UC SANTA BARBARA

Clean Energy Master Plan

Town Hall

Wednesday June 5, 2024

Presenters

Susannah Scott, Co-Chair
Chair, Santa Barbara Division of the Academic Senate; Distinguished Professor, Chemical Engineering and Chemistry & Biochemistry, Mellichamp Academic Initiative in Sustainability; Chair in Sustainable Catalytic Processing
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Renée Bahl, Co-Chair
Associate Vice Chancellor, Design, Facilities & Safety Services; Co-Chair, Chancellor's Sustainability Committee
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Agenda

Introduction

Decarbonization Strategy & Cost Estimates

Environmental Justice and Equity

Climate Action Planning Gap Analysis

Living Laboratory Opportunities

Q&A

Closing Comments

UCSB Decarbonization Study Project Committee

Susannah Scott, Co-chair
Chair, Santa Barbara Division of the Academic Senate; Distinguished Professor, Chemical Engineering and Chemistry & Biochemistry, Mellichamp Academic Initiative in Sustainability Chair in Sustainable Catalytic Processing

Renée Bahl, Co-Chair
Associate Vice Chancellor, Design, Facilities & Safety Services, Co-Chair, Chancellor's Sustainability Committee

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UCSB Student Interns at Introba

Orla Ayton
Student Engagement
&
Outreach

Kaden Lee
New Technologies

Maya Ades
Climate Equity
&
Justice

Zach Zavodnik
Data Analysis

How it all started

1

UC Carbon Neutrality Initiative (CNI)

- To accelerate its transition away from fossil fuels, the UC in 2013 adopted climate action goals that **prioritize direct emission reductions, limit the use of carbon offsets** and **align UC's climate goals with those of the state of California**.

2

UCOP Pathways to Fossil Free UC Task Force

- In 2022, President Drake convened a task force under the UC Global Climate Leadership Council to **address the campus decarbonization challenge**
- New policy goals emerged that supersede the CNI and put in place a framework to fully decarbonize UC campuses and health centers **no later than 2045**

3

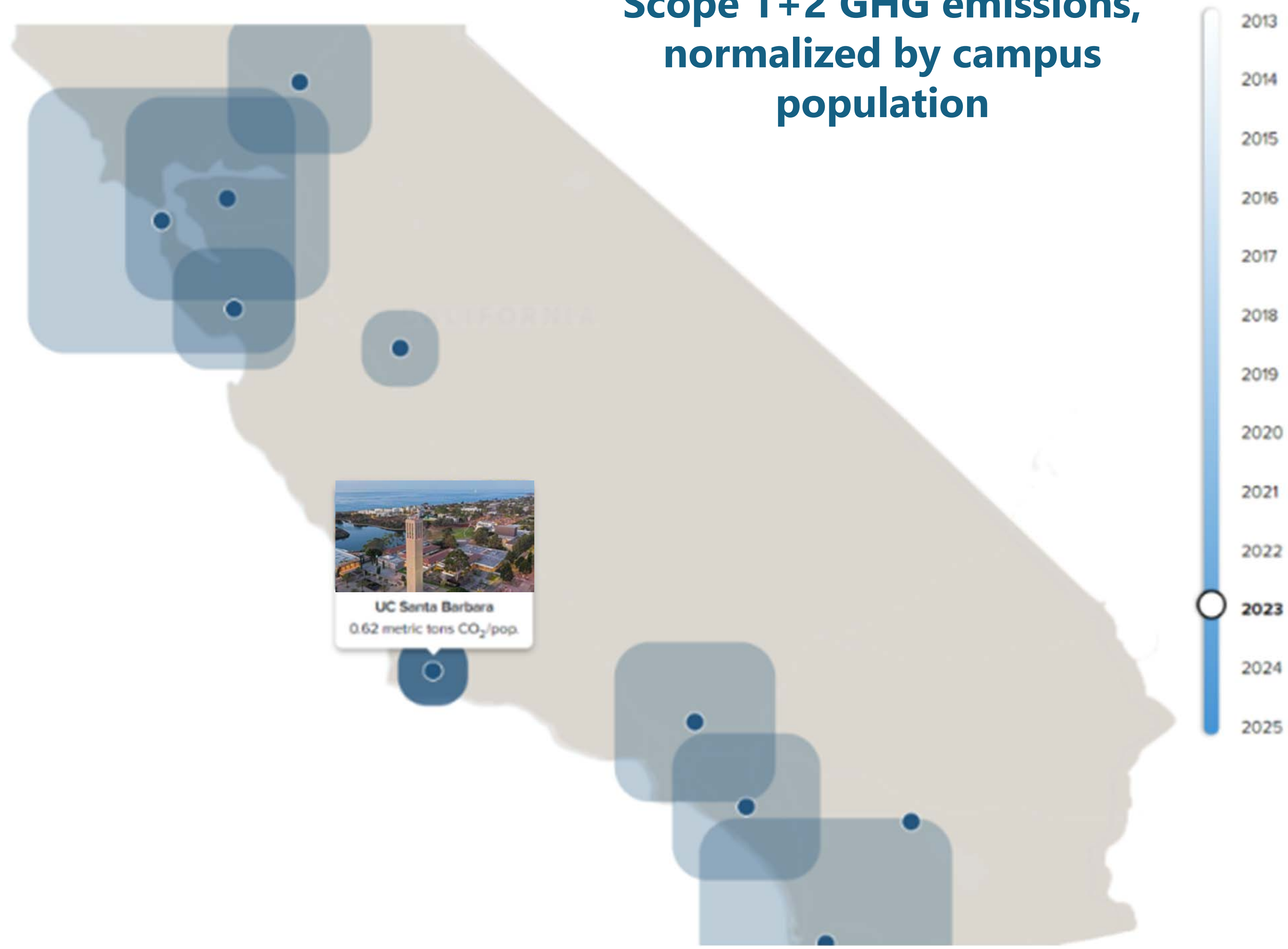
State-Funded Decarbonization Studies

- To inform **emissions reduction strategies**, **emission targets** and **location-specific climate action plans**
- **$1M** in state funding

Decarbonizing UC Santa Barbara

1. Mild climate and flat terrain
2. No fossil fuel burning central plant
3. No healthcare facilities with emissions to manage
4. Major expansion of student housing underway, with all-electric construction
5. Largest fraction of total energy needs supplied by UC Clean Power Program
6. Lowest Scope 1+2 emissions of any UC campus, both by area and campus population

Scope 1+2 GHG emissions, normalized by campus population



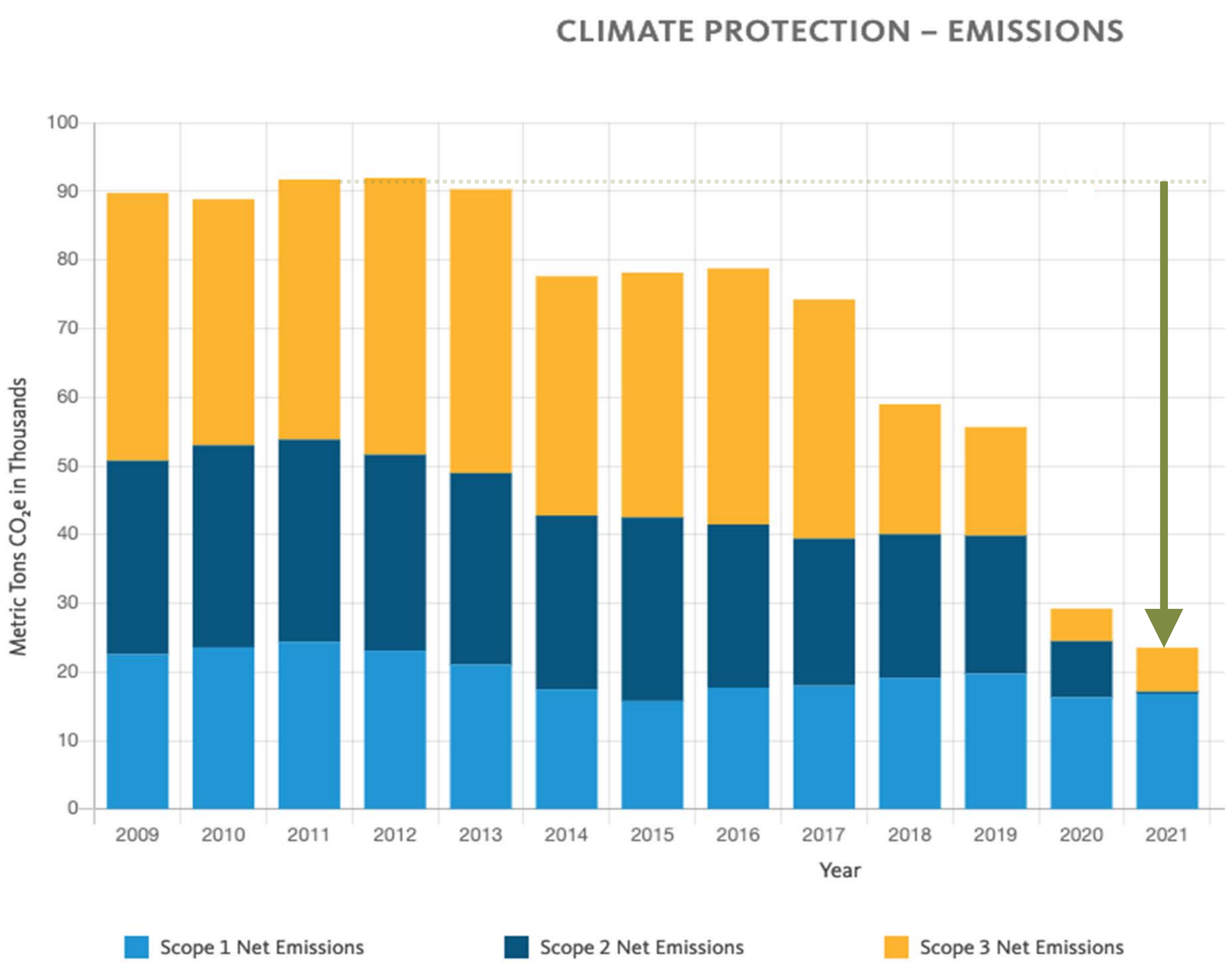
[* https://cnidashboard.ucop.edu/](https://cnidashboard.ucop.edu/)

Decarbonizing UC Santa Barbara

In the **last decade**, UC Santa Barbara has reduced its CO_{2e} emissions by more than **two-thirds**

Primary challenge will be **remaining Scope 1** (on-site combustion) **emissions**

Inspired by UC's goals, and aided by $1M in state funding, UCSB initiated a request for a plan



UCSB'S Decarbonization Study Objectives

1. Produce a **strategy for a 90% or greater reduction in Scope 1 emissions from fossil gas use** in campus energy systems from a 2019 baseline

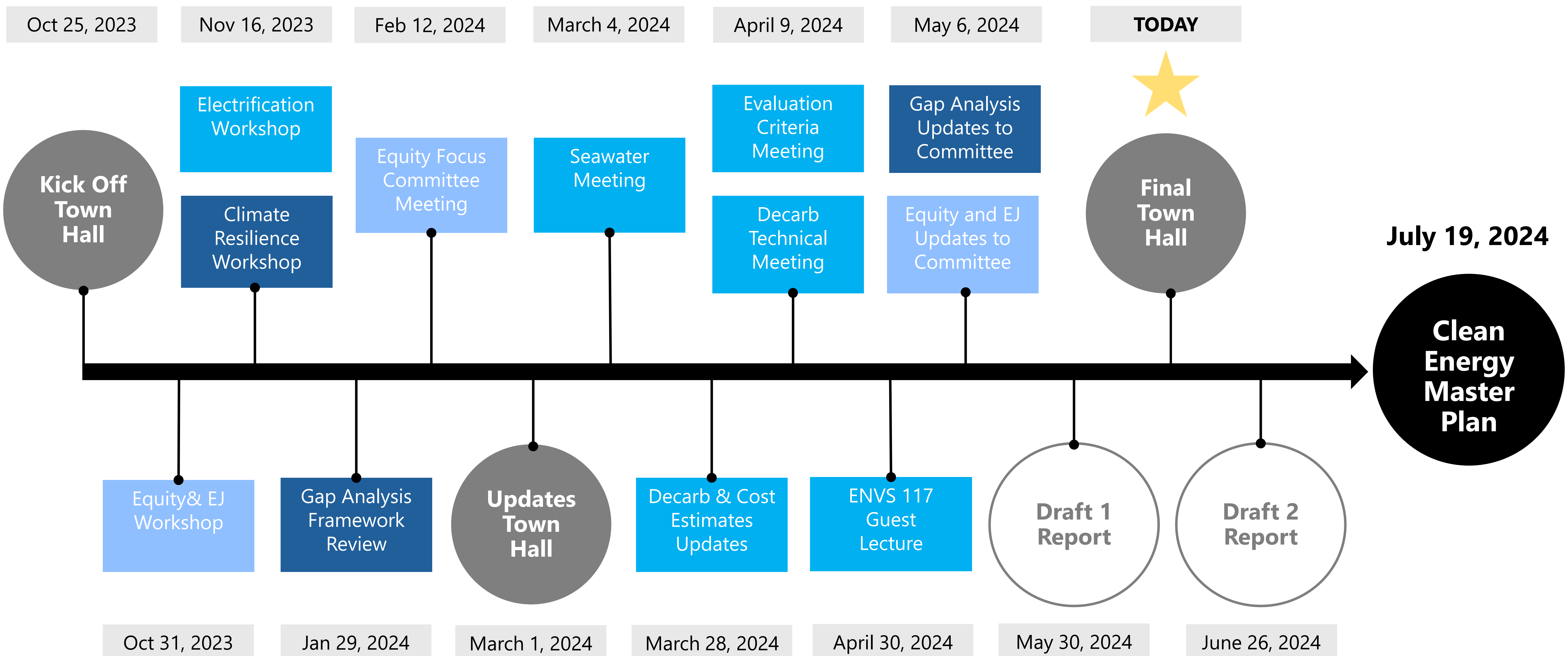
2. Provide **high level estimates of total capital and operational costs and savings**, to support funding requests as well as inclusion in the campus' capital financial plan

3. Identify **environmental justice and equity considerations** related to the transition to fossil fuel free infrastructure

4. Document **knowledge gaps, and subsequent studies and analyses** needed to conduct climate action planning

5. Identify research, education and other opportunities for **campus as a "living laboratory"** for climate action and sustainability

UCSB Decarbonization Study Timeline



Decarbonization Strategy

Campus Decarbonization Opportunities

Toolkit: Technologies & Components

Solutions

Options Comparison

Recommendations

Next Steps

UCSB Scope 1 Emissions and Opportunities

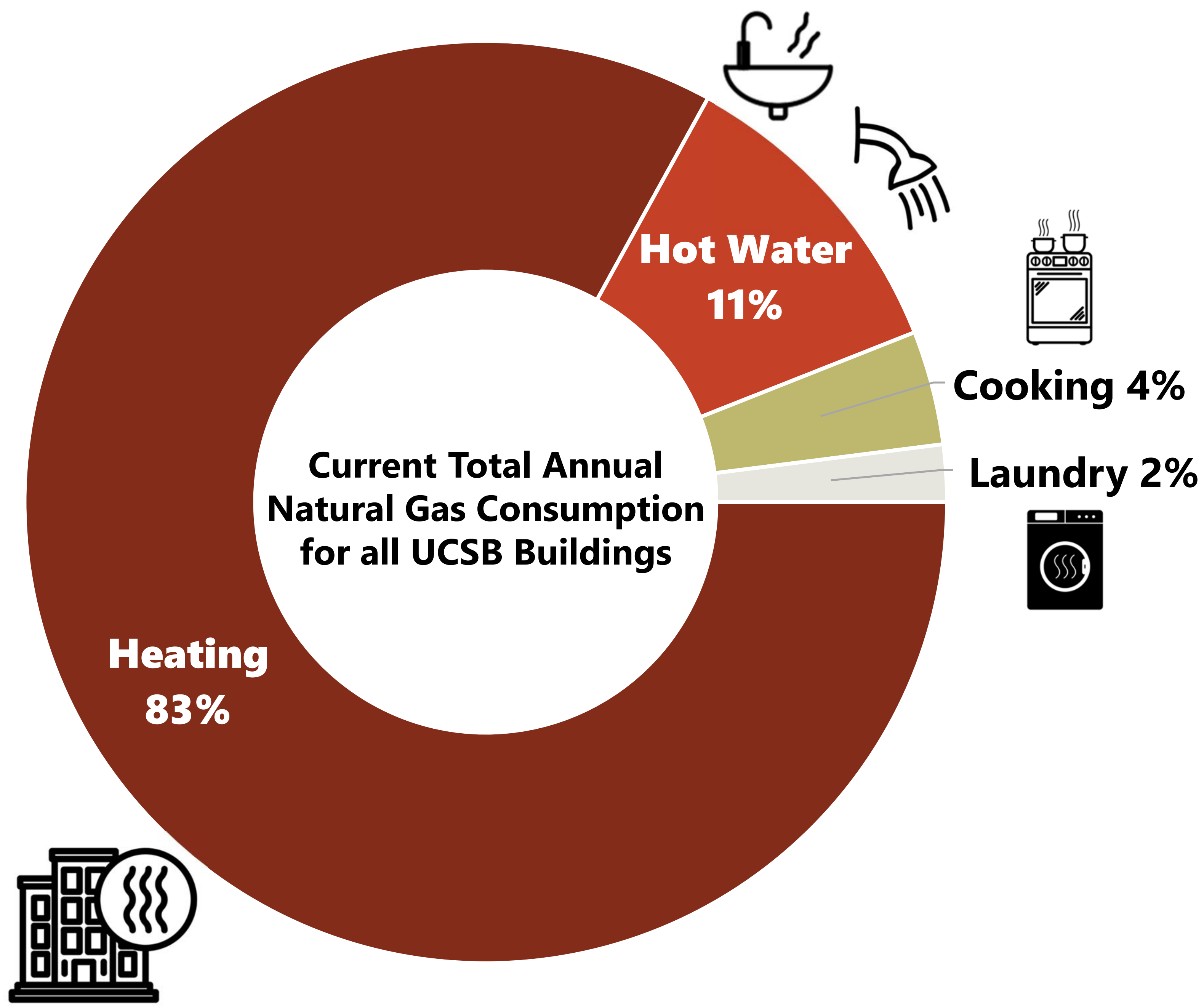
Critically, Heating and Hot Water combine for

94% of UCSB's total natural gas consumption

Natural Gas Services at UCSB:

