U.S. DEPARTMENT of ENERGY | Federal Energy Management Program

Thermal Energy Networks: Sharing Resources for Resiliency and Efficiency

T04-S04, August 6th, 2025

FEMP Summer CAMP (Courses Aligned with Mission Priorities)

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MEP + Energy Practice Leader

CDM Smith

Agenda

- Session Learning Objectives
- Thermal Energy Networks
- Thermal Energy Network Design & Implementation Considerations
- Sharing Resources for Resiliency
- Conclusion and Q&A

Session Learning Outcomes

1. Identify the components and benefits of thermal energy networks, including geothermal, heat recovery, and thermal storage solutions
2. Recognize the role of thermal networks in improving energy efficiency and resilience in building portfolios
3. Evaluate site-specific opportunities and challenges for deploying thermal energy networks
4. Recognize system modeling techniques to assess feasibility and performance of thermal energy solutions

Eric Nyenhuis

Director, Energy Consulting

Southland Industries

Thermal Energy Networks

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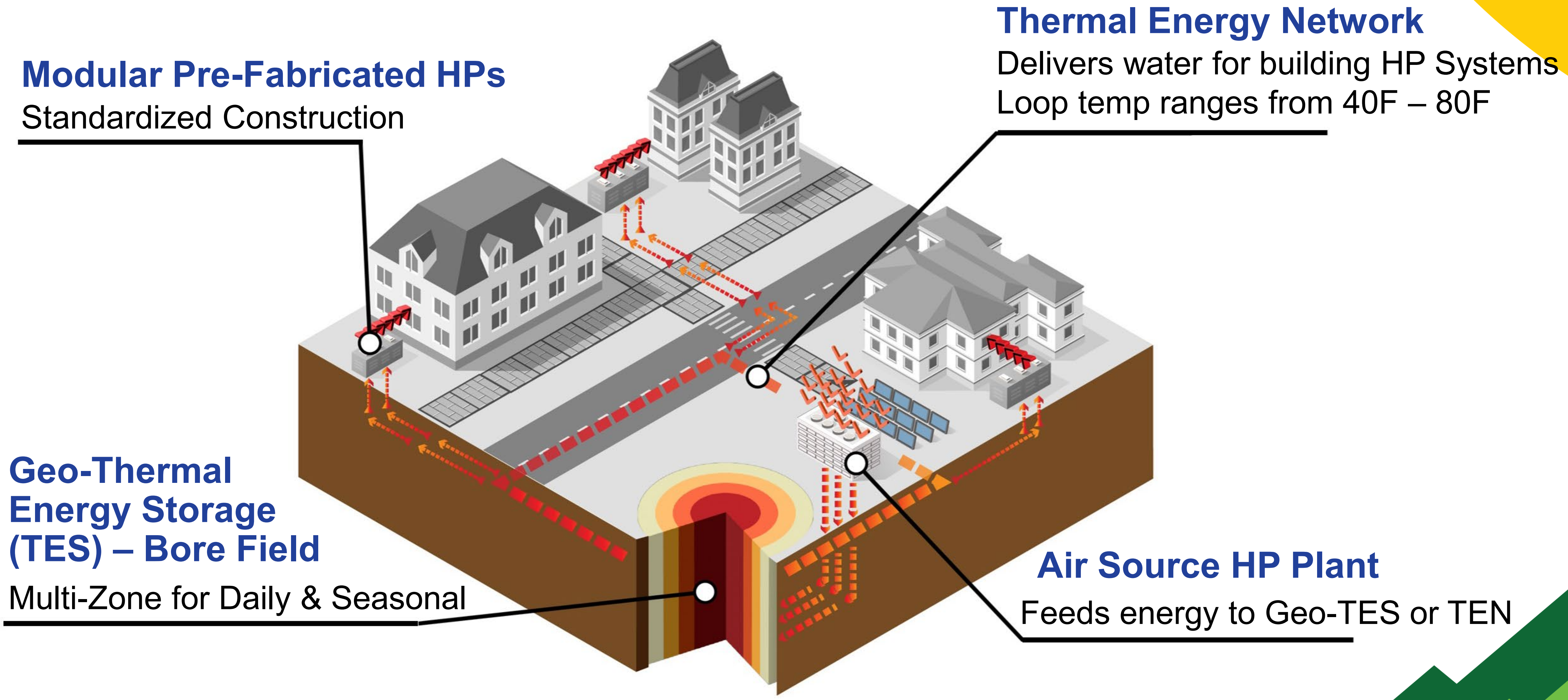
Agenda

- What is a Thermal Energy Network (TEN)
- Lawrence Berkeley National Laboratory (LBNL)/Southland TEN Study
- Developing Topics

What is a Thermal Energy Network (TEN)?

What is a Thermal Energy Network?

