Salas O'Brien

Decarbonization Planning Meeting

Salas O'Brien Introduction

Decarbonization • Electrification •
Energy Master Planning

October 25, 2024

Introductions

Essi Najafi

Managing Principal

Mike Walters, PE

Principal, District Energy Market Leader

Quick Salas O'Brien Stats

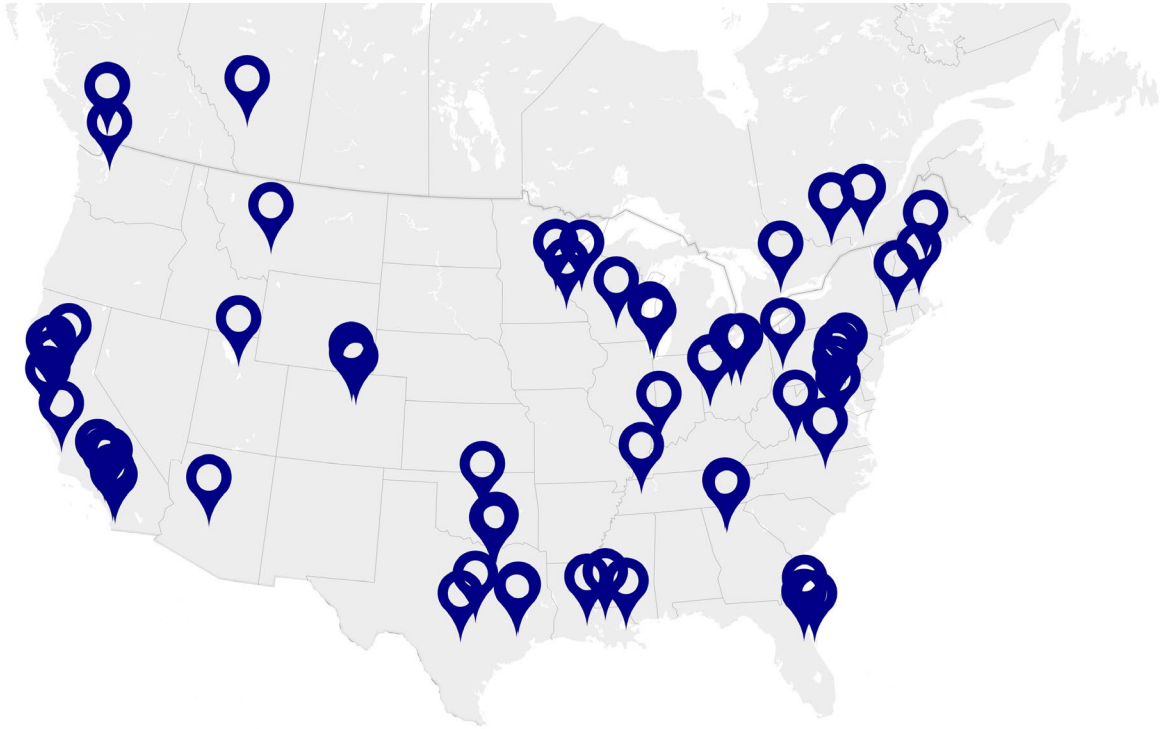
90+
OFFICES

3,800+
TEAM MEMBERS

~50
YEARS IN BUSINESS

90%+
ANNUAL RETENTION RATE

Local Everywhere, International Resources



MEP GIANTS 2024 #9

#3 BUILDING DESIGN + CONSTRUCTION TOP 70 ENGINEERING FIRMS 2024

2024 ENR TOP 150 GLOBAL DESIGN FIRMS #79

Inc. 5000 12x HONOREE 2024 AMERICA'S FASTEST-GROWING PRIVATE COMPANIES

Hot Firm 2024

Energy Services

BUILDING SIMULATION

- Computational Fluid Dyanmics
- Fire and Smoke Simulation
- Daylighting Simulation
- Shading Analysis
- Building Component Thermal Analysis

ENERGY MODELING

- "Shoebox" Modeling
- LEED Energy Modeling
- Energy Utility Analysis

ENERGY ASSESSMENT

- Life Cycle Cost Analysis
- Energy Audits
- Energy Conservation Measures

LEED & SUSTAINABILITY

- LEED Charrette
- LEED Design and Documentation

RENEWABLE/ SUSTAINABLE ENERGY

- Photovoltaic Systems
- Solar Thermal Systems
- Wind
- Bio-solids
- Geothermal
- Wastewater Heat Recovery

NET ZERO

- Energy Reduction
- Energy Efficiency
- Renewable Energy Sources

Critical Markets That Impact Everyday Life & Improve the Human Experience

Healthcare

Data Centers & Telecom

Science & Technology

Food & Beverage

Pharmaceuticals

Industrial Manufacturing

Transportation

Education

K-12
Higher Education

Commercial

High-Rise
Mixed-Use
Multi-Family
Retail
Corporate
Tenant
Improvement
Hospitality

Government

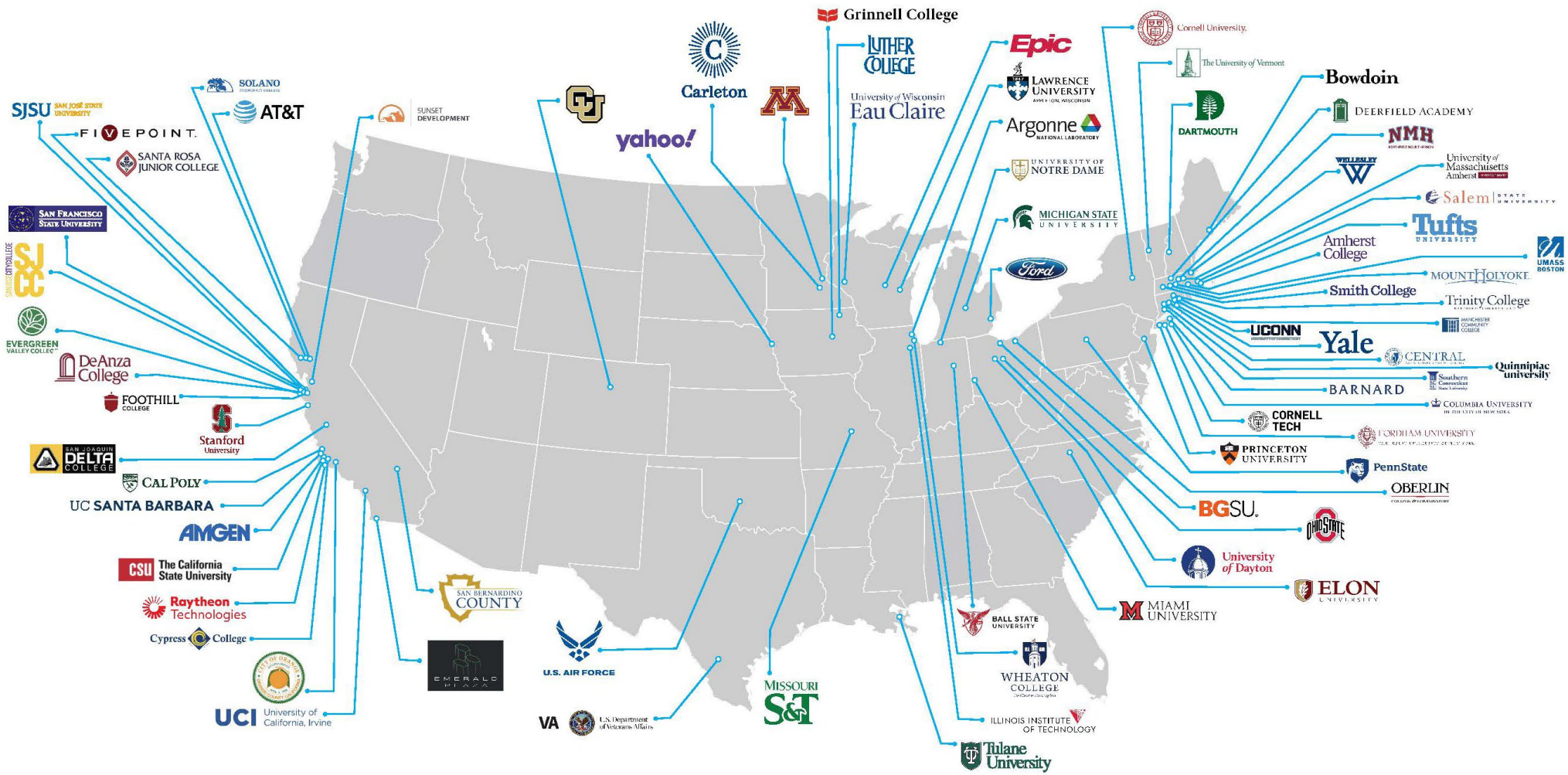
Federal
Military
State & Local

Venue

Entertainment & Arts
Sports
Theme Parks

MEP Prime Term Contract
Georgetown University

Decarbonization + Energy Planning



Cogeneration ■ Decarbonization/Electrification ■ Geothermal System Conversions ■ Utility & Energy Master Plans

