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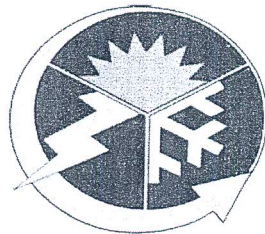
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Laclede Gas Building

Site Report for CHP Applications

Midwest Regional Application Center
CHP for Buildings

Case Study MAC #2003-001



MIDWEST
CHP
APPLICATION
CENTER

September 2003

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Case Study *Separate Folio Document*

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1. Site Description



Figure 1: The LaCledde Gas Building

1.1 General

The LaCledde Gas Building is a 31 floor high-rise office building located downtown Saint Louis, Missouri. The building is named after its major tenant, the LaCledde Gas Company. The LaCledde Gas Company is a public utility, engaged in the storage and distribution of natural gas in the Saint Louis area and the surrounding counties. The building itself, however, is owned and managed by Stirling Properties, a nationally operating real estate firm.

The LaCledde Gas Building (LGB) was constructed in the late 1960's. The power plant in the building with the CHP facility at its core is part of the original building design. The power plant serves **all** of the building's electricity, heating, hot water, and cooling requirements.

The plant started commercial operation in 1969 and since then has achieved a remarkable reliability record. In fact there have been no major power outages within the building since 1980.

1.2 Site Location

The LaCledde Gas Building is located at 720 Olive Street in Saint Louis, Missouri. This address is in the heart of the downtown office district and about 1500 feet from the Saint Louis Gateway Arch landmark.

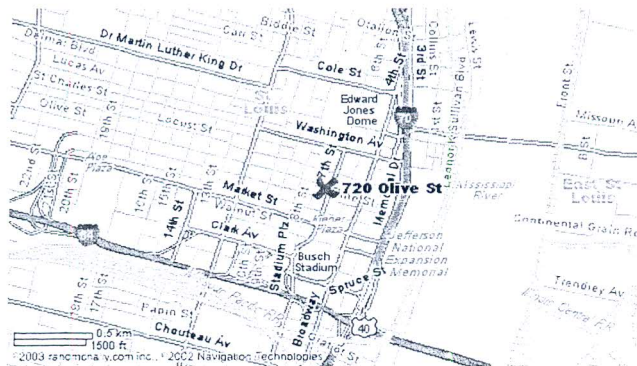


Figure 2: Location of LaCledde Gas Building

1.3 Site Characteristics

The plant serves a total of 500,000 square feet of floor space located across 30 floors, the 31st floor houses the HVAC equipment. The plant operates in a stand-alone mode, which means it is *NOT* interconnected to the local electricity provider, Ameren UE. Backup power is provided by the multi-unit configuration of the power plant. The primary fuel for the power plant is natural gas, which is purchased from CenterPoint Energy Gas Marketing and distributed to the building by Laclede Gas Company.

The Laclede Gas Building has a relatively high occupancy load factor due to extended operating hours during the week. The load factor, however, drops significantly on weekends. There have been no significant additions to the building since its construction. However, around 1990 one major tenant reduced the size of its computer room from 8,000 sqf to 4,000 sqf, thus reducing the heating and cooling requirements from the plant.

2. Market Segment Evaluation

Offices with extended operating hours, such as the Laclede Gas Building, provide generally a good fit for CHP systems.

Because of the cold winters and hot summers in Saint Louis, it is regionally well suited for BCHP 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 Configuration

The energy system at LGB consists of six ebullient cooled engines with heat recovery units, one absorption chiller, two mechanical chillers, and two additional boilers. The power plant was configured with the building and started operation in 1969. Since then two engines have essentially been replaced; the other four engines received parts replacements in accordance with the maintenance schedule.

The BCHP system runs 24 hours per day, 365 days a year. During on-peak hours, 4 or 5 engines are normally operated to meet the building's heating, cooling, and hot water needs, while three engines are sufficient to service the building during off hours. The load-factor on the engines varies between 75% and 90% in order to achieve the maximum efficiency on the system. Engine use is rotated to assure homogenous wear and tear on the equipment.