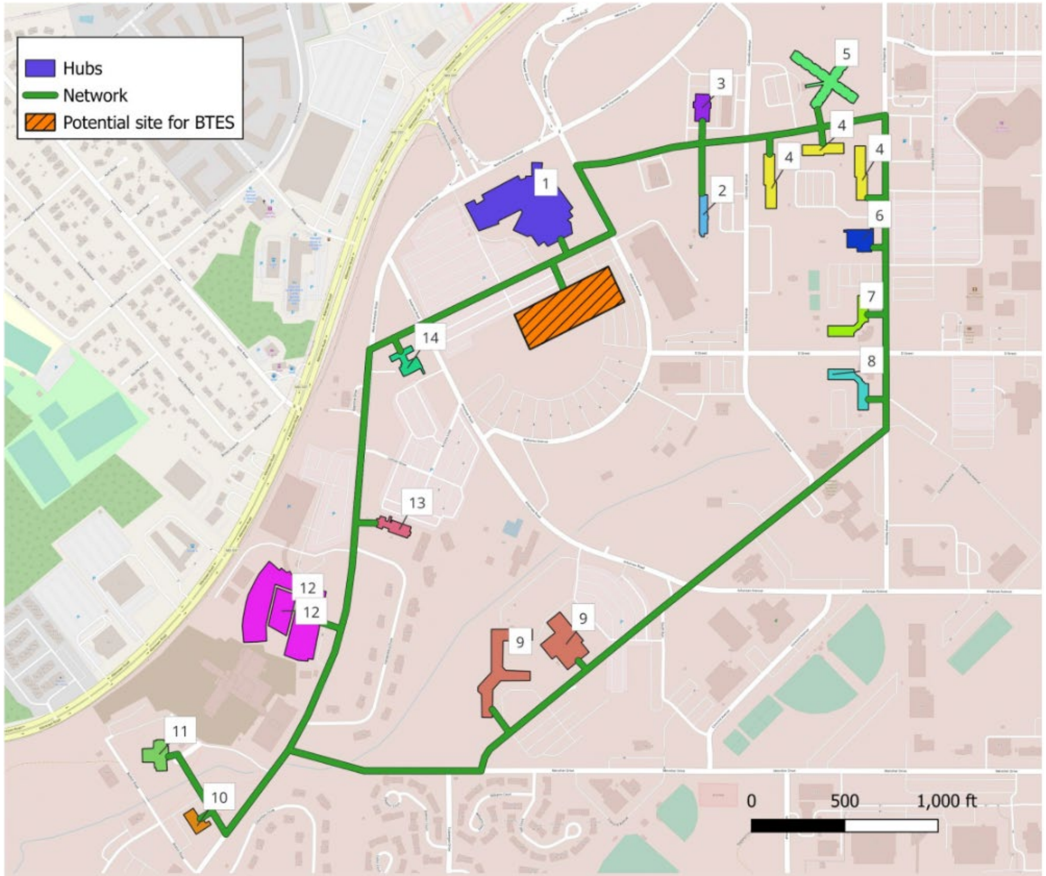


LBNL/Southland TEN Environmental Security Technology Certification Program (ESTCP) Feasibility Study

Joint Base Andrews

LBNL/Southland ESTCP Study (EW23-BB-7686)

- A TEN uses an ambient loop and heat pumps to connect buildings and energy storage systems
- High energy efficiency and resilience
- Increased energy supply security
- Flexible use of renewable energy resources
- Financially viable staged investments
- Replicable assessment process recognizing every TEN is unique
- Near real-time model of optimal alternative to test proposed design decisions



Analyzed thermal energy network (TEN) at JBA

Feasibility Study Elements

Building Assessment / Energy Efficiency

- Baseline metering data
- Building design data
- Building models (eQuest)
- Energy conservation measures (ECMs)
- Building deficiencies

Conceptual (MILP)

- Building heating, ventilation, and air conditioning (HVAC) upgrades
- TEN Loop configurations
- Preliminary costs
- Energy rates
- Escalation
- Incentives/grants

Detailed (Modelica)

- Optimal alternatives
- First principal model
- Simulate control strategies
- Functional assessment
- Sensitivity analysis