- Heating
- Hot Water
- Cooking
- Laundry
- Other Process

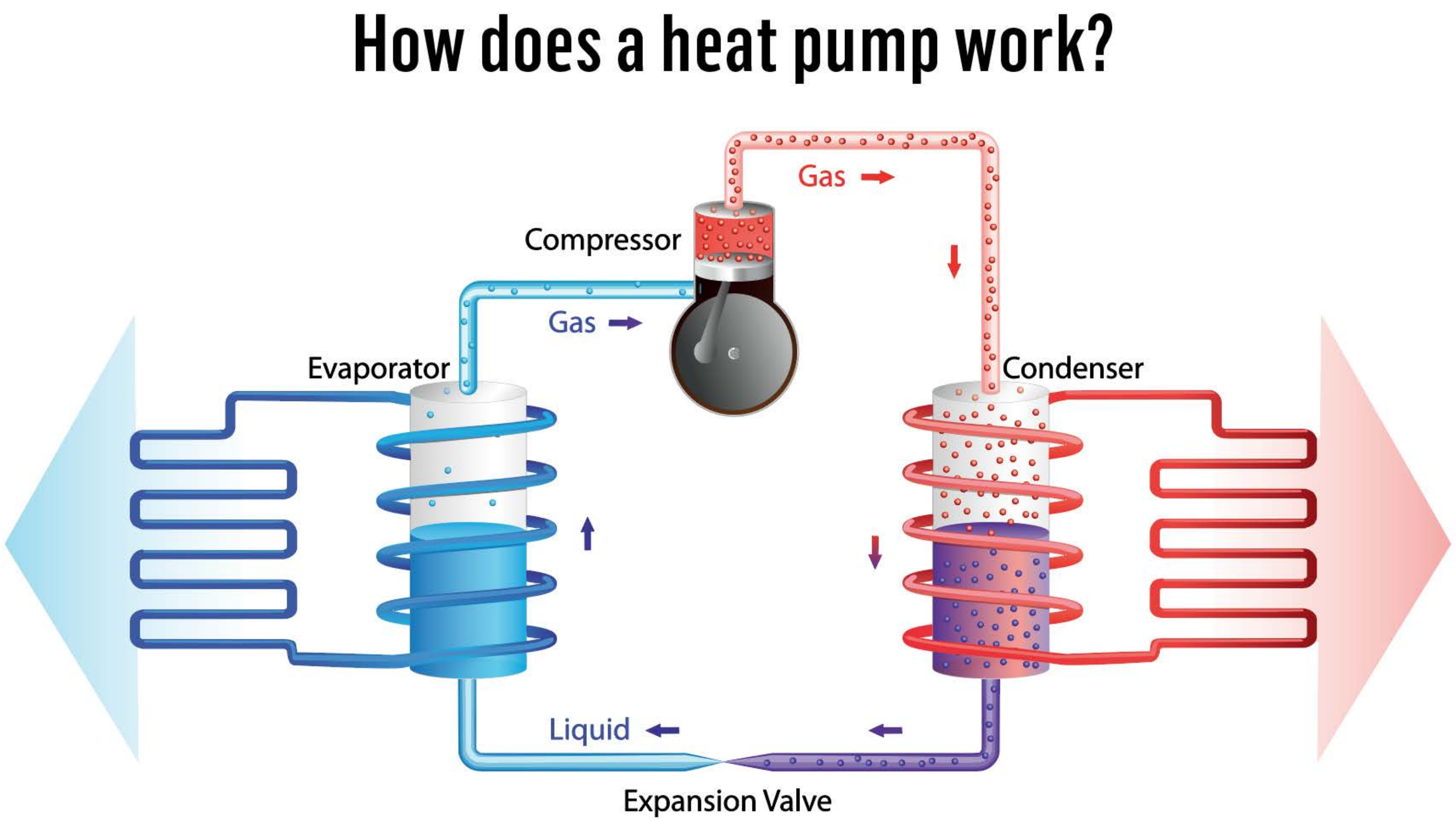
Need: Electrification to Reduce Onsite Fossil Fuel Use by at least 90%



Thermal Load Patterns

Heating vs. Cooling vs. Simultaneous

The Other is Free



Make One

Every time a heat pump makes heating it also makes cooling, and visa versa. If that free production isn't saved via coincident need or a storage tank to save it for later, then it is wasted.

Thermal Load Patterns

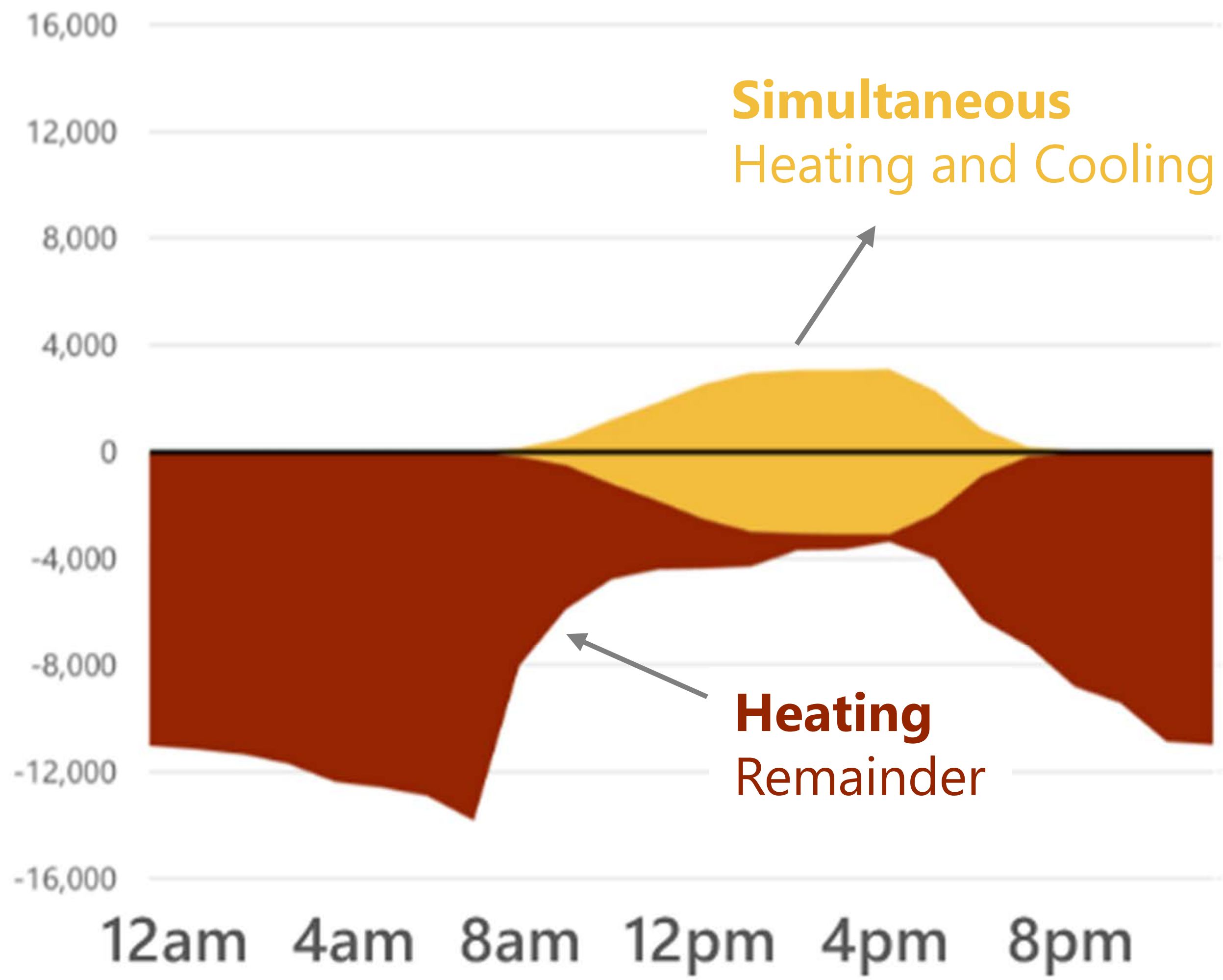
Heating vs. Cooling vs. Simultaneous

Winter:

- Very Heating Dominant
- Most hours heating is well beyond cooling and needs a heat-source for to provide via a heat pump instead of electric boiler.
- Middle of day is about balanced, but small loads

Typical Winter Day Load Profile

(kWh) (Average Day in February)

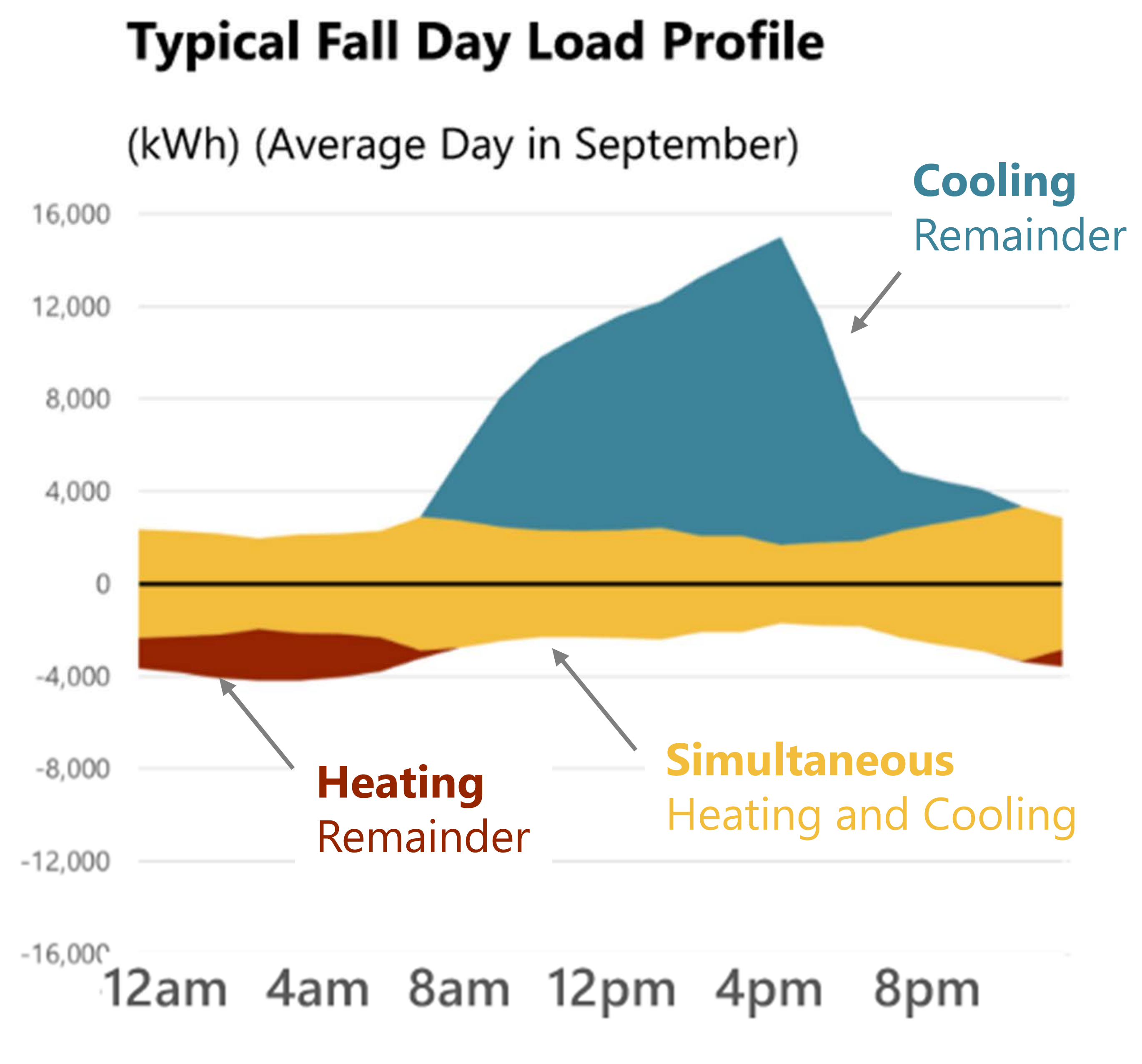


Thermal Load Patterns

Heating vs. Cooling vs. Simultaneous

Fall (and summer):

- Very Cooling Dominant (Particularly mid day)
- Slightly Heating Dominant over night/early morning



Thermal Load Patterns

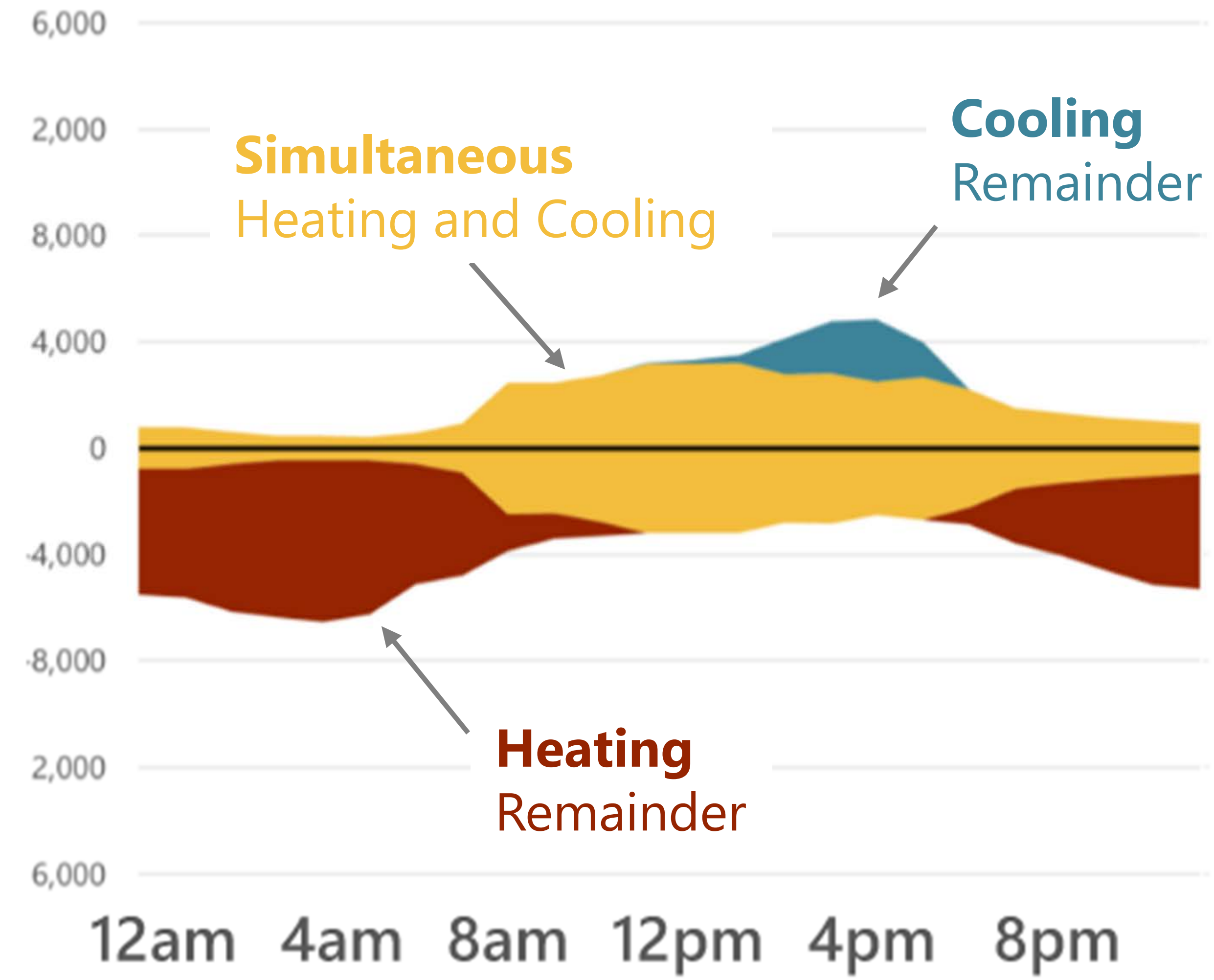
Heating vs. Cooling vs. Simultaneous

Spring:

- Most Days are Heating Dominant
- Simultaneous loading about half the load
- Balanced during the day
- Heating Dominant evening/night/morning

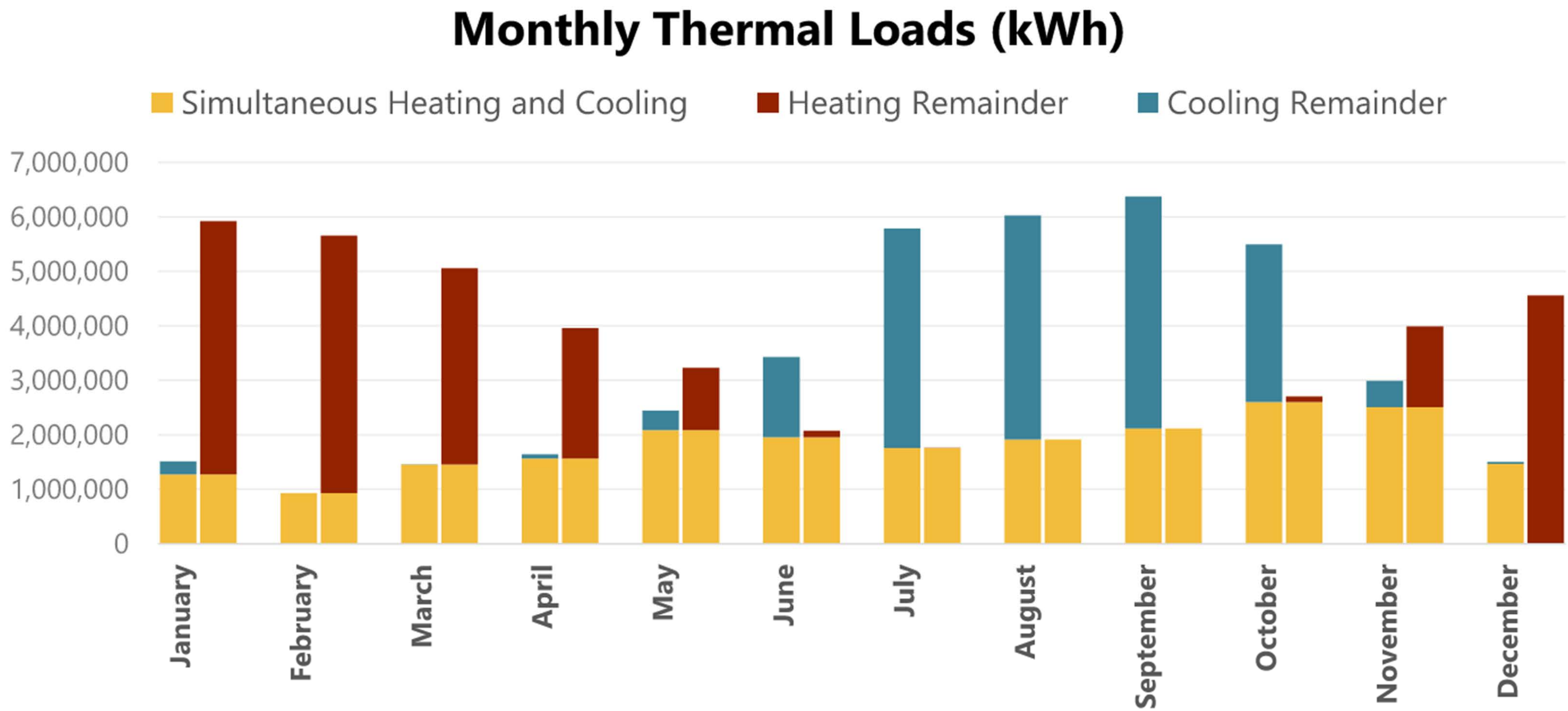
Typical Spring Day Load Profile

(kWh) (Average Day in May)



