

# Integrate a Cogeneration Plant in a University Setting — The Economic Benefits



## Case Study

## University of Illinois at Chicago

(MAC #2001-001 )

**Midwest CHP Application Center**  
**Cooling, Heating, and Power**



**Center for Business Initiatives**  
**June 27, 2002**  
**Chicago, IL**

*Leslie E. Farrar*  
*University of Illinois, Chicago*  
*Energy Resources Center*

# University Of Illinois at Chicago

## Why We Did What We Did ...

To Provide Lower Cost Energy More Efficiently and Reliably to Meet the Needs of a Growing Urban Campus

The Public Research  
University in the Great City  
of Chicago

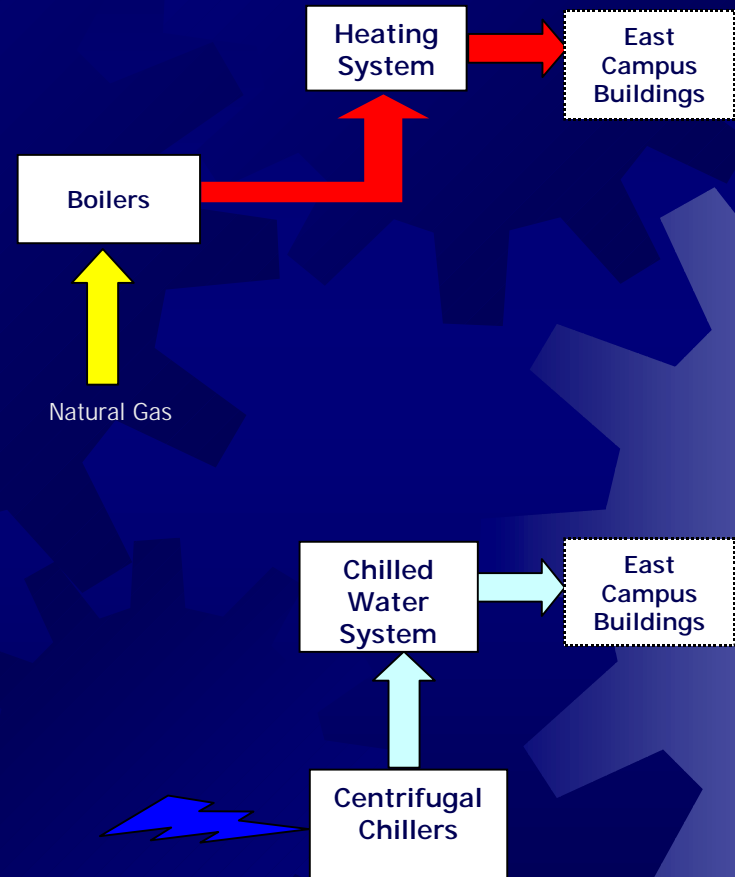


# East Campus

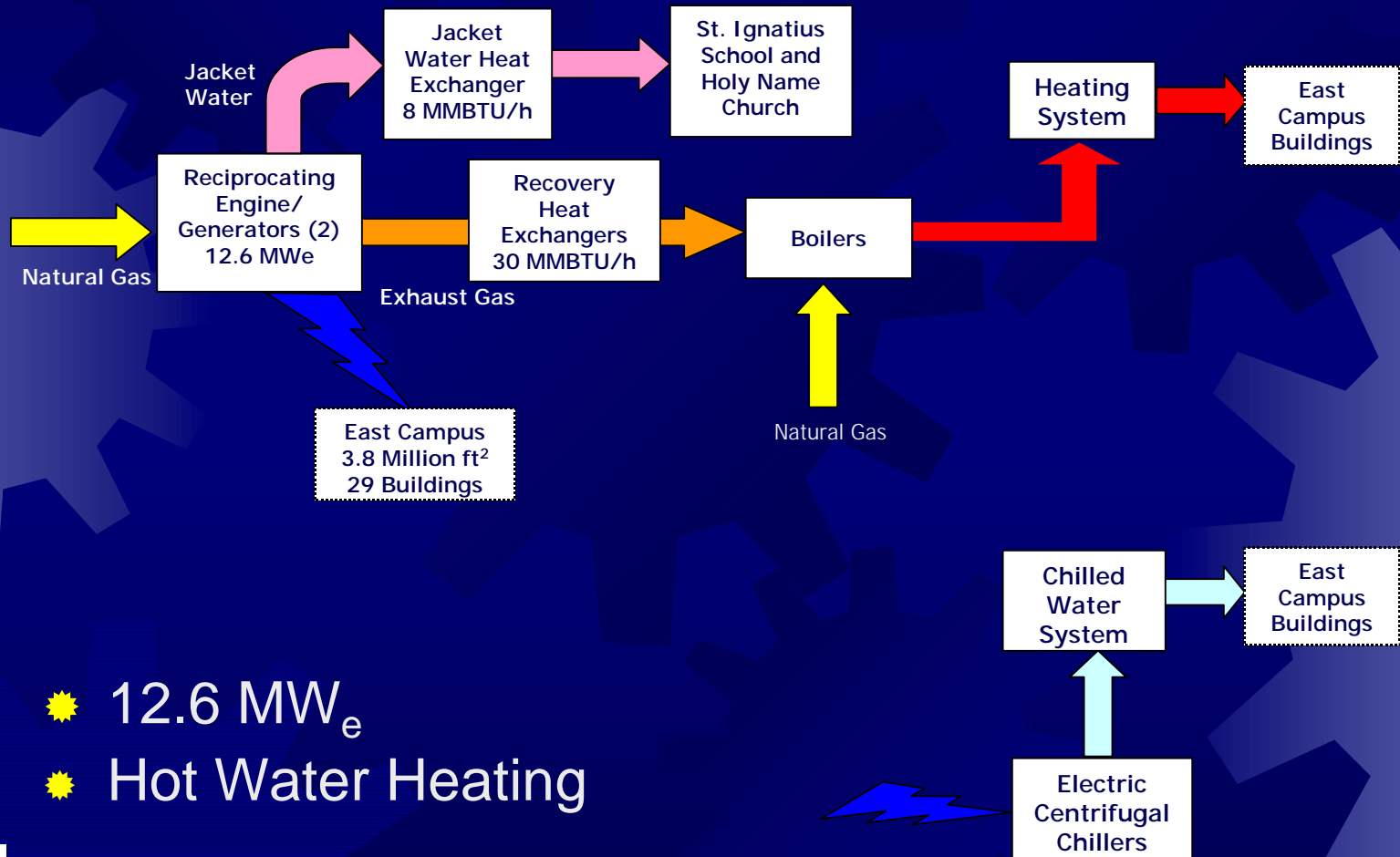


# Site Development – Original East Campus

## Central Heating and Cooling Plant



# Site Development - Cogen East Campus



- 12.6 MW<sub>e</sub>
- Hot Water Heating

# Cooling, Heating and Power Systems East Campus

## Electrical Generation

Reciprocating Engine – Generators

Cooper – Bessemer (Dual Fuel)

2 @ 6.3 MW<sub>e</sub> *each*  
(1993)