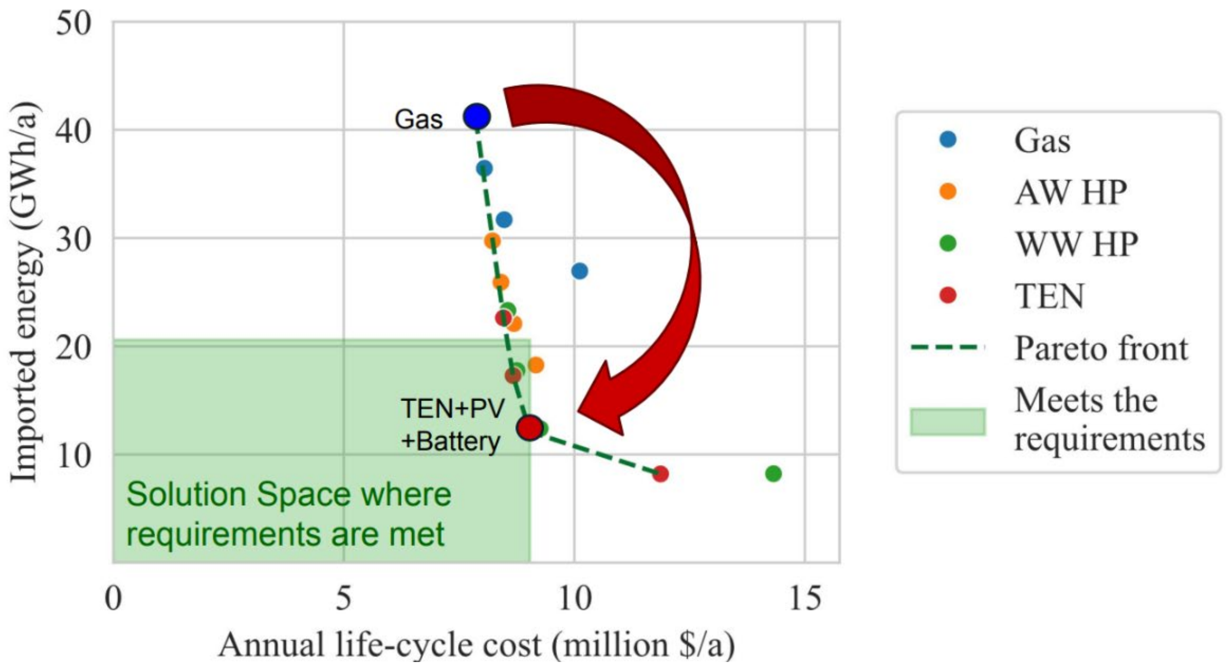
Findings

1. Energy efficiency in non-HVAC equipment changes was 12% (envelope, lighting, controls)

2. Selected alternative configuration was TEN + photovoltaic (PV) + battery

3. Selected alternatives resulted in 45% peak demand reduction and 70% energy use index (EUI) reduction

4. LCC of TEN 115% vs reference case (without external benefits)



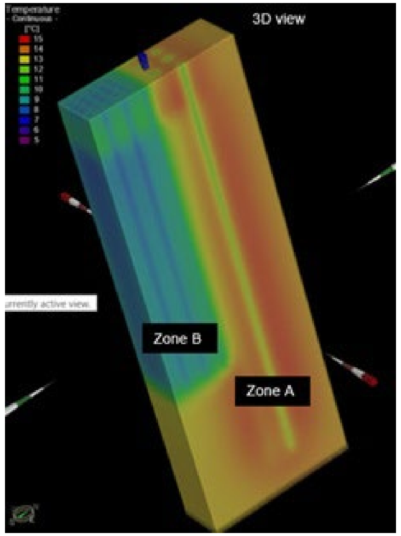
Benefits

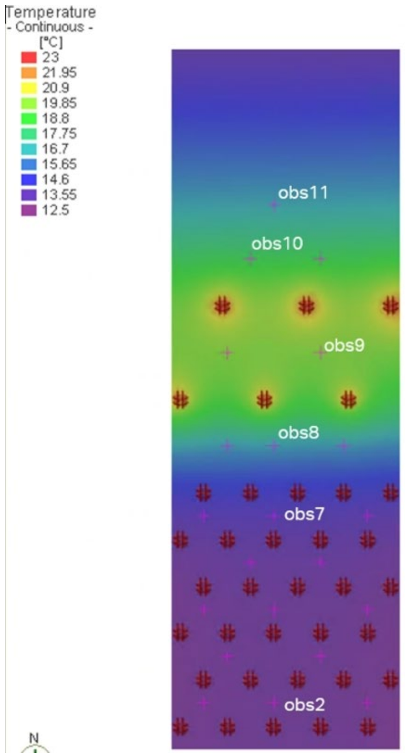
- Low energy intensity → resilience
- Ground or thermal storage → resilience
- Low-cost future operation
- Flexible operation with storage allows for easier integration of other renewable or cogeneration resources the “hybrid” effect
- Standardization of modular HP systems simplifies operations and maintenance (O&M), diagnostics, repair, and replacement (R&R) (operational resilience)

Ongoing Development

Developing Topics

Bore Field Design





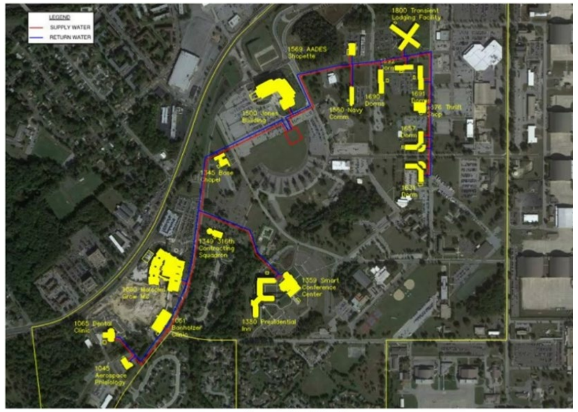


Figure 1: Tree Network

Network Configuration

- Network piping configuration
- Use of existing fuel heating sources for peaking
- Integration with existing building systems
- Approach to prefabrication
- Bore field design/operational strategies
- Federal acquisition ownership contract structure

Related Project Work

Project	Parties	Status
West Point Geothermal Source Heat Pump (EW25-A2-8866)	Southland Industries; American Water	Awarded for FY26
Heat Pump Design Guide/Digitized Workflow (EW25-A8-8639)	LBNL; Pacific Northwest National Laboratory (PNNL); Construction Engineering Research Laboratory (CERL); Southland Industries; Building Intelligence Group (BIG)	Awarded for FY26
Marine Corps Logistics Base (MCLB) in Albany, GA - Geo-TES Demonstration (EW-201135)	Respec; Kitzworks	Completed
GABESS Case Studies: Baker Lake, Nunavut, north of the Arctic Circle, City of Vernal, UT	Respec	Completed

Sam Gerber, PE

Mechanical Engineer, CDM Smith

Thermal Energy Network Design and Implementation Considerations

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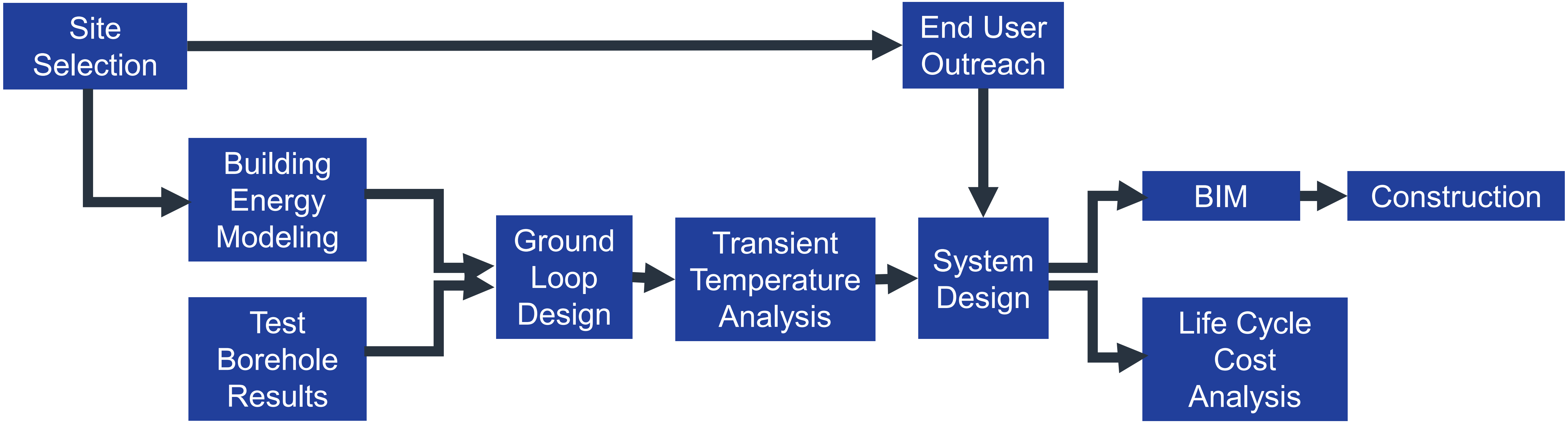
TEN Project Lifecycle



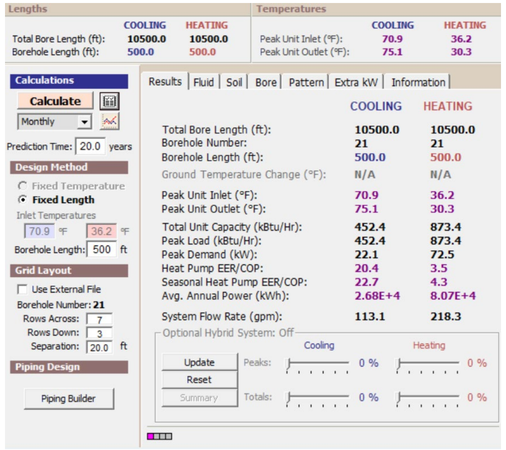
Building Energy Modeling for TENs

Goal: Capture Actual Building Energy Performance

- "8760" Building Energy Models feed forward into ground system design
- Accurate annual usage and peak demand are equally important