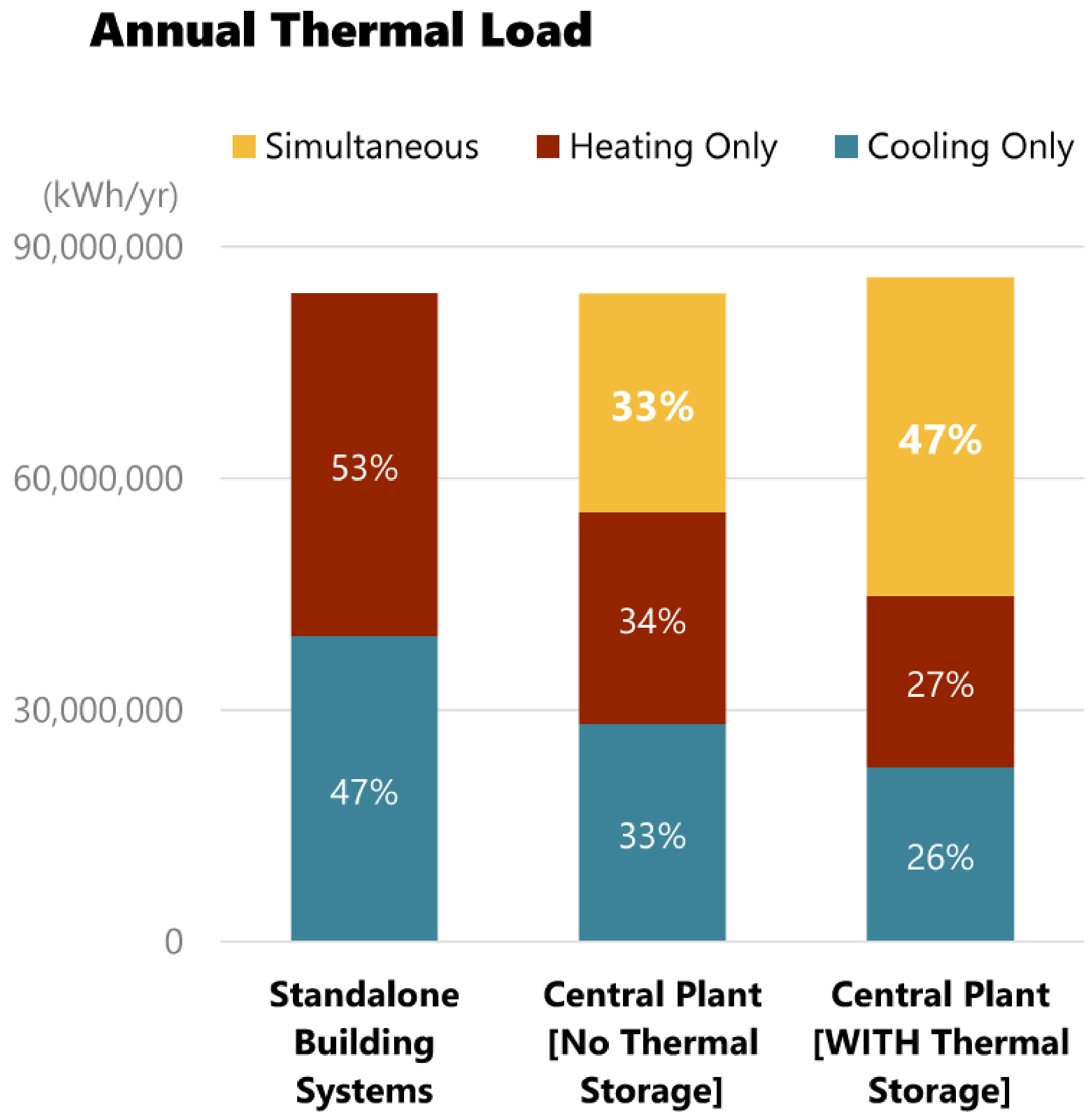
Thermal Load Patterns

Heating vs. Cooling vs. Simultaneous



Simultaneous Heating & Cooling

Opportunities : Leveraging Waste Heat

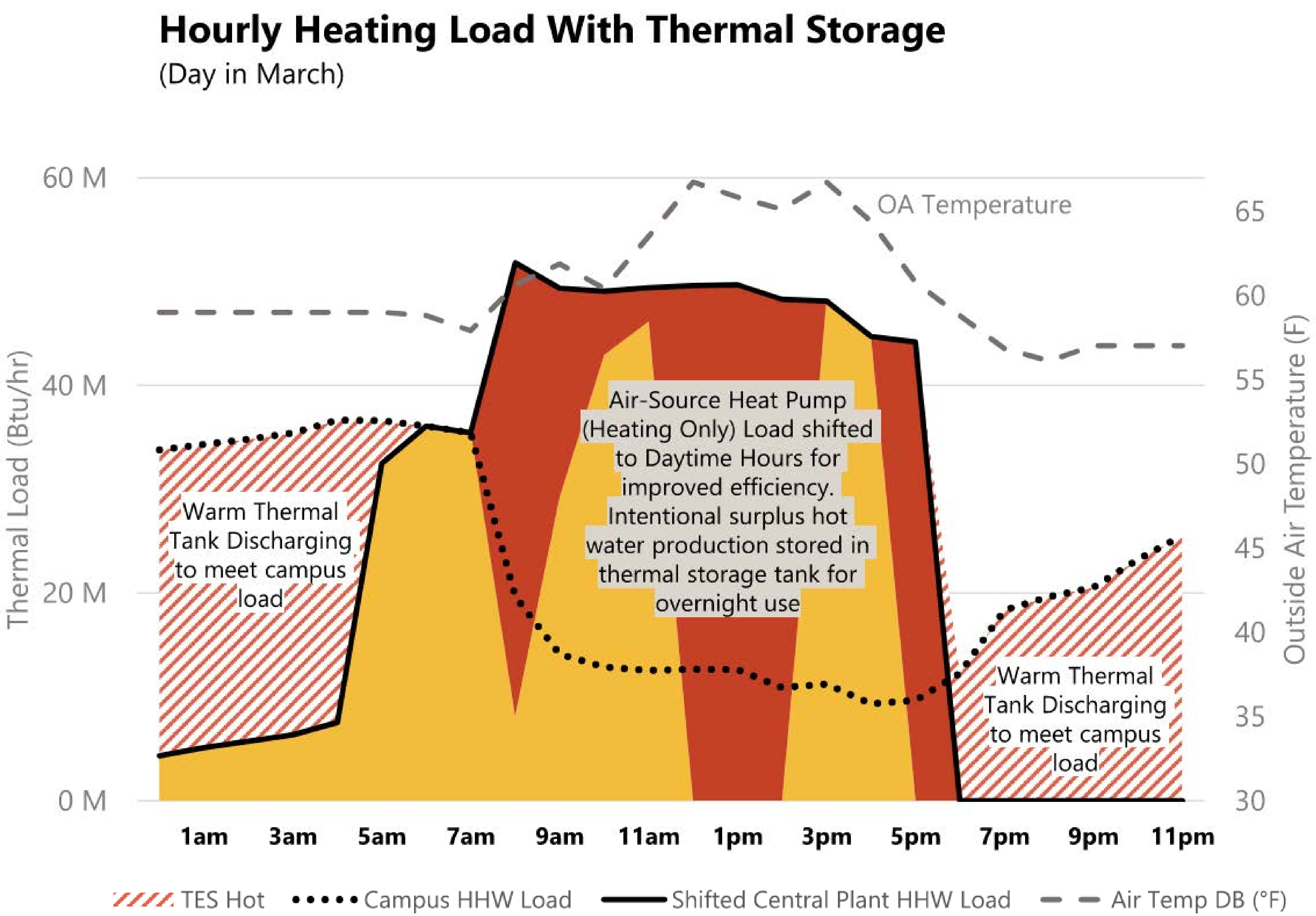


With thermal storage, about half the of the heating and cooling load can be met through heat recovery

Shift to Lower Use Energy Times

Opportunities : Energy Use

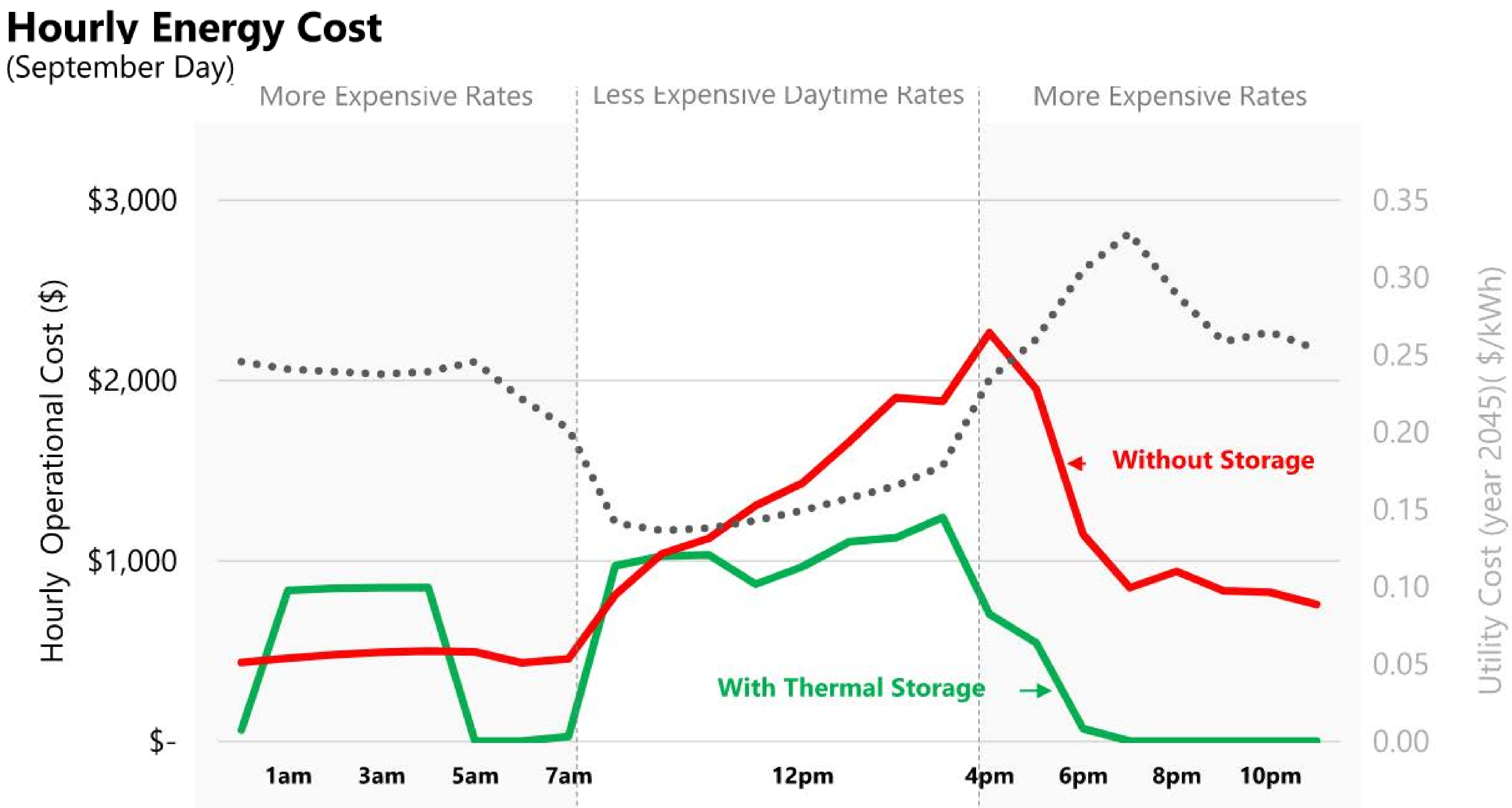
Capturing excess heat generated using warmer daytime air temperatures as a heat source,



Shift to Lower Cost Times

Opportunities : Energy Cost Savings

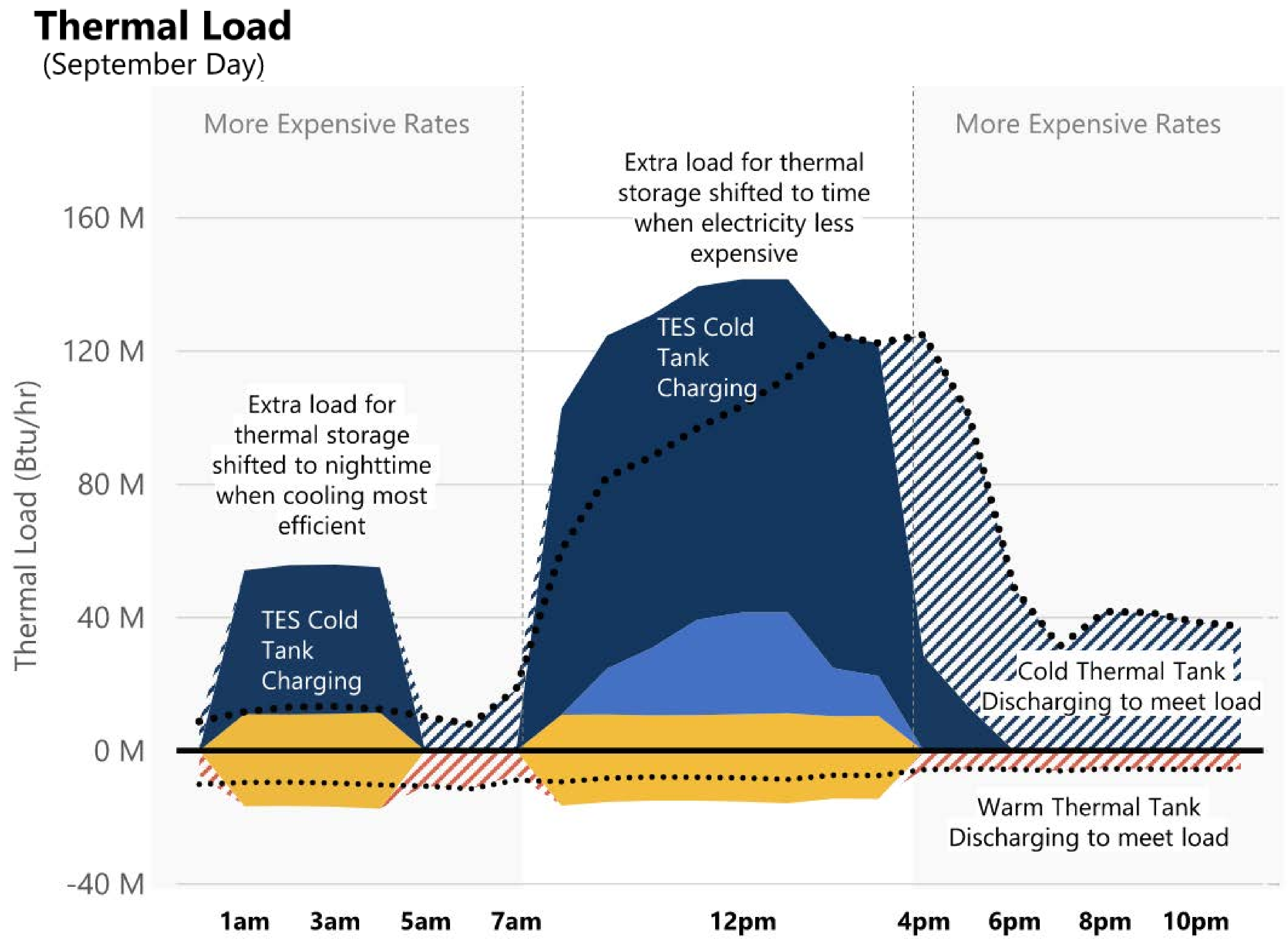
UCOP Time-of-Use electricity rates disincentivize use during summer afternoon and overnight hours by charging more during those times.



