UC SANTA BARBARA

Clean Energy Master Plan

October 2024

Introba

Acknowledgement

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Student Internships

To ensure that the UCSB clean energy master plan best learns from and is best positioned for acceptance by the campus community, we created (4) paid internship positions for UCSB students in collaboration with the university. Each student intern worked for 10 hrs per week over a 6-month period on tasks ranging from community engagement to analysis, and research.

Aside from their focus areas, the students actively participated in the overall development of the draft report. They also attended all the townhalls, workshops as well as a guest lecture on campus, and presented their work.

Each of the four student internships had a special focus as follows:

Internship #1: Data Collection And Analysis: Zach Zavodnik helped close gaps in measured data and helped synthesize energy modeling data. His tasks focused on Objective 1 of the study.

Internship #2: Student Engagement and Outreach: Orla Ayton facilitated our communications with the UCSB student community and help us get the best ideas, feedback, and ultimately buy-in from the community. She helped with outreach for all townhalls and workshops.

Internship #3: Climate Justice and Equity: Maya Ades worked with our Environmental Justice team to engage in discussions with campus stakeholders, and solicit feedback to ensure the Clean Energy Master Plan is implemented in the most just and equitable manner possible. Her work focused on Objective 3.

Internship #4: New Technologies Research: Kaden Lee worked with the engineering team to research new thermal technologies such as seawater heat exchange and prepared solidworks models for the same. His tasks focused on Objective 1 of the study.

Glossary

Air – air (as heat source or sink)

ASHP – air-source heat pump

BAU – business as usual

Btu – British thermal unit

Btu/h – British thermal units per hour

CEQA - The California Environmental Quality Act

CHW – chilled water

CO2 – carbon dioxide

CO2e – carbon dioxide equivalent emissions

COP – coefficient of performance

CT – cooling tower

DHW – domestic hot water

F – Fahrenheit

ft2 – square feet

ft3 – cubic feet

Gal – gallons

Geo - geothermal

GHG – greenhouse gas

HDPE – high-density polyethylene

HHW – heating hot water

HP – heat pump

HW – hot water

kBtu – 1,000 Btus

kW - kilowatt

kWh – kilowatt-hour

LCC – life cycle cost

MT CO2e – metric tonnes of carbon dioxide equivalent emissions

MW - megawatt

MWh – megawatt-hour

O&M – operations & maintenance

PPA – power purchase agreement

PV - photovoltaic

R – return

S – supply

S&E – supplies & Equipment

Scope 1 – Scope 1 emissions

Scope 2 – Scope 2 emissions

Scope 3 – Scope 3 emissions

Sea – sea/ocean (as heat source or sink)

TCO – total cost of ownership

TES – thermal energy storage tank

therms – heat energy in natural gas

Tons – tons heating or cooling (12,000 Btu/h)

UCOP – University of California Office of the President

UCSB – University of California Santa Barbara

WSHP – water-source heat pump

Land Acknowledgement

As a land grant institution, UC Santa Barbara acknowledges the Chumash peoples as the traditional land caretakers of the unceded territory where campus is located.

UC Santa Barbara acknowledges our presence on the traditional, ancestral and unceded territory of the Chumash peoples.

UC Santa Barbara acknowledges the Chumash peoples as the traditional caretakers of Santa Barbara County. As a land grant institution, we pay our respects to the ancestors, elders, and relatives past, present, and emerging.

Contents

EXECUTIVE SUMMARY 1

CLEAN ENERGY MASTER PLAN : BACKGROUND 5

DECARBONIZATION STRATEGY & FINANCIAL ANALYSIS 8
Existing Conditions 10
Campus Decarbonization Opportunities 15
Toolkit: Technologies & Components 24
Solutions 34
Evaluation Criteria 42
Options Comparison 44
Recommendations 60
Next Steps 89

ENVIRONMENTAL EQUITY AND JUSTICE 91
Current Context 93
Methodology and Findings 96
Recommendations 103
Next Steps 107

CLIMATE ACTION PLANNING GAP ANALYSIS 115
Context 117
Methodology 119
Gap Analysis Findings 123
Roadmap for Future Success 126

LIVING LABORATORY FOR CLIMATE ACTION AND SUSTAINABILITY 130
Existing Practices 132
Living Laboratory Opportunities 134
Next Steps 136

APPENDICES 138
1-1 – Current Campus Use 139
1-2 – Energy & Carbon Analysis 163
1-3 –Thermal Equipment Modeling 167
2-1 – Financial Analysis & Assumptions 174
3-1 – Climate Action Gap Analysis Results Summary 188

UC SANTA BARBARA

EXECUTIVE SUMMARY

1

UCSB Clean Energy Master Plan

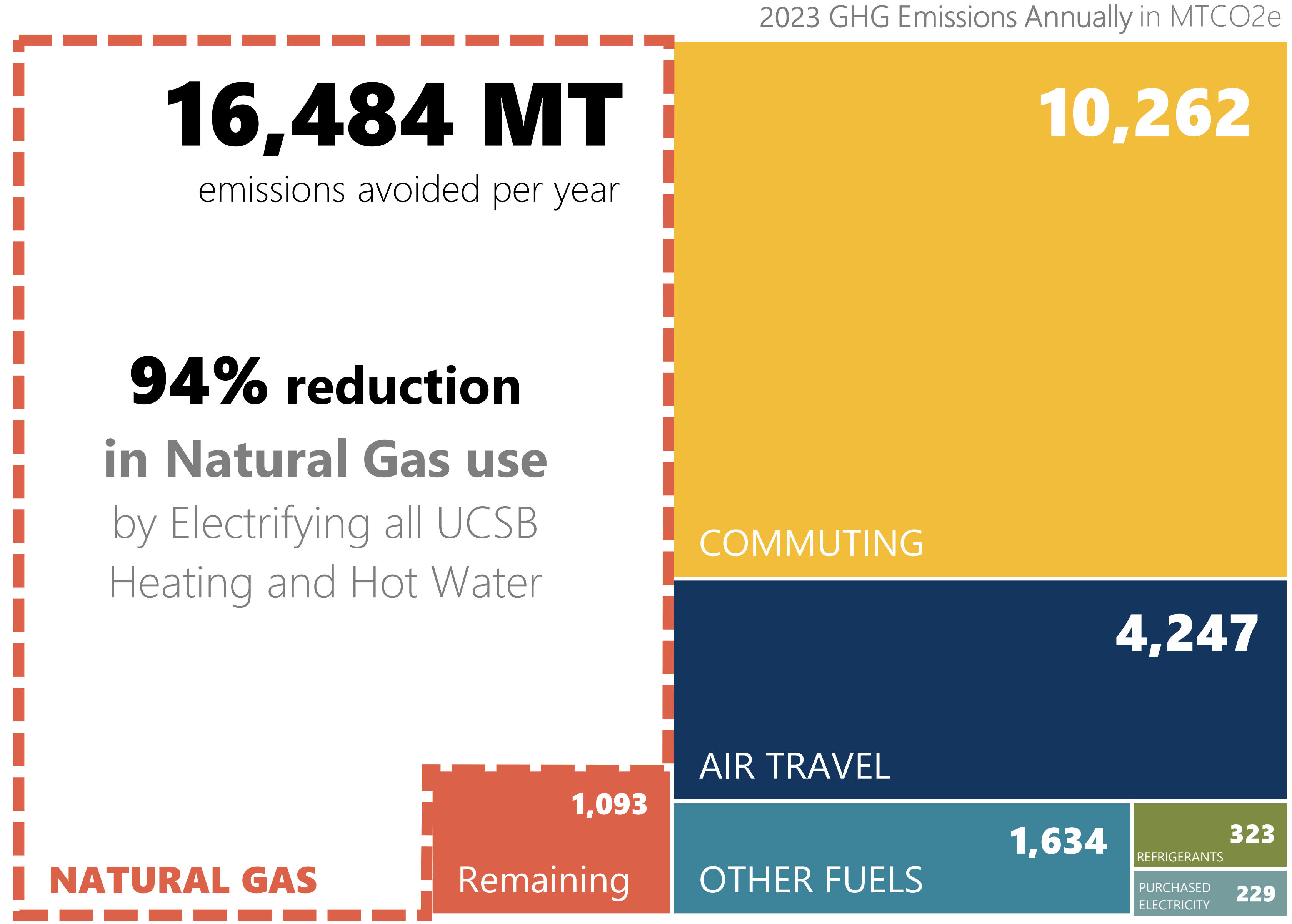
The University of California acknowledges the urgency of the climate crisis and has committed to reducing greenhouse gas emissions across all campuses. As part of the UC Sustainable Practices Policy, each campus will achieve a minimum 90% reduction in total greenhouse gas emissions by 2045, relative to 2019 levels. To guide this transition, UCSB has developed the Clean Energy Master Plan, a comprehensive strategy focused on achieving a 90+% reduction in UCSB's scope 1 greenhouse gas emissions by electrifying heating and hot water systems serving campus facilities.

While UCSB already procures 100% clean power from the UC Clean Power Program, heating and hot water provided by distributed combustion-based equipment throughout campus buildings account for approximately 94% of UCSB's natural gas consumption.

By electrifying all heating and hot water sources, UCSB will eliminate 16,484 metric tons of carbon dioxide equivalent (MTCO2e) emissions annually, equal to 50% of the University's total greenhouse gas emissions (2023).

The Plan evaluates alternatives for replacing existing fossil fuel-based thermal energy systems, including a new central utility plant (CUP) and expanded hot and chilled water distribution network serving 154 buildings on campus (82% of UCSB's current total building area). Off campus buildings not connected to the new CUP are proposed to have standalone all-electric thermal systems.

This Plan and its recommendations are largely the result of a year long State-funded decarbonization study overseen by the UC Santa Barbara Decarbonization Study Project Committee. While funding is expected to inform and guide the phased implementation through 2045, it is the overall UCSB campus community's goal to work collectively towards expediting this timeline.



19 UCSB -Sized Forests
Area of average U.S. forests for equivalent carbon sequestration annually

3,923 Cars
Number of U.S. gasoline-powered passenger vehicles' annual driving

12,256 Homes
Number of California homes' average annual electricity use

Key Highlights of the Clean Energy Master Plan

The UCSB Clean Energy Master Plan will eliminate 94% of current Natural Gas emissions and significantly reduce UCSB's operational costs and complexity compared to a non-decarbonized future.

Saves

432,500 MTCO2e
in GHG Emissions

$120M
in Operational Cost

through 2070

Electrify all Heating and Hot Water
Eliminate 94% of UCSB Scope 1 Emissions

Centralized Campus Thermal Plant
Provides Cooling, Heating, and Hot Water

Thermal Energy Storage Tanks
~50% of all Thermal Work made Simultaneously

High-Temp Heat Pump Chillers
Allows for just Pumps and Valves at each Building

Air-Source CO2 Type Heat Pumps
Save ~20% Electricity Leveraging Mild Climate

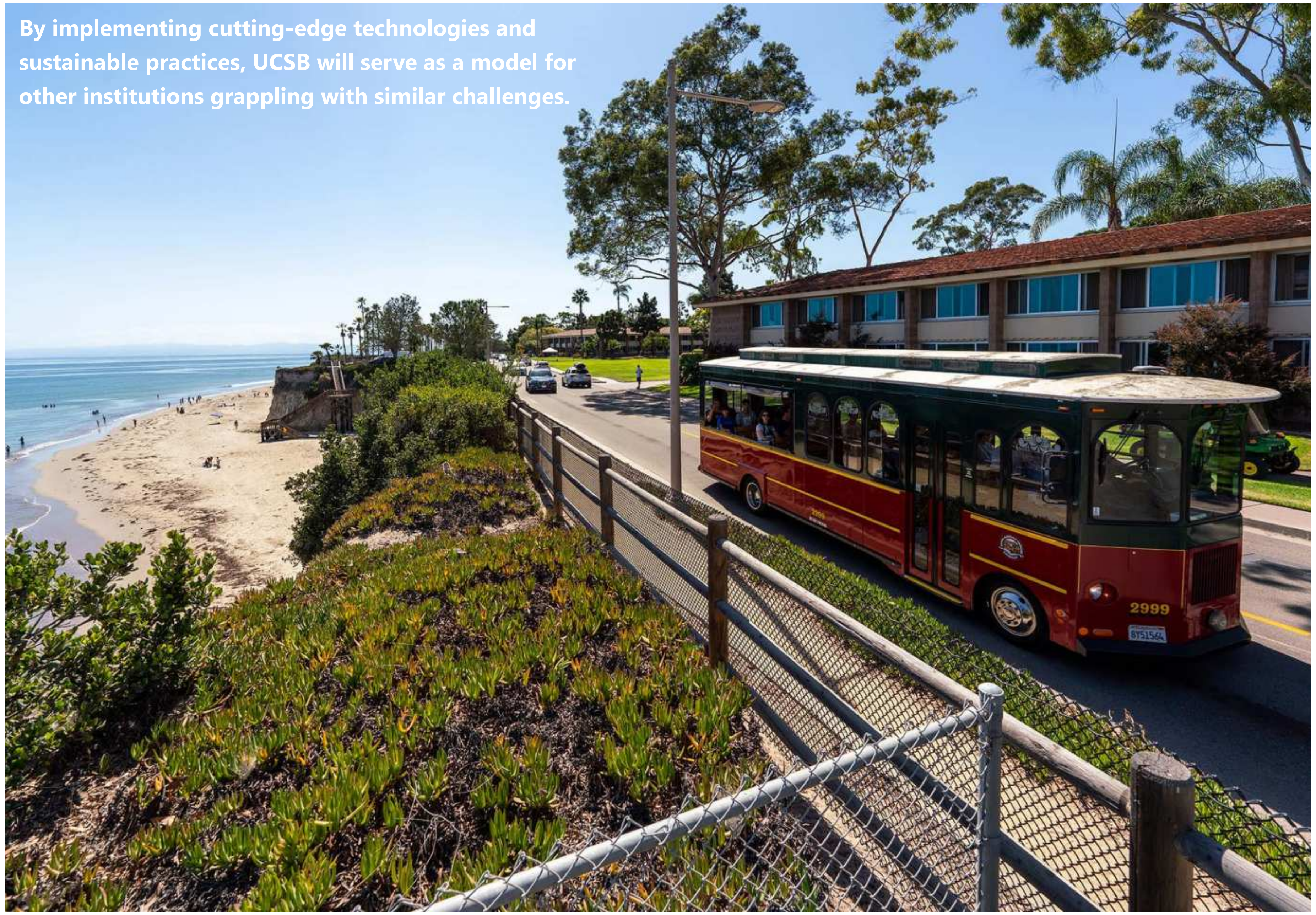
Optimized Size and Operation
Minimize Energy Cost, Balanced with Investment

Battery Backup Power
Use Tanks as Batteries, and Backup Pumps

Reclaimed Water and Treatment
Reduce Potable Water Use for Cooling Towers

Prioritize Building Plant and Distribution
Central Backbone and Main Piping

Phase by Emissions, Proximity, Maintenance
Accelerate Impact and Avoid Repairing Abandoned Assets



Funds used to conduct decarbonization studies at each UC location were used to produce the following five deliverables:

- 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
- 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
- Identify environmental justice and equity considerations related to the transition to fossil fuel free infrastructure
- Document knowledge gaps, and subsequent studies and analyses needed to conduct climate action planning
- Identify research, education and other opportunities for campus as a "living laboratory" for climate action and sustainability

Additional context on the five Study deliverables is in the appendices.

The Clean Energy Master Plan considers factors such as utility use and cost, operational complexity, maintenance, replacement, and total cost of ownership to optimize operational efficiency, redundancy, and energy resilience as the campus transitions to fossil fuel free thermal systems.

Equity and Environmental Justice are central to the UCSB Clean Energy Master Plan, which aims to provide new skills and green job opportunities equitably among existing equipment operators and ensure accessibility to all community members during the phased implementation, which anticipates construction activities through 2045.

UCSB has already made strides in energy efficiency and carbon neutrality through investments in onsite renewables and clean power procurement. With this ongoing effort and the implementation of the Clean Energy Master Plan, UCSB is well-positioned to meet the UC Climate Action goals and to accelerate its transition toward becoming an all-electric campus. Aside from decarbonizing the campus, the Clean Energy Master Plan will also lay out Living Lab opportunities for innovation and education.

CLEAN ENERGY MASTER PLAN : BACKGROUND

2

Transitioning Away From Fossil Fuels

UC Santa Barbara has successfully implemented energy efficiency improvements across the campus over the last three decades and has made substantial investments in on-site renewable energy development and procurement of clean power.

UCSB completely replaced and upgraded the campus electrical substation and service between 2004 and 2009, and the 12.47 kV distribution system has sufficient capacity for the demands of an all-electric campus. On-campus renewables, over 6 MW of on-site solar installed between 2016-2019, have been generating 15% of UCSB's electrical power needs. The campus has been procuring carbon-free electricity via the UC Clean Power Program since 2020, which serves a large fraction of the campus's total energy needs. UCSB is also the only UC campus that does not have a fossil fuel-burning central plant or cogeneration plant to serve their heating needs.

Collectively, all the reasons above make UCSB well positioned to achieve a fully decarbonized campus, and do so in a quicker, smoother, highly cost-effective, and equitable manner.

UCSB's operational greenhouse gas (GHG) emissions are the lowest among UC campuses in absolute terms and when normalized for both building area and campus population.

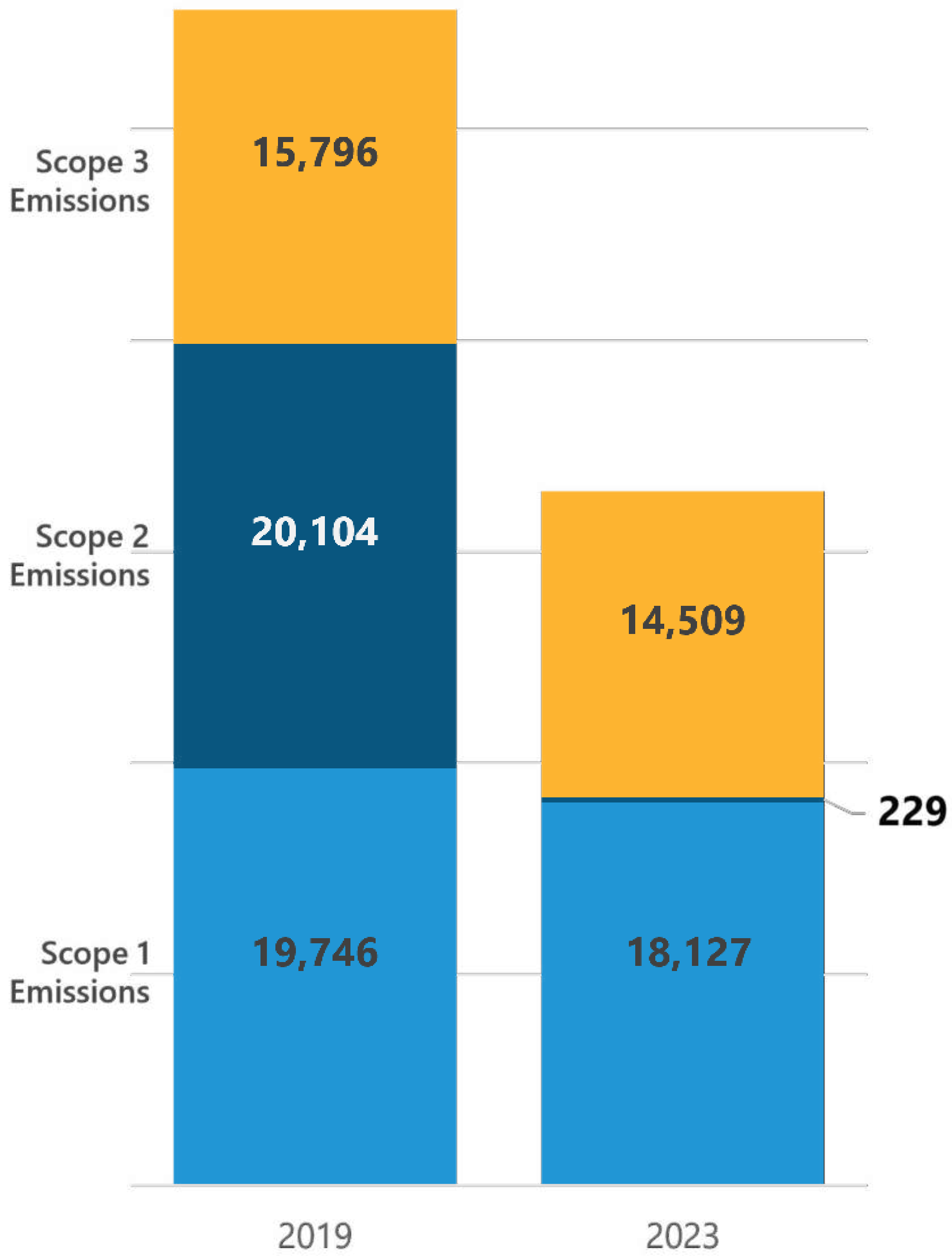
Clean Energy Master Plan

In the fall of 2022, UC President Michael Drake convened the Pathways to a Fossil Free UC Task Force (P2FFUC) under the UC Global Climate Leadership Council (GCLC) to address the challenge of decarbonizing UC locations' central energy systems. The objectives of the Task Force are to develop recommendations on steps and timelines to eliminate fossil fuels in each location's energy systems – including change management needs and budget implications, as well as opportunities to advance climate research, education, and student experience.

While electrification is the main focus of the task force, the following are the five main objectives that form the basis for the UC Santa Barbara Clean Energy Master Plan:

- 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
- 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
- Identify environmental justice and equity considerations related to the transition to fossil fuel free infrastructure
- Document knowledge gaps, subsequent studies and analyses needed to prepare a climate action plan for UC Santa Barbara
- Identify living lab opportunities

UCSB Total GHG Emissions (MTCO2e)



Scope 1 Emissions
Direct emissions originating from campus-owned or controlled fossil fuel combustion-based equipment and fugitive emissions such as refrigerant leakage

Scope 2 Emissions
Indirect emissions from generation of purchased energy

Scope 3 Emissions
All other indirect emissions from non-owned assets such as commuting and air travel

UC SANTA BARBARA

DECARBONIZATION STRATEGY & FINANCIAL ANALYSIS

3

Overview – Decarbonization Strategy and Financial Analysis

This section provides an overview of contents covered within the Decarbonization Strategy and Financial Analysis chapter. The purpose of this combined objective is to formulate a comprehensive strategy for achieving a reduction of 90% or more of Scope 1 emissions from a 2019 baseline. This reduction primarily targets fossil gas used on-site in campus energy systems, which constitutes the majority of UC Santa Barbara's remaining emissions and is therefore the main focus of the Plan. Additionally, it includes high-level estimates covering both total capital and operational costs, as well as resultant savings. These financial insights are crucial in comparing each decarbonization strategy.

Existing Conditions

- Campus Regions
- Campus Heating and Cooling Infrastructure
- Current Campus Energy Use & Campus Emissions
- Data Analysis and Modeling

Campus Decarbonization Opportunities

- Thermal Load Patterns
- Diversified Building Loads
- Simultaneuous Heating & Cooling
- Shift to Lower Energy Use Times
- Shift to Lower Cost Times
- Other Opportunities

Toolkit: Technologies & Components

- Equipment Technologies
- Central Utility Plant (CUP)
- Campus Piping Distribution
- Building Connections
- Standalone Building Systems

Solutions

- Option 0 : Building Air- Source Heat Pumps
- Option 1 : Heat Recovery Chillers
- Option 2 : Heat Recovery Chillers with Storage
- Option 3 : Air-Source Heat Pumps with Storage
- Option 4 : Geo-Source Heat Pumps with Storage
- Option 5 : Sea-Source Heat Pumps with Storage
- Option 6 : Combination-Source Heat Pumps with Storage

Evaluation Criteria

- Supporting Evaluation

Options Comparison

- First Costs
- Operations & Maintenance Costs
- Energy Costs
- Water Use
- All Criteria - Part I
- Life Cycle Costs : Capital Costs
- Life Cycle Costs : Operational Costs
- Life Cycle Costs : Total Costs
- All Criteria - Part I & II

Recommendations

- Recommended Option - Heat Pumps (Air-Source) + Storage
- Plant Equipment Size Optimization
- Plant Equipment Sequence of Operation
- CO2 Heat Pumps
- Backup Power
- Buildings Not Connected To Central Plant
- Inflation Reduction Act Opportunities
- Phased Implementation
- Addressing Campus Growth
- Recommendations Summary

Next Steps

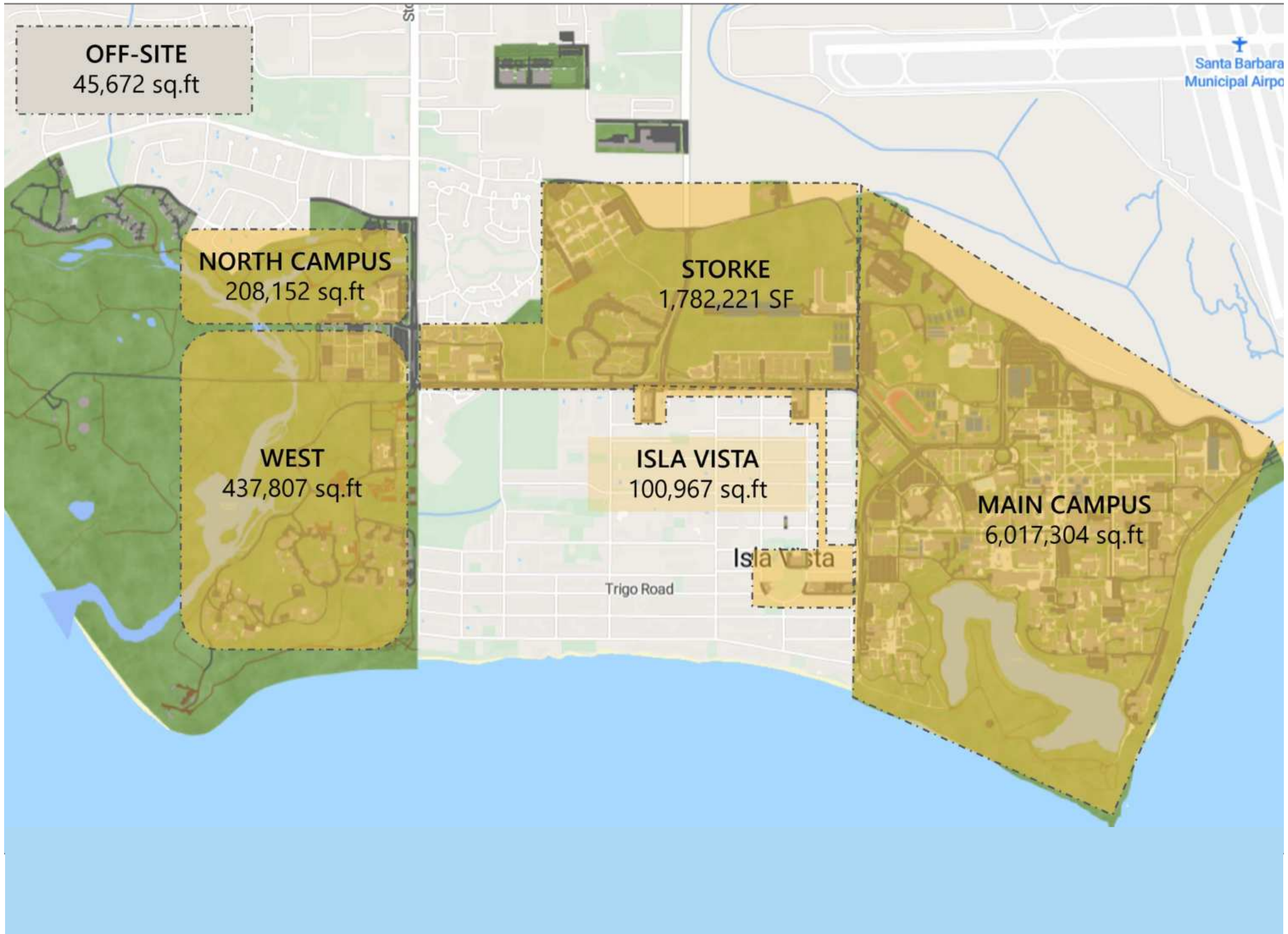
- Central Plant & Spatial Planning

EXISTING CONDITIONS

CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA
OPTIONS COMPARISON
RECOMMENDATIONS
NEXT STEPS

UC SANTA BARBARA

Map of UCSB Regions



Buildings on the Main Campus constitute 70% of the total floor area and 78% of total energy use in all UCSB

The map shown here illustrates approximately each region within UCSB's total set of building assets, along with the total gross square footage of building area in each region (as it exists in 2024).

Current Cooling and Heating Infrastructure

The UCSB campus heating infrastructure comprises distributed dedicated boiler plants at the building level. Plants are of varying capacities, ages, configurations, and design supply water temperatures. The first phase of the campus district heating system was completed in 2013 and serves three research laboratory facilities from a single condensing boiler plant located in the Engineering II building.

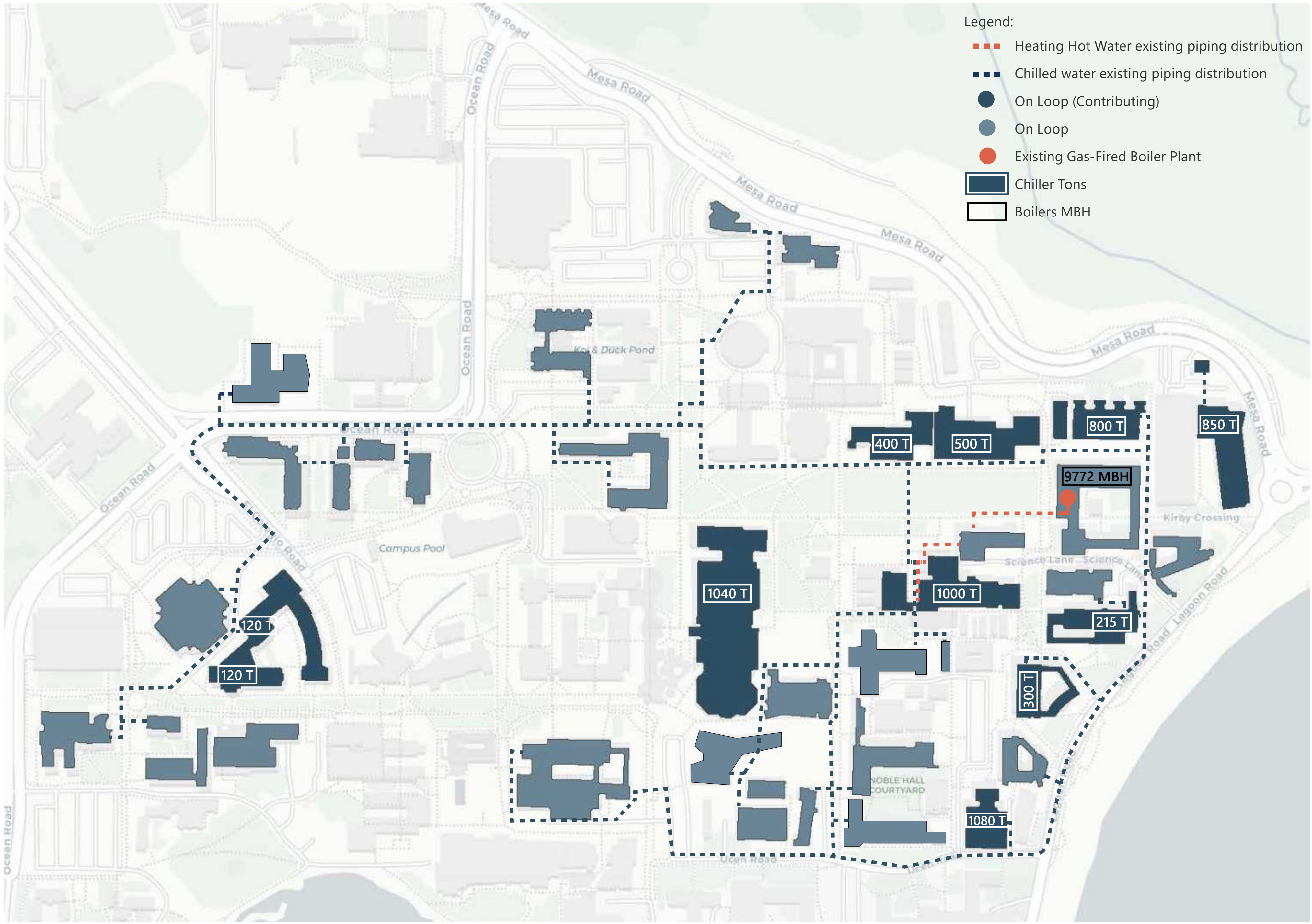
UCSB's district cooling system serves approximately 45 major buildings with chilled water produced by twelve separate chiller plants.

District Cooling: 6500 tons

District Heating: 9780 kBtu

All other buildings not served by the existing district chilled and heating hot water systems are served by any combination of gas-fired boilers, gas-fired furnaces, direct expansion (DX) packaged cooling systems, or standalone chillers as the main sources of cooling and heating. Other auxiliary systems include single-zone split systems and unit heaters.

District Cooling And Heating Main Campus Map

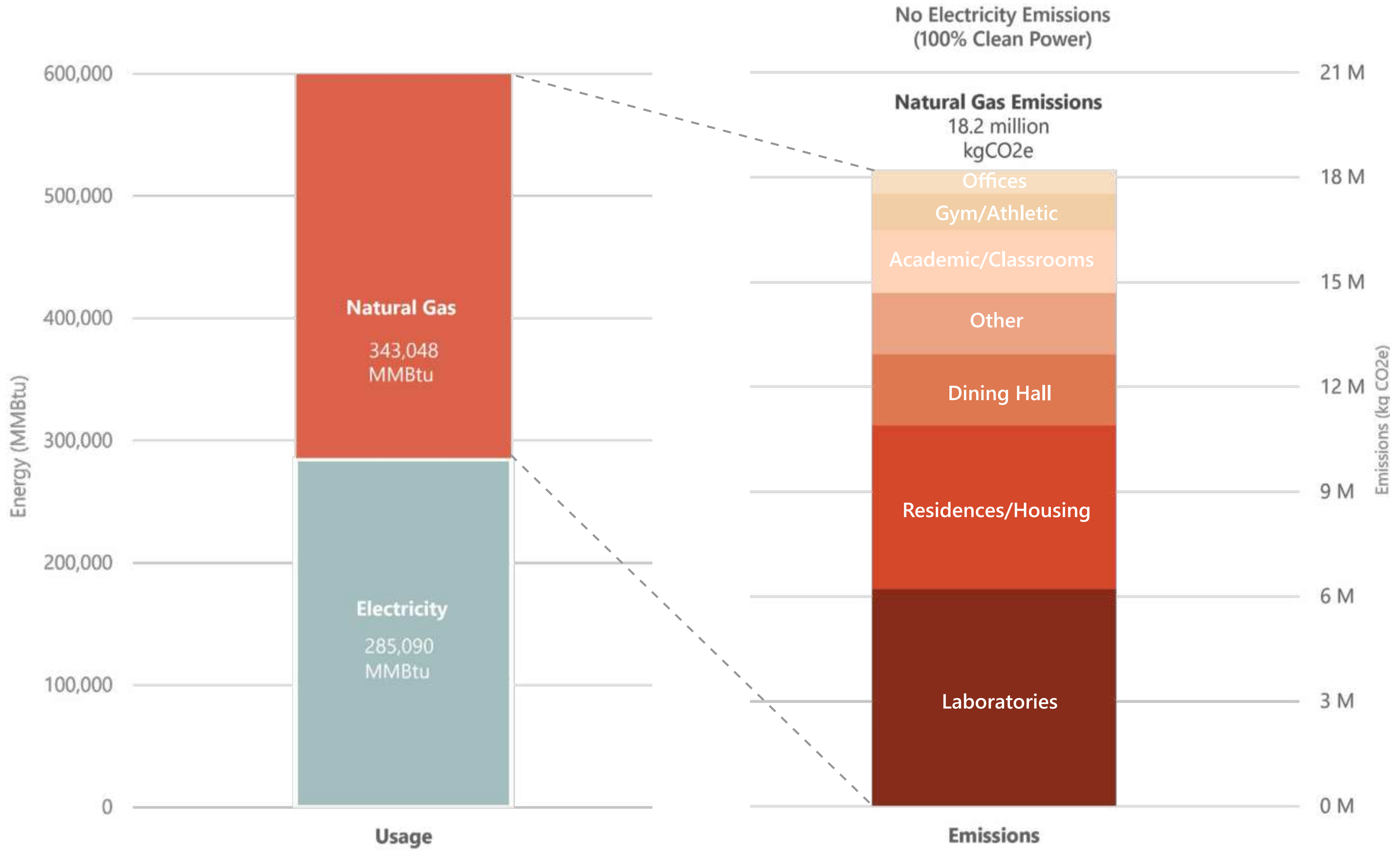


Energy By Portfolio Regions And Related Emissions

While UCSB's energy use profile is split relatively evenly between electricity and natural gas, nearly 100% of the campus's electricity is procured through the UC Clean Power Program, resulting in zero scope 2 emissions from electric usage. Natural gas usage, therefore, results in the majority of UCSB's operational GHG emissions as illustrated below.

Laboratories are the biggest gas users on campus, having both high domestic hot water and process-gas loads and a high outside air requirement resulting in high heating energy use. University-operated student and family residences are the second highest gas users as a category, primarily due to space heating, laundry and domestic hot water loads from showers. Together, these two building types make up more than 50% of the total gas use (and resulting emissions).