Utility Framework ■ Carbon Mitigation ■ Campus Distributive Energy Studies ■ Campus Conversions

Technical Delivery and Project Examples

1. What to invest in

2. How to deliver it

BAU Development Data, Criteria, Vision → Evaluations of Options → Modeling and Scenario Testing → Recommendations & Implementation

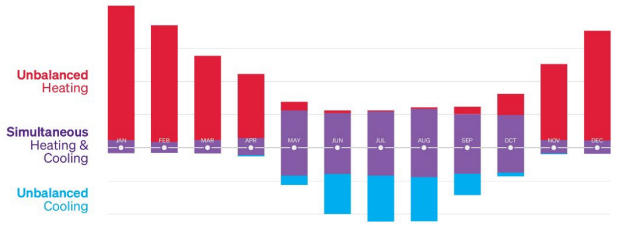
Financial + Operational

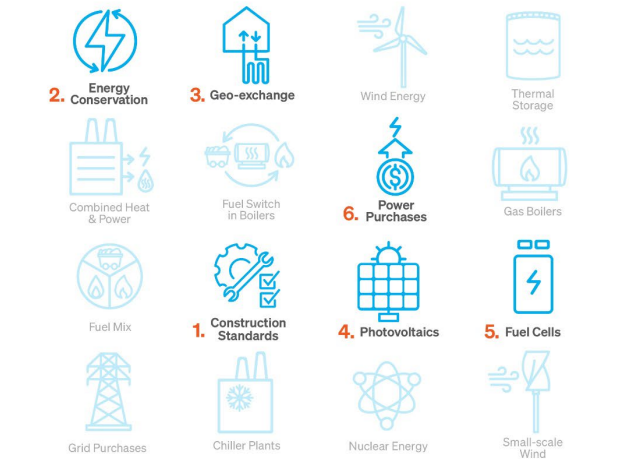
- Annual O & M
- Capital Renewal
- Greenhouse Gas Emissions
- Fiscal Constraints
- Life-cycle Cost of Ownership

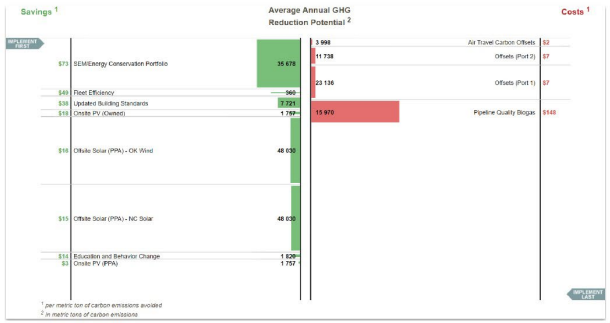
Strategic Plan

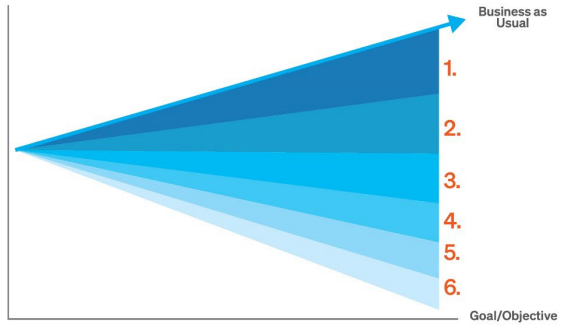
Campus Development

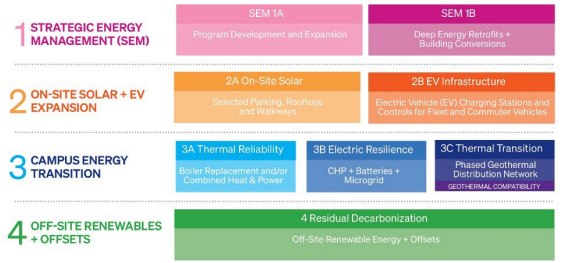
- Greenhouse Gas Emissions
- Fiscal Constraints