Shift to Lower Cost Times

Opportunities : Energy Cost Savings

Thermal Storage allows heating and cooling production to shift to the middle of the day, when electricity is cheapest (and also lowest emissions burden on the grid)



Campus Decarbonization Opportunities

Toolkit: Technologies & Components

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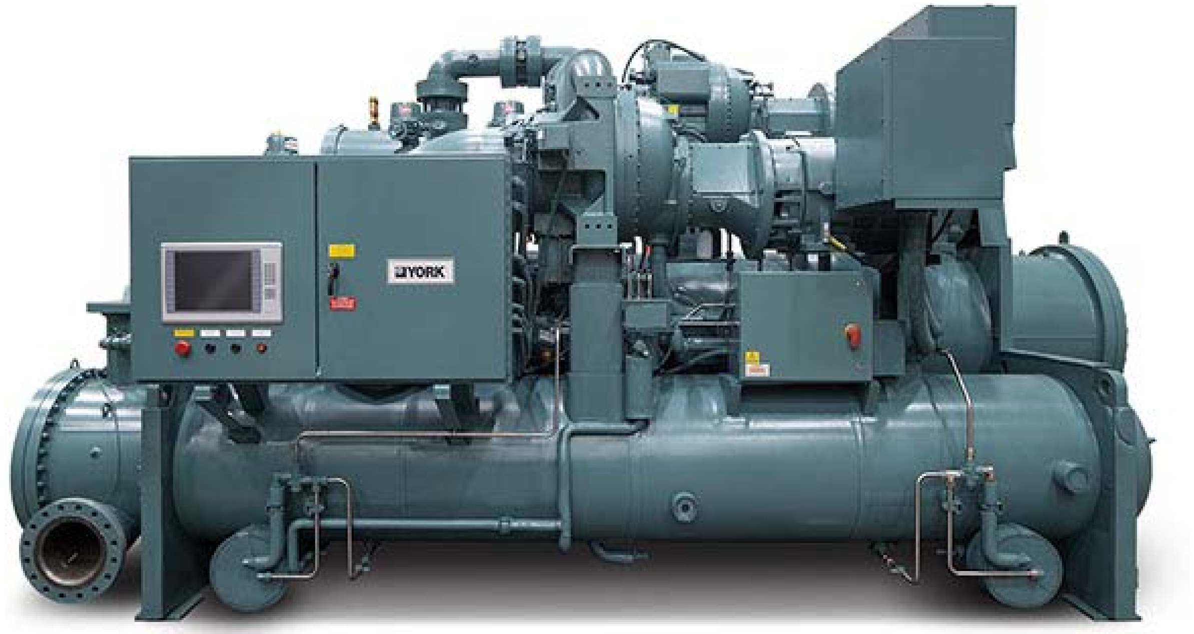
Heating Equipment

Electric Resistance Boilers

COP ~ 1



Heat Recovery Chiller (Two-Pass)

COP ~ 3

Heat Pump Chiller (CO2)

COP ~ 5

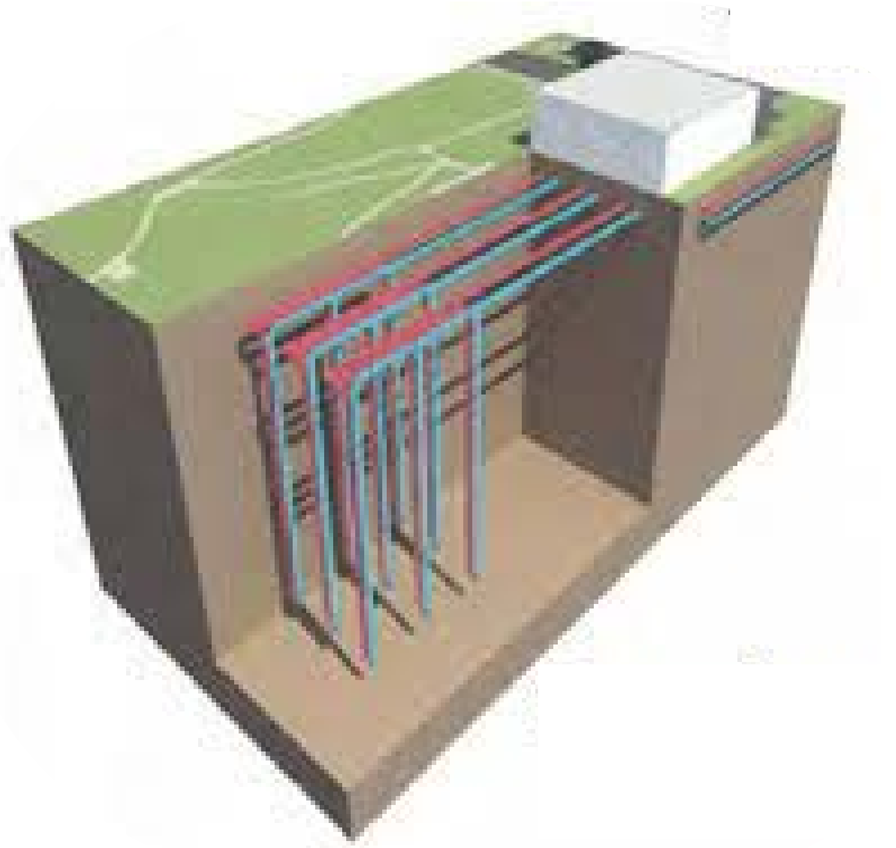
Cooling Only Equipment

Chiller

Cooling Tower

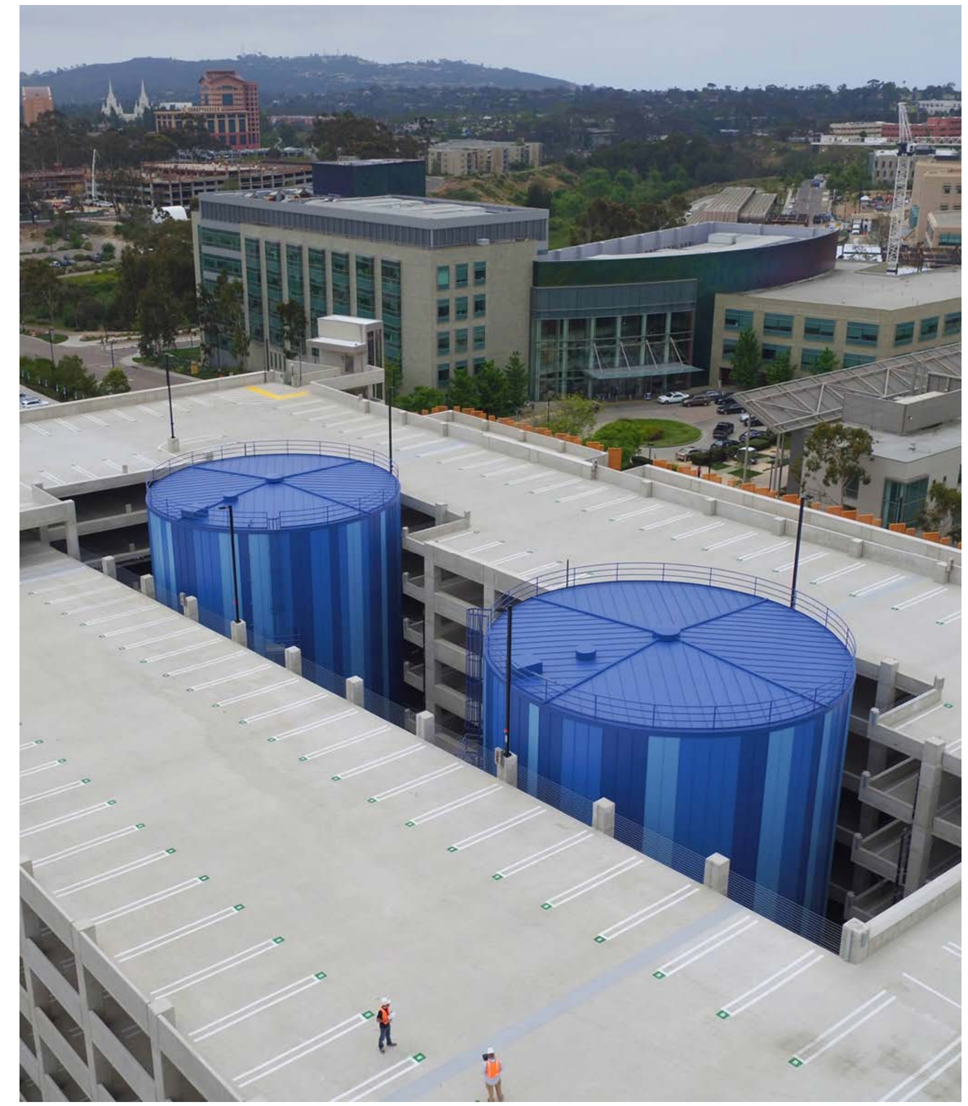
Heat Source/Sink Equipment

Air-Source
(Gas Cooler)



Geo-Source

Thermal Storage

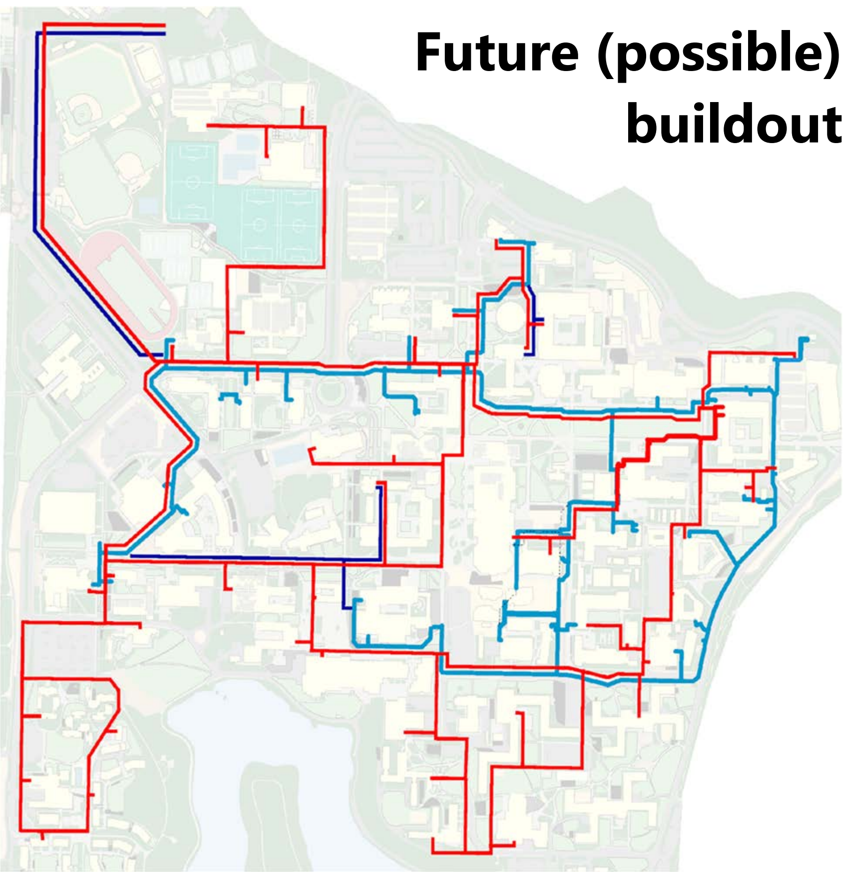


Thermal Storage Tanks (TES)

Central Plant Building

Campus Pipe Distribution

Future (possible) buildout



Building Connection

Pumps and Valves

Indirect Water Heater

Off Campus

Each Building Has
Dedicated Heat Pumps

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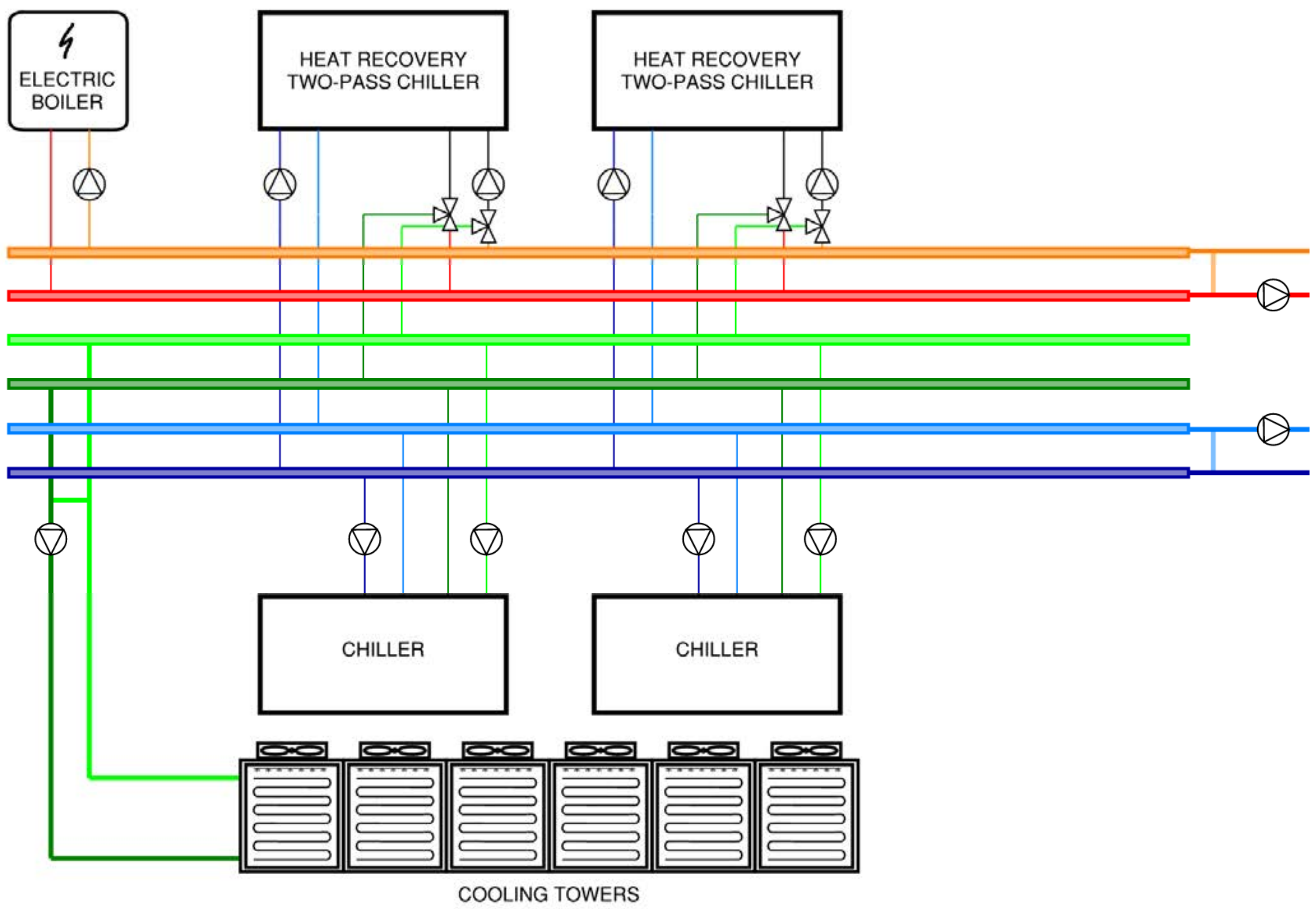
(Central 1) Heat Recovery Chillers

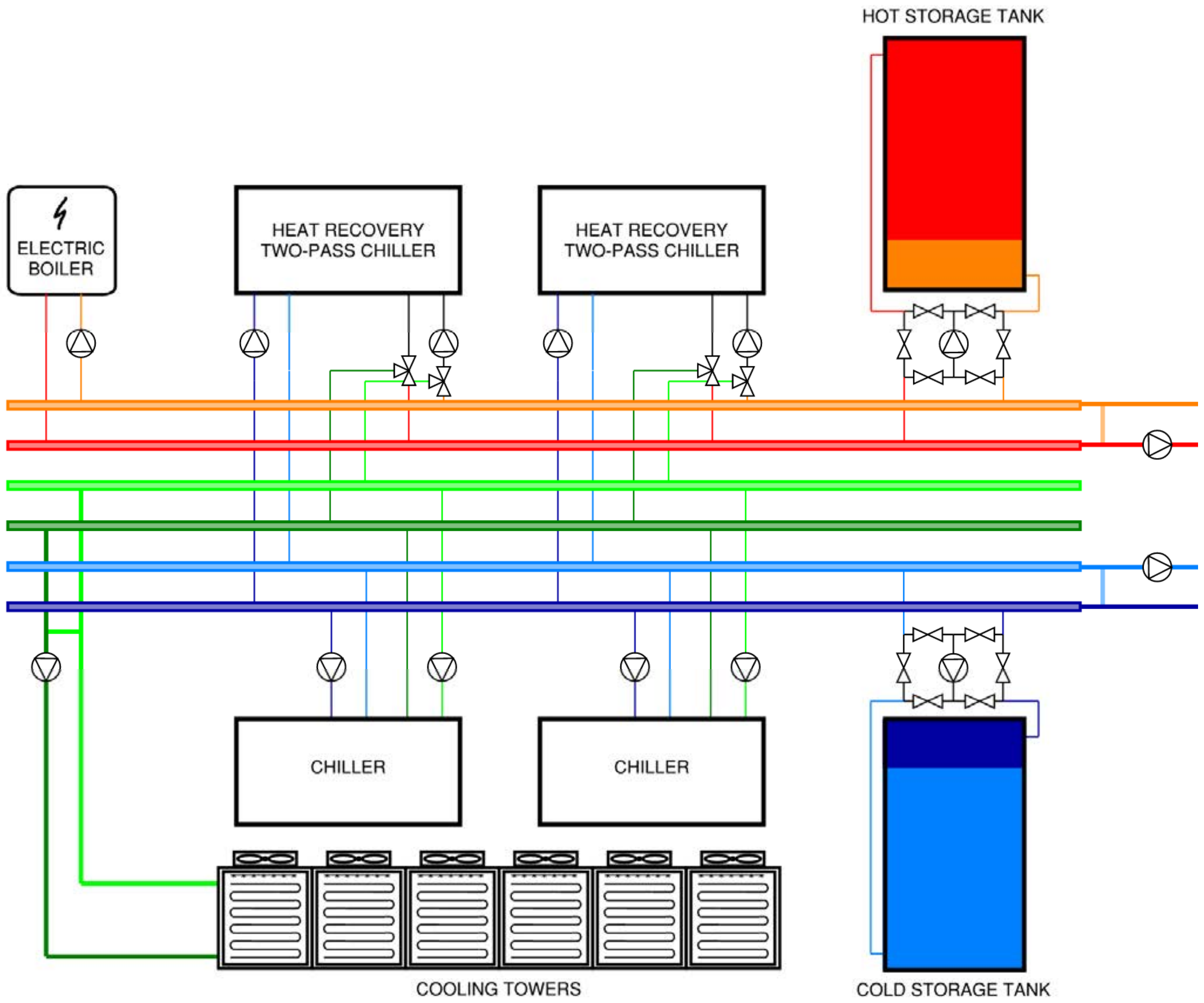
Simplest, and cheapest install, but uses a LOT of electric boiler energy



Electric Boiler	✔	**6000** tons
Heat Recovery Chiller	✔	**1500** tons
Heat Pump Chiller		
Chiller	✔	**8000** tons
Thermal Storage		
Air-Source (Gas Cooler)		
Cooling Tower	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

