University of Illinois East Campus Cooling, Heating, and Power Facility

Case Study (MAC #2001-001)

Midwest Application Center

Cooling, Heating, and Power for Buildings

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Site Development

- Initial Site
  - 12.6 MWe
  - Hot Water Heating
- Today
  - 20.2 MWe
  - Electrically Cross Connected to New West Campus Facility
    - Additional 37.2 MWe
  - Hot Water Heating
  - Absorption Cooling

East Campus Facility

- Meets the Electrical Demand of the East Campus
- Electrically tied to West Campus with 69 KV line
- 30 MMBTU/h available to offset the heating & cooling demands of 3.8M ft^2 in 29 buildings
- 8 MMBTU/h available to adjacent school and church

Cooling, Heating and Power Systems
East Campus

- Electrical Generation
  - 2 Cooper-Bessemer Reciprocating Engine-Generators (1993)
    - Dual-Fuel
    - 6.3 MW_e *each*
  - 2 Wärtsilä Reciprocating Engine-Generators (1999)
    - Natural Gas
    - 3.8 MW_e *each*

Cooling, Heating and Power Systems
East Campus

- Heat Recovery Systems
  - 4 Exhaust Gas Systems
    - Total Recovered Energy of 30 MMBTU/h
  - 2 Jacket Water Systems
    - Total Recovered Energy of 8 MMBTU/h
- Heating Systems
  - 3 High Temperature Hot Water Generators (HTHWGs)
    - Natural Gas or #6 Fuel Oil
    - 2 at 75 MMBTU/h
    - 1 at 50 MMBTU/h

Cooling, Heating and Power Systems
East Campus

- Absorption Chillers
  - Activated by Hot Water Loop
  - Remote Building Chillers
    - Total of 1350 RT
      - 2 @ 500 RT on Engineering Research Facility
      - 1 @ 350 RT on Transportation Building
  - 1 Trane Chiller (May 2001)
    - Two-Stage
    - 1000 RT
- Electrical Centrifugal Chillers
  - 3 York International
    - 2000 RT *each*

Cooling, Heating and Power Systems
West Campus

- Electrical Generation
  - 3 Wärtsilä Reciprocating Engine-Generators
    - Natural Gas
    - 5.4 MW_e *each*
  - 3 Solar Taurus Turbines
    - Natural Gas
    - 7.0 MW_e *each*

Cooling, Heating and Power Systems
West Campus

- Heat Recovery Systems
  - 3 Exhaust Gas Systems with Duct Burners
    - Solar Taurus Turbines Only
    - Total Capacity 90,000 lb/hr to 360,000 lb/hr of Steam
- Heating Systems
  - 2 Boilers
    - Natural Gas or #6 Fuel Oil

Cooling, Heating and Power Systems
West Campus

- Absorption Chillers
  - Activated by Steam Loop
  - 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 Expected in Late 2001)
  - Total Cost: $38M
  - Original Goal: Payback in 7 years
  - Actual Performance: First Full Year 2002
  - Operating Savings: Estimated $7M

Case Study
Year 2000 Parameters

- BCHP Plant Operation in 2000
  - Wärtsilä Engine-Generators
    - Began Operation July 2000
    - Not Included in First 6 Months of Operation
  - Trane Absorption Chiller
    - Commissioned May 2001
    - Not Included in the Analysis