3.2 CHP System Design

Ross and Baruzzini, Inc. was responsible for the design and engineering of the power plant. Ross and Baruzzini, Inc. was founded in 1953 and is headquartered in St. Louis, with additional offices in Illinois and Florida. The company specializes in professional engineering as well as architectural and project management.

3.2.1 Electrical Parameters

3.2.1.1 Overview

The CHP system at Laclede runs 24 hours per day and 7 days a week. Electricity generated by the electric generation prime movers meets all of the electric demand of the building; this is critical since

the building is a stand-alone electric generation facility, it is not interconnect to the local electrical distribution system. As such, the power plant does not provide any electricity for resale to third parties.

3.2.1.2 Electric Generation Prime Mover

The prime movers employed at the LGB power plant are as follows:

- 4 Waukesha VHP engine-generators rated at 800 kW/1200 rpm (VHP is an internal Waukesha engine designation).
- 2 Waukesha VHP engine-generators rated at 550 kW/ 900 rpm

Since the original installation, the engines have been significantly upgraded. The upgrades include solid state ignitors, solid state speed switches, upgrade carburetors, and starters.

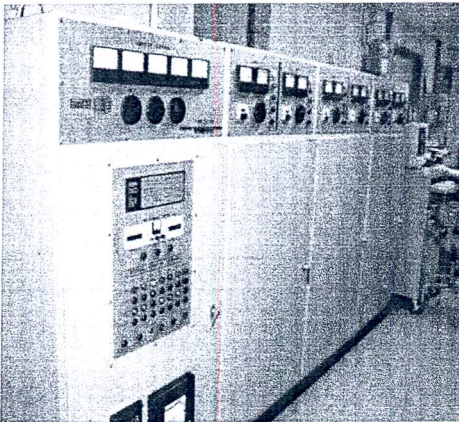


Figure 3: Waukesha Engine Control Panels Figure 4: Single Waukesha Engine

3.2.1.2.1 Generator (Type/Size)

The generators are manufactured by Electric Machinery Company, Inc. There are 4-1000 kWe generators and 2- 687.5 kWe generators. All generators are single-bearing, brush-less, and synchronous type generators.

3.2.1.2.2 Fuel Type

The Waukesha engines operate on 900 Btu/ft² minimum of commercial quality natural gas at 25 psig.

3.2.1.3 Backup/Standby Power

The power plant is operated in a completely islanded condition with no backup (other than redundancy built into the CHP system) or standby power supply arrangements in place.

3.2.1.4 Grid Supply

The power plant is completely islanded with no grid electric supply arrangements in place.

3.2.1.5 Interconnection Requirements

None, the power plant is completely islanded without interconnection to the local electricity grid.

3.2.2 Fuel Supply Description

The fuel for the power plant is natural gas; there is no secondary fuel source. The natural gas commodity is purchased from CenterPoint Energy Gas Marketing. Firm transportation is purchased from Laclede Gas Company.

3.2.3 Thermal Recovery Systems

3.2.3.1 Heating and Hot Water

The engines utilize an ebullient cooling system. The heat from the engines is being recovered using Killibrew Entelecon Heat Recovery Units rated as follows:

- 2 units are rated at 3,200 pounds of low-pressure steam per hour.
- 4 units are rated at 4,700 pounds of low-pressure steam per hour.

3.2.3.2 Cooling

Low pressure steam is also directed to a 1050-ton absorption chiller manufactured by York. The unit is rated at 18,000 pounds per hour.

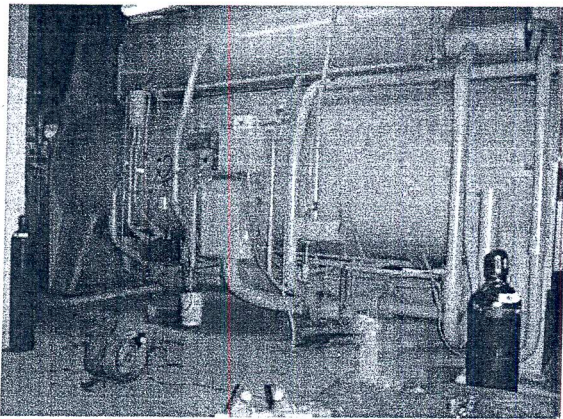


Figure 5: York Absorption Chiller

3.2.4 Non-Recovery Thermal Systems

Non-recovery thermal systems consist of the following equipment:

- 2 boilers rated at 200 horsepower each.
- 2 natural gas engine driven chillers rated at 350 tons each and manufactured by York.
- Plant heat is rejected through two Marley lube oil cooling towers located on the roof of the building.