Borefield Modeling and Sizing

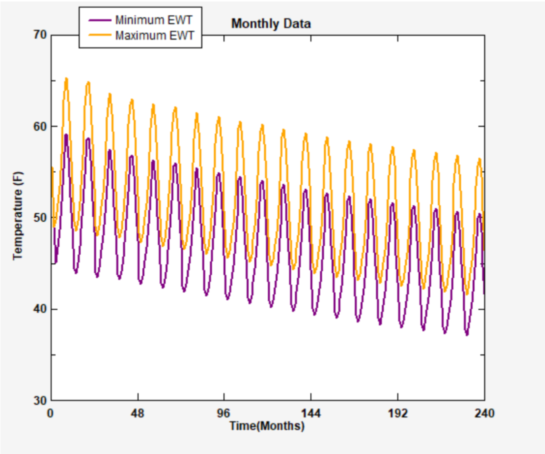
Combine BEM with ground characteristics to determine borefield size



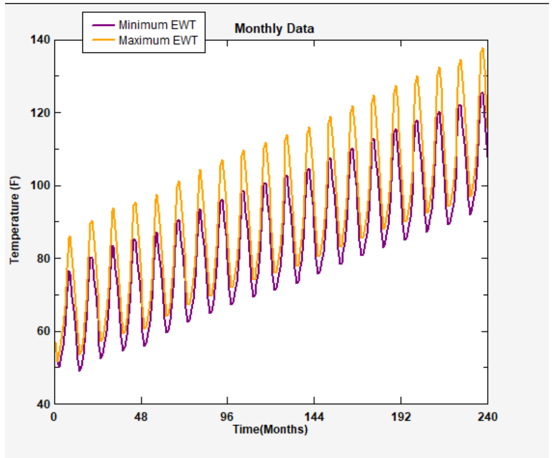
Borefield Sizing Impacted By:

- Ground Thermal Conductivity/Diffusivity (Test Borehole Outputs)
- End User Peak and Annual Loads (Thermal Balance)
- Heat Pump Efficiency
- Borehole Depth and Spacing
- System Hybridization

Heating Dominant



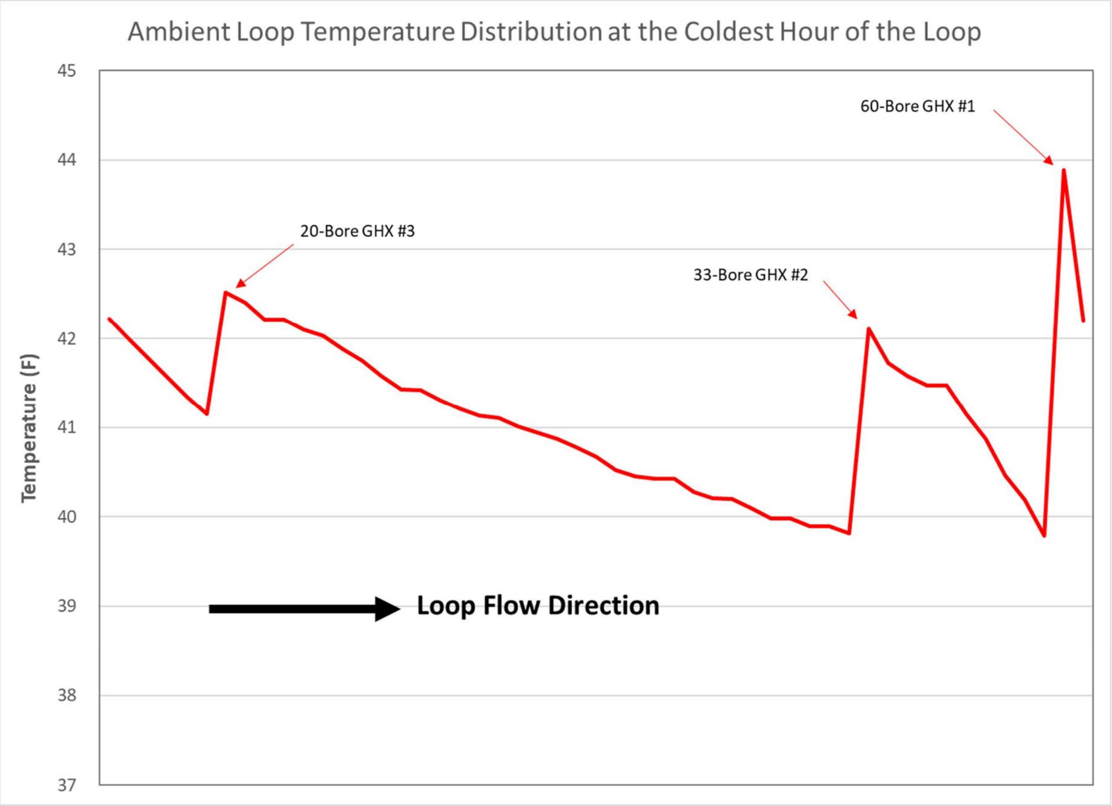
Cooling Dominant



TRNSYS Modeling

Iterative Model of Energy Inputs and Outputs

- Transient modeling to assess the performance of the thermal system
- Ensure customers get similar entering water temperatures along the loop
- Recharge borefields boost temperature