(Central 2) Heat Recovery Chillers + Thermal Storage

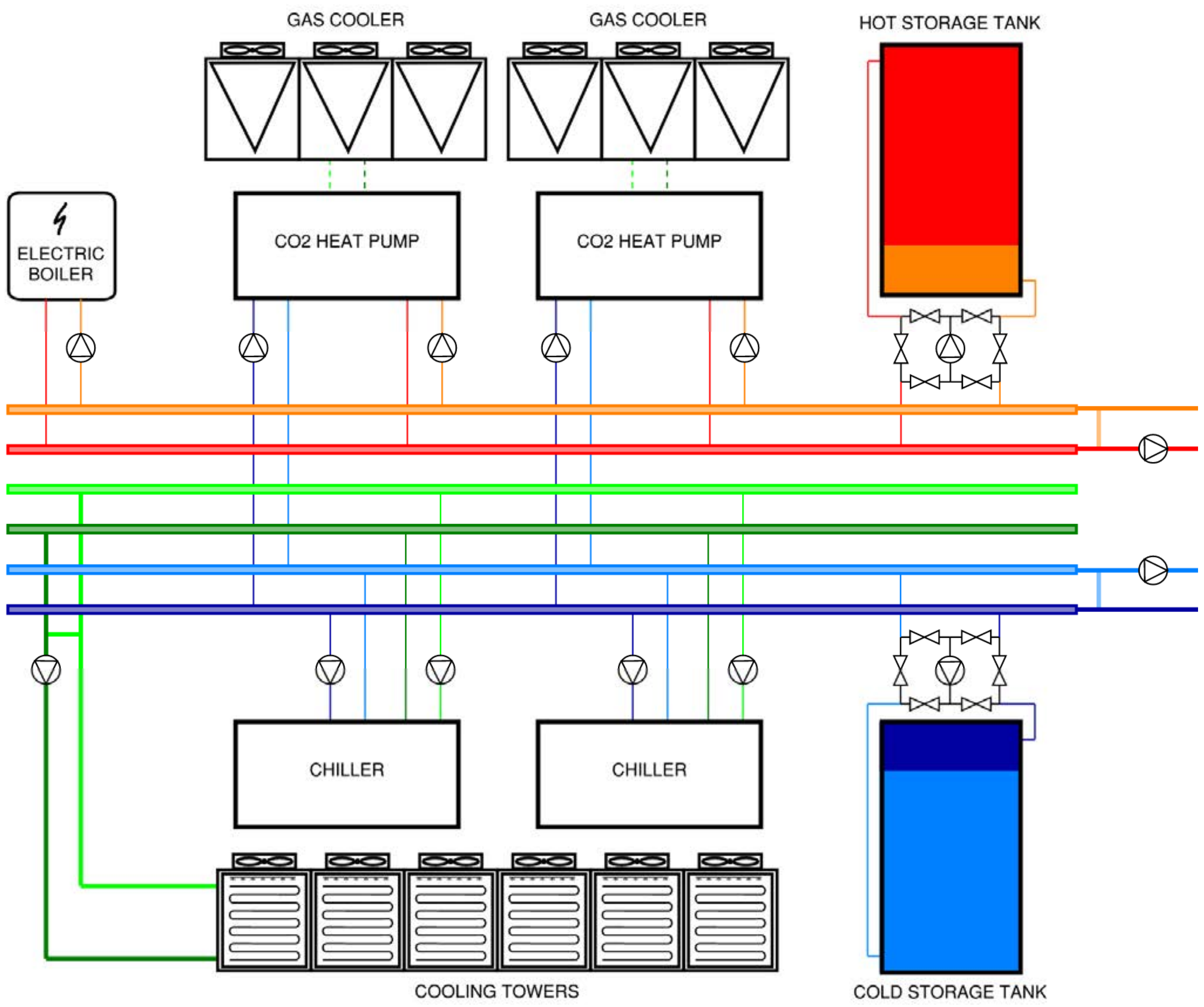
Adds Thermal Storage to Reduce Energy (still uses lot of Electric Boiler)



Electric Boiler	✔	**6000** tons
Heat Recovery Chiller	✔	**3500** tons
Heat Pump Chiller		
Chiller	✔	**6000** tons
Thermal Storage	✔	**5.8M** gal
Air-Source (Gas Cooler)		
Cooling Tower	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

(Central 3) Air-Source Heating/Cooling + Thermal Storage

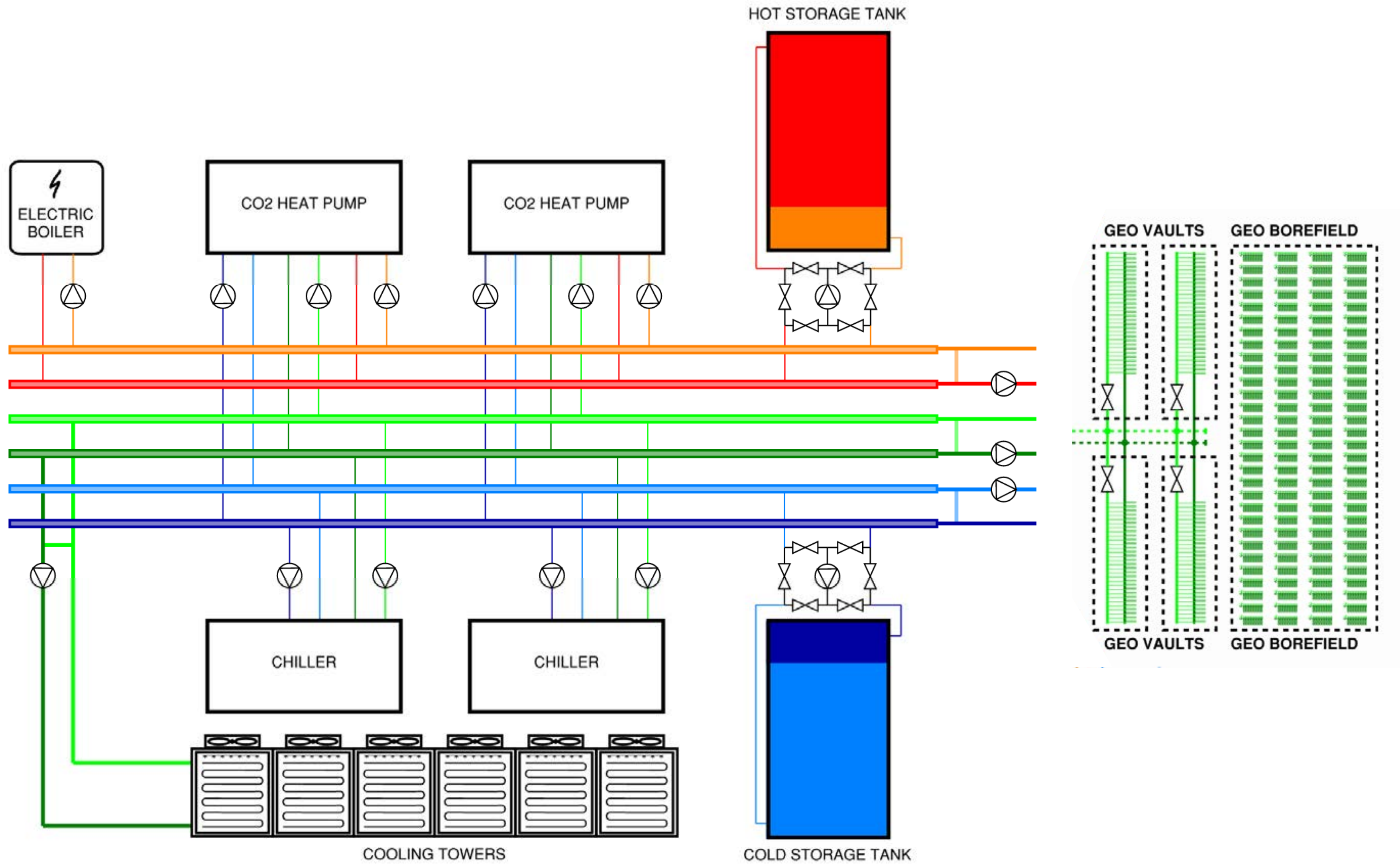
Uses Heat Pump Chillers which SIGNFICANTLY reduce heating energy



Electric Boiler	✔	**2500** tons
Heat Recovery Chiller		
Heat Pump Chiller	✔	**4500** tons
Chiller	✔	**6000** tons
Thermal Storage	✔	**5.8M** gal
Air-Source (Gas Cooler)	✔	**4500** tons
Cooling Tower	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

(Central 4) Geo-Source Heating/Cooling + Thermal Storage

Removes Air-Source and Replaces with Geothermal (reduces cooling energy)



Electric Boiler	✔	**2500** tons
Heat Recovery Chiller		
Heat Pump Chiller	✔	**4500** tons
Chiller	✔	**6000** tons
Thermal Storage	✔	**5.8M** gal
Air-Source (Gas Cooler)		
Cooling Tower	✔	**9000** tons
Geo Heat Exchange	✔	**950000** ft
Lagoon Heat Exchange		
Sea Heat Exchange		

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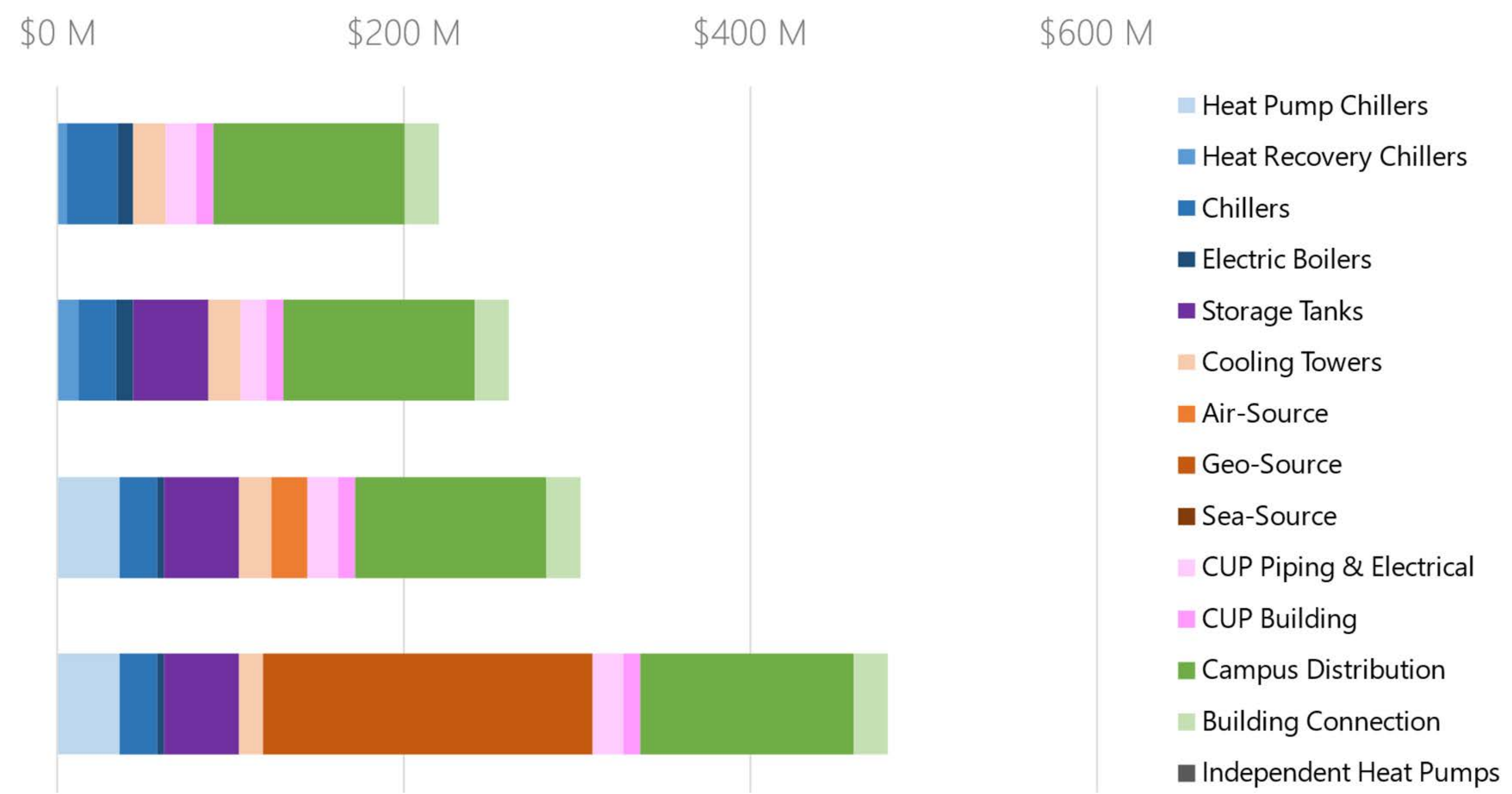
First Cost

New Central Plant Served Infrastructure

The First Part of the Options Comparison isolates to only the parts that vary between considered options

#	Strategy	First Costs
1	Heat Recovery Chillers	**$225.5 M**
2	Heat Recovery Chillers + Storage	**$261.1 M**
3	Heat Pumps (Air-Source) + Storage	**$302.2 M**
4	Heat Pumps (Geo-Source) + Storage	**$480.0 M**



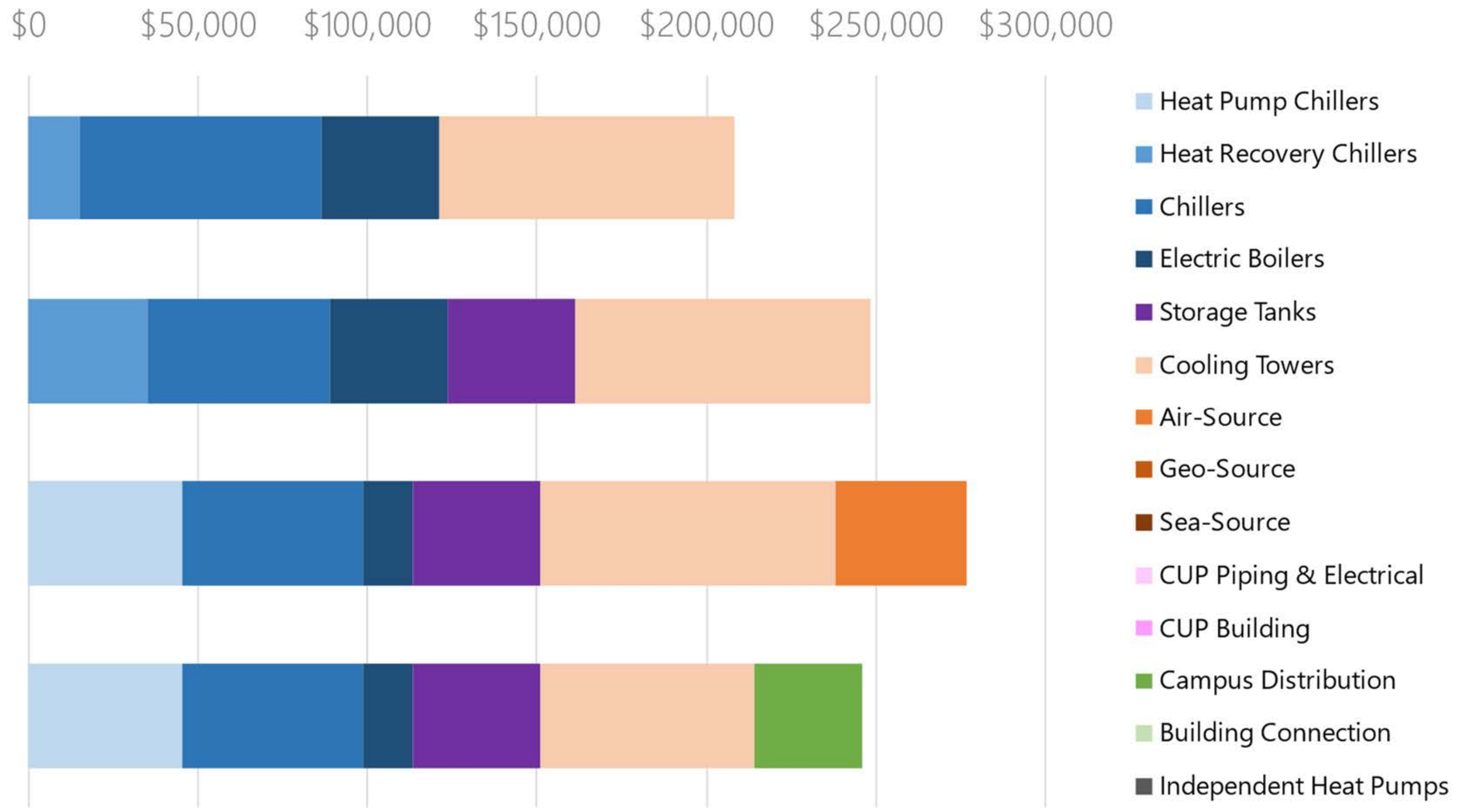
Starting with the lens of First Cost, Option 4 (Geo-Source) is significantly more expensive to install than all of the central plant options.