3.2.5 Plant Equipment Location

Figure 6 below summarizes the location of the plant equipment within the building.

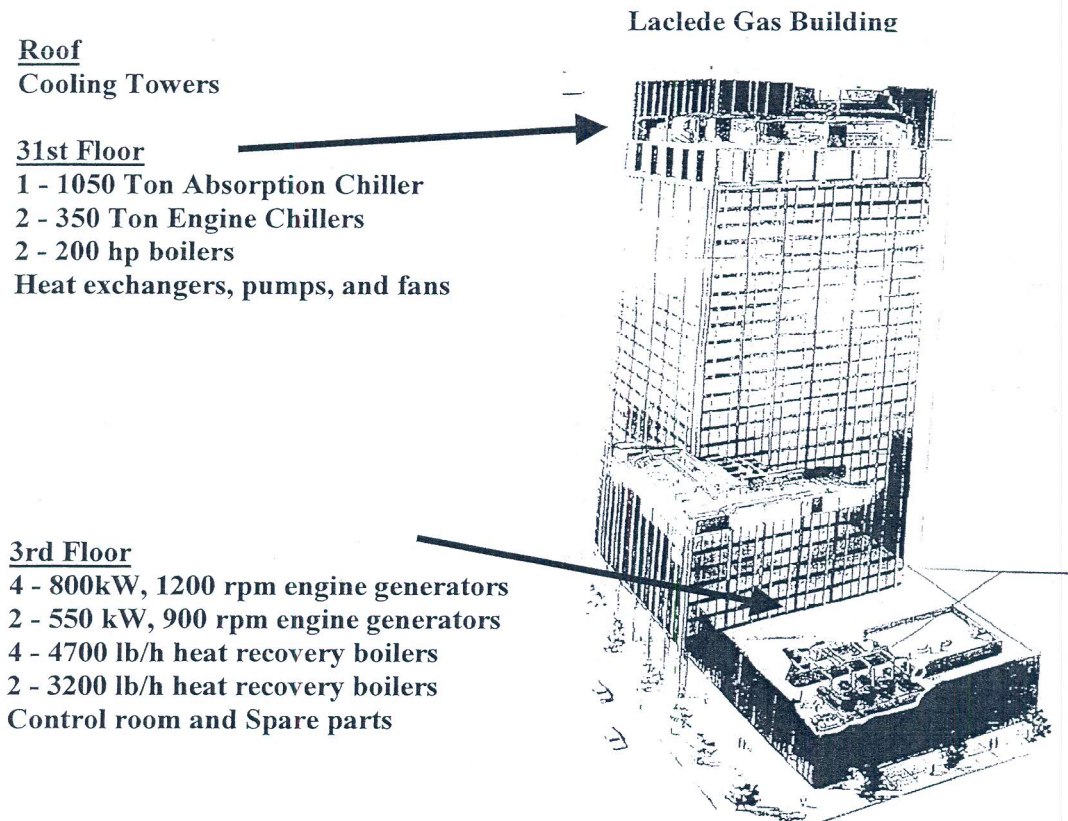


Figure 6: Location of power plant equipment

3.3 Baseline System Configuration

The case study compares the operation of the Laclede Gas Building power plant, referred to as the CHP Plant, for the year starting July 2002 to June 2003, against an energy supply from local utility companies that can be considered the more conventional alternative, which will be referred to as the Baseline Plant.

The electric energy generated from the engine-generators of the CHP Plant is assumed to be replaced by electricity from the local utility, Ameren Union Electric Company under Large General Service Rate for the Baseline Plant. Additional fuel provided to the boilers will compensate for the loss of the recovered thermal energy from the engine-generators. Conservatively, fuel prices are assumed to be the same for both the CHP Plant and the Baseline Plant.

