ENERGY MASTER PLANS – CENTRAL TO REGIONAL BUILDING ELECTRIFICATION

Moderator: Derek Dwyer / *Enertech Global*

Speakers: Joel Serface / *VHB*

Joe DiSanto / *Ramboll*

Nicholas Fry / *Jacobs*

Jeff Urlaub / *Salas O'Brien*

ENERGY MASTER PLANS – CENTRAL TO REGIONAL BUILDING ELECTRIFICATION

Joel Serface / VHB

vhb

energy evolution practice

Powering Progress. Driving Innovation.

Energy Master Plans

October 22, 2024 | NY-GEO 2024

VHB Background

Founded in

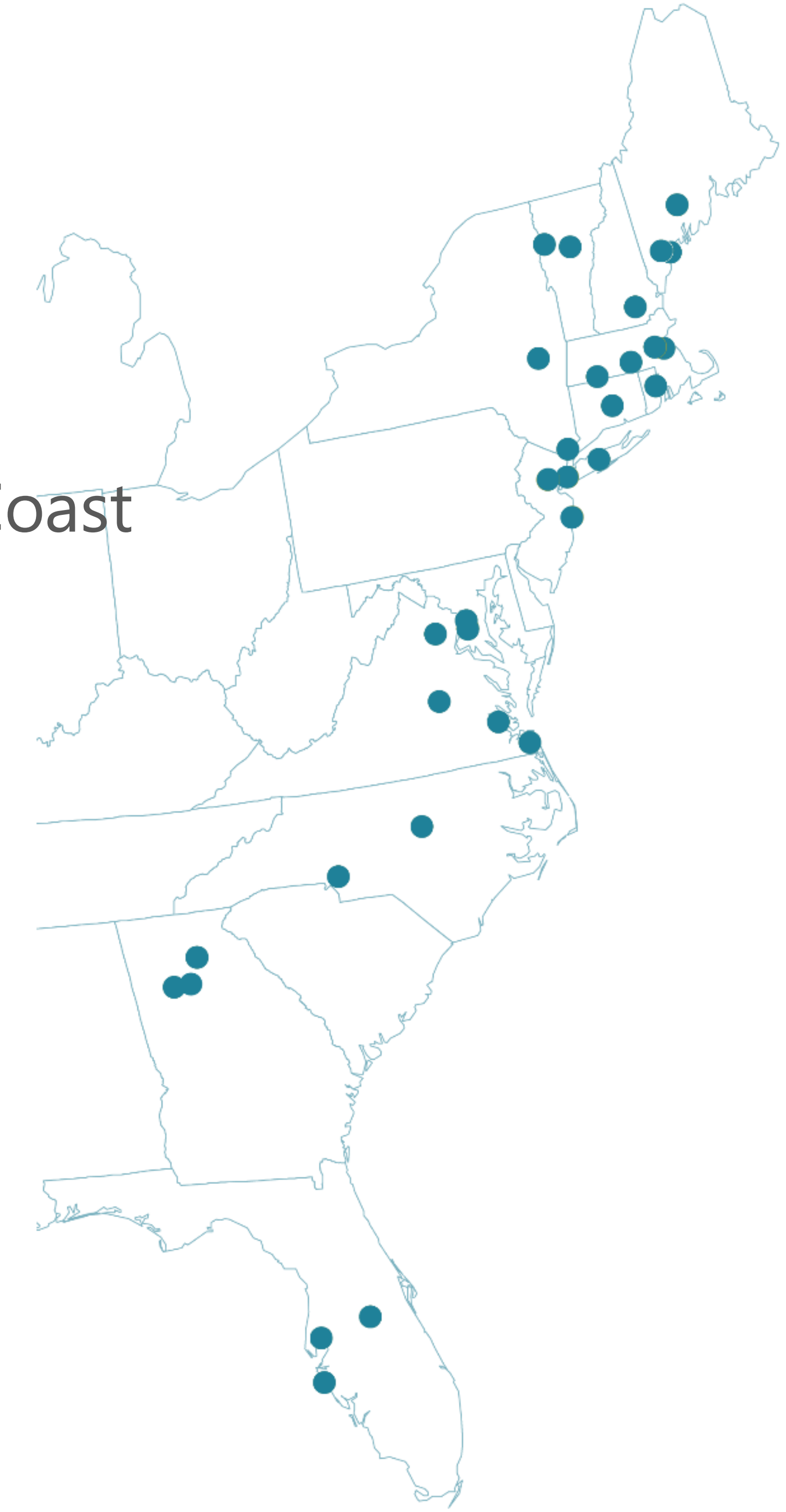
1979

Mission

Partnering
with our clients
and communities
to create a
sustainable, resilient,
and equitable future.

30+

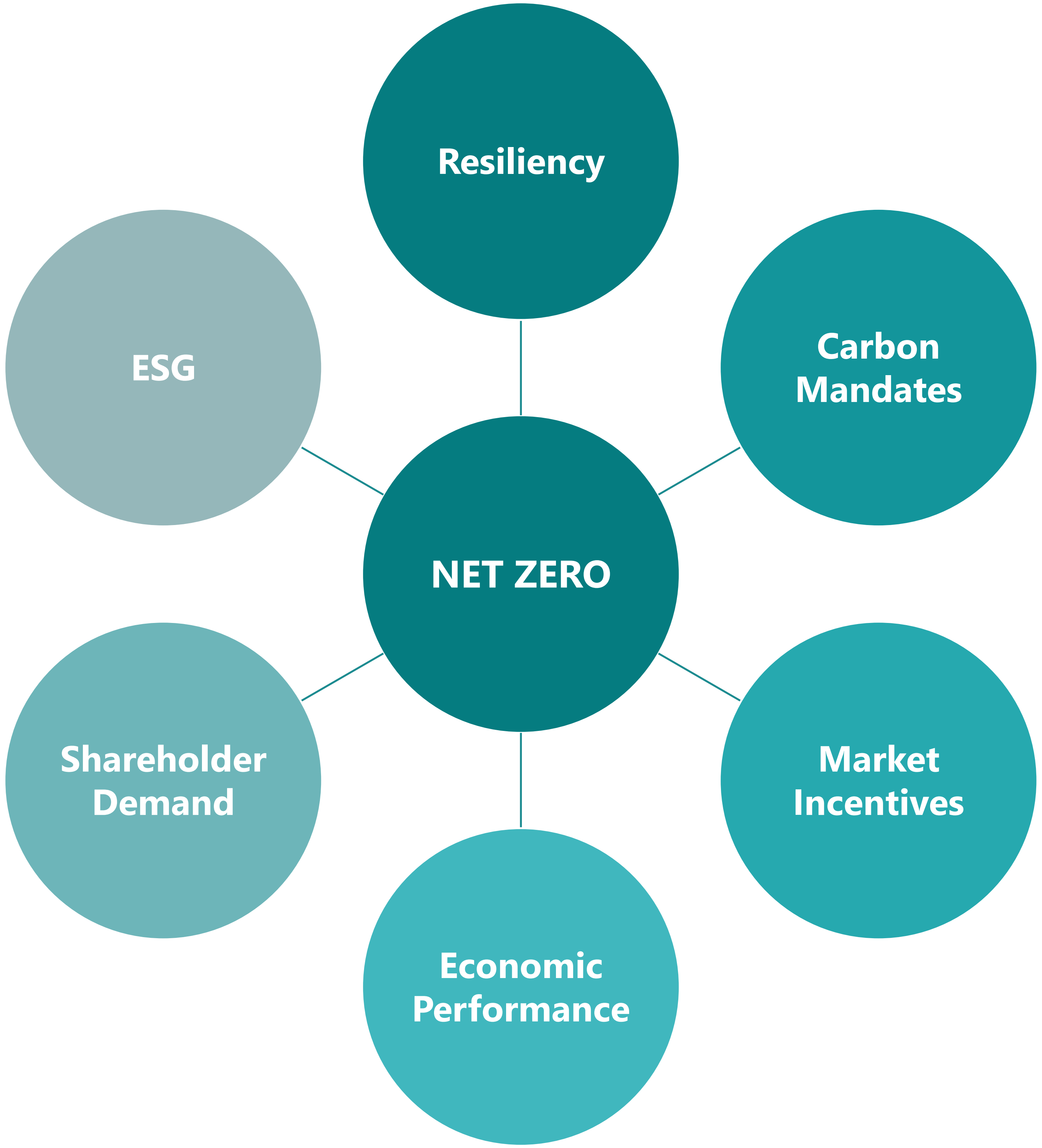
Locations
on the East Coast



2,200+

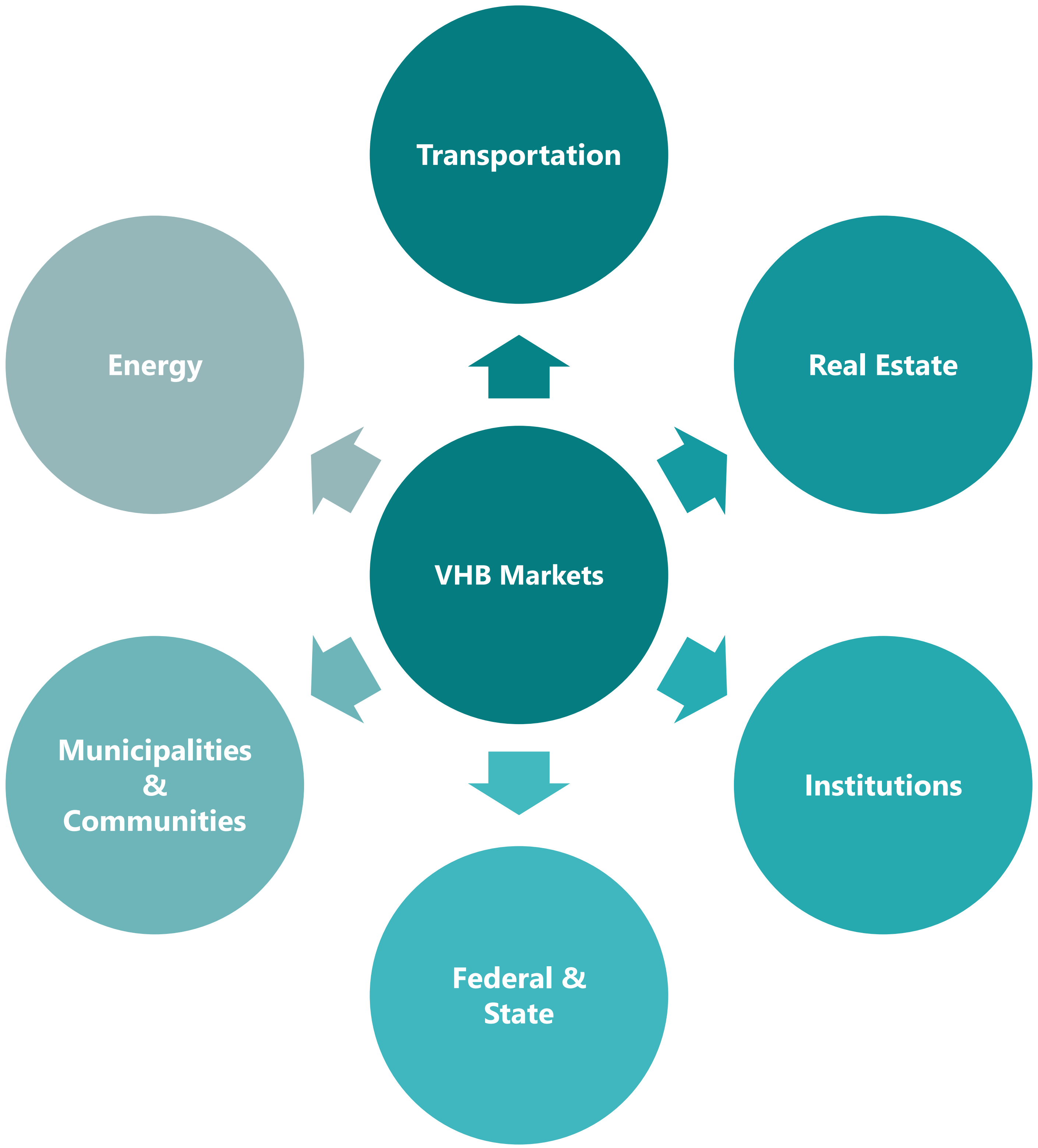
Passionate professionals
Engineers, Scientists, Planners and Designers

Market Drivers



- Imperative to get to **Net Zero** and **100% resiliency**
- Rapid **advancement of new energy technologies** and **reduction in renewables cost**
- Radical shift in **self-ownership value** from **IRA Direct Pay benefits**