Service & Maintenance Costs

New Central Plant Served Infrastructure

Continuing with the lens of Operations & Maintenance, All the options are relatively similar, especially compared against energy

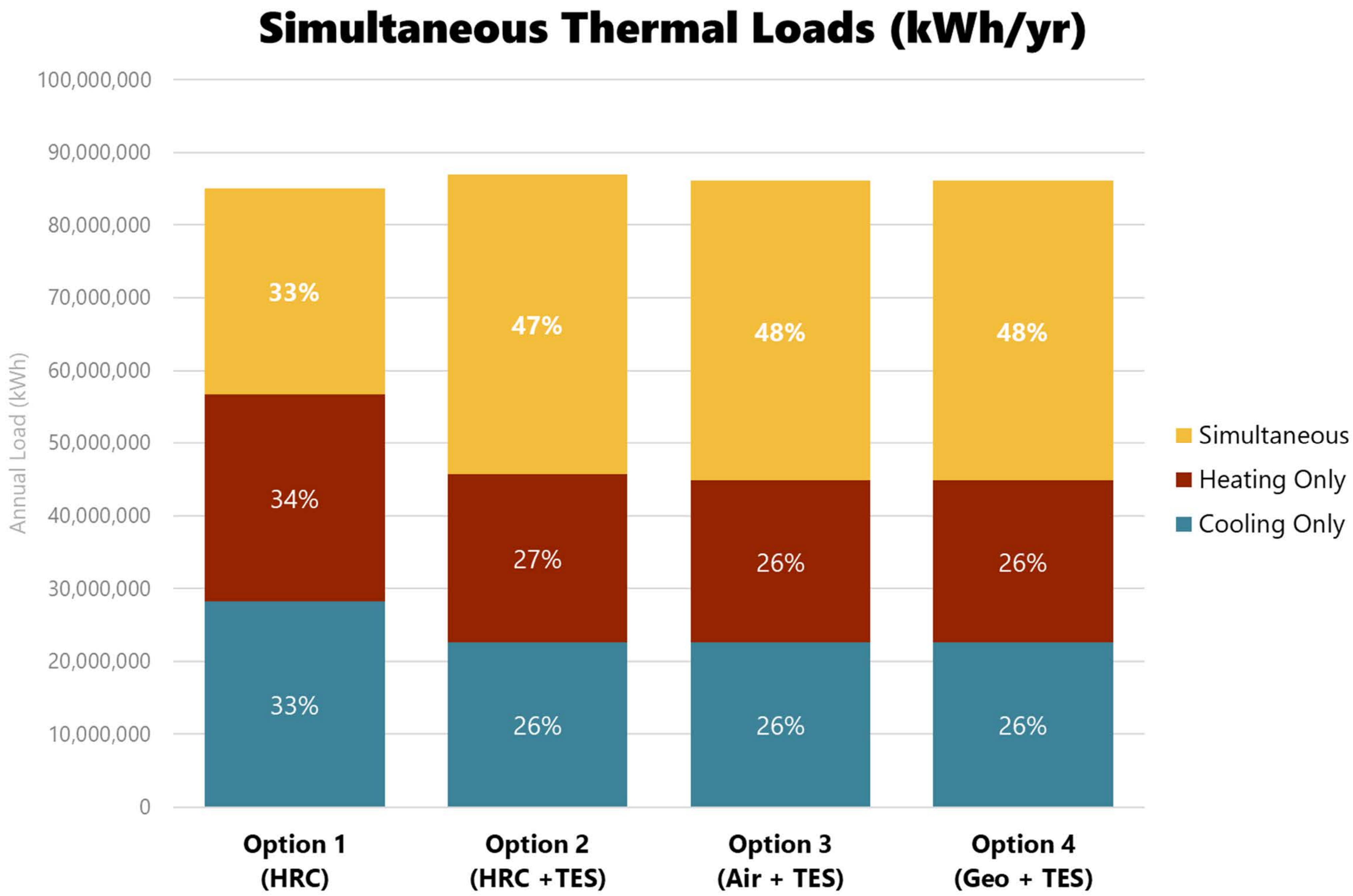
#	Strategy	O&M Cost
1	Heat Recovery Chillers	**$210,000**
2	Heat Recovery Chillers + Storage	**$250,000**
3	Heat Pumps (Air-Source) + Storage	**$280,000**
4	Heat Pumps (Geo-Source) + Storage	**$250,000**



Energy Costs

Simultaneous Production

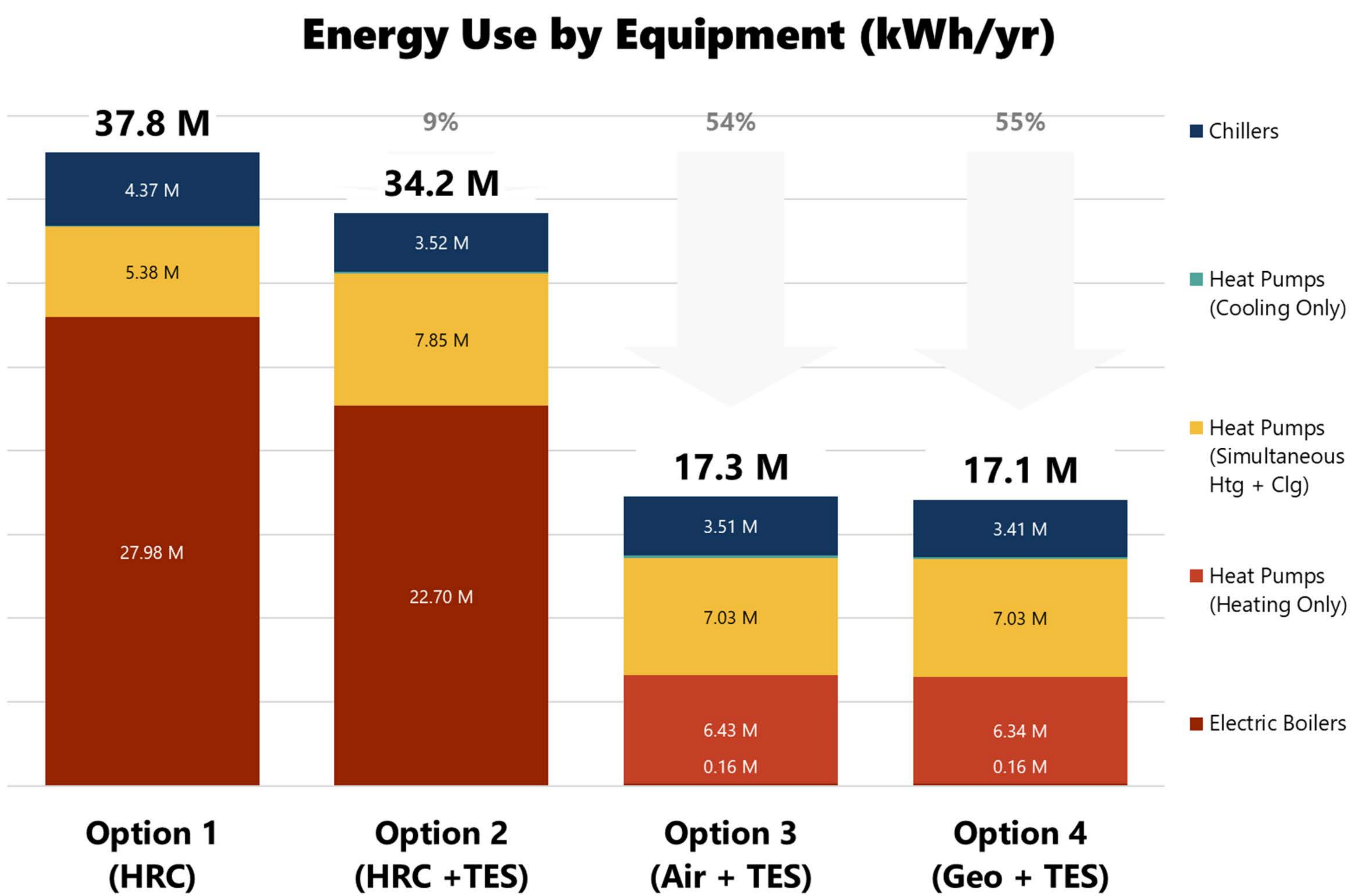
Simultaneous Production of Heating and Cooling increases significantly with the use of Thermal Storage Tanks (TES).



Energy Costs

Energy Use by Equipment Breakdown

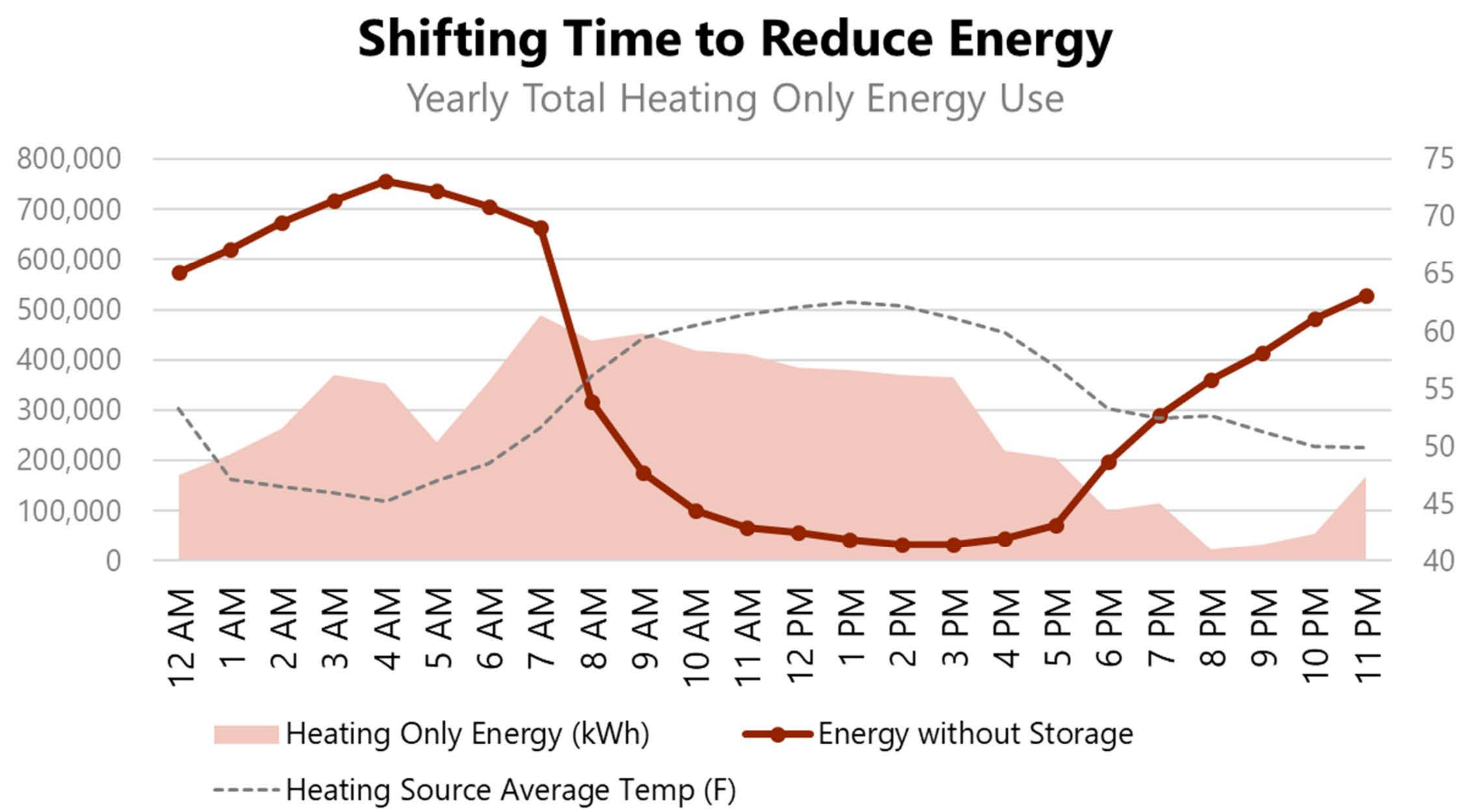
The introduction of a heating source beyond campus cooling drastically reduces energy use.



Energy Costs

Shifting Time to Reduce Energy and Rates

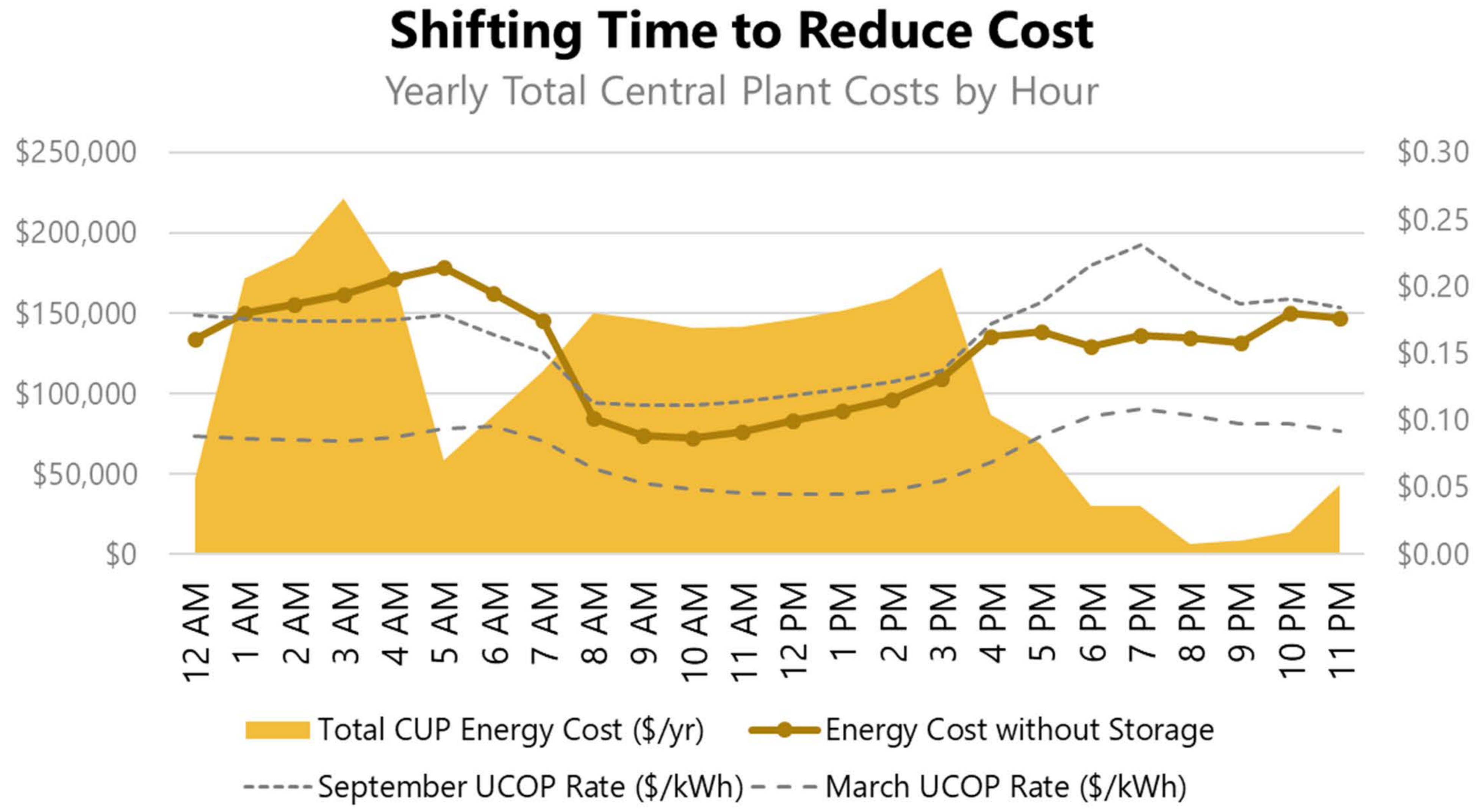
Option 3, shown here, shifts heating production significantly into the middle of the day when it is warmer, using less energy to make the same heating.



Energy Costs

Shifting Time to Reduce Energy and Rates

Shifting electricity use to the middle of the day, when UCOP electricity rates are cheaper, also saves significantly on electricity cost.

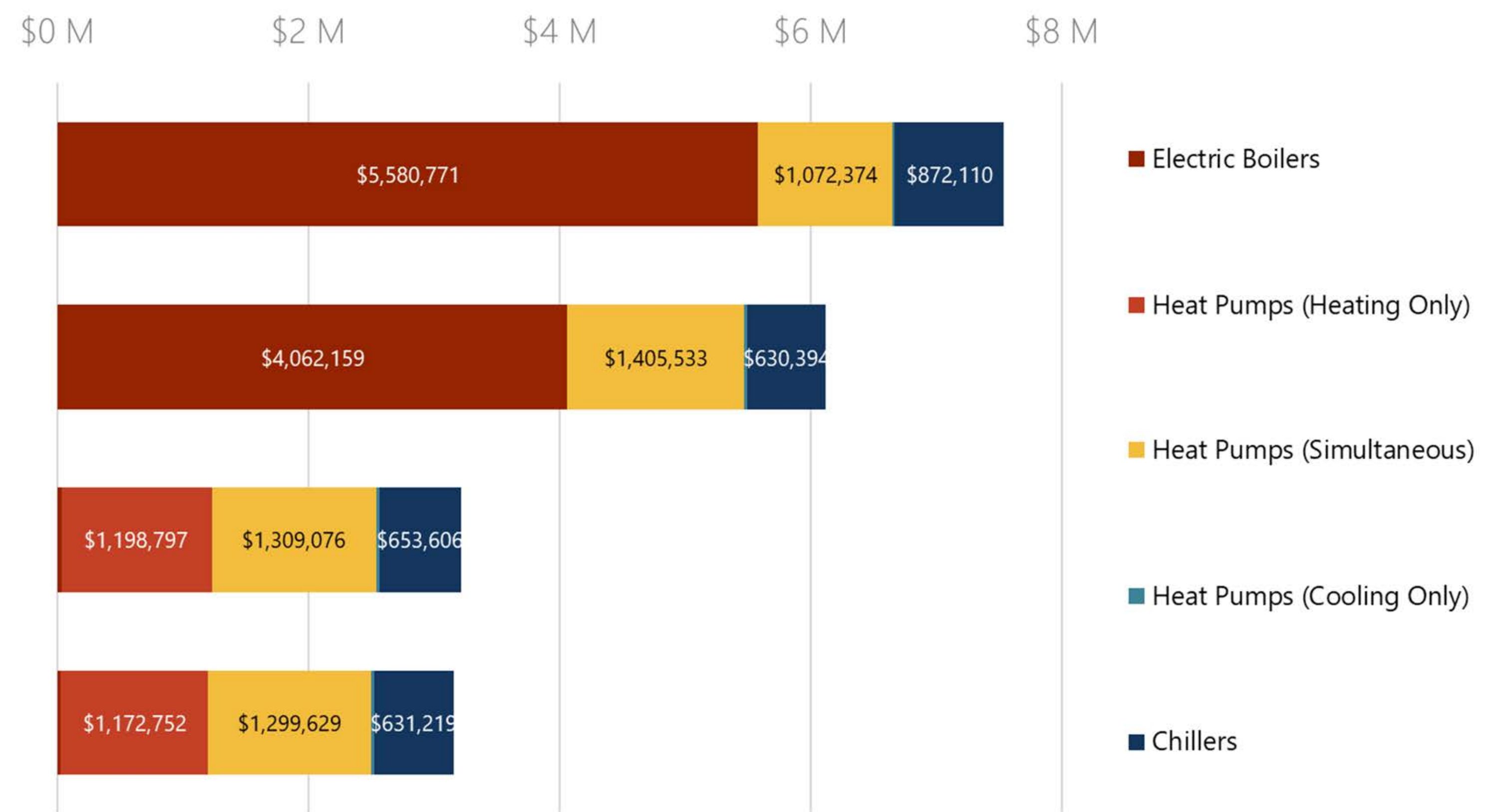


Energy Costs

New Central Plant Served Infrastructure

Summarizing from the lens of Central Plant Energy Costs, Options 3 and 4 (all with thermal storage and a heat-source) have similar energy costs – about $3.2 M per year. This is over $4M or nearly 60% less than Option 1 (which does not have thermal storage or a heat source), and nearly $3M or 50% less than Option 2 (which has thermal storage but not a separate heat source).