Current Total Annual Gas Consumption for All UCSB Buildings

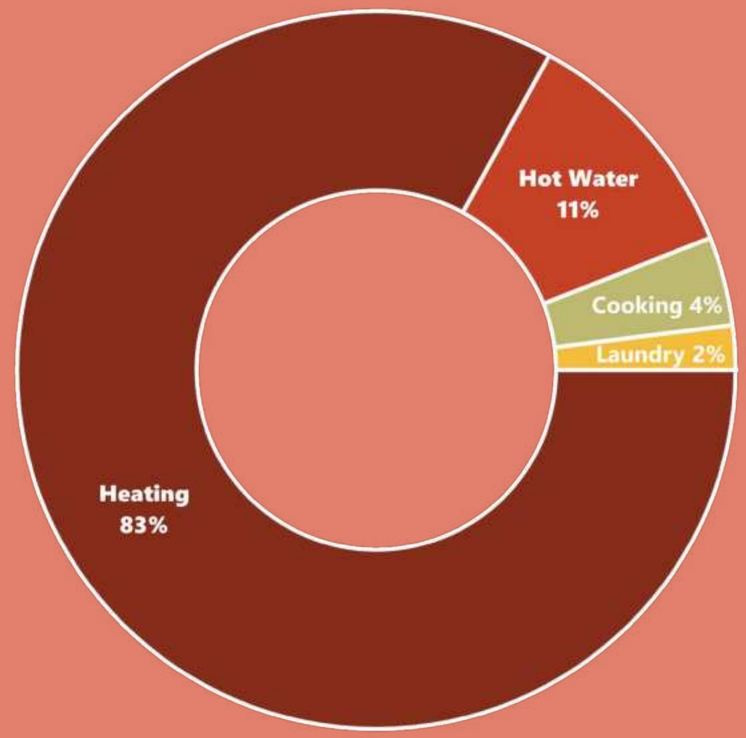


Reducing 90% Natural Gas Use

UCSB's natural gas use serves the following functions : Heating, Hot Water, Cooking, Laundry, Other Process. The chart shown here shows how much of UCSB's total natural gas use is spent on each of these service functions.

Critically, Heating and Hot Water combine for 94% of UCSB's total natural gas consumption. Decarbonizing and electrifying space heating and domestic hot water infrastructure will result in eliminating over 90% gas use and hence all scope 1 emissions related to this use.

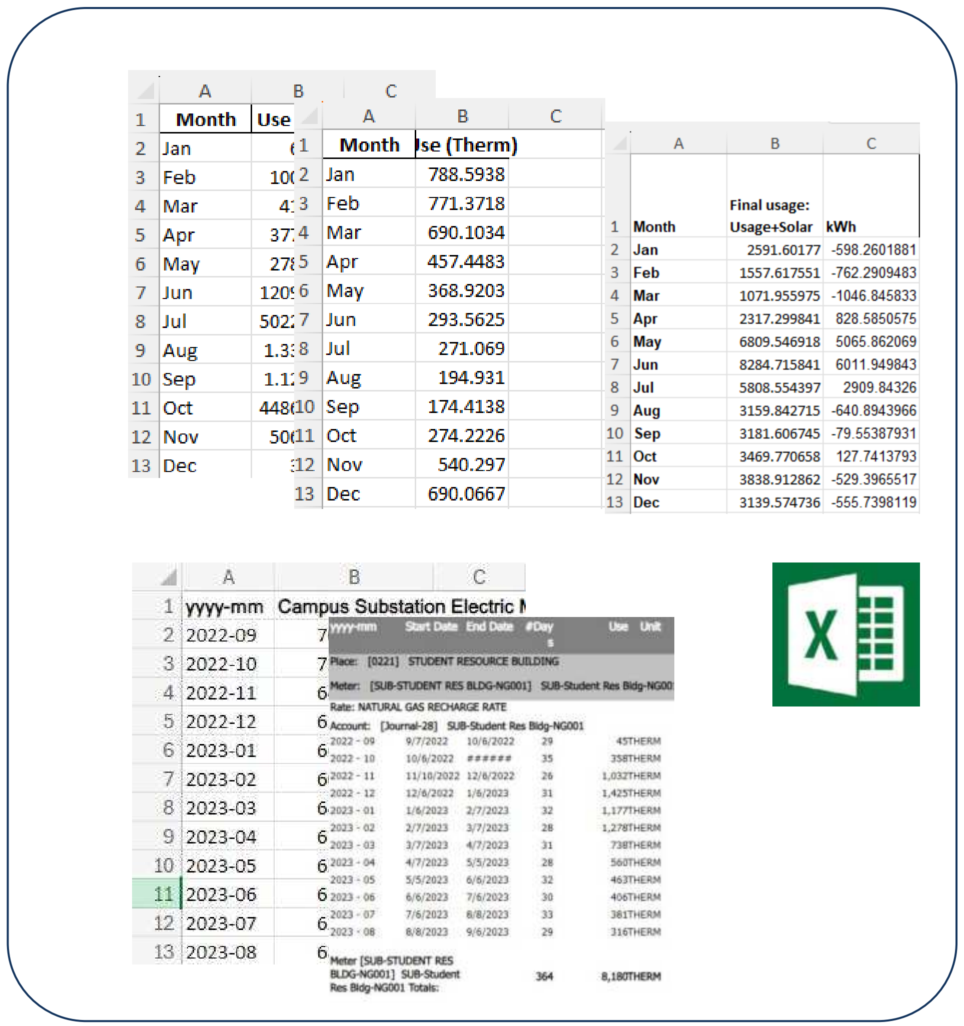
The remaining ~6% emissions can be addressed in the future by electrifying laundry and cooking related natural gas use.



Digital Twin Modeling & Calibrations

Existing data and processing

Introba developed hourly heating and cooling load profiles for each facility to feed into the engineering models for plant sizing and analysis. Energy consumption data provided by UCSB included a mix of monthly and hourly energy use by utility type. The data was processed in order to be able to associate monthly energy use by utility for each building. Buildings with insufficient data were accounted for by estimating energy use based on UCSB's existing building stock as well as Pacific Northwest National Laboratory (PNNL) prototype energy models.



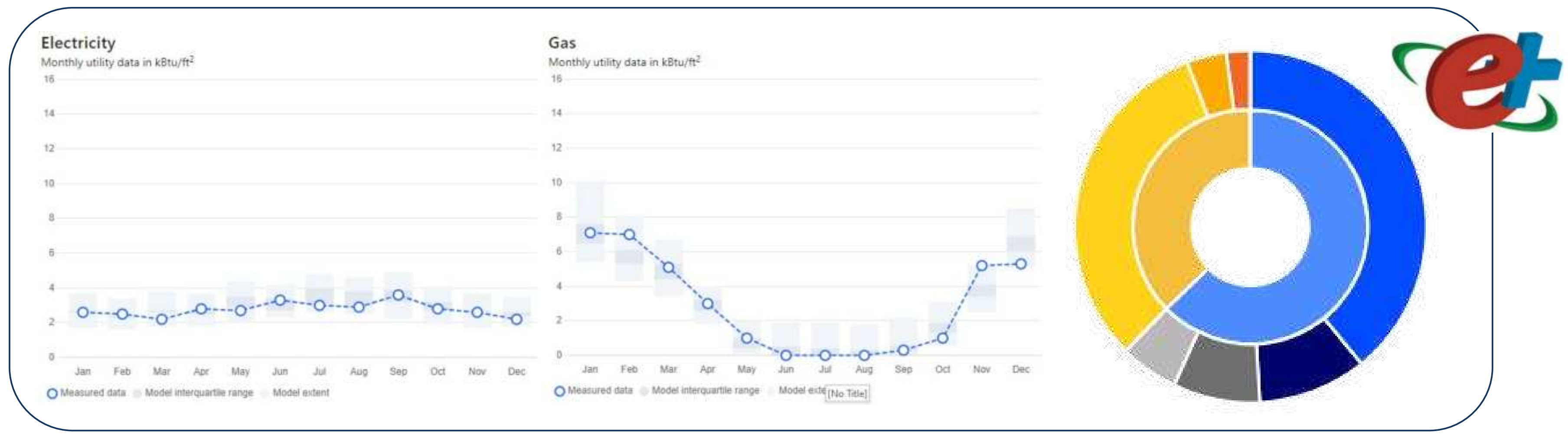
Model calibration and disaggregation

Monthly energy use data, program type, location, and square footage are the only parameters needed to calibrate each building and pick an energy model that is approximately representative of the building's characteristics and operation. This set of variables yields a 'digital twin' of each facility. Having an energy model associated with each building allows for disaggregation of the building's energy by end-use. These planning-level models are an efficient method of design-assist for concept engineering and are not intended to replace detailed engineering calculations.

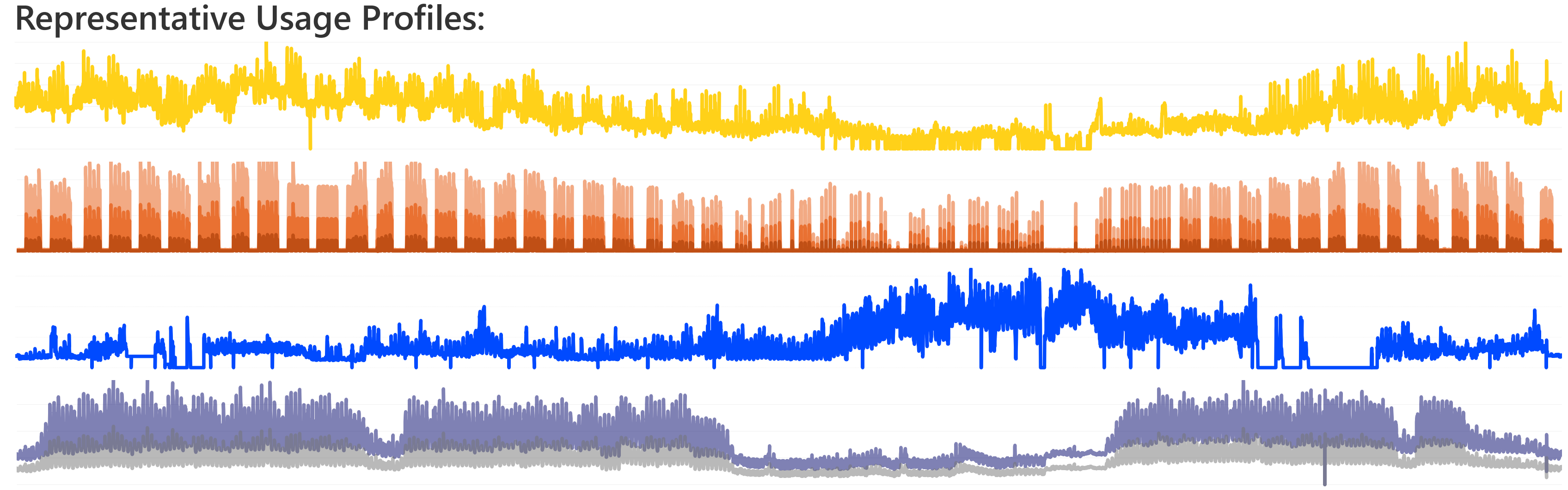
Disaggregated hourly profiles by end-use

Sizing of equipment and estimating of energy cost and GHG emissions requires an analysis with hourly or sub-hourly resolution for higher fidelity. The benefit of having an energy model as a digital twin is the ability to extract hourly load profiles for each end-use that can be leveraged as inputs to the engineering models. Profiles have been extracted for the following end-uses:

1)Cooling Building, 2)Heating, 3)Domestic Water Heating, 4)Cooking/Laundry, 5)Non-Thermal Electricity



Representative Usage Profiles:



-Heating hot water -Domestic hot water & Cooking -Chilled water -Lighting -Plug Loads

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA
OPTIONS COMPARISON
RECOMMENDATIONS
NEXT STEPS

Heating vs. Cooling vs. Simultaneous

From the calibrated digital twin models, seasonal profiles of heating and cooling for UCSB's campus are evident. **Analysis of average days in each season:**

Winter

- Thermal loads are Very Heating Dominant
- For most hours, the heating load exceeds the cooling load and needs a supplemental heat-source to provide heat via a heat pump instead of electric boiler.
- Towards the middle of the afternoon, heating and cooling loads are closer to being balanced.

Fall and Summer

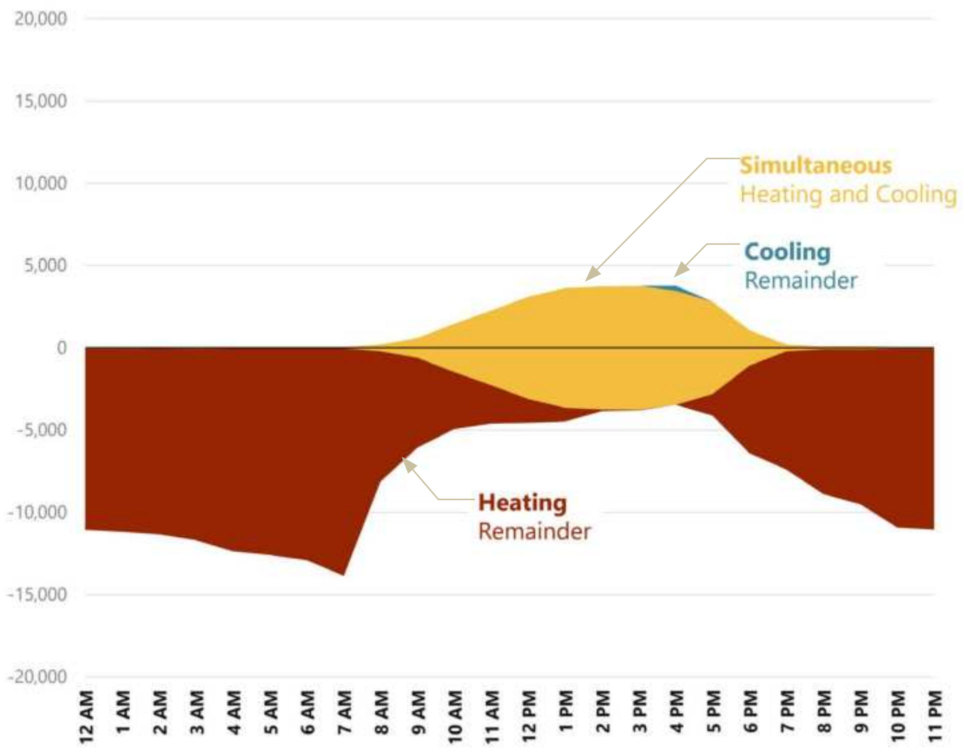
- Thermal loads are Very Cooling Dominant (particularly in the afternoon)
- The loads are slightly Heating Dominant over night and in the early mornings.
- There is substantial simultaneous heating and cooling load all hours of the day

Spring

- Most days, thermal loads are Heating Dominant, especially during evenings, nights, and early mornings.
- Approximately half of the heating and cooling load can be satisfied simultaneously.
- During the daytime, heating and cooling loads are relatively even with more cooling in the late afternoon.

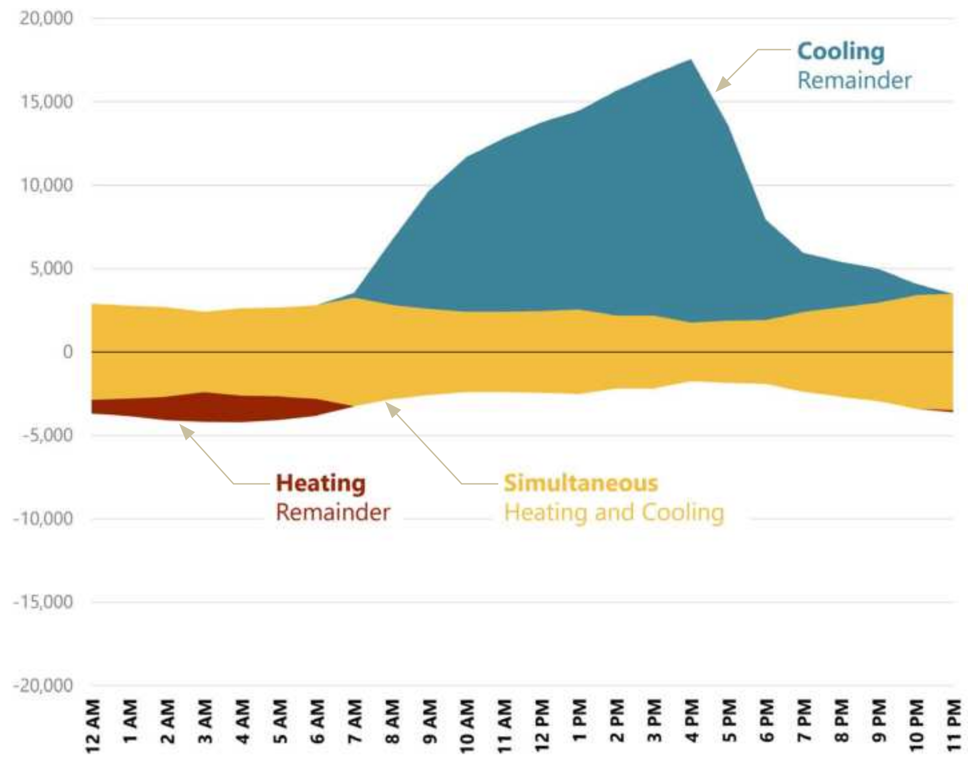
February

Typical Day Thermal Loads (kWh)



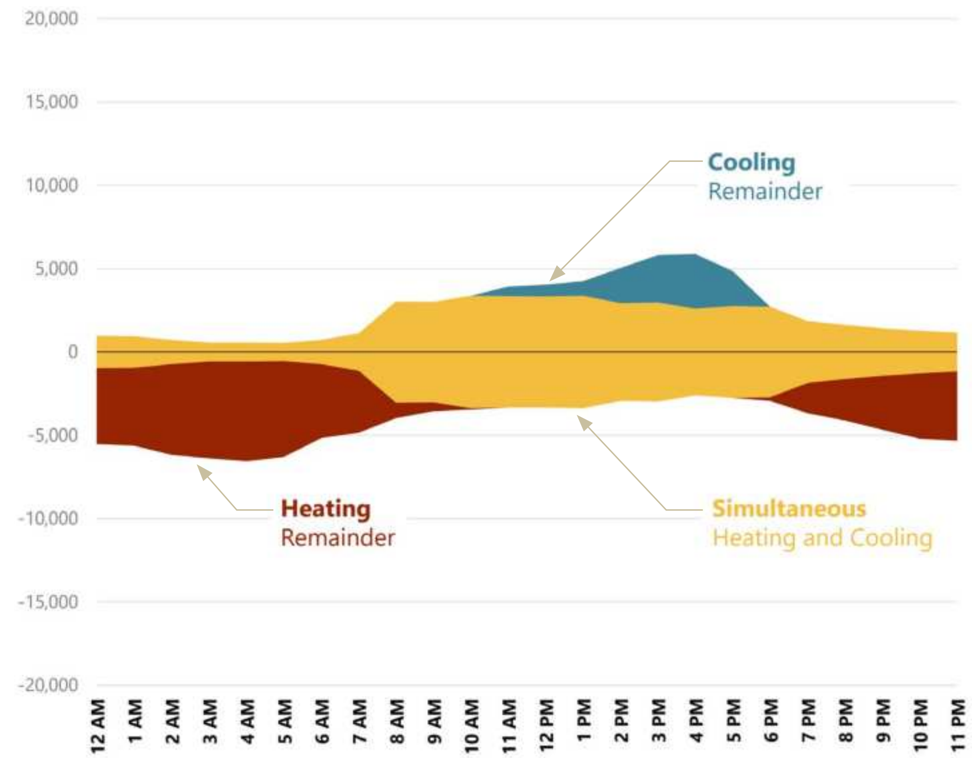
September

Typical Day Thermal Loads (kWh)



May

Typical Day Thermal Loads (kWh)



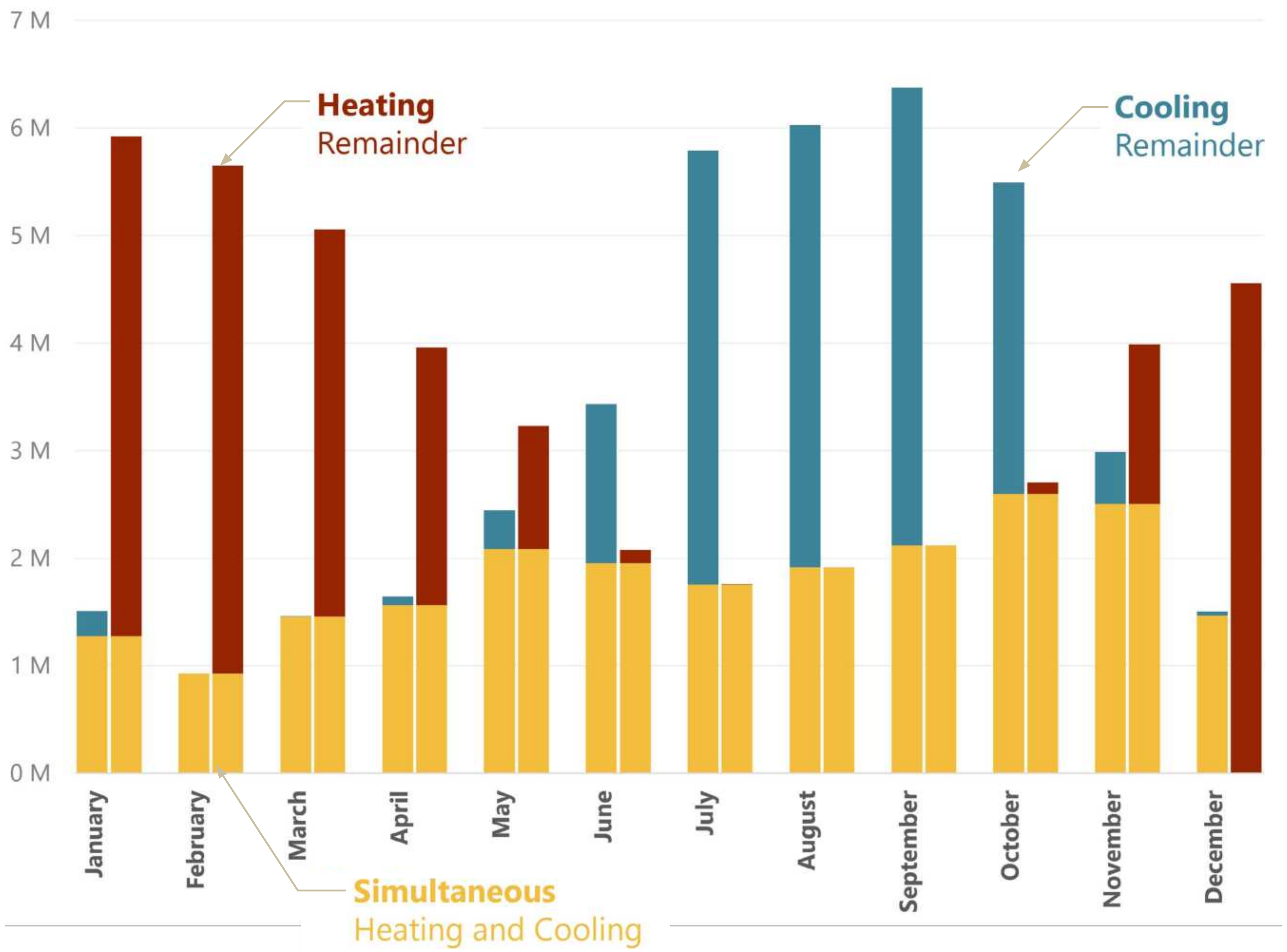
Heating vs. Cooling vs. Simultaneous

Annually, **UCSB is roughly even between heating and cooling** with about 53% heating load and 47% cooling load (heating here includes both space heating and domestic hot water).

While the annual heating and cooling split is roughly similar, they do not always occur at the same time.

There is considerable amount of simultaneous cooling and heating in nearly every month, but most months are heating dominant, many (such as December through April) significantly heating dominant. The summer and early fall are cooling dominant.

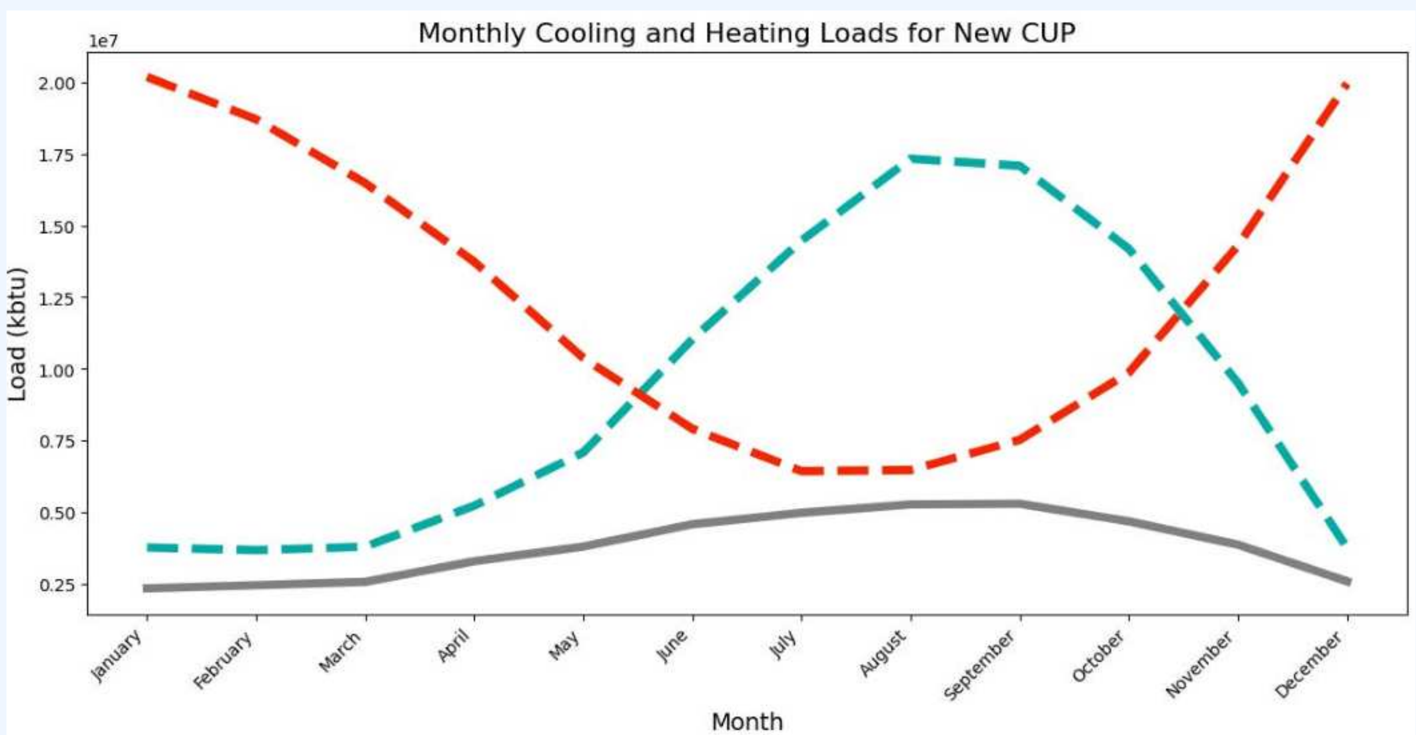
Monthly Thermal Loads (kWh)



Opportunities : Leveraging Waste Heat

A central heating and cooling plant serving a diverse mix of buildings on a campus, from Student housing and Dining facilities that primarily need heat to Labs and Academic buildings requiring year-round cooling, offers a significant benefit: waste heat recovery. Heat generated by academic buildings with high internal and ventilation loads during the day can be captured by the central plant. This captured heat can then be used to meet the hot water and/or space heating demands of buildings with high heating demand. This synergy minimizes energy waste and maximizes energy efficiency by reducing reliance on external sources for heating and cooling generation.

Heating vs Cooling Loads - New Central Utility Plant (CUP)

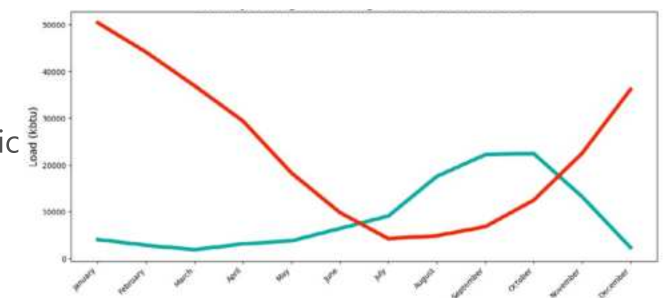


- Heating Load

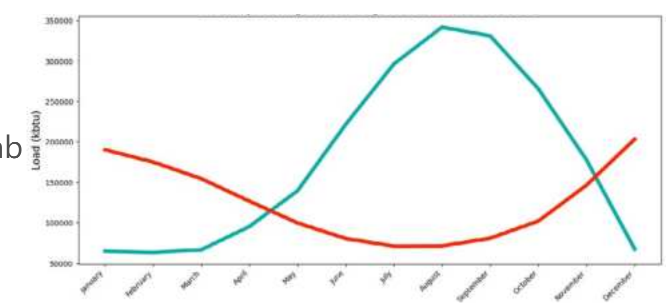
-Cooling Load

-Simultaneous Loads

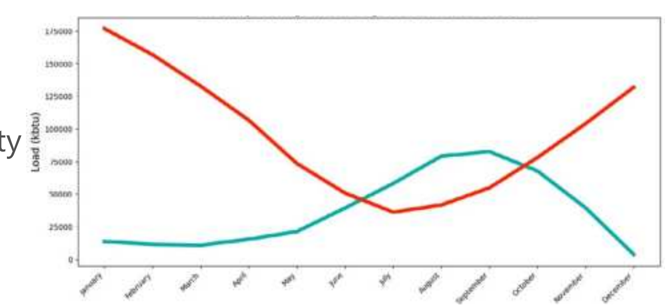
Academic



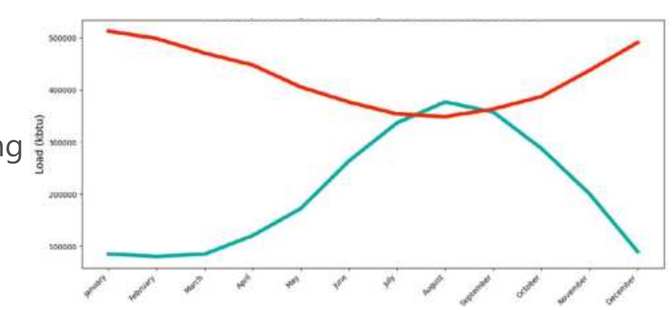
Lab



Community



Dining



Heating and Cooling Dominated

Classrooms

Administration

Labs

Community

Heating Dominated

Showers

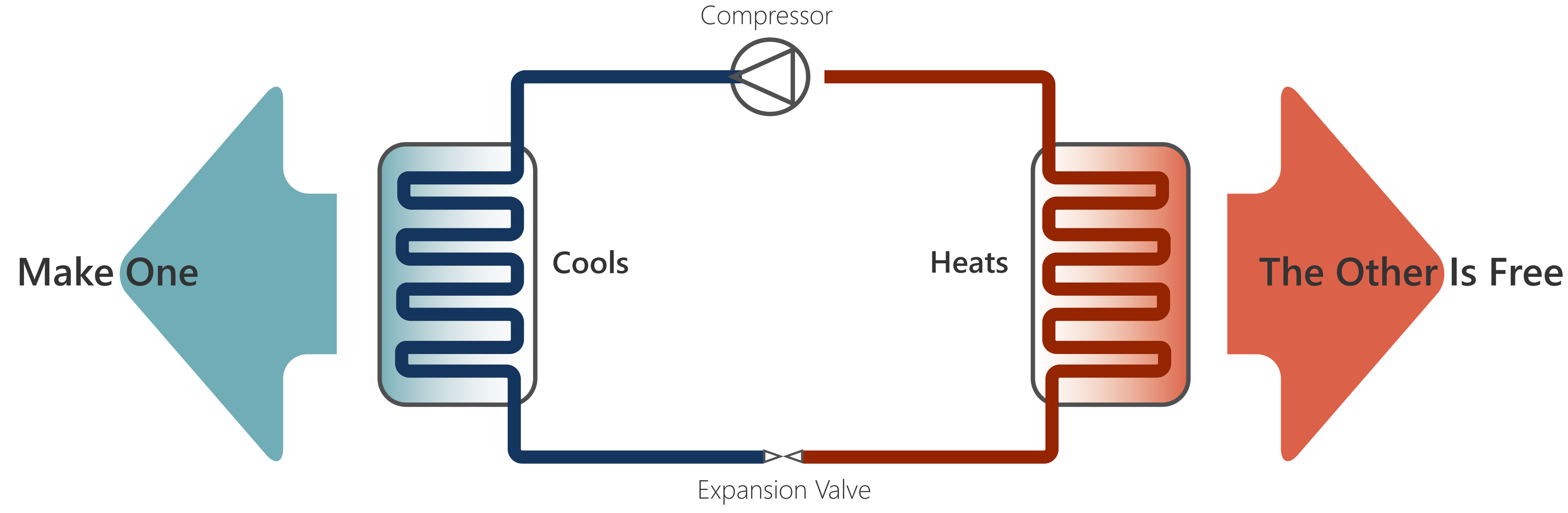
Residence

Meals

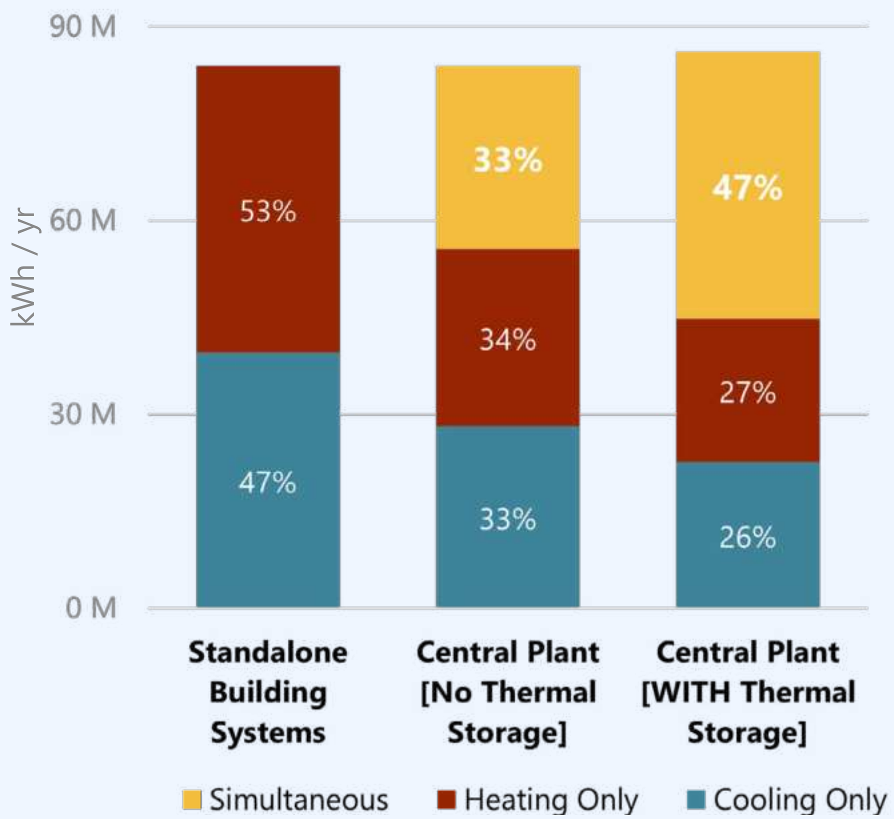
Opportunities : Thermal Storage

Every time a heat pump makes heating hot water, it also makes chilled water for cooling, and visa versa. If that free production isn't utilized via a coincident need or stored in a storage tank for later, then it is wasted. UCSB's thermal loads present an enormous opportunity for simultaneous heating and cooling production if Thermal Storage is utilized.