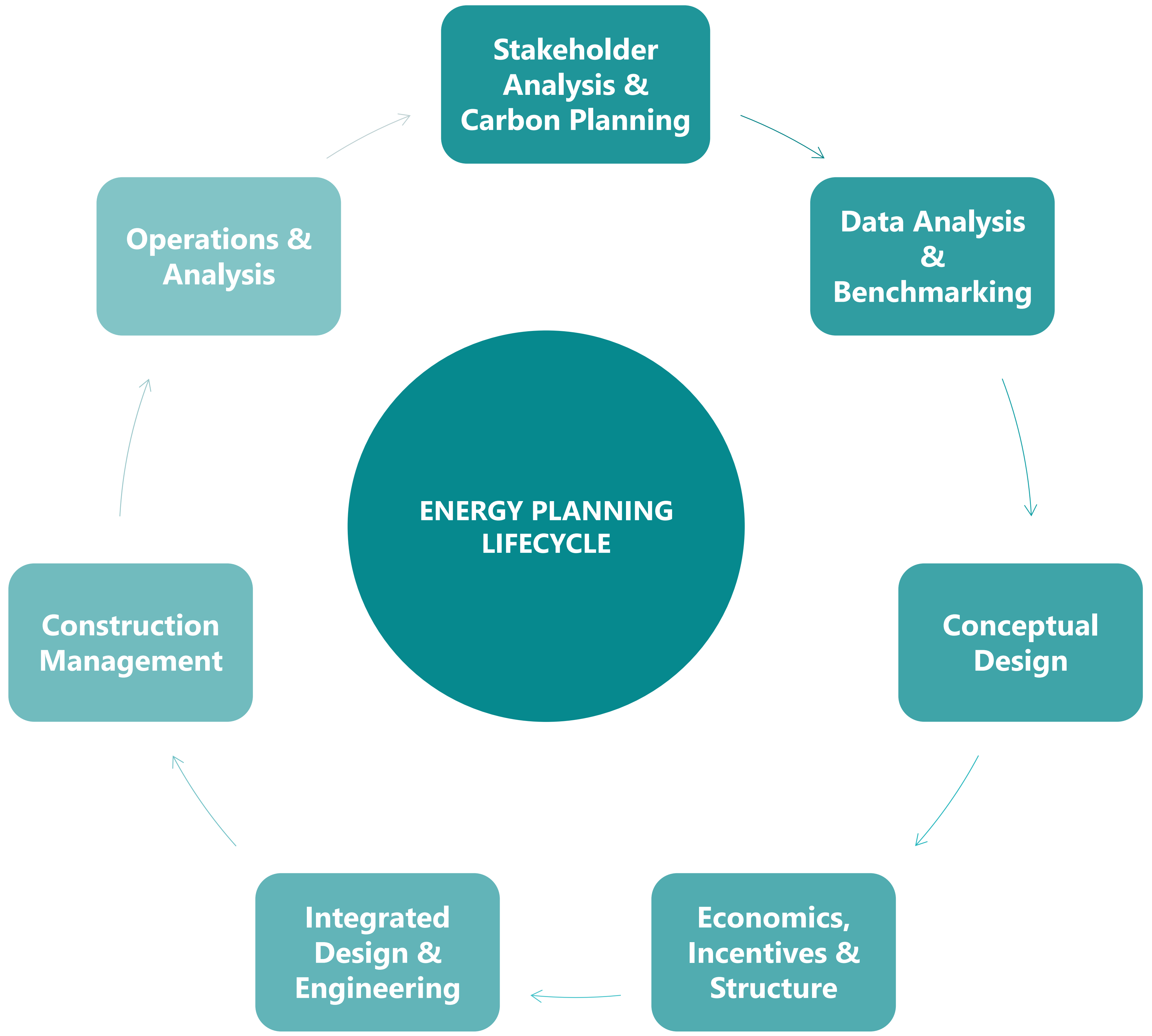
Energy Planning Across Markets



- VHB supports clients across its Core Markets develop **Carbon and Energy Plans** to achieve their **Climate and Resiliency Objectives**
- These include innovative approaches **greenfield development, re-development & portfolio strategic plans**

Energy Planning Lifecycle

Our clients need a **Trusted Advisor** that can work with them across their entire **Energy Planning Lifecycle**



Energy Planning Components

Developing integrated solutions and economics is more important than any single technology

Baseline & Targets

- Stakeholder Analysis
- Carbon Accounting
- Portfolio Analysis & Prioritization
- Predictive Analytics & Benchmarking
- Site Planning and Design
- ESG Alignment
- Community Inputs
- Smart Growth

Built Environment

- Net Zero Design
- Load Modeling
- Energy Efficiency
- Audits & Data Analytics
- Building Automation & Controls
- Energy Management
- Energy & Thermal Loads
- Embodied Carbon

Energy Systems

- **Solar**
- **Battery**
- **Microgrid**
- **Geothermal & Heat Pumps**
- **Grid Interoperability / DERS**
- **Energy Economics**
- **Market Participation**
- **PPAs & RECs**
- **Virtual Power Plants**

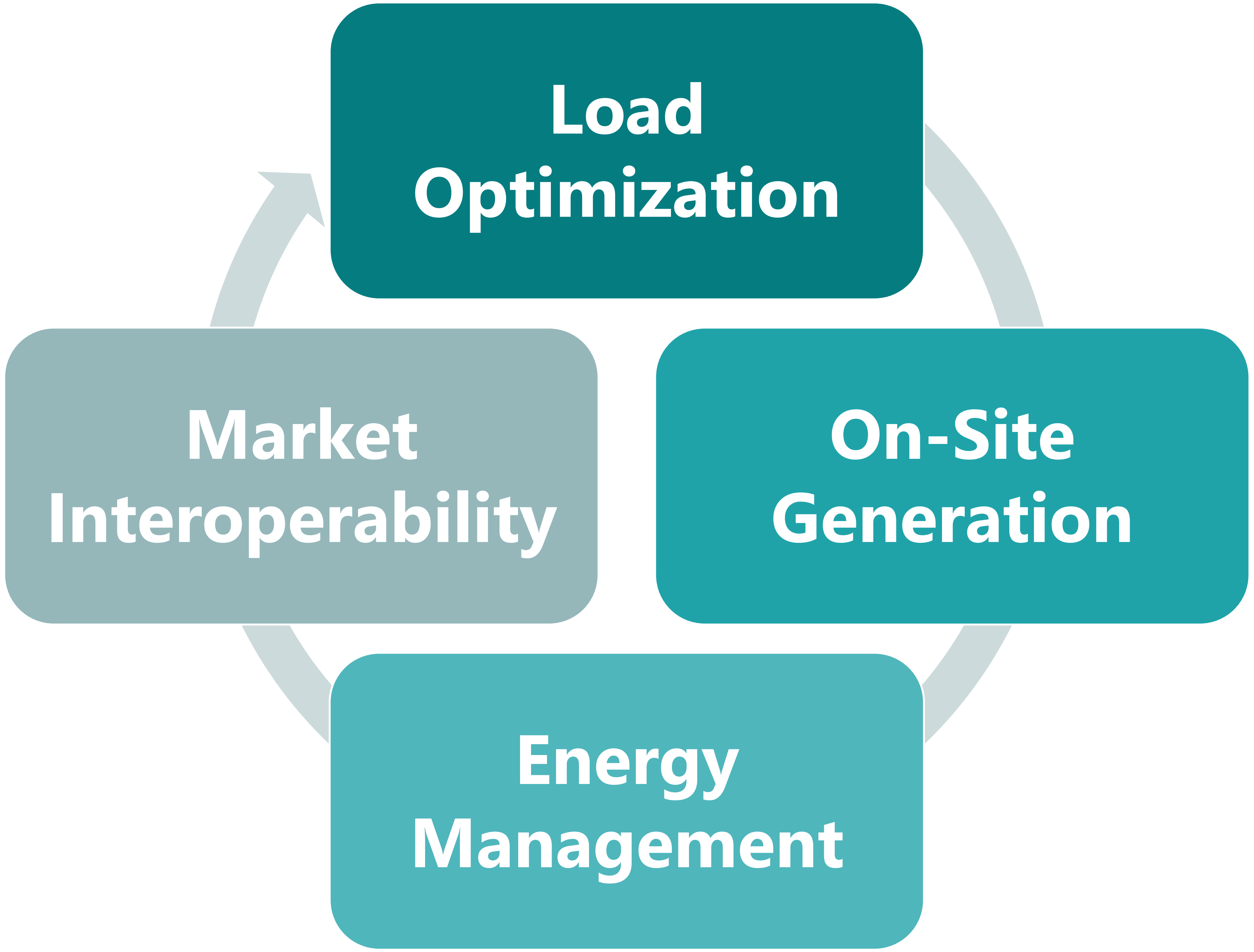
Transportation

- Clean Mobility
- Charging & V2G
- Accessibility
- Fleet Electrification
- Autonomy Planning
- Asset Re-Positioning
- New Mobility-Oriented Development

Other Critical Systems

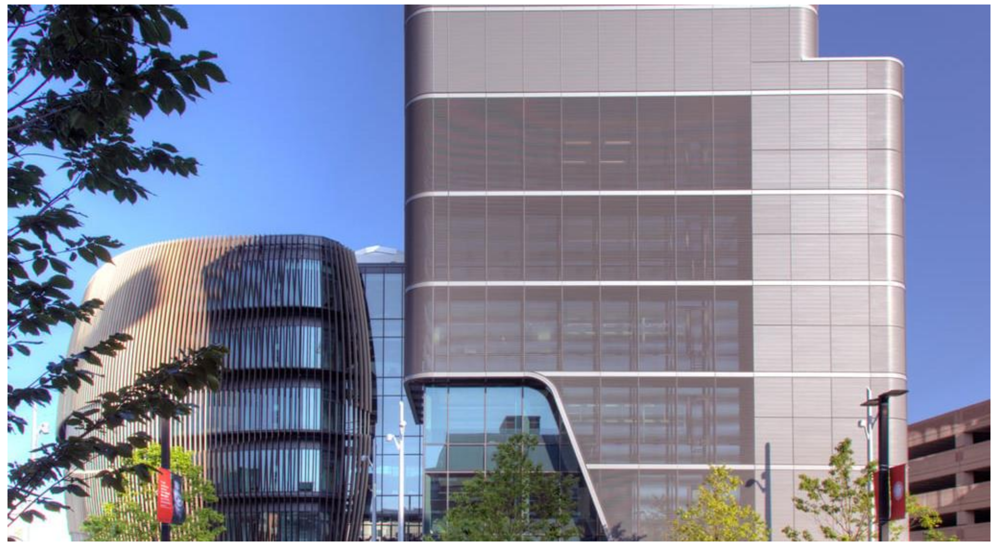
- Water & Wastewater
- Food, Waste & Recycling
- Communications & Security
- Nature Based Services & Landscape Architecture
- Carbon Capture & Storage
- Street Lighting
- Fire & Flood Protection
- Equity, Social & Health

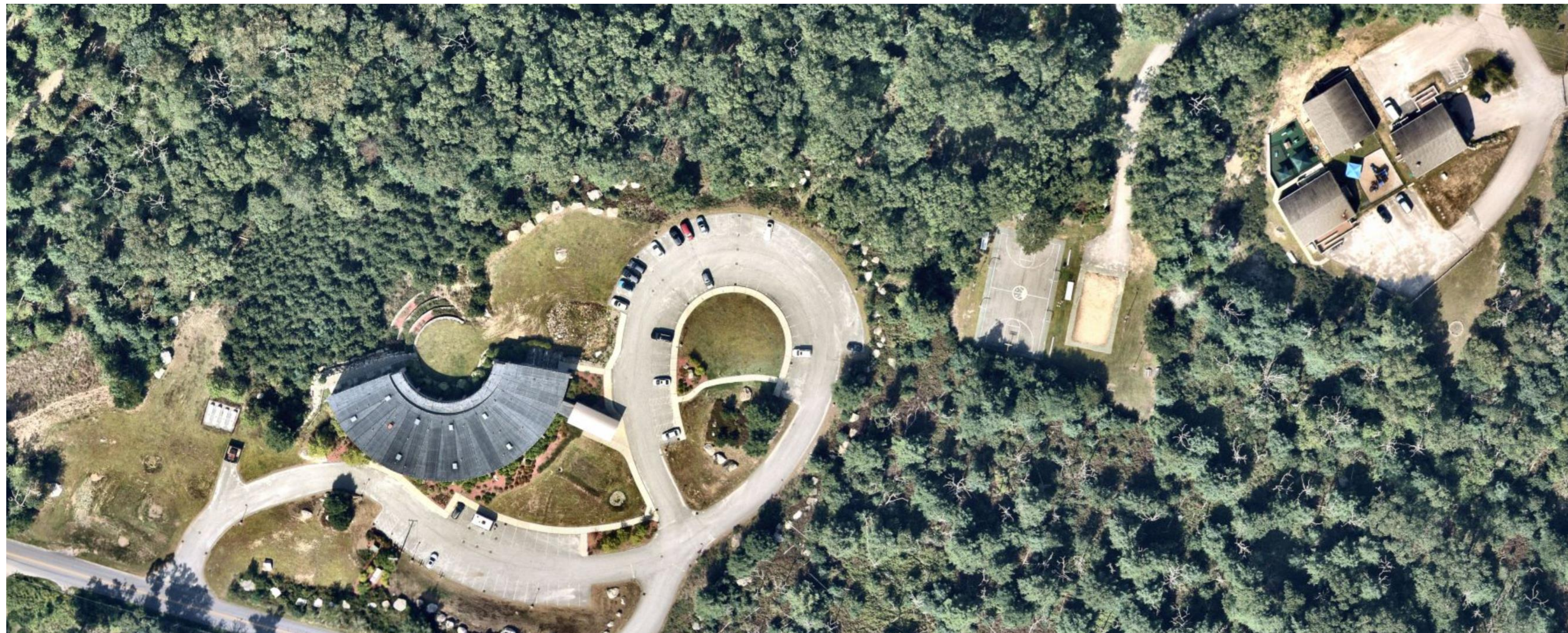
Balancing & Managing Energy



- Going beyond **Net Zero** requires **balancing loads** and **on-site generation** moderated by active **energy management** and **market interoperability**
  - Greenfields require **early participation in the Master Planning Process** and **Model-Based Design of loads and generation**
  - Retrofits require similar modeling, but a greater reliance on **data analytics**, **audits**, and care in **integrating new infrastructure**