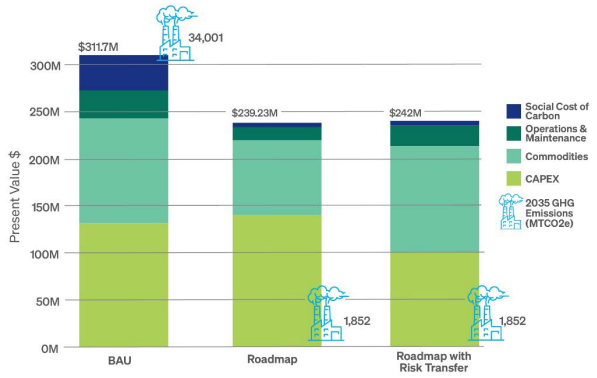


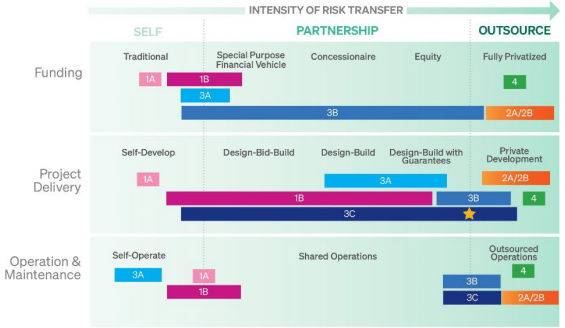


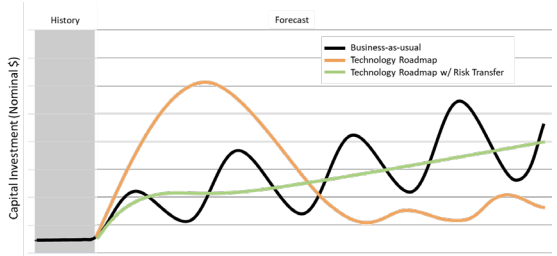




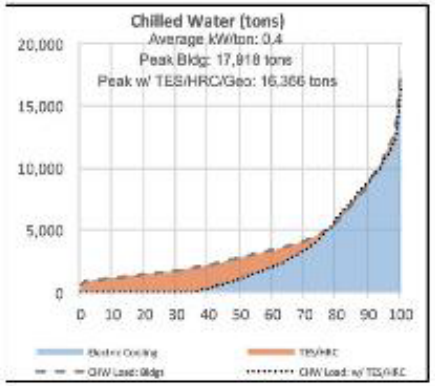


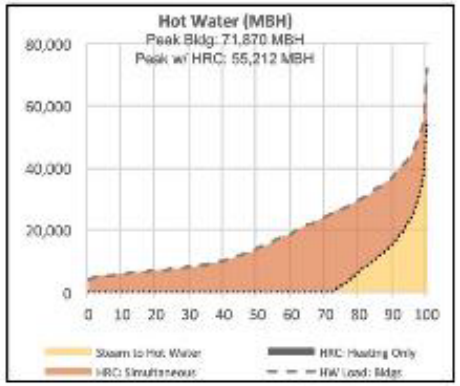


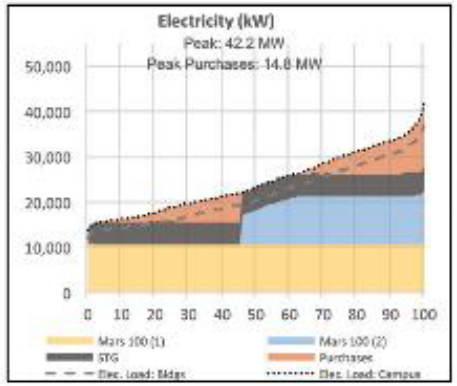


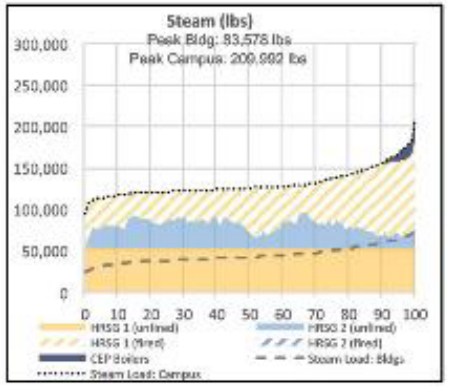


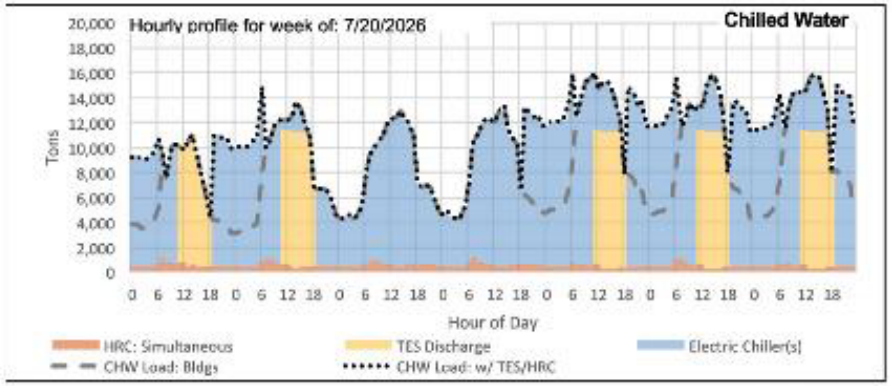
Loads and Asset Dispatch Modeling

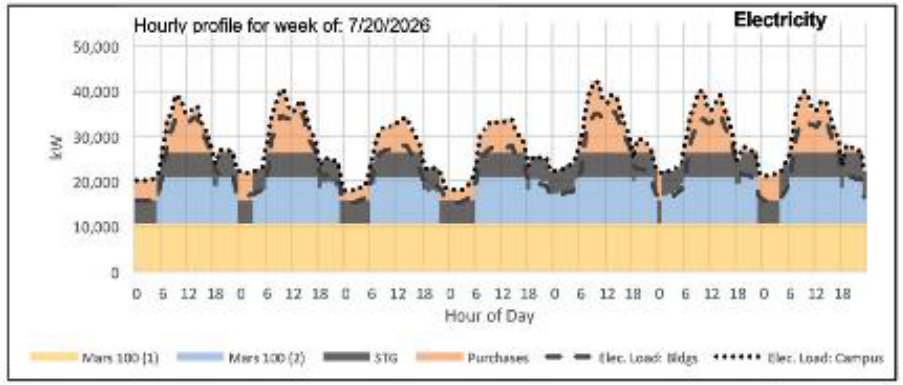