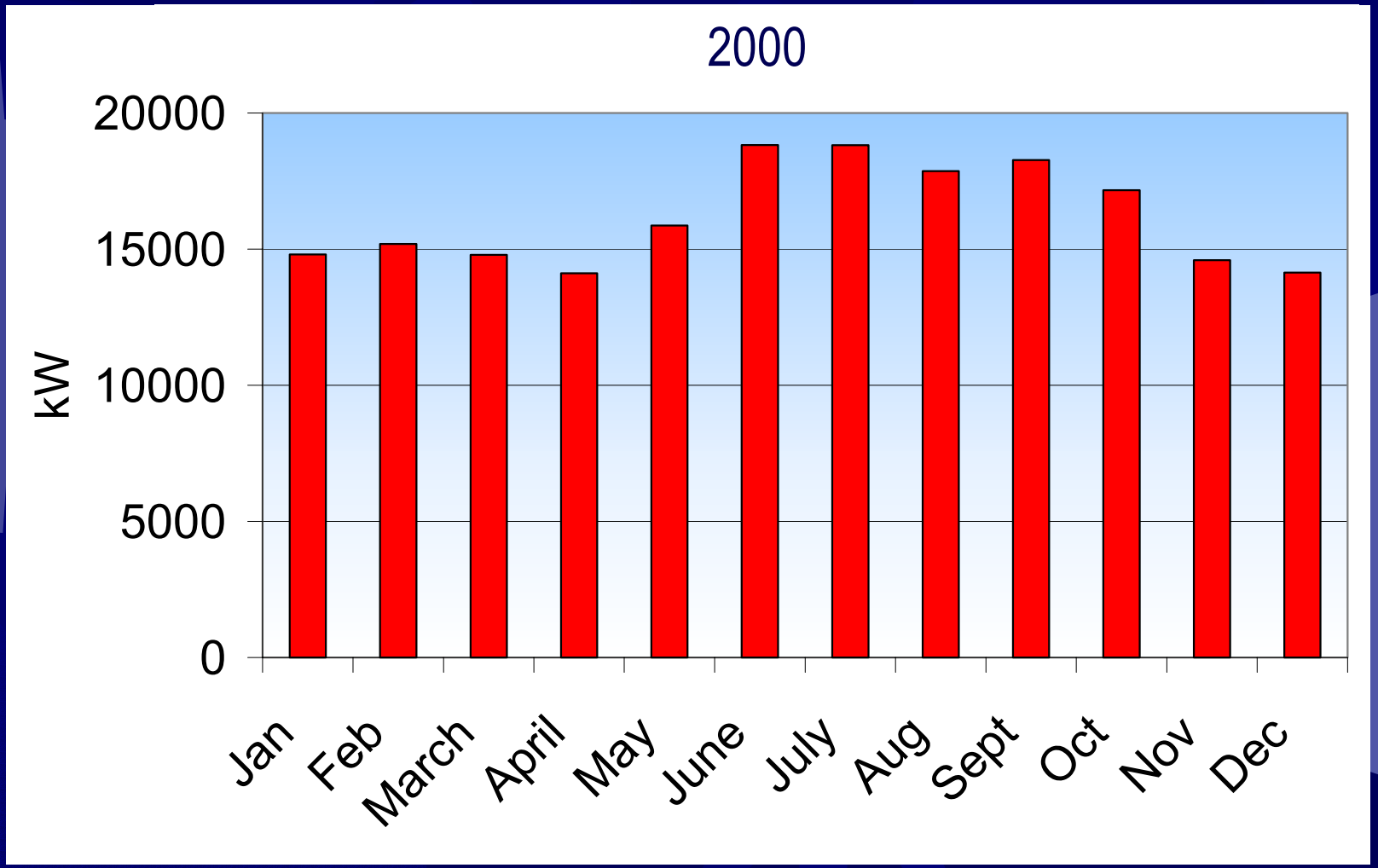
Case Study
Year 2000 Parameters

- BCHP Plant
  - East Campus Electrical Demands are Generally Met by Onsite Generation
    - Demand exceeds generation, power is purchased from the Utility.
    - Generation exceeds demand, excess is sold back to the Utility.
  - Part of the Thermal Load is Provided by Recovered Engine Heat
  - Annual Costs are Based on the Actual Monthly Expenditures