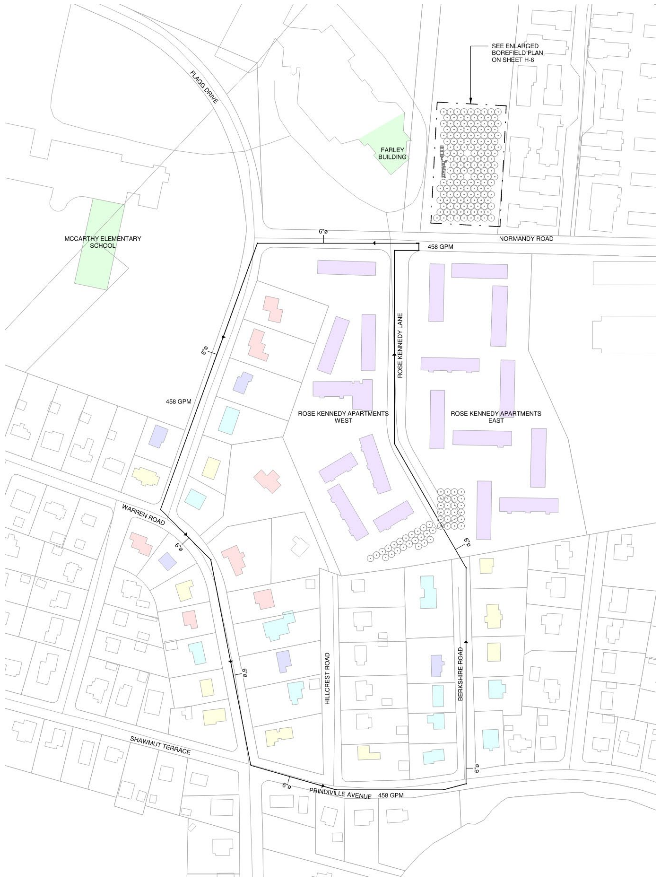


Single Pipe vs Two-Pipe System

Single-Pipe

Fluid flows in a loop around the UTEN and is “recharged” using thermal resources

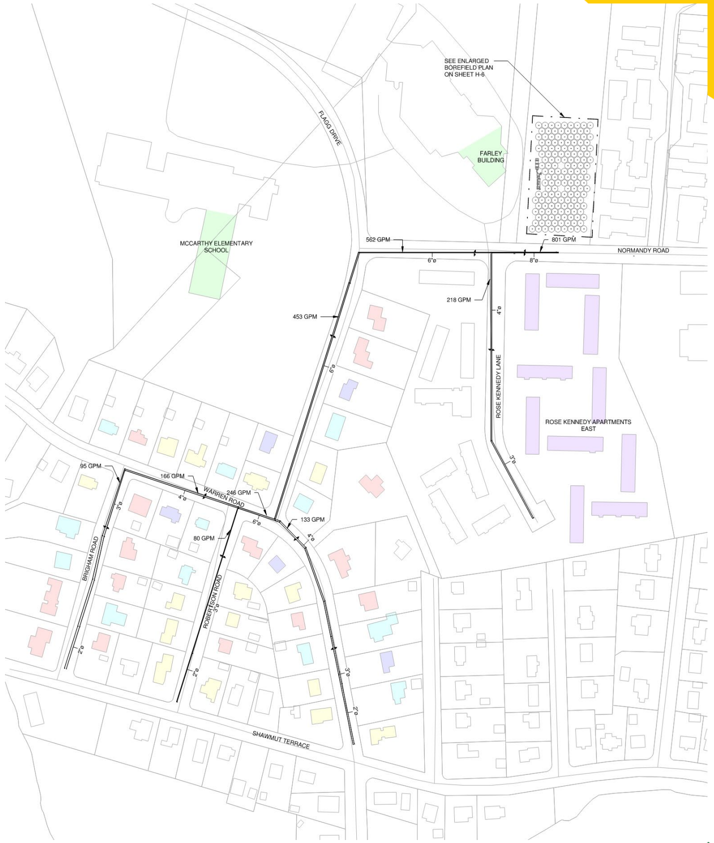
Best when thermal resources are widely distributed



Two-Pipe

Fluid in supply pipes goes to end users, and returns to thermal resources in return pipes

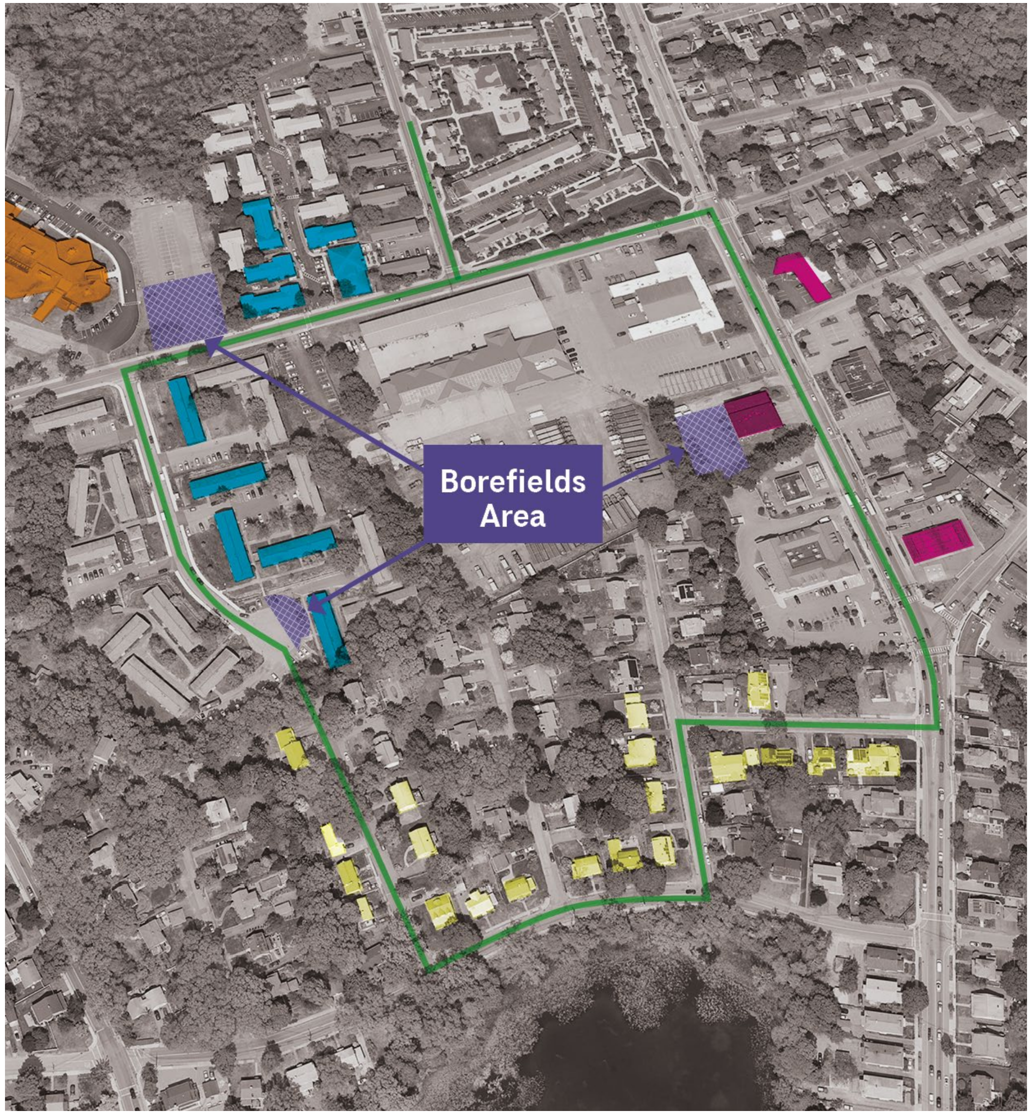
Best when thermal resources are centralized



