BALL STATE UNIVERSITY

Campus Conversion to Geothermal

Ball State University's Conversion to a Campus Geothermal System

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Learning Objectives

- History of the Ball State Project
- Applying Geothermal to a campus
- Benefits of the Ball State Project
- Lessons Learned

History of Ball State University

- Founded in 1918
- 7.1 Million SF
- 47 Major Buildings
- 731 acres
- 22,113 students
- *Beneficence* is a 6 ft. bronze statue that has graced the BSU campus since 1937. Her name, means the quality of performing acts of kindness and charity.

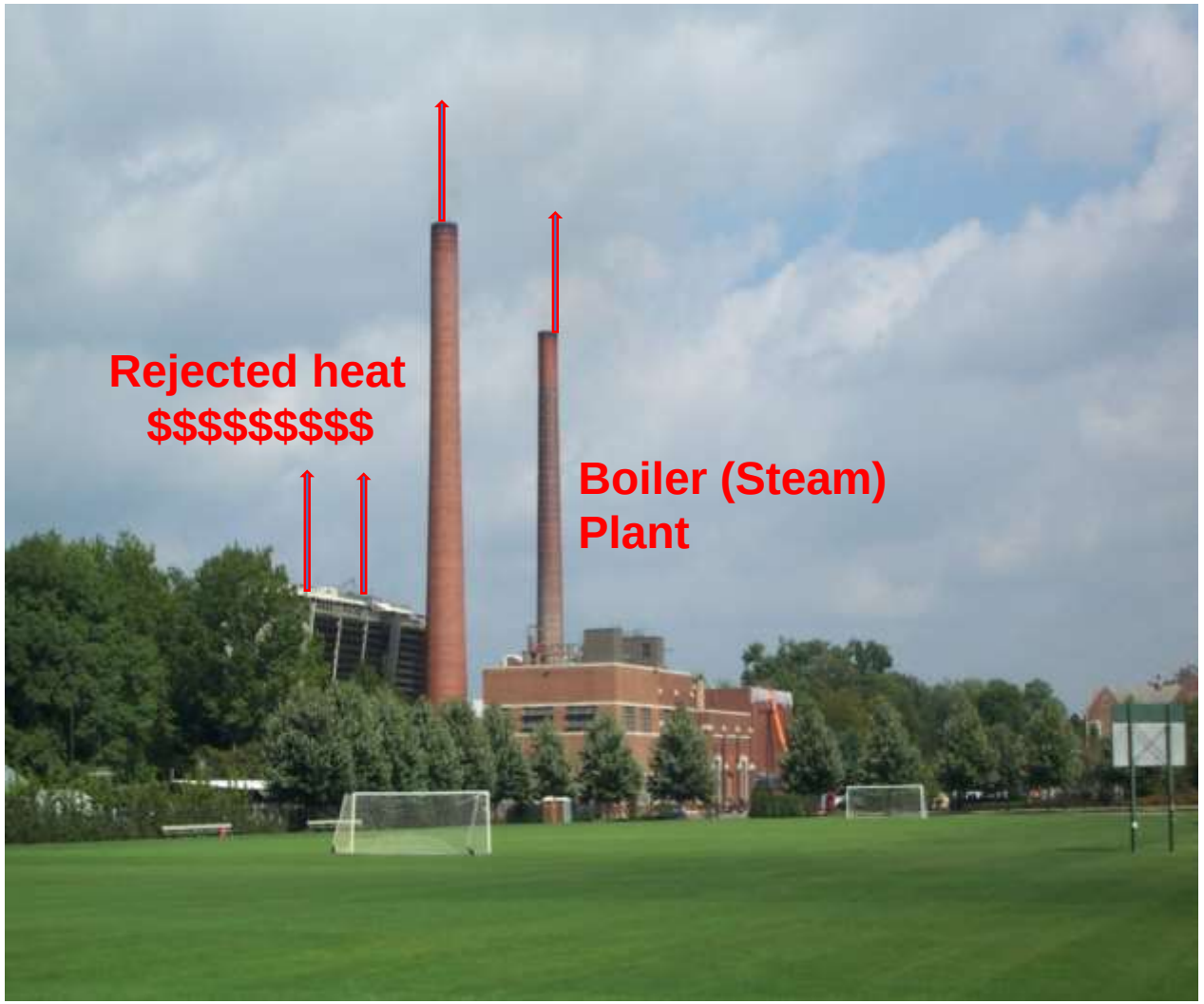
Steam and Chilled Water Plant Operations

Steam Plant:

- 4 Coal Fired Boilers
- 3 Natural Gas Fired Boilers
- 320,000 Lbs./Hr. nameplate
- 700,000,000 Lbs./Year

Chilled Water Plant:

- 5 Electrical Centrifugal Chillers
- 9,300 ton capacity
- 25,000,000 Ton Hours/Year



Pollutants / Waste Produced from Burning 36,000 tons of Coal

• Carbon Dioxide	85,000 tons	(Global Warming)
• Sulfur Dioxide	1,400 tons	(Acid Rain)
• Nitrogen Oxide	240 tons	(Smog)
• Particulate Matter	200 tons	(Breathing)
• Carbon Monoxide	80 tons	(Headache)

- Multiple Hazardous Air Pollutants now regulated by EPA's Boiler MACT rules: Mercury
- 3,600 tons of coal ash

Alternatives Evaluated

Fossil Fuel Boiler (CFB)
High capital cost
No CO2 reduction
High maintenance costs
Emission control equipment
Alternative fuel capable

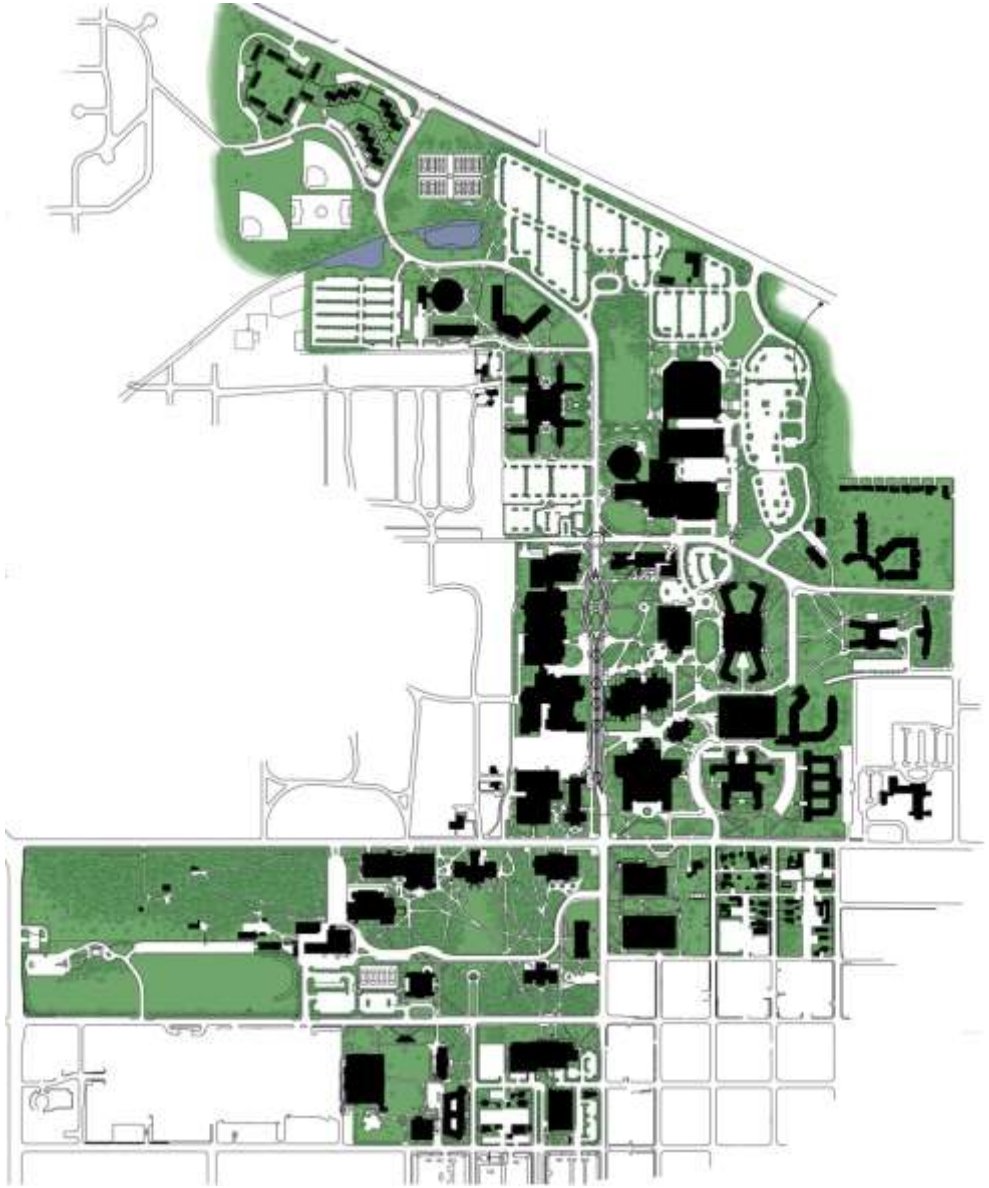
All Natural Gas Boiler
Low capital cost
CO2 half that of coal
Low maintenance cost
No emission control
High fuel costs

Ground Source Geothermal Heat Pump
Highest capital cost
Campus CO2 reduced 50%
Low maintenance cost
No emission control
Electric power dependent

BSU needed to make changes due to:

- Age/condition of equipment
- EPA regulations
- Growth in campus
- reduction in equipment capacity