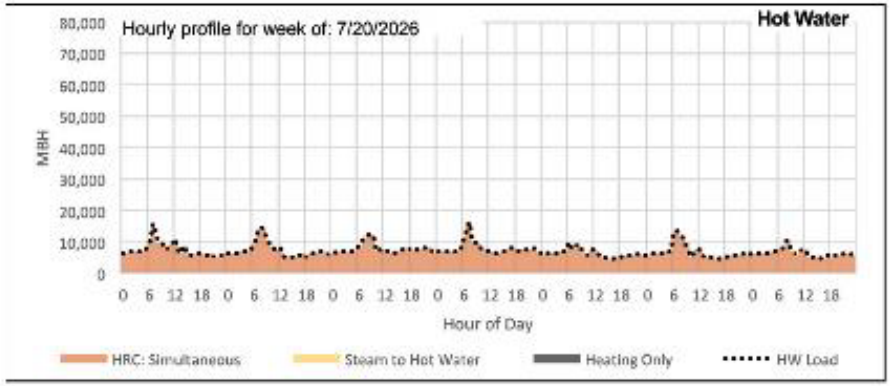


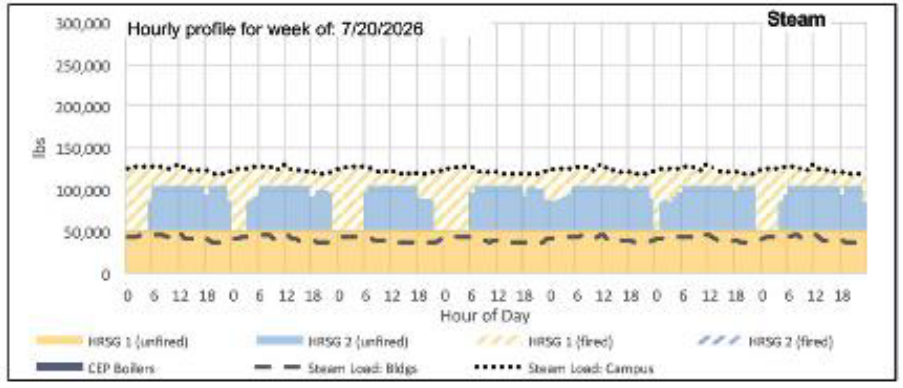




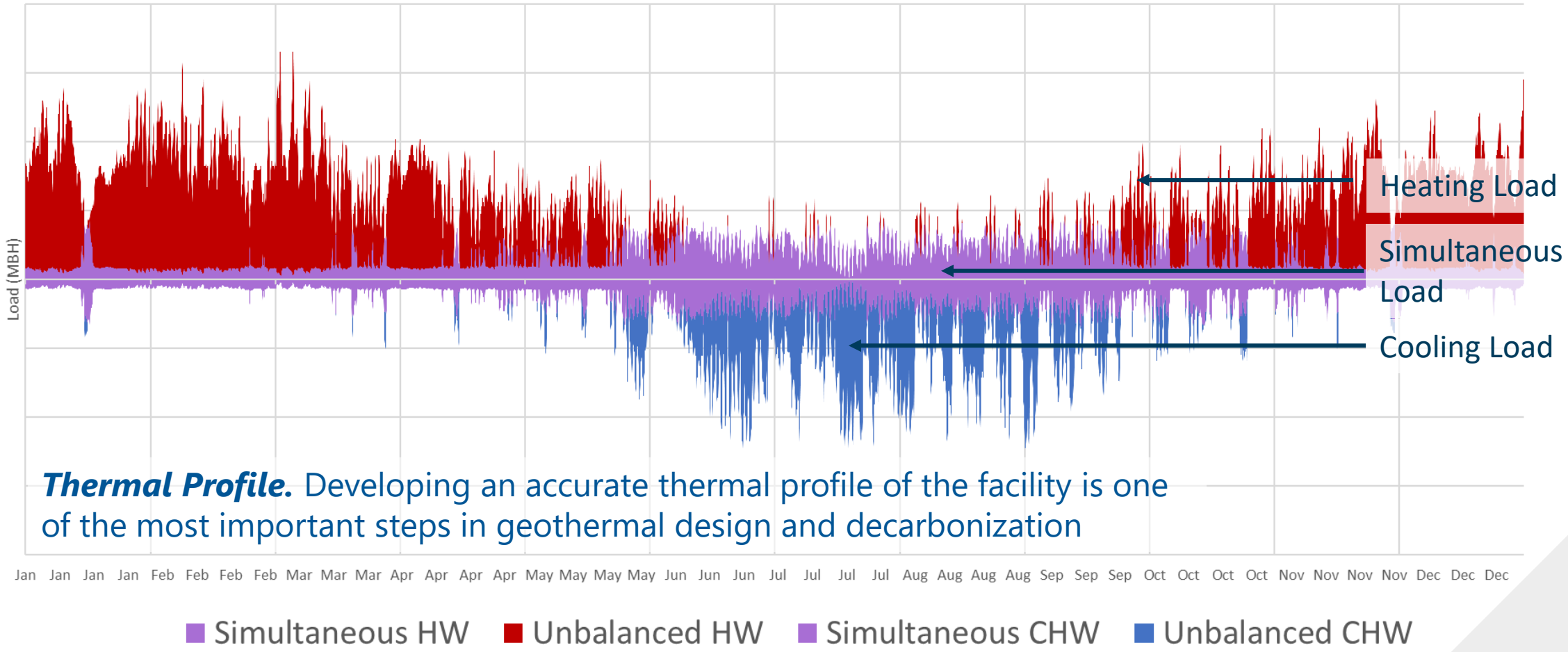






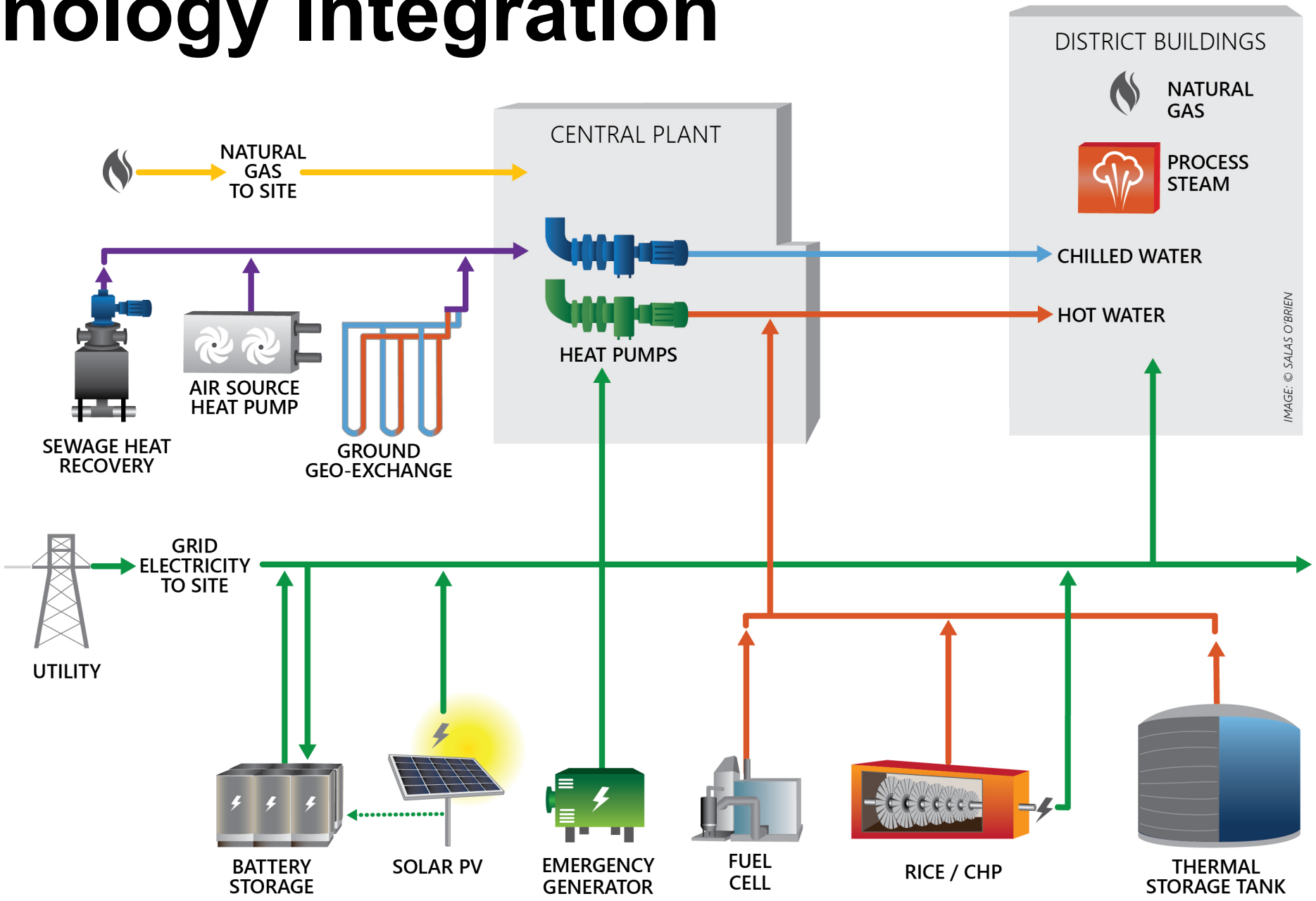


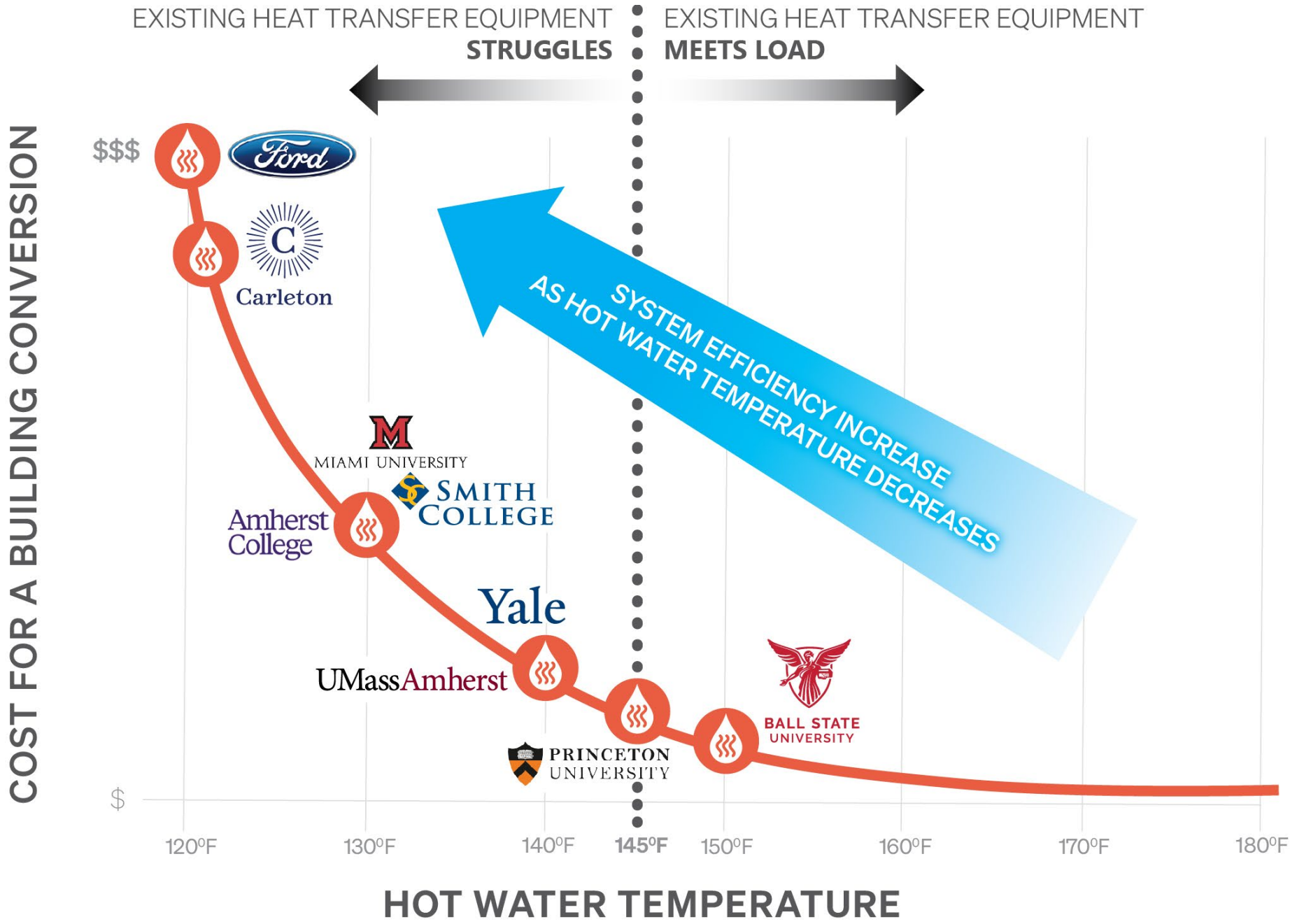
Facility Thermal Profile



Thermal Profile. Developing an accurate thermal profile of the facility is one of the most important steps in geothermal design and decarbonization