# Cooling, Heating and Power Systems East Campus

## Heat Recovery Systems

### Exhaust Gas Systems

Total Recovered Energy of 30 MMBTU/h





# Cooling, Heating and Power Systems East Campus

## Heat Recovery Systems

### Jacket Water Systems

Total Recovered Energy of 8 MMBTU/h





# Cooling, Heating and Power Systems East Campus

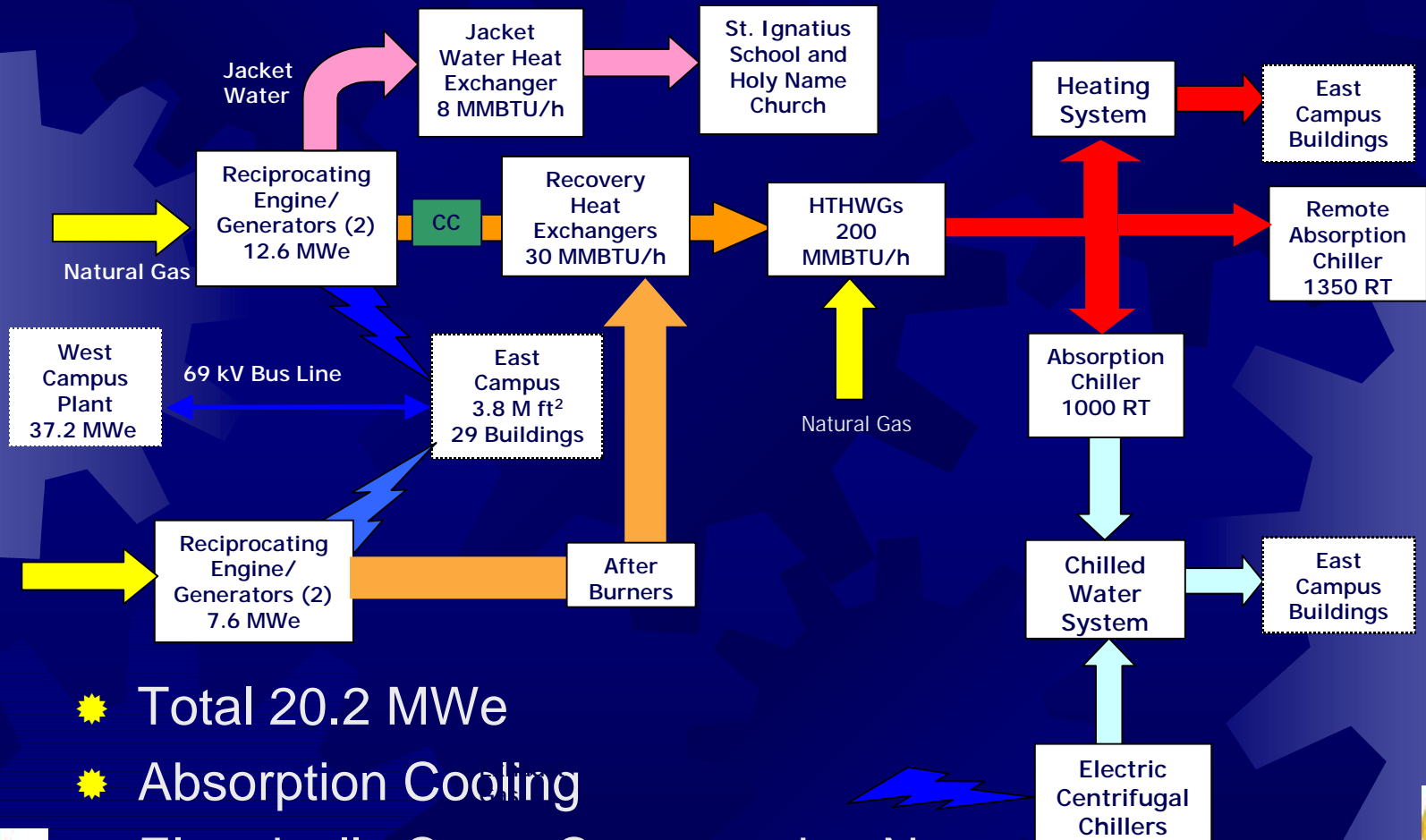
## Electrical Centrifugal Chillers

York International  
3 @ 2000 RT *each*



# Site Development – Today

## East Campus



- ★ Total 20.2 MWe
- ★ Absorption Cooling
- ★ Electrically Cross Connected to New West Campus Facility



# Cooling, Heating and Power Systems East Campus

## Electrical Generation

Reciprocating Engine-Generators

Wärtsilä (Natural Gas)

2 @ 3.8 MW<sub>e</sub> each  
(1999)



# Cooling, Heating and Power Systems East Campus

## Heating Systems

High Temperature Hot Water Generators  
(Natural Gas or #6 Fuel Oil)

2 @ 75 MMBTU/h

1 @ 50 MMBTU/h



# Cooling, Heating and Power Systems East Campus

## Absorption Chillers

Trane Chiller

Two-Stage

1000 RT  
(2001)

*Plus ...*

*Additional 1350 RT*

- *2 @ 500 RT on  
Engineering  
Research Facility*
- *1 @ 350 RT on  
Transportation  
Building*