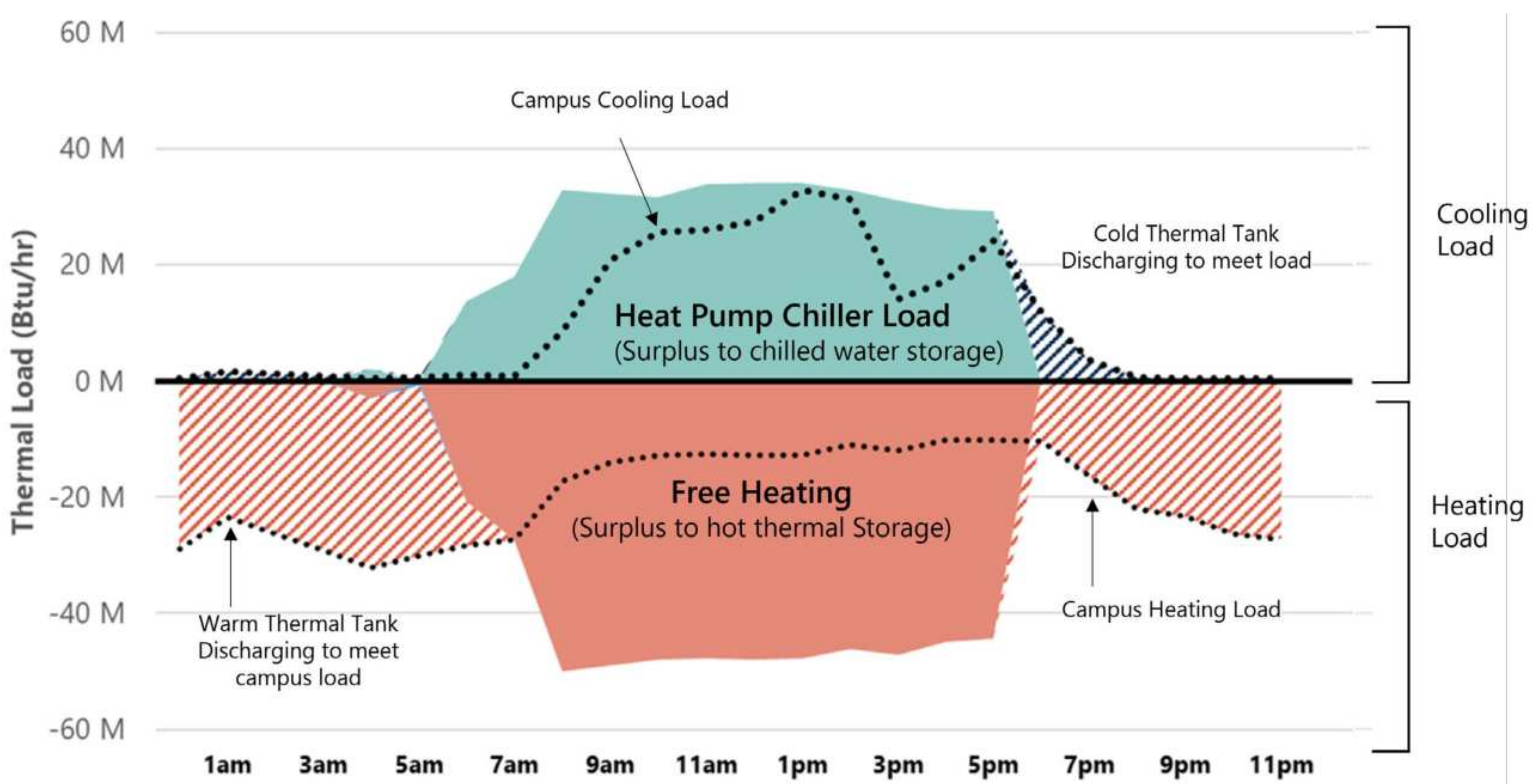
With thermal storage, about half the of heating and cooling needs can be met through heat recovery or simultaneous heating and cooling.



Annual Thermal Load



Hourly Central Plant Load Profile | Central Plant With Thermal Storage

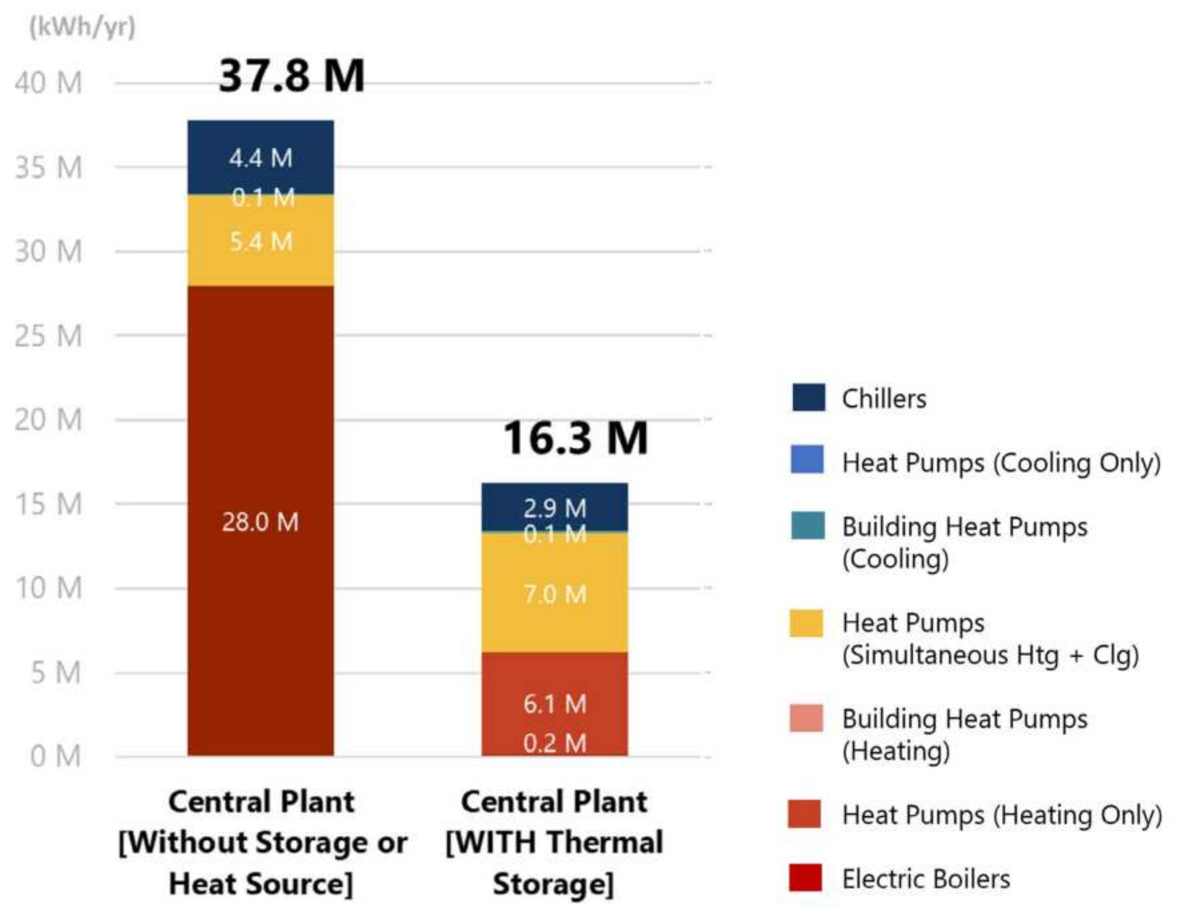


Opportunities : Thermal Storage

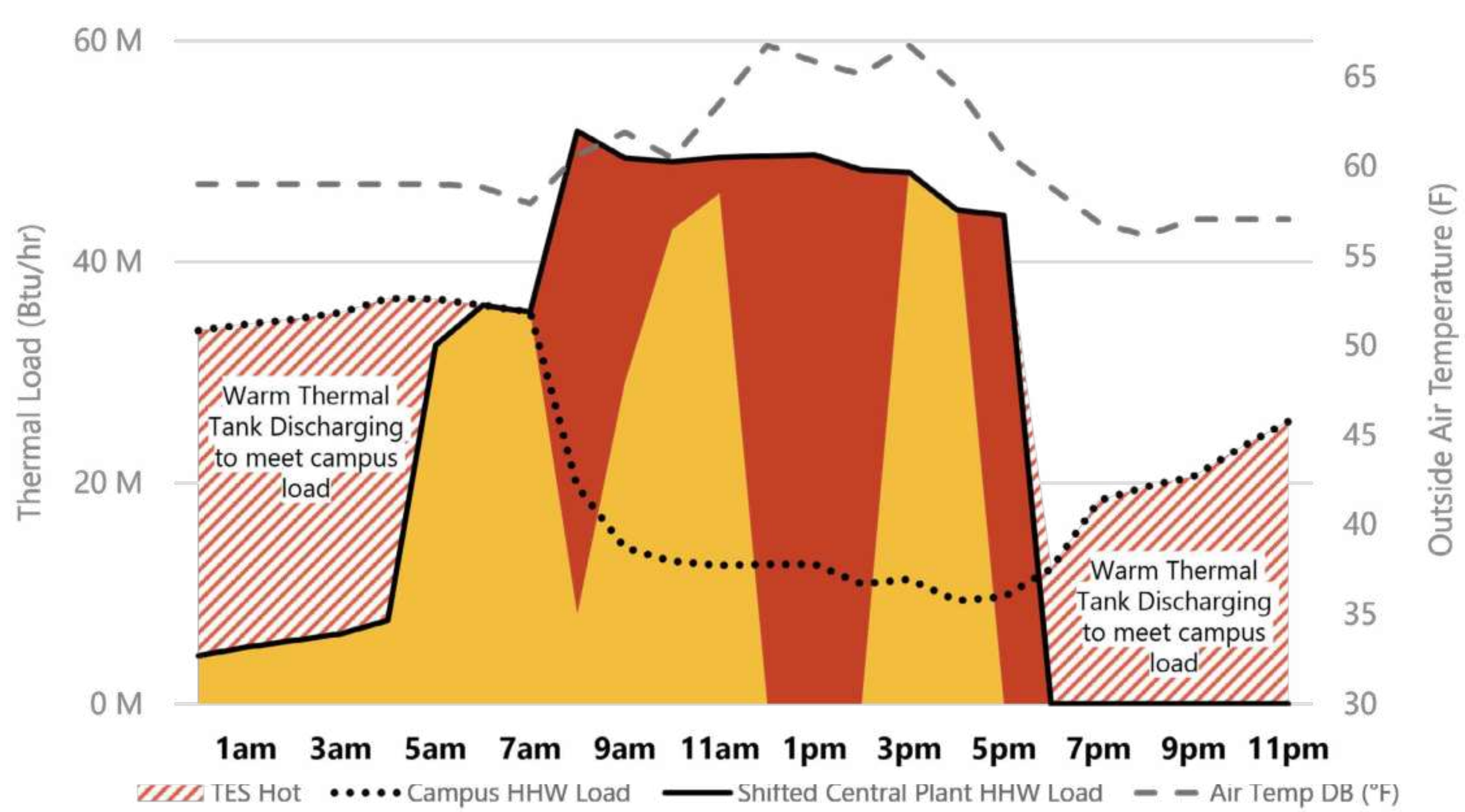
A campus heating and cooling plant equipped with thermal energy storage unlocks a valuable opportunity: strategic scheduling of hot and chilled water production. By incorporating thermal storage tanks, the plant isn't restricted to producing chilled water and hot water only when it's immediately needed and can better employ the higher equipment efficiencies resulting from simultaneous heating and cooling.

Heat pumps use less energy to make heat the warmer it is outside. Thermal storage allows a central plant to shift heat production from evenings/overnight (when it's colder) to daytime (when it's warmest), by storing extra heat for later use. This time-shifting approach greatly reduces heating energy use, by leveraging Santa Barbara's mild climate.

Energy Use By Equipment



Hourly Heating Load With Thermal Storage (Day in March)

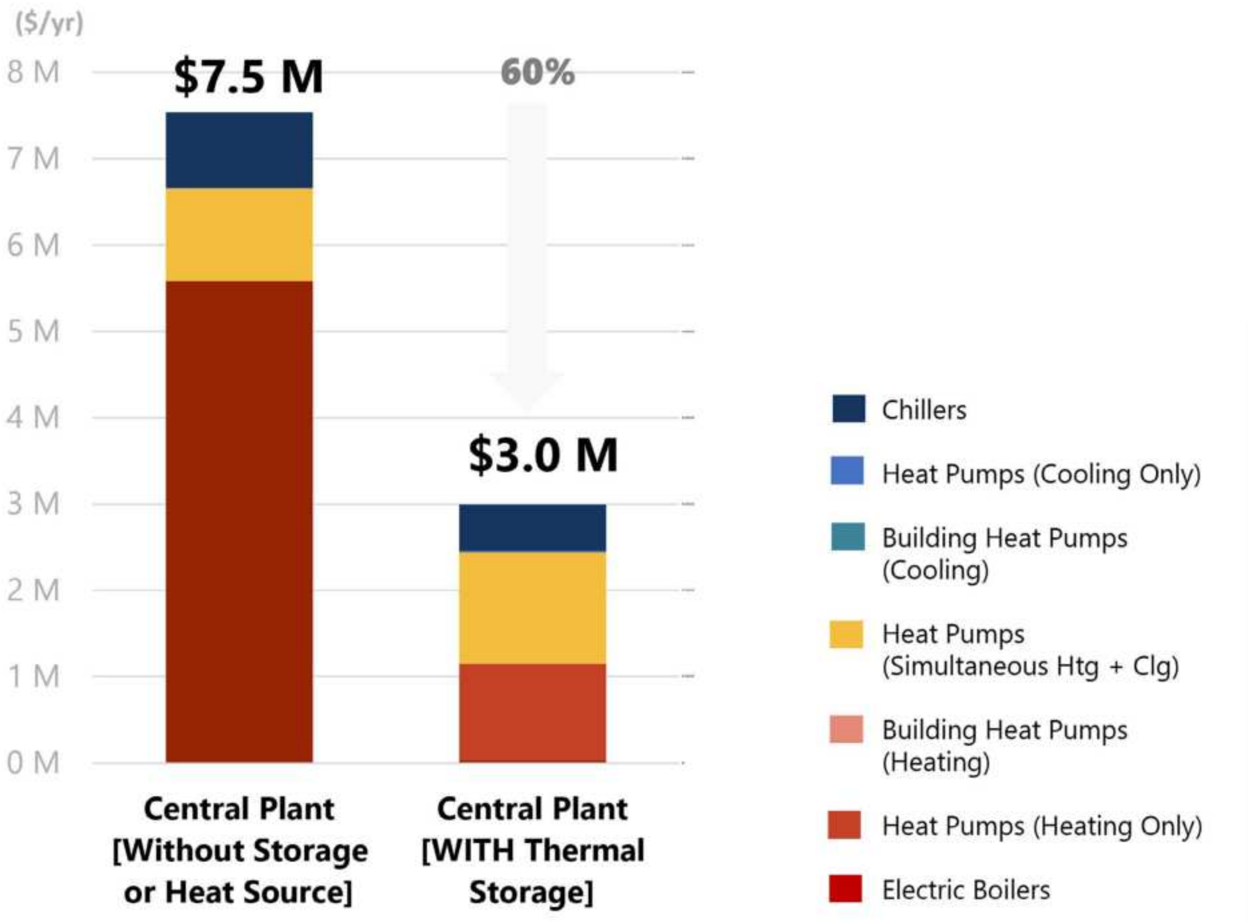


Opportunities : Thermal Storage

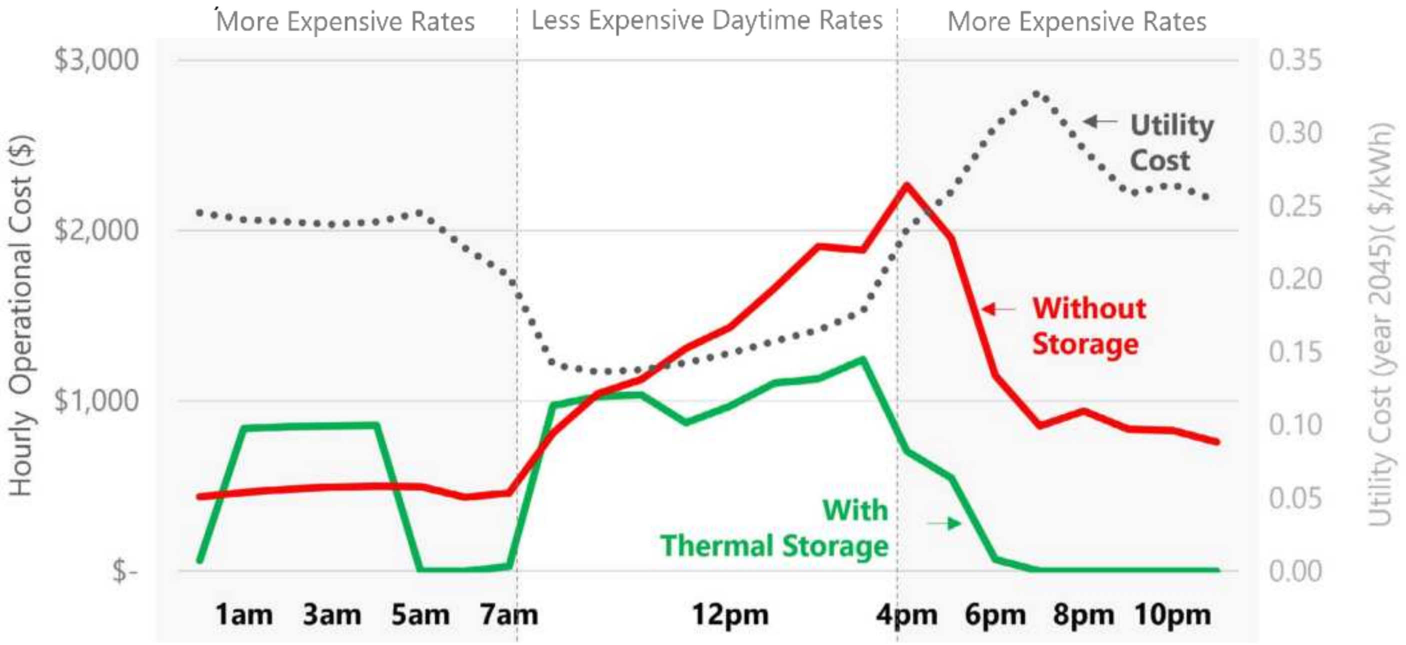
Time-of-Use electricity rates for UCSB disincentivize use of electricity during summer afternoon and overnight hours when power is more costly. With standalone building systems, the peak demand for cooling coincides with peak electricity pricing, resulting in high operating energy costs.

Pairing thermal storage with a central heating and cooling plant creates the opportunity for power demand to be shifted to times of day when electricity rates (and grid emissions) are lowest.

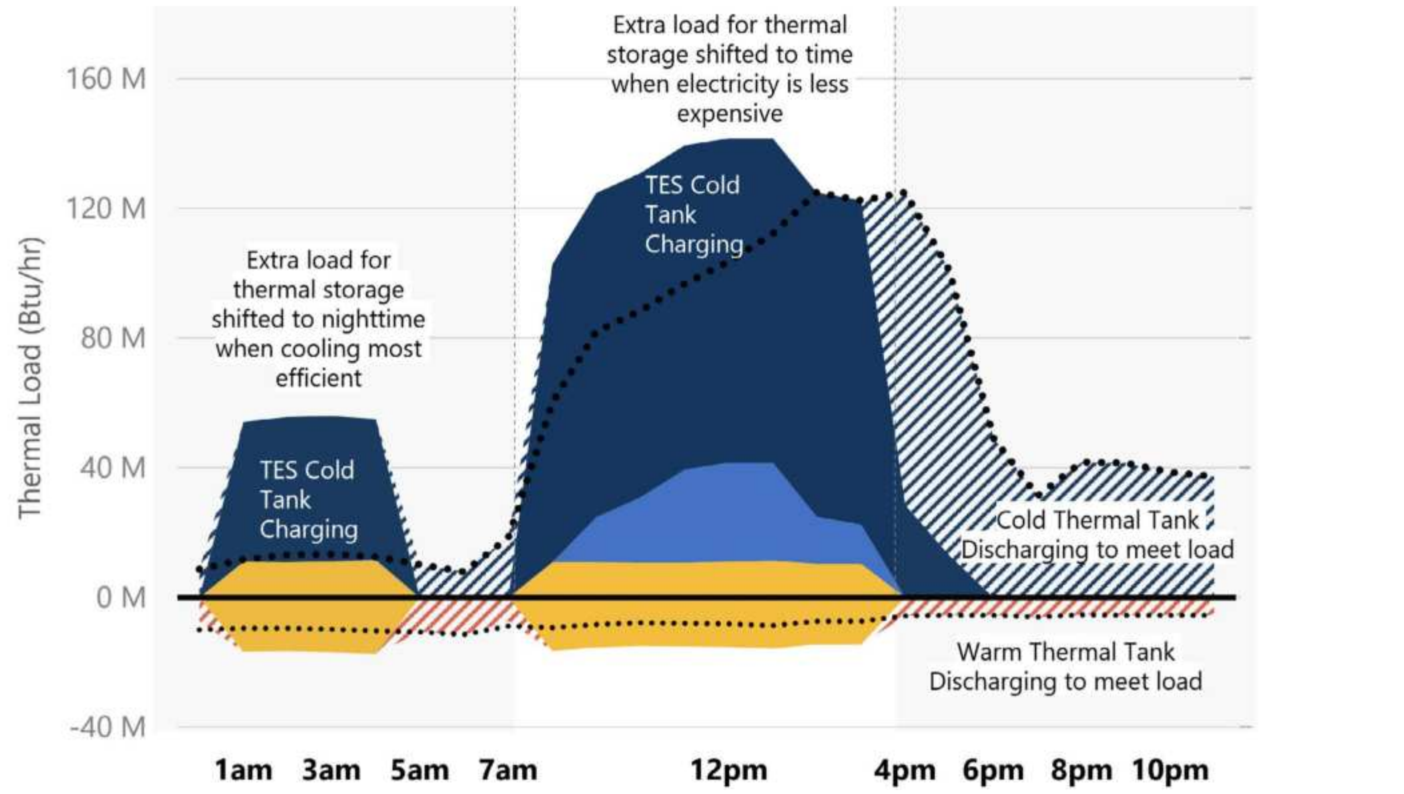
Operational Energy Cost By Equipment



Hourly Energy Cost (September Day)



Thermal Load (September Day)



Operational Opportunities

High Temperature Hot Water
Supplying High Temp Hot Water, like Campus uses currently

Eliminates Extensive Building Retrofits
Allows Heating and Hot Water to be met by Same System

Most of UCSB's existing building infrastructure has hydronic heating piping that uses high temperature hot water. While buildings have been employing condensing boilers that use slightly lower temperature hot water, in general temperatures of 130°F to 180°F are currently utilized. While most buildings could likely use a lower temperature supply water without having to increase any equipment or pipe sizes, it would be a considerable effort to retrofit enough buildings to use lower temperature hot water, such as 100°F to 120°F. A central plant that can supply campus with high temperature hot water will provide considerable cost and simplicity savings to UCSB. Not only will it allow all buildings to work without replacing equipment or pipes, it also allows for domestic hot water, which needs to be able to make 140°F, to receive its heat directly from this same system.

Centralization
Just Valves and Pumps at Buildings

Significantly Less Equipment
All Major Equipment in One Place

Currently UCSB has a somewhat pieced together district cooling system that has come together as independent pieces were joined over time. This is an opportunity to build a more cohesive and extensive cooling and heating district system within campus and eliminate the large amount of time and money spent trying to maintain heating equipment at each building and disparate chillers. With a central plant approach, all equipment can be in one place with just valves and pumps at buildings.

Future Flexibility and Phasing
Using District Approach

Future Buildings To Just Connect to District Piping
During Transition, Buildings Can Use their Current Systems

As UCSB transitions to an all-electric campus, it is an opportunity to provide more flexible infrastructure for future new buildings. Having piping distributed through campus means a new building simply ties in to that pipe network rather than having to build a heating or cooling plant with every new building or group of buildings.

Finance Opportunity

Financing Incentives & Tax Credits

The Inflation Reduction Act (IRA) Offers new opportunities for installing Thermal Energy Storage and Geo Heat Exchange systems as part of the Investment Tax Credit provisions (this also includes sea heat exchange systems). This funding mechanism allows for the first time for non-tax paying institutions, such as UCSB, to receive direct cash payments. This payment equals up to 30% of the total cost for qualifying items. In this context, this includes the entirety of the central plant, campus distribution from the central plant to each building, and any building connections. The benefit applies for 100% of the 30% for directly related components (geoexchange piping or thermal storage tanks), and for 75%+ of that 30% for Hybrid Components (everything else) depending on how much that hybrid equipment is utilized for Thermal Storage or Geo Exchange. For the thermal energy storage provision, there is a requirement that the energy source come from a clean renewable, such as solar, wind, geothermal power, hydro, etc. Since UCSB receives it's electricity from UCOP's 100% clean power sources, there is grounds that this satisfies the requirement. This will require further exploration and discussion.

Many higher education institutions have proceeded with these system types and applied to secure this funding. There is uncertainty given UCSB's timeline and the potential for a new federal administration starting in 2025 – regardless of that outcome, it is worth exploring.

- **Directly Related Components (100% of the full 30% credit)**
  (e.g. Thermal Storage Tanks or Geothermal Bores)
- **Hybrid Components (75%+ of the full 30% credit)**
  (e.g. All Other Central Plant Equipment and District Piping and Building Connections)
- **Could be Upwards of $80 Million**
  Want to Apply as Soon as Possible to Secure Funding

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA
OPTIONS COMPARISON
RECOMMENDATIONS
NEXT STEPS

UC SANTA BARBARA

Boilers and Heat Pumps : High Temperature Heating

Electric Resistance Boilers

This type of boiler uses an electric heating element to create high temperature hot water. They are simple and effective, but not very efficient.

Electric resistance boilers convert almost all input energy to heat, so efficiency is close to 100% (COP ~1).

Heat Pumps (Two-Pass)

A heat pump is a device that moves heat from one place to another. When "creating" heat, it is technically using a compressor and refrigerant to move heat from a hot source to a cold sink – this makes the source colder and the sink warmer.

A heat pump requires substantially less energy to move heat from source to sink than electric resistance takes to create the same amount of heat. A Two-Pass type heat pump generally uses about 3 times less energy than an electric boiler to make high temperature hot water.

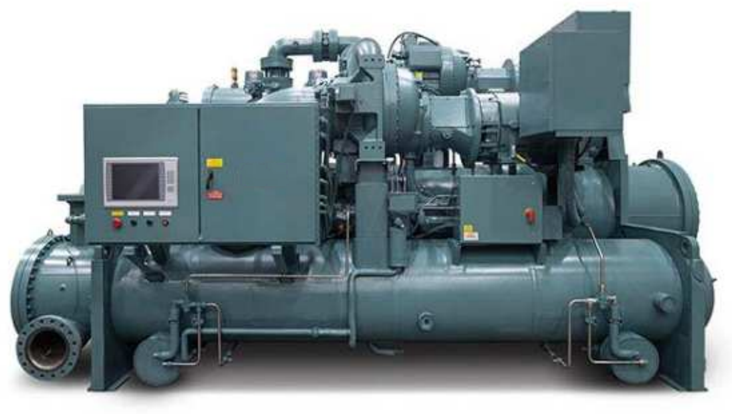
Heat Pumps (CO2)

Heat pumps that use CO_2 as a refrigerant can operate at much higher temperatures and pressures. High pressure CO_2 can absorb more heat from the source and reject heat more efficiently by skipping the condensation stage required for other refrigerants.

A CO_2 type heat pump generally uses about 5 times less energy than an electric boiler to make high-temperature hot water.

Electric Resistance Boilers

COP~1



Heat Pumps (Two-Pass)

COP~3

Heat Pumps (CO2)

COP~5

Chillers

Cooling Only

A centrifugal chiller served by a water source provides chilled water mechanically using the least energy (excluding passive non-compressor based technologies), all else equal. These devices pull heat out of a water loop and reject that heat as waste to a water-source, such as cooling towers, geo exchange, or sea exchange.

This cooling only approach is utilized to make cooling when there is no place, means, or desire to use the waste heat. Since the heat is rejected and not used again, it is considered **waste heat.**

A Centrifugal Compressor Type Water-Source Chiller is a highly efficient cooling device. It comes in large capacities, appropriate and common at university campus scales. It is easier for compressors to make conventional cooling temperatures than high-temperature heating.

COP~9

Heat Recovery Chiller

A heat recovery chiller can make high-temperature hot water from the heat it pulls out of cooling, producing cold and hot water simultaneously.

Since the heat has been recovered from this process, it is no longer waste heat - instead, it is **free heat** created using the same process and energy to make cooling.

The major downside of a heat recovery chiller is that it cannot make more heat than is recovered from cooling. If there is ever more heating needed, all heating needed in excess of cooling is produced by an electric boiler.

Heat Pump Chiller

A heat pump chiller is able to produce heating and cooling simultaneously, regardless of which one is larger, but to do so they require a heat source. These devices can produce heating only (rejecting all cooling as waste to a source), cooling only (rejecting all heating as waste to a source), and simultaneous heating and cooling (utilizing all waste to make **heating and cooling for free**).

For a Water-Source type heat pump chiller, the heat source must be sized to be a large enough thermal reservoir to not be depleted as heat is removed. This water-source is typically a geo exchange or sea exchange system.

For an Air-Source type heat pump chiller, the heat source is the ambient air which requires equipment to provide that heat transfer. CO2 Heat Pump Chillers are the only type available that can utilize an air-source, due to the mechanics of their refrigerant cycle.

Thermal Storage Tanks

A thermal storage tank is a large insulated tank that stores chilled water or hot water for future cooling or heating use. They can be charged whenever it is advantageous for the equipment to do so. This can include:

- Charging when electricity prices are low
- Charging when equipment would be more efficient
- Charging when recovered heating or cooling needs a place to go

The thermal storage tank brings true flexibility to a heating and cooling plant by allowing loads to be shifted from one hour to the next. In many cases, heating and cooling do not occur in the same hour, or if they do, the load for one is much larger than the other. A tank is a place to put the cooling or heating created when it is desirable to run a chiller in heat recovery or heat pump mode. And, if there is a cooling or heating need later in the day, the tanks can be discharged instead of bringing on another chiller or boiler to meet that need.

Many institutions that use thermal energy storage have embraced their 50- to 100-foot-tall cylinders of metal by transforming them into architectural pieces of art, providing a canvas for artists, or giving them a second function (rock climbing wall as a possibility). For UCSB, given height restrictions, 60ft high tanks are being considered.

UC San Diego Thermal Storage Tanks

Heat Sources and Sinks

Gas-coolers

Air can be a heat source or sink for cooling and heating processes. In fact, since air is continually circulating, it can for a single piece of equipment be considered an infinite source – that is no one piece of equipment has the capacity to change the temperature of the local ambient temperature via heat exchange.

A gas-cooler cycles CO2 refrigerant through heat exchangers while blowing ambient air across them to exchange heat. In cooling mode, hot refrigerant is cycled through and cool air is blown across, cooling refrigerant and rejecting heat to the outside air. Conversely in heating mode, cold refrigerant is cycled through and warm air is blown across, heating the refrigerant and absorbing heat from the air. The main difference between a condenser and a gas cooler is that in a condenser, the refrigerant goes through a phase change – transforming from a gas to a liquid or from liquid to gas – and requires more thermal energy to do so. A gas-cooler does not involve phase change, and the gas is simply cooled or heated. CO2 heat pumps use gas coolers, while conventional refrigerants require a condenser.

Gas-coolers will work with CO2 heat pumps, but do not work with conventional two-pass centrifugal heat pump chillers.

Cooling Towers

Cooling towers can be used only to reject heat as part of a cooling process. Warm water made from waste heat from cooling equipment is exposed to open air media with fans for enhanced air circulation, cooling the water. Cooling towers work through evaporation – as some of the water raining down on the media evaporates, the remaining water is cooled as evaporation has a cooling effect.

The water which evaporates from a cooling tower is lost (along with the heat) and can't be reclaimed. In addition, water must be periodically cycled due to build up of salts and other particulates, and chemical water treatment is required to prevent scale build up on the cooling tower media.

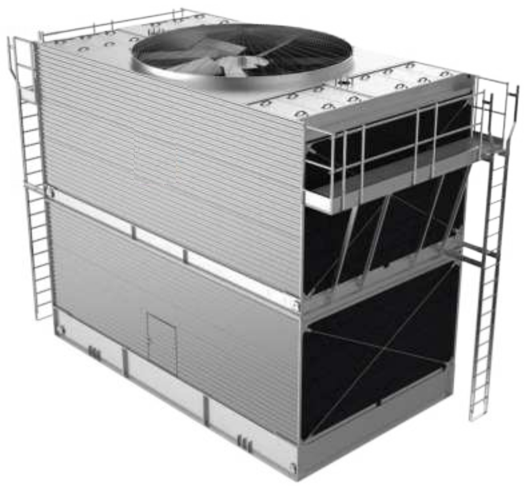
Geoexchange

The ground can also be used as a heat source or sink. Unlike the air, the temperature of the ground stays a fairly consistent temperature month to month, slowly rising and falling as heat is added or removed over the year. As a heat source or sink, this is excellent because the temperatures remain mild compared to the water needing to reject or absorb heat. Additionally, the heat rejected to the ground stays in the ground until it is absorbed again.

In this way, the ground acts like a long-term thermal battery. During the summer, heat is rejected to the ground, and due to its high thermal mass, the ground holds that heat throughout the summer. In the winter, there is now heat in the ground which can be extracted and used for heating. This is how, in a sense, the ground allows heating or cooling energy to be recovered.

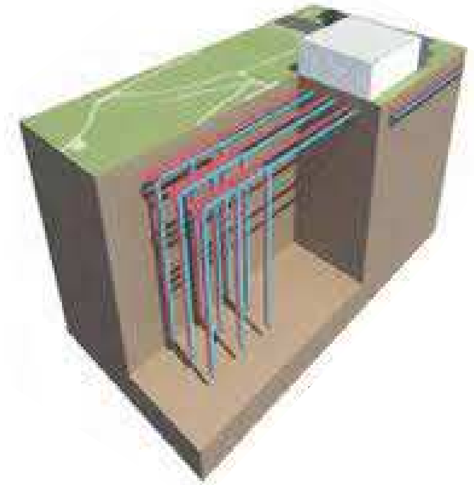
Air Based Source And Sink

Gas-coolers



Cooling Towers

Geo Based Source And Sink



Geoexchange

Heat Sources and Sinks

Ocean

The ocean is possibly the largest heat source or sink available. In the same way that the air can be considered an infinite heat source or sink – because the air is large and continually being recirculated – the ocean can also be considered infinite. However, the ocean has the additional benefit of more mild temperatures, which is easier on equipment and makes heat exchange highly efficient, especially for cooling.

To use the ocean as a source or sink, a set of pipes is run from the central plant to the ocean. These pipes are arranged into a series of coils (see images at right)that will act as the heat exchanger to reject or absorb heat. The piping structure is a closed loop and does not exchange water with the ocean - same water that leaves the central plant returns to the plant warmer or colder, depending on the mode of operation. And by spreading the coils out over a large area, heat exchange is not localized which does not cause any one area to become hotter or colder. The proposed location for this seawater system would be by the existing seawater intake, half a mile southeast of Goleta Point.

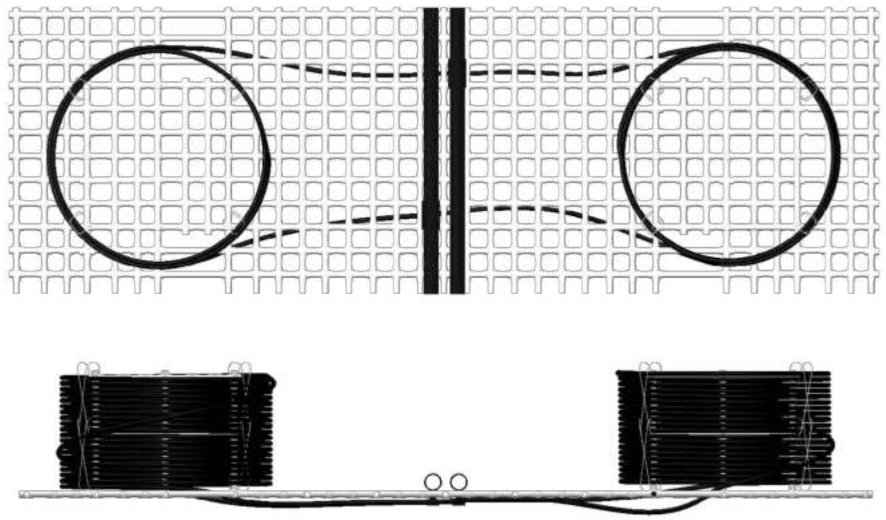
Lagoon

The Lagoon is another potential source or sink for heat exchange. However, given its small size in comparison to the ocean, it can't be considered infinite.

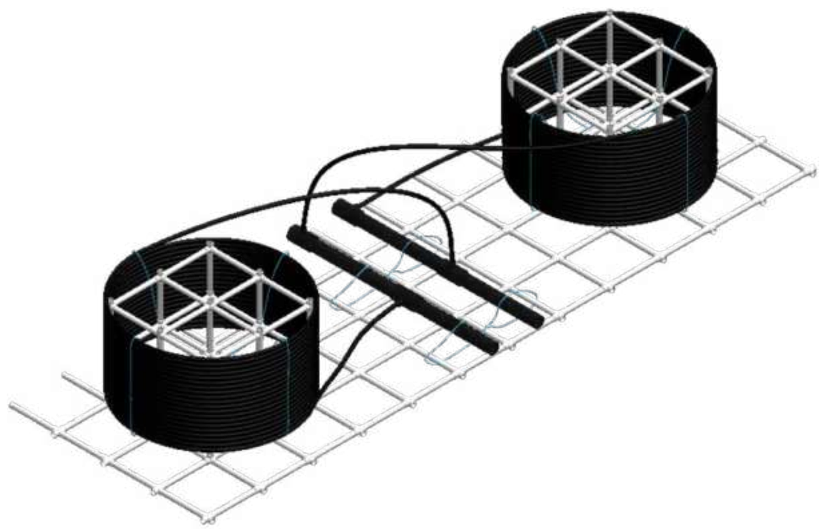
A lagoon heat exchange system would look the same as the seawater system, except that it would not need as much reinforcing to withstand ocean currents. Because the lagoon is smaller and doesn't experience circulating currents like the ocean, it is possible to heat or cool the lagoon significantly. For this reason, the lagoon would be limited to a buffering heat source or sink, in that it would never function as the main source or sink for a plant. Accordingly, it would be paired with geoexchange to create a net thermal capacity large enough for UCSB's needs.