#	Strategy	Energy Cost
1	Heat Recovery Chillers	**$7.54 M**
2	Heat Recovery Chillers + Storage	**$6.12 M**
3	Heat Pumps (Air-Source) + Storage	**$3.22 M**
4	Heat Pumps (Geo-Source) + Storage	**$3.17 M**



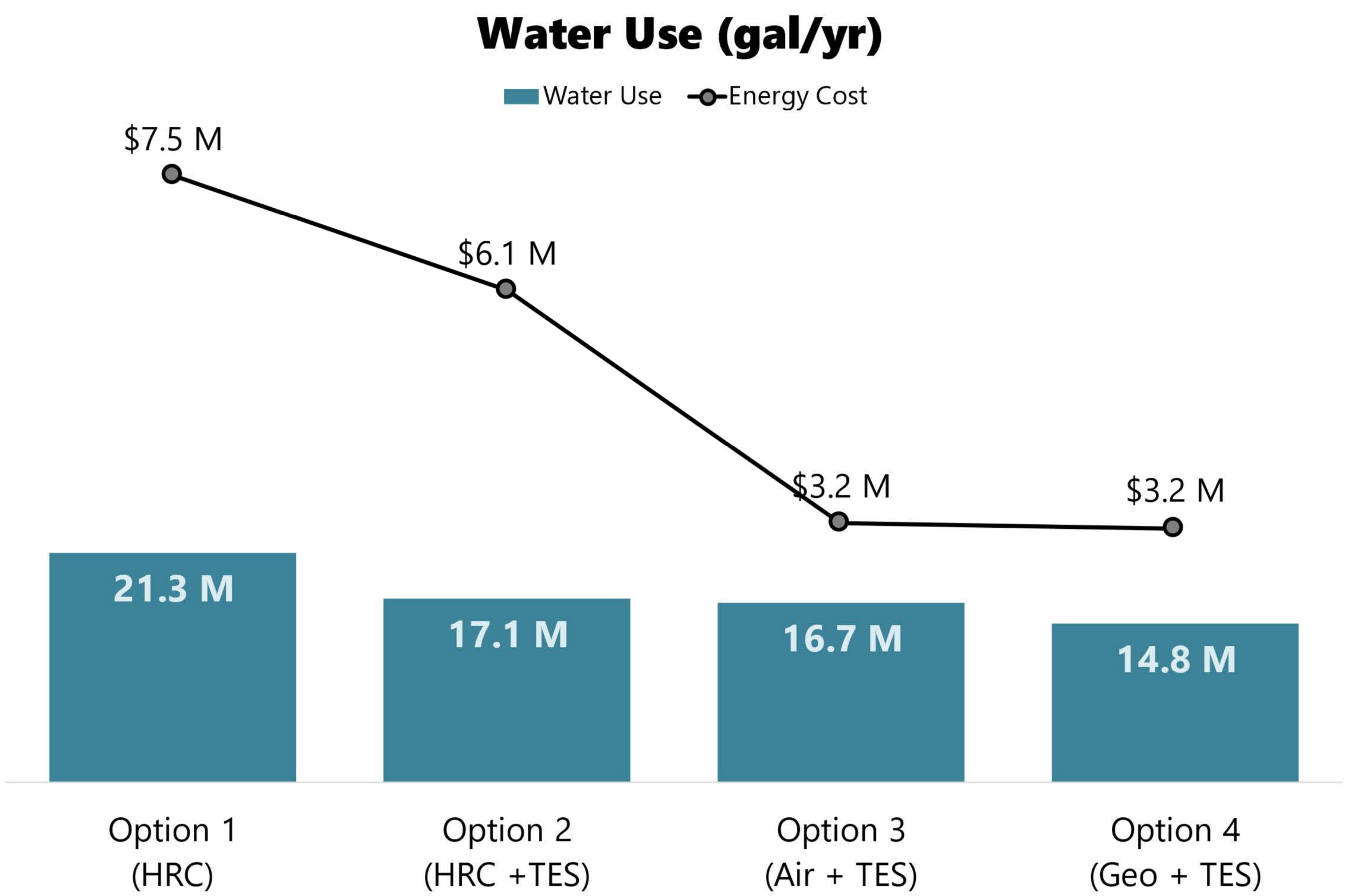
Water Use

System Comparison

From a Water Use lens, all options consume water through cooling tower evaporation.

Potential avenues for to use less potable water

1. Cooling Tower Water Treatment that uses chemistry to achieve high cycles of concentration
2. Treatment that allows for use of Recycled Wastewater source available to UCSB.



Capital Costs (2025-2070)

Life Cycle Cost

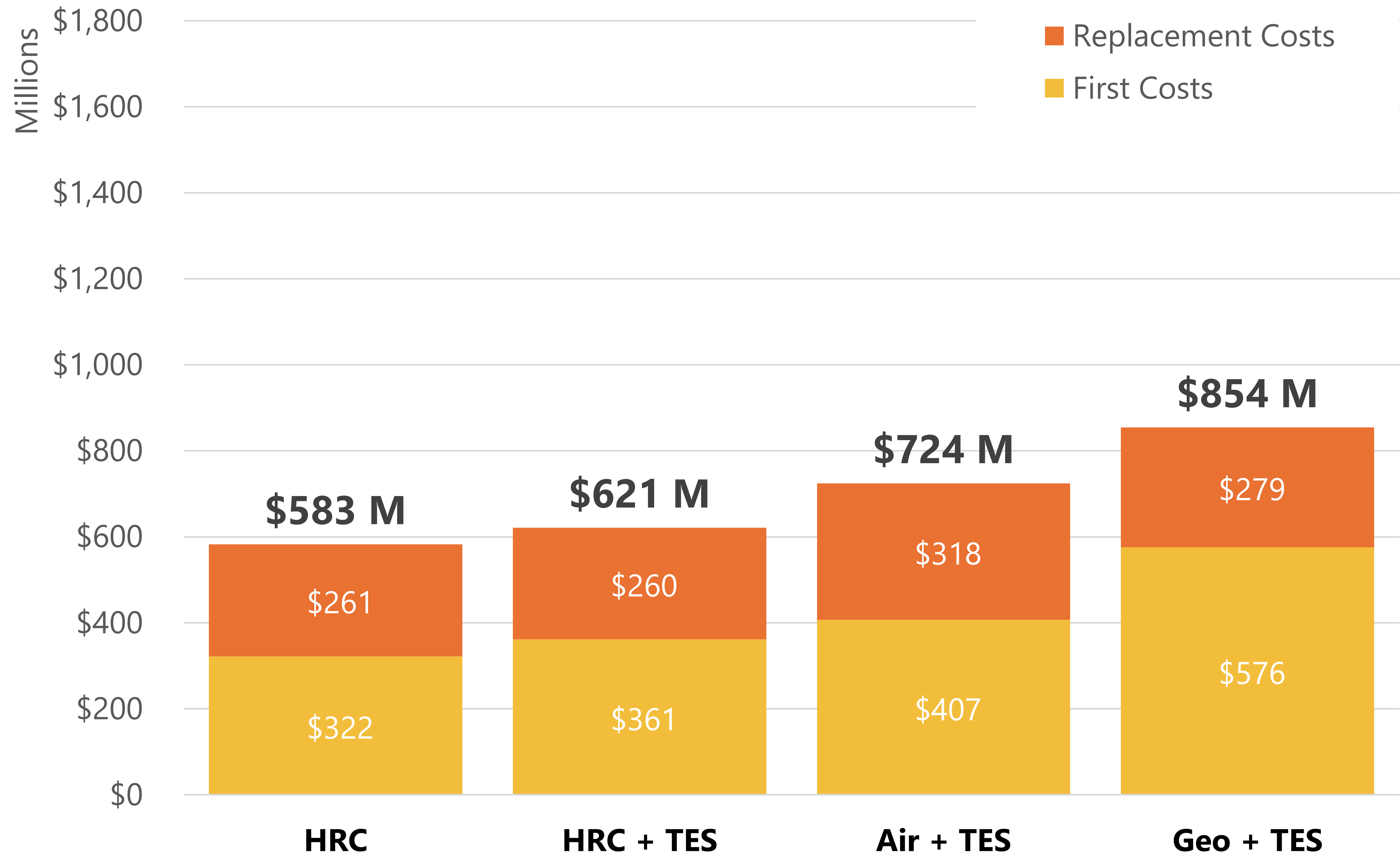
Capital Costs Include:

- First Costs
- Replacement Costs

Long Lasting Infrastructure (50 yr+)

- Thermal Storage Tanks
- Campus Pipe Distribution
- Geo Exchange Network
- Central Plant Building

Everything else replaced every ~15 – 25 years



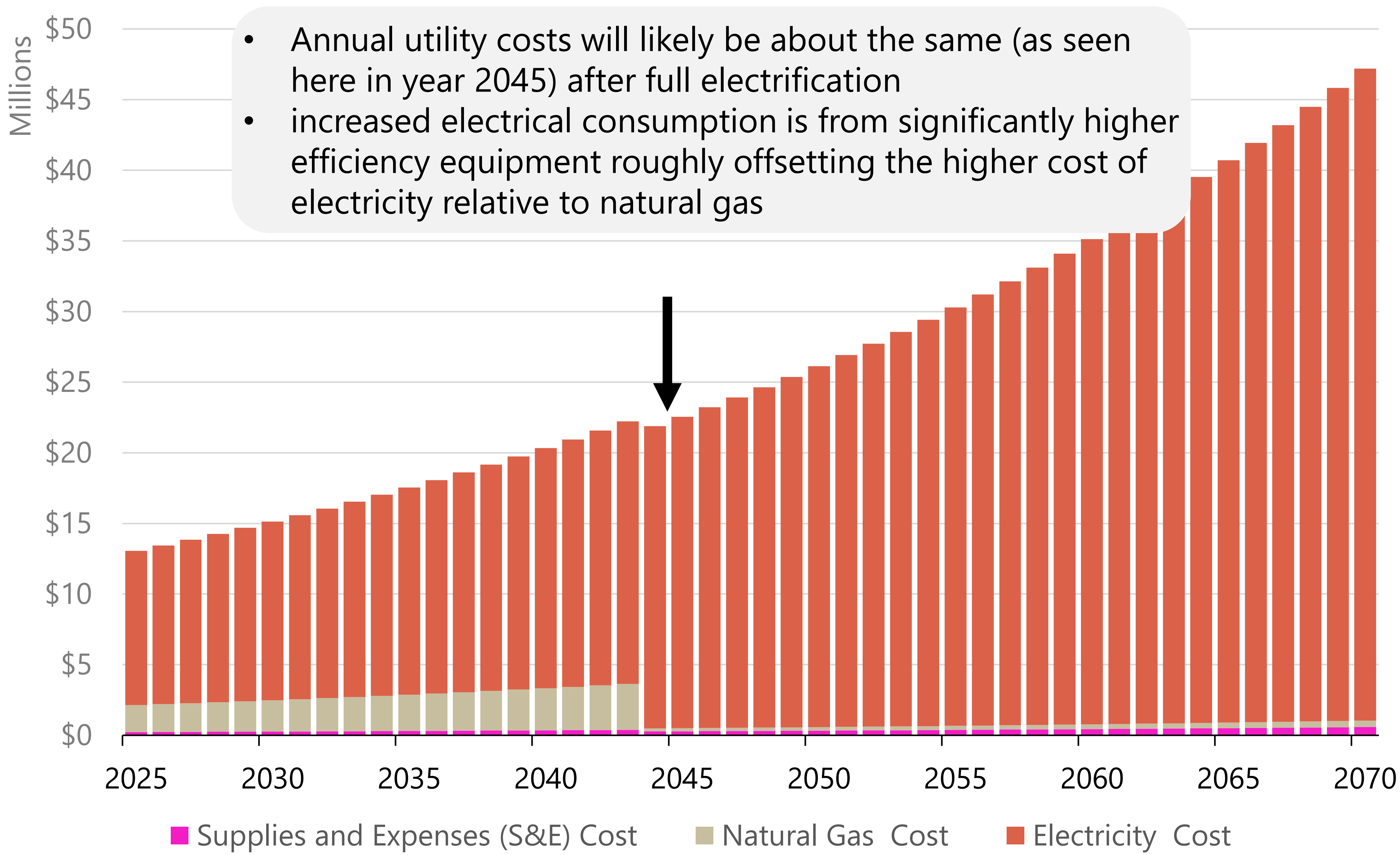
Operations Costs (2025-2070)

Life Cycle Cost

Operations Cost Includes:

- Maintenance (Supplies & Equipment)
- Utility Costs

Overall UCSB Operation costs expected to decrease after Clean Energy Master Plan is implemented compared to Business as Usual.



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Total Cost of Ownership (2025-2070)

Life Cycle Cost

Total Cost of Ownership includes:

Capital Cost

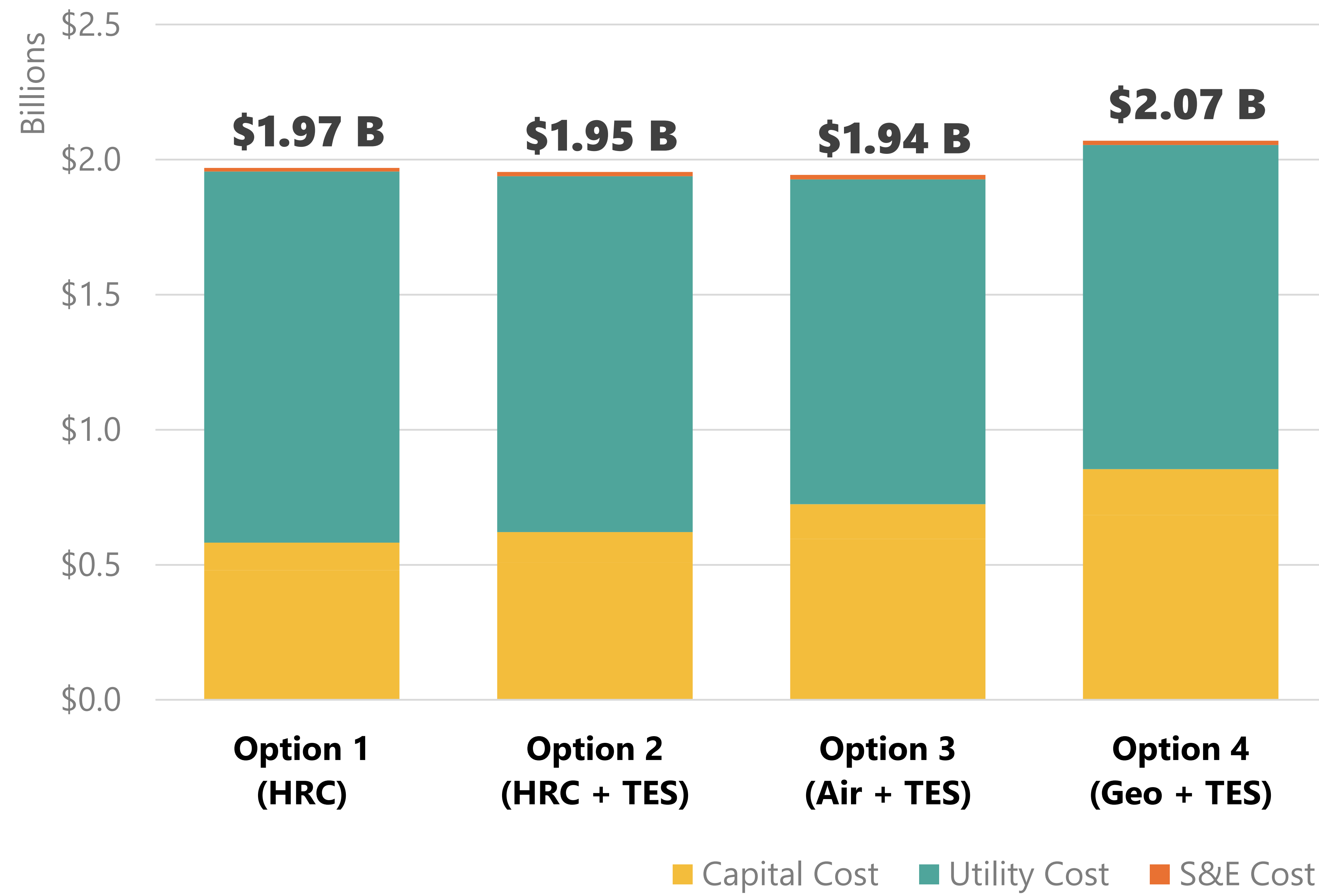
- First Costs
- Replacement Costs

Operations and Maintenance Costs

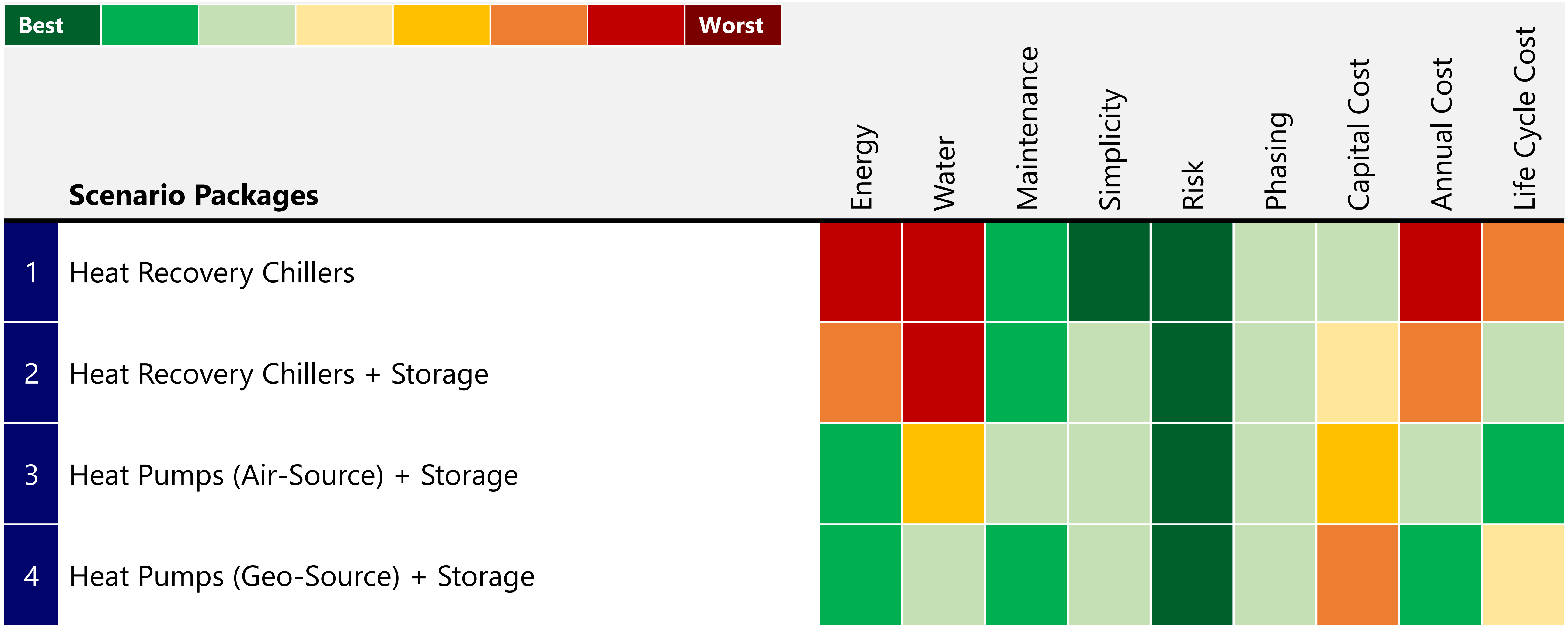
- Utility/ Energy costs
- Supplies and Expenses/ Maintenance (S&E) costs