Geothermal for Campus Systems



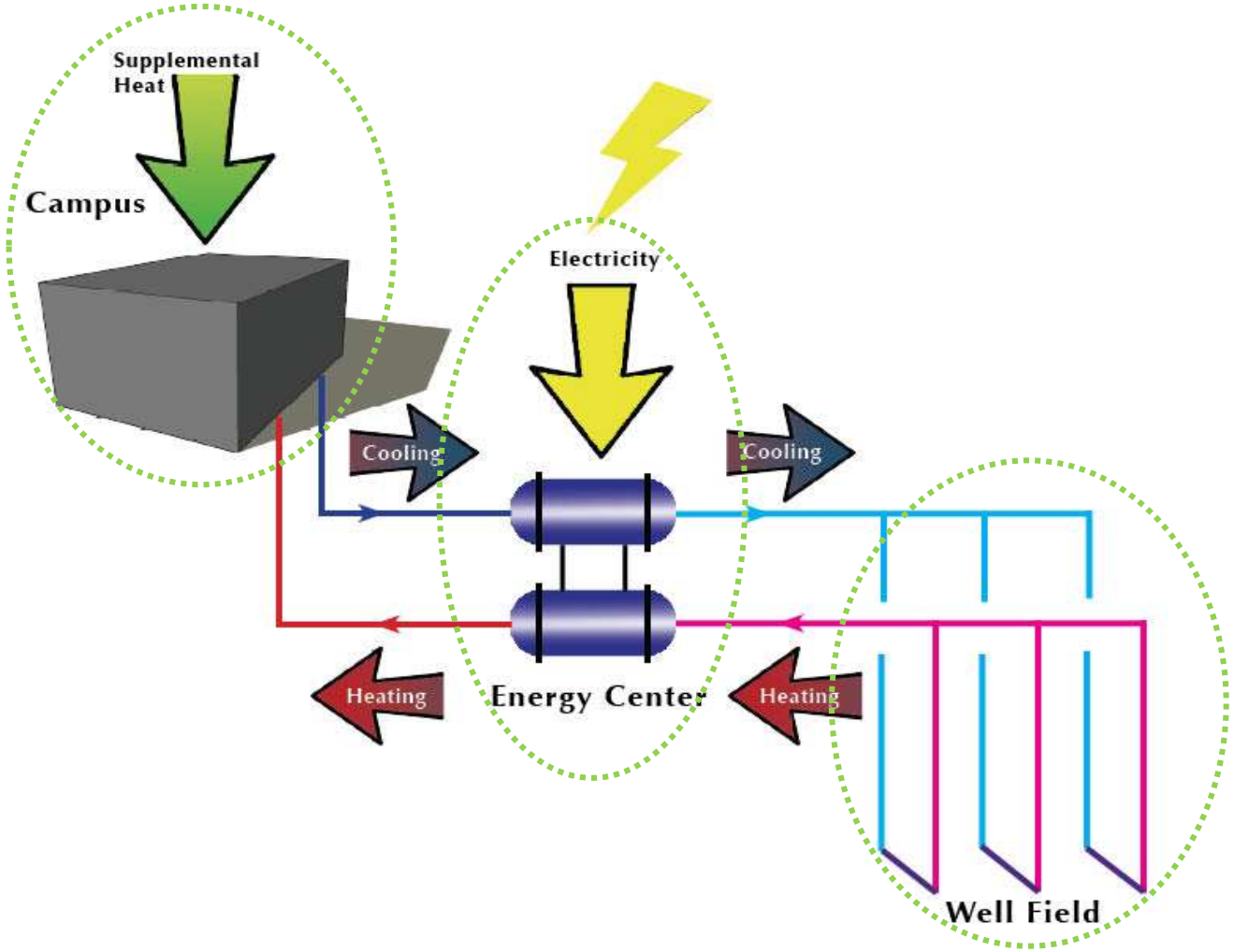
- Appling Geothermal Systems in a New Way
- Take Advantage of Campus Simultaneous Heating and Cooling Loads
- Potential to Eliminate Coal and Gas Fired Boilers
- Reduce Energy Footprint, Carbon Emissions and Utility Costs
- Reduce Water Usage

Many Different Ways to Apply Geothermal to a Campus

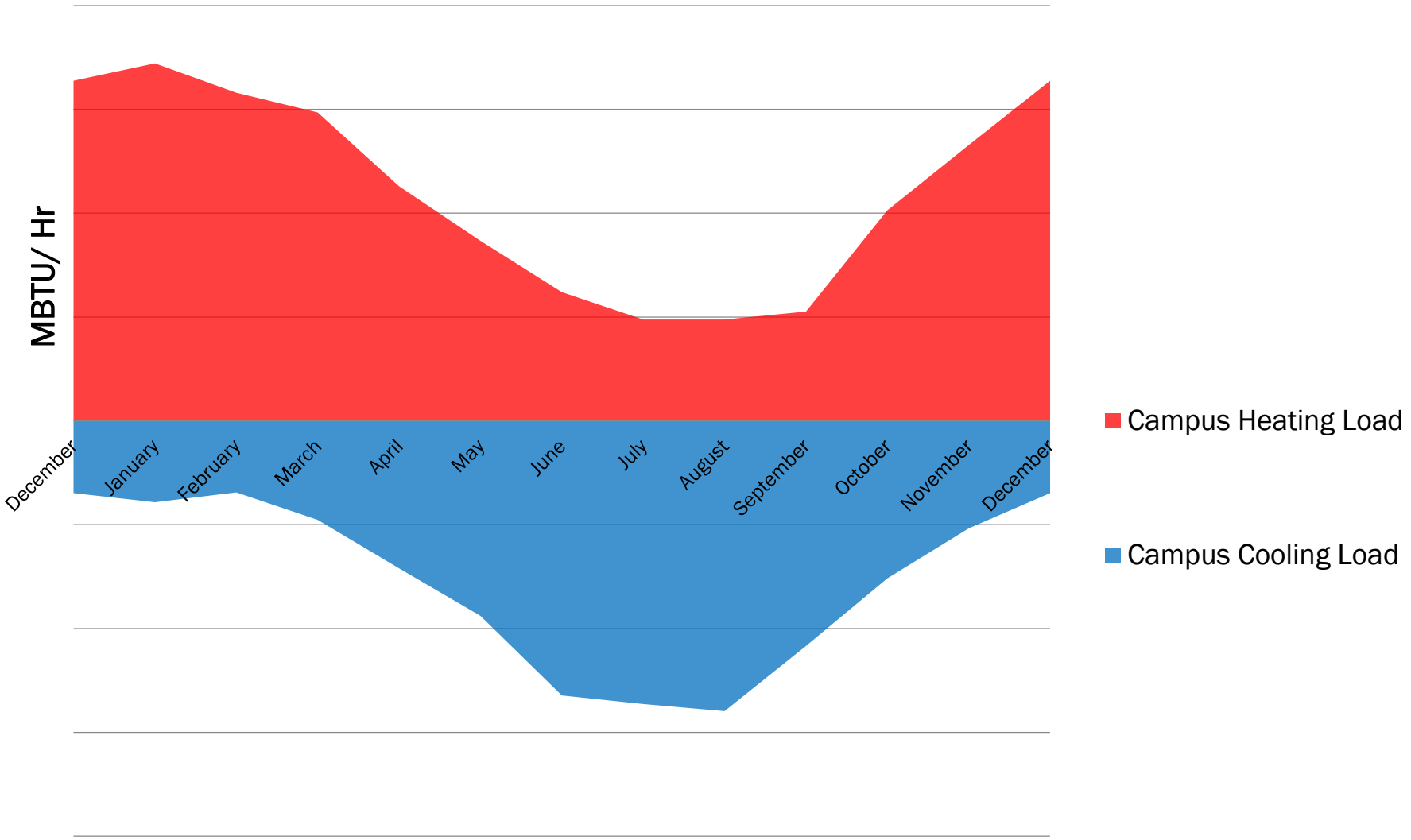
Key pieces of information to evaluate to decide what is best for the campus

- Identify the Campus Thermal Profile
  - 3 years of monthly energy consumption with peak rate
- Existing Infrastructure
- Master Plan
- Phasing and Funding
- Potential Bore Location
- Geology
- Well Field Model
- Building Conversions and Hot Water Temp
- Equipment Selection