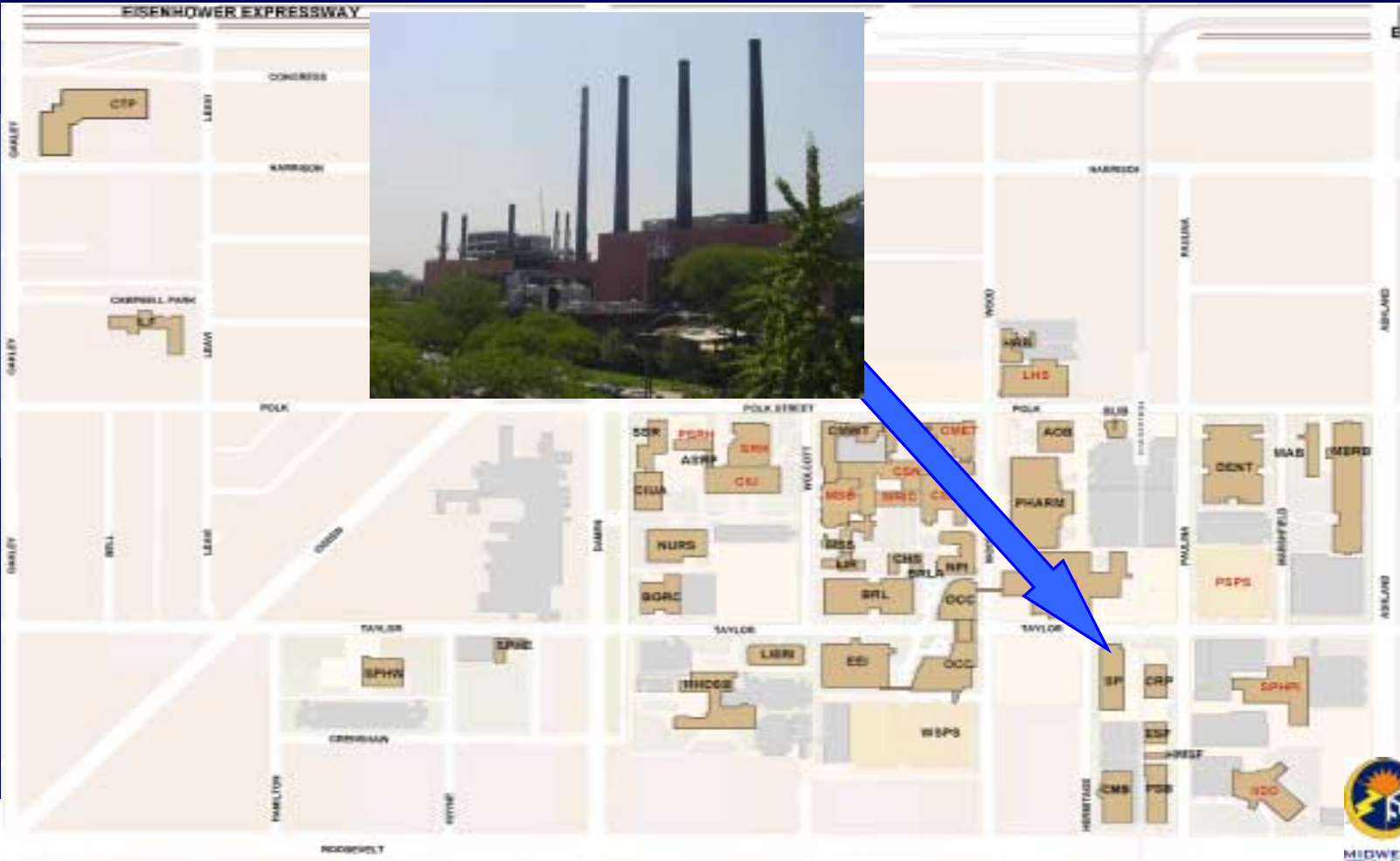
# Cooling, Heating and Power Systems East Campus