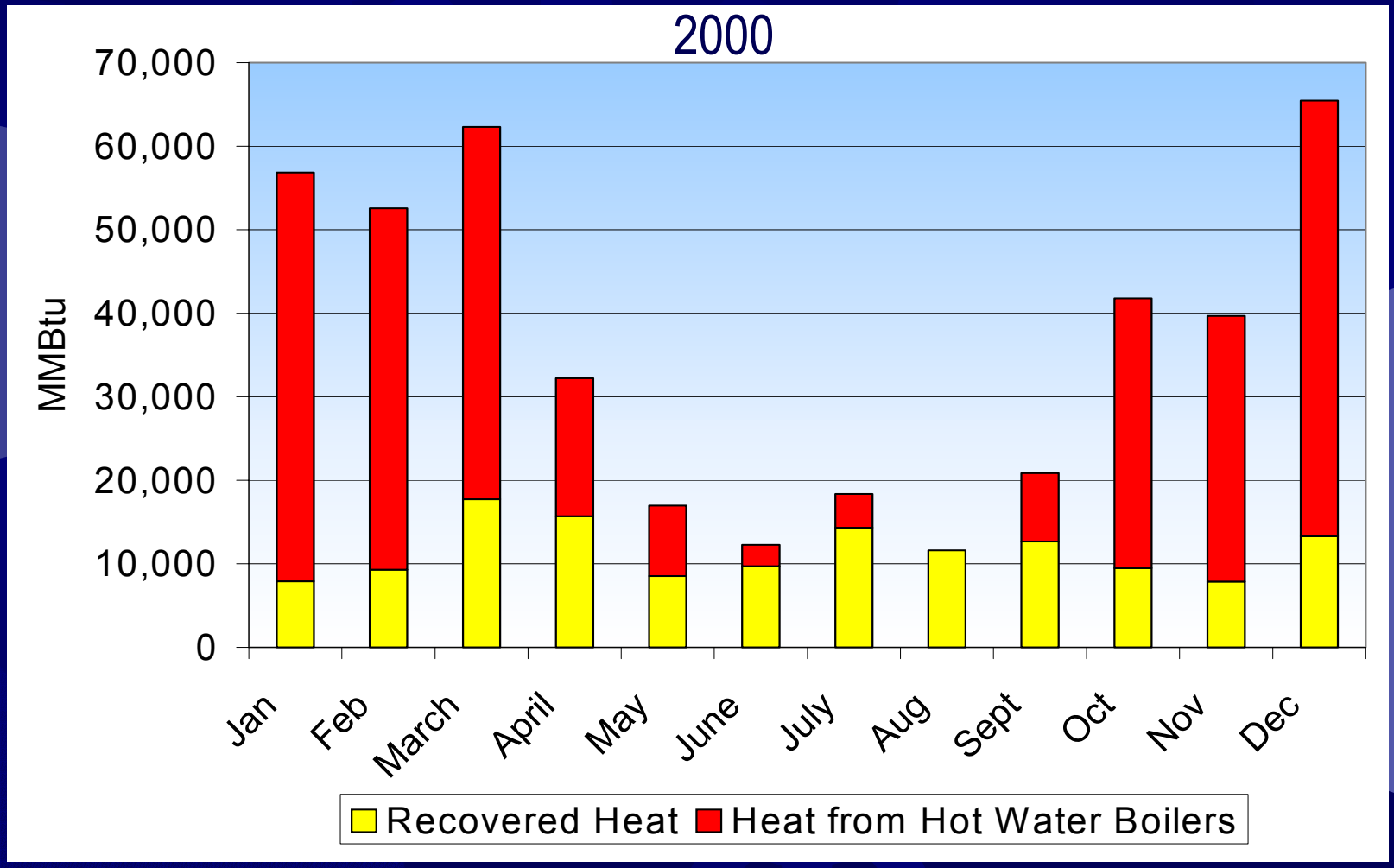
Case Study
Year 2000 Parameters

- Baseline Plant
  - All Electricity is Purchased from the Utility
  - Baseline Plant Has the Same Thermal Loads as the BCHP Plant
  - All Thermal Loads are supplied by the HTHWGs
  - Annual Costs are Based on Energy Usage and Applicable Energy Rates for Each Monthly Period

Electric Demand Profile



Annual Thermal Energy Profile



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
4.68	**18.62%**	**$1,931,518**
5.0	16.50%	$1,750,238

Results

- Overall Source Energy Reduction
  - 14.15% (236,856 MMBTU/year)
- Emissions
  - CO_2
    - 28.5% (236,856 Tons/Year)
  - NO_x
    - 52.8% (126 Tons/Year)
  - SO_2
    - 89.1% (551 Tons/Year)

Photo Tour

East Campus

Cooling, Heating and Power Systems
East Campus

Absorption Chillers

Trane Chiller

Two-Stage

1000 RT

Cooling, Heating and Power Systems
East Campus

Electrical Centrifugal Chillers

York International

3 @ 2000 RT *each*

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

Electrical Generation

Reciprocating Engine-Generators

Wärtsilä (Natural Gas)

2 @ 3.8 MW_e *each*

Cooling, Heating and Power Systems
East Campus

Electrical Generation

Reciprocating Engine – Generators

Cooper – Bessemer (Dual Fuel)

2 @ 6.3 MW_e *each*

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

Gas Distribution Station

Cooling, Heating and Power Systems

East Campus

Electrical Substation

Photo Tour

West Campus

Cooling, Heating and Power Systems
West Campus

Electrical Generation

Solar Taurus Turbines

Natural Gas

3 @ 7.0 MW_e *each*

Cooling, Heating and Power Systems
West Campus

Electrical Generation

Reciprocating Engine-Generators

Wärtsilä (Natural Gas)

3 @ 5.4 MW_e *each*

Cooling, Heating and Power Systems
West Campus

Heat Recovery Systems

Solar Turbine Exhaust Gas Systems

with Duct Burners

Total Capacity 90,000 lb/hr to 360,000 lb/hr of Steam