10.2.3. Cogeneration Requested

A classroom and lab addition project was in the plans at ECC. The bids came in well under the allowable budget of the proposed plan. As a result, cogeneration was considered with the excess amount available for the project. The entire project at ECC, including the classroom addition, the lab addition and the CHP system, totaled $15.8 million. Along with the classroom and lab additions that were bid in December 1994, ECC requested that a cogeneration study be performed. In November 1993 a feasibility study was performed for the college in which a four 800 kWe engine system was recommended to provide demand and peak-shaving electrical cost savings.

The classroom and lab addition project was designed with a second floor shell space for a future cogeneration system above the new loading dock. A new cooling tower for a future chiller and roof penetrations for the cogeneration system were also added on to the roof above this shell space.

10.2.4. Bids and Costs

Bids for this project came in under the budget for the new classroom and lab addition at a surprising savings of $2.7 million. ECC requested that the savings be used toward the cogeneration project with three 800 kW engines and an alternate for a fourth engine and room for a fifth.

This was the first cogeneration project ever funded by the IBHE for a community college and the first Capital Development Board (CDB) cogeneration project. KJWW designed the project around a Caterpillar system but as is the general rule with public projects funded by the state and run by the CDB, single sourcing is not allowed and Waukesha was approved as an equal.

The bid was let in October 1995. Morse Electric Company was the low electrical prime contractor and Waukesha, through their local representative, Charles Equipment Company, won the bid.

10.2.5. CHP Project Retrospect

In retrospect, ECC would have liked to proceed like they did for their last chiller bid package. On that project ECC bid to several manufacturers and awarded the equipment package for manufacturing. In a cogeneration system like ECC's, while the engines and switchgear are in production, the engineer could draw up the plans for the specific engine package. Unfortunately, due to the original funding scenario, ECC was under the requirement to build the shell space first and then they were to purchase the cogeneration system much later as funding became available. ECC was fortunate in that they were able to change the structure and roof penetrations with very little cost.

10.3. Lessons Learned

10.3.1. Renting vs. Purchasing Transformers

The issue of renting verses purchasing the transformers became an issue, but was quickly resolved. The members at Elgin Community College decided to rent the transformers from ComEd, particularly due to the responsibility of possibly having to quickly replace a blown or malfunctioning transformer in the future. Hypothetically, if ECC were to own their own transformers and one would malfunction or break down, the college would be trapped into finding and purchasing a replacement. Renting through ComEd enables ECC not to worry in case a transformer malfunctions because ComEd would have to replace their rented equipment and has more ready access to transformer than ECC.

10.4. Future

Elgin Community College plans to install an 800-ton Trane absorption chiller in the later part of the fiscal year 2002 to cover over 50% of the campus' cooling needs through absorption cooling. The cost of the new Trane 800 ton absorption chiller with a new cooling will be $784,000 plus architect engineering fees of approximately $50,000. At this time, the 25-year-old Trane absorption chiller will be demolished and removed.

ECC is also looking to install another 805 kWe Waukesha engine as well in the near future. This would provide greater reliability in the case of an engine break down or maintenance when one is down for repairs leaving the remaining engines to cover the electric demand. When installing the four original engines, ECC designated space for a fifth engine in the engine room. This insight will lower the total installed cost of installation for the additional engine generator. The additional engine will also enable the CHP Plant to cover the entire electric load of Elgin Community College.

10.5. Business Practices

Key individuals and corporations involved with installation and servicing of the CHP Plant include the following:

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