VHB Projects





Questions & Follow-Up

Joel Serface

VHB Director of Energy Innovation

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ENERGY MASTER PLANS – CENTRAL TO REGIONAL BUILDING ELECTRIFICATION

Joe DiSanto / Ramboll

Energy Master Planning – Energy and Carbon Reduction Mandates

Preliminary energy analysis	Building assessments Energy audits	Technology screening	Scenario planning	Implementation and phasing	Clean Energy Master Plan
Heating load Cooling load EUI Future projections	Business as Usual Energy Conservation Measures	Low carbon Renewable Electrification Fossil fuel	Heating and cooling alternatives analysis Carbon and energy metrics	Near-term Long-term Enabling/critical path projects	Vision summary Viable technology Actions roadmap Sequence & phasing

Base Load/Peaking Technologies

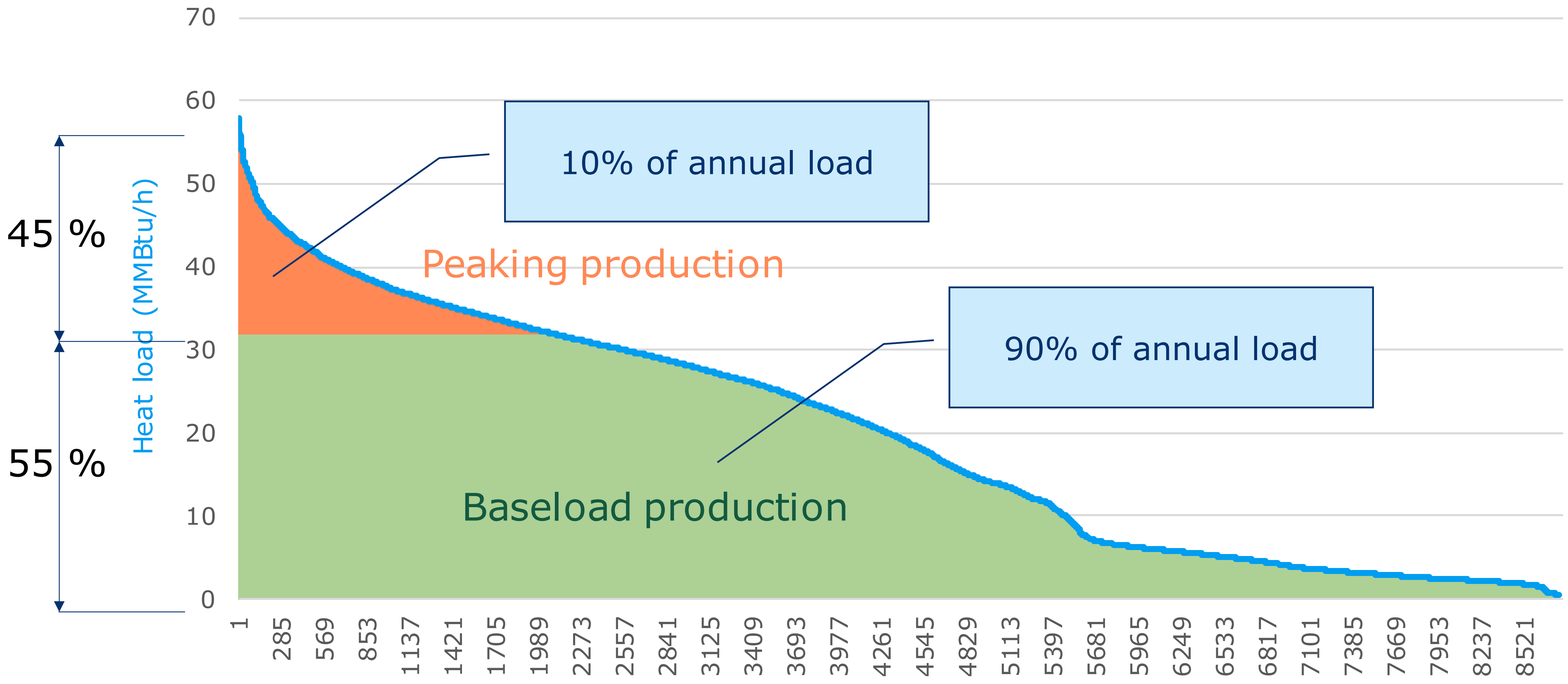
Some baseload technologies characteristics

- 55% of peak demand covers approx. 90% of annual load
- High Capital Expenditure (CapEx) (should operate many hours annually)
- Should have low fuel costs

Some peaking/backup technologies characteristics

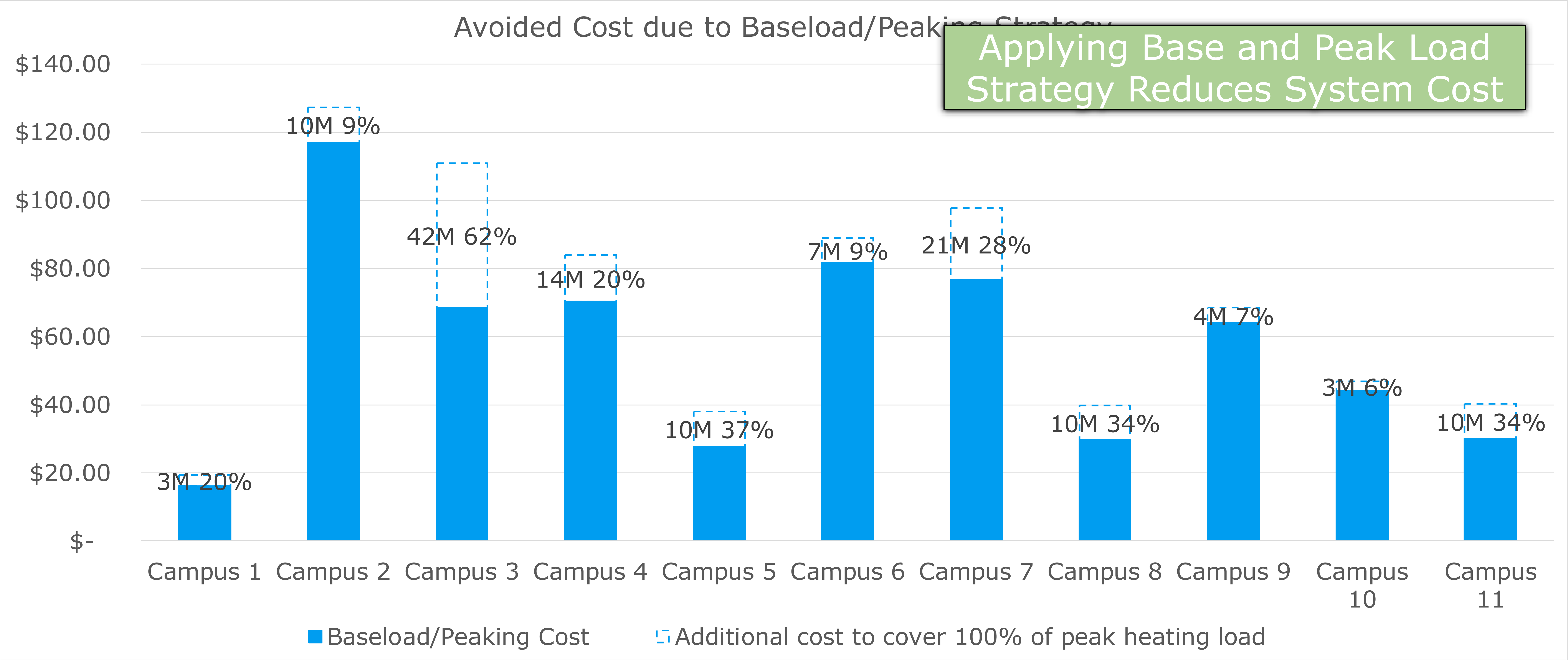
- 45% of peak demand covers 10% of annual load
- Low CapEx (*e.g.*, boiler)
- High technology reliability (backup)
- High fuel supply reliability
- Higher fuel costs