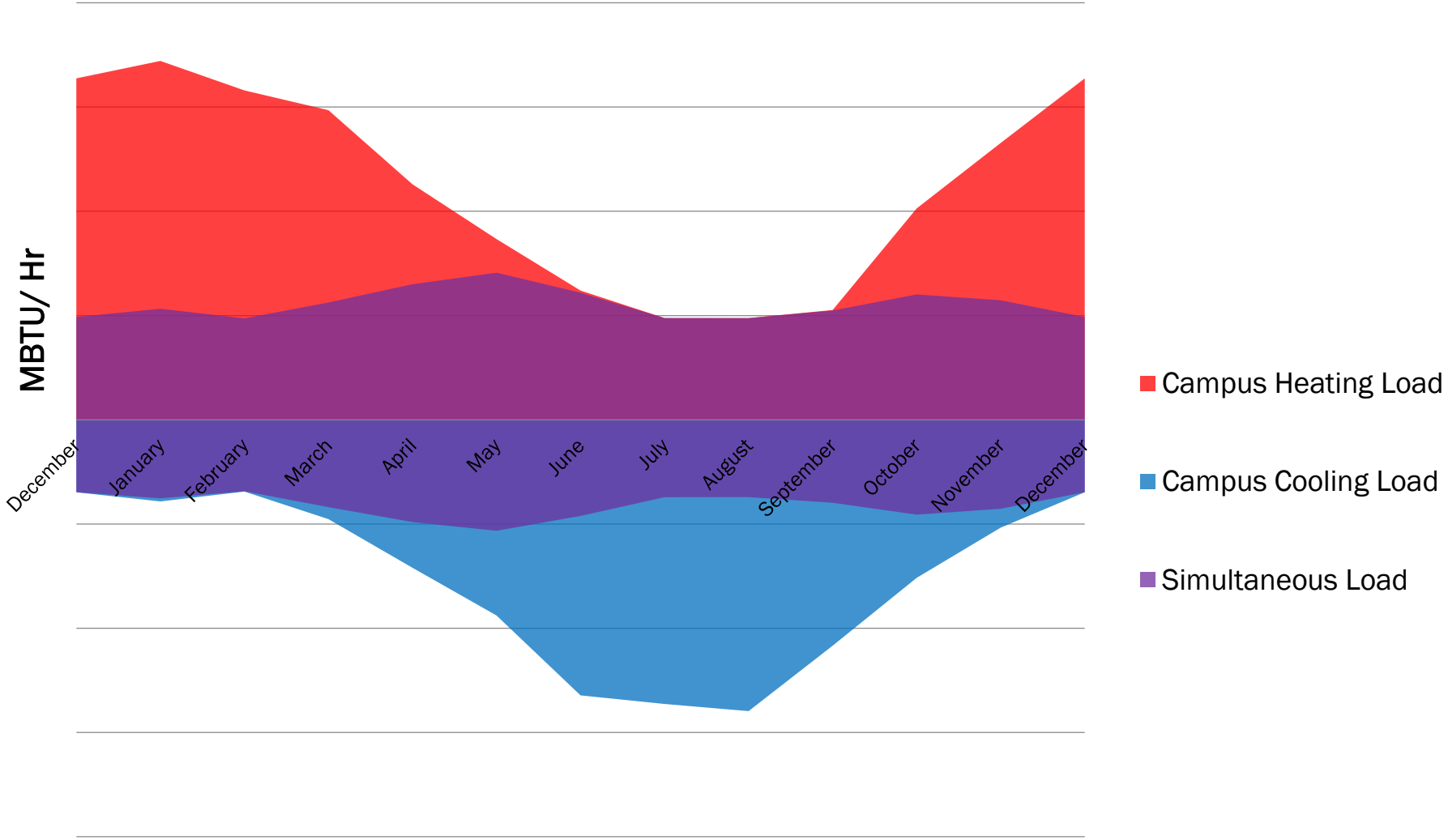
Heating & Cooling Loads for the Campus



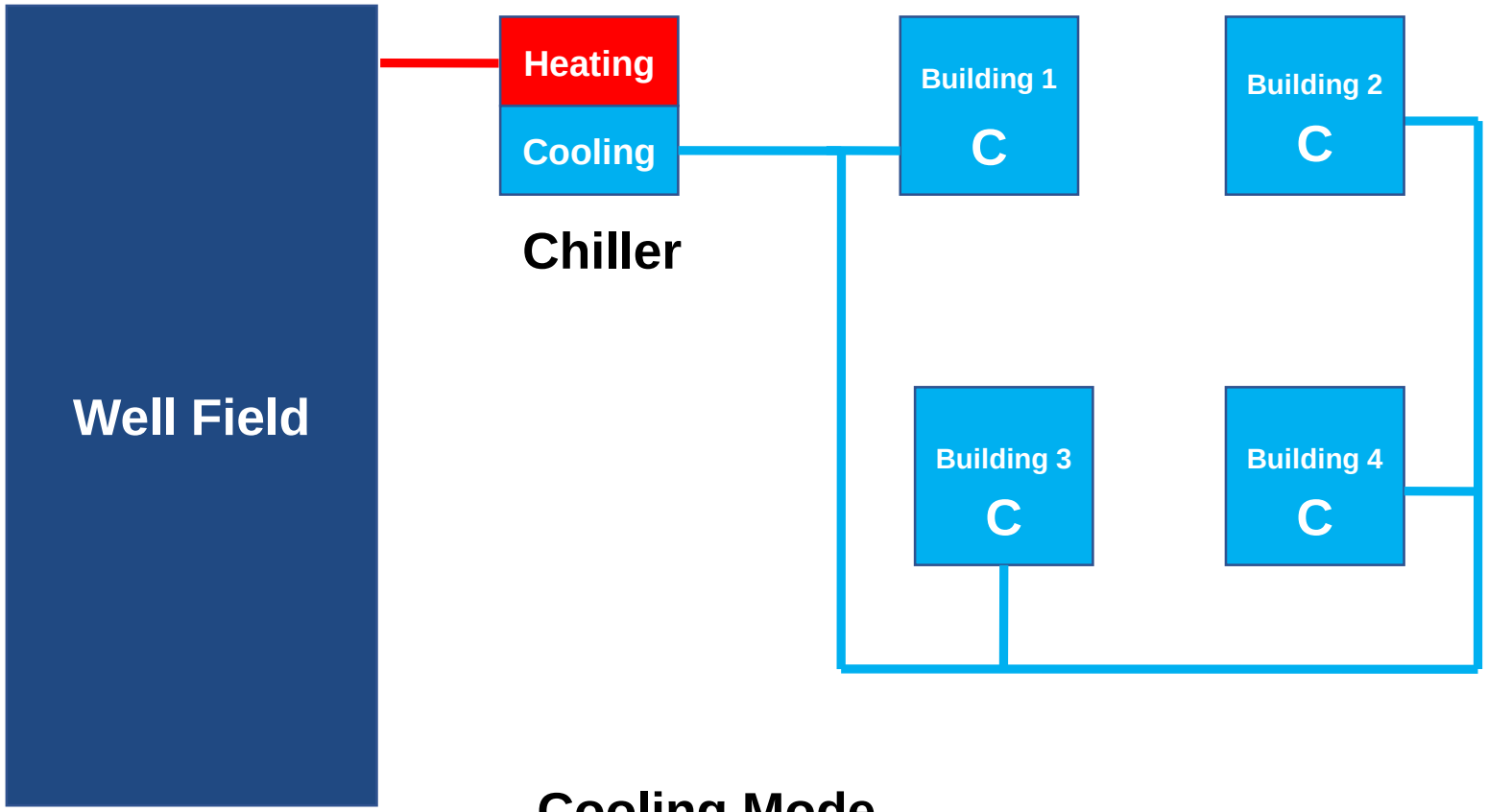
Campus Heating & Cooling Loads



Campus Heating & Cooling Loads

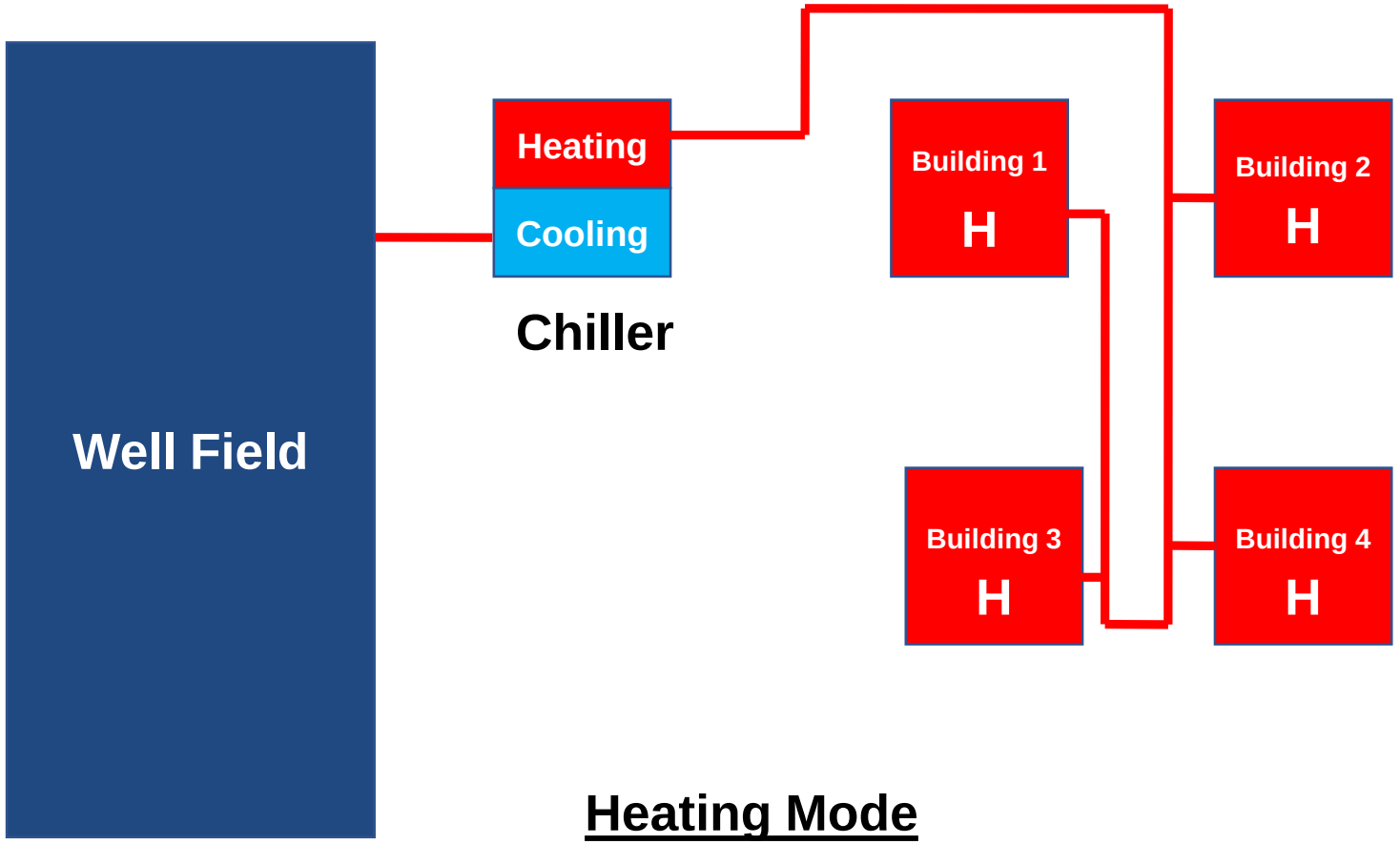


Central Energy Plan



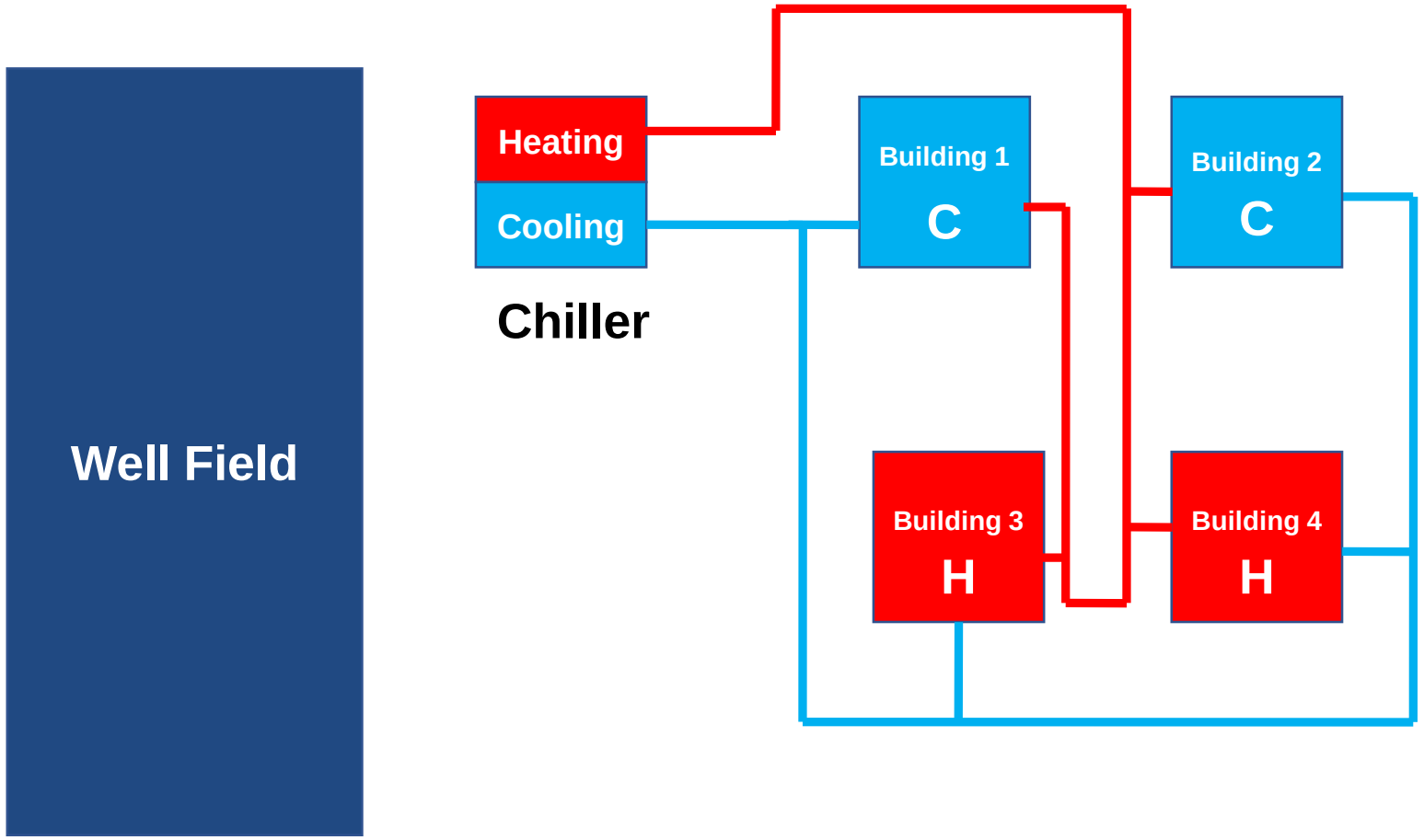
<u>Cooling Mode</u>