The images to the right show sections of a seawater/lagoon heat exchange system. A set of large-diameter pipes are connected to several coils arranged on a structural support lattice. Water flows from the central plant in the large pipes and is circulated through the coils until it has had time to reject or absorb heat, then travels back to the central plant.

Ocean Heat Exchangers



Lagoon Heat Exchangers



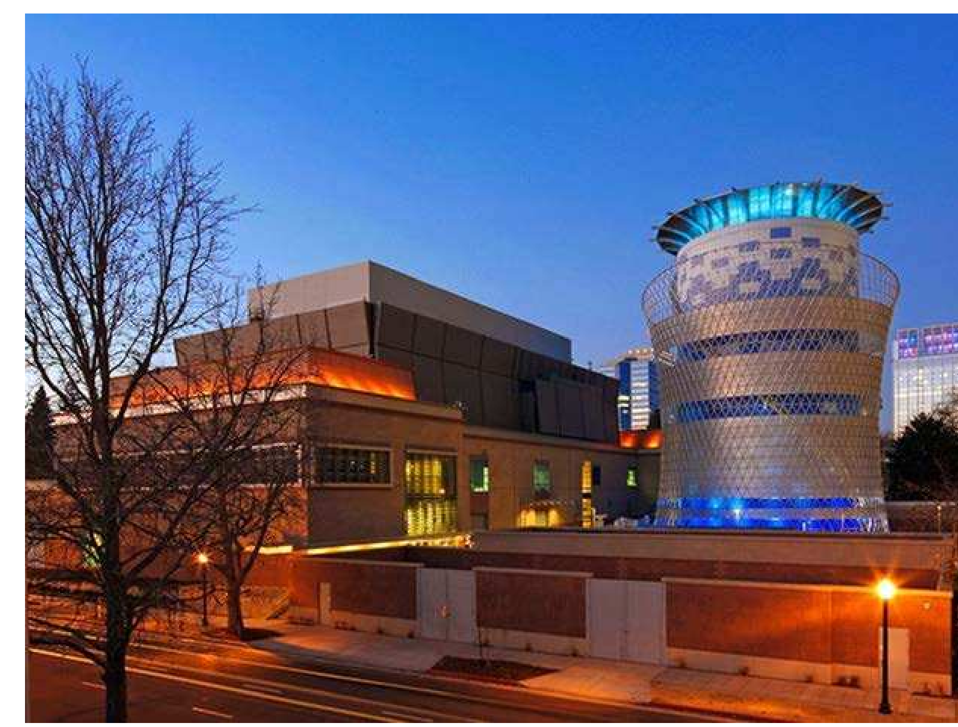
Infrastructure Components

All of the physical equipment mentioned up to this point – heating equipment, cooling equipment, and thermal energy storage – would be located in one centralized location. This Central Utility Plant – or CUP – would provide all the heating, cooling, and thermal storage for a vast majority of buildings on the main campus. The CUP will be a physical building that houses the heating and cooling equipment (boilers, chillers, and heat pumps). Equipment will be all electric; therefore, adjacency to the campus electrical substation is imperative given the electrical load for the CUP, once built out. Heating and cooling equipment will feed into a common supply and return main pipes that will take the hot and chilled water to/from campus. Piping to each source or sink employed will also connect to the CUP. Outside the CUP building will be the thermal energy storage tanks – one for hot water and one for chilled water, with piping leading to and from each tank to the CUP building. Also outside will be any cooling towers and gas-coolers, depending on the option selected. Cooling towers will be on-grade next to the CUP building, while the gas-coolers can be installed on the roof of the CUP building.

The plant is powered exclusively by zero-emissions electricity, so the plant will be emissions free. The equipment that generates the most noise (chillers and heat pumps) will be inside the building, and measures can be taken to sound-proof the inside from the outside. The only components that would create noise being located outside would be cooling towers or gas-coolers. Currently, there are cooling towers located outside of several buildings and parking garages all around campus.

The location of the CUP building and tanks is still to be determined. An example location being explored is an existing eucalyptus grove (white circle on map to the right). Like the storage tanks, the CUP building can add to the aesthetics of campus, showcasing efficient technology as well as architecture. To the right are some examples of institutions that have successfully designed their plants to add beauty to campus.

University of Chicago West Campus Combined Utility Plant



California Dept. of General Services Central Utility

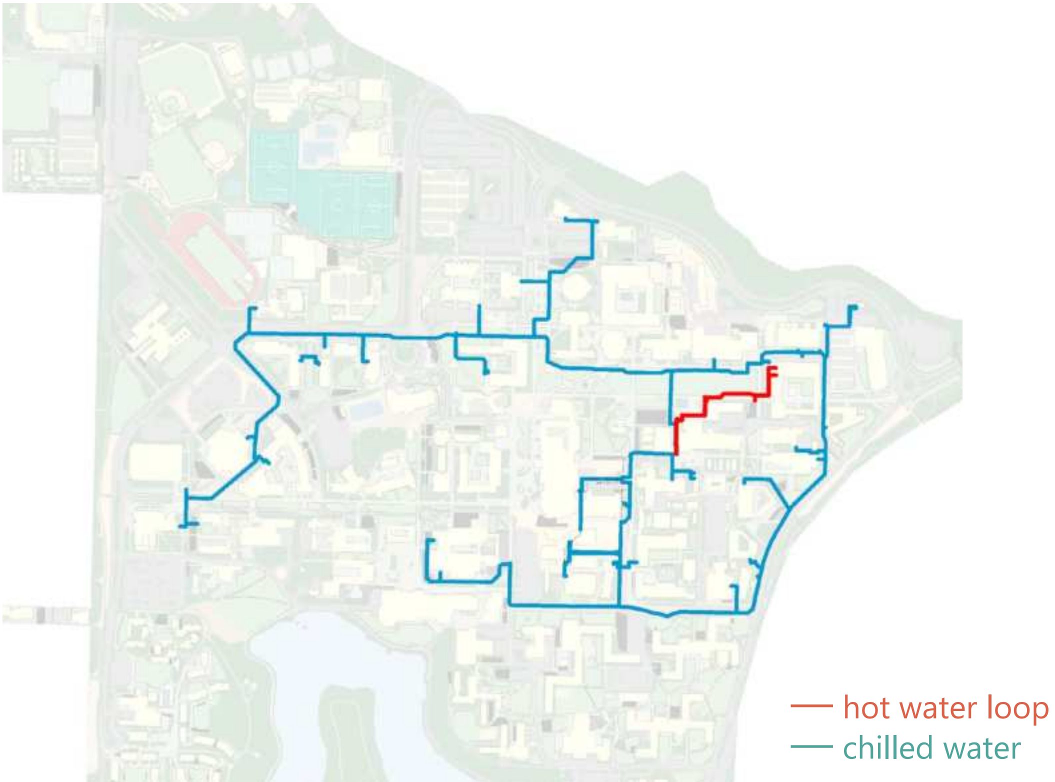
Infrastructure Components

From the CUP, hot and chilled water will be distributed to buildings on campus via an underground piping loop. Piping will be installed across campus in trenches – these will contain the chilled water supply and return, hot water supply and return, and in some cases the piping to and from the heat source or sink.

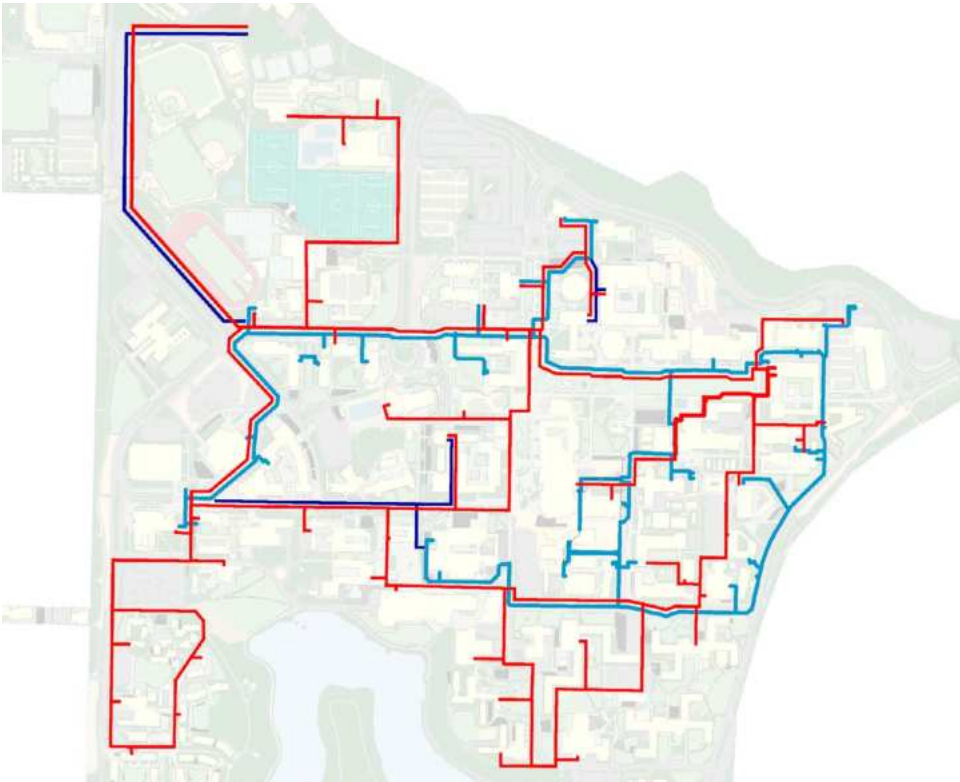
The current configuration has many distributed chillers on a shared chilled water loop – buildings pull from the loop when cooling is needed, and chillers add to the loop to maintain temperature. There is also a small hot water loop that consists of a single gas boiler plant and supplies hot water to three buildings. There have been issues maintaining adequate chilled water supply temperatures and controlling flow with the current configuration, so the future design aims to resolve many of these quality issues.

For the future buildout, the existing piping will be used where possible, and additional branches will be added to expand the cooling and heating to many additional buildings on campus. Current layouts include as many as 154 buildings on and near the main campus region to be connected to the new heating and cooling loop.

Current configuration of hydronic heating/cooling



Example buildout of the future hydronic system



Equipment Technologies

With virtually all of the mechanical equipment located in the CUP building, the only task remaining is to connect individual buildings to the CUP via the hot and chilled water loops. This will involve a buried piping connection from the loop to a location in the building that will house the necessary distribution equipment. For any building without a district connection (which is nearly for all buildings with heating equipment only currently), a new connection from the adjacent buried pipe into the building will be made.

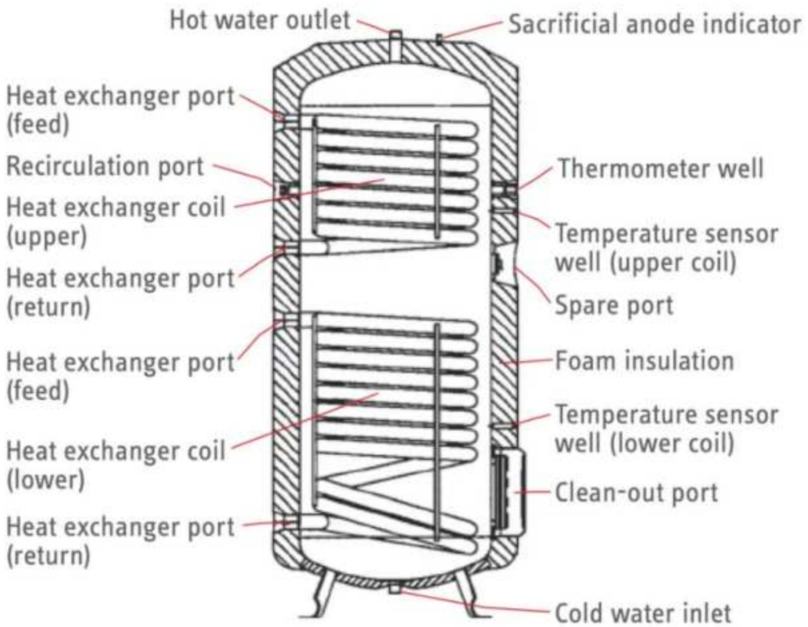
Pumps and Valves

Since existing hot and chilled water temperatures in the new design were matched to the existing condition, there is no need to make upgrades in the building farther than connecting to the loop. Each building could have its own circulation pump for heating and chilled water that will pull water from the loop to the building HVAC equipment. Additionally, each set of pipes for heating and cooling would have a series of valves for control and maintenance purposes.

This configuration saves space in the building by limiting the amount of equipment and required clearances in each building. In addition, pumps and valves are fairly low maintenance devices, so most of the required service for new equipment will occur at the CUP building.

Indirect Water Heaters

For domestic water heating, an indirect water heater will be installed in each building and connected to the heating hot water pipe. These water heaters use the high temperature hot water from the CUP to heat domestic cold water. Besides valves and a domestic water distribution pump, there are no other mechanical or powered components to an indirect water heater (it is a heat exchanger). The tank also has some storage capability, so the flow of hot water to the tank can be shut off in some applications when the internal temperature of the domestic water in the tank reaches the desired setpoint.



Air Source Heat Pumps

For buildings where it is not feasible to connect to the CUP – either because they are far away, the building is too small to warrant hydronic piping, or any other reason – building heating, cooling, and domestic hot water will be handled with independent systems. There are a few options in this case.

For space heating and cooling, some buildings that have existing hydronic heating or cooling, or those that are large enough to warrant it, can use a building independent air-to-water heat pump. These units use air as a heat source and sink to produce hot and cold water.

Where no hydronic system is desired, a building independent air-to-air heat pump can be used. These are very similar to residential heat pumps with a refrigerant loop is piped to an interior unit that provides the space heating and cooling.

For domestic water heating, heat pump water heaters are the most efficient and cost-effective option. Options range from CO2 Heat Pumps to small hybrid electric heat pump water heaters.

Each option listed is air-source, the coefficient of performance (COP) for each is approximately 3 - 4, depending on the exact application.

COP~3

EXISTING CONDITIONS
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TOOLKIT: TECHNOLOGIES & COMPONENTS
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Building Air-Source Heat Pumps

A fairly energy efficient baseline option – considered standard for new buildings in a non-campus setting

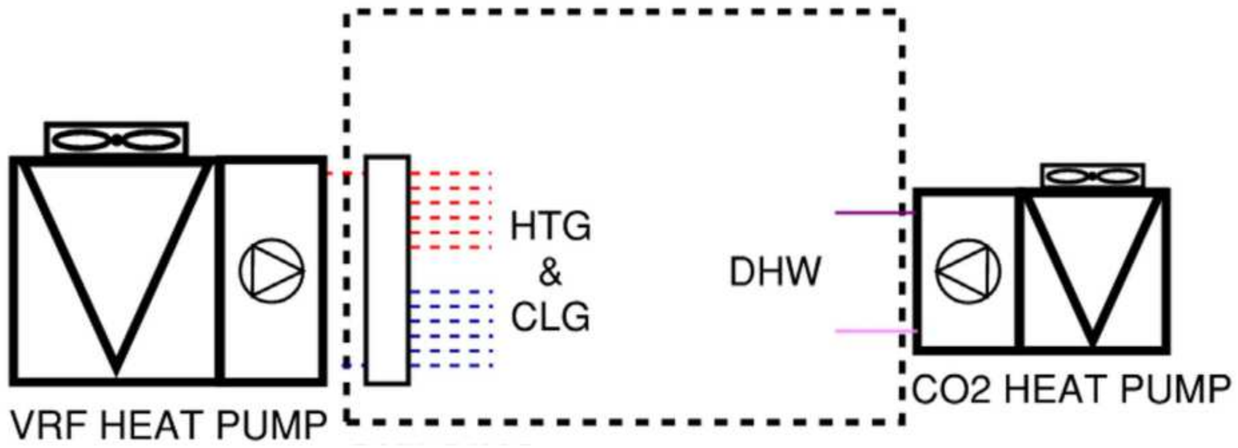
The base option keeps buildings as their own building independent systems. Installed at each building are air-source heat pumps for cooling, heating, and domestic hot water production. As an independent system, each building is responsible for producing its own heating and cooling, matching the heating and cooling demand for the day.

For install, existing gas heating or domestic water heating equipment, and any existing chillers will be demolished. Where possible, existing air-handlers and zone equipment can remain. These will be paired with an appropriate heat pump system – air-to-air or air-to-water.

Sizing for each of the heat pumps will need to be according to the building peak demand for cooling, heating, and domestic hot water – this option does not take advantage of any load shifting or diversity of loads across multiple buildings as many of the CUP options. While this will have minimal impact on small building equipment sizing, this can result in very large equipment sizes for some of the larger campus buildings. Additionally, equipment come in fixed step sizes, so often much larger equipment (percentage wise) must be purchased to meet a capacity need.

Air source heat pumps are very efficient for heating, cooling ,and domestic hot water, and this option does not rely on electric boilers at all (electric boilers being the least efficient equipment in any option). However, a primary concern of the design team is the salinity in the air (as a result of UCSB's proximity to the ocean) that will likely take its toll on the air-source equipment in this option. Salty air is known to be very corrosive to air-cooled equipment, and unless treated with a special coating, can potentially reduce the life of the equipment by corroding the coils. This will have a substantial impact on replacement costs, as these systems will be located at every building.

Maintenance in this option will also require more labor hours, as there will be more equipment spread out across campus. Maintenance will need to take place on site at each building.



Heat Recovery Chillers

Simplest, and lowest cost, but uses a LOT of electric boiler energy

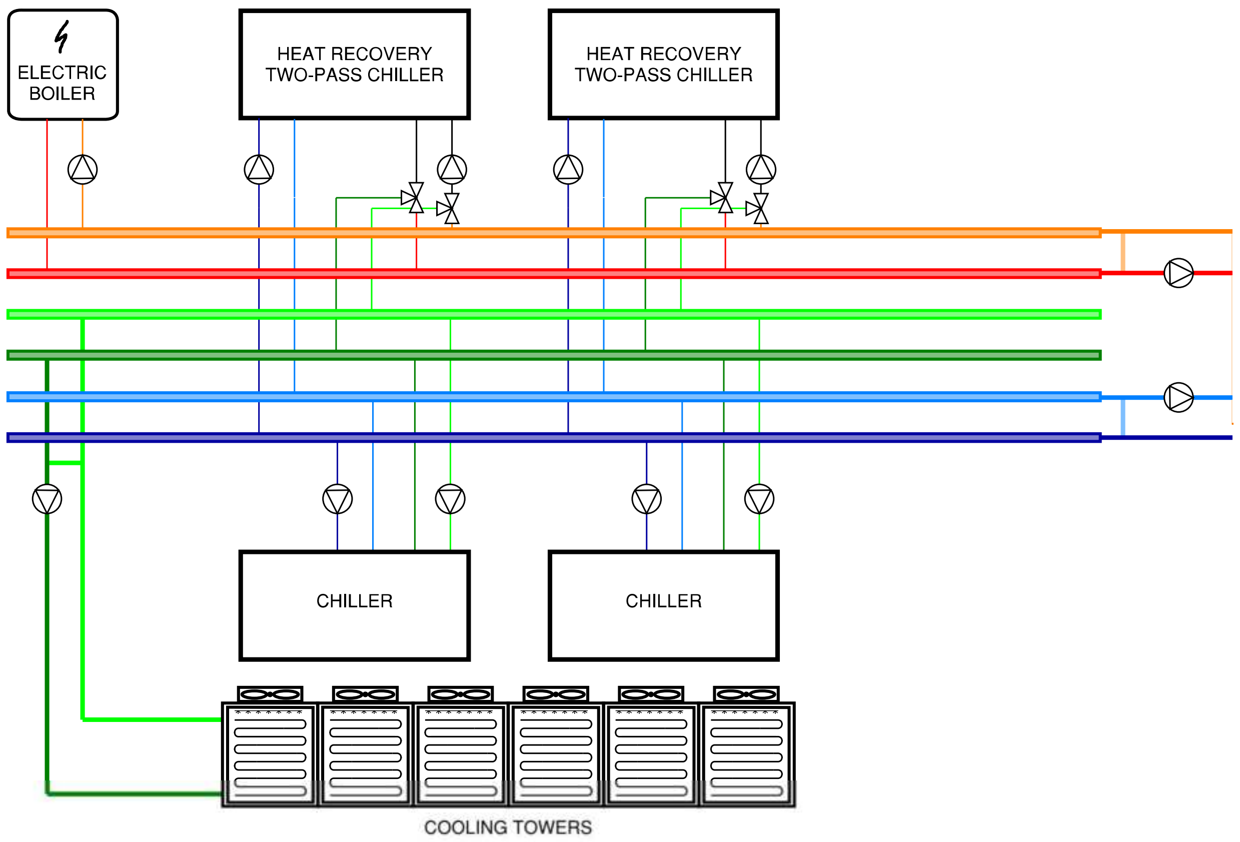
The first of the central plant options relies on heavily on cooling only chillers and electric boilers. In addition, a portion of the cooling and heating load can be met by a heat recovery chiller for higher efficiency heating and recovered cooling. Cooling towers are used for heat rejection. On a central plant, sizing will be the coincident peak (plus some redundancy) for all buildings connected to the Central Plant.

This means that, typically, equipment can be sized much smaller by taking advantage of load diversity across many different buildings.

This option also has the benefit of all thermal equipment being located in one place, reducing effort and cost associated with maintenance.

Without any means of load shifting, the Central Plant is still responsible for providing cooling and heating energy on demand – in the same instant the loads are occurring – which minimizes incidences of simultaneous heating and cooling. For this reason, the heat recovery chiller is only sized to meet the maximum amount of heating load that occurs during a coincident cooling demand on campus.

The chillers are the most efficient option for cooling-only operation available to the campus, while the electric boiler is the least efficient heating-only option. This results in this option being one of the least efficient options available to the campus.



Electric Boilers	✔	**6000** tons
Heat Recovery Chillers	✔	**1500** tons
Heat Pump Chillers		
Chillers	✔	**8000** tons
Thermal Storage Tanks		
Air-Source (Gas Coolers)		
Cooling Towers	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

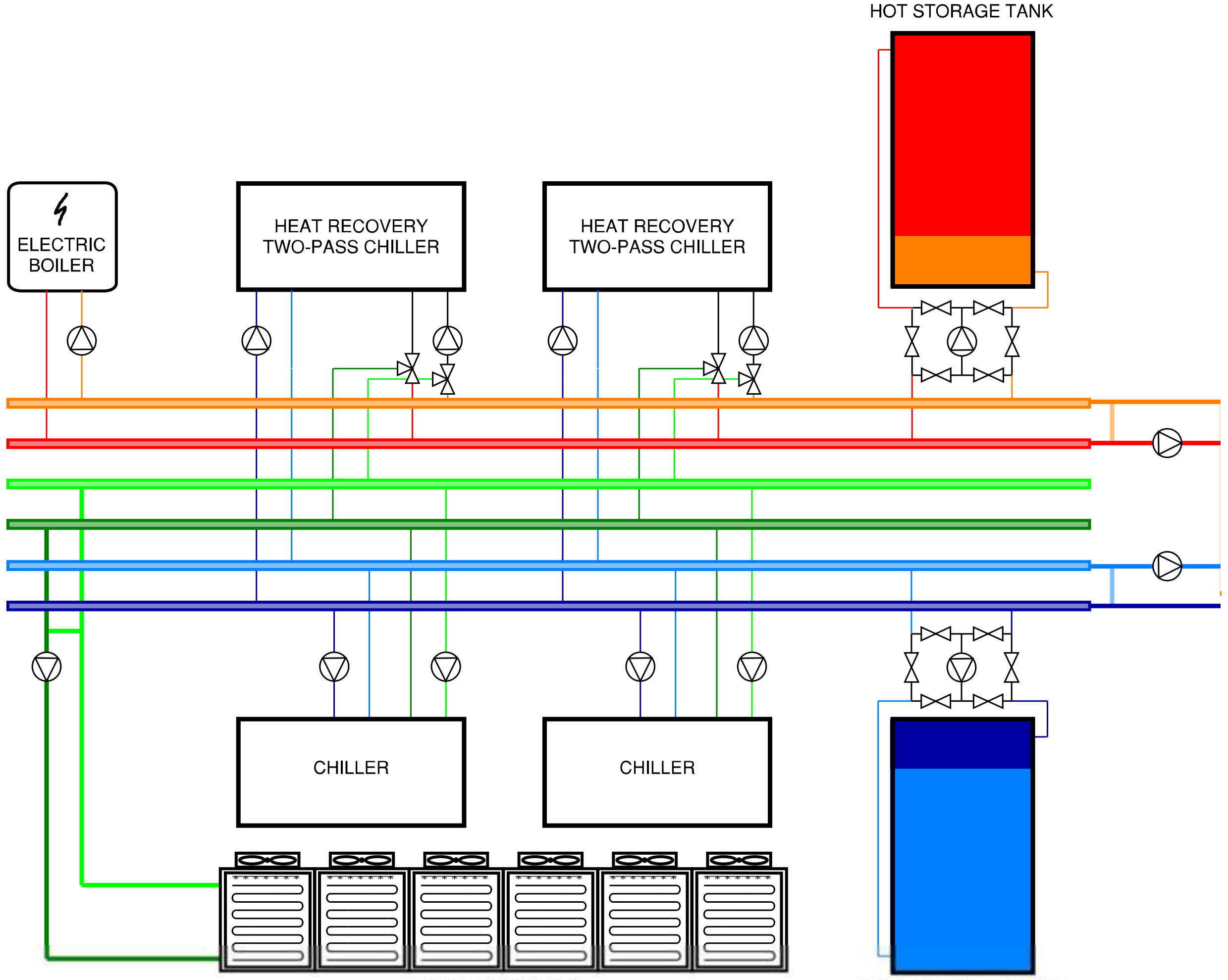
Heat Recovery Chillers with Thermal Storage

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

This option is the same as Option 1, but includes 5.8 million gallons of hot water and chilled water energy storage. With load shifting now available to the CUP equipment, more simultaneous heating and cooling can occur, resulting in a larger amount of heating handled by the heat recovery chiller. This reduced the required capacity of the cooling-only chillers from 8,000 tons down to 6,000 tons, a 25% decrease.

The same capacity of electric boilers is required to meet the peak heating demand, but they are used far less often, resulting in a more efficient plant.

In this option and the remaining options, thermal storage tanks were controlled to minimize operational costs, so there was little impact on reduced equipment size from. Schedules were chosen to charge only during the times where the UCOP rate was the lowest, targeting a 12-hour charging period, with the remaining time in the day available for discharging the tanks. For a consistent comparison across all options with thermal storage, the same schedule for charging and discharging is used in all options. The cooling only chiller still is the most efficient cooling option and handles most of the cooling demand, and more heating demand is shifted from the inefficient electric boiler to the heat recovery chiller, resulting in a more efficient plant overall.



Electric Boilers	✔	**6000** tons
Heat Recovery Chillers	✔	**3500** tons
Heat Pump Chillers		
Chillers	✔	**6000** tons
Thermal Storage Tanks	✔	**5.8M** gal
Air-Source (Gas Coolers)		
Cooling Towers	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

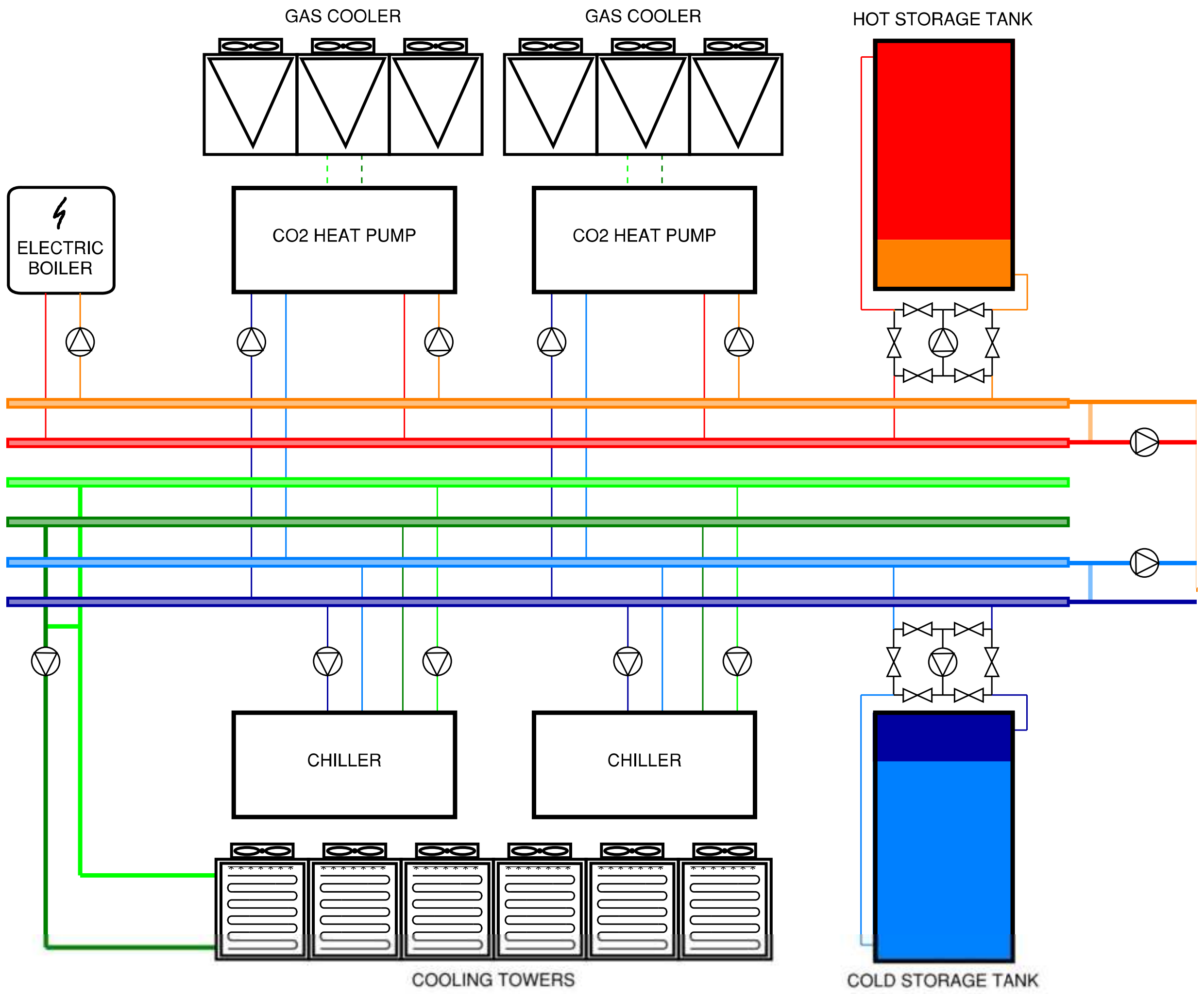
Air-Source Heat Pumps with Thermal Storage

Uses Heat Pump Chillers which significantly reduce heating energy

In this option, heat pump chillers are used instead of heat recovery chillers. As stated previously, heat pump chillers can operate in cooling-only, heating-only, and simultaneous cooling and heating modes. Since the heat pumps can now be used in heating-only, they are available to reduce some of the peak heating load. The heat pumps could be sized to reduce all of the peak heating load and eliminate electric boilers entirely, but this would be cost prohibitive – therefore 2,500 tons of electric boilers remain to handle the peak heating days.

This option includes only air-source heat pumps, which rely on gas-coolers to reject and absorb heat, which will be installed on the CUP roof. With the thermal storage tanks and the increased capacity of the heat pumps, the maximum amount of simultaneous heating and cooling can be achieved, resulting in higher efficiency cooling and heating for the plant. Cooling towers are still required to run the cooling-only chillers in the plant.

Although the heat pumps are a more efficient means for heating-only operation and simultaneous heating and cooling operation, cooling only chillers are still more efficient than cooling only heat pumps. Therefore, the chillers are used first when cooling only is needed to maximize the efficiency of the plant.

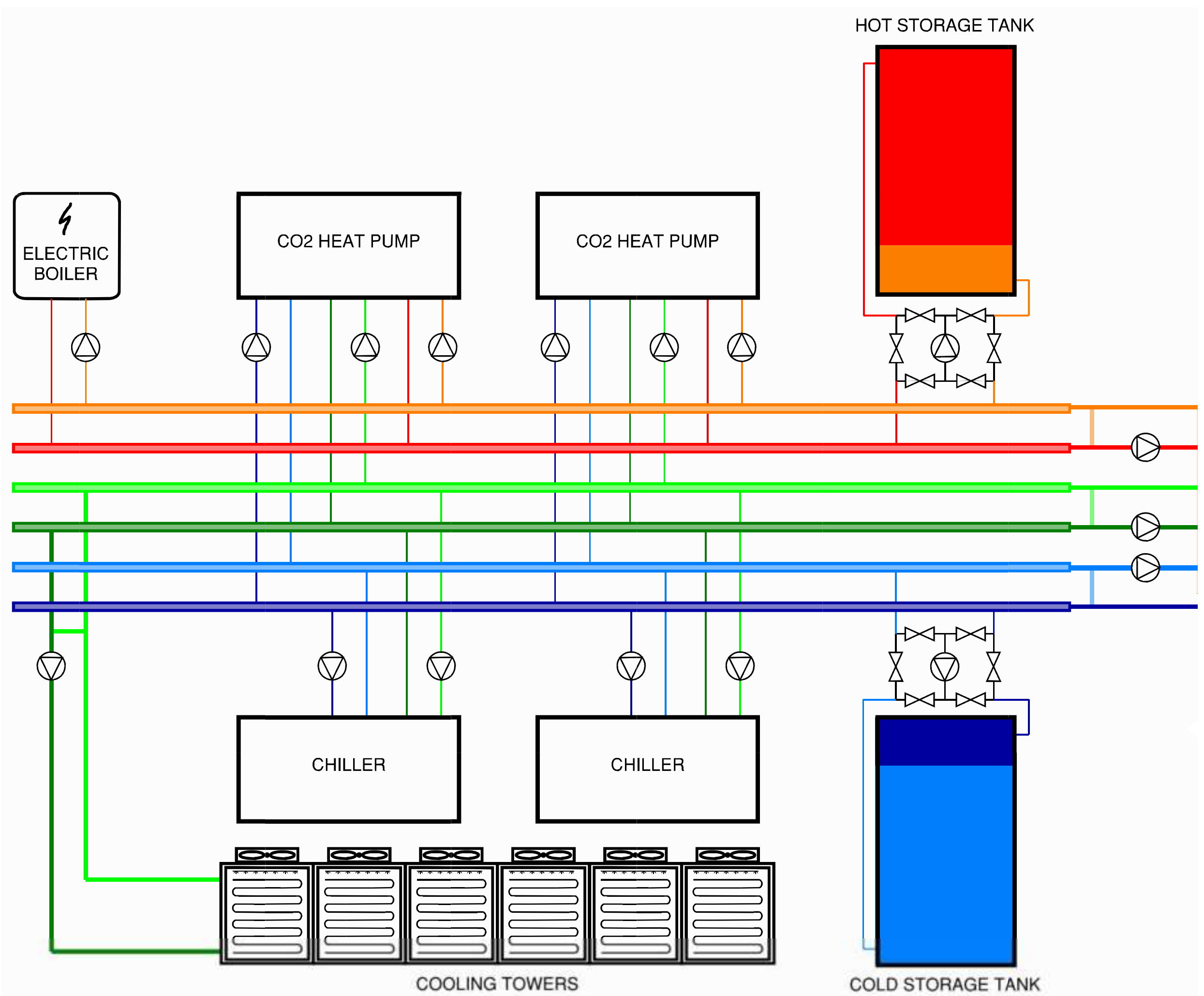


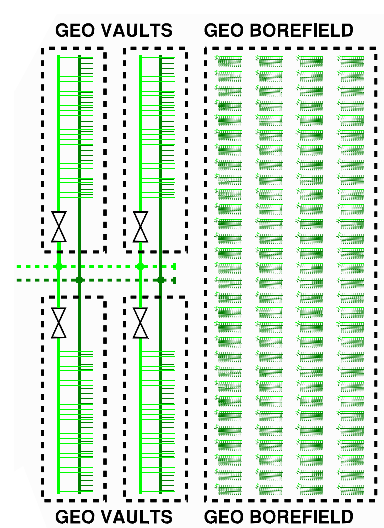
Electric Boilers	✔	**2500** tons
Heat Recovery Chillers		
Heat Pump Chillers	✔	**4500** tons
Chillers	✔	**6000** tons
Thermal Storage Tanks	✔	**5.8M** gal
Air-Source (Gas Cooler)	✔	**4500** tons
Cooling Towers	✔	**9000** tons
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange		

Geo-Source Heat Pumps with Thermal Storage

Replaces Air-Source with Geo-Source (reduces cooling energy)

This option removes the air-source heat pump chillers and replaces them (and the associated gas-coolers) with a ground-source heat pump system. The ground as a heat sink is often milder when compared to the air, resulting in increased efficiency for cooling and, in some times of the year, a more efficient heat source for heating. This heat source and sink applies to both the heat pumps and chillers. The cooling towers remain in this option, but their required capacity is decreased since the ground is available for heat rejection. The plant in this option chooses between the ground and the cooling towers for heat rejection depending on which source is cooler for increased cooling efficiency.