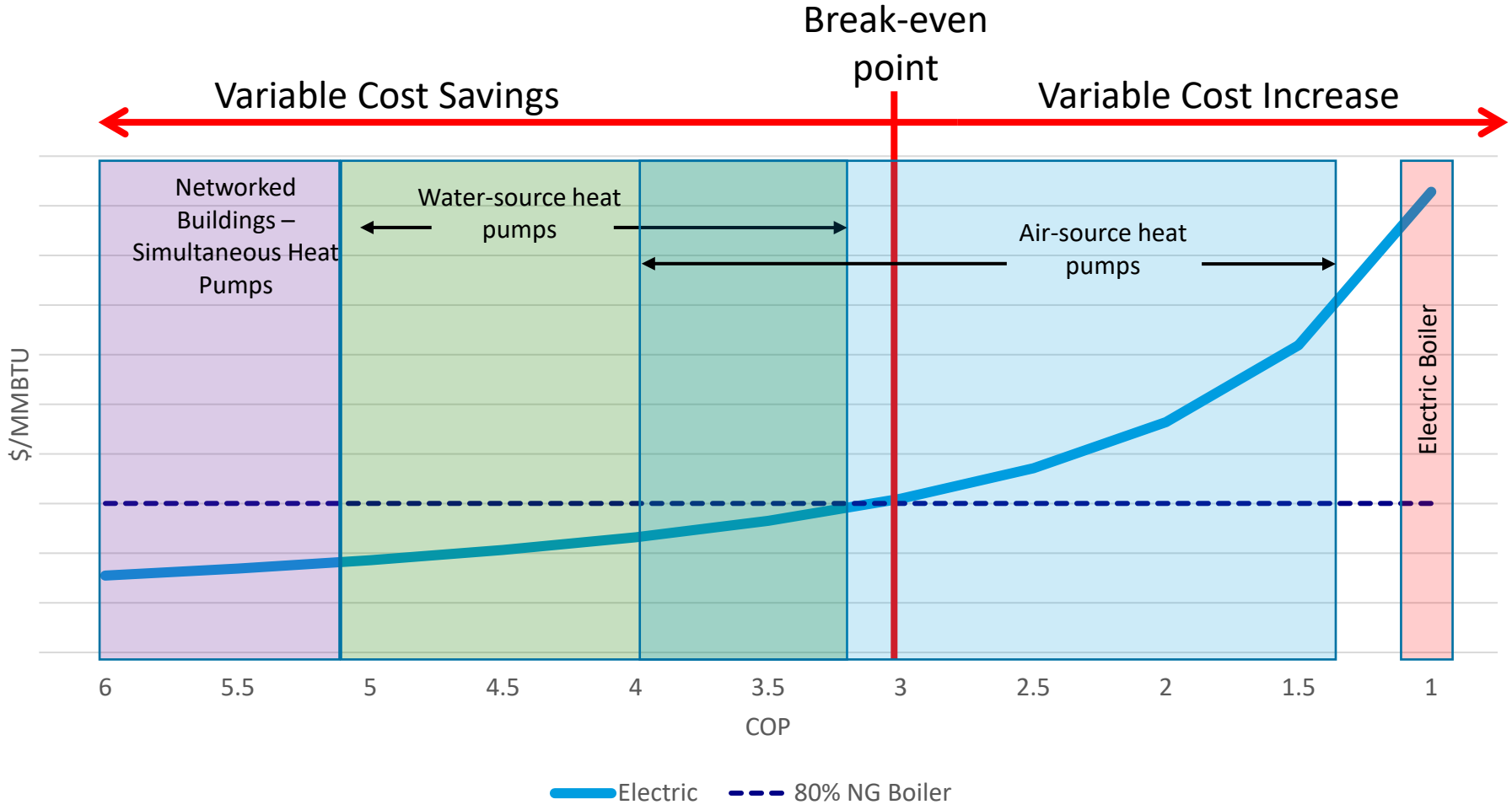
Technology Integration




EXISTING HEAT TRANSFER EQUIPMENT
STRUGGLES
EXISTING HEAT TRANSFER EQUIPMENT
MEETS LOAD
$$$
$
COST FOR A BUILDING CONVERSION
Ford
Carleton
MIAMI UNIVERSITY
SMITH COLLEGE
Amherst College
Yale
UMassAmherst
PRINCETON UNIVERSITY
BALL STATE UNIVERSITY
SYSTEM EFFICIENCY INCREASE
AS HOT WATER TEMPERATURE DECREASES
120°F
130°F
140°F
145°F
150°F
160°F
170°F
180°F
HOT WATER TEMPERATURE

Supply Side Measures - Variable Energy Cost vs. COP

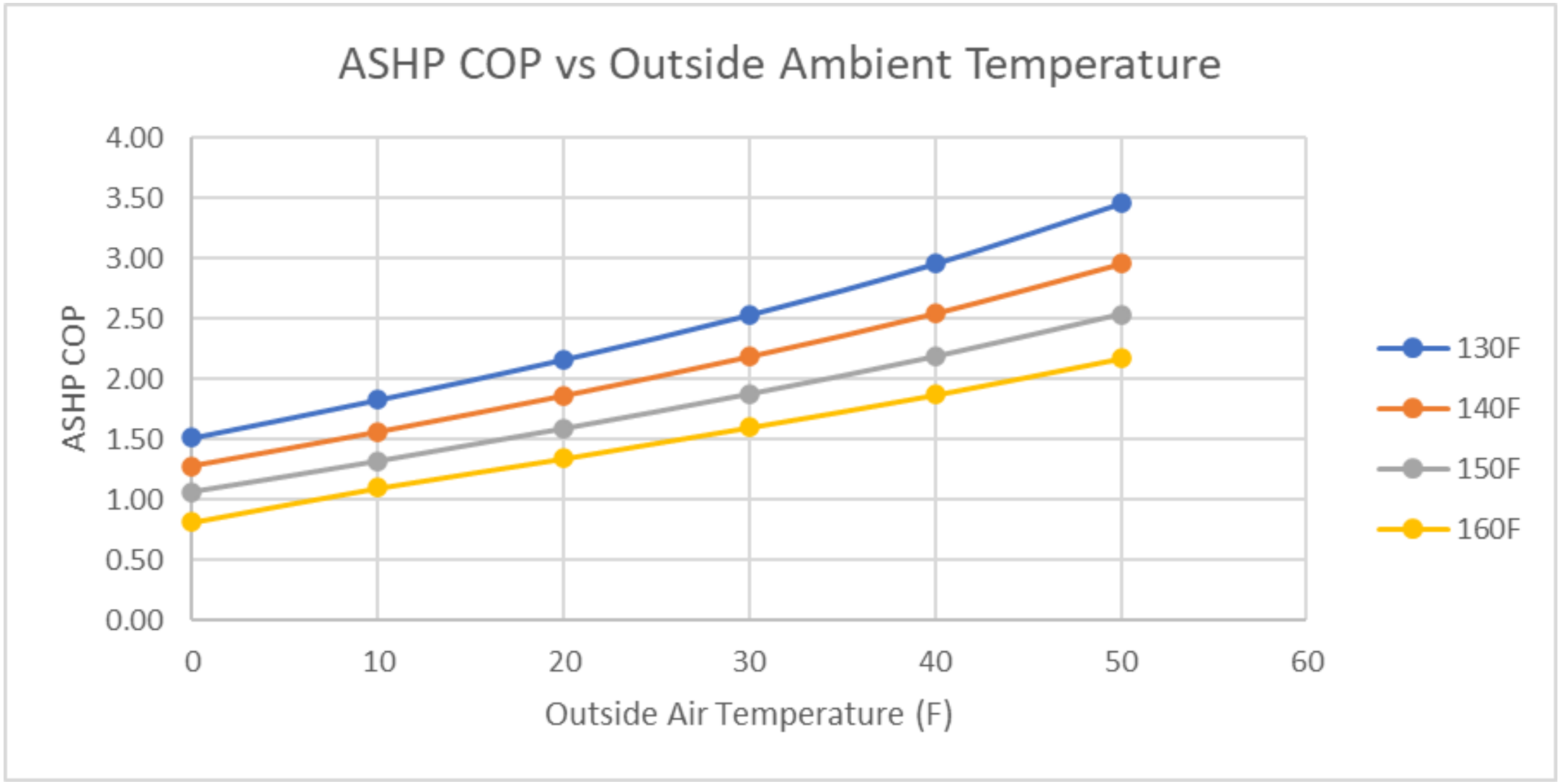
Example Electrified Technologies vs. Fossil Fuel Baseline



The **Coefficient of Performance (COP)** is a measure of the efficiency of heating, cooling, or refrigeration systems. It represents the ratio of useful heating or cooling output to the amount of energy input required.

For heating systems: $\mathrm{COP} = \frac{\text{Heat Output (kW or BTU)}}{\text{Energy Input (kW or BTU equivalent)}}$

For cooling systems: $\mathrm{COP} = \frac{\text{Cooling Output (kW or BTU)}}{\text{Energy Input (kW or BTU equivalent)}}$


ASHP COP vs Outside Ambient Temperature
ASHP COP
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
10
20
30
40
50
60
Outside Air Temperature (F)
130F
140F
150F
160F

CO2 Heat Pump

- Heat source: Air or Water
- Heat transfer: Air, water or combined

  Air: Best efficiency
  - Lower compressor energy
  - No pumping energy

  Lower installation cost
  - No pumping station
  - Smaller diameter piping compared to water (3 to 1 ratio)

  Water: Packaged units
  - No pressure piping outside of the unit
  - No refrigerant outside of the unit

- Operating modes: Heating; cooling or simultaneous

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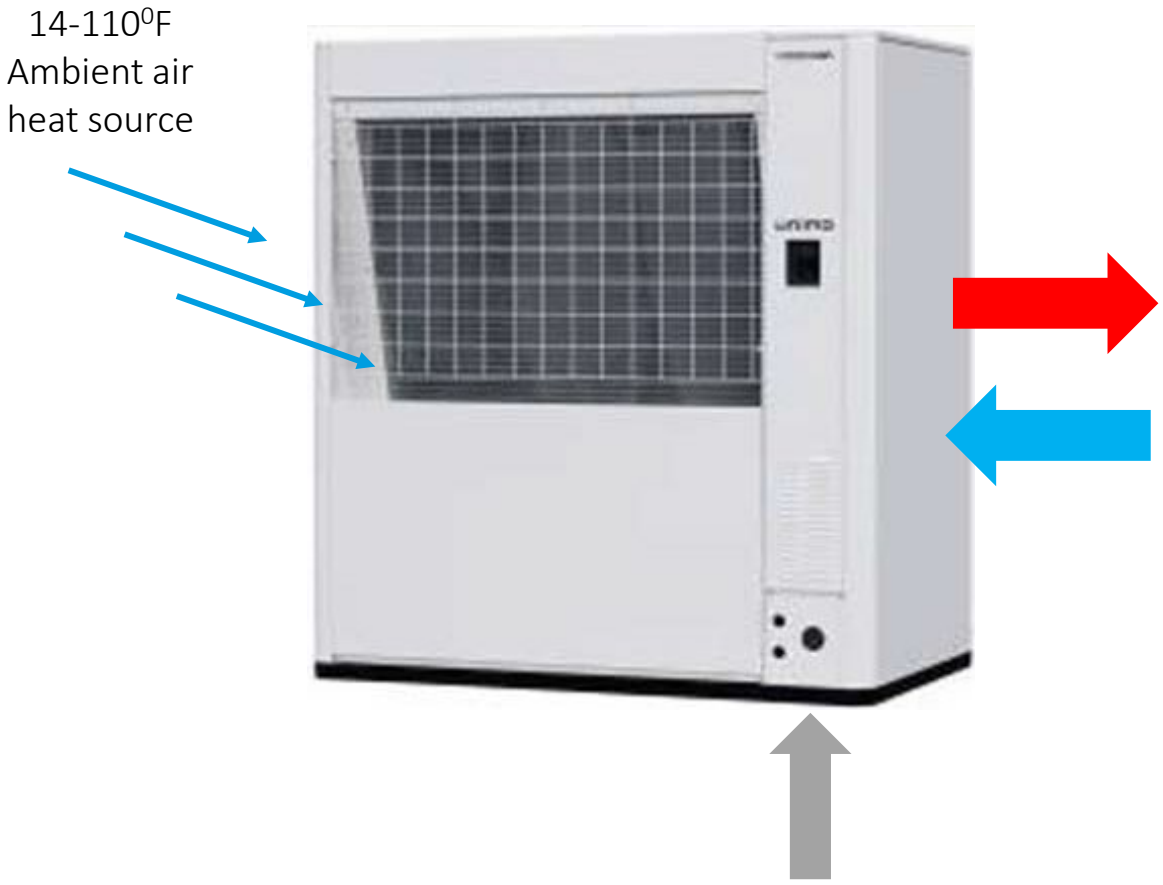
Air source CO_2 Refrigerant Heat Pump