COP = 5.93 / EER 20.23 (Avg.)

Central Energy Plan



Heating Mode
COP = 3.4

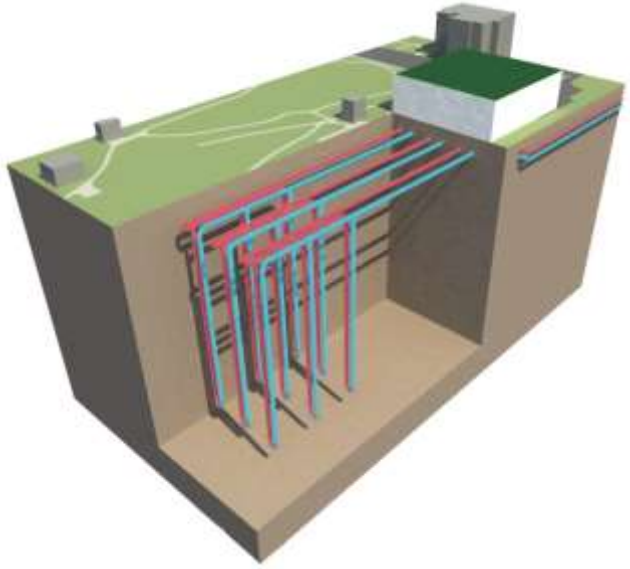
Central Energy Plan



Simultaneous Heating/Cooling

COP > 7

Heat Exchanger Options



- Vertical Heat Exchanger

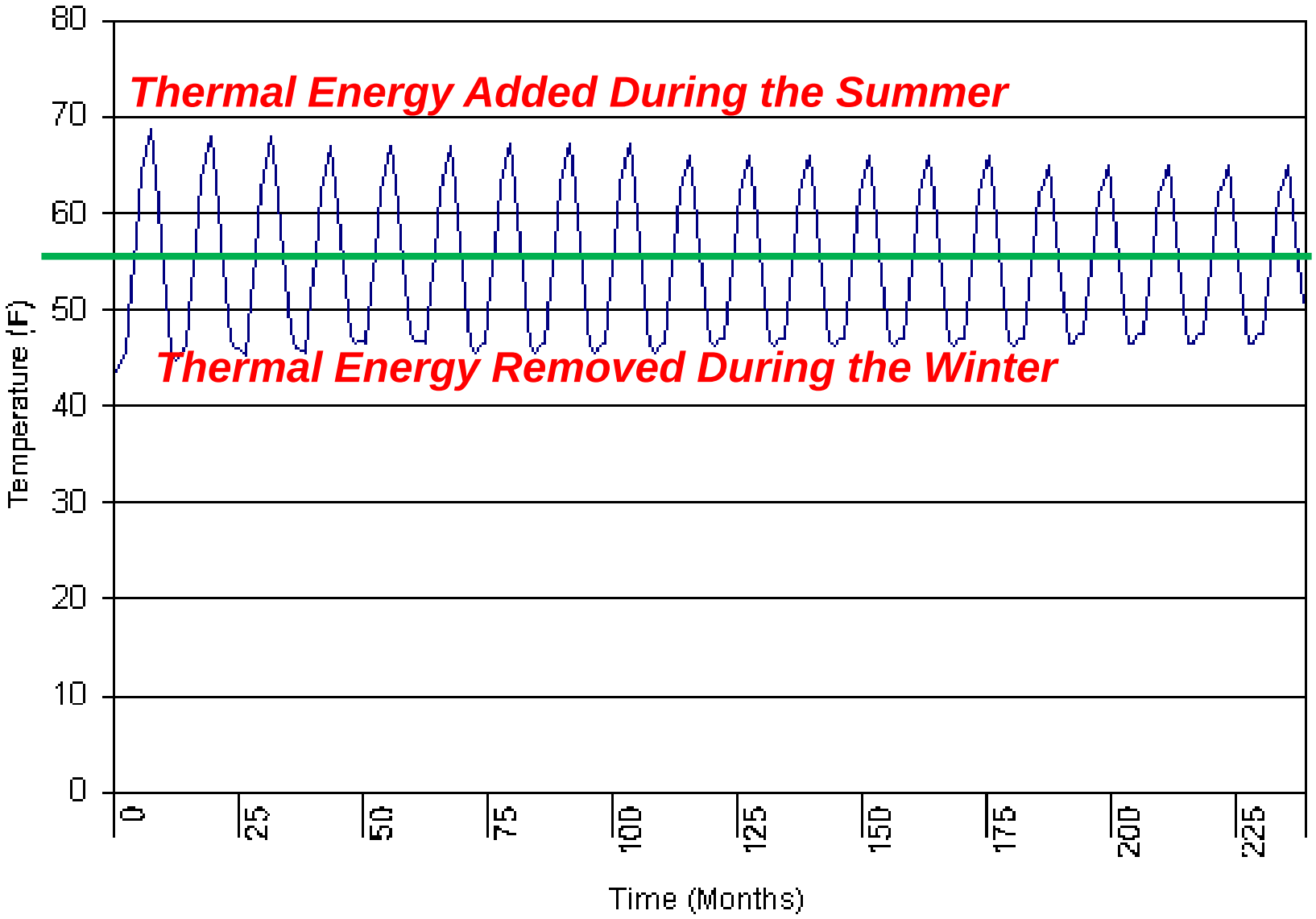
- Open Pit Horizontal
- Directional Bore Horizontal