Electric Boilers	✓	**2500** tons
Heat Recovery Chillers		
Heat Pump Chillers	✓	**4500** tons
Chillers	✓	**6000** tons
Thermal Storage Tanks	✓	**5.8M** gal
Air-Source (Gas Coolers)		
Cooling Towers	✓	**6500** tons
Geo Heat Exchange	✓	**950,000** ft
Lagoon Heat Exchange		
Sea Heat Exchange		

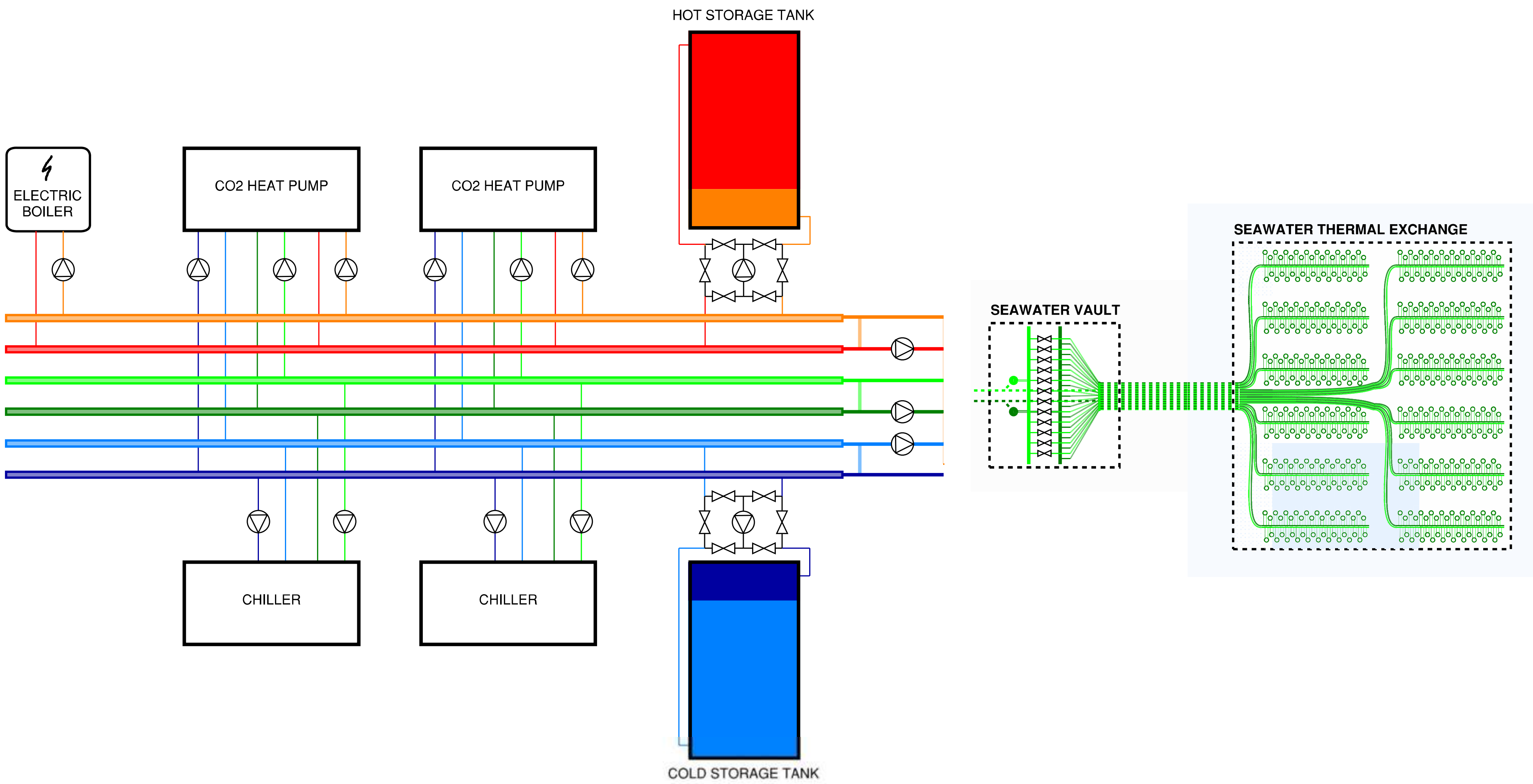
Seawater-Source Heat Pumps with Thermal Storage

Uses Sea Exchange to Eliminate Water Consumption and Further Reduce Cooling Energy

The ocean heat exchange option would have significant benefits. The heat exchangers would allow for no cooling towers to be used which would eliminate water consumption for thermal systems and any maintenance for cooling towers. The heating and cooling energy would also be reduced by being able to tap into the relatively stable ~55-65F ocean temperatures.

The main challenge to the ocean heat exchange option is the cost. The system needs a higher density of support structure to sufficiently strengthen, anchor, and protect the heat exchanger assemblies out at sea so they last their full 50-100+ year lifespan without a need for maintenance. The distance at ~2500ft off the coast of campus point also adds considerable cost. The removal of the artificial berm that encloses the lagoon in the eventual future also means that more trenching would have to occur to get the pipes to the shore before they go into the ocean (rather than crossing the bottom of the lagoon, which is less expensive than trenching).

The other concern is the interaction of the marine ecology with the seawater heat exchangers. One aspect is how the seawater heat exchange system interacts with the marine environment, both to attempt to minimize negative impacts and to potentially yield beneficial outcomes (eg. serving as an artificial reef). The other aspect is how the marine environment impacts the sea heat exchange system. Some species of sea urchins can be known to drill into rocks when attempting to eat plants growing on its surface. This concern makes putting the sea exchange system in a kelp forest environment subject to the risk that sea urchins might puncture the heat exchangers.

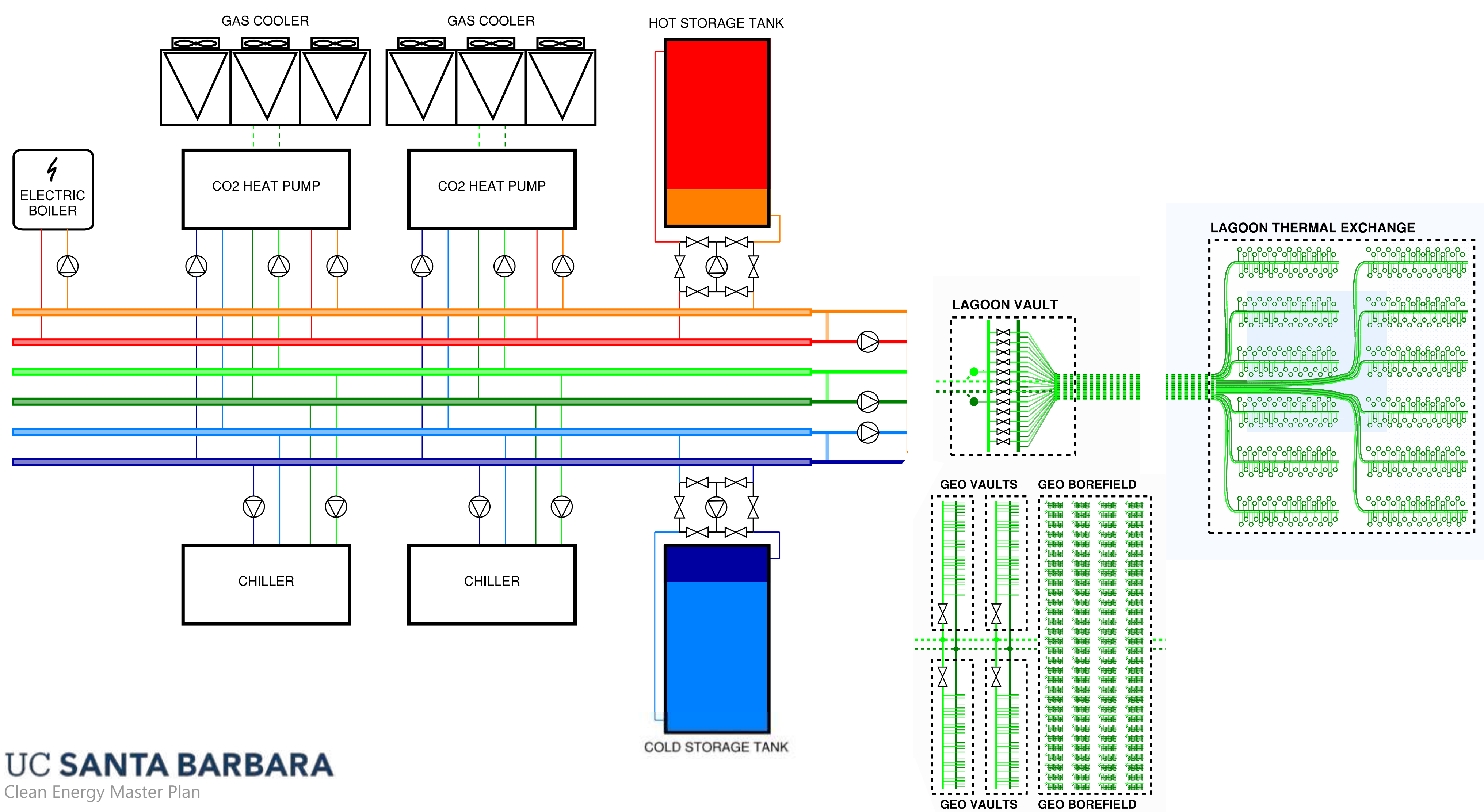


Electric Boilers	✔	2500 tons
Heat Recovery Chillers		
Heat Pump Chillers	✔	4500 tons
Chillers	✔	6000 tons
Thermal Storage Tanks	✔	5.8M gal
Air-Source (Gas Coolers)		
Cooling Towers		
Geo Heat Exchange		
Lagoon Heat Exchange		
Sea Heat Exchange	✔	

Combination-Source Heat Pumps with Thermal Storage

Uses Combination of Air + Geo + Lagoon to Eliminate Water Consumption and Minimize Energy

The lagoon heat exchange option would have significant benefits. The heat exchangers would be less costly to install as it would be significantly less distance between it and the central plant than the ocean location by the seawater intake, which is ~2500ft off Campus Point. The heat exchangers would require a far simpler and relatively inexpensive structure as there would not be subject to ocean current or storm forces. Access would also be significantly easier. If the lagoon heat exchange is coupled with a geothermal vertical bore installation, together they could forgo the need for cooling towers and thus eliminate the use of water for thermal systems. The main challenge to the lagoon heat exchange option is that the sea level adaption plan has the lagoon eventually opening up to the ocean as the artificial berm that encloses the lagoon is not to be maintained. This will lower the height of the water in the lagoon area significantly and not be tall enough during all tides to fully submerge the lagoon heat exchangers, which would be ~4ft tall. Opening the lagoon would also reduce the volume of water to do heat exchange to too little of a volume generally, and especially at low tides. The heat exchange infrastructure would have a 50-100+ year life span and thus would not make sense to invest should the lagoon be going away in the next few decades. Together, this option cannot currently be recommended to pursue further given the cost of maintaining the berms, if allowed by the coastal commission.



Electric Boilers	✓	**2500** tons
Heat Recovery Chillers		
Heat Pump Chillers	✓	**4500** tons
Chillers	✓	**6000** tons
Thermal Storage Tanks	✓	**5.8M** gal
Air-Source (Gas Cooler)	✓	**4500** tons
Cooling Towers		
Geo Heat Exchange	✓	**950000** ft
Lagoon Heat Exchange	✓	
Sea Heat Exchange		

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS

EVALUATION CRITERIA

OPTIONS COMPARISON
RECOMMENDATIONS
NEXT STEPS

Decision Making Criteria

Technical

This section will describe the technical factors that we established based on similar projects, as well as on the basis of stakeholder input from the evaluation criteria workshop.

Energy	Compares the relative energy performance/ energy usage of the systems options, best system being one with highest cooling and heating efficiencies and using least amount of energy for campus needs
Water	Compares the relative water usage of the systems options, best system not using any water and worst system relying heavily on cooling towers for heat rejection and using lot of water (and chemical treatment)
Electrical Requirements	Compares the relative electrical usage of the systems options with the best system using the least amount of power due to highest efficiencies
Maintenance	Compares the periodic ongoing maintenance requirements for the systems with the worst systems requiring most maintenance due to increased number of equipment pieces and/ or exposure to marine environment
Simplicity	Compares the simplicity of operating the systems with the best system requiring least amount of complexity of equipment controls and equipment connections
Constructability	Compares the constructability of the systems – both at building level and central plant level with best system being one with least amount of equipment connections and reduced needs for campus pipe distribution, trenching, boring wells etc.
Risk	Compares the risk involved with future uncertainties e.g. reduced lagoon levels or growth of sea urchins on sea water infrastructure
Phasing	Compares the ease of phasing the implementation of the system options with worst systems requiring larger installations with longer construction times to get the systems to serve efficiently
Capital Cost	Compares the first costs of the system options without the benefit of available tax credits
Operational Cost	Compares the operational costs of the systems including system component replacement, operations, maintenance, and equipment upgrades
Life Cycle Cost	Compares the life cycle costs of the systems for a predetermined period (e.g. 20 years), and therefore considers the annual operational cost savings against the capital costs of the systems

Influencing

This section will describe the influencing factors that we established based on similar projects, as well as on the basis of stakeholder input from the evaluation criteria workshop

Accessibility	Compares the accessibility for various groups on campus during construction and system implementation with the worst systems causing most disruption
Climate Resilience	Compares the relative ability of the systems to adapt to future climate changes such as warmer temperatures
Ecological Protection	Compares the disruption caused to the environment by the construction and implementation of the systems

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA

OPTIONS COMPARISON

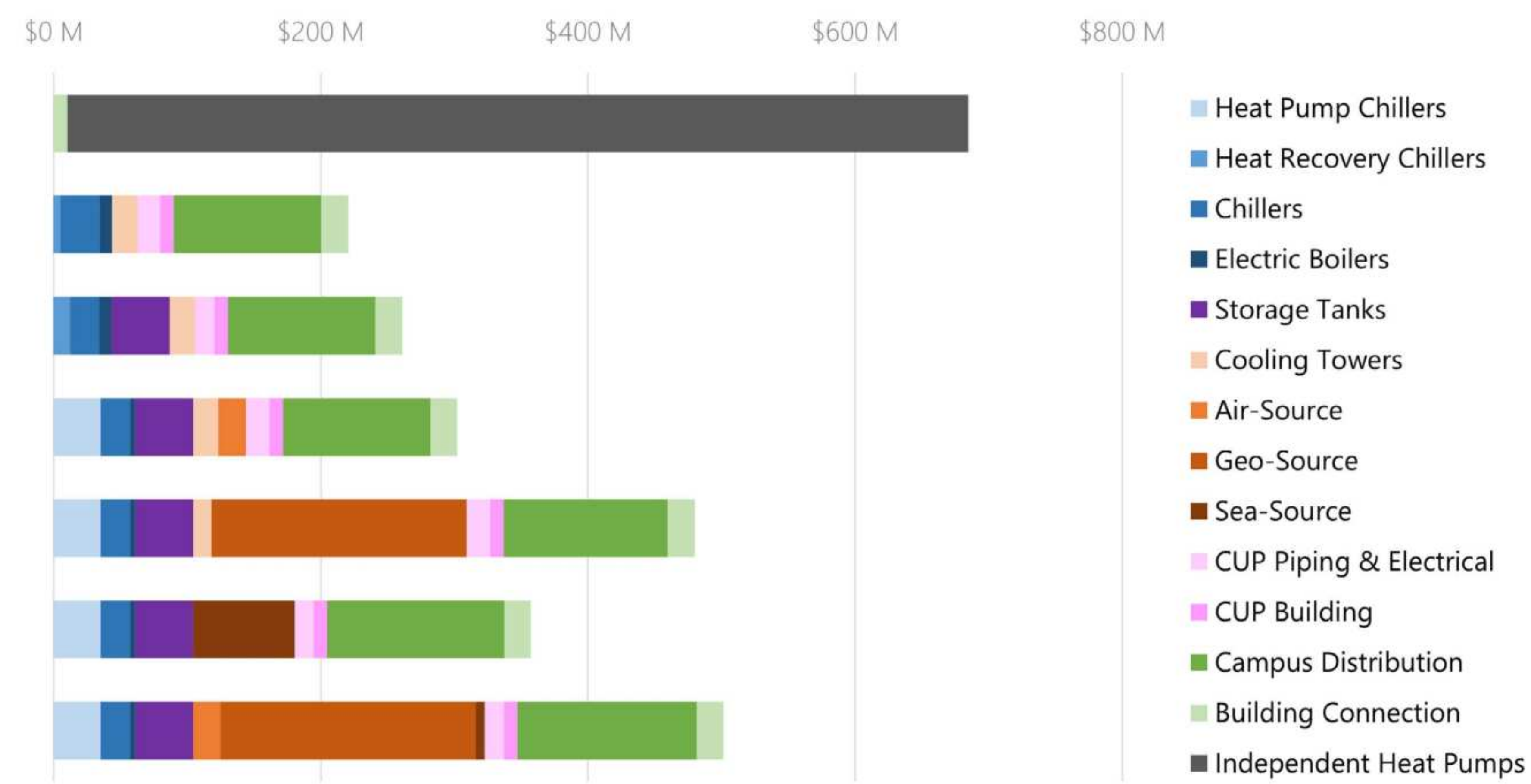
RECOMMENDATIONS
NEXT STEPS

New Central Plant Infrastructure - All Options

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

To this effect the following pages present results for the New Central Plant options and the buildings that plant would serve. For the Option 0, where each building would have its own Building Independent Heat Pumps, the results are for those same buildings that are served by the central plant in the other options.

#	Strategy	First Costs
0	Building Air-Source Heat Pumps	$684.8 M
1	Heat Recovery Chillers	$220.5 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
5	Heat Pumps (Sea-Source) + Storage	$357.3 M
6	Heat Pumps (Combo-Source) + Storage	$501.5 M



The table above summarizes first costs for all system strategies considered. Costs include materials and installation of all necessary equipment, piping distribution across campus as well as piping and connections within buildings. To be conservative, all scenarios have all installation occur in 2044. All costs are shown for 2045 and include 3% annual escalation on 2024 cost estimates and an extra 35% for soft costs (inclusive of design and construction services, UCSB additional project management staff, etc). These costs are for only the New Central Plant and its Served Infrastructure.

Starting with the lens of First Cost, Option 0 (Building Independent Air-Source Heat Pumps) is significantly more expensive to install than all of the central plant options.

New Central Plant Infrastructure - Options 1-4

Looking at these same First Costs again, but this time focusing on only Options 1 through 4. Option 0 is removed because of its significantly higher cost, and Options 5 and 6 are removed because of feasibility and risk issues.

#	Strategy	First Costs
1	Heat Recovery Chillers	**$220.5 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**

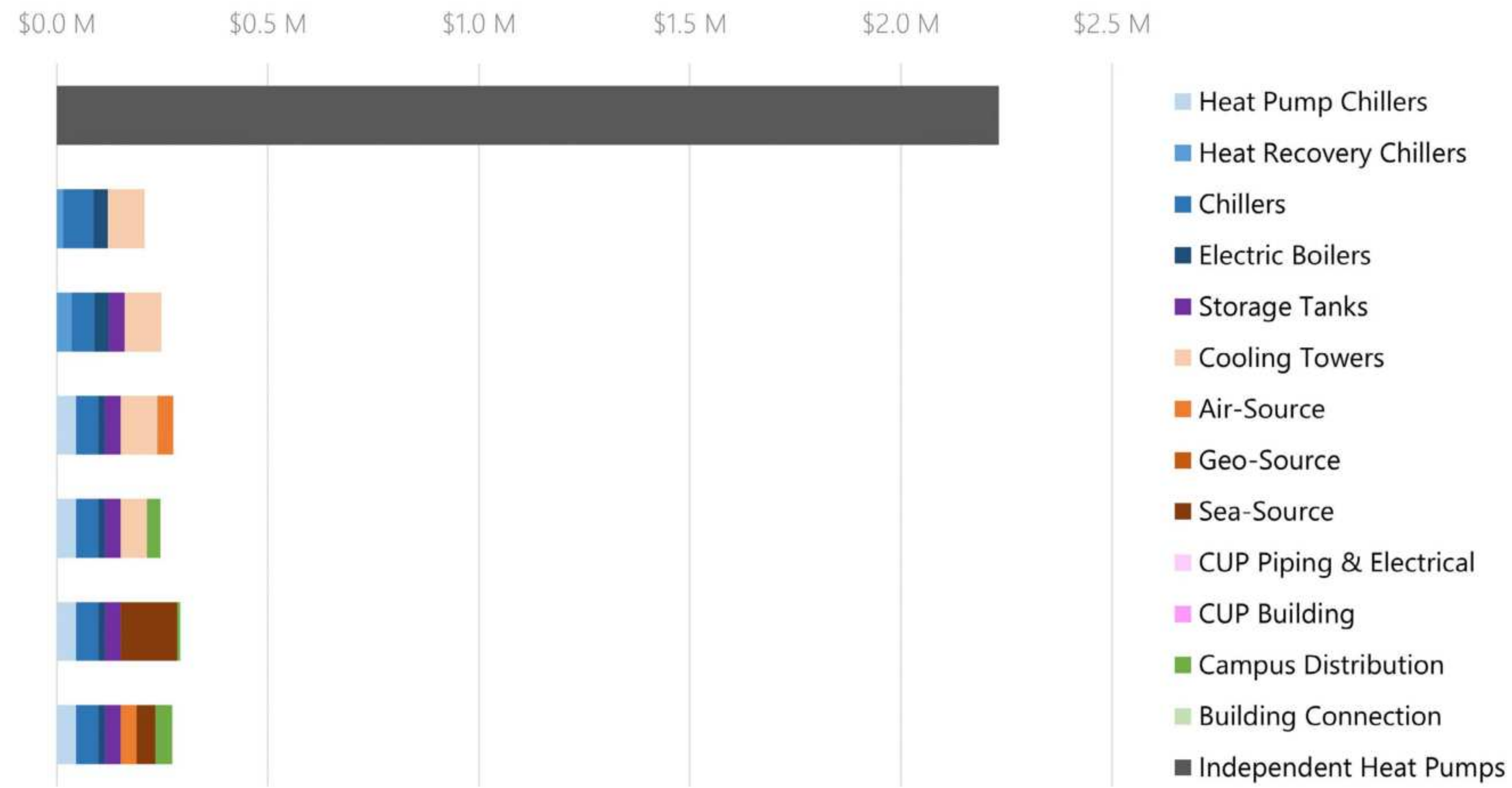
The table above summarizes first costs for all system strategies considered. Costs include materials and installation of all necessary equipment, piping distribution across campus as well as piping and connections within buildings. To be conservative, all scenarios have all installation occur in 2044. All costs are shown for 2045 and include 3% annual escalation on 2024 cost estimates and an extra 35% for soft costs (inclusive of design and construction services, UCSB additional project management staff, etc). These costs are for only the New Central Plant and its Served Infrastructure.

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

New Central Plant Infrastructure - All Options

Continuing with the lens of Operations & Maintenance, Option 0 (Building Independent Air-Source Heat Pumps) is significantly more expensive to maintain than all of the central plant options. This is because of the several orders of magnitude more equipment that would have to be maintained.

#	Strategy	O&M ($/yr)
0	Building Air-Source Heat Pumps	$2,230 K
1	Heat Recovery Chillers	$210 K
2	Heat Recovery Chillers + Storage	$250 K
3	Heat Pumps (Air-Source) + Storage	$280 K
4	Heat Pumps (Geo-Source) + Storage	$250 K
5	Heat Pumps (Sea-Source) + Storage	$290 K
6	Heat Pumps (Combo-Source) + Storage	$270 K

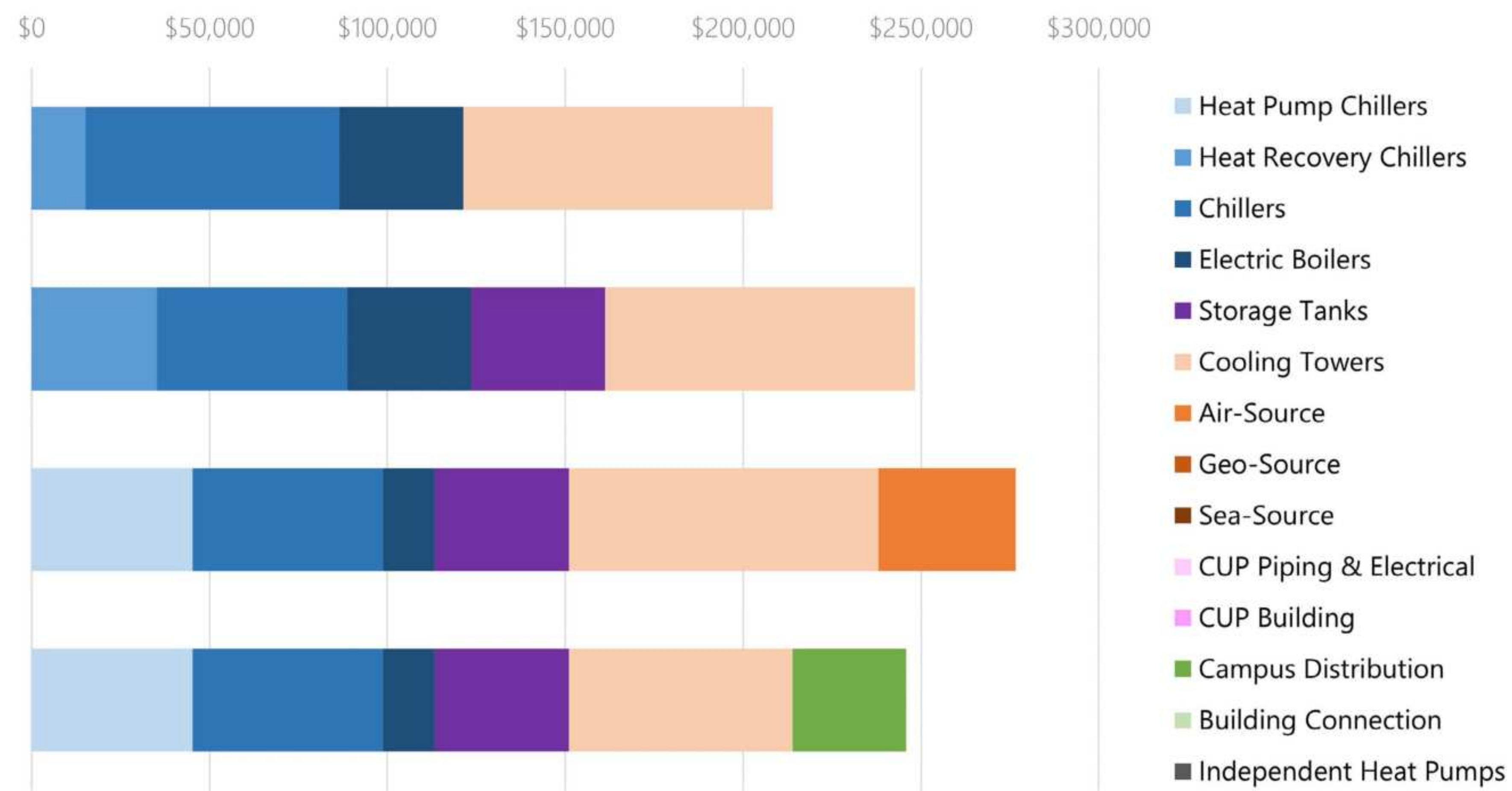


The table above summarizes the operation & maintenance costs, supplies and equipment only (excluding UCSB operations & maintenance staff labor), for all system strategies considered. All costs include 3% annual escalation and are shown for the year 2045. These costs are for only the New CUP and its Served Infrastructure.

New Central Plant Infrastructure - Options 1-4

Looking at these same O&M Costs again, but this time focusing on only Options 1 through 4. Option 0 is removed because of its order of magnitude higher O&M, and Options 5 and 6 are removed because of feasibility and risk issues.

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



The table above summarizes the operation & maintenance costs, supplies and equipment only (excluding UCSB operations & maintenance staff labor), for all system strategies considered. All costs include 3% annual escalation and are shown for the year 2045. These costs are for only the New CUP and its Served Infrastructure.

With the lens of Operations & Maintenance, all currently feasible options have relatively similar O&M costs, especially compared against the scale of energy costs

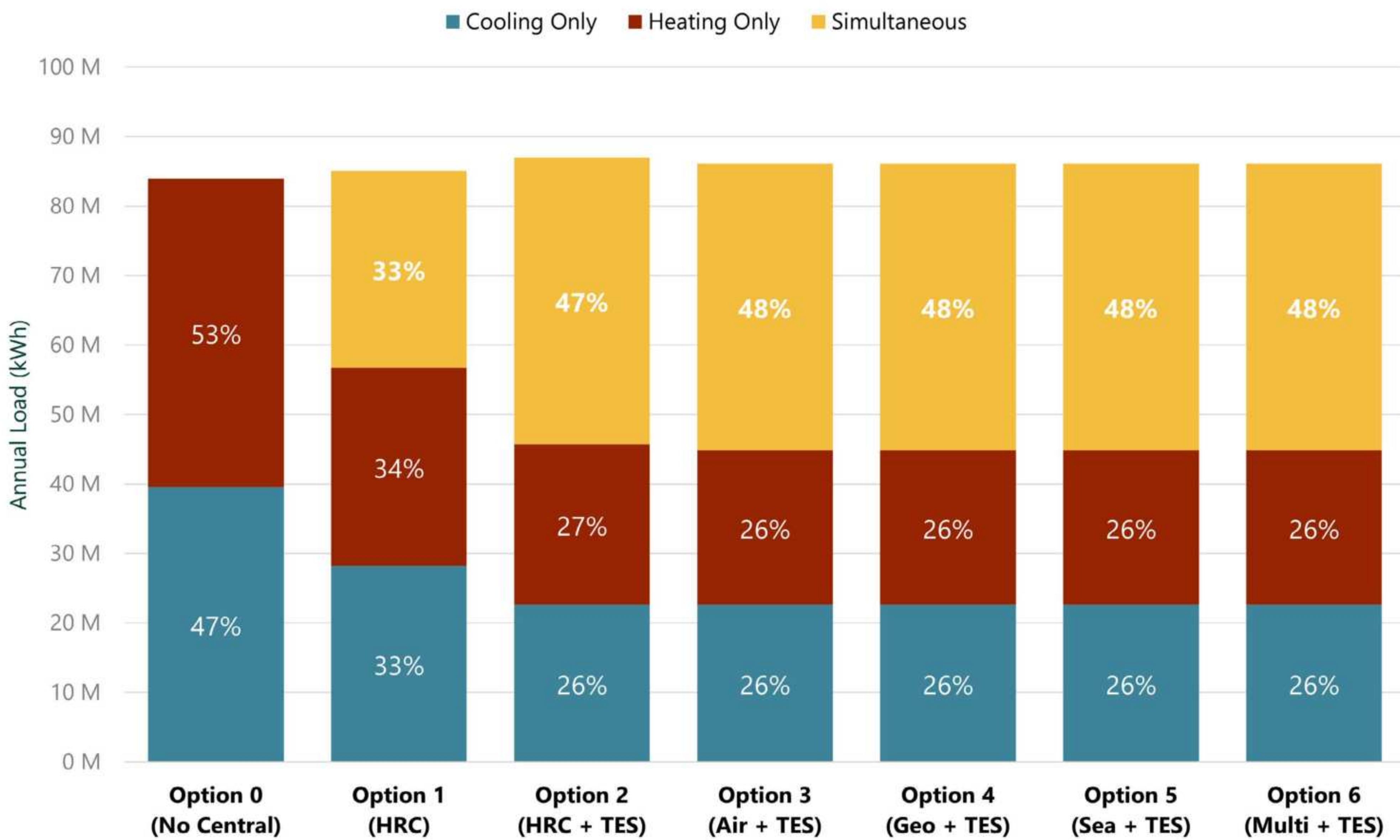
Simultaneous Production

From the lens of Energy Use, Simultaneous Production of Heating and Cooling increases significantly with the use of Thermal Storage Tanks (TES).

> Options 2 through 6 all utilize Thermal Storage and produce nearly Half of thermal work (Cooling, Heating, and Hot Water) in a Simultaneous Production manner.

Option 1, which does not have thermal storage, is able to produce about One-Third in a Simultaneous manner from the coincidental need for heating and hot water while there is demand for cooling.

Simultaneous Thermal Loads (kWh/yr)



This chart summarizes the amount of thermal load delivered in a simultaneous production manner (hot and cold made at the same time, and thus one made for free) vs. heating and cooling load made in isolation. These results are for only the New CUP Served Infrastructure.

Energy Use by Equipment Breakdown

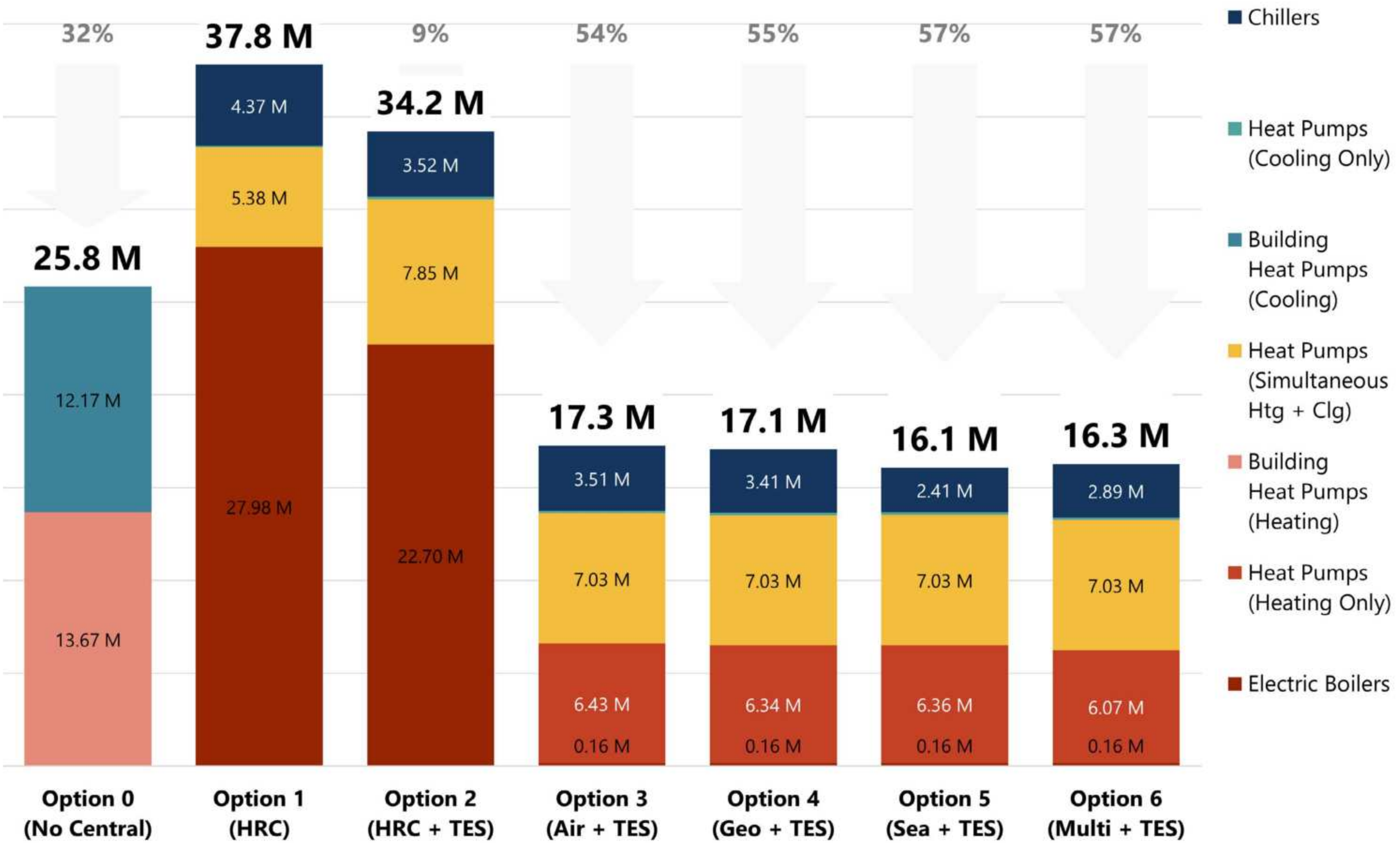
Continuing with the lens of Energy Use, the introduction of a heating source beyond campus cooling drastically reduces energy use.

> Options 1 and 2 both do not have a separate heating source, and as a result produce all of that heating only load with Electric Boilers which use over 3x the electricity of Heat Pumps (which are able to use a separate heating source).

Options 3 through 6 all utilize different Heat Sources, and all use over 50% less electricity than central options without a heat-source.

Option 3, which utilizes an Air-Source for heating allows for nearly the same energy use and energy cost reduction as Options 4, 5, and 6 (which utilize Geo, Sea, and Combination Geo/Lagoon/Air respectively).

Simultaneous Thermal Loads (kWh/yr)



This chart summarizes the amount of electricity use consumed by each type of thermal equipment. These results are for only the New CUP Served Infrastructure.