## Electrical Substation



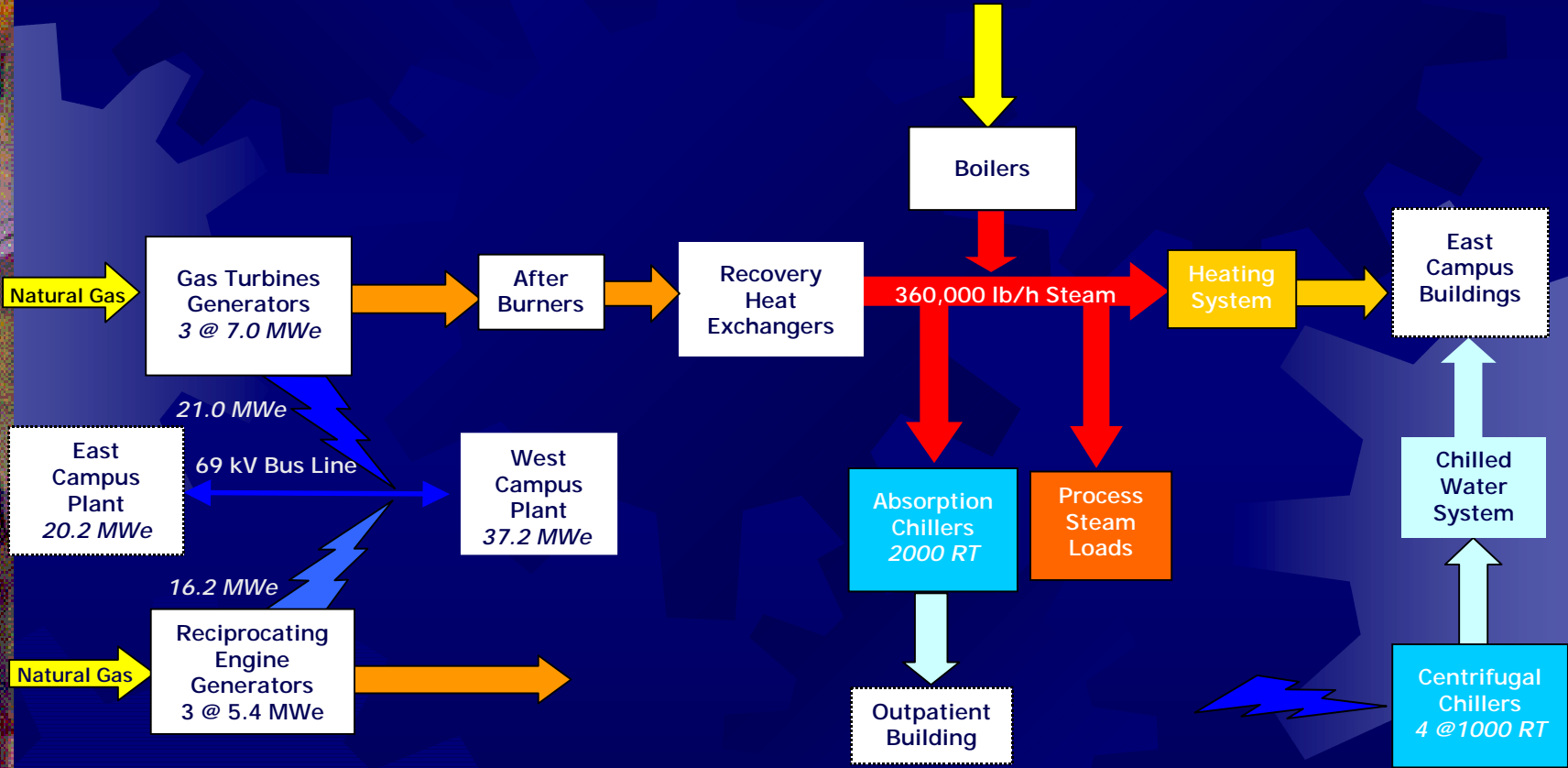


# West Campus





# West Campus – Layout



# Cooling, Heating and Power Systems West Campus

## Electrical Generation

Solar Taurus Turbines

Natural Gas

3 @ 7.0 MW<sub>e</sub> *each*



# Cooling, Heating and Power Systems West Campus

## Heat Recovery Systems

### Heat Recovery Steam Generators

Total Capacity 90,000 lb/hr to  
360,000 lb/hr of Steam  
with Supplemental Duct Firing



# Cooling, Heating and Power Systems

## West Campus

### Electrical Generation

Reciprocating Engine-Generators

Wärtsilä (Natural Gas)

3 @ 5.4 MW<sub>e</sub> *each*



# Cooling, Heating and Power Systems

## West Campus

- ★ Remote Absorption Chillers

- ★ University of Illinois Hospital  
Outpatient Building

- 3 Carrier Units (Total of 2000 RT)
  - 2 @ 500 RT
  - 1 @ 1000 RT

# Financial Statistics

## ★ Original 12.6 MW East Campus Plant *(Operational in 1993)*

- ★ Total Cost: \$15M
- ★ Original Goal: Payback in 10 years
- ★ Actual Performance: Payback in 7.5 years
- ★ Operating Savings: Approximately \$2M/yr



# Financial Statistics

## ★ Additional 7.6 MW East Campus Plant *(Operational in Mid-2000)*

- ★ Total Cost: \$10.7M
- ★ Original Goal: Payback in 10 years
- ★ Actual Performance: First Full Year 2001
- ★ Operating Savings: \$1.9M for 2000\*

\* *(With only 6 months of operation with the additional 7.6 MWe and all time high gas prices.)*



# Financial Statistics

## ★ New 37.2 MW West Campus Plant *(Operation Late 2001)*

- ★ Total Cost: \$38M
- ★ Original Goal: Payback in 7 years
- ★ Actual Performance: First Full Year 2002
- ★ Operating Savings: Estimated \$7M