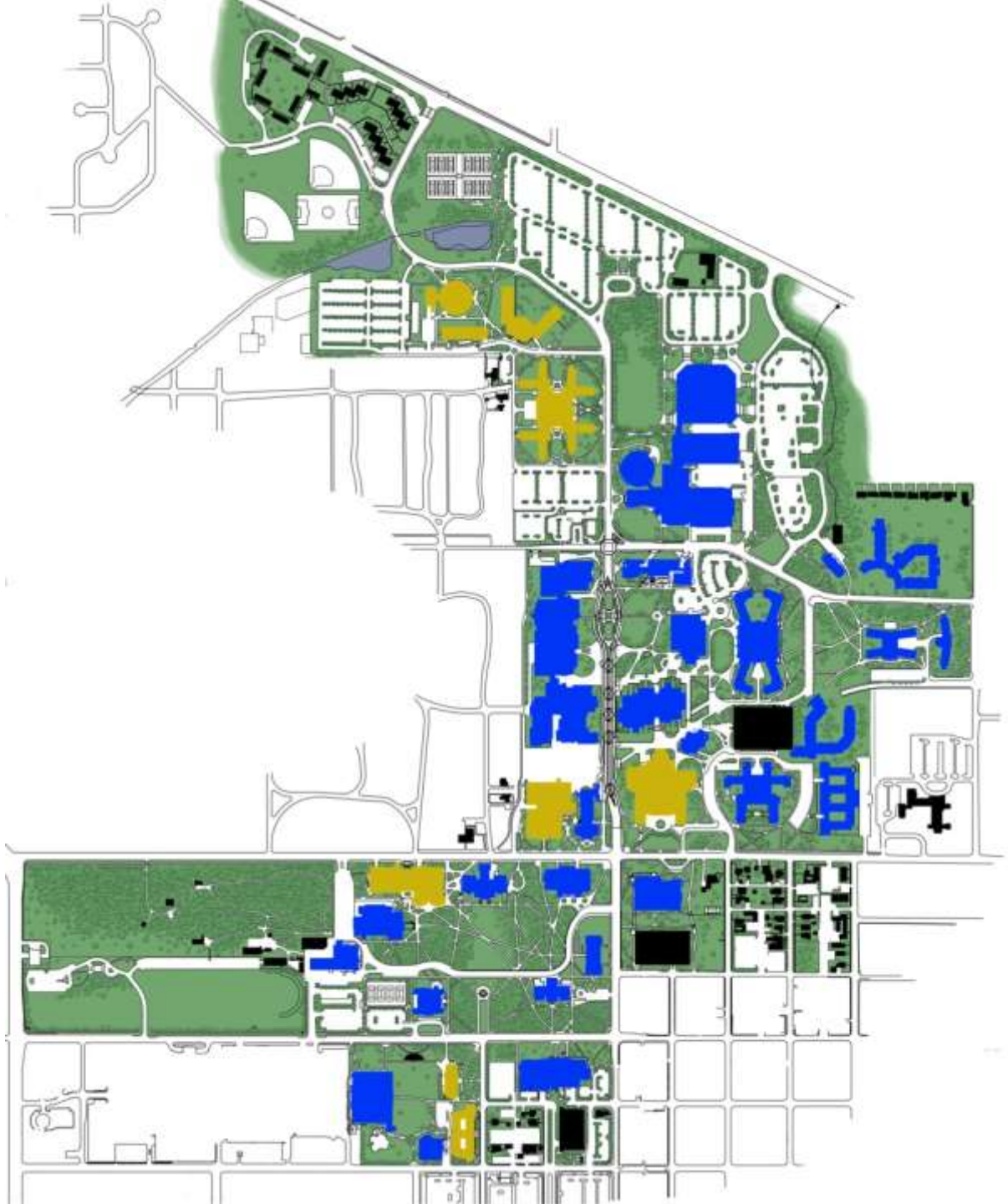
- Closed Loop Pond/Lake
- Open Loop Pond/Lake

Drill Test Well

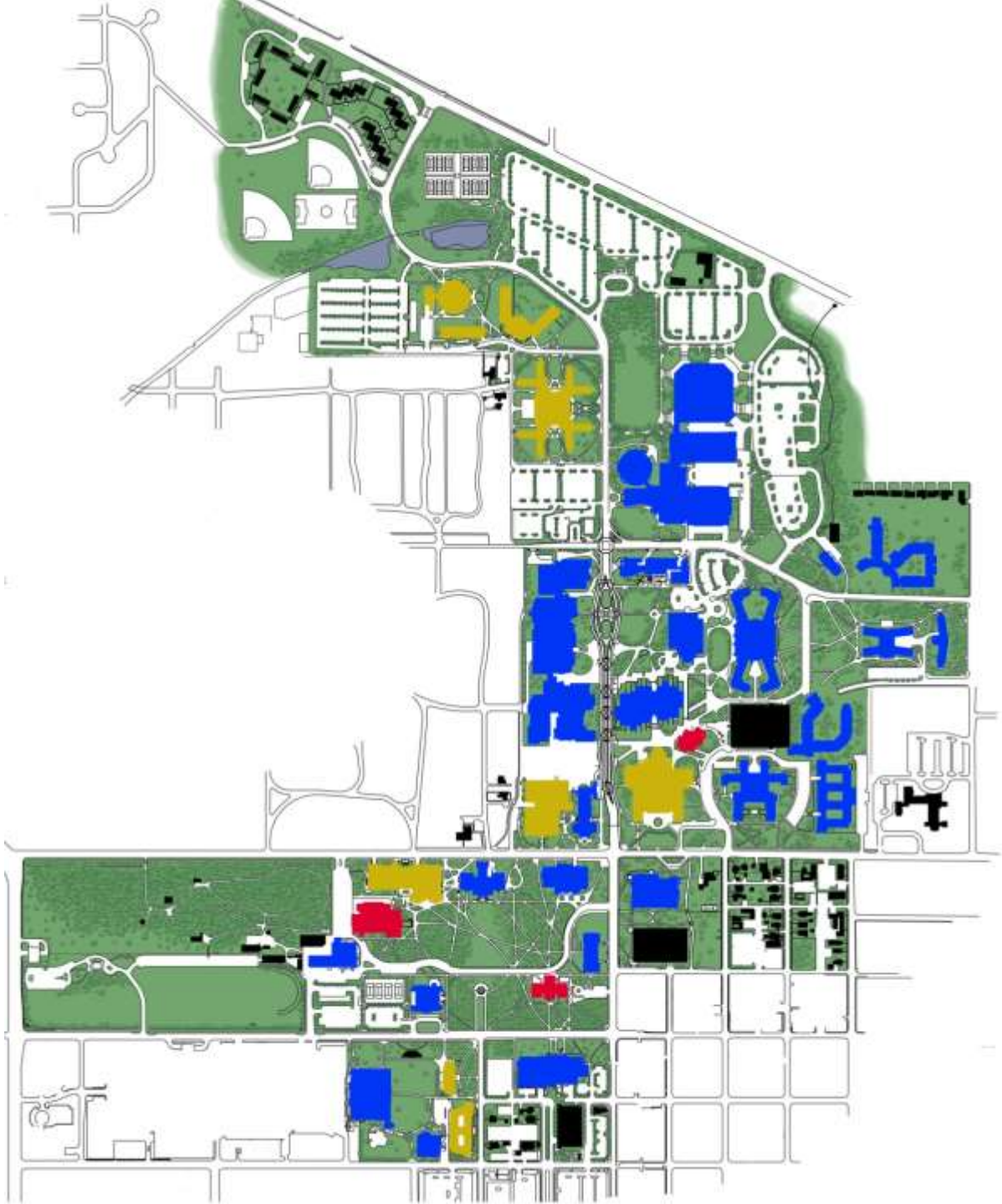
- **Outcomes of Test Well**
  - Geological Conditions
  - Conductivity
  - Diffusivity
  - Earth Temperature