Base Load vs Peak Load



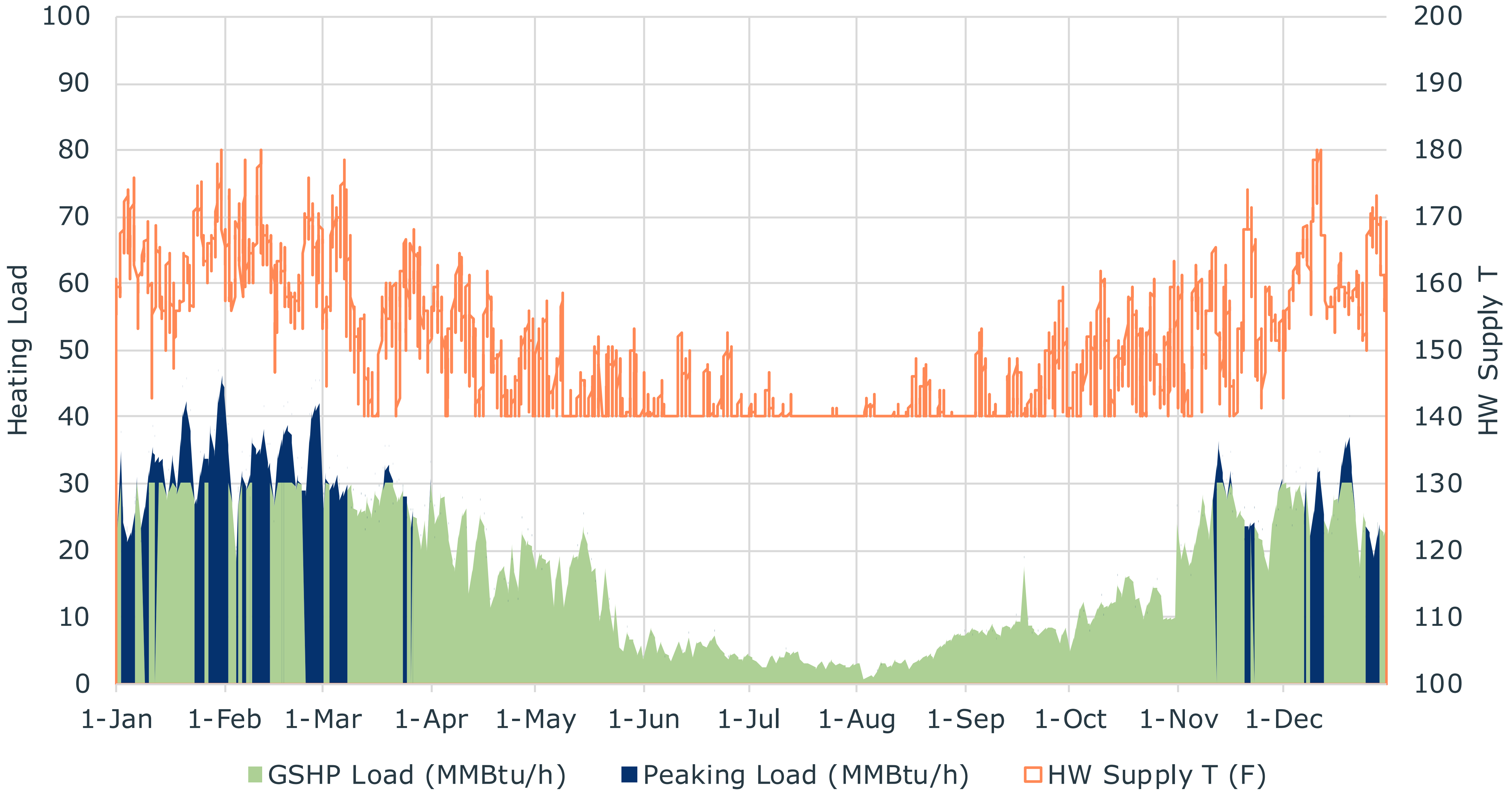
Example Heat Load

Avoided CAPEX – Base and Peak Supply Technologies



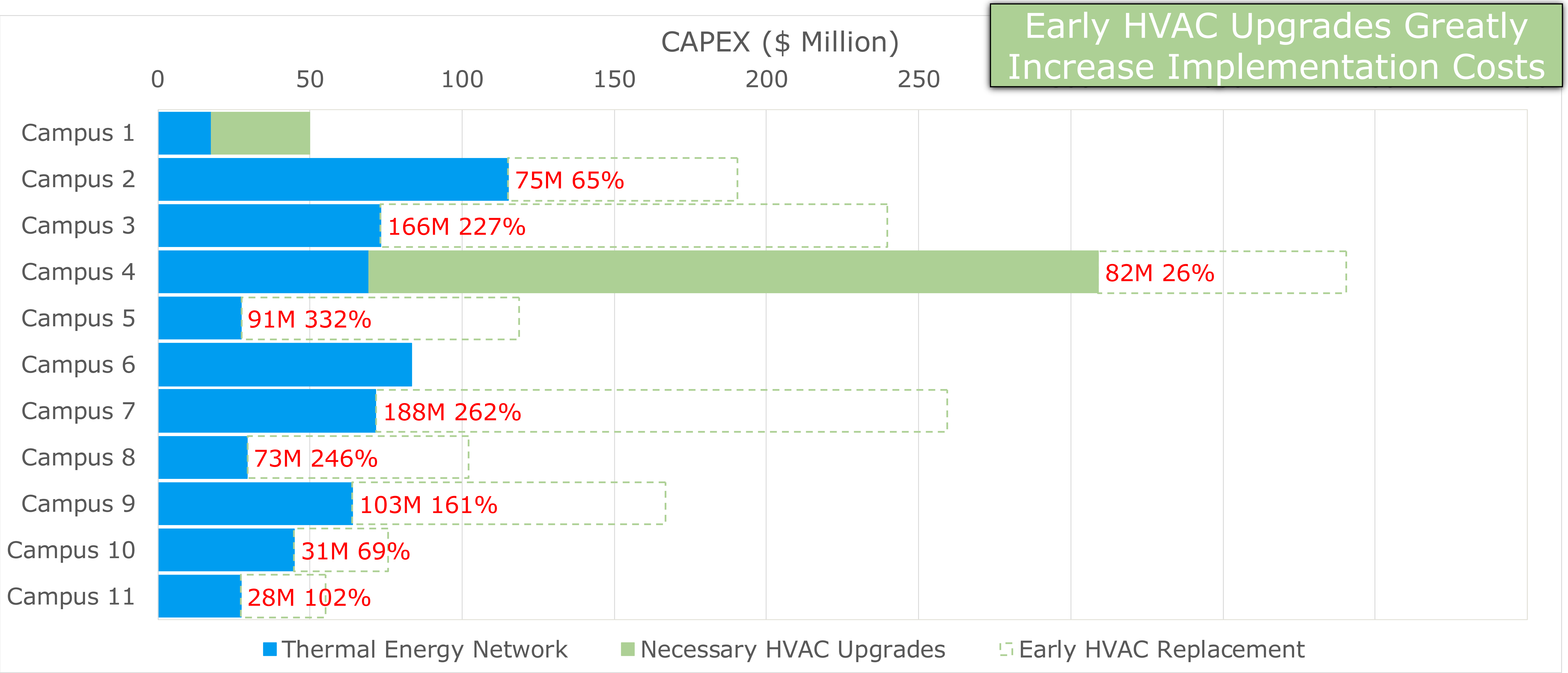
Are Building Upgrades Needed for LTW?

GSHP Cutoff = 165 F

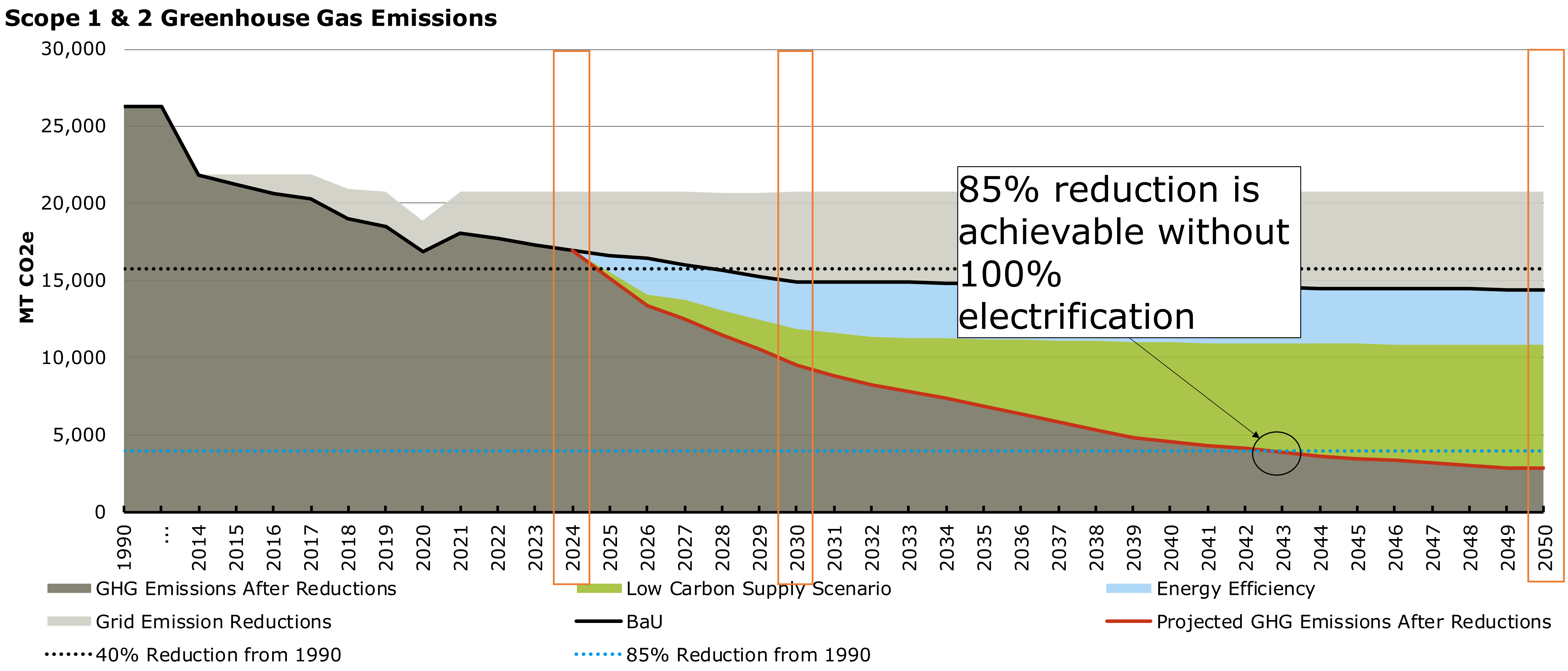


- HW Reset from 180F @ 0F to 140F @ 60F
- GSHP operates 90% of the year
  - Produces up to 165F
  - Provides 80% of the annual load
- Peaking Boilers operate 10% of the year
  - Produces HW from 165F to 180F
  - Provides 20% of the annual load
- Building upgrades would lower LTW distribution temperature
  - More hours of GSHP operation
  - Improves efficiency of GSHP

Avoided Capital for Early HVAC Replacement



Potential GHG trendline



Key Takeaways

1. Most campuses achieve greater than 85% carbon emission reduction even with fossil fuel peaking
2. CAPEX reductions through base & peak supply technologies
3. Early HVAC upgrades can significantly increase CAPEX and extend implementation – target end-of-life upgrade
4. Consider best mix of heat pump sources/technologies to reduce NPV
5. Compare results to other energy and carbon savings options
6. Install building level thermal metering
7. Monitor building level hot water data and explore lower building supply temperature

ENERGY MASTER PLANS – CENTRAL TO REGIONAL BUILDING ELECTRIFICATION

Nicholas Fry / Jacobs

Jacobs Challenging today. Reinventing tomorrow.

Energy Master Planning

Moving Beyond the Pilot

About

Nicholas Fry – Thermal Energy Networks Market Lead NA

- Based in Calgary with Jacobs as the Thermal Energy Networks Market Lead for North America.
- Sustainable energy scientist with a specialization in geothermal district energy systems.
- Experience includes project management, modeling and simulation of reservoirs, subsurface heat exchangers, hydraulic network design, city-scale building energy simulation, and stakeholder engagement.
- Ground coupled heating and cooling clients have presented Nicholas with projects in North America, Asia-Pacific, Europe, and the Middle East.

Who We Are

Jacobs — Challenging today. Reinventing tomorrow.

BY THE NUMBERS

40+ COUNTRIES

400 OFFICES

45K+ TALENT FORCE

$27.9B BILLION IN BACKLOG

$2.5B BILLION IN CLIENT SAVINGS

$16B ANNUAL REVENUE

Net Zero
Carbon for operations and business travel

FOCUS AREAS

MISSION-CRITICAL OUTCOMES
For the first time in history, security and defense threats have no borders. From testing and training to intelligence and engineering and analytics, we work with defense, intelligence and law enforcement communities around the globe to ensure people, their information and our most critical networks stay protected.

CUTTING-EDGE MANUFACTURING
Rapidly evolving, complex facilities require fast-paced, innovative solutions. Bringing an inspired blend of collaborative, creative excellence we deliver innovation — at any budget — from electronics to pharmaceuticals, to universities and governments around the world.

OPERATIONAL ADVANCEMENT
It is one thing to dream up new solutions. At Jacobs, we also deliver them. To turn abstract ideas into realities that transform the world for good, it takes foresight into what's possible, courage to create solutions for the unknown and the knowledge and skills to make them real.

SCIENTIFIC DISCOVERY
We solve some of the most complex challenges of exploration — both in space and closer to home. From wind tunnels to launch and from research to results, we invent by imagining what's possible.

RESILIENT ENVIRONMENTS
Environmental stewardship and climate change are the defining issues of our time. We tackle these challenges differently because we know that whatever we face, we have greater opportunities today to emerge stronger tomorrow.

THRIVING CITIES
Prosperous communities. Healthy cities. A brighter future. By working together to build a better future for everyone, we envision and deliver cities that are smarter and more connected. Inclusive and competitive. Safe and resourceful.

Engineering News-Record 2023 Rankings

Overall

#1
- Top 500 Design Firms
- Top 100 Pure Designers
- Top 50 Program Management Firms

Relevant Disciplines

#1
- Solar Power
- Environmental Consulting and Clean Air Compliance

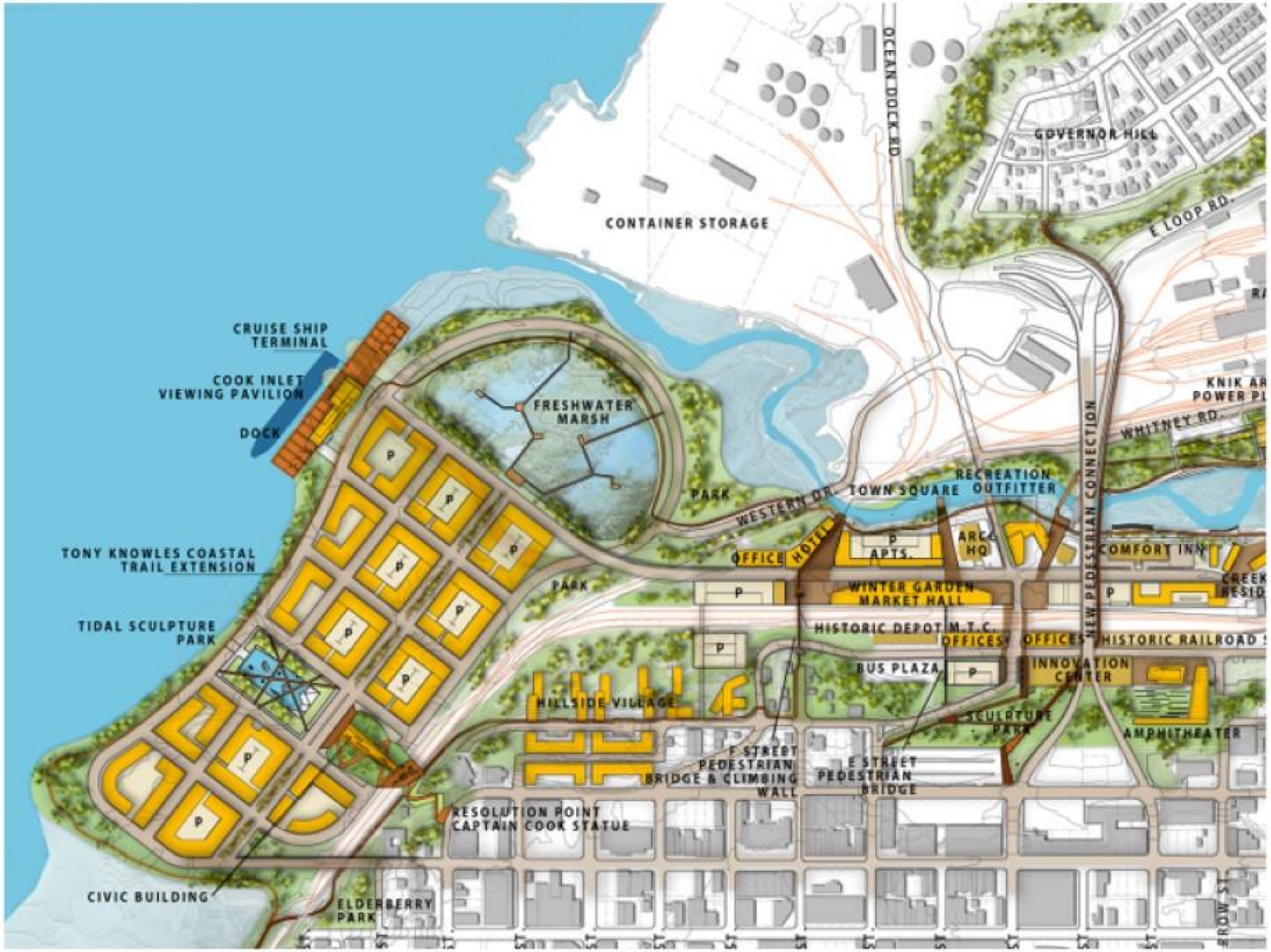
Top 10
- Transmission Lines & Cabling
- Transmission & Distribution
- Wind Power
- Co-Generation Power
- Marine & Port Facilities
- Transportation

Traditional Master Planning Example

Project Description:
The Municipality of Anchorage and the Alaska Railroad Corporation targeted a 70-acre grouping of former Railroad yards and warehouse sites for redevelopment. Jacobs was selected to develop a new urban design master plan, economic development strategy and financing plan to position this critical area just north of downtown for new development.