4. Energy Analysis of the CHP Plant

4.1 General

During the case study year, July 2002 to June 2003, the Laclede CHP Plant consumed 1,797,710 therms of natural gas and generated 12,868,233 kWh of electricity. The CHP plant recovered 657,750 therms of energy, which resulted in a total efficiency of 68%. Without heat recovery the efficiency of the system would have been 27% (gross efficiency, includes auxiliary power generation). These efficiency figures are conservative calculations; due to measurability difficulties these efficiency figures do not include steam that is being diverted to heat the building's lobby, which would increase the overall system efficiencies.

4.2 Electrical Parameters

Total electricity generation during the case study year July 2002 through June 2003 was 12,868,233 kWh. Electricity generation peaked during July and August at approximately 1,300,000 kWh based on the high cooling needs of the building. Electricity generation is about 30% less in the winter month of February with approximately 900,000 kWh of generated electricity. Higher electricity generation during the summer months is primarily due to higher electricity demand from the cooling tower fans, chilled water pumps, and the air handling units.

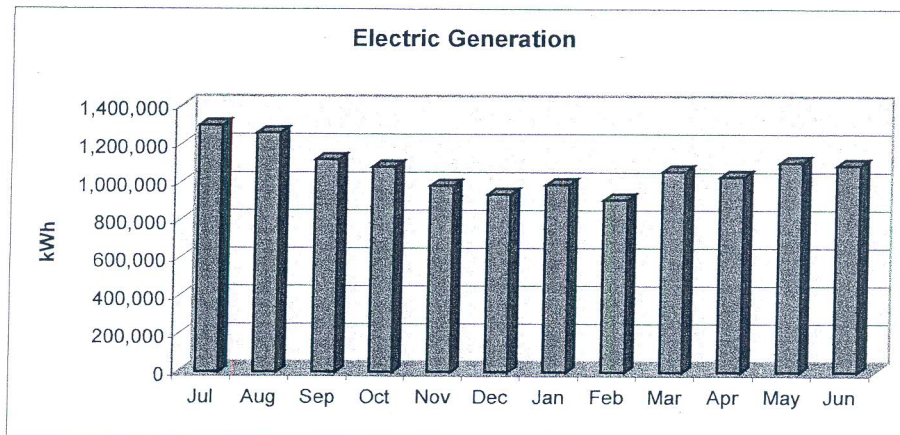


Figure 7: Annual Electric Usage

4.3 Thermal Requirements

4.3.1 Thermal Loads

It is estimated that a total of 657,750 therms of thermal energy are being recovered on an annual basis from the engines of the CHP Plant.

4.4 Fuel Usage

Total fuel usage during the case study year, July 2002 through June 2003, was 1,797,710 therms of natural gas. Consistent with electricity generation and operation of the engine driven chillers, natural gas usage peaked during July and August at approximately 200,000 therms (HHV) based on the high cooling needs of the building. Also consistent with electricity generation, natural gas usage was less

during the winter months with 30% less gas usage in the winter month of February compared to the July peak.

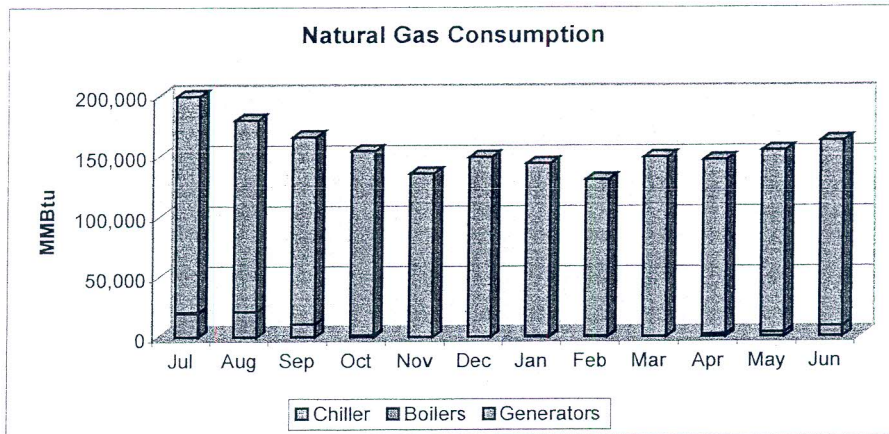


Figure 8: Annual Fuel Usage

5. Financial Analysis (Baseline Plant versus CHP Plant)

5.1 CHP Project Cost

The major equipment of the CHP Plant was installed in 1969. This means that in financial terms, which look at the most at 20-year investment horizons, this equipment would be considered "past its useful life." In addition, the initial costs, financing, and energy costs in relationship to present terms for a system with similar capabilities would have no readily ascertainable correlation. Taking these factors into consideration, an analysis of the original capital cost will not be performed, but instead will focus on the more relevant annual operating and maintenance costs associated with a system of this age.