# Financing

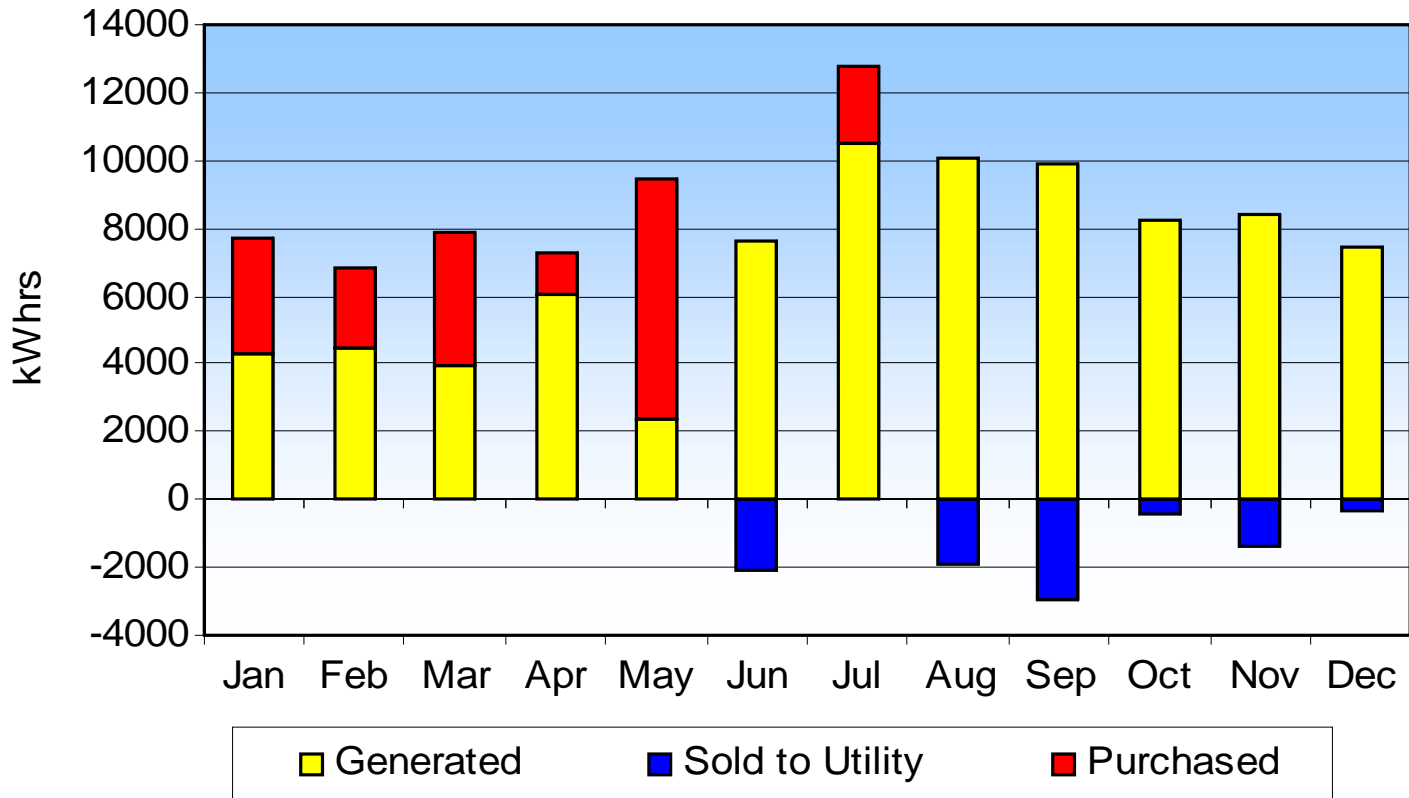
## ☀ East Campus

- ☀ 10 Year Bond
- ☀ Energy Savings
  - Paid Bond
  - Provided for Additional Energy Saving and Infrastructure Enhancements

## ☀ West Campus

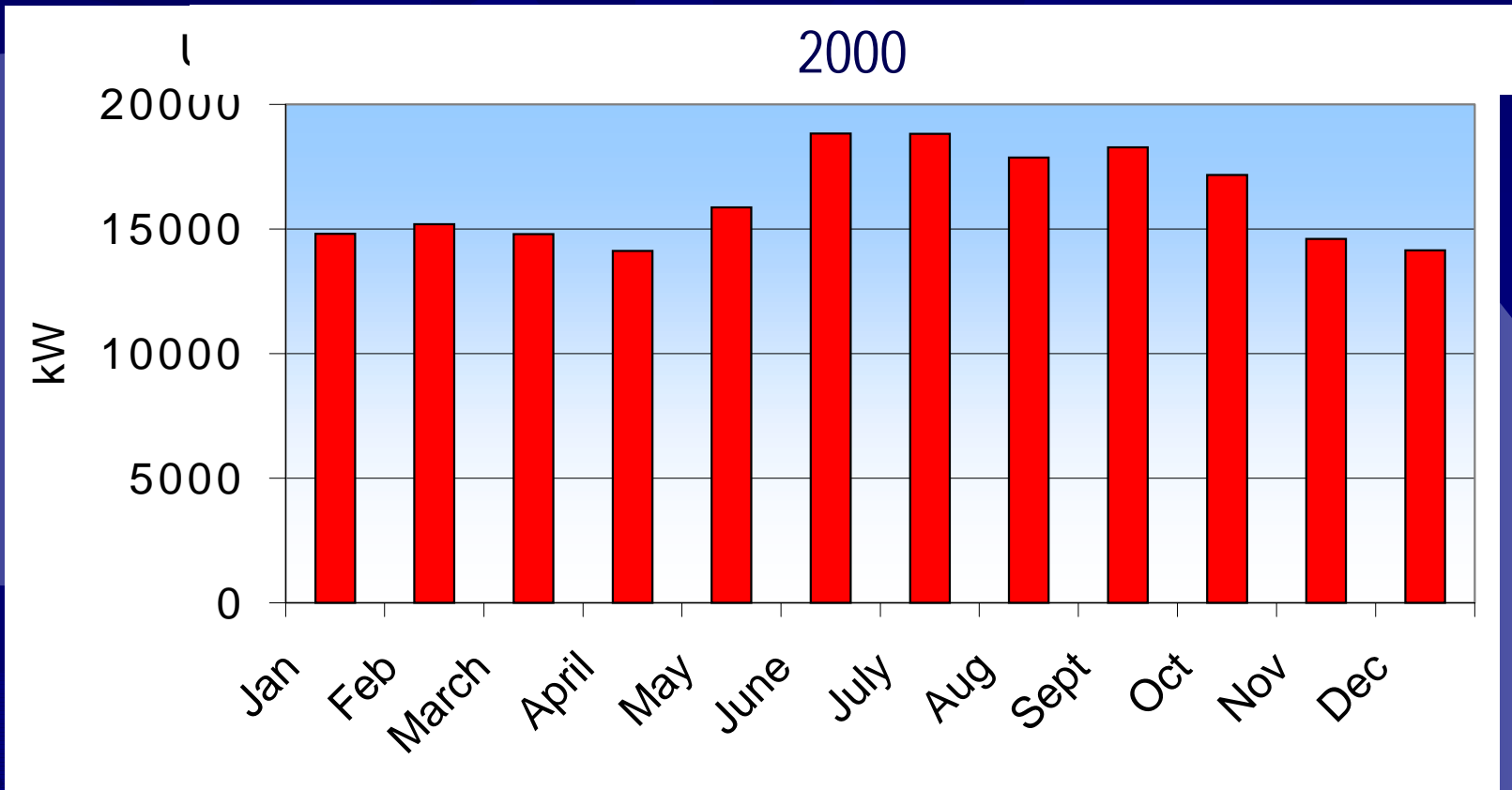
- ☀ 10 Year Bond

# Case Study Year 2000 Electrical Use

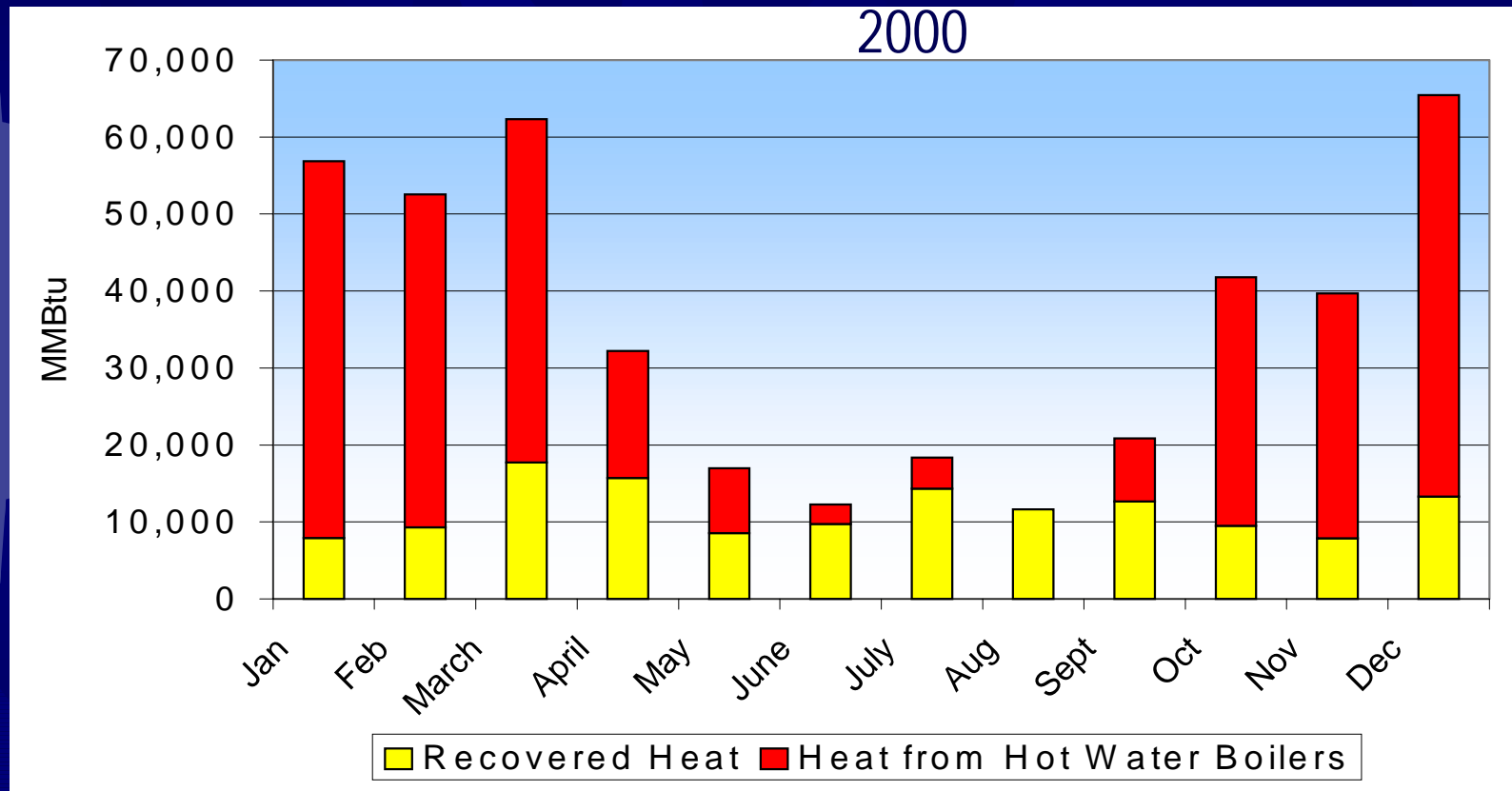


# Case Study Year 2000

## Electric Demand Profile



# Case Study Year 2000 Thermal Energy Profile



# Case Study

## Year 2000 Comparisons

	BCHP Plant	Baseline
<b>INCOME</b>		
Sold electricity	\$ 135,858	N/A
St Ignatius School	\$ 70,827	N/A
<b>GENERAL EXPENSES</b>		
Salaries	\$ 204,619	\$ 204,619
<b>ELECTRICAL EXPENSES</b>		
Electricity Wages	\$ 481,400	N/A
Electricity Fuel Oil	\$ 177,477	N/A
Electricity Gas	\$ 3,804,883	N/A
ComEd Electricity	\$ 1,131,845	\$ 6,710,545
Electricity Water/Sewer (a)	\$ 57,723	N/A
Maintenance	\$ 120,000	N/A
<b>HEATING &amp; COOLING EXPENSES</b>		
Heating & Cooling Wages	\$ 886,600	\$ 886,600
Heating & Cooling Fuel Oil	\$ -	\$ -
Heating & Cooling Gas	\$ 1,674,764	\$ 2,462,380
Heating & Cooling Water/Sewer (b)	\$ 52,437	\$ 52,437
Maintenance	\$ 58,200	\$ 58,200
<b>TOTAL</b>	<b>\$ 8,443,263</b>	<b>\$ 10,374,782</b>
(a) City Water and Sewer Service for engine cooling towers		
(b) City Water and Sewer Service for chiller cooling towers		

# Results

## ★ Savings

- ★ 18.62%

- ★ \$1,931,518

- ★ Lower Than Previous Years

- Uncharacteristically High Natural Gas Costs
- Operated Wärtsilä Engine-Generators for Extended Periods for Testing



# Results

## Savings at Various Gas Prices

Natural Gas Average Price [\$/MMBTU]	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
<b>4.68</b>	<b>18.62%</b>	<b>\$1,931,518</b>
5.0	16.50%	\$1,750,238

# Results

## ☀ Overall Source Energy Reduction

- 14.15% (236,856 MMBTU/year)

## ☀ Emissions

- CO<sub>2</sub>
  - 28.5% (236,856 Tons/Year)
- NO<sub>x</sub>
  - 52.8% (126 Tons/Year)
- SO<sub>2</sub>
  - 89.1% (551 Tons/Year)