Project Location:
Anchorage, Alaska

Project Size:
70 acres



Traditional Master Planning Examples

Project Description:
Envision Duluth laid the groundwork for a thriving downtown centered on the Duluth Town Green. Ten years later, Duluth engaged Jacobs again to prepare the 10-Year Update to Envision Duluth. This update provides a framework for pulling the redevelopment energy that's grown around Duluth Town Green across Buford Highway providing a more visible city gateway. This framework is coupled with an aggressive slate of multimodal transportation improvements designed to enhance the pedestrian connectivity within the city and provide links to existing and planned regional transit networks.

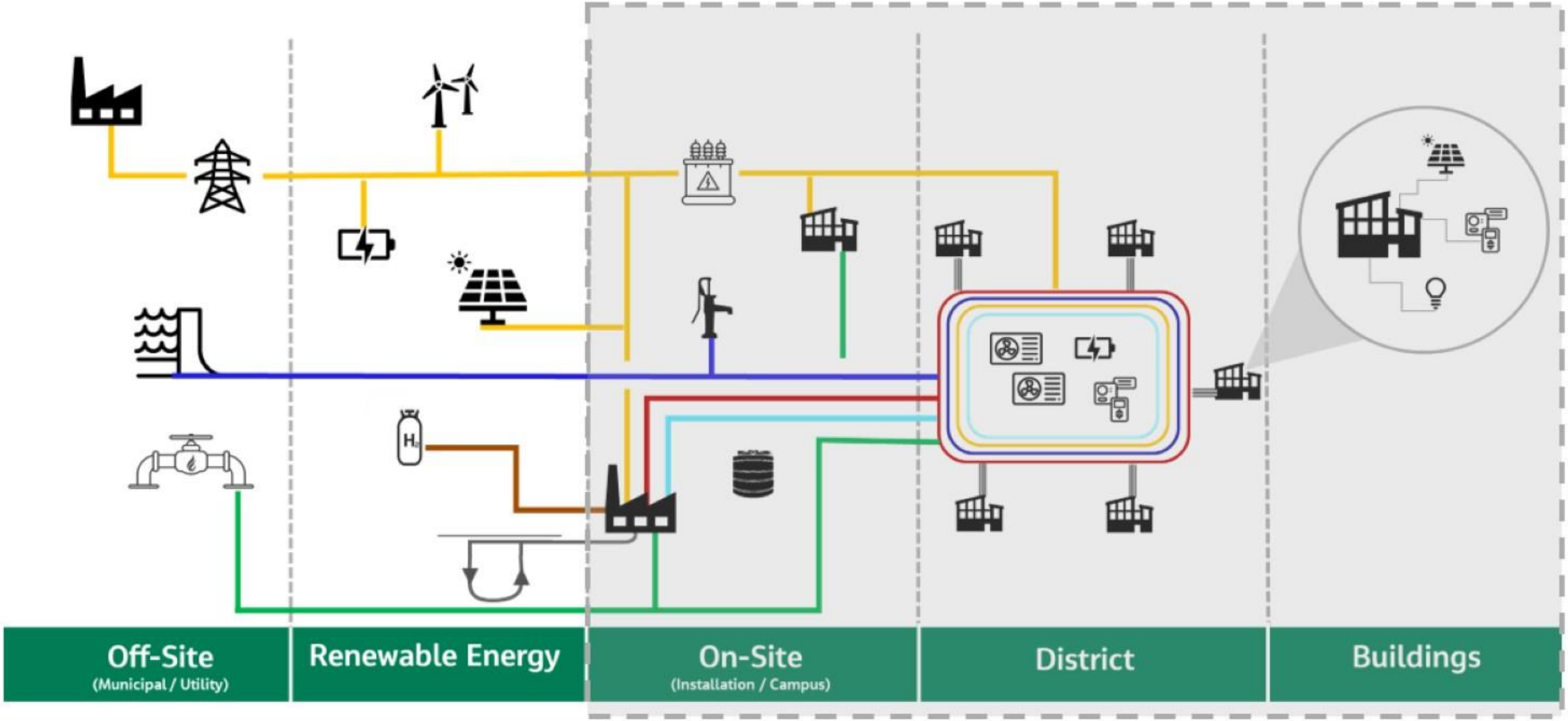
Project Location:
Duluth, Georgia

Queens Transmission Line Siting Plans

Project Description:

- Proposed 138 kV underground transmission line
- Features
  - Socioeconomic metrics
  - Modes of transportation
  - Street fairs and events
  - Utility corridor congestion
- Siting Process:
  - Opportunity & constraint analysis
  - Route development and refinement
  - Stakeholder engagement
  - Proposed route documentation

Challenges of Planning a Complex, Interdependent Energy Infrastructure



Three Keys to TEN Success

Optimize Sources and Sinks

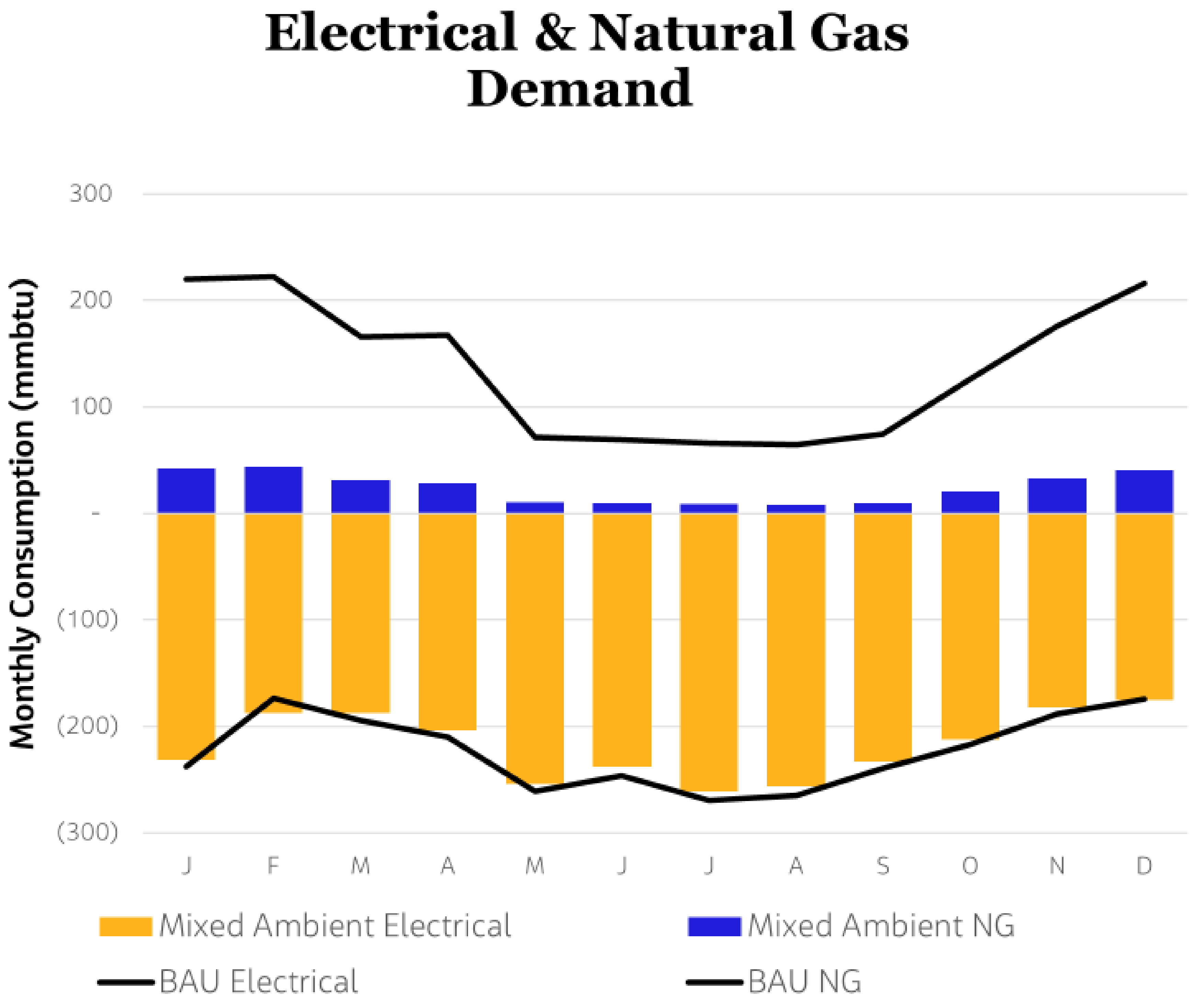
Efficient Distribution & Pumping

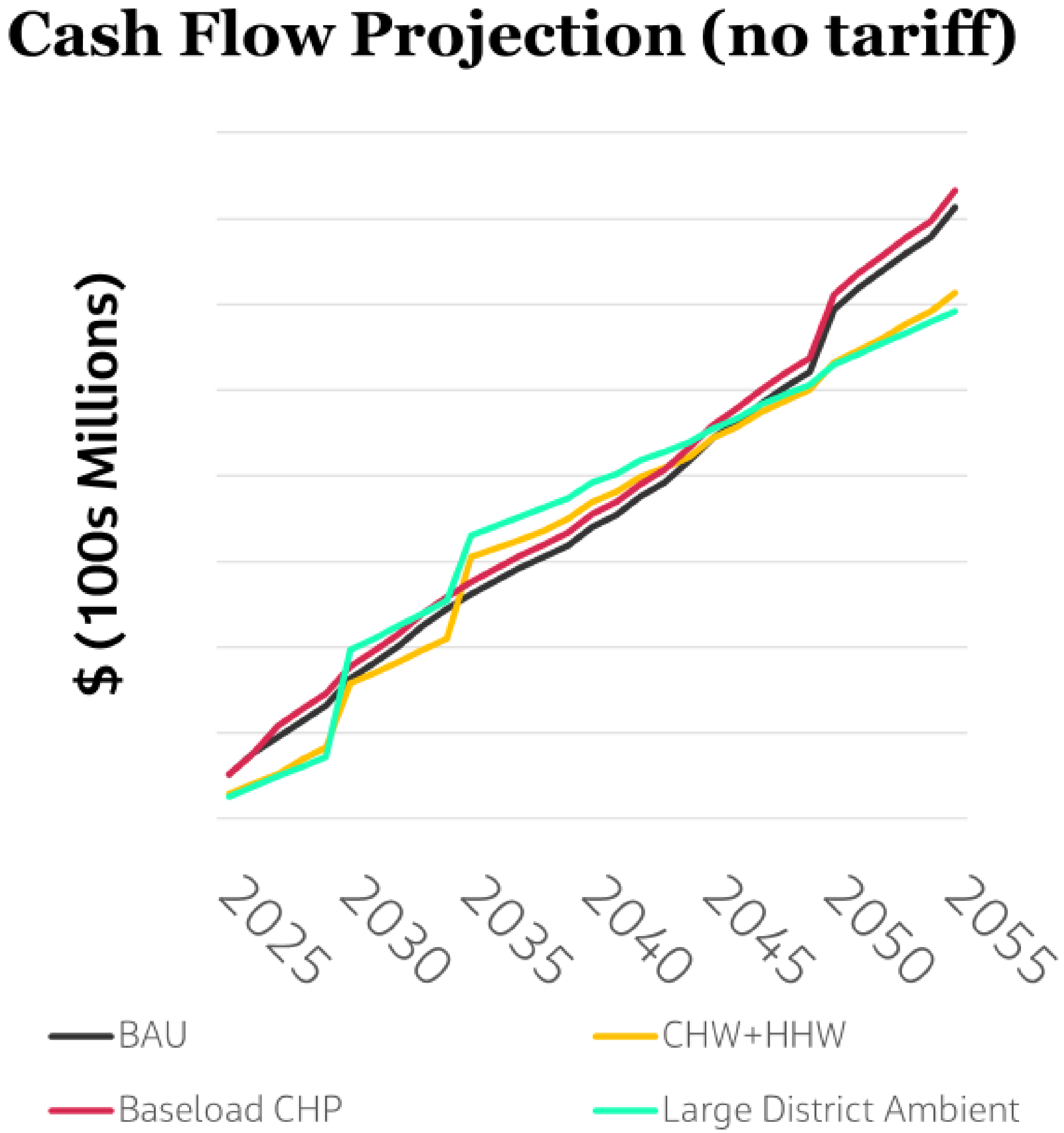
Effective Demand Side Integration & Management

Virtual Infrastructure

Virtual Infrastructure is a utility infrastructure digital twin that provides dynamic, data driven solutions which are easily digestible to efficiently and accurately inform stakeholders on complex challenges including ***decarbonization, resiliency, and cost optimization*** while offering a holistic modeling engine that is fluid with future development

Ambient Loop – Energy & LCCA Summary





Lessons Learned for Thermal-Electric Utilities

Scaling geothermal regionally **requires new tools**

The gas-to-geo development path is similar to:
- Transmission & distribution
- City revitalization roadmaps

Combining city-scale and regional planning process with thermal-electric utility features is necessary to move beyond the pilot.