5.2 Annual Costs

5.2.1 Operating Costs

5.2.1.1 Electrical Costs

CHP Plant

Since the CHP Plant is not connected to the incumbent utility company, Ameren Union Electric, there are no stand-by or backup-power costs incurred by the facility.

Baseline Plant

A detailed estimated bill for the Baseline Case was developed in accordance with the rates and riders specified in the Ameren Union Electric Service Classification No. 3 (M) Large General Service Rate. The applied rates are listed in Table 5-1. The month-by-month blended electricity rate estimations are shown in Figure 9.

Table 5-1 Applied Electric Rates

	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	2002	2002	2002	2002	2002	2002	2003	2003	2003	2003	2003	2003
Customer Charge (\$)	66	66	66	66	66	66	66	66	66	66	66	66
Energy Charge for first 150 kWh per kW demand (cents)	7.64	7.64	7.64	4.78	4.78	4.78	4.78	4.78	4.78	4.71	4.71	7.52
Energy Charge for next 200 kWh per kW demand (cents)	5.76	5.76	5.76	3.58	3.58	3.58	3.58	3.58	3.58	3.53	3.53	5.67
Energy Charge over 350 kWh per kW demand (cents)	3.86	3.86	3.86	2.79	2.79	2.79	2.79	2.79	2.79	2.74	2.74	3.80
Energy Charge Seasonal Charge per kW of total demand (cents)				2.79	2.79	2.79	2.79	2.79	2.79	2.74	2.74	
Demand Charge (\$ per kW demand)	3.69	3.69	3.69	1.32	1.32	1.32	1.32	1.32	1.32	1.3	1.3	3.64
Average Electric Rate applied (cents/kWh)	6.45	6.48	6.80	4.12	4.18	4.25	4.23	4.33	4.16	4.18	4.10	6.86

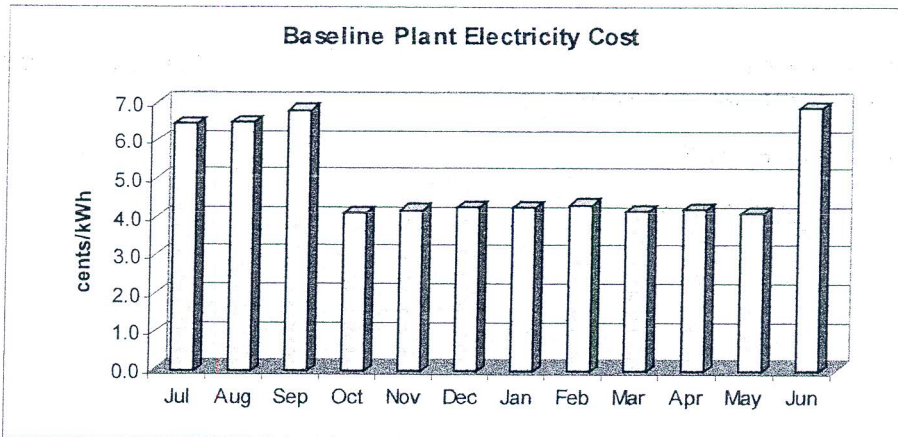


Figure 9: Estimated Blended Electricity Rates for Baseline Plant

The estimated monthly blended electricity rates result in total yearly electrical cost of \$655,696 with an average rate of 5.01¢/kWhr for the Baseline Plant.

5.2.1.2 Fuel Costs

CHP Plant

The CHP Plant purchases its natural gas commodity from CenterPoint Energy Gas Marketing and pays Laclede Gas Company a transport fee to deliver it to the facility. The blended commodity and transportation rates are shown in Figure 10.