Soft costs

- New Central Plant and Systems: Staffing Costs
- New Central Plant and Systems: Hiring Design Services



All Technical Evaluation Criteria – UCSB Wide Totals



Combining all the lenses presented above

Option 3 (Air-Source Heat Pumps + Thermal Storage) **appears to be the most compelling.**

Campus Decarbonization Opportunities
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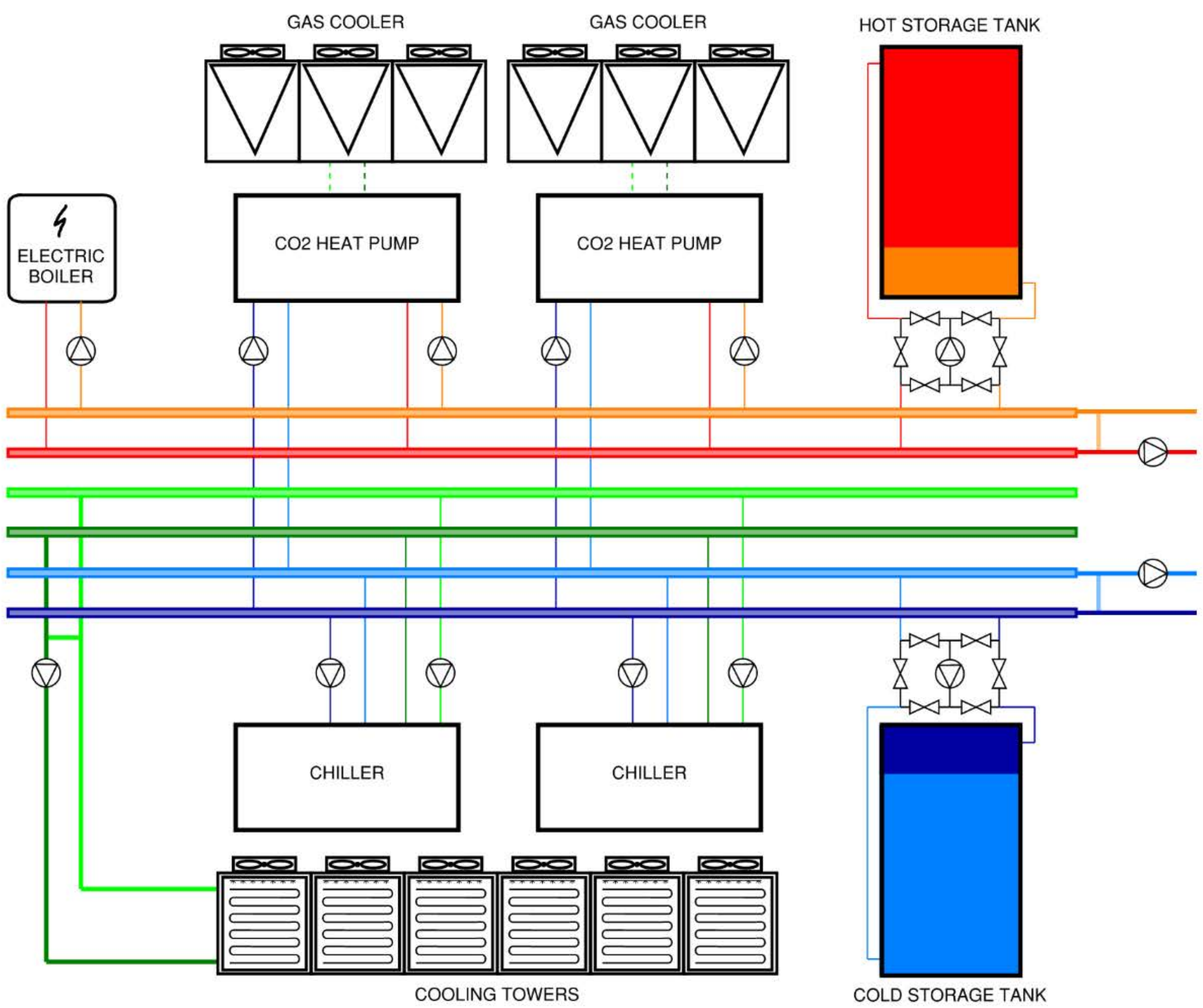
Recommendation : Heat Pumps (Air-Source) + Storage

PROS

- Energy Cost is one of the lowest options
- First Cost is ~$50M - $200M cheaper than all other comparable energy use options
- Climatic match to minimize energy use, energy cost, and electricity emissions
- One of the lowest Operating Costs of any currently feasible option

OPPORTUNITIES

- Potable use could be mitigated by using recycled water and treatment chemistry



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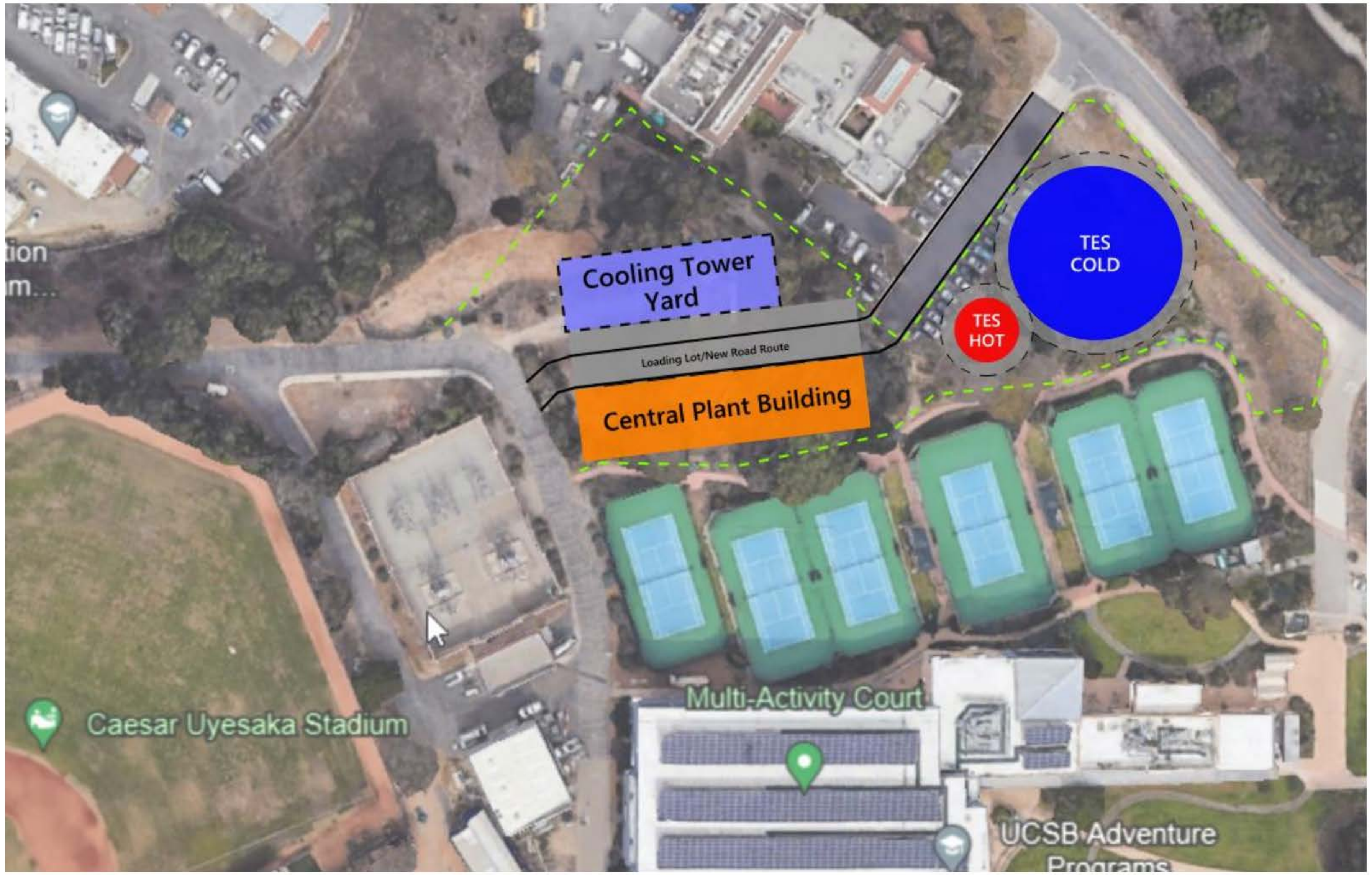
Central Plant & Spatial Planning

Infrastructure Needs Assessment

The UCSB Clean Energy Master Plan assumes the Eucalyptus Grove as an example location for the Central Utility Plant. UCSB will be looking at this and other sites across the campus, and proposed sites will need to go through CEQA and required analysis.



Central Plant Building	200 ft Long x 50 ft Wide by 60ft Tall (including two stories and height of rooftop equipment)
Cooling Tower Yard	150 ft Long x 50 ft Wide by 50ft Tall
Hot Storage Tank (TES)	44 ft Diameter x 60 ft Tall (with 10 ft clearance around tank)
Cold Storage Tank (TES)	120 ft Diameter x 60 ft Tall (with 10 ft clearance around tank)

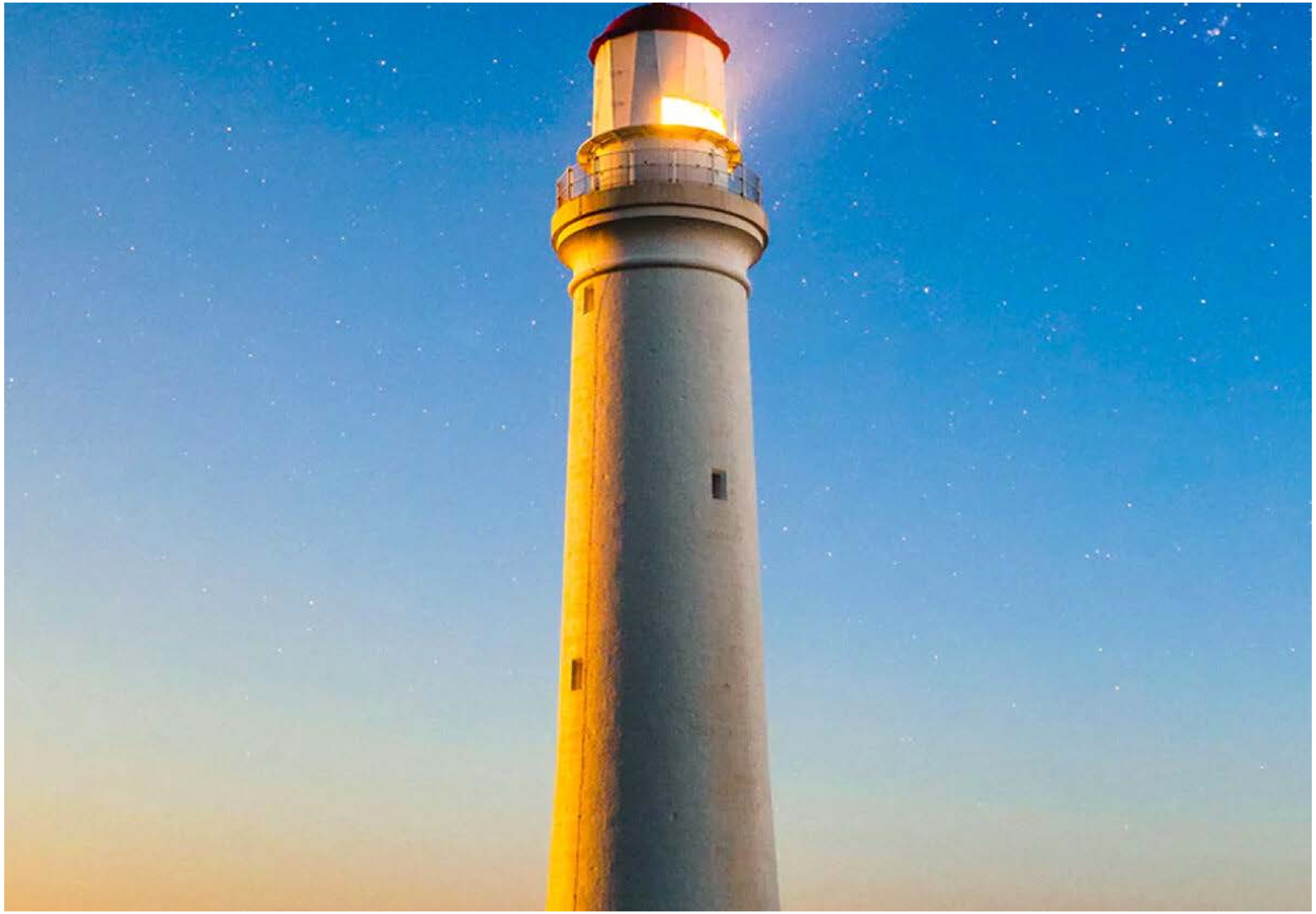
Phasing

Pathways to Implementation

- **Prioritizing Central Utility Plant Build Out**
- **Prioritizing Campus Piping Distribution Build Out**
- **Building Connection Prioritization**
- **New Buildings on Hydronic Heating Only**
- **Phasing Plan**

Buildings proposed to be included on the New Central Utility Plant

Opportunity to be a Lighthouse in Decarbonization



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Environmental Justice And Equity

DELIVERABLE 3

UCSB Clean Energy Master Plan

Stakeholder Engagement Efforts

1. **Town Halls and Equity Focus Group Workshops**
   - *Focus – What are issues and opportunities?*
   - *Vision – Who benefits? Where are the needs?*
   - *Action – next steps and building equity framework*

2. **UCSB Decarbonization Committee Meetings**
   - *Identifying social and vulnerable categories*
   - *Equity Tradeoffs & Cost-benefit analysis*
   - *Labor Unions, Community groups*

3. **Community Group Outreach**

- Environmental Affairs Board (EAB)
- Graduate Student Association (GSA)
- Chumash & other Indigenous Communities
- Disabled Student Association (DSA)

Suggested Equity Considerations for Future Implementation

Decarbonization Consideration	How Equity Can Influence or Impact
Effects to Workforce	• Electrification **jobs training** that transitions skillsets for existing staff • Grow **partnerships** with local institutions offering trainings
Prioritization of buildings to be transitioned/decarbonized	• Buildings where **existing systems** may need most attention (e.g. indoor dining, non-functioning HVAC)
Campus buy-in of the proposed approach: awareness, education, and input on direct/indirect impacts.	• Equitable engagement: **Stakeholder Advisory Group** to continue collaboration and input during planning and implementation • Build **transparency and trust** in decision making
Pipe routing options that minimizes ecologic disturbance and quality of life impacts	• Areas of disturbance: **campus mobility**, housing, **building accessibility**, land use
Addressing emissions impact through decarbonization	• Acquire/establish **baseline health indicators** to quantify impact

Climate Action Planning Gap Analysis

DELIVERABLE 4

UCSB Clean Energy Master Plan

Net-Zero Gap Analysis Findings

Sample Strengths in Net Zero Planning

- Renewable Electricity
- Existing Buildings
- New Construction

Sample Gaps → Recommended Next Steps

Sample Gaps	Recommended Next Steps
Refrigerants	Implement refrigerant leakage reduction strategies. Implement a policy for low GWP refrigerants.
Fleet	Develop strategy for 100% electric fleet as part of updated Climate Action Plan.
Air Travel	Establish procedure for tracking & reporting and develop offset program.

Climate Resilience Gap Analysis Findings

Sample Strengths in Climate Resilience Planning

- Managing Power Outage & Energy Resilience
- Managing Drought/ Water Insecurity
- Managing Severe Storms
- Managing SLR, Storm Surge, & Coastal Flooding

Sample Gaps → Recommended Next Steps

Sample Gaps	Recommended Next Steps
Managing Extreme Heat	Require mechanical cooling for new residential units. Designate at least one refuge space on campus.
Managing Poor Air Quality	Identify spaces for advanced air filtration. Designate at least one clean air shelter on campus.
Managing Wildfire	Include provisions for wildfire in future design guidelines for buildings and landscape (e.g. wildfire buffers, non-combustible materials)

Living Laboratory Opportunities

DELIVERABLE 5

UCSB Clean Energy Master Plan

Living Laboratory Opportunities

Current Strengths and Programs

Participation in Clean Energy Master Plan

Participation in UC Equity-Centered Resilience Initiative

Green Labs
LabRATS

Key Gap:

Less emphasis on climate resilience in current courses and applied learning

Additional Opportunities for Living Laboratory

Create specific opportunities for resilience-focused learning (e.g. nature-based solutions engineering).

Increase student engagement in sustainable food and dining programs, zero waste efforts.

Leverage Clean Energy Master Plan as a case study and course material.

Showcase the positive work on campus to promote cross-sharing and collaboration.

Q&A

UC SANTA BARBARA

Thank you for joining us!

See our website for updates:

https://www.energy.ucsb.edu/clean-energy-master-plan

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