- 80^0-100^0 kW heating capacity
- 149^0-194^0 F hot water supply
- Warm-up from start to 149^0 F in less than 30 seconds
- VFD for compressor and evaporator fans to maintain optimum performance
- Rugged outdoor cabinet
- Rapid defrost cycle for low temperature ambient conditions

CO2 Heat Pump Unit Project Performance – Domestic Water Application

- 74kW (252,500 btu/hr) heating capacity
- 75 F inlet water / 194 F outlet water (130 F to use)
- 51 kW (14.5 TR) cooling capacity
- 44 F chilled water outlet / 54 F chilled water inlet
- 24.9 kW power consumption (460/3/60)

194 F hot water outlet condition:

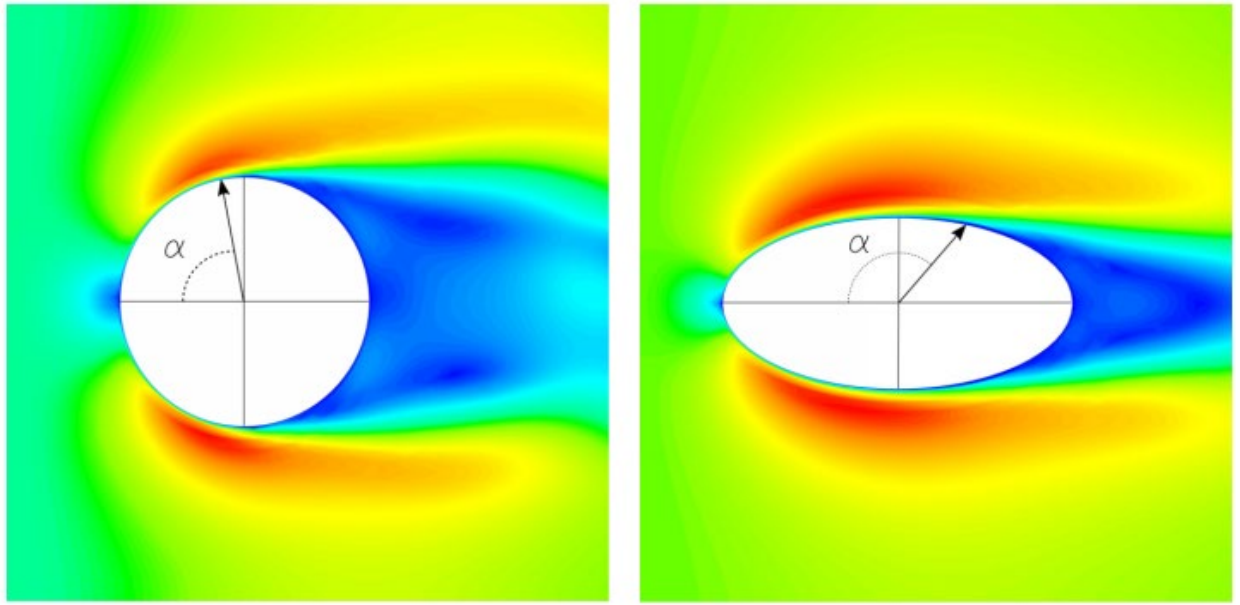
- Unit heating COP: 2.95
- Unit cooling COP: 2.04
- Unit combined COP: 4.99

149 F hot water outlet condition:

- Unit heating COP: 3.47
- Unit cooling COP: 2.55
- Unit combined COP: 6.02

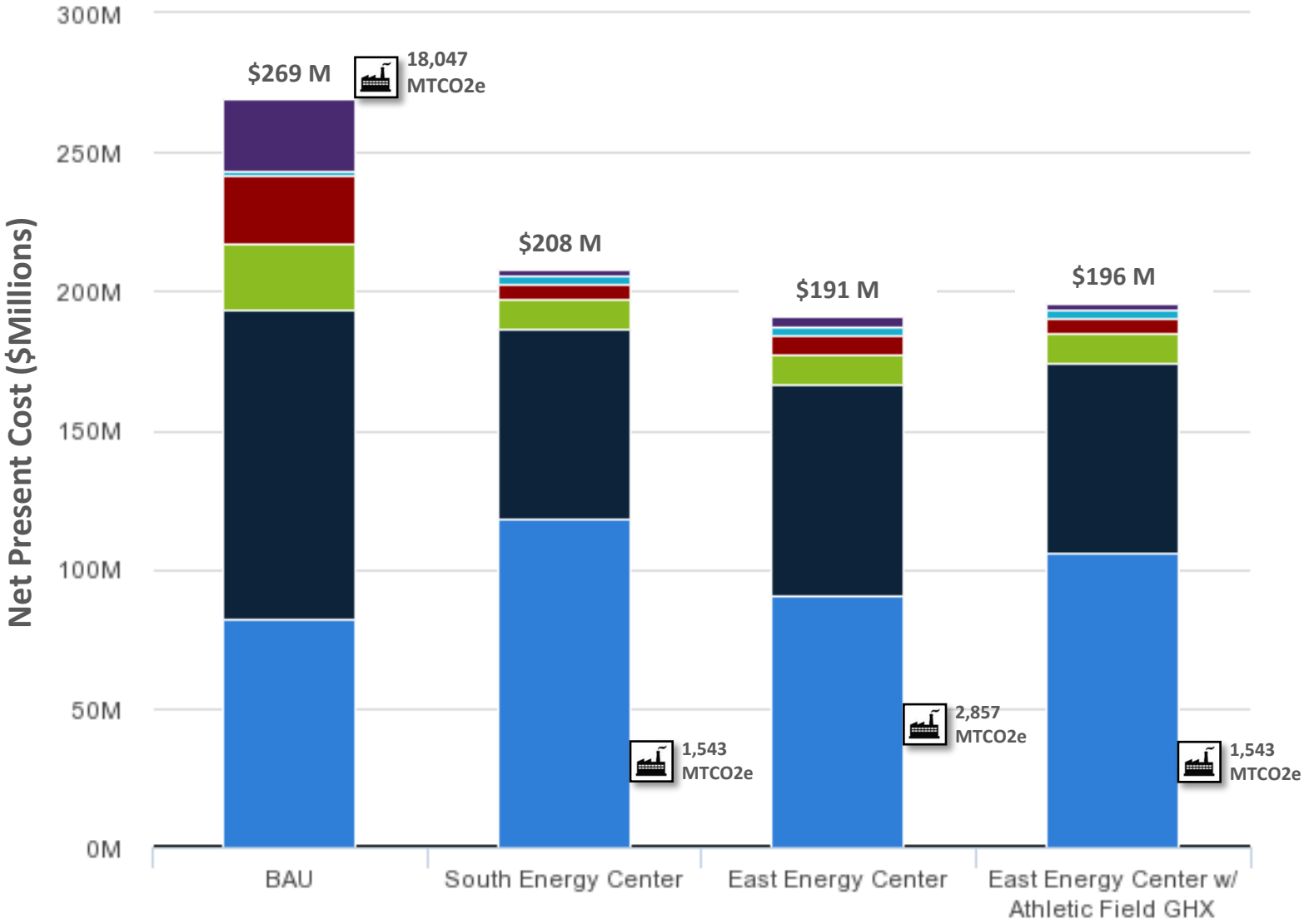
Round verses oval heating/cooling coils

Description	Round Tube Coil	Oval Tube Coil
Tube Diameter (in.)	0.625	0.500 (base stock)
FH x FL x Depth	55.5 in. x 84 in. x 6.0 in.	55 in. x 84 in. x 4.33 in.
Number of Coils per Bank	4	4
Fin Type	Waffle	Oval Raised Lance
Fins per Inch	11.5	10
Number of Feeds	19	44
CFM	76000 ACFM	
Entering Air Temps (DB/WB)	120°F/67°F	
Gallons per Minute	284 GPM	
Entering Water Temp	63°F	
Capacity	3,083,000 Btu/hr	3,073,000 Btu/hr
Water Pressure Drop	5.4 Psi	5.4 Psi
Air-side Pressure Drop	**0.47 in. H_2O**	**0.285 in. H_2O**