Need to quantify electrical substation impacts
- Critical path seeking

A good master plan is dynamic with adaptive roll-outs and sensitivity analysis
- Informs strategies and goals
- KPIs

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Important

Be in touch.

nicholas.fry@jacobs.com
Thermal Energy Networks Market Lead

ENERGY MASTER PLANS – CENTRAL TO REGIONAL BUILDING ELECTRIFICATION

Jeff Urlaub / Salas O’Brien

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

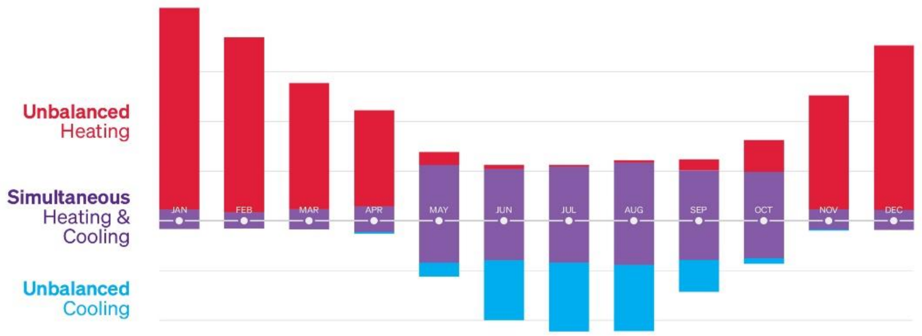
Greenhouse Gas Emissions | Fiscal Constraints

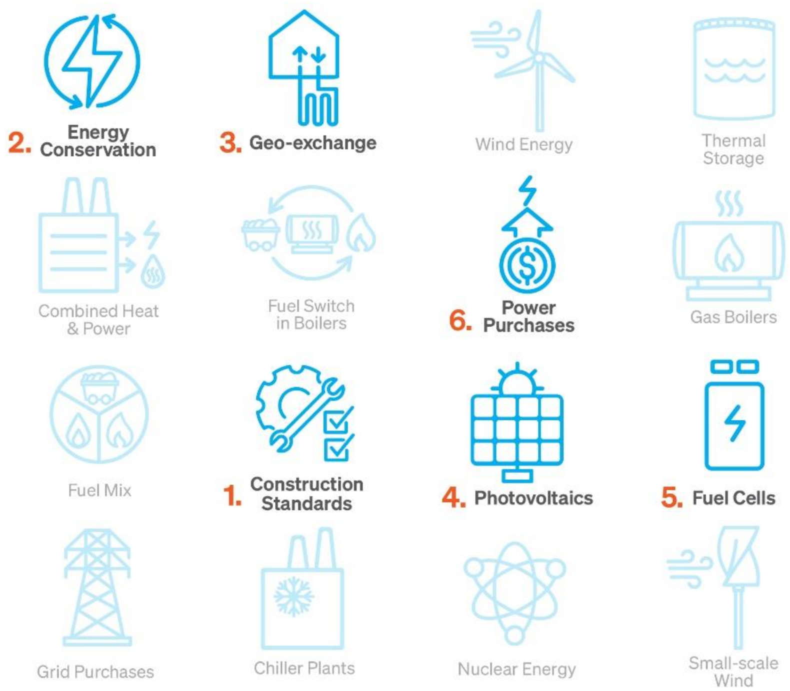
Life-cycle Cost of Ownership

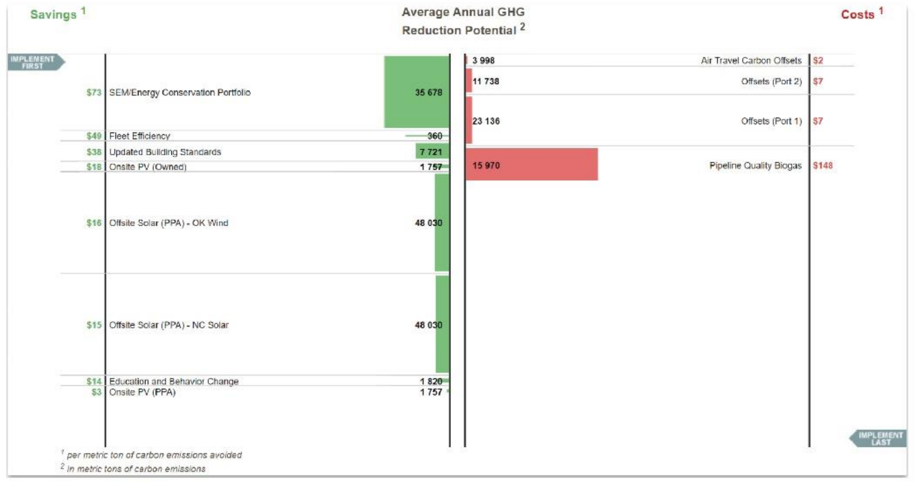
Strategic Plan

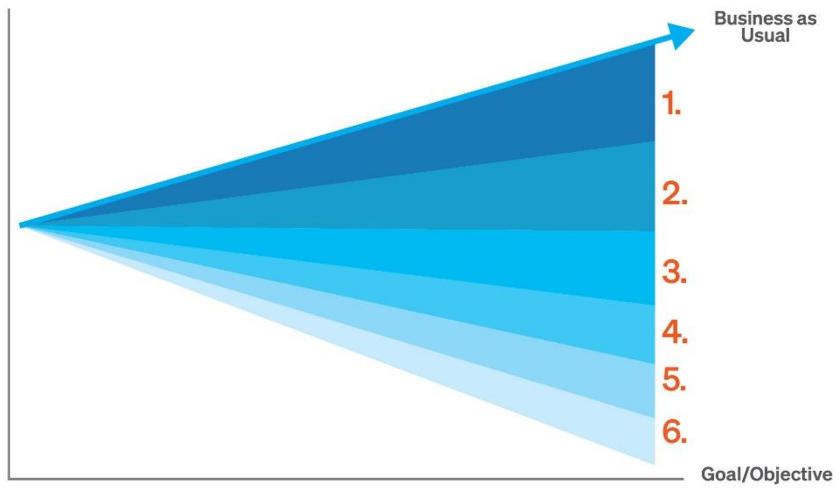
Campus Development

Greenhouse Gas Emissions | Fiscal Constraints







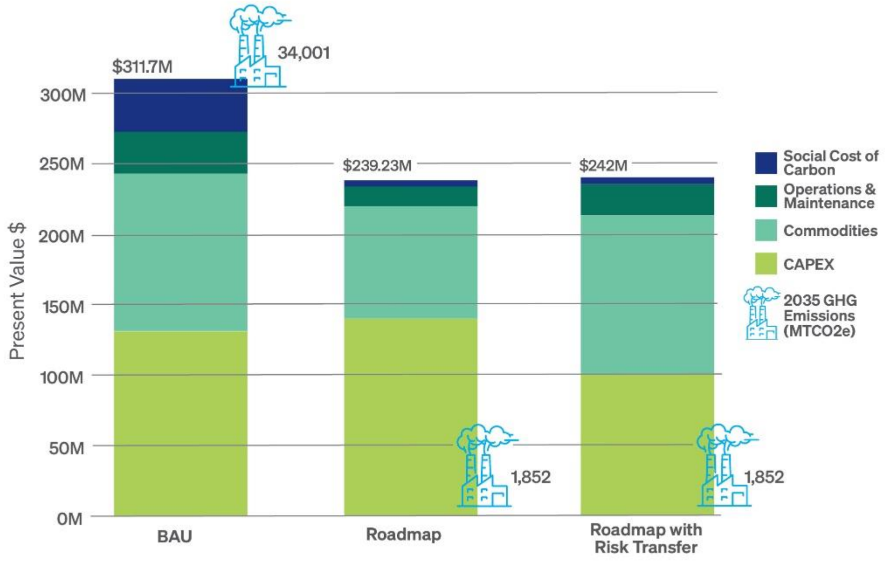


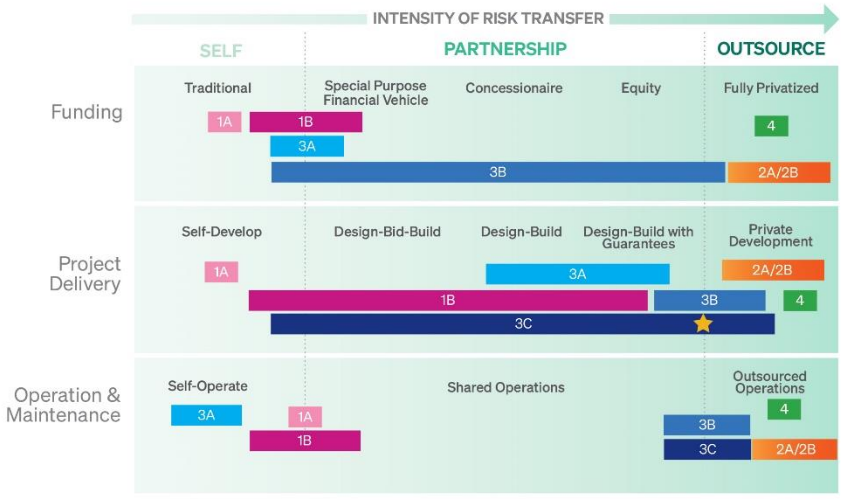
1 STRATEGIC ENERGY MANAGEMENT (SEM)
- SEM 1A: Program Development and Expansion
- SEM 1B: Deep Energy Retrofits + Building Conversions

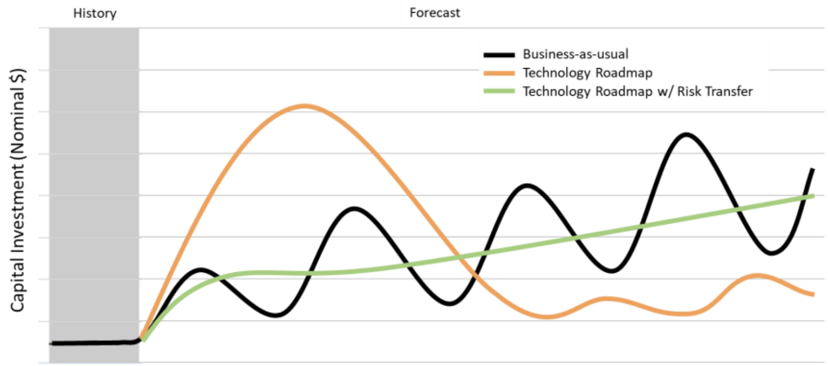
2 ON-SITE SOLAR + EV EXPANSION
- 2A On-Site Solar: Selected Parking, Rooftops and Walkways
- 2B EV Infrastructure: Electric Vehicle (EV) Charging Stations and Controls for Fleet and Commuter Vehicles

3 CAMPUS ENERGY TRANSITION
- 3A Thermal Reliability: Boiler Replacement and/or Combined Heat & Power
- 3B Electric Resilience: CHP + Batteries + Microgrid
- 3C Thermal Transition: Phased Geothermal Distribution Network, GEOTHERMAL COMPATIBILITY