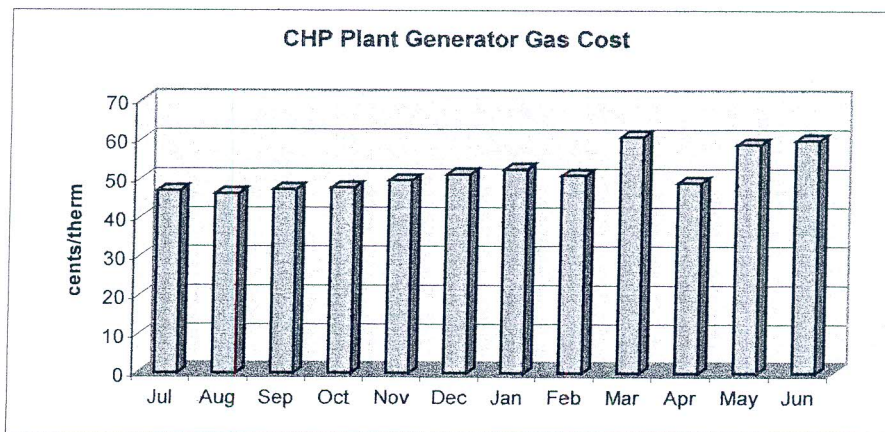


Figure 10: Generator Gas Rates

Baseline Plant

In order to provide the estimated fuel costs for the Baseline Plant, actual monthly expenditures in terms of cost per therm have been applied to the estimated quantities of natural gas that would need to be purchased. These quantities have been evaluated by dividing the thermal energy recovered from the engines boiler efficiency of 80% and multiply the derived number by the blended monthly gas rate.

The estimated yearly natural gas bill for the hypothetical baseline plant to generate the equivalent of the heat recovered with the CHP Plant would be \$424,340.

5.2.1.3 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 CHP equipment specific costs were taken into account. Sterling Properties provided the following figures on CHP equipment specific cost:

Generator maintenance labor was estimated to require approximately 350 person-hours per month. At an average rate of \$24 per hour the total yearly labor cost attributable to generator maintenance were estimated to be \$100,800.

Maintenance parts for the CHP equipment were estimated to total \$15,000 per year, not including engine oil, which was also estimated to cost \$15,000 per year. Finally emissions payment to comply with Missouri emission regulations was estimated to total \$7,000 per year.

5.2.2 Total Costs and Savings

For the CHP Plant, the annual costs are based on the actual monthly expenditures paid by the plant. For the Baseline Plant, estimates have been made for the annual cost of electricity and natural gas as described in the previous section. Annual costs and savings are summarized in Table 5-2.

Table 5-2 Total Annual Costs and Savings

Operating Savings with CHP	Utility and O&M Cost		Annual Energy Consumption	
	Baseline	CHP	Baseline	CHP
Electricity				
Utility Electricity	\$655,696	\$0	12,868,233 kWh	--
Generated Electricity	--	\$0	--	12,868,233 kWh
Natural Gas				
Boilers	\$424,340	\$0	65,775 MMBtu	--
Engine	\$0	\$928,642	--	179,771 MMBtu
Maintenance	\$0	\$137,808		
Total Operating Cost	\$1,080,036	\$1,066,450		
Annual Savings from CHP		\$13,585		

Fuel constitutes the largest cost component. Hence the economics for this CHP Plant depend largely on natural gas prices. The table below shows the annual savings from the CHP Plant at the monthly blended rates given in Section 5.2.1.2, as well as the estimated annual savings assuming a 20% gas price increase, and a 20% gas price decrease from current levels.

Table 5-3 Gas Price Sensitivity

Gas Price Movement	Yearly Savings (\$)
Current Savings	\$13,585
20% Decrease	\$114,446
20% Increase	-\$87,275

Figure 11 shows the above yearly savings on a month-by-month basis. As can be seen the CHP Plant achieves the majority of the total savings during the summer months. This is due to the high level of heat recovery during these months for air conditioning purposes.