Ground Temperature Model

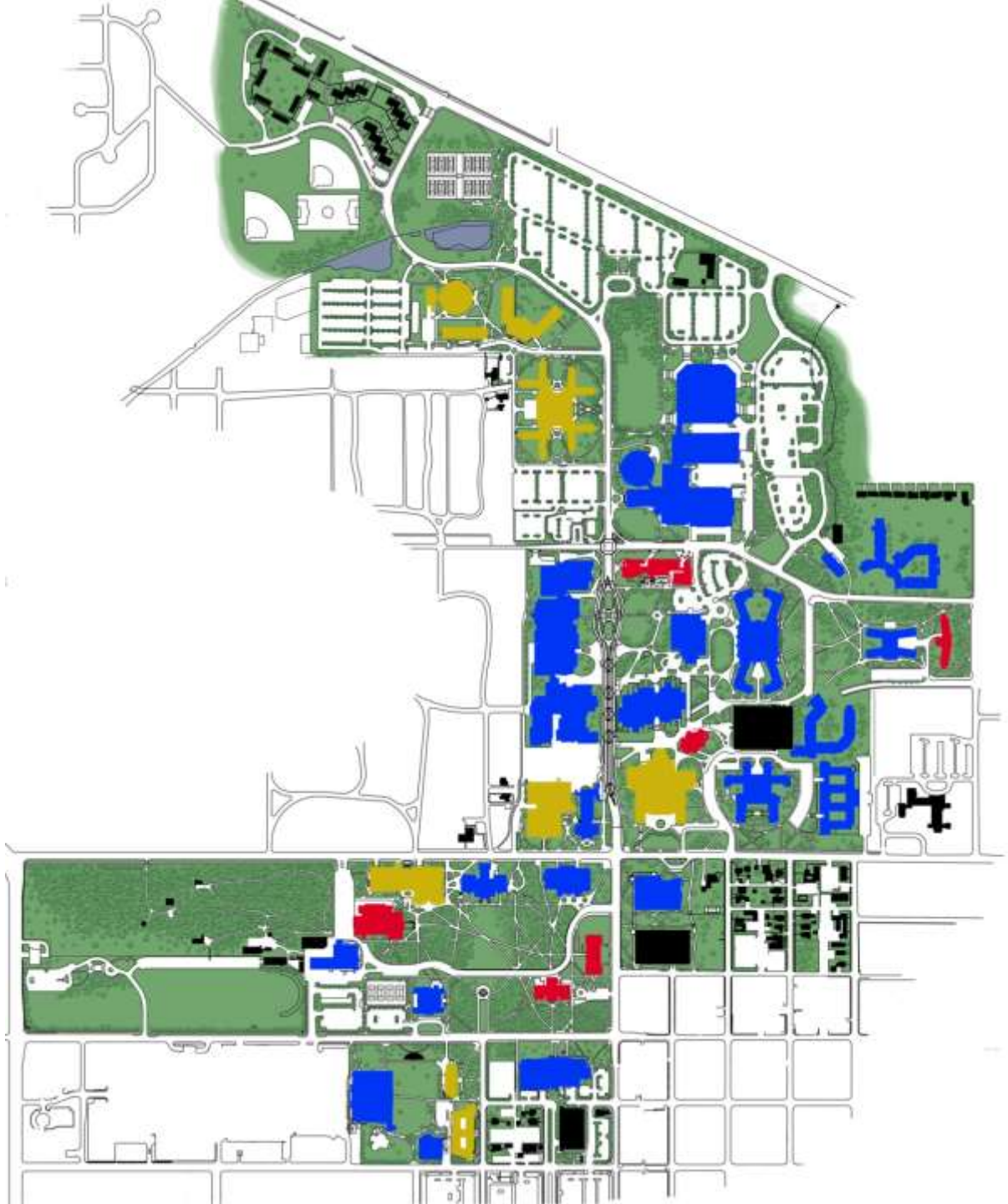




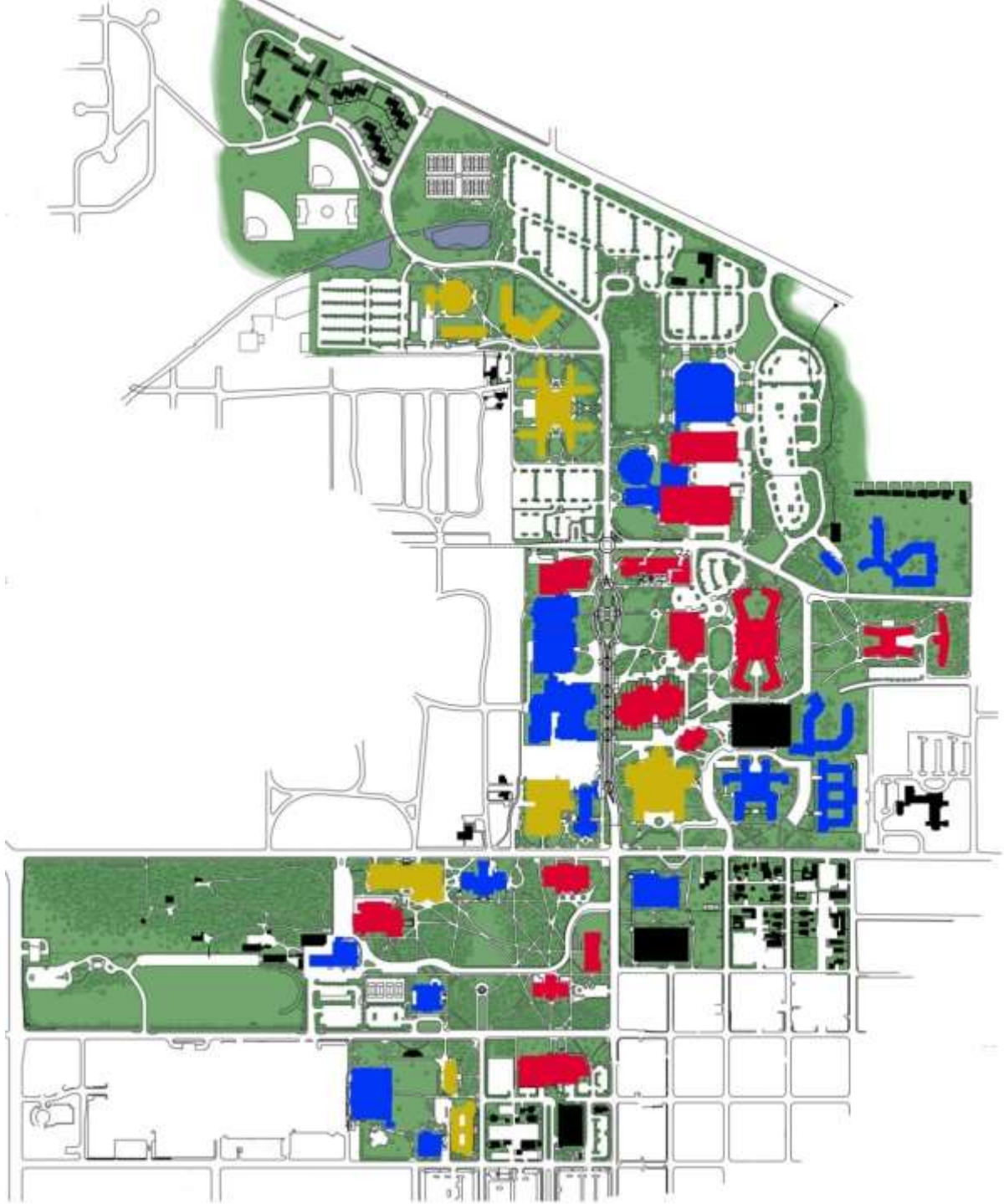
Effects of Different Hot Water Temps



170° Hot Water Temperature



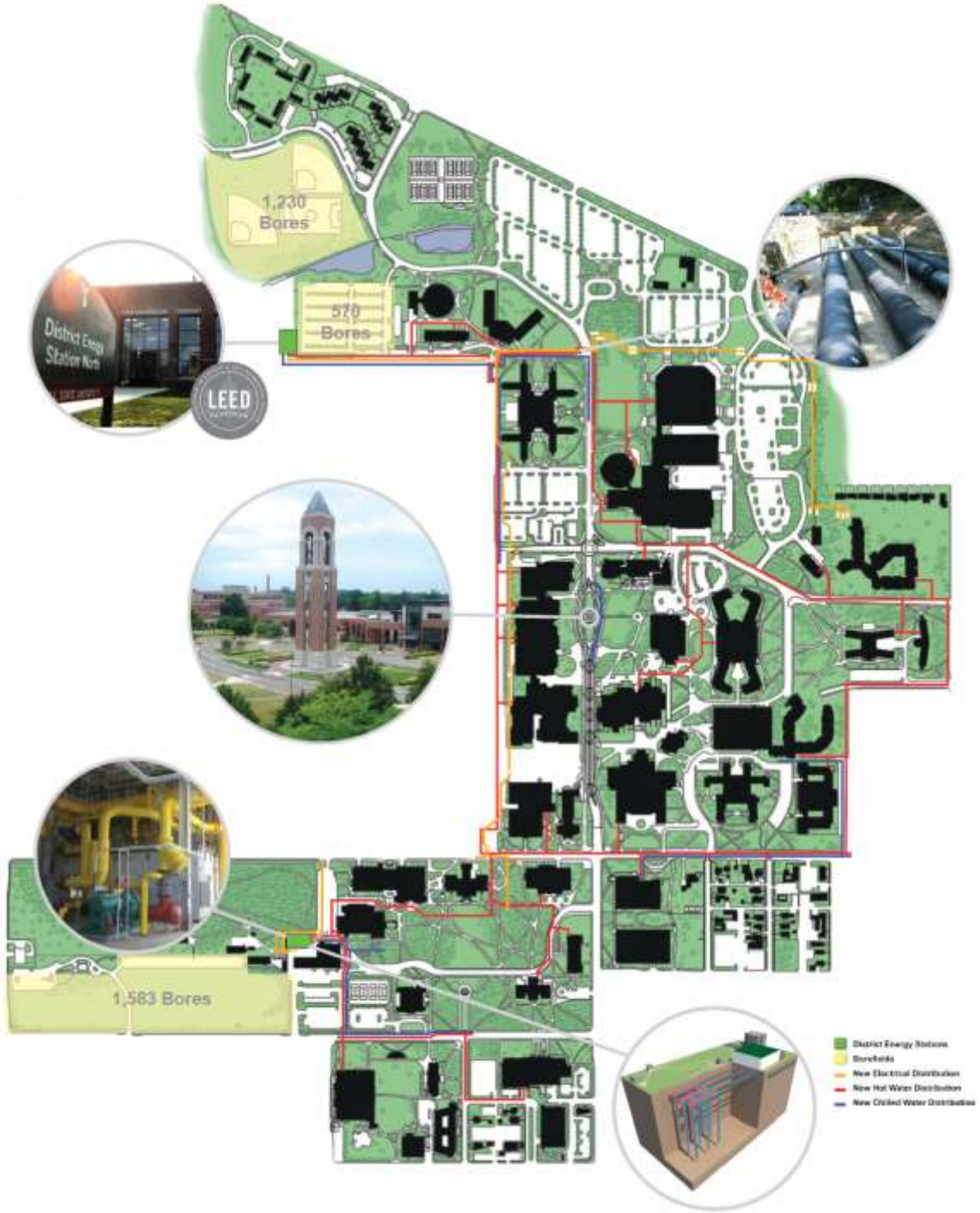
150° Hot Water Temperature



135° Hot Water Temperature

Heat Pump Chillers

- **Centrifugal Chillers**
  - 600 - 2500 Tons
  - Up to 155 F HW temp
  - Up to 170 F HW temp
- **Screw Chillers**
  - 50 to 430 Tons
  - Up to 140 F HW temp
- **Scroll Chillers**
  - Up to 150 Tons
  - Up to 120 F HW temp



Conversion Facts

- 5,600,000 GSF Heating Conversion
- 47 Building Heating Conversion
- Includes 300,000 GSF of Expansion
- 1,800 - 400 ft. Bore Holes
- 1,583 - 500 ft. Bore Holes
- 2 Well Fields
- 152,000,000 BTU/HR Heating
- 150°F HWS
- 20°F HW Delta T
- 10,000 Tons Cooling
- 2 Major Phases

North & South Bore Hole Site

- 3,383 Total Bore Holes
- North Bores completed 2010
- South Bores completed 2014
- Over 1,000 miles of pipe

Bore Hole Construction

Drilling 400/500 Feet

Installing the Pipe

One borehole per day per rig

Bore Hole Design

- 15 feet apart
- 225 SF per borehole
- 400/500 feet deep
- Double and Single Loop
- 1-1/4 inch diameter pipe
- High Density Polyethylene
- **Final borehole drilled October 17, 2014**

District Energy Station – North

Completed June 30, 2011

District Energy Station – North

- 12,000 SF
- (2) 2,500 Ton Compound Centrifugal Compressor Heat Pump Chillers
  - 38,000,000 BTU/HR
- Accessory Components
- 1,000 Ton Fluid Cooler
- Heating - 150° Hot Water
- Cooling - 42°Chilled Water
- LEED Gold Certified