4 OFF-SITE RENEWABLES + OFFSETS
- 4 Residual Decarbonization: Off-Site Renewable Energy + Offsets





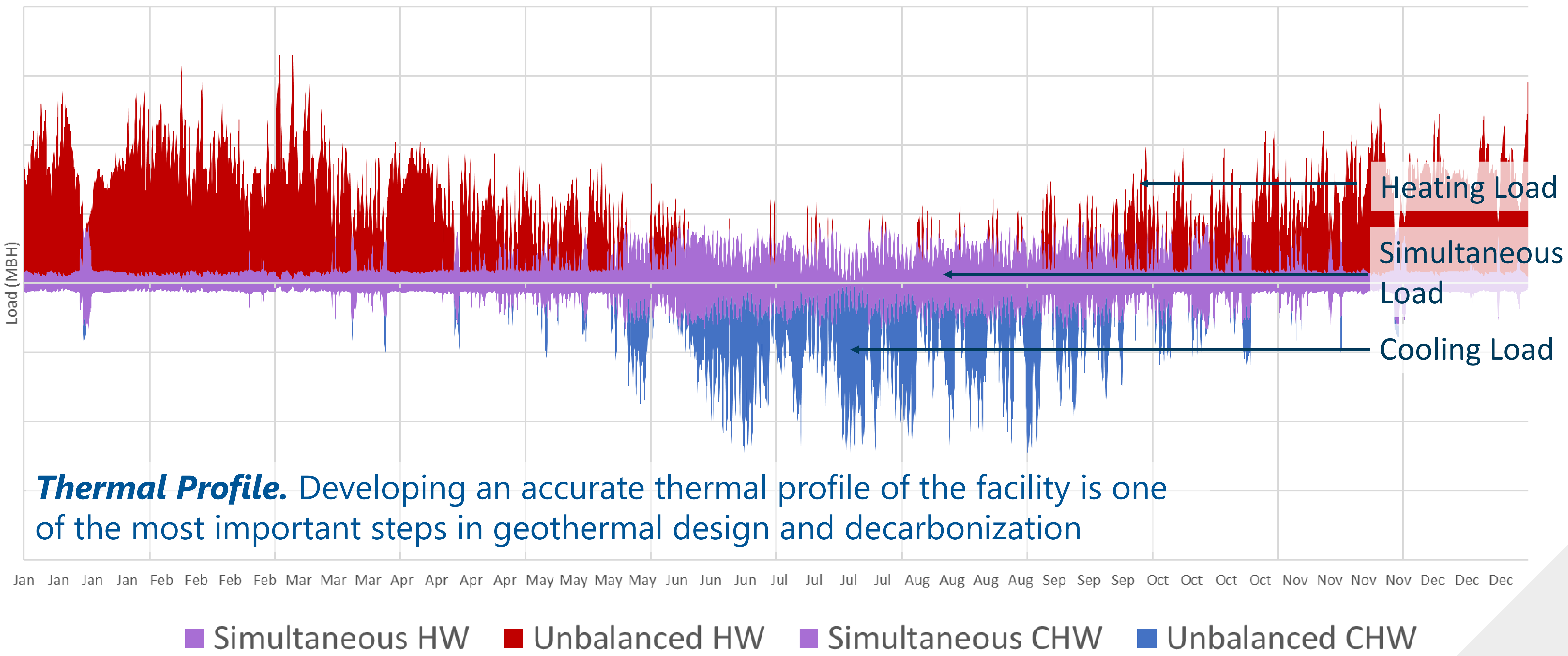


Life-Cycle Cost of Ownership

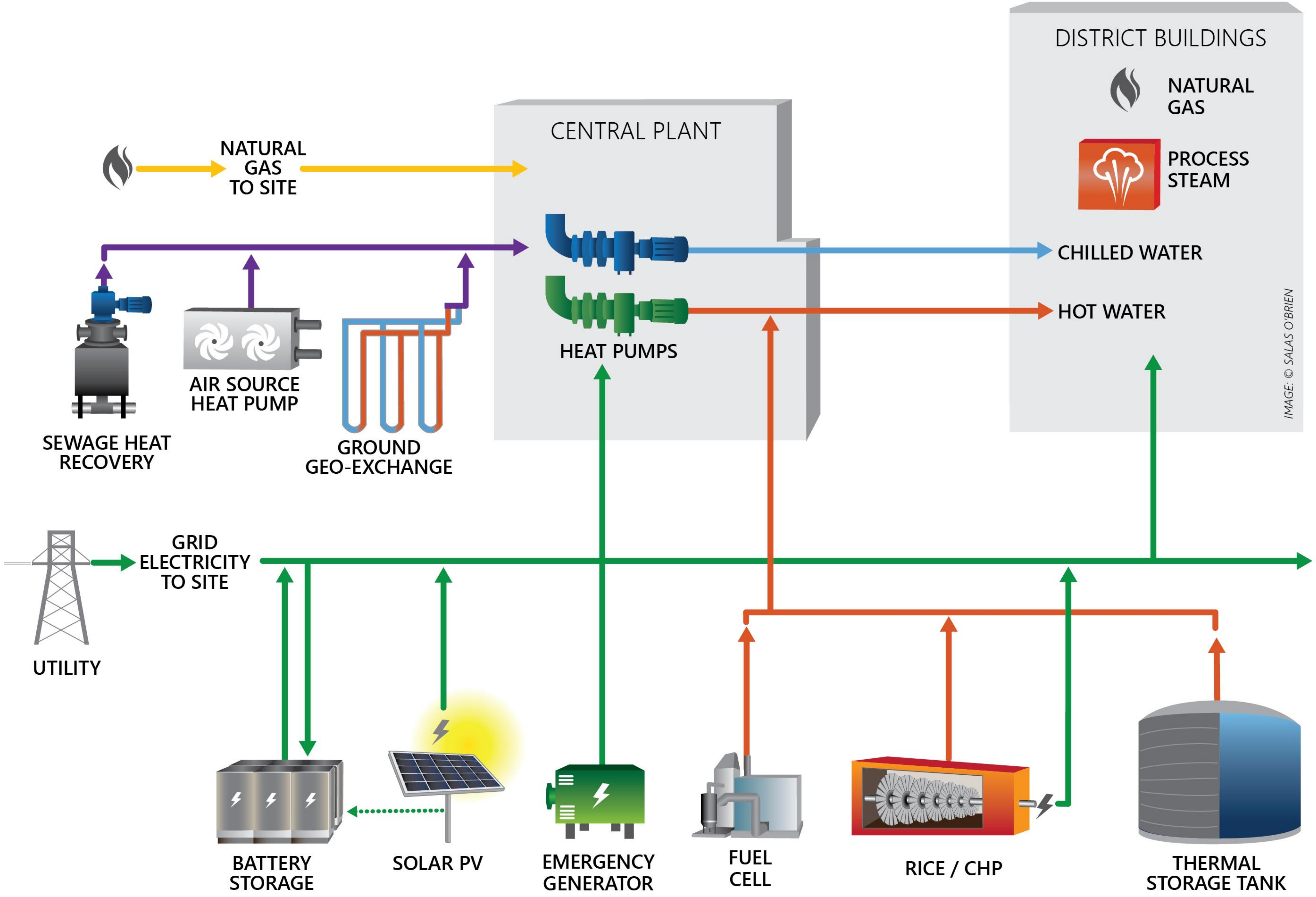
Item	Annual	30-year Forecast (incl. Escalation): Cumulative	30-year Forecast (incl. Escalation): Present Value*
Utility Bills (Purchased Electricity and Fuels only)	$ 8.3 M	$364 M	$ 179 M
O&M - Central Plant**	$ 4.7 M	$ 208 M	$ 103 M
Capital Renewal – Central Plant**	$ 4.0 M	$ 174 M	$ 85 M
O&M - Distribution**	$ 1.6 M	$ 69 M	$ 34 M
Capital Renewal – Distribution**	$ 1.2 M	$ 52 M	$ 26 M
O&M – Building HVAC	$ 1.2 M	$ 69 M	$ 34 M
Capital Renewal – Building HVAC***	$ 3.0 M	$ 130 M	$ 64 M
Total	$ 24.3 M	$ 1.07 B	$ 526 M
Carbon Risk****	$ 4.0 M	$ 177 M	$ 87 M
Total with Carbon Risk	$ 28.3 M	$ 1.24 B	$ 613 M

* Discount Rate = 5%
** Based on low range of Big 10 and Friends Central Plant Benchmark Study
*** Based on industry standard building HVAC renewal estimate of $25/GSF
**** Assumes $51 / MTCO2e escalating at 5% per year. Read more: https://www.wired.com/story/the-biden-administration-weighs-the-social-cost-of-carbon/

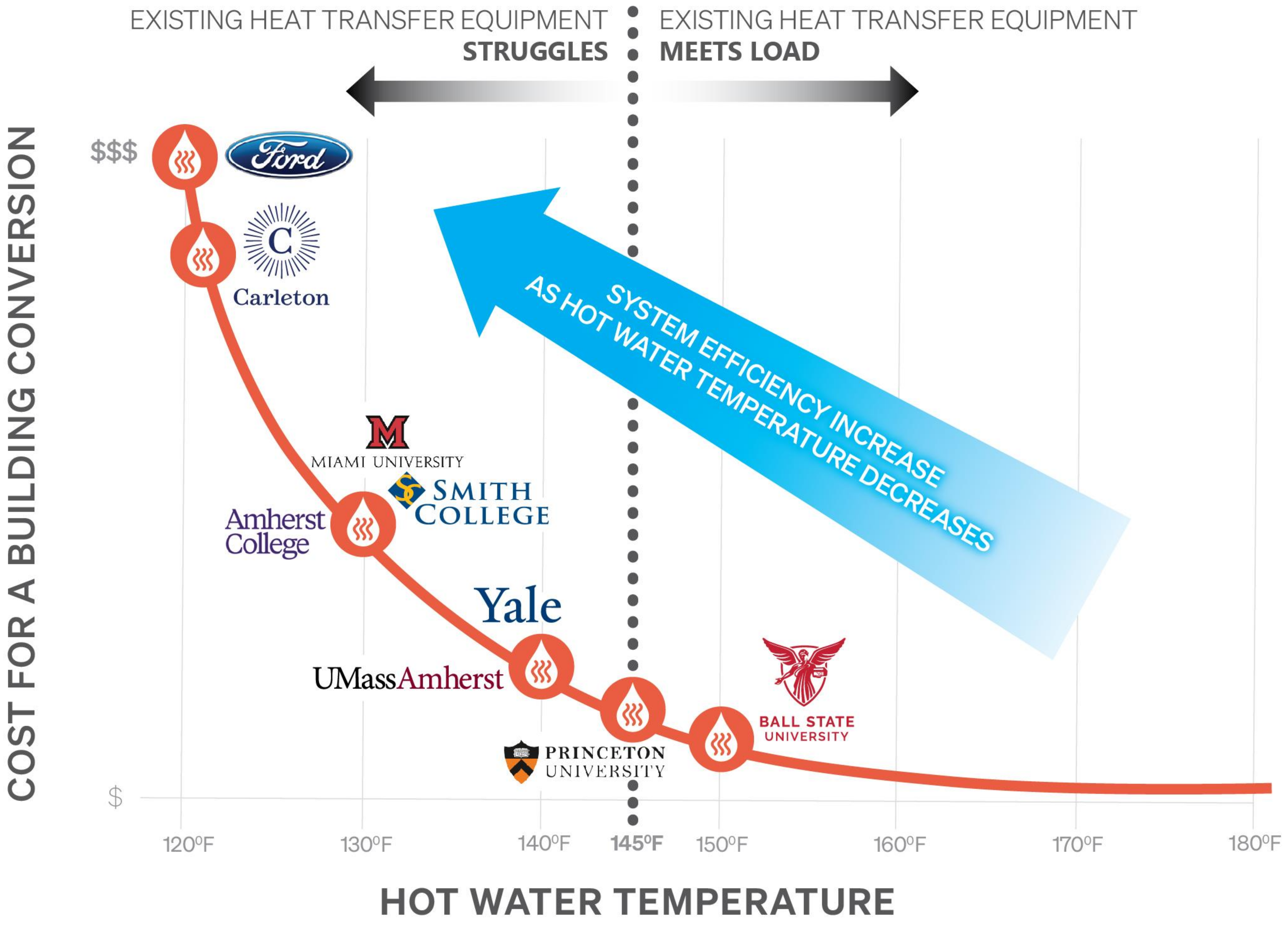
Facility Thermal Profile



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



DISTRICT BUILDINGS
NATURAL GAS
PROCESS STEAM
CHILLED WATER
HOT WATER
IMAGE: © SALAS O'BRIEN
CENTRAL PLANT
NATURAL GAS TO SITE
HEAT PUMPS
SEWAGE HEAT RECOVERY
AIR SOURCE HEAT PUMP
GROUND GEO-EXCHANGE
GRID ELECTRICITY TO SITE
UTILITY
BATTERY STORAGE
SOLAR PV
EMERGENCY GENERATOR
FUEL CELL
RICE / CHP
THERMAL STORAGE TANK