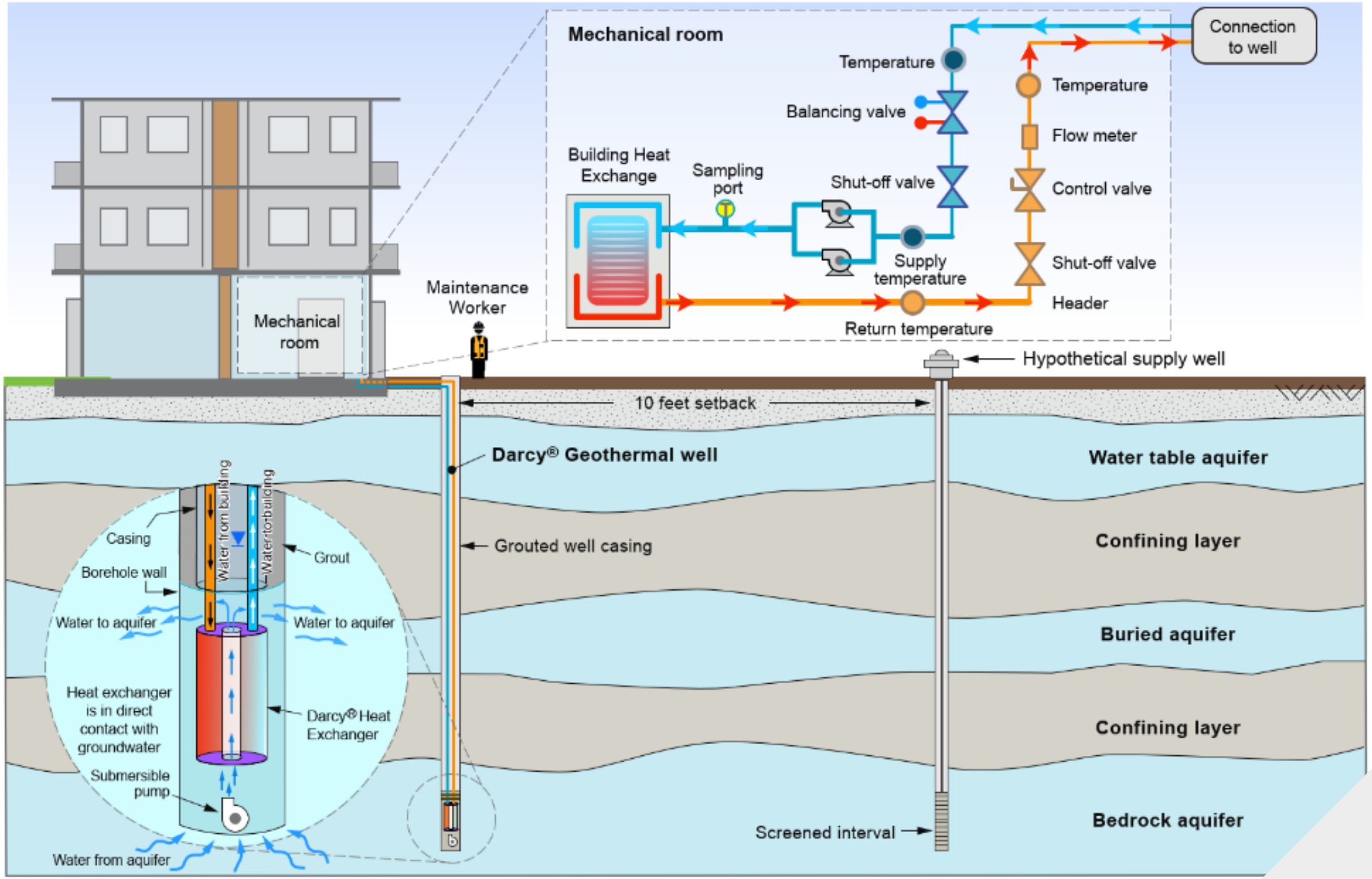
40% less fan energy, with the same heat transfer!

Life Cycle Cost Comparison

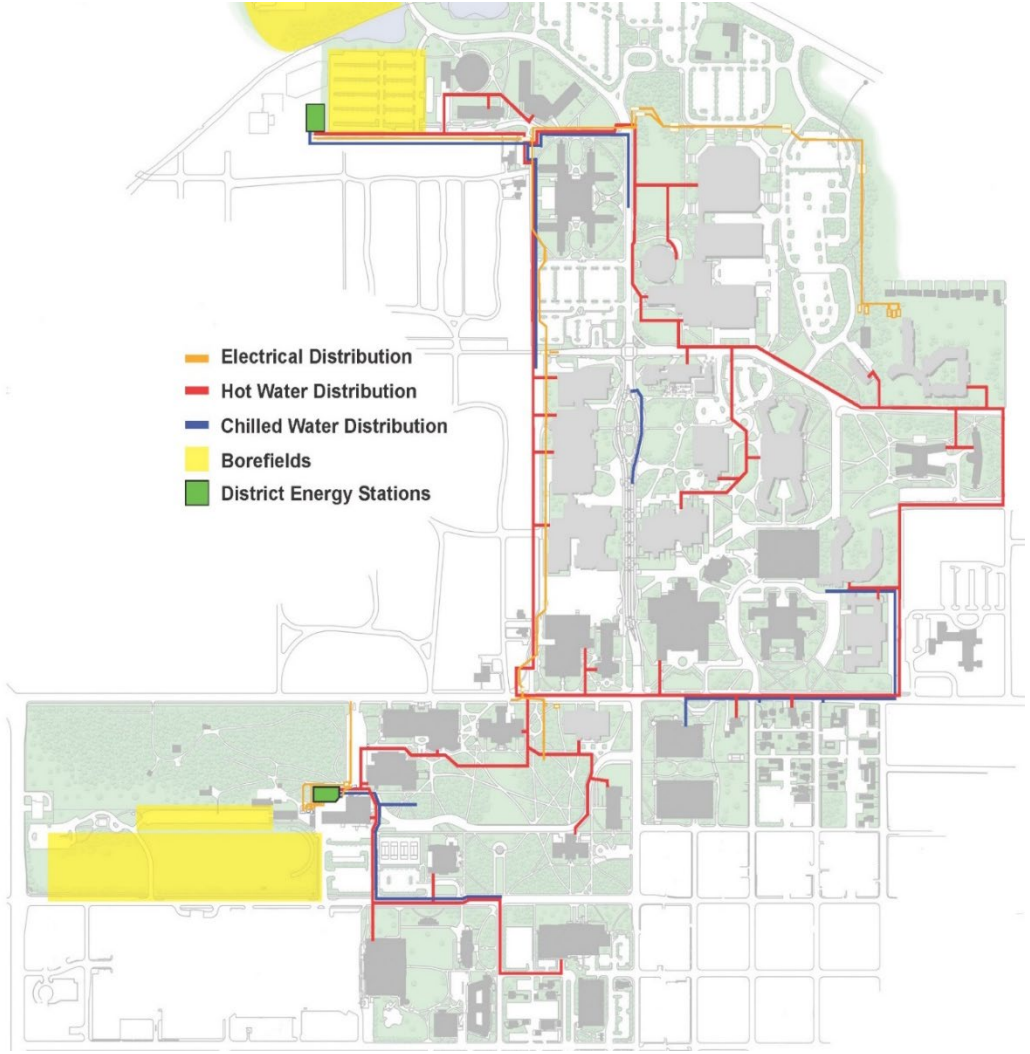


- Cost of Offsets
- Renewable Electricity
- Carbon Tax
- Operations & Maintenance
- Commodities
- Capital Expenditures
- 2030 Scope 1 & 2 GHG Emissions

$MTCO_2e$ = Metric Tons of Carbon Dioxide Equivalent
DEMP = District Energy Master Plan
AEC = Alternative Energy Certificates
GHG = Greenhouse Gas Emissions


Mechanical room
Temperature
Balancing valve
Building Heat Exchange
Sampling port
Shut-off valve
Supply temperature
Return temperature
Temperature
Flow meter
Control valve
Shut-off valve
Header
Connection to well
Maintenance Worker
Mechanical room
Hypothetical supply well
10 feet setback
Darcy® Geothermal well
Grouted well casing
Water table aquifer
Confining layer
Buried aquifer
Confining layer
Bedrock aquifer
Screened interval
Casing
Water from building
Water-to-building
Grout
Borehole wall
Water to aquifer
Water to aquifer
Heat exchanger is in direct contact with groundwater
Darcy® Heat Exchanger
Submersible pump
Water from aquifer