Site Layout

Project Example: Eversource Geothermal Pilot (Framingham, MA)

- One main borefield, two recharge borefields (fields and parking lots)
- Mix of end user types to create a balanced system
- 1+ mile of ambient loop piping under ROW
- Constructed June 2024



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Mechanical Engineer, PE (NM), CEM, GBE

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Sharing Resources for Resiliency

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Photo Source: Sandia National Laboratories

Harnessing the Power of Low-Grade Waste Heat

- Many campuses across the country release low-grade waste heat with cooling towers and wet/dry fluid coolers
- How can a campus use this heat?
- Where to start?
- This is Sandia's evolving journey…

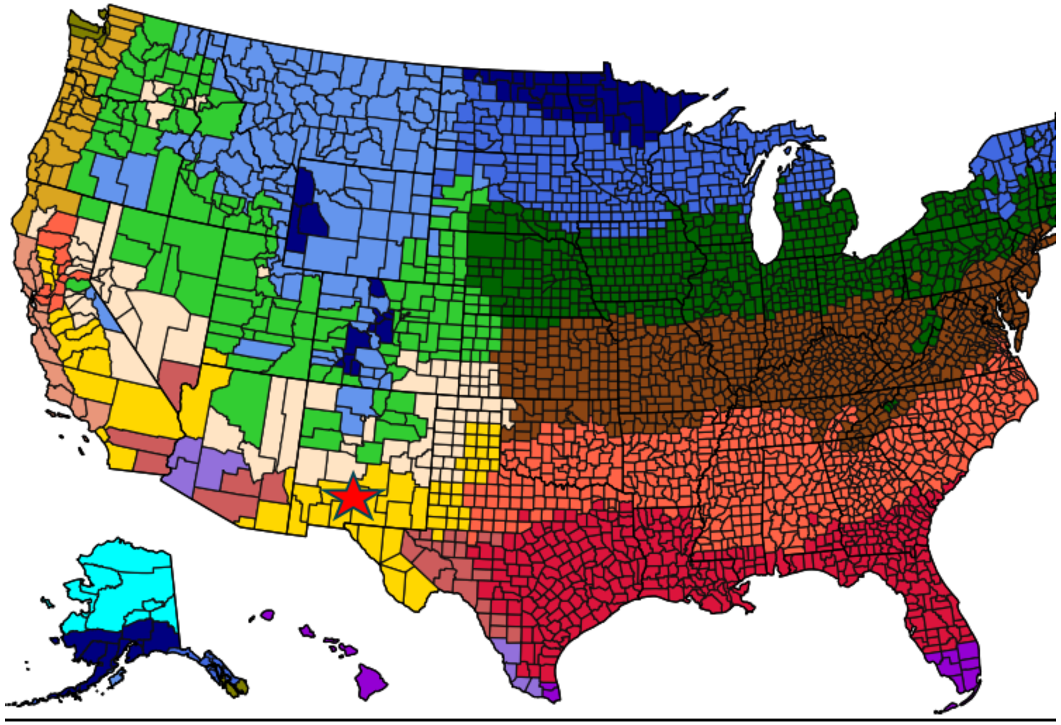
Agenda

- Background
- Planning
- Testing
- Results
- Discussion
- Next Steps at Sandia National Laboratories (SNL)
- What to Look for at Your Site?
- Conclusion

Photo Source: Randy Montoya, Sandia National Laboratories

Background

- Executive Order 14057 (December 2021; since revoked)
- Net Zero study at SNL in 2023
    - Removing building carbon emissions
    - Convert to heat pumps and electric boilers
- Most Buildings were designed for 180°F supply temperature
    - Pushes limits for heat pumps in NM
    - Increase power needed for electric boilers
- Could the buildings run at a lower supply temperature?
    - ASHRAE design for ABQ is 22.4°F (99%)
        - Zone 4B "Mixed-Dry" Climate
    - SNL requires a design of 12°F



Reference: ANSI/ASHRAE Addendum a to ANSI/ASHRAE Standard 169-2020 "Climatic Data for Building Design Standards"

Planning

- Team of mechanical engineers and controls formed in January 2024
- Started evaluating office buildings
- Main types of systems
  - Condensing Boilers
  - Non-Condensing Boilers
  - Primary Only Loops
  - Primary-Secondary Loops
  - Constant Volume
  - Variable Volume