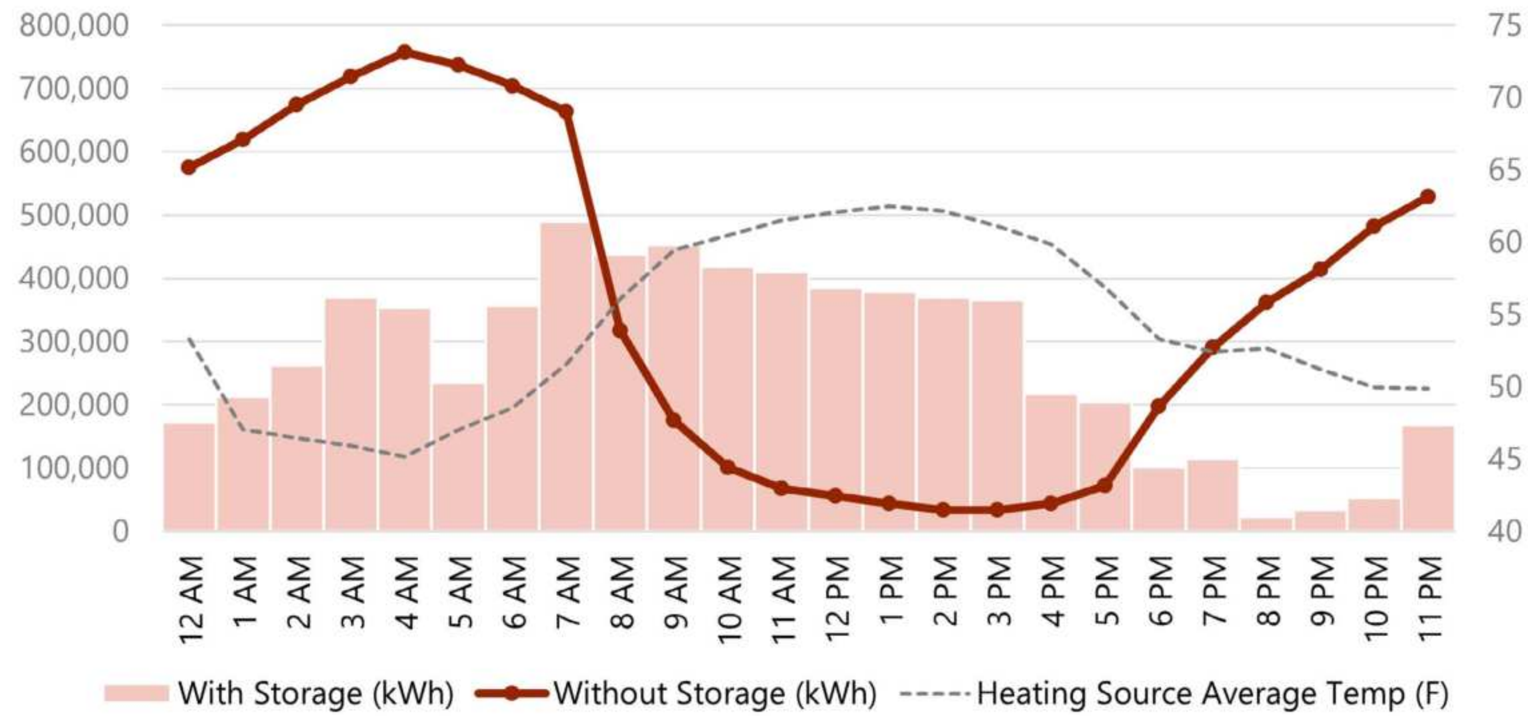
Shifting Time to Reduce Energy and Rates

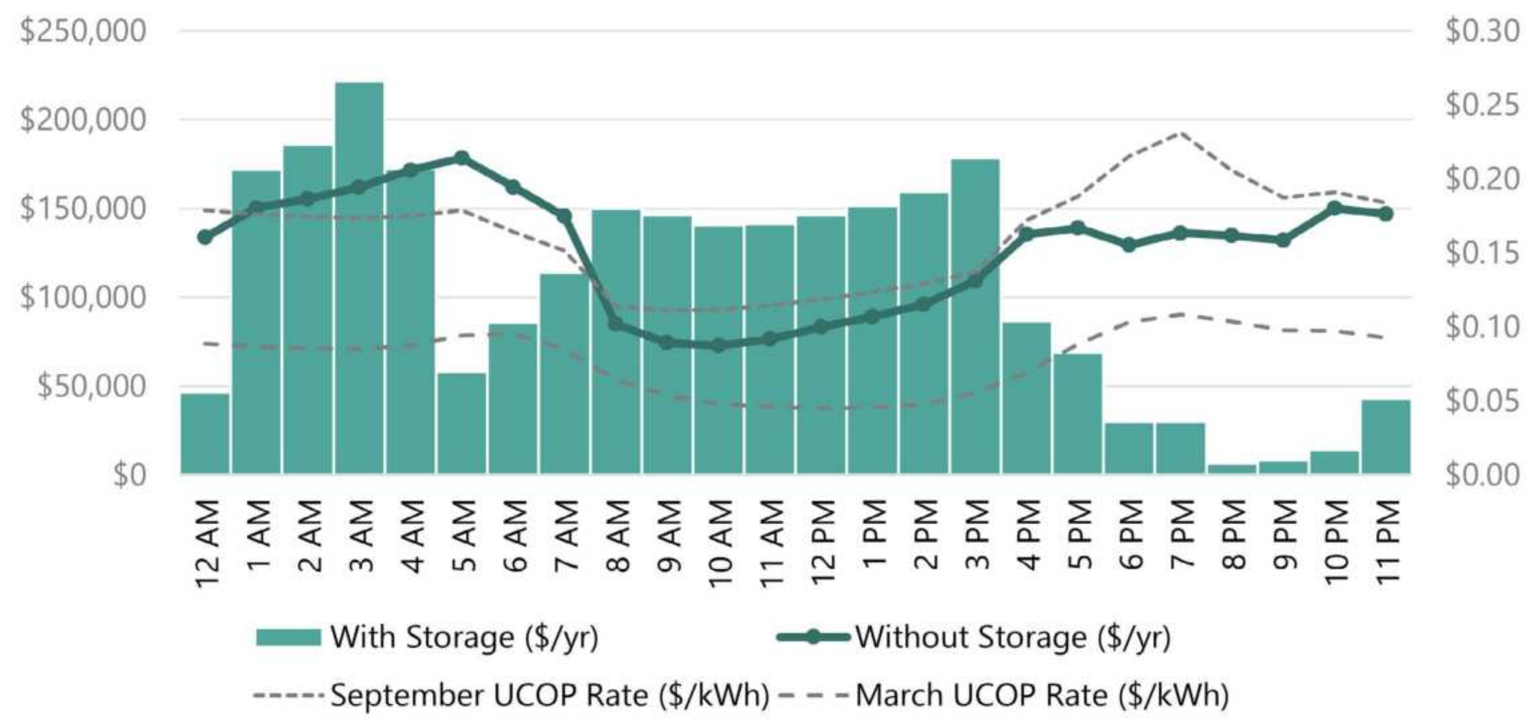
Continuing further with the Energy Use lens, the ability to use thermal storage tanks to shift the time heating and cooling is produced from the time it is needed, allows for lower energy use times of production (leveraging gentler heat source/sink times) and for lower energy cost times (leveraging variances in electricity cost over different times of day).

Option 3, shown here, is able to shift heating production significantly into the middle of the day when it is warmer, and thus uses less energy to make the same heating.

Furthermore, by shifting electricity to the middle of the day, when UCOP electricity rates are lower, this shift also saves significantly on electricity cost. The plots to the right illustrate this pattern – showing the annual totals by hour of day with this shifting compared against a universe without thermal storage.

Options 4, 5, and 6 are able to accomplish shifts of heating and cooling leveraging their heat sources and sinks to achieve very similar, though slightly lower energy use and cost.





These charts show Option 3 heating only energy use and energy cost vs. the same option but without thermal storage. The air temperature is shown as the weighted average for when heating load is produced. These results are for only the New CUP Served Infrastructure.

New Central Plant Infrastructure - All Options

Summarizing from the lens of Central Plant Energy Costs, Options 3, 4, 5, and 6 (all with thermal storage and a heat-source) all result in similar energy costs – about $3.0M - $3.2M 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 ($/yr)
0	Building Air-Source Heat Pumps	$5,269,042
1	Heat Recovery Chillers	$7,745,358
2	Heat Recovery Chillers + Storage	$6,331,690
3	Heat Pumps (Air-Source) + Storage	$3,319,530
4	Heat Pumps (Geo-Source) + Storage	$3,257,107
5	Heat Pumps (Sea-Source) + Storage	$3,036,412
6	Heat Pumps (Combo-Source) + Storage	$3,089,025

The table above summarizes the annual energy costs for all system strategies considered. Costs are shown for the year 2045 assuming 3% annual escalation. These costs are for only the New CUP and its Served Infrastructure.

New Central Plant Infrastructure - Options 1-4

Looking at these same Energy Costs again, but this time focusing on only Options 1 through 4. Option 0 is removed because of its order of magnitude higher O&M, and Options 5 and 6 are removed because of feasibility and risk issues.

#	Strategy	Energy Cost ($/yr)
1	Heat Recovery Chillers	**$7,745,358**
2	Heat Recovery Chillers + Storage	**$6,331,690**
3	Heat Pumps (Air-Source) + Storage	**$3,319,530**
4	Heat Pumps (Geo-Source) + Storage	**$3,257,107**

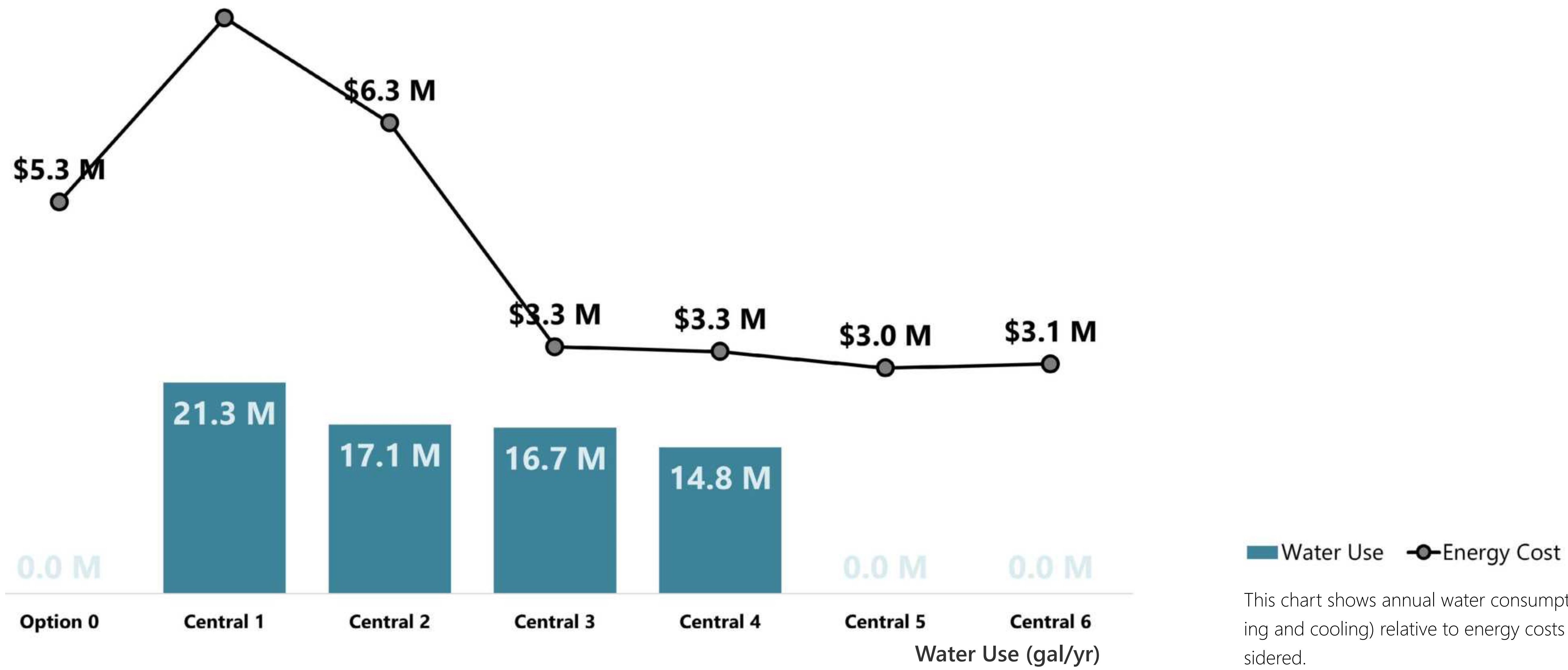
The table above summarizes the annual energy costs for all system strategies considered. Costs are shown for the year 2045 assuming 3% annual escalation. These costs are for only the New CUP and its Served Infrastructure.

With the lens of Energy Costs, Option 3 and Option 4 are by far the most compelling of all currently feasible options, having both thermal storage and a heating-source. Option 3 (Air-Source + TES) and Option 4 (Geo-Source + TES) both cost over $4M/yr or 60% less than Option 1 (no heat-source and no TES) and over $3M/yr or 50% less than Option 2 (no-heat source + TES).

System Comparison

From a Water Use lens, Options 5 and 6 are appealing as they do not consume any water for thermal purposes. This is because all waste heat made from the production of cooling can be rejected to either the ocean or a combination of geo exchange, lagoon exchange, and air-exchange respectively.

Options 3 and 4 consume water through evaporation at cooling towers, with Option 4 using a little less due to the ability to reject some heat to the ground instead of through evaporation. There are worthy potential avenues for Options 3 and 4 to use less potable water through (1) Cooling Tower Water Treatment that uses chemistry to achieve high cycles of concentration, and (2) Treatment that allows for use of Recycled Wastewater source available to UCSB.

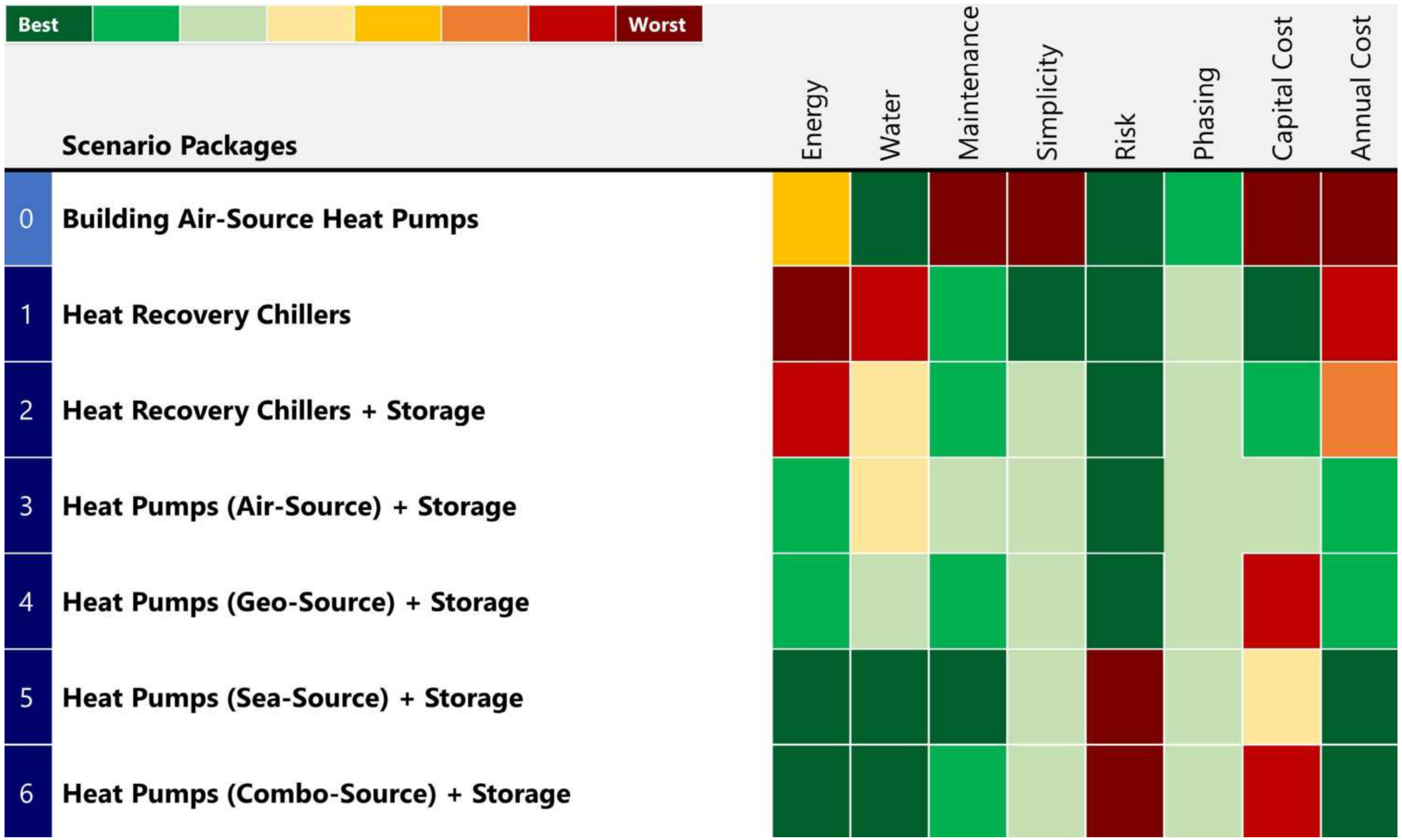


This chart shows annual water consumption for thermal systems (heating and cooling) relative to energy costs for all system strategies considered.

New Central Plant Infrastructure

Summarizing the First Part of the Options Comparison that isolates to only the parts that vary between considered options, the table below presents how each explored option compares relatively speaking on a best to worst scale. This is qualitative and meant to reflect the findings in this section.

Combining all the lenses presented above, Option 3 appears to be the most compelling. For the Second Part of the Options Comparison, a life cycle cost lens is taken for the total cost of implementing these strategies across all UCSB assets. This includes total Energy Costs (not just thermal energy) and all UCSB buildings (not just those served by a new central plant)



Note: Options 5 and 6. which utilize the ocean and lagoon respectively, currently have significant barriers to feasibility given a combination of regulatory and physical challenges uncovered during this study (see Solutions section for more detail).

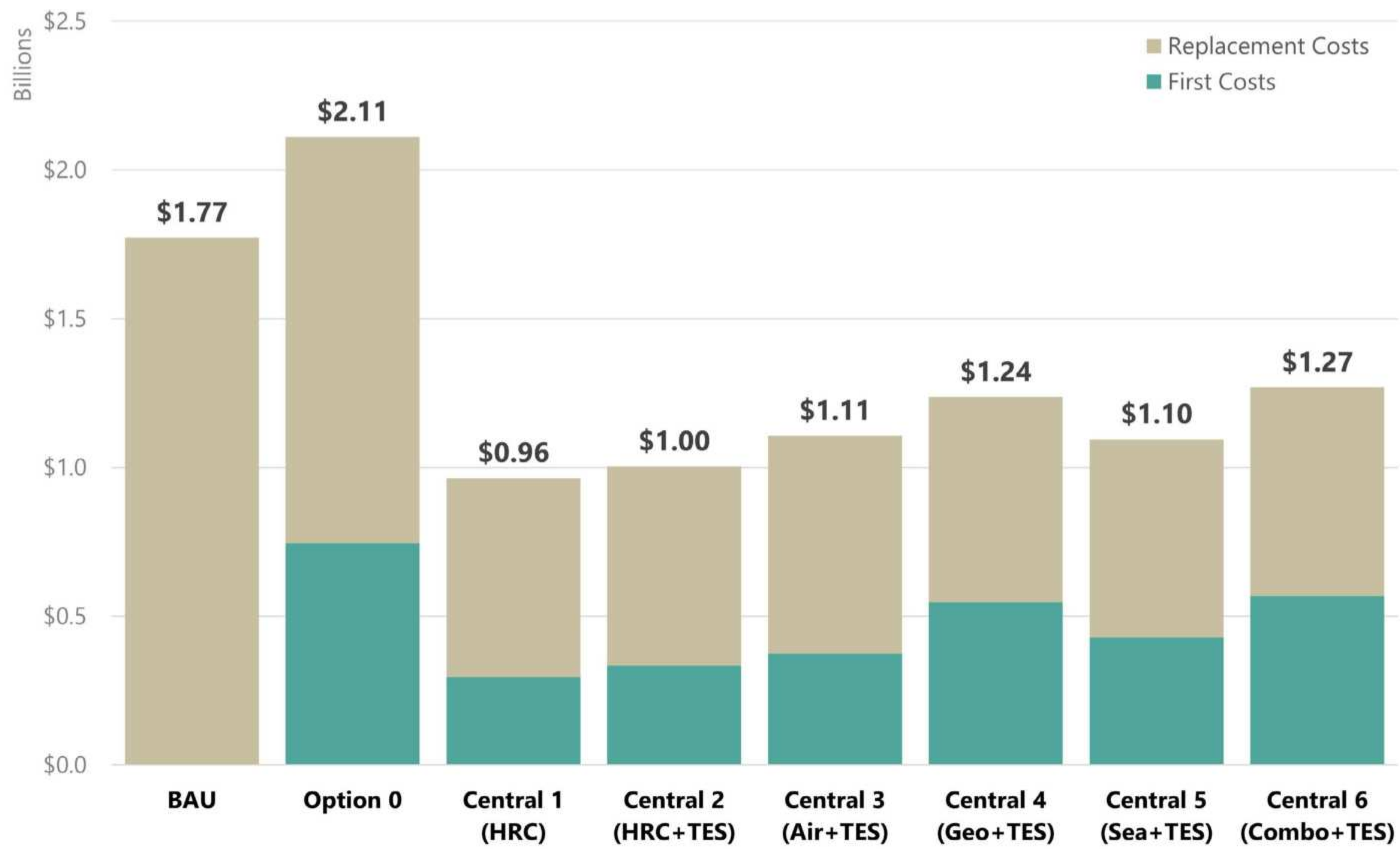
First Costs and Replacement Costs

First costs of proposed decarbonized systems will be higher than business as usual for all options. This is due to the high equipment costs- cost of replacing the heating and cooling infrastructure entirely, as well as adding new piping across campus and connecting to each building. While the upfront costs are high, the savings are substantial. First costs should be reviewed in conjunction with energy costs savings, and they should be reviewed against costs avoided such as the deferred maintenance costs, staffing costs for deferred maintenance, and cost of carbon.

Option 0 with standalone heat pump systems at each building has the highest capital cost. The building standalone heat pumps also have shorter life spans compared to chillers and cooling towers (15 years v/s 25 years), making replacements more frequent over time and more expensive compared to the other options.

Option 4 and Option 6 have higher capital costs associated with the drilling and geothermal installation.

Capital Costs (2025-2070)- Over Time

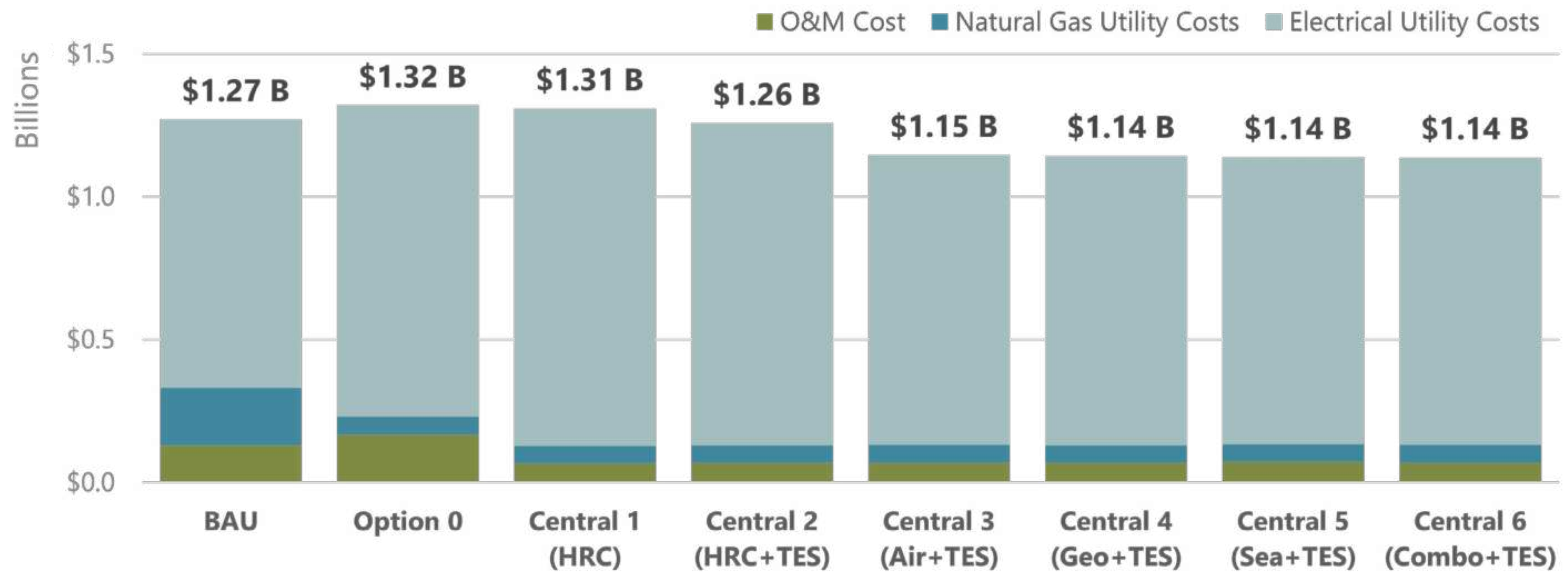


Capital costs in the analysis account for both first costs as well as replacement costs such as the business-as-usual deferred maintenance costs and the cost of replacing new equipment in future. Costs include soft costs for design, staffing and consulting services for small and major upgrade projects.

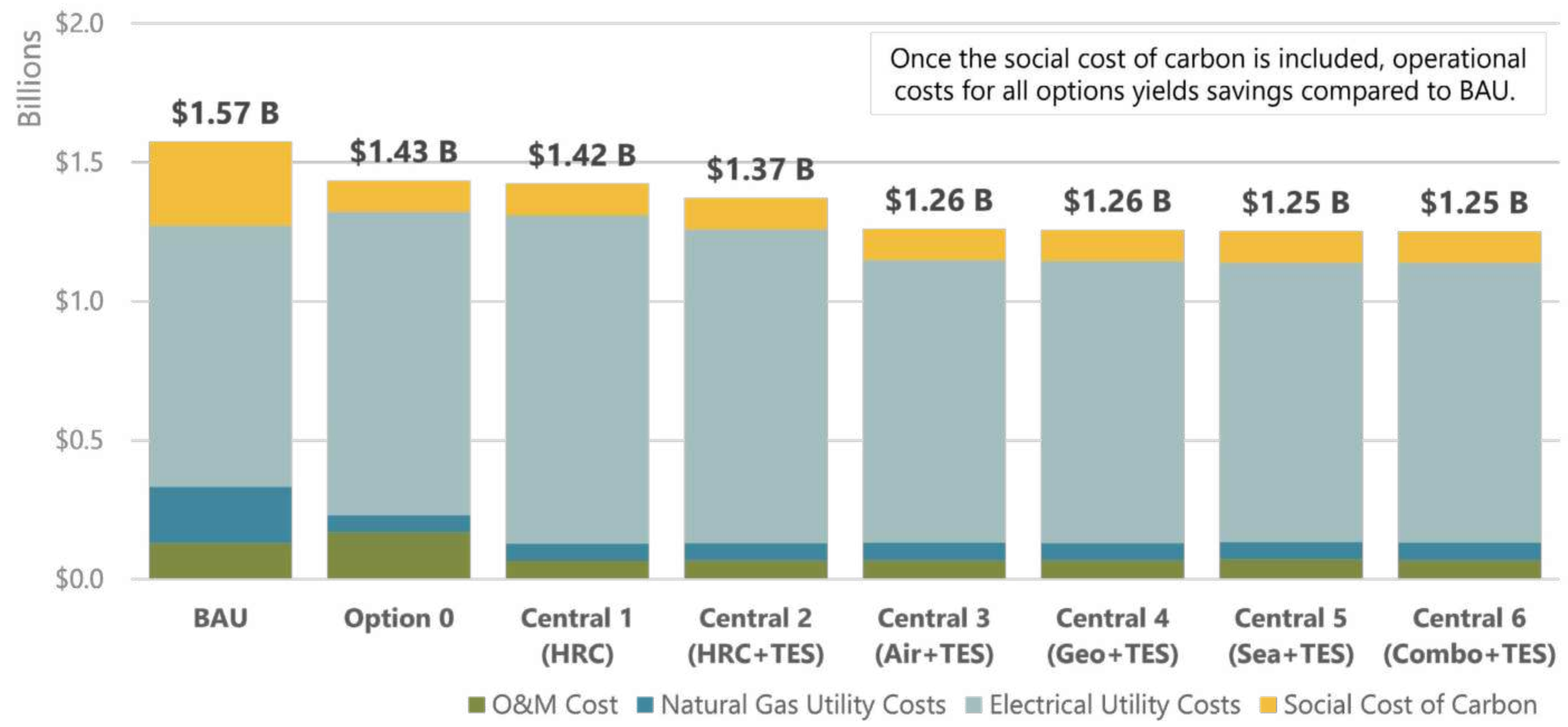
Utility Costs and O&M Costs

Operational costs include supplies and expenses costs, salaries for additional operations and maintenance team members overseeing deferred maintenance and electrical and natural gas utility costs. Despite the increase in electrical consumption and electrical utility costs, overall operational costs for options 2 through 6 are lower than BAU due to the lower natural gas usage and the reduced O&M costs. Central Utility Plant equipment requires lesser maintenance and eliminate the need for additional operations and maintenance personnel for ongoing deferred maintenance projects.

Options 3-6 all have similar operational savings and increase in electrical usage. Option 2 has slightly higher operational savings compared to Option 1 due to the addition of thermal energy storage but still uses a lot of electric boiler-based heating.



While Option 0 and Central Plant scenarios 1 and 2 do not have substantial energy savings compared to BAU, the overall operational costs become lower compared to BAU once the social cost of carbon is considered. It is important to factor this in for a clear understanding of the business case.



Total Cost of Ownership

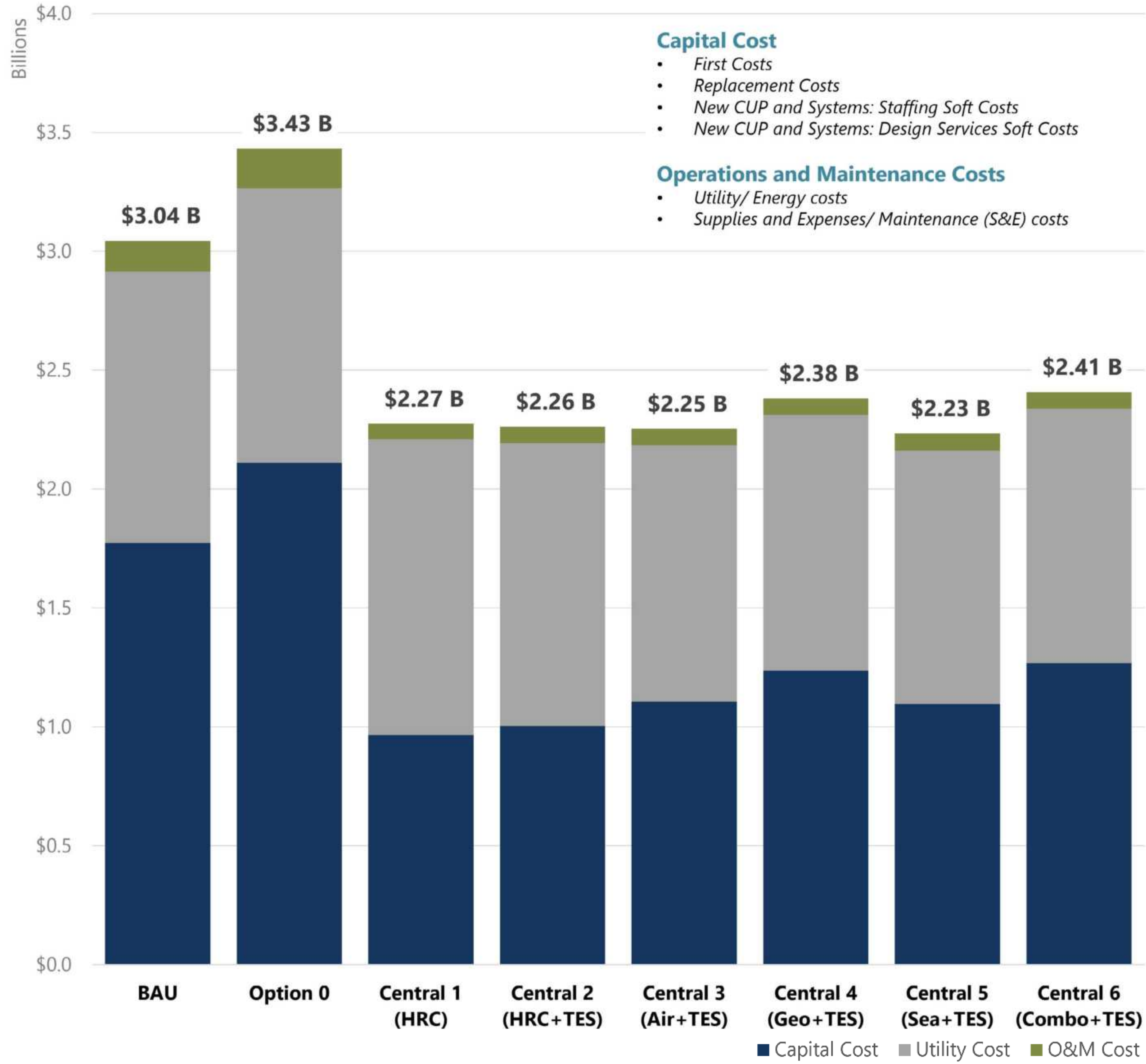
A total cost of ownership (TCO) model was developed to further inform the business case and decision-making around the transition away from fossil fuel-based heating systems.

TCO is the highest for Building Independent Option 0 given the distributed infrastructure needs which in turn increase both the capital costs and the operational costs.

TCO of Central Plant Option 3 (Air Source + TES) and Central Plant Option 5 (Seawater + TES) are the lowest with a 25% reduction compared to TCO of BAU systems.

All scenarios were run for a total life cycle period of 45 years starting 2025. Note that this analysis model assumes all implementation on Day 1 in the year 2044 for a fair comparison, but the actual implementation for the recommended option will be phased based on campus's needs, funding availability and other factors.

The Business As Usual (BAU) scenario is based on UCSB's current infrastructure and systems. This scenario is being shown to compare costs to highlight that there are potential solutions that can result in lower life cycle costs compared to existing operations, an additional benefit beyond complying with the UCSB directive.

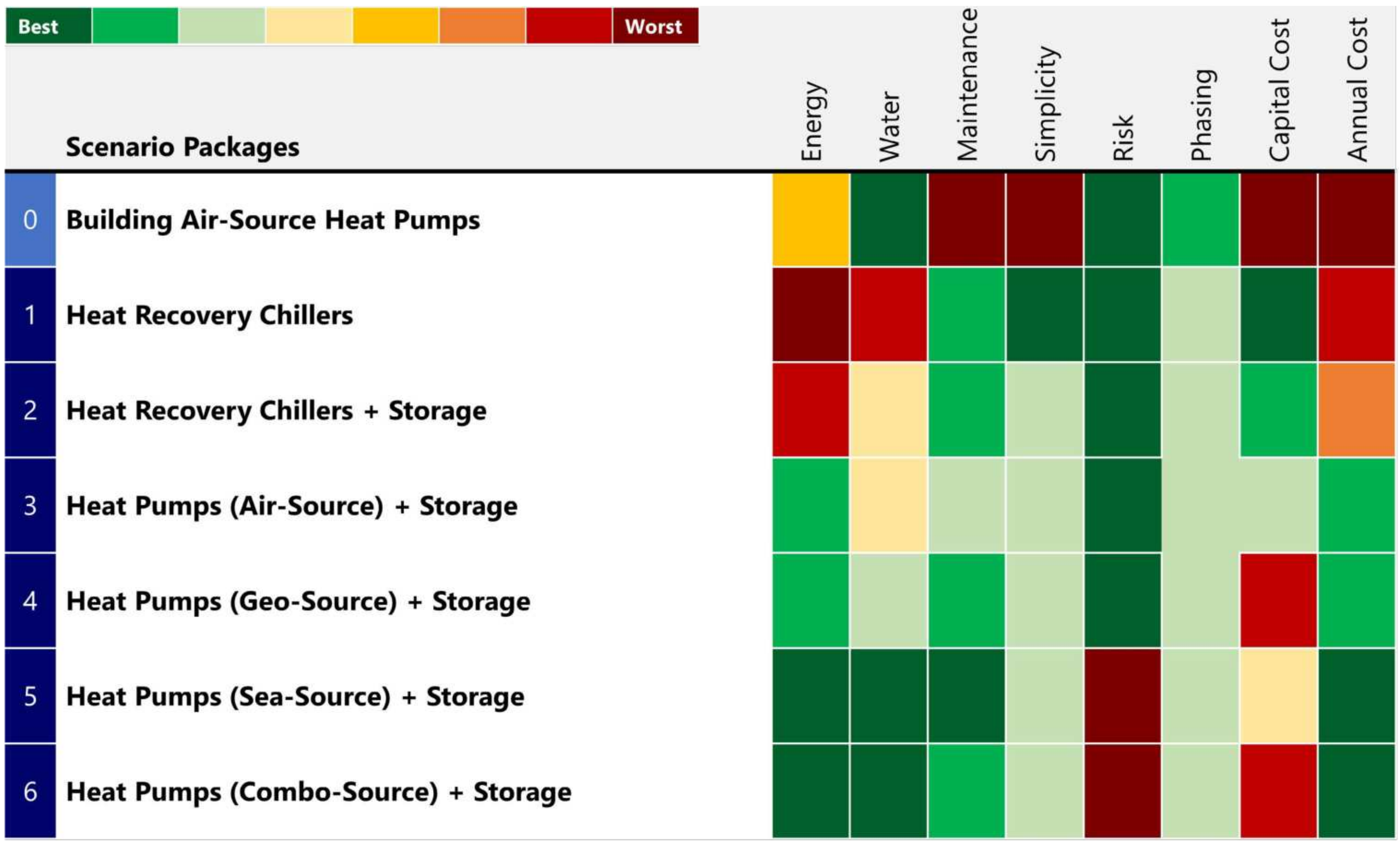


Campuswide Totals

Summarizing the Both Parts 1 and 2 of the Options Comparison, the table below presents how each explored option compares relatively speaking on a best to worst scale. This is qualitative and meant to reflect the findings in this section.