Ball State Geothermal Conversion



CLIENT
Ball State University

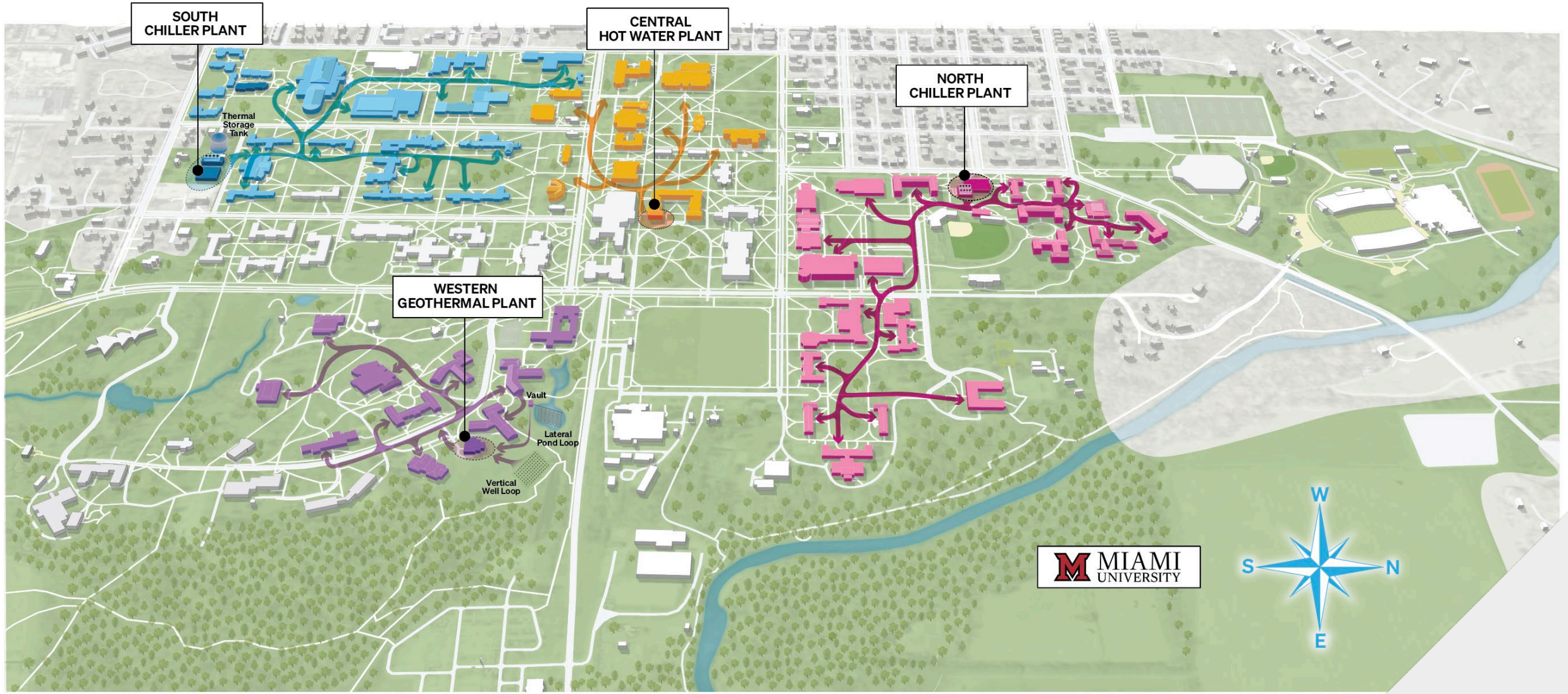
SERVICES
Geothermal conversion

LOCATION
Muncie, IN

YEAR
2017

- Electrified with heat pumps, steam to low temperature hot water
- The University has cut its carbon footprint in half and realized over $2M in annual energy savings
- This system provides heating and cooling for 47 campus buildings comprising of 5.6M square feet

Programmatic Progress to Neutrality

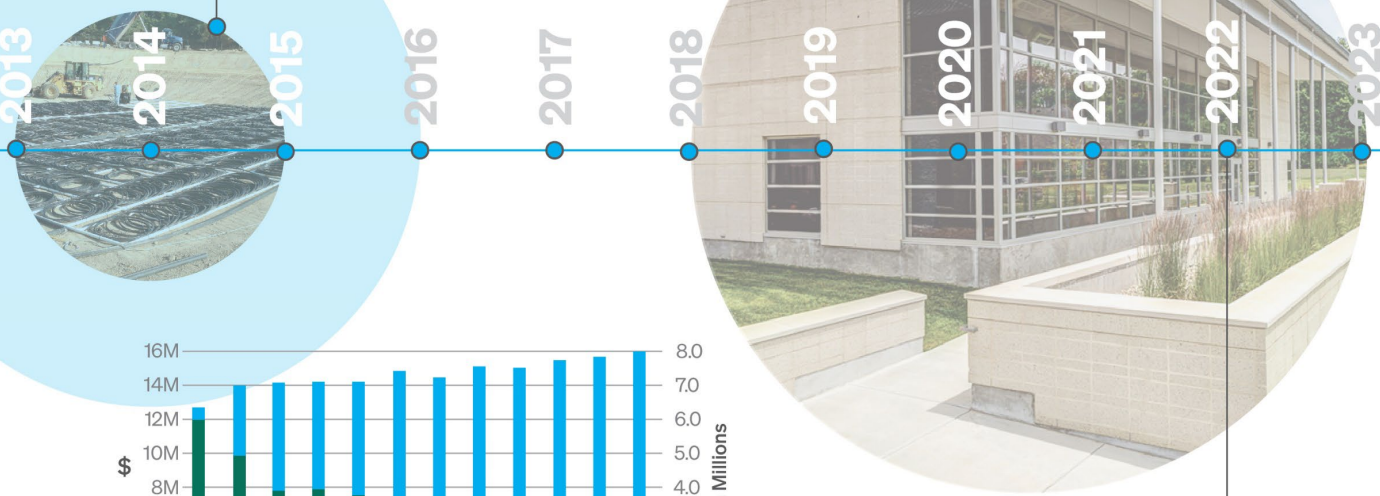


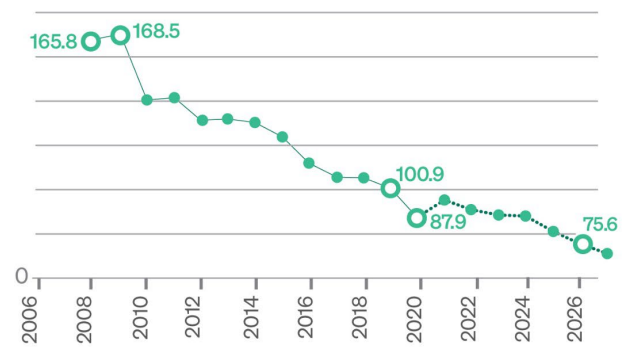
Miami University Master Planning

Project 1:
Western Campus Geothermal Infrastructure Phase 1 & 2

Project 2:
North Chiller Plant and East Quad Infrastructure & Renovations

Project 3:
South Quad Hot Water Conversion





Drastic Energy Use Intensity Reduction (KBTU/SF/YR)
Resulted in a 56% reduction in carbon emissions

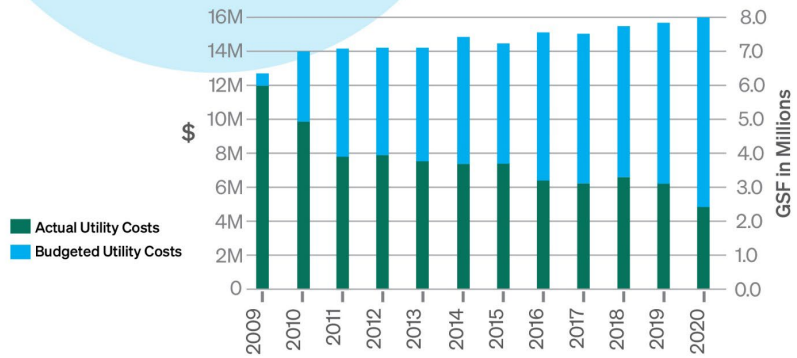
2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026

Project 4:
Central Quad HHW Conversion

Project 5:
Expand Western Geothermal to all Western Buildings

Project 6:
North Chiller Plant Conversion to Geothermal

Project 7:
Steam Plant Conversion to Heating Hot Water



Consistent Improvement in Annual Utility Costs
Ongoing project implementation over the last 15 years, across 8M GSF

Decarbonization in an historic setting

CLIENT

Smith College

SERVICES

Master plan, geothermal

LOCATION

Northampton, MA

YEAR

Master Plan 2019

Implementation in progress

- Campus energy master plan for achieving carbon neutrality by 2030
- Steam to low-temperature hot water conversion, supported by a 500 bore geothermal vertical heat exchanger
- Conversion of 90 historical buildings

Merging Sustainability with Historical Preservation in School Renovation

CLIENT

DC Department of General Services

LOCATION

Washington, DC

SERVICES

Mechanical, Electrical, Plumbing

YEAR

2023

- Modernization of 85,000 SF Historic Raymond Elementary School
- Over 100 geothermal wells, solar canopies, and energy-efficient systems integrated
- Targeting LEED Gold and Net Zero Energy certifications


Solar Array
Historic Steam Plant
Water Source
Loop Field
Thermal
Energy Storage
Central Energy Plant
Geosource Borefield

Questions?