District Energy Station – South

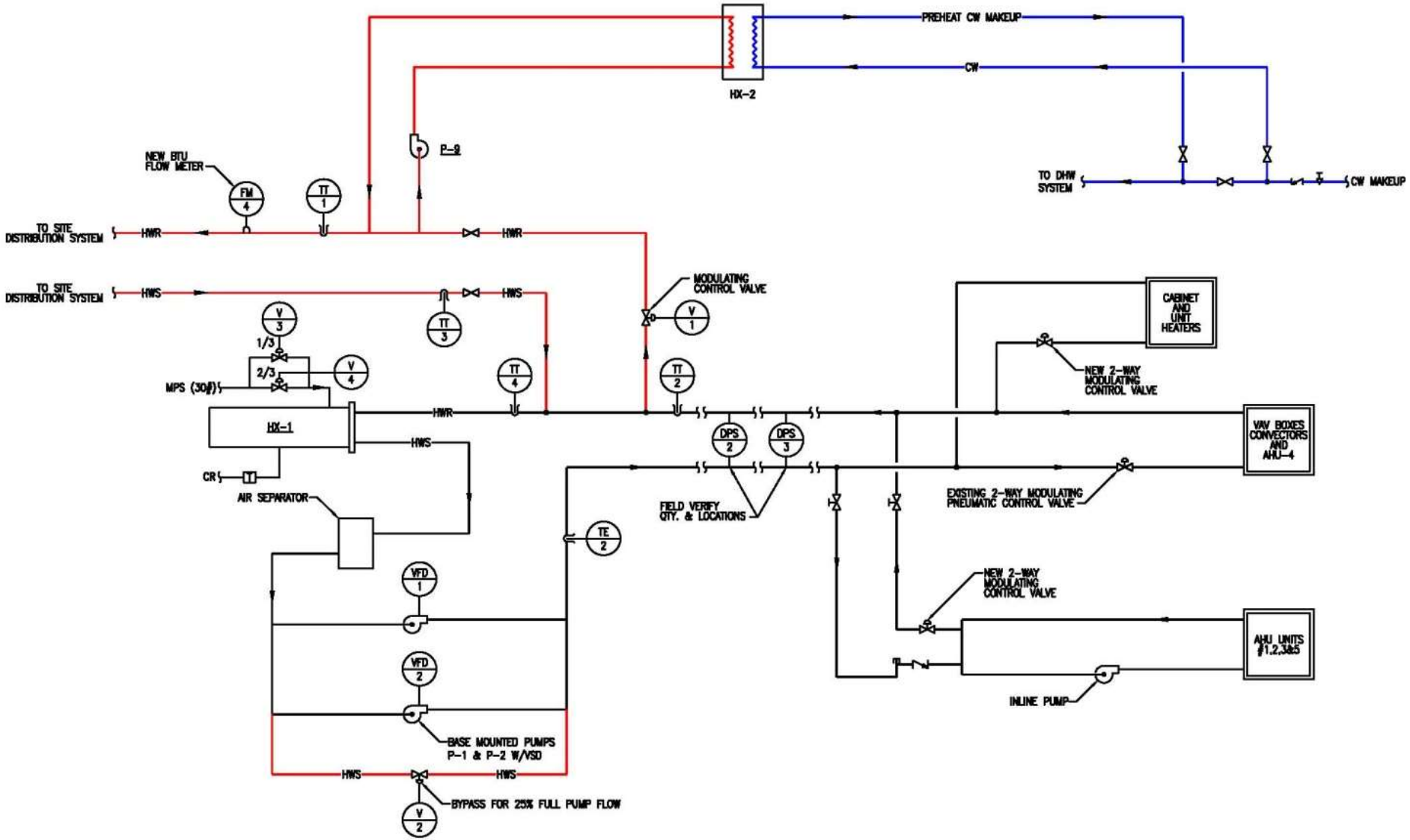
District Energy Station – South

- 16,480 SF
- (2) 2,500 Ton Compound Centrifugal Compressor Heat Pump Chillers
- Accessory components
- (4) 1,000 Ton Cooling Towers
- Reuse (2) existing Water-Cooled Chillers
- Anticipated LEED Silver

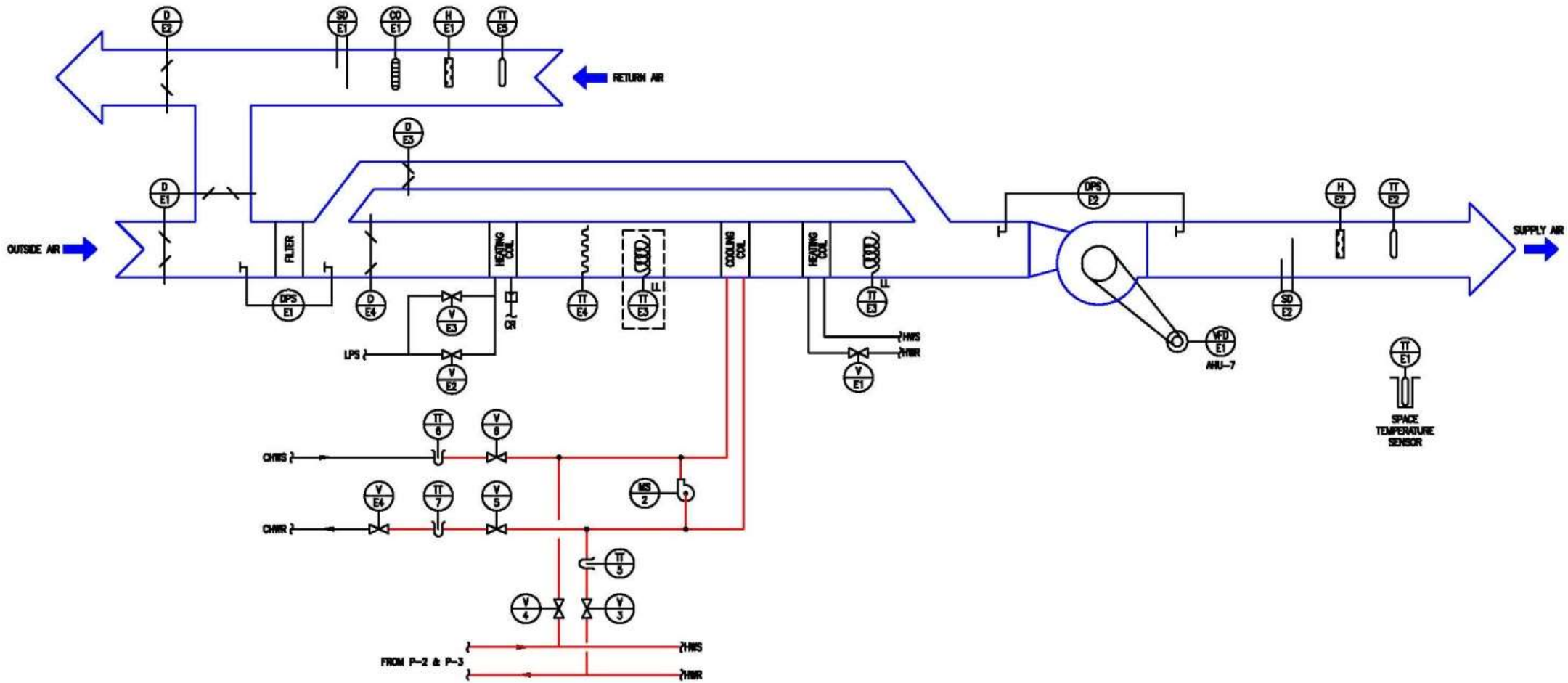
Distribution Utilities

- **8 Utility Packages**
- **10 Miles of Hot & Chilled Water piping installed**

Building Interface Connections



Building AHU Connections



BSU Geothermal Benefits

Reduction in Emissions

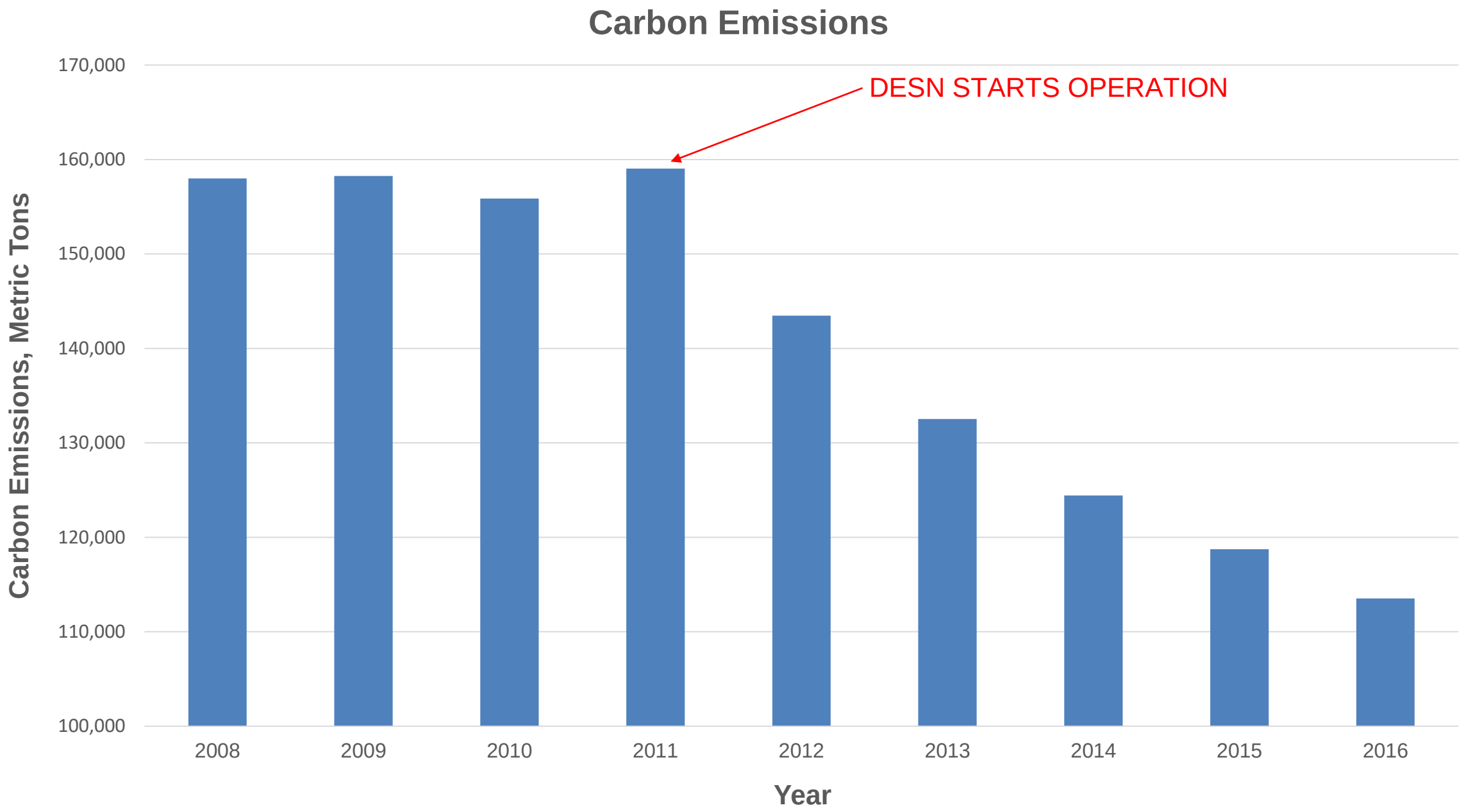
• Carbon Dioxide	75,000 tons
• Sulfur Dioxide	1,400 tons
• Nitrogen Oxide	240 tons
• Particulate Matter	200 tons
• Carbon Monoxide	80 tons
• Coal ash	3,600 tons

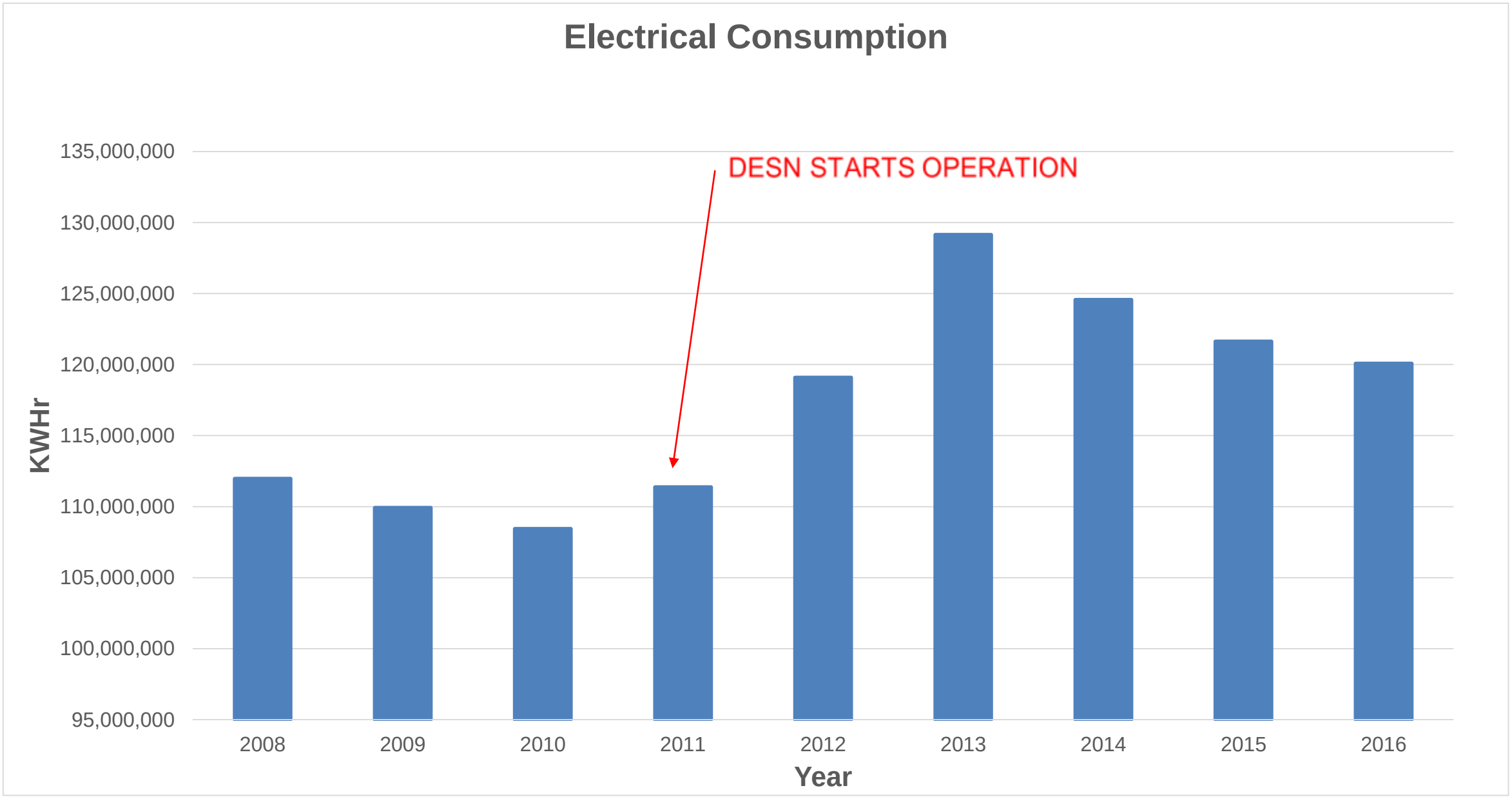
Other Benefits

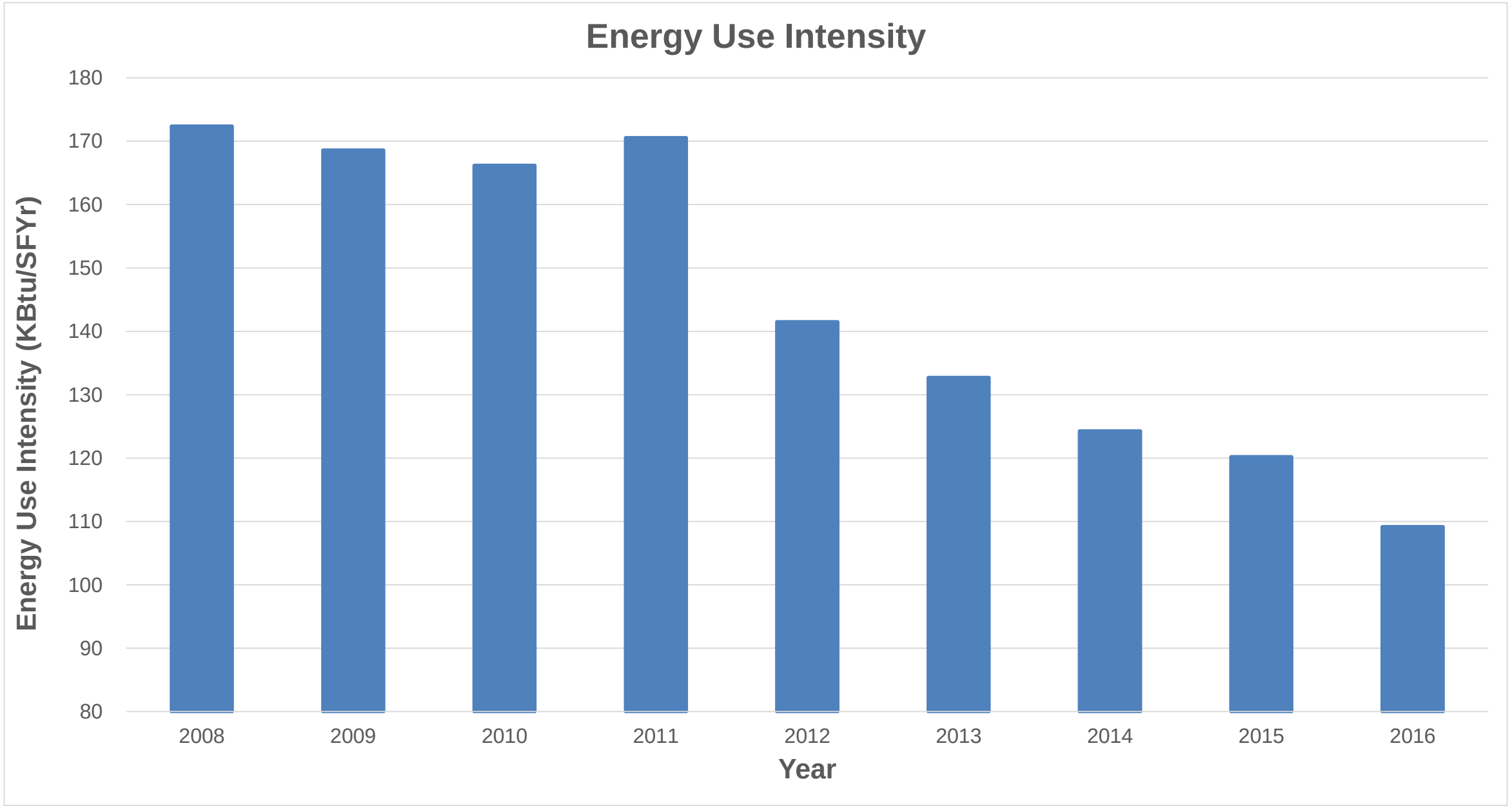
BTUs per year reduction:	500,000,000,000	
BTUs/SF/Year reduction:	175,000 to 105,000	*(FY 15/16: 109,088)*
Water reduction:	45,000,000 gallons	
Dollars Saved:	$2,200,000	

Geothermal Conversion Costs ($ Millions)

Bore Holes	$27
Distribution Pipe	$18
Building HVAC Modifications	$8
District Energy Buildings	$18.4
Heat Pump Chillers	$7.5
High Voltage Improvements	$4
Total Construction Cost	$82.9*
* US Department of Energy	$5
* State of Indiana	$77.9


Carbon Emissions
DESN STARTS OPERATION
Carbon Emissions, Metric Tons
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year


Electrical Consumption
DESN STARTS OPERATION
135,000,000
130,000,000
125,000,000
120,000,000
115,000,000
110,000,000
105,000,000
100,000,000
95,000,000
KWHr
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year


Energy Use Intensity
Energy Use Intensity (KBtu/SFYr)
180
170
160
150
140
130
120
110
100
90
80
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

Lessons Learned

- **Keep the System Clean!**
- **Know your true heating and cooling loads for good balance**
- **Equipment Turn Down & Phasing of Construction**
- **Obtaining Hot Water Delta T at the Buildings**
- **Campus can operate at lower hot water temperature then predicted.**

Purging Equipment

Debris Moved from Well Field

Questions?

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