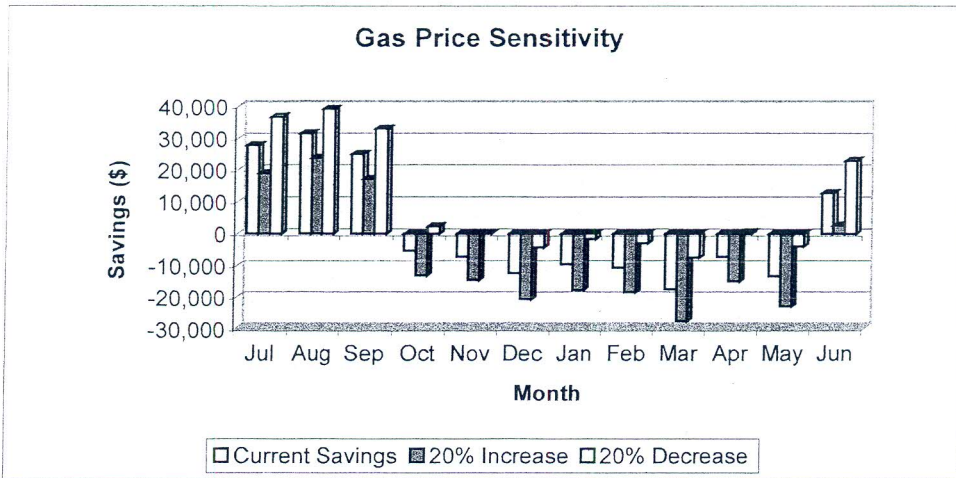


Figure 11: Month-By-Month Gas Price Sensitivity

Table 5-4 and Figure 12 below illustrate the hypothetical savings assuming that all available steam from the generators could also be recovered during the winter months. The resulting savings show that any additional use of the steam during the winter month would provide significant additional savings and hence a hedge against natural gas price increases.

Table 5-4 Additional Steam Recovery

Gas Price Movement	Yearly Savings (\$)
Current Savings	\$13,585
Additional Steam Host	\$99,175

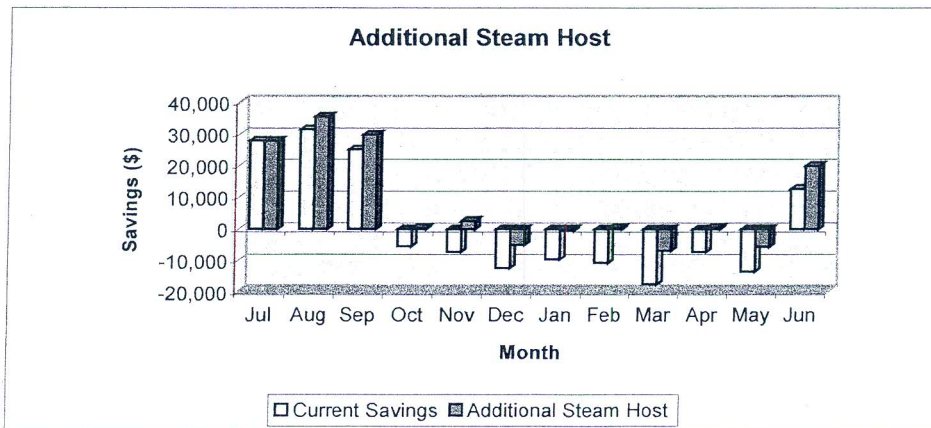


Figure 12: Month-By-Month Additional Steam Recovery

6. Operability Analysis (Baseline versus BCHP)

6.1 Efficiency

With the addition of the heat recovery the overall efficiency of the generators is increased from 27% to 68%. A rigorous preventative maintenance schedule detailed below assures that the overall efficiency of the power plant is maximized.

6.2 Reliability

The CHP Plant has a remarkable reliability record. There has not been an unplanned outage of the system since 1980.

One reason for this reliability record is again the rigorous preventative maintenance schedule applied to servicing the engines. Top end overhauls for each engine are performed between every 20,000 to 25,000 hours of operation, while full engine inspections are performed every 40,000 to 50,000 hours of operation. Particular emphasis is placed on engine oil changes, which are performed based on oil samples every 650 to 1000 hours of operation.