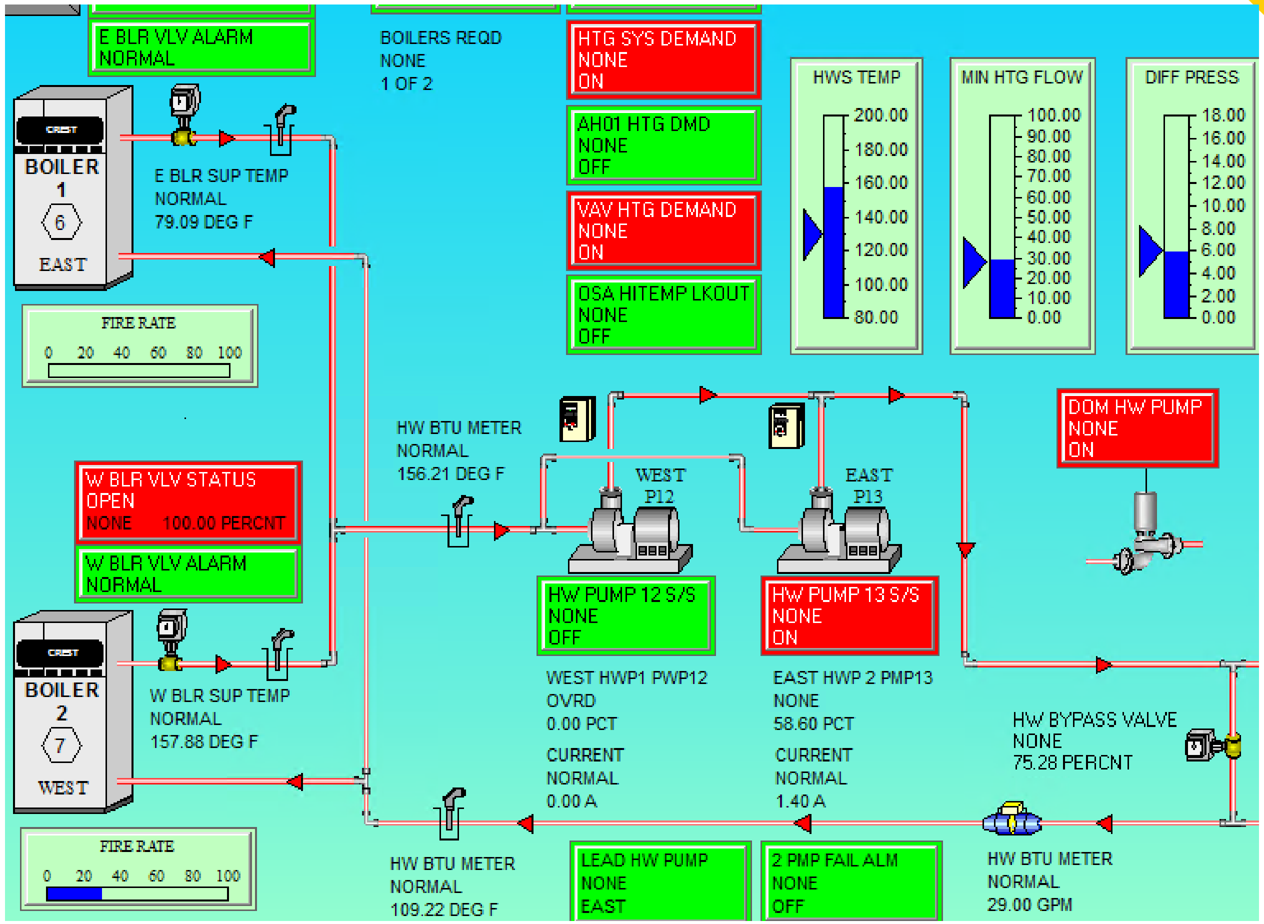


Photo Source: Sandia National Laboratories

Testing

- Started conversion of 20 buildings (Jan 2024)
  - 130^{o}F supply temperature for condensing boilers
  - 140^{o}F return temperature for non-condensing boilers
- Held weekly meetings to discuss any issues
- Realized buildings could handle the lower supply temperatures
- Continued converting all buildings through the summer of 2024
- DOE released "Guidance Document on Space Heating Electrification for Large Commercial Buildings with Boilers" in April 2024

Strategy
Some existing hydronic distribution networks can be adapted to provide equivalent heating comfort with **lower-temperature water** (120–150°F).
Building efficiency measures such as insulation upgrades and heat recovery can reduce the building heating load, reducing the capacity and cost of the installed heat pumps.
Heat pumps operate much more efficiently than fuel-fired boilers and can allow for **operating cost savings** in many regions of the country.
Spreading out the decarbonization project over multiple stages as an **incremental retrofit project** can lower the initial cost burden and disruption to existing tenants while also incorporating greater energy efficiency to make an easier transition to electrification.

From "*Guidance Document on Space Heating Electrification for Large Commercial Buildings with Boilers*"

Results

- Excellent design day testing in January 2025
  - Did run systems in 24/7 mode during cold snap
- Discovered areas with radiant heat
  - Changed set point to 160^{o}F for cold days
- Higher heating water temperature was hiding other issues
  - Heating valves not modulating
  - Bad temperature sensors
  - Outside air dampers not closing
  - Modifying programing on staging boilers and pre-heat/reheat coils

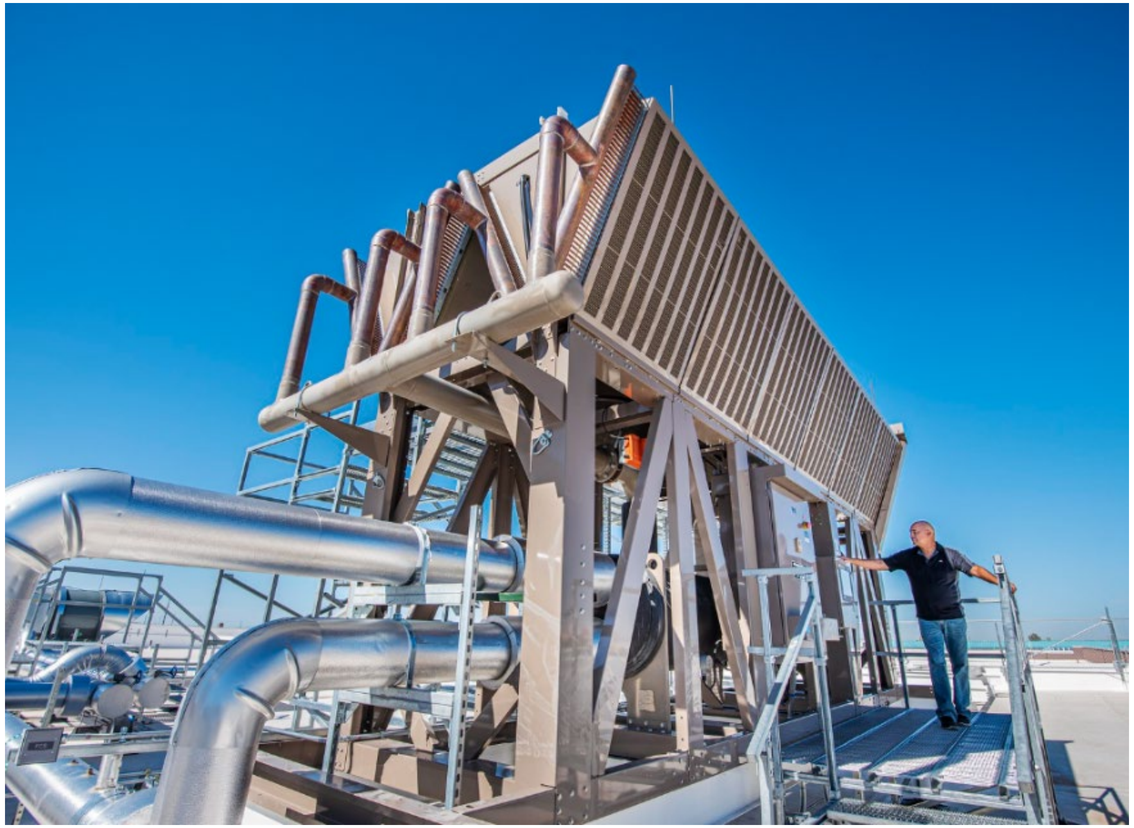


Photo Source: Randy Montoya, Sandia National Laboratories

Discussion

- When in doubt… make the coil a little bigger
  - Has been done for many years
- Increased energy?
  - A little
    - Earlier building start ups
    - Pumping energy
- Creating better functioning heating systems across campus
- Improving resiliency
  - Electricity
  - Natural gas

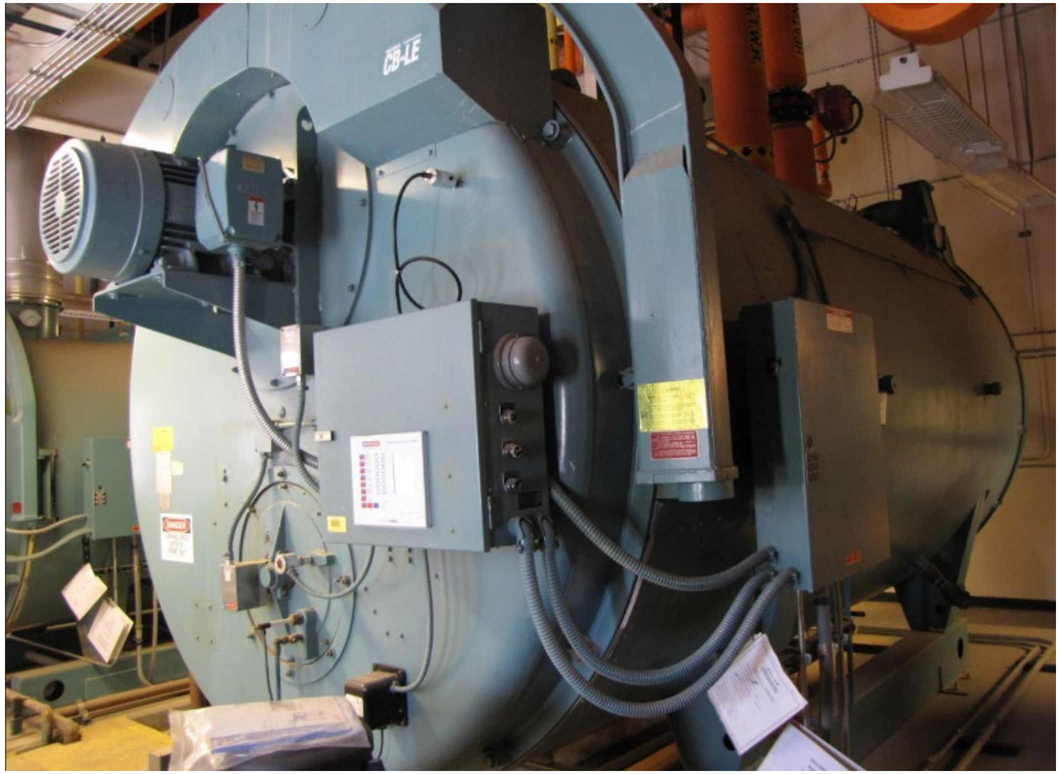


Photo Source: Sandia National Laboratories

Next Steps at SNL

- All mechanical equipment needs to be replaced eventually
  - Evaluate each system during replacement
  - Install 2 pass coils
- Campus Plan
  - Capture waste heat and transfer to other buildings
  - Data centers
  - Year-round process loads
  - Geo exchange
- Water to Water Heat Pumps
  - Heat recovery chillers
- Baby Steps…

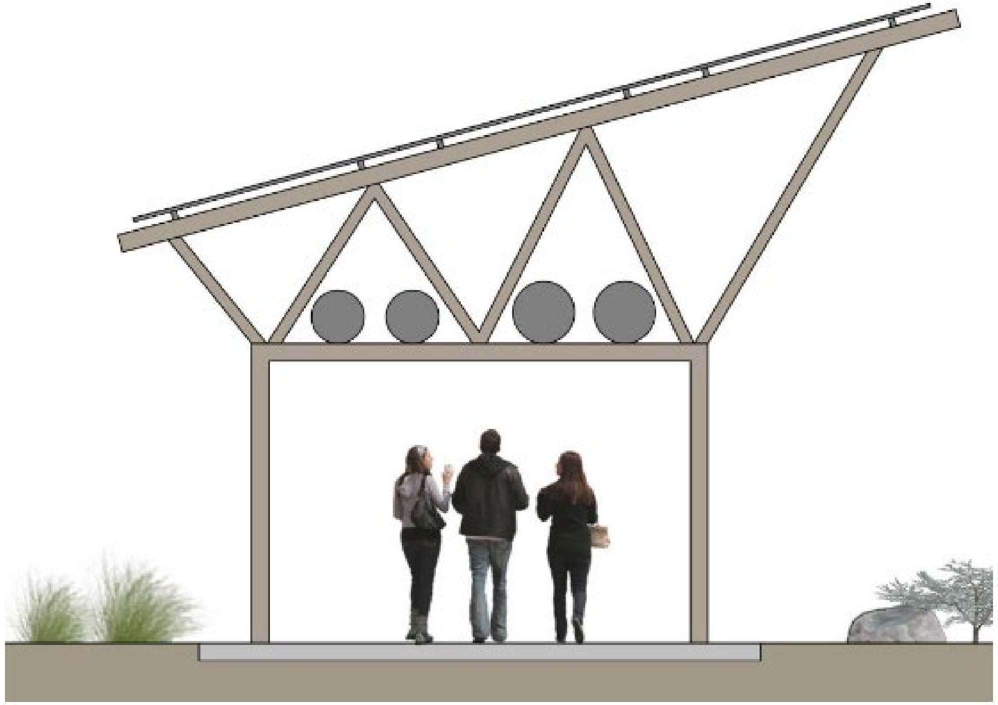


Image Source: Sandia National Laboratories

What to Look for at Your Site?

- Configuration of Heating Water Systems
  - How does the building get domestic hot water?
  - Condensing and/or non-condensing boilers?
  - Primary/secondary/tertiary loops
  - 3-way valve on decoupler
  - Radiant heaters
  - Staging of boilers
- Prepare to catch hidden issues
- Condensate neutralization kits
- How can the system be modified for lower temperatures?
- Understand the year-round cooling demands for the campus

Photo Source: Sandia National Laboratories

Conclusion

- Lowering the heating water set point was a great test
- Discover hidden issues with existing system
- When replacing equipment:
    - Introduce other forms of heating water technology
    - Can waste heat from other systems be used?
    - Geo-exchange
- Increase resiliency and redundancy

Photo Source: Randy Montoya, Sandia National Laboratories

Questions?

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