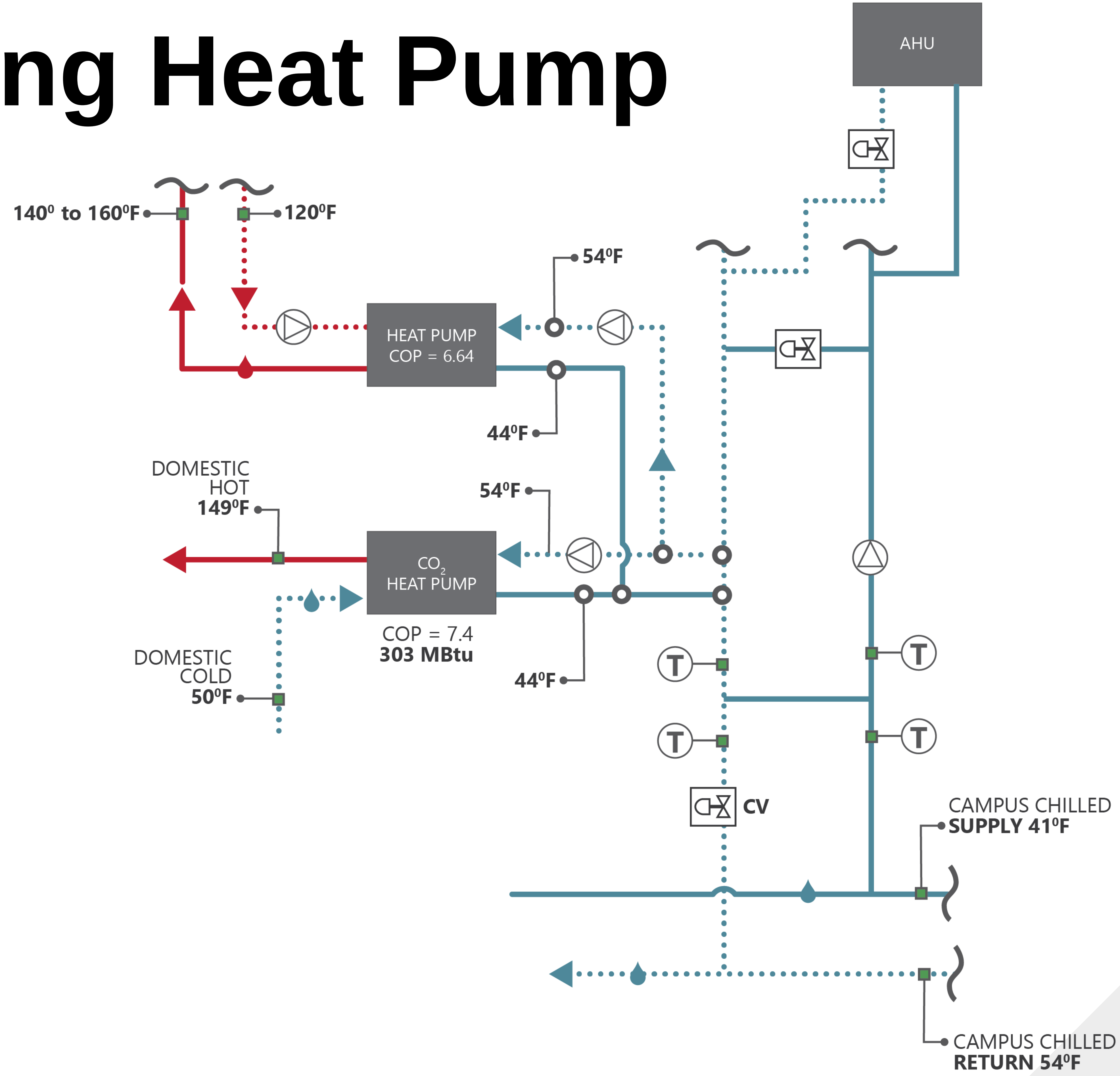


EXISTING HEAT TRANSFER EQUIPMENT
STRUGGLES
EXISTING HEAT TRANSFER EQUIPMENT
MEETS LOAD
SYSTEM EFFICIENCY INCREASE
AS HOT WATER TEMPERATURE DECREASES
COST FOR A BUILDING CONVERSION
$$$
$
Ford
Carleton
MIAMI UNIVERSITY
SMITH COLLEGE
Amherst College
Yale
UMassAmherst
PRINCETON UNIVERSITY
BALL STATE UNIVERSITY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

Ground Source Heat Pumps

Individual Building Heat Pump

- Use the chilled water as an energy source
- This scenario will allow the CEP LWT to be lower.



Oilon Industrial Heat Pumps

Type	P-series	S-series	RE-series
Heating Output ***Max.Temperature***	**102.4 – 1534 MBTU/h** **248°F**	**614-6824 MBTU/h** **185°F**	**716 - 1433 MBTU/h** **144°F**
Compressor:	Piston	Screw	Scroll
Refrigerant:	R134a, R513A, R450A, R1233zd	R134a, R513A, R450A, R1233zd	R410A

Heat Pump Chiller Technology

York YK

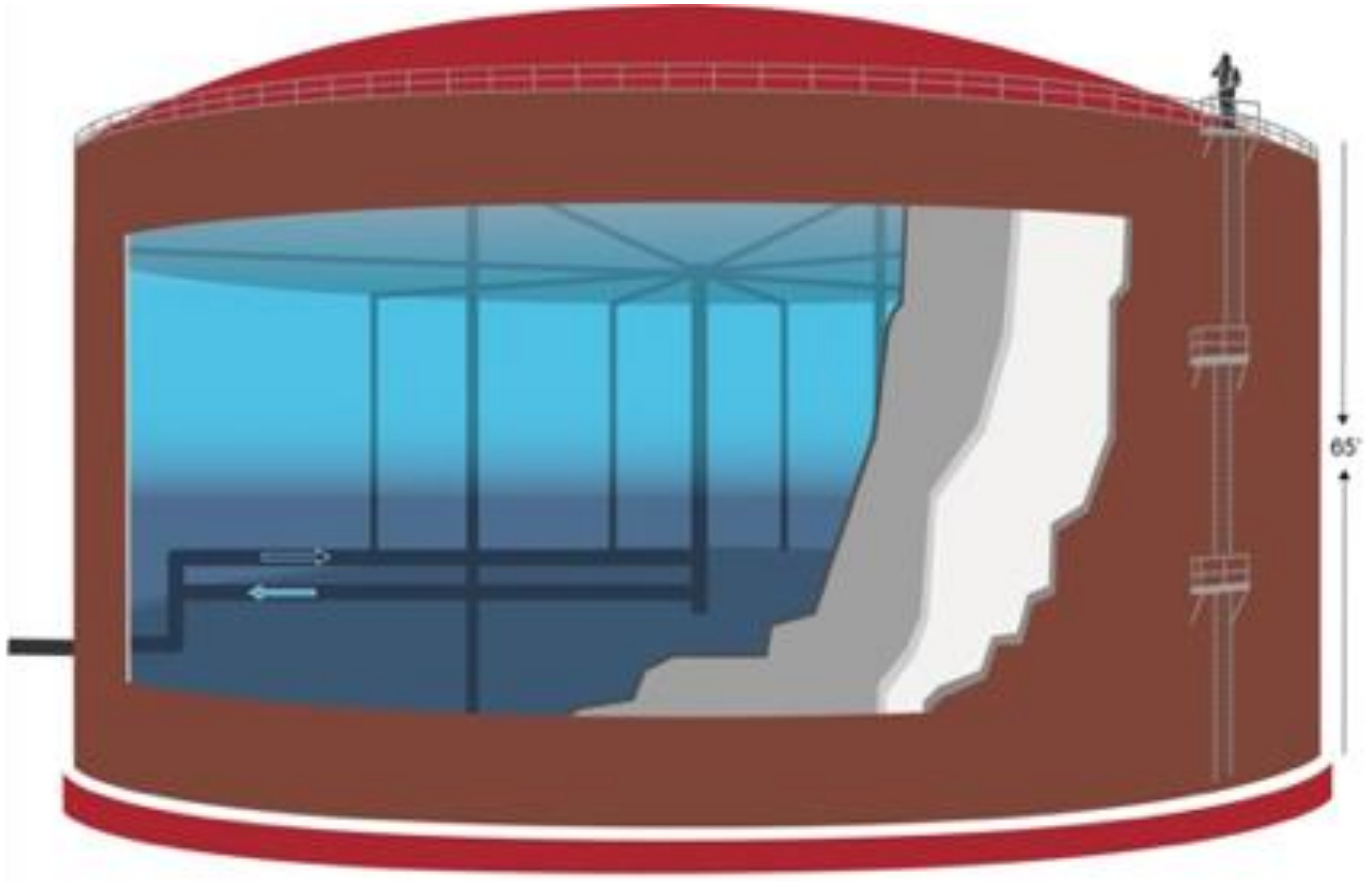
York CYK

Carrier 19DV

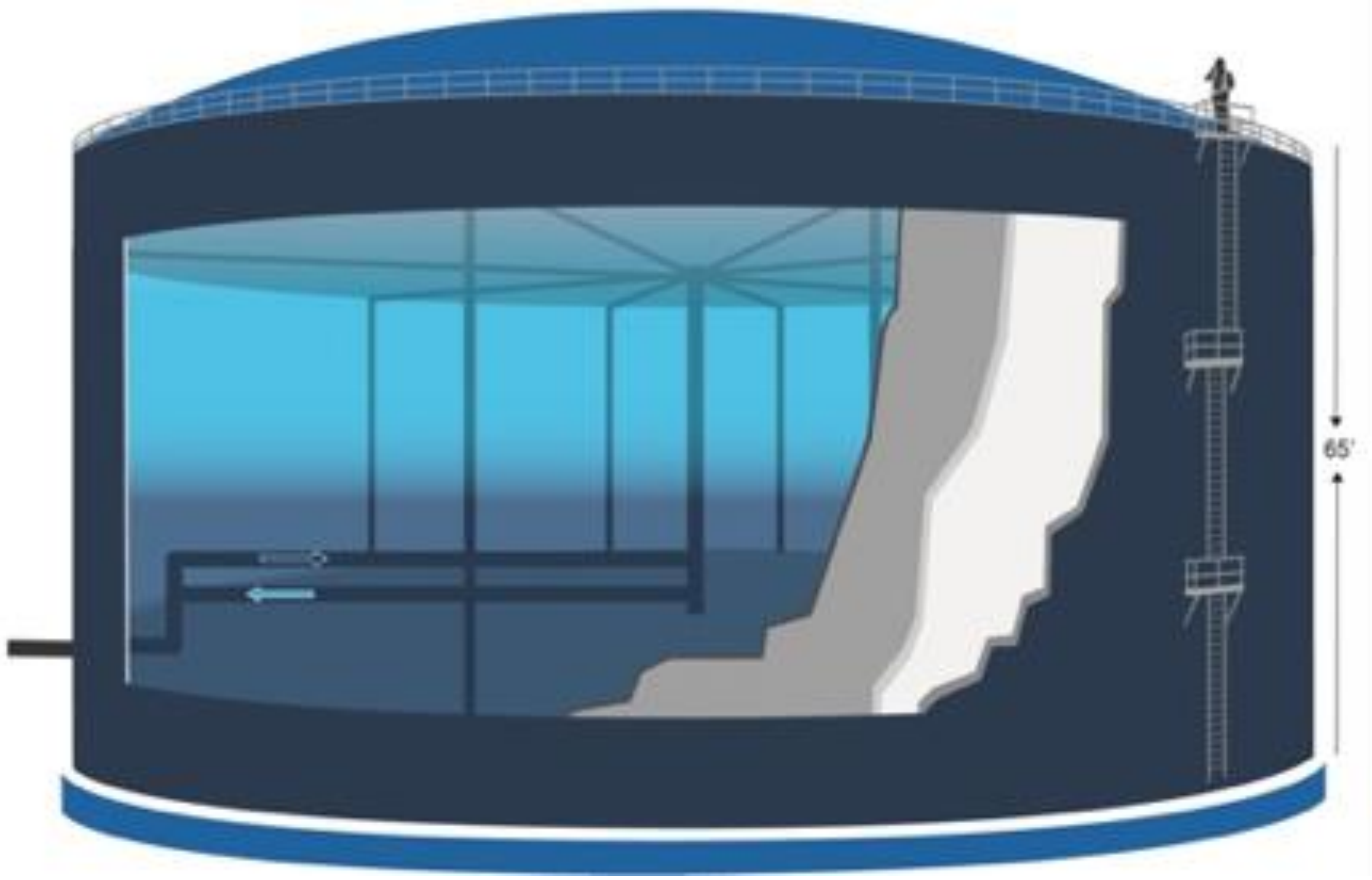
Multistack Centrifugal

Trane Centravac

Thermal Energy Storage



Hot thermal storage



Chilled thermal storage

Heat Pump Chiller Technology

ClimaCool

Waterfurnace Variable Speed Dual SCrew

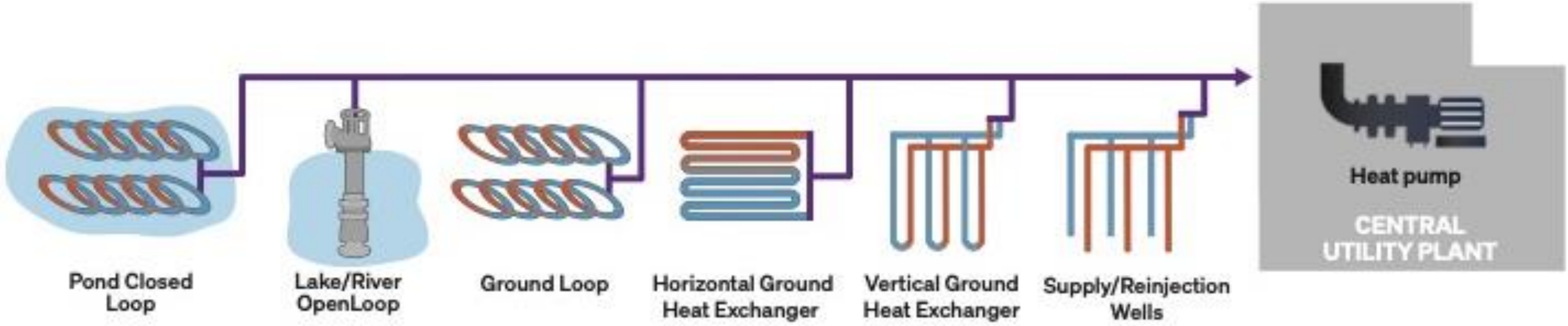
Water furnace Modular Scroll

Trane RTWD

Multistack Modular

Ground Source Heat Exchangers

Ground Heat Exchanger Options



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Q&A

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