Besides engine overhauls additional tests and inspections are performed as follows:

- A water analysis is performed daily by in-house staff and monthly by a consulting company (GE Betz) to assure proper quality and conductivity. Appendix A shows an example of the monthly report.
- Every 6 months engine controls, generators, heat recovery units, and circuit breakers are inspected.
- Every 6 months a vibration analysis of the chiller compressors is performed.
- Every 12 months a load test of the battery bank is performed. Furthermore, an infrared analysis of the switchgear is performed. As part of this analysis heat sensitive cameras are used to detect unusually hot switchgear components, which may indicate loose or unstable electric connections.
- Every 36 months an Eddy current test of the chiller tubes is performed (a process that tests the thickness of the chiller tube walls in a nondestructive way).

A second reason for this reliability record is plant design, where the six engines provide inherent redundancy; peak loads can generally be served with four or five engines and off-peak loads with three engines. The load factor for each engine is kept between 75 to 90 percent to maximize the efficiency of the engine electrical output. Each engine motor is equipped with its own speed and malfunction controls.

Finally, the staffing of the plant contributes to the reliability of the system. The power plant is staffed Monday through Friday from 5 a.m. through 11 p.m., and on weekends from 6 a.m. through 2 p.m. Outside these times an autodialer system is used to call staff to alert them to off-normal power plant conditions.

7. Installation Analysis

The power plant was part of the original design of the Laclede Gas Building. The building was occupied in 1969; the power plant started operation at the same time.

8. Environmental Considerations

The power plant is operated under an EPA Title V permit, which requires semiannual compliance reports and annual emissions inventory reports. The plant manager contracts with an environmental consultancy company, Burns & McDonnell, to oversee regulatory compliance.

9. Regulatory, Financial, and Lessons Learned

9.1 Regulatory

The power plant was installed in the late 1960s. Therefore, little information is available regarding the regulatory requirements for the installation of the plant. A consulting company has been retained in the past to assure current environmental compliance.

9.2 Financial

As discussed above the power plant is owned and operated by Stirling Properties. Each October the plant manager sets a yearly budget and submits it for corporate approval.

9.3 Lessons Learned

The studied CHP facility has a remarkable reliability record with no major outage during the last 20 years. This shows that a CHP facility can provide long-term, reliable power with positive economics.

The positive economics of this particular facility could be improved further if excess steam available during the winter months could be sold to an additional steam host. A new parking garage and retail space is currently in construction adjacent to the Laclede Building. Stirling Properties is evaluating to serve the energy needs of this new structure from the CHP Plant. This arrangement would provide a good hedge against any natural gas price increases in the future.

Appendix A: Sample Water Report



GE Betz Water and Energy Consulting Report

Company: Laclede Gas Building
 Address: 720 Olive
 St. Louis, MO 63101
 System: Boiler Acct #: 31111

Attn: Mr. Robert Creech
 Copy: Mr. Bill Jalinsky

TESTS	City	Soft	FW	Cond	3	31	1	2	3'	4'	5	6'	N Boiler	S Boiler	CONTROL			
															Soft 0-5	HRU	Con	
Hardness		0.1	0	0 0														
PH	9.4		10.0	8.6 8.5														8.0-8.5
COND(N)	420	444	279	37 33	3250	3660	2950	3606	1748	2915	2260	1130						3000-3500
P Alk								438	550		483	650	655					
OH								321	425		346	560	448					300-600
Sulfite								22	24		15	220	72					20-40
%T								34	37		32	40	41					20-40

SUMMARY & RECOMMENDATIONS

Date: 6/24/03

Softener: Unit is producing approximately 0.1 ppm total hardness.

HRUs: Unit number 5 conductivity is lower than the other units for some reason.

All the remaining HRU units are in very good control. Sulfite, polymer and alkalinity are all within control range, though the sulfite is toward the lower end of the range. As cheap as sulfite is, I recommend operating more toward the middle of the range by increasing sulfite feed slightly. No other changes are required.

Condensate: Conductivity is excellent and no changes are required.

Boilers: The North boiler is well within the wet-layup control range. The South boiler sulfite is lower than we normally operate for an off-line boiler. I suggest increasing the sulfite feed to be greater than 100 ppm of sulfite.

Thank You, Jeff Balleau