Option 2 has a little lower capital costs, but much higher operating costs. Option 4 has much higher capital costs with the same energy costs, but allows for lower water use.

Combining all the lenses presented above, Option 3 appears to be the most compelling.

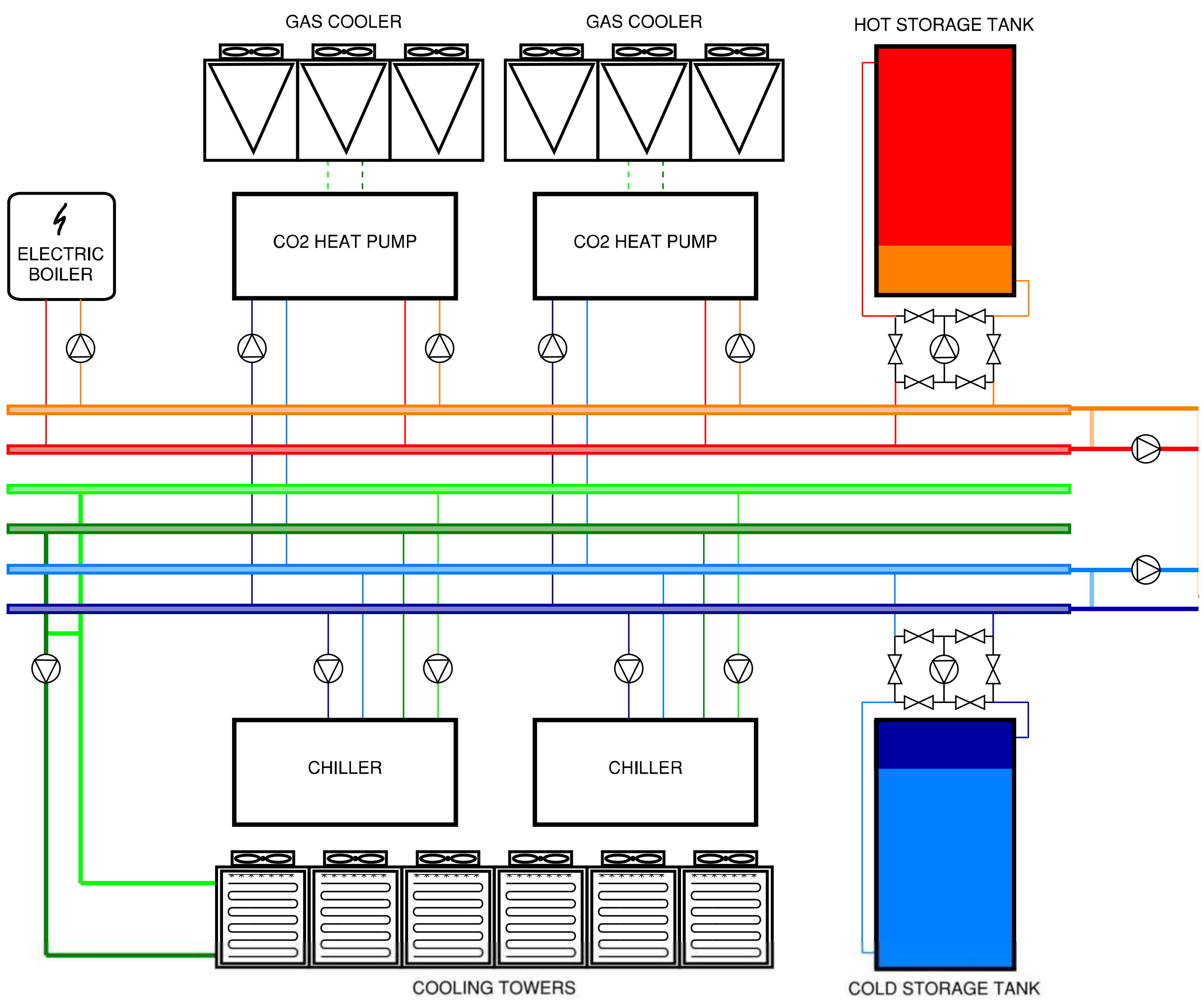


Note: Options 5 and 6. which utilize the ocean and lagoon respectively, currently have significant barriers to feasibility given a combination of regulatory and physical challenges uncovered during this study (see Solutions section for more detail).

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA
OPTIONS COMPARISON
RECOMMENDATIONS
NEXT STEPS

Central Plant Option #3 | Air Source Heat Pumps with Thermal Storage

Based on the options comparisons, Central Plant Option 3, Air-Source CO2 Heat Pump Chillers with Thermal Storage is our recommended option.



PROS

- Energy Cost is one of the lowest options
- First Cost is ~$50M - $200M less than all other comparable energy use options
- Climatic match leveraging UCSB's heating dominant loads and Santa Barbara's mild climate with daily temperature swings to minimize energy use, energy cost, and real marginal electricity emissions
- One of the lowest Operating Costs of any currently feasible option
- Can potentially receive IRA Cash Payment up to 30% of entire initial capital cost through Thermal Storage IRA provision

CONS

- Water Use highest of the 4 low energy cost options (though no more water than is currently consumed by cooling towers and potable water use could be mitigated by using available recycled water and chemistry-based water treatment)

System Comparison

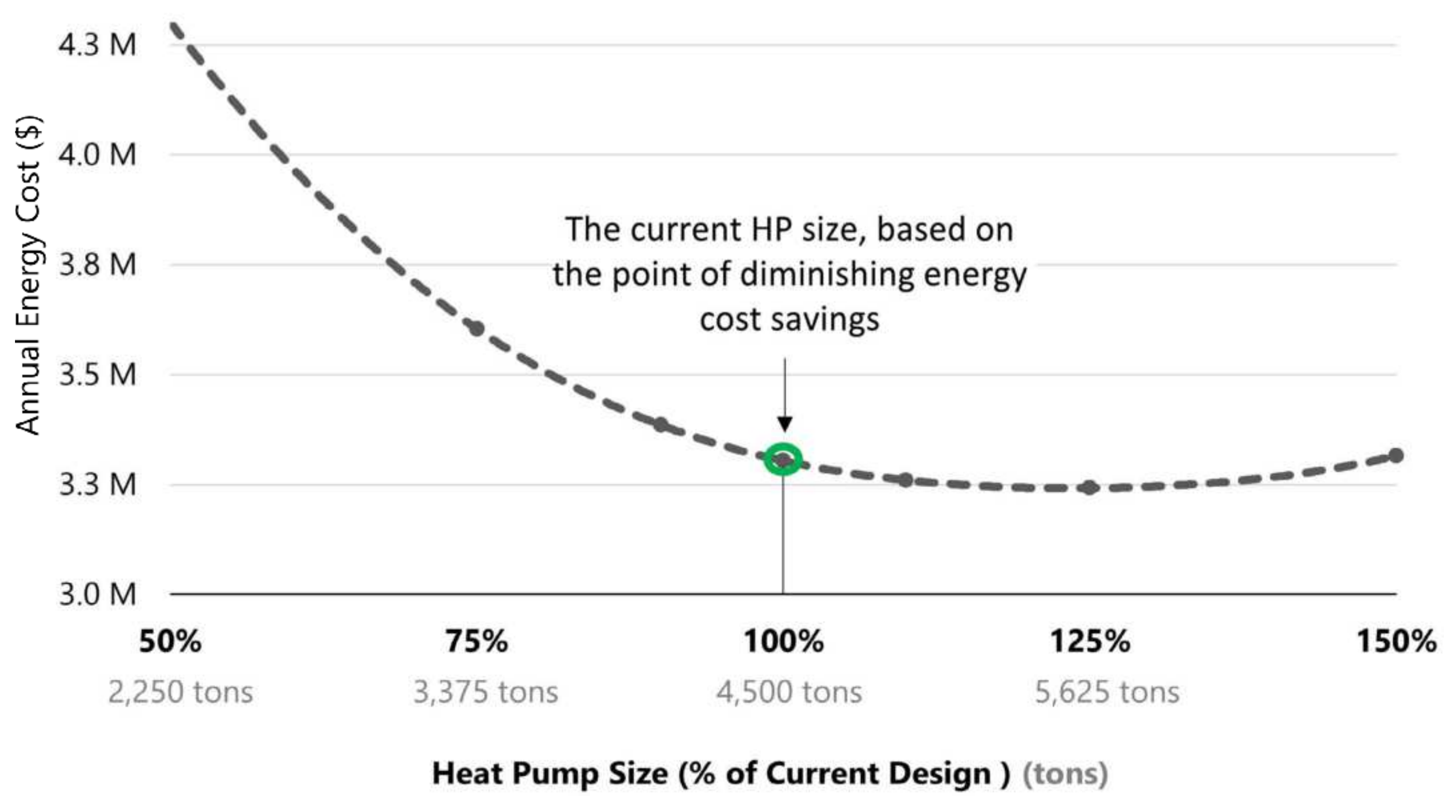
Heat Pump heating capacity and Electric Boiler size are inversely related: As the heat pump heating capacity increases, a smaller electric boiler capacity is needed to meet the remainder of the load. The heat pumps could be sized to reduce all of the peak heating load and eliminate electric boilers entirely, but this would lead to a prohibitively large heat pump size and associated first cost.

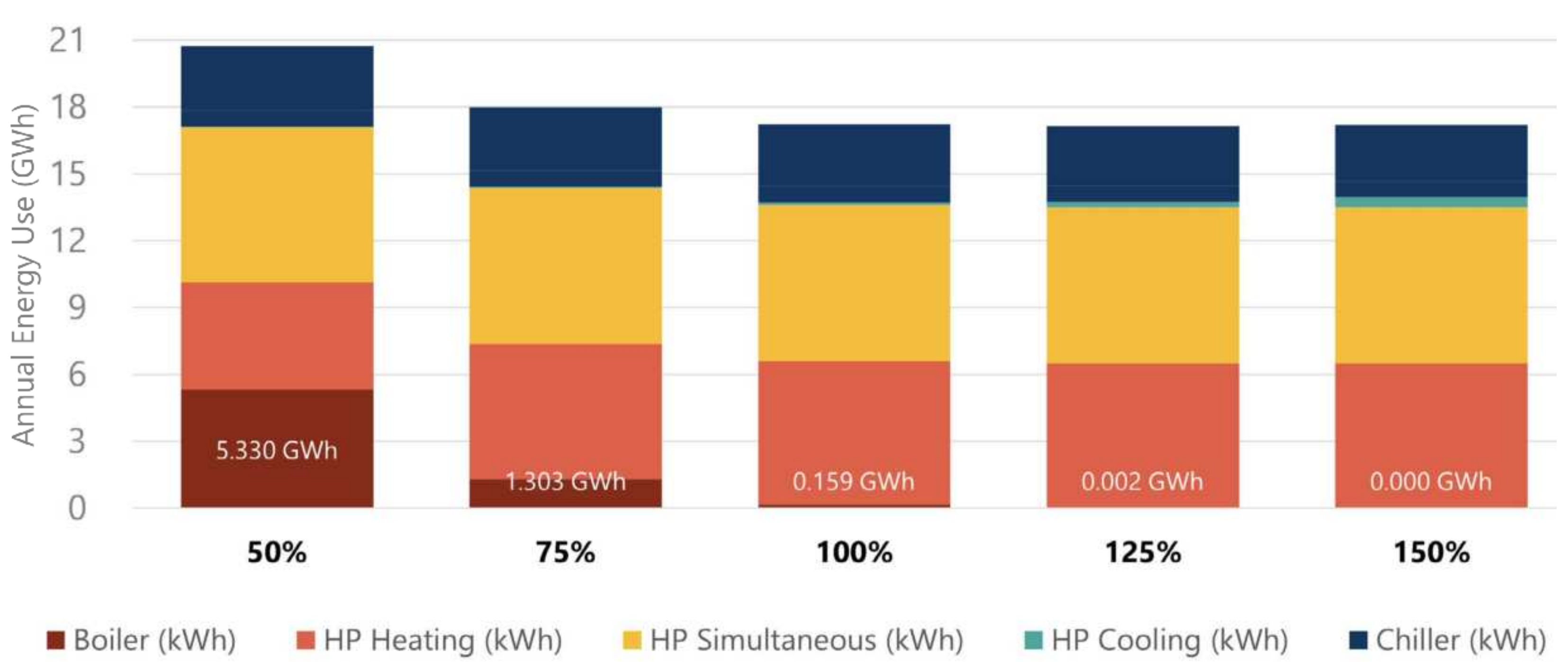
In order to optimize the amount of heat pump heating capacity at the central plant, a sensitivity analysis was conducted in which varying heat pump sizes were evaluated relative to energy cost. This analysis demonstrates that increasing the heat pump size to the current design recommendation shows significant energy cost savings due to a reduction in electric boiler runtime.

The total peak heating load was found to be 66,000 MBH (5,500 tons). In order to allow for redundancy and a safety factor (~25%), a total of 84,000 MBH (7,000 tons) of plant peak heating capacity is recommended. The Electric Boiler capacity is sized to compliment the heat pump capacity to achieve this total 84,000 MBH (7,000 tons) plant heating capacity.

We recommend Heat Pumps sized for 4,500 tons heating capacity and Electric Boilers sized for 2,500 tons, as increasing the heat pump size further shows diminishing energy cost benefits.

Heat Pump Size | Sensitivity Analysis





Hot Thermal Storage Tank

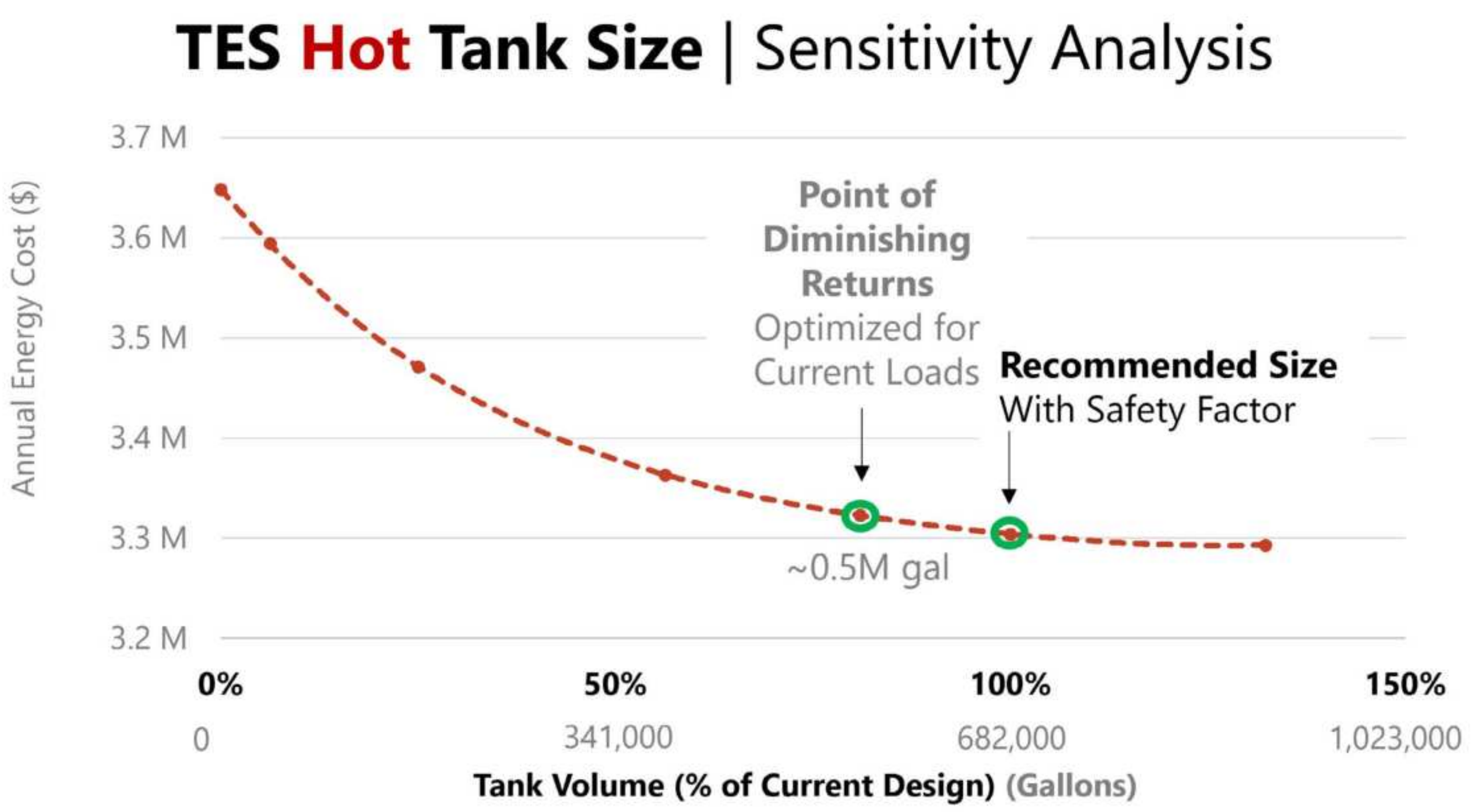
Thermal energy storage in the form of hot water and chilled water storage tanks serves two primary purposes:

- Maximizing Simultaneous Load (Heat Recovery)
- Shifting Load to Lower Cost Times

Given the climate and load profile of UCSB, the Hot and Cold Water Storage tanks each have their own unique optimal size. Separate sensitivity analyses were conducted for the hot and cold water tanks to identify the tank sizes which exist at the point of diminishing energy cost savings.

Safety Factor

- Tank capacity at any given time is dependent on the difference (or delta) in top-of-tank temperature and return water temperature. In reality, this delta may not be as high as the ~70°F modeled, and if it were instead 5F smaller, that's a 7% decrease in tank heating capacity.
- There is more heating energy use expected with future buildout of more residences in the central plant served main campus (during the tank's over 50 year life span).
- Collectively, for the heating storage tank, we recommend adding 20% capacity to the current loads modeled optimal hot storage tank sizing to arrive at the recommended Hot Storage Tank size used in pricing.

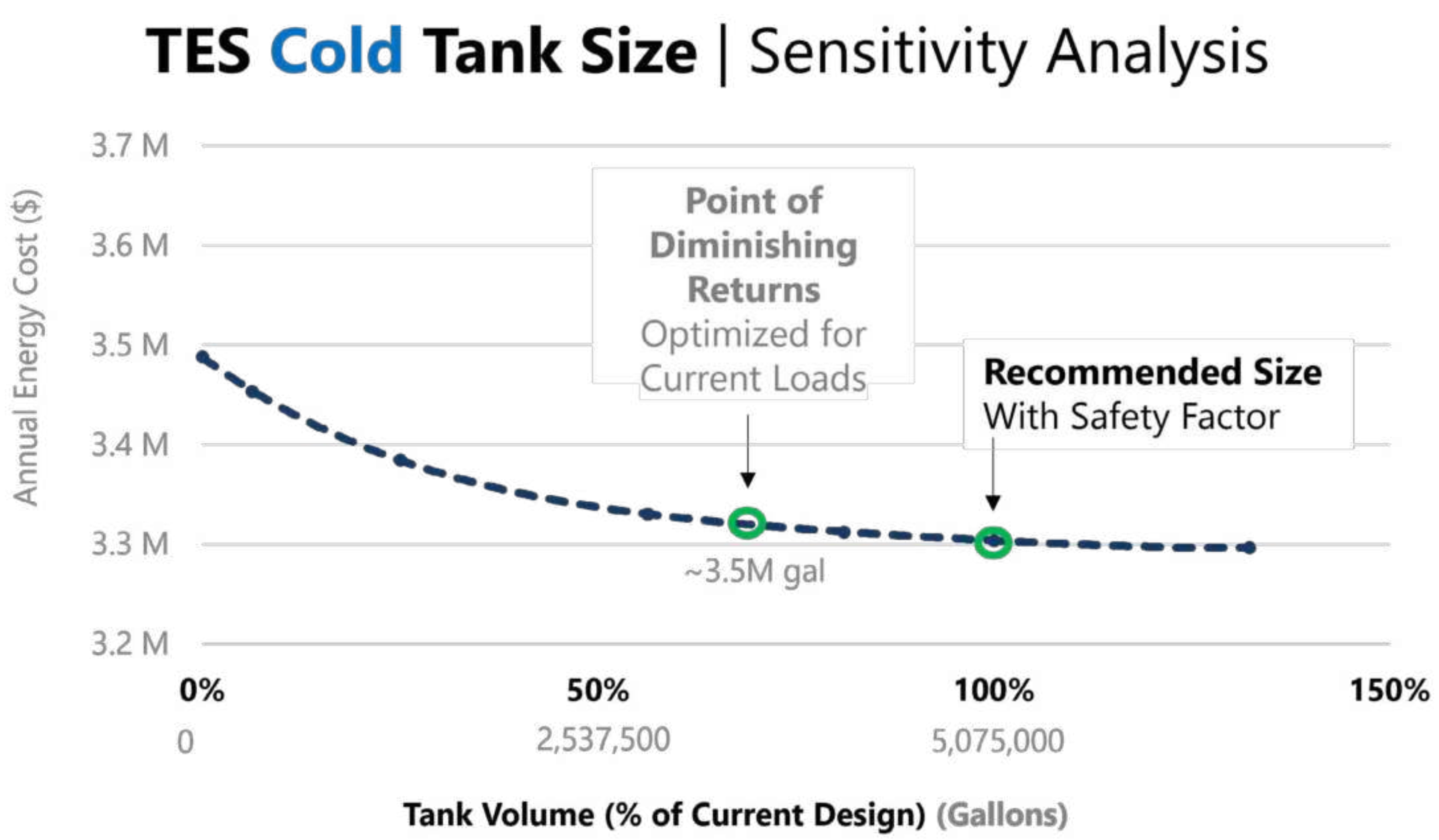


We recommend a Hot Storage Tank size of 682,000 gallons (44 ft diameter by 60 ft high), as increasing the hot tank size further shows diminishing energy cost benefits.

Cold Thermal Storage Tank

Safety Factor

- Similar to the hot tank, the capacity of the cold tank is dependent on the temperature delta between the bottom-of-tank temperature and the return water temperature. In reality, this delta in the cold storage tank might not be as high as the 15°F modeled. If it were 10°F, for instance, that's a 33% decrease in tank cooling capacity.
- More cooling energy use is expected with climate change within the cold tank's over 50 year lifespan.
- Cooling may be added to buildings (or replacement buildings) that don't have cooling programmatically now, such as residences, within the cold tank's lifespan.
- Collectively for the cooling storage tank, we recommend adding 40% capacity to the current loads modeled optimal cold storage tank sizing to arrive at the recommended Cold Storage Tank size used in pricing.



We recommend a Cold Storage Tank size of 5,075,000 gallons (120 ft diameter by 60 ft high), as increasing the cold tank size further shows diminishing energy cost benefits.

Sensitivity Analysis Summary | Recommended Central Plant Equipment Sizes

HEATING EQUIPMENT	RECOMMENDED SIZE
CO2 Heat Pumps	**4,500** tons Heating Capacity at 170F
Electric Boilers	**2,500** tons
Air-Source (Gas Coolers)	**4,500** tons
Hot Thermal Storage Tank	**682,000** gallons (44' Diameter by 60' Tall)

COOLING EQUIPMENT	RECOMMENDED SIZE
Chillers	**6,000** tons Cooling Capacity at 44F
(same CO2 Heat Pumps)	***3,000*** *tons*
Cooling Towers	**9,000** tons
Cold Thermal Storage Tank	**5,075,000** gallons (120' Diameter by 60' Tall)

Thermal Energy Storage Charging Schedule

The proposed UCSB central energy plant strives to leverage thermal energy storage (TES) systems to minimize operating energy cost and reduce carbon emissions associated with campus heating and cooling.

The sequence of diagrams at right outline a methodology for defining when TES tanks should be allowed to charge in order to minimize operational energy cost.

1. Charge and Discharge TES Based on Energy Cost

Allow thermal storage tanks to be charged during the 12 hours of the day with lowest energy cost. Based on UCSB's 2029 electricity rate projections, the thermal energy storage tanks should generally be charged between 7am – 4pm when electricity costs are the lowest and discharged in the evening and overnight hours.

2. Avoid Charging during Peak Heating/Cooling Periods

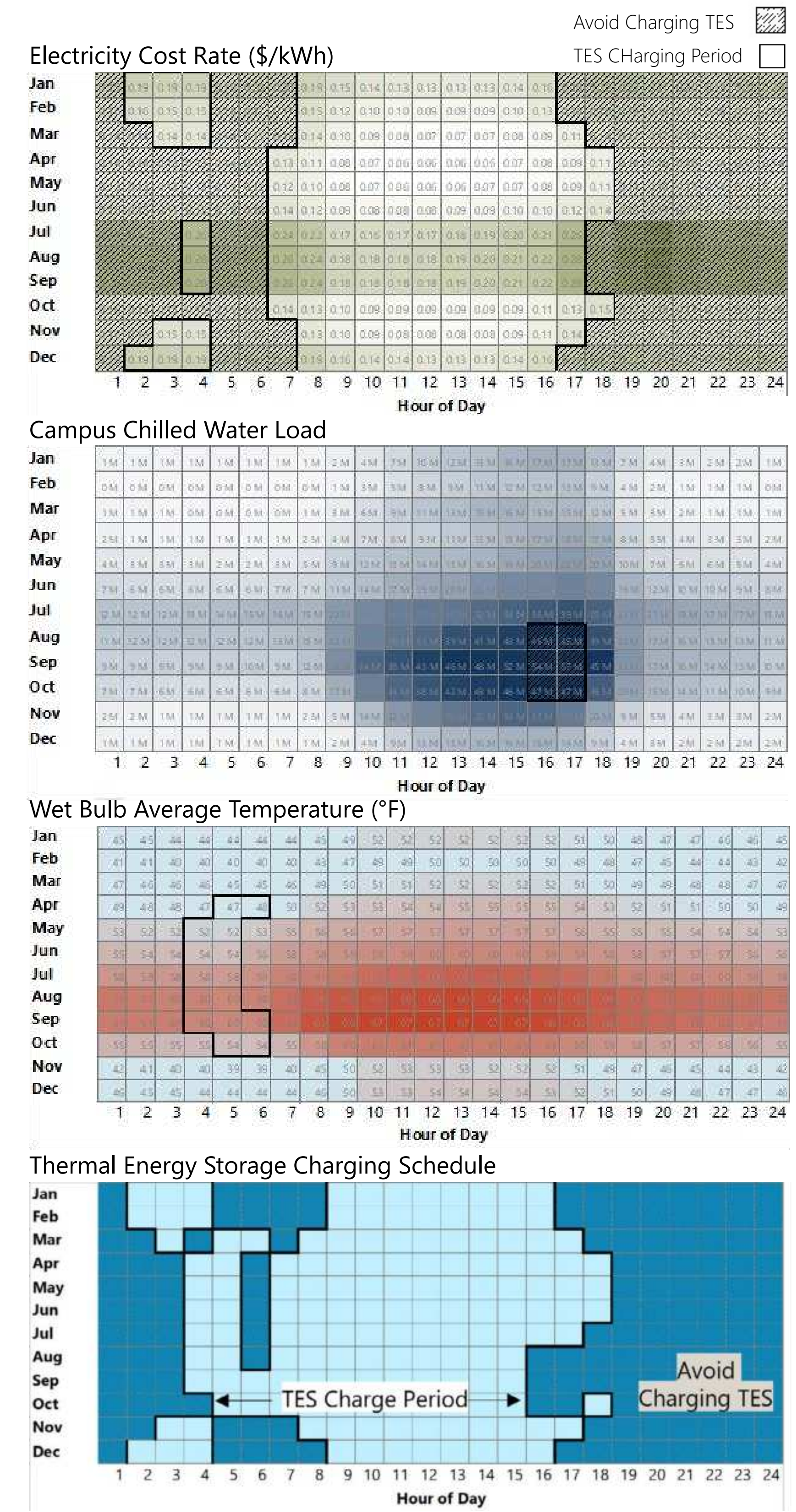
Avoid charging thermal energy storage at times when campus heating or cooling loads are high to avoid oversizing central plant equipment. For example, during the months of August, September, and October, avoid running a chiller or heat pump to charge the TES cold tank between 4-5pm when the central plant equipment is already running near full capacity to meet the cooling load.

3.Charge the Cold Tank when it is Most Efficient

During months with substantial cooling load, allow the chilled water thermal storage tank to be charged in the early morning (4-5am) when the outdoor wet bulb temperature is lowest, and the water-cooled chiller will operate most efficiently.

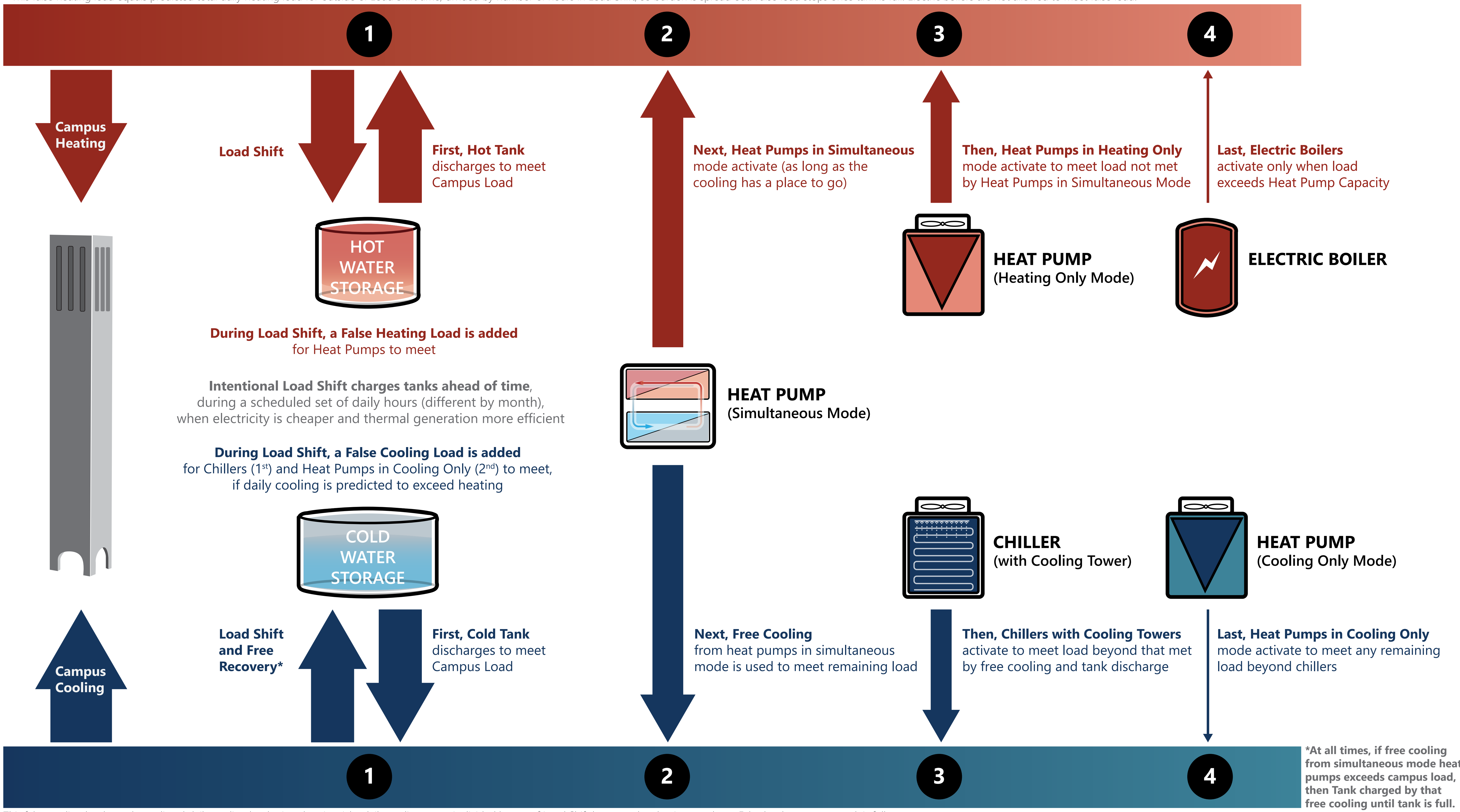
Resulting Thermal Energy Storage

The TES charging schedule at right leverages the 12-hour window with the lowest electricity costs. However, adjustments are made to account for peak load times and prioritize efficient chiller operation during hot months.



Plant Equipment Sequence of Operation

This false heating load equals predicted total daily heating load for outside of Load Shift time, divided by number of hours in Load Shift, so burden is spread out. False load stops once tank is full. Electric boilers are not allowed to meet false load.



This false cooling load equals predicted daily cooling load minus heating (aka daily cooling excess), divided by no. of Load Shift hours, so burden is spread out. False load stops once tank is full.

Typical Winter Day

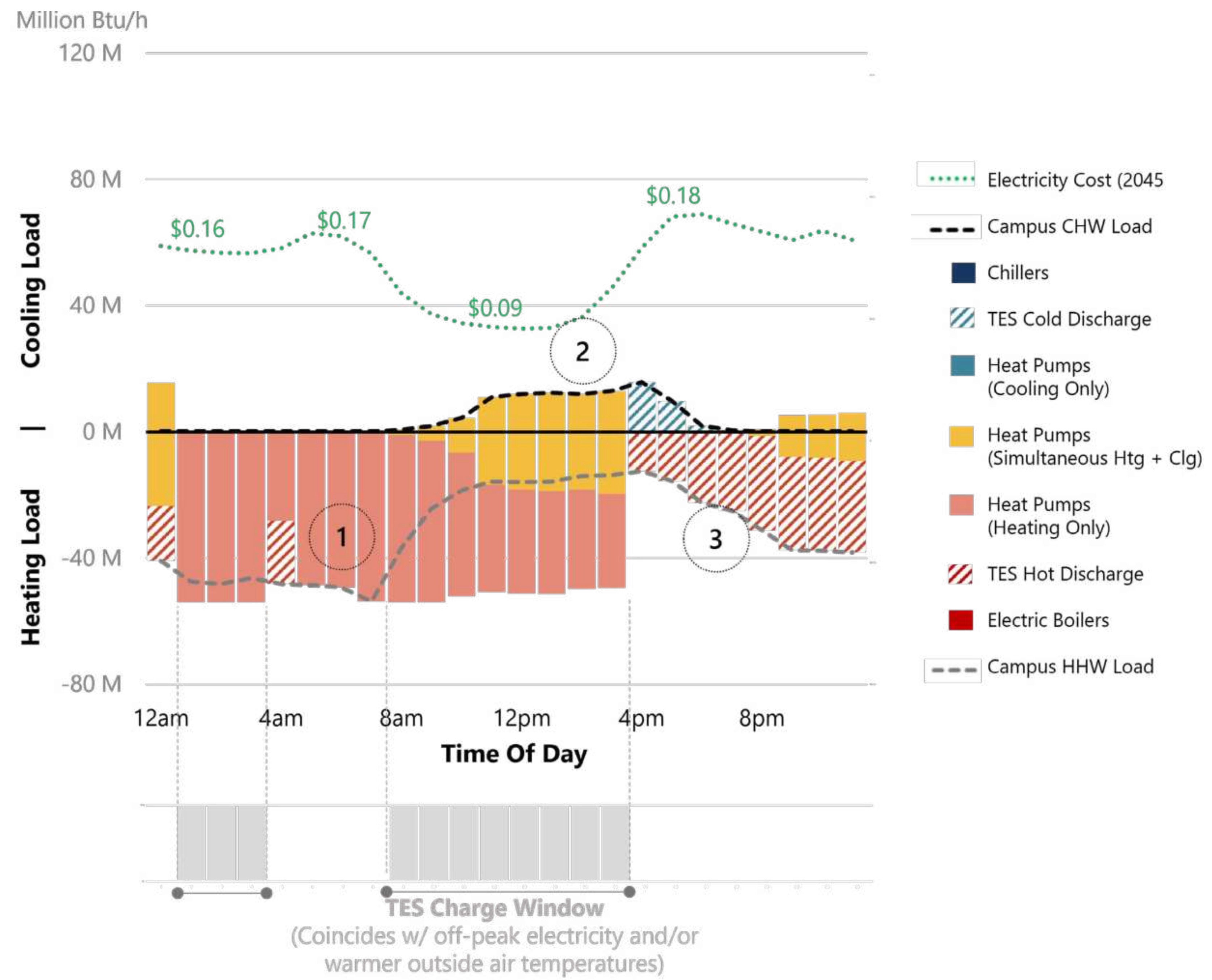
A typical winter day on campus is heating dominant with small amounts of cooling in the late morning to the afternoon. In the early morning from 1am until 7am, the campus experiences a heating load with no demand for cooling. To meet load, the heat pumps operate in heating-only mode, using the gas coolers to pull heat from the air **(1)**. This is the most efficient form of heat available in this time window. After heat pumps, the electric boilers will turn on to meet the remainder of the load.

There is a small cooling load from 8am until 3pm **(2)**. This cooling is produced in simultaneous mode, where the heat pumps make approximately 0.75 units of cooling for every unit of heat. This happens despite the fact that the TES cold tanks are completely full during these hours – this feature prioritizes producing cooling for free, while preserving the charge in the TES tanks for future times when there may be a cooling load and no coincident heating load.

From 4pm onward, the hot and cold TES tanks are allowed to discharge to meet the heating and cooling load **(3)**. The tanks meet as much demand as they can, followed by mechanical equipment if it is needed. On this day, tanks are able to meet both loads fully until about 9pm, at which point the hot tanks reach their maximum discharge rate, and the heat pumps turn on in simultaneous heating and cooling mode to meet the remainder of the heating demand while charging the cold tanks for free.

Hot tanks are only allowed to charge when electricity rates are low and there are warmer outside air temperatures for more efficient heating production. Cold tanks are also allowed to charge during this time, but can also be charged if cooling can be produced for free by the heat pumps.

Load Profile by Equipment (Typical Winter Day | February)



Typical Spring/Early Summer Day

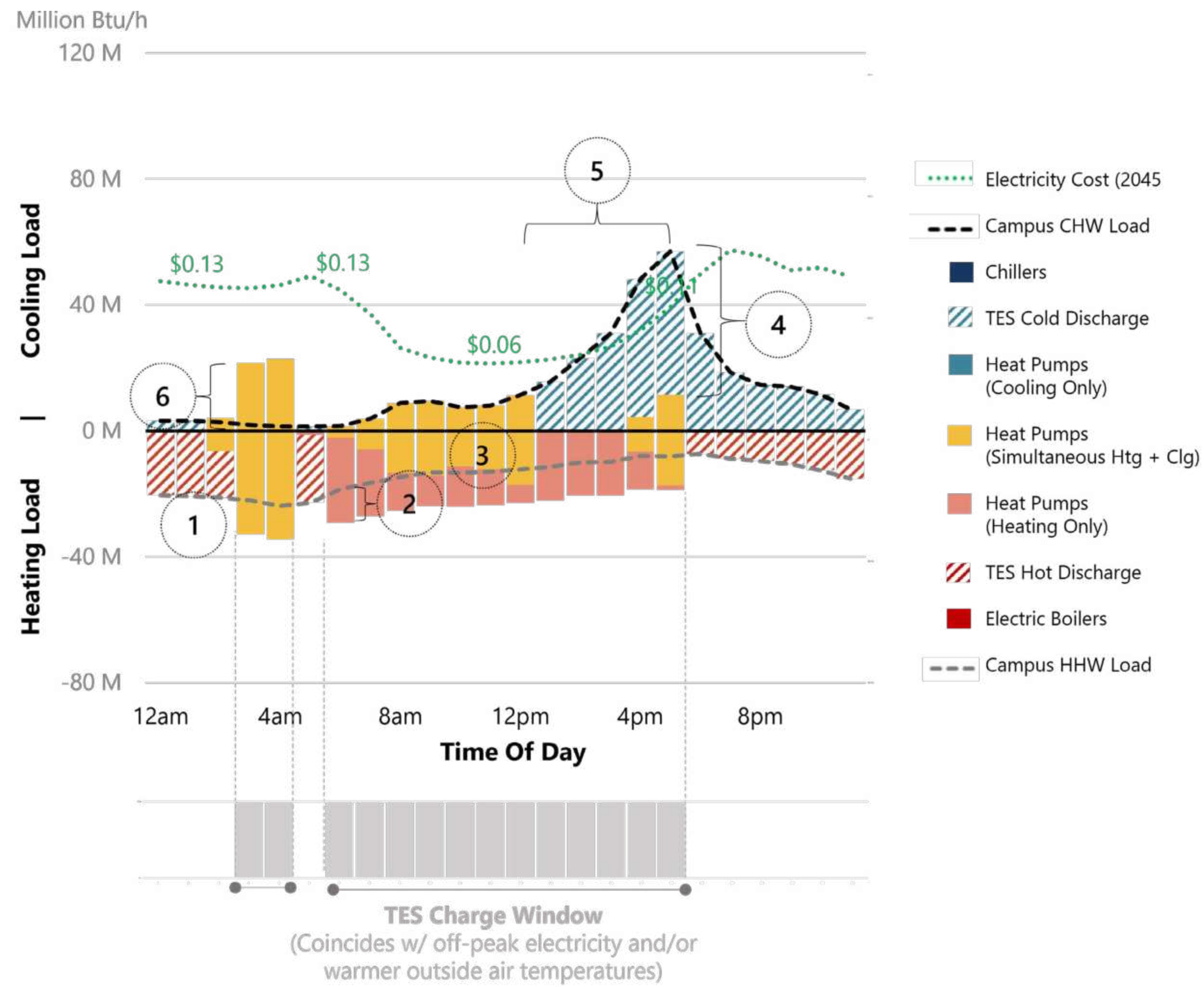
A typical day in the spring or early summer has cooling and heating loads fairly equal, although mismatched – cooling demand has a large peak much later in the day, while heating demand is fairly constant. On a day like this, the benefit of the TES tanks become much more apparent.

In the morning hours, heating is met with the tanks when electricity rates are high and ambient temp is favorable for heating **(1)**. During charge windows (from 3am-5am and from 6am-5pm) hot tanks are charged as a priority **(2)**, first with simultaneous heat pump operation to maximize free-cooling, and second with heating only heat pumps **(3)**. The TES cold tanks can be charged during this window as well to further capture free-cooling; however, on this day the cold tanks are full, so maximum free-cooling is in proportion to the hourly cooling demand.

To avoid the late-afternoon peak rate, the TES cold and hot tanks discharge up to their maximum discharge rates to meet the cooling and heating demand **(4)**. Additionally, the cold tank is allowed to discharge within the Charge Window **(5)**, since it was completely full and the model is forecasting plenty of future heating dominant hours. For the remainder of the day and into the next, the tanks are able to meet the loads completely without the need for mechanical equipment.

Without the TES tanks, a significant amount of chiller energy would be needed to meet the cooling peak at 5pm **(4)** – additionally, much less simultaneous heating and cooling would occur from 3am-5am, since the cooling load at this time is close to 0 **(6)**.

Load Profile by Equipment (Typical Spring/Early Summer Day | May)



Typical Late Summer Day

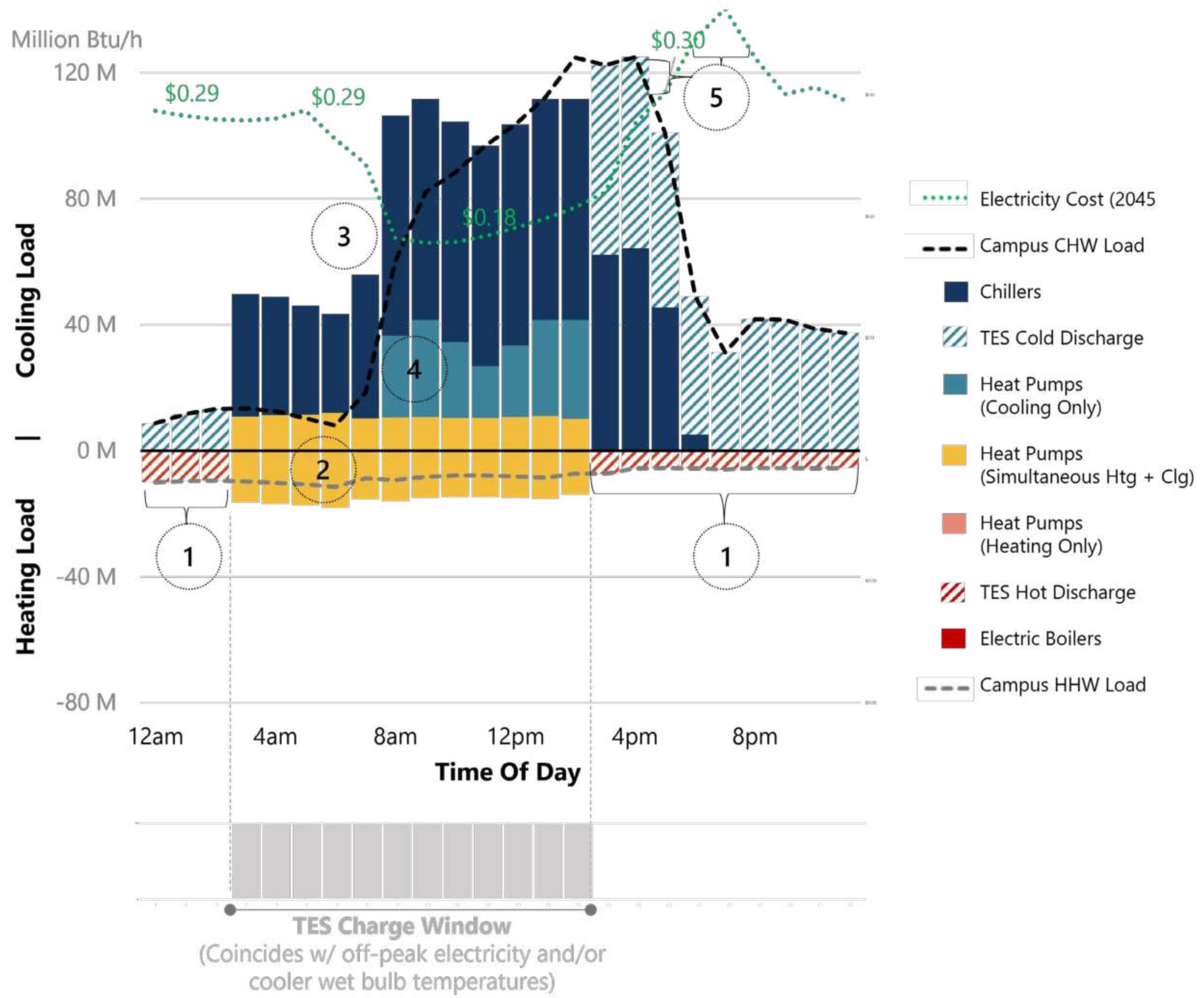
A typical day in the later parts of summer are much more cooling dominant than throughout the rest of the year - simply for the sake of exploring this type of operation, it is helpful to switch the mindset of heating with free-cooling, to cooling with free-heating.

Even in the hottest days of summer, there is still a constant heating demand throughout the day – mostly due to domestic water heating. In this case, even if it were not for the TES hot tanks, all of the heating load (with the exception of that during 12am) would be made with free-heating, since the cooling load is greater in each hour. With the hot tanks however, the only mechanical heating needed during the day is during the charge window **(1)** – the rest can be met with the hot tank discharge (which is normally full during this time of year).

Priority is given to the heat pumps to produce cooling and free-heating first. After as much cooling load is met with the heat pumps in simultaneous mode **(2)**, cooling load is met with the chillers **(3)**, as they are more efficient than cooling-only heat pumps. The heat pumps will only operate in cooling-only mode when the chiller capacity is exceeded – which does happen between 9am and 3pm **(4)**.

In this season, a spike in electricity happens every day due to cooling in the afternoon/evening. The tanks spend enough time charging in the morning and throughout the day when electricity rates are low to build up capacity and discharge in the evening, avoiding setting a higher peak and the most expensive hours of electricity of the year **(5)**.

Load Profile by Equipment (Typical Late Summer Day | September)



CO2 Heat Pumps

The Opportunity

For high temperature hot water production of 170°F (or greater), there are only two types of heat pumps options: (1) CO2 Heat Pumps, and (2) Two-Pass Centrifugal Heat Pumps.

CO2 Heat Pumps have the potential to generate high temp hot water with significantly less energy than Two-Pass type heat pumps, if the return water temperatures are kept low (more on following pages). Additionally, the Two-Pass type only works as a water-source heat pump and requires a water-source for heating, such as geo-exchange. The CO2 type can work with an air-source (using a gas cooler) for heating and/or a water-source.

Given the enormous capital savings from using air-source gas coolers in lieu of installing a geoexchange vertical borefield system and the potential to use significantly less energy, CO2 Heat Pumps present a major first cost and energy savings opportunity.

Building Connections to Reduce Campus Return Temperature

Every building receives 170°F supply water from the campus distribution heating loop. That heating supply water feeds a connection to two functions at each building:

- Heating for Space Conditioning (HHW)
- Heating for Hot Water (DHW)

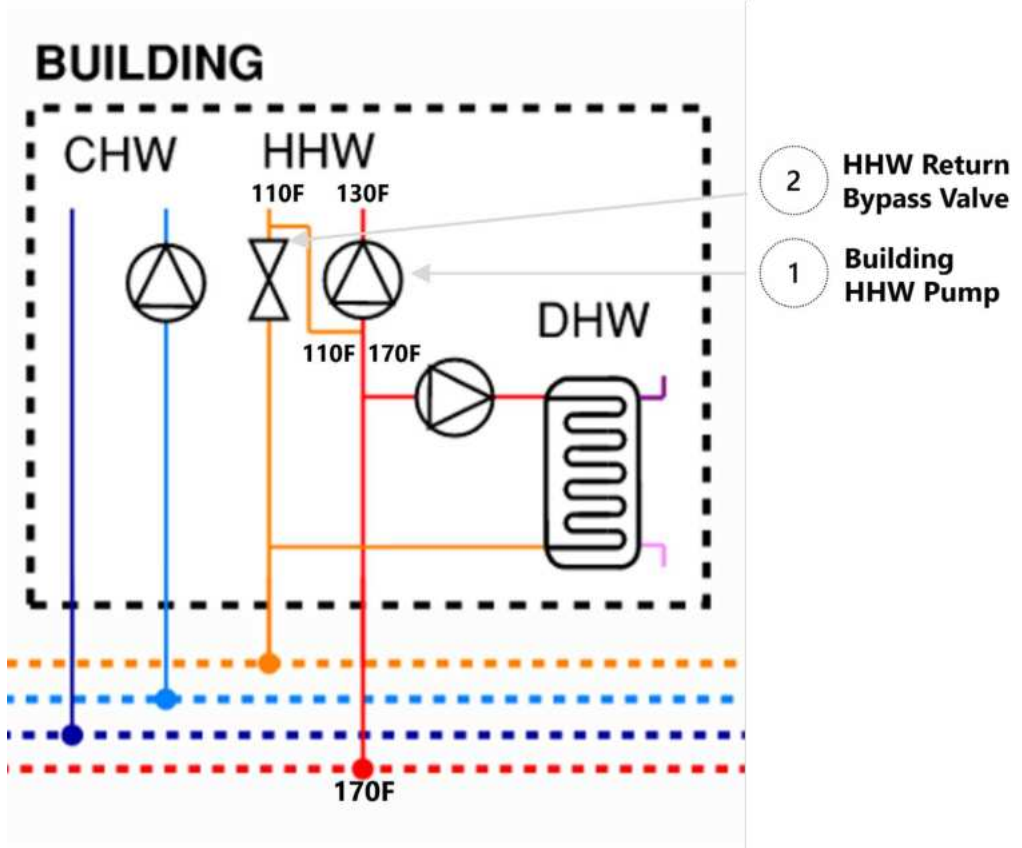
Heating for Space Conditioning (HHW) Connection

Heating for Space Heating (HHW) is accomplished at each building by a (1) HHW pump and a (2) Bypass Valve on the return leg.

This assembly allows each building to have its own HHW supply temperature set point. The bypass valve modulates to maintain the building HHW supply set point, while the pump modulates to maintain building HHW differential pressure (as per typical control approach). As the valve becomes more closed, more of the return flow is diverted via the bypass leg back to the building HHW supply to mix with the 170°F from the campus loop. As it becomes more open, less is diverted back to the building HHW supply. This approach allows 170°F to be trickled in so that 130°F is sent to the building and say 110°F comes back, with the valve diverting some of that 110°F to mix back with some new 170°F to create that 130°F and start the journey again. For example, if 100 gpm of 130°F HHW supply is circulated in a building and comes back at 110°F, 33 gpm of 170°F would mix with 67 gpm of that 110°F to achieve 130°F. The valve would modulate into a more closed position until the building HHW supply temp reaches 130°F, causing most of the flow (in this example 67 gpm or 2/3rds) to divert through the bypass leg, while the remainder (in this example 33 gpm or 1/3rd) flows through the valve at 110°F.

The expected scenario assumes the average building can be served by 130°F HHW Supply Water without any change in piping or equipment at the building. Some buildings will need a higher temperature HHW Supply, such as 150°F, while others will be able to work with lower, such as 120°F. We expect that the weighted average of all these uses will equate to around 130°F for the Building HHW Supply Set Point.

This recommended connection ensures the 170°F campus heating returns back from the building HHW assemblies as low as possible, at about 110°F on average (varying with load).



Heating for Hot Water (DHW) Connection

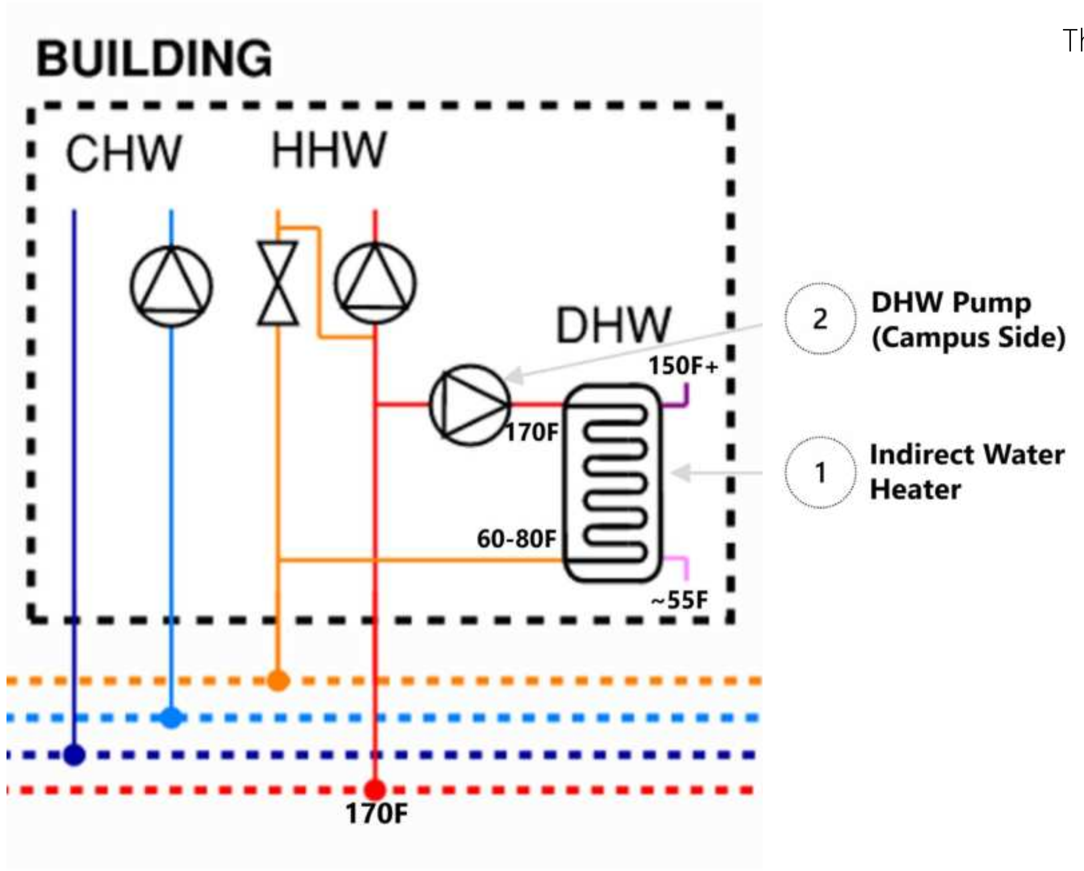
Heating for domestic hot water is accomplished at each building by an (1) Indirect Water Heater and a (2) DHW Pump.

The heat itself is transferred from the campus heating pipe to the domestic cold water via an Indirect Water Heater. This device has a closed loop coil inside a water tank. The campus heating hot water (170°F) flows through the closed loop coil and that heats the domestic cold water to 140°F or higher by the time it leaves the tank as the DHW supply. This indirect water heater replaces the hot water boiler(s) (or whatever the water heating equipment is at each building. It allows all other hot water piping, including any storage tanks and distribution throughout the building, to remain unchanged.

A dedicated pump on the campus loop side of the Indirect Water Heater provides temperature control for the domestic hot water. As domestic water flow varies, the pump varies its speed to maintain a set point of 140°F or higher temperature leaving the indirect water heater. The slower the pump the lower the return temp, since it has more time to exchange its heat.

Indirect Water Heaters are the recommended heat exchanger type as they will have the lowest approach and least maintenance of all available heat exchanger types. The approach here means how close that 170°F supply "approaches" the domestic cold water temp by the time it leaves the unit. Reasonably sized Indirect Water Heaters will achieve 20°F Approach at peak domestic hot water flow and 5°F at 50% or lower domestic hot water flow. This means the 170°F will leave the indirect water heater at ~60°F – 80°F depending on time of year (domestic cold water ranges from ~55°F – 60°F) and the domestic hot water load (5F at lower loads – 20°F at higher loads).

This recommended connection ensures the 170°F campus heating supply will leave the DHW heating assembly at broadly ~70°F.



Combined Effect of HHW Building Connections on Return Temp

Together, this will create a campus return heating water combined temperature from all buildings that varies broadly between ~70°F – 110°F, depending on the building's mixes of particular HHW supply temp set points, loads, and the time of day and year.

The next page explores how these temperatures are expected to vary.

Achieving Lower Return Water Temperature

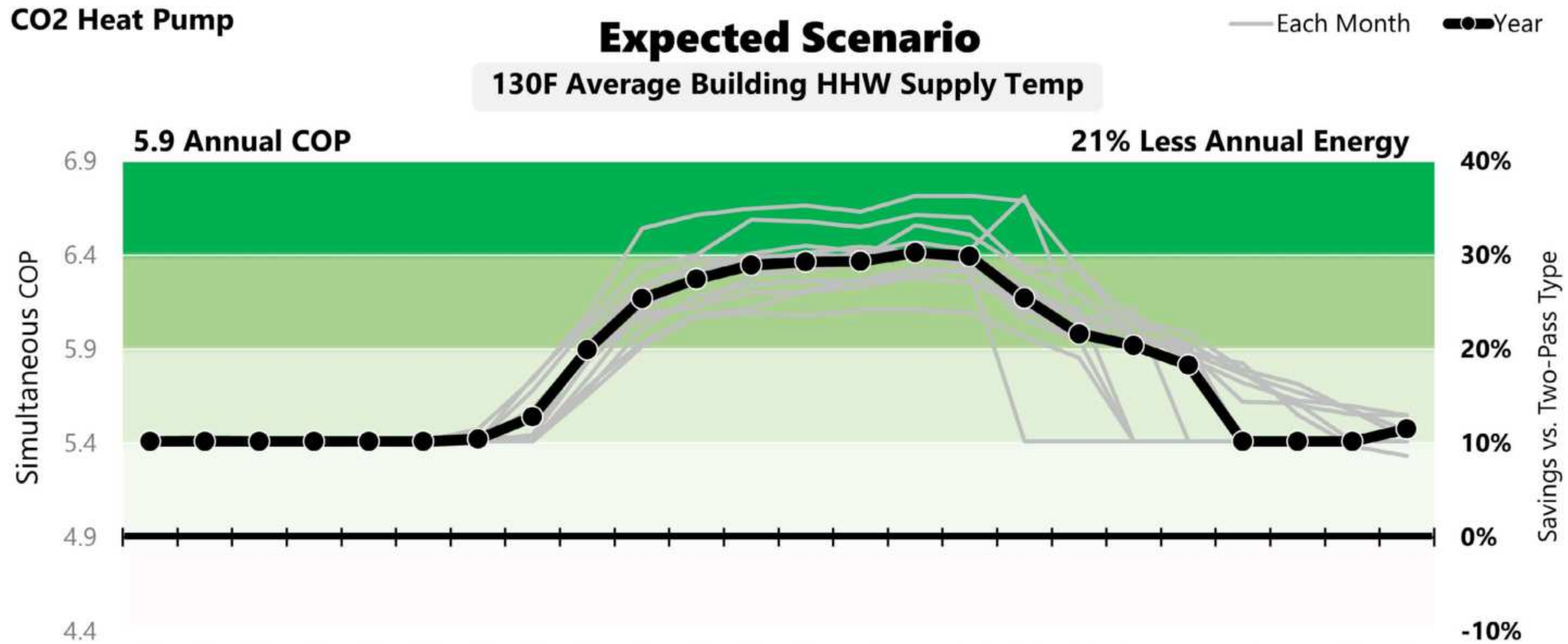
Two-Pass Heat Pumps have a Simultaneous COP of 4.9 to make 170°F Heating and 44°F Cooling. This is a flat value over the whole year, since two-pass heat pumps' energy use is just a function of lift, which is the difference in the supply temperatures of the chilled water and hot water leaving the heat pumps (and a little bit of part loading as long as equipment are staged reasonably per standard of care). CO2 Heat Pumps' energy use, on the other hand, is greatly dependent on the entering (return) heating water temp, so it will vary depending on the temperature of that central plant heating return.

In general, if the return water temperature is less than 112F, CO2 Heat Pumps will use less energy than Two-Pass Heat Pumps.

The adjacent table shows the average blended return temp by hour for each month of the year, along with the same values for the year as a whole, based on modeling every buildings' unique annual hourly profile of heating (HHW) and hot water (DHW) loads. The total campus heating loop blended return is expected to vary from ~85F in the middle of the day to ~105F in the middle of the night, with some variance between winter and summer.

The adjacent plot shows the relative energy use for CO2 Heat Pumps making Simultaneous Heating and Cooling compared against Two-Pass heat pumps, for these resulting return water temperatures.

Based on modeling of every buildings unique annual hourly profile of HHW and DHW heating loads, the CO2 Heat Pumps are expected to have an annual Simultaneous COP of 5.9, which is 21% Higher than the Two-Pass Type.

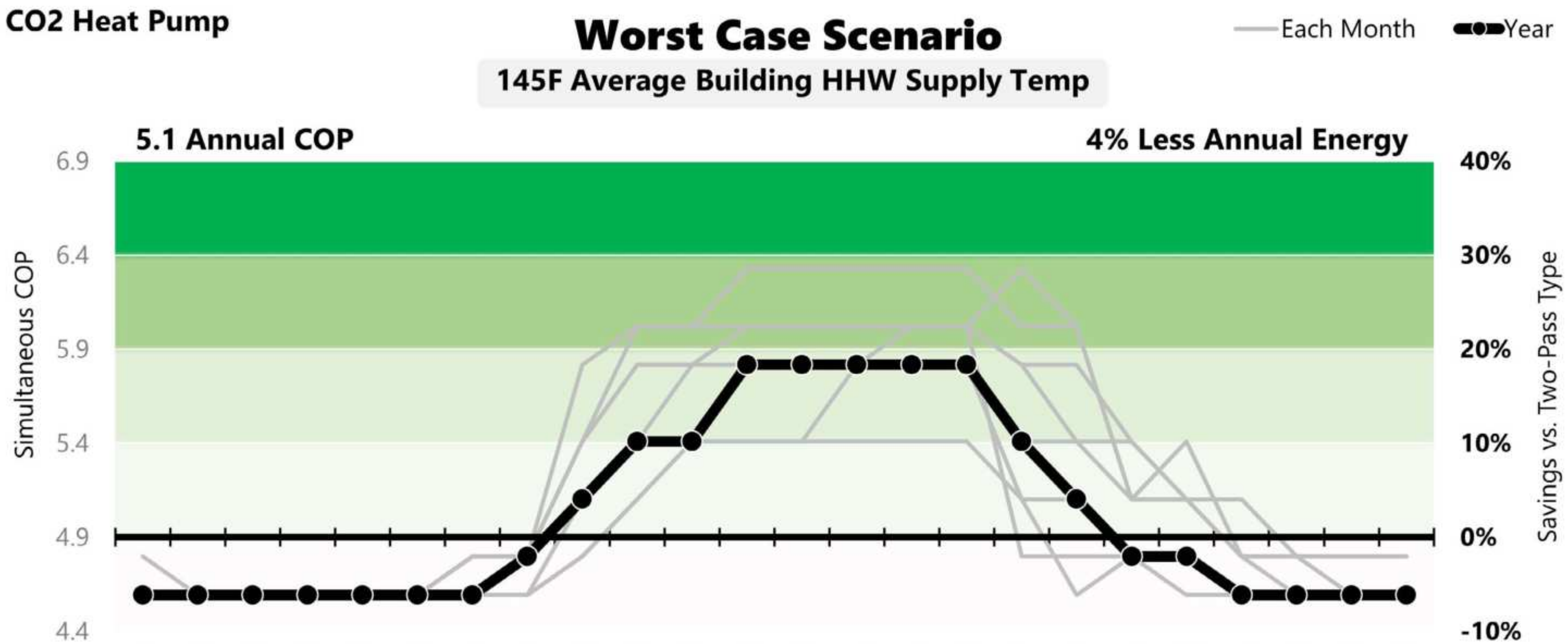


	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
Jan	106	106	107	107	107	107	106	106	104	100	97	96	95	94	94	94	98	100	101	102	105	105	105	105
Feb	106	106	107	107	107	107	106	106	103	99	96	94	93	93	92	92	104	104	104	104	105	105	105	106
Mar	106	106	106	106	106	106	106	105	101	96	94	92	92	91	90	91	95	97	104	104	104	105	105	105
Apr	106	106	106	106	106	106	105	103	99	95	93	92	91	90	90	90	94	96	97	104	105	105	105	106
May	106	106	106	106	106	105	104	103	98	95	94	93	92	92	91	91	94	96	95	98	102	105	105	105
Jun	104	105	106	106	105	105	104	102	96	92	90	89	89	89	88	89	91	92	98	99	102	103	103	104
Jul	104	105	105	105	105	105	103	102	94	90	89	88	87	88	87	87	91	91	97	100	101	103	103	104
Aug	105	105	105	106	105	105	104	103	93	88	87	85	85	85	84	84	88	88	100	96	102	103	105	105
Sep	105	105	105	106	105	106	104	103	97	92	90	89	89	89	88	89	86	89	97	101	101	103	103	104
Oct	105	105	106	106	106	106	105	103	97	92	90	90	89	89	89	89	93	94	98	99	102	103	103	103
Nov	106	106	106	107	106	107	106	106	101	95	92	91	91	90	90	90	101	104	104	104	105	105	105	105
Dec	106	106	107	107	107	107	106	106	104	100	97	95	94	93	93	94	97	113	105	105	105	106	106	106
Year	**106**	**106**	**106**	**106**	**106**	**106**	**105**	**104**	**100**	**96**	**94**	**92**	**92**	**91**	**91**	**91**	**95**	**97**	**101**	**102**	**105**	**105**	**105**	**105**

CO2 Heat Pumps

We also examined a worst-case scenario where all buildings on average need 145F HHW supply water temperature. In this worst case scenario, the CO2 Heat Pumps still have a higher annual COP (5.1) than the Two-Pass type (4.9).

All together, we strongly recommend CO2 type Heat Pumps and the Building Connection Assemblies that ensure lower return heating water temperature, given the ability to use an air-source instead of requiring geothermal, its significantly higher potential efficiency, the good fit with UCSB's mix of loads and weather, and university desire to serve all heating (both space and hot water) with a centralized high-temp campus heating loop.



	12 AM	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 PM	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM
Jan	119	120	120	120	120	120	120	120	116	111	107	105	105	103	103	103	108	111	113	113	118	118	118	118
Feb	119	120	120	120	120	120	120	119	116	110	106	103	102	101	101	101	116	117	116	116	118	118	118	119
Mar	119	120	120	120	120	120	119	118	112	106	103	101	100	99	98	99	104	107	116	116	117	118	118	118
Apr	119	120	120	120	120	119	118	116	110	104	102	100	99	97	97	98	103	105	107	117	118	119	119	119
May	119	120	120	119	120	119	117	115	109	104	103	101	100	100	99	99	104	106	105	109	115	118	118	119
Jun	117	119	119	119	119	118	116	114	105	100	98	96	96	96	95	95	99	101	109	111	114	115	116	117
Jul	117	118	118	119	118	118	116	114	103	97	96	94	94	95	94	94	99	99	107	111	113	115	116	117
Aug	118	118	119	119	119	118	117	115	102	95	93	91	91	91	90	90	94	94	111	106	114	116	118	118
Sep	118	118	119	119	119	120	117	116	107	100	98	96	96	96	95	96	91	96	108	112	112	115	116	117
Oct	118	118	119	119	120	119	118	116	107	100	98	97	96	96	96	96	101	103	109	110	114	115	115	115
Nov	119	120	120	120	120	120	120	120	112	104	101	99	99	98	97	97	113	117	117	117	118	118	119	119
Dec	120	120	120	120	120	120	120	120	116	112	107	104	103	102	102	102	108	129	117	118	119	119	119	120
Year	**119**	**119**	**120**	**120**	**120**	**120**	**119**	**117**	**111**	**106**	**103**	**101**	**100**	**99**	**98**	**99**	**104**	**108**	**113**	**114**	**118**	**118**	**119**	**118**

Thermal Storage and Campus Distribution

Currently, UCSB does not have backup power to its district cooling or heating systems. Accordingly, any building on campus that has an emergency backup generator does not have a heating or cooling system on backup power. Furthermore, with the electrification of hot water, without a backup system, buildings would not have hot water in a power outage.

We recommend providing a 4 hour, 700kW (2.8 MWh) battery backup power system to the central plant that serves the hot and cold storage tank pumps along with the campus hot and chilled water distribution pumps. Additionally, we recommend providing a total of 70kW of battery backup for each building's pump that delivers heat to the DHW indirect water heaters (distributed amongst every building connected to the central plant).

At any given moment UCSB might lose power it is very likely that the hot and cold storage tanks will be at least partially filled with hot and cold water, as they are being charged every day. By backing up the pumps to move that stored hot and cold out to campus buildings, UCSB can provide heating and cooling to any building that has emergency power for space conditioning systems, and by backing up the DHW indirect water heat pumps at each building, UCSB can provide heating for hot water to all buildings in a power outage.

A nice benefit of the battery approach, is it is sized larger to handle motor start (3x larger), so the available energy storage capacity is very large relative to the peak power discharge, once the pumps are up and running. Accordingly, the battery can be used to store PV generation and use it later during peak rate times when it is worth more (saving UCSB money), while still preserving full ability to start motors and provide energy for the duration of a power outage.

This approach requires a significantly smaller battery than backing up even one 500 ton heat pump, and orders of magnitude smaller than backing up the entire central plant.

Given constraints from the air resource board regarding particulate emissions from a diesel generator, we recommend a battery backup system. By just backing up the pumps, it allows for an orders of magnitude smaller battery then backing up the whole plant, even when accounting for increased size for motor start, making it a feasibly affordable option.

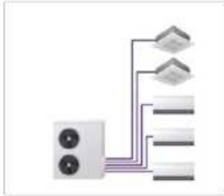
This is a nice compromise compared to backing up the entire central plant or all of campus, as some of other UC institutions are challenged with doing given their existing fossil-fuel powered co-generation power plants.

Building Dedicated Heat Pumps

For the buildings that cannot be connected to a future central plant, we recommend using air-source heat pump technologies to individually electrify each buildings' heating and hot water. Depending on existing conditions, this may include a variety of products and approaches.

The table here provides a general overview of the types of building independent heat pumps and their typically best scales of application.

These type of space heating air-source heat pumps produce at most 130°F supply water, so some building retrofits may be needed to accommodate lower temperature supply water. All of the domestic hot water heat pumps produce the industry standard 140°F+ hot water.

Space Heating	Rooftop Package Unit	Air-to-Water Heat Pump	Split System	VRF*
				
	Use integral heat pump to provide heating and cooling via ducted air	Generates Heating Hot Water (HHW) to circulate through existing HHW piping	Outdoor unit feeds nearby dedicated indoor fan coils connected via refrigerant lines	Outdoor unit feeds multiple indoor fan coils over building via long refrigerant lines.
Ideal Scale				
Small	✓		✓	
Medium		✓		✓
Large		✓		

Domestic Hot Water	Hybrid Electric Heat Pump	CO2 Air-Source Heat Pump
		
	Indoor tank has small heat pump + full electric resistance. Heat pump ducted to outside.	Outdoor unit makes heat for hot water stored in storage tanks
Ideal Scale		
Small	✓	
Medium		✓
Large		✓

Notes:
* VRF systems have large volumes of high global warming potential (GWP) refrigerant that are circulated through field fabricated piping notorious for leaking. While a somewhat popular all-electric solution, it has very high maintenance costs and is difficult to maintain as it is all controlled by a "black box". There are also regulatory concerns with high GWP refrigerants. We recommend only using VRF if there are no other viable options.

Thermal Storage Credit

We recommend pursuing the Thermal Energy Storage provision of the Investment Tax Credit (ITC) in the Inflation Reduction Act (IRA), as this has the potential to be worth upwards of $80 Million in cash payment for UCSB or the funding institution.

Since the recommended approach includes thermal energy storage in a fully integrated manner, the entire cost of the central plant system, campus distribution, and building connections qualify for a cash payment worth up to 30% of that total cost.

Directly Related Components (100% of the full 30% credit)
(e.g. Thermal Storage Tanks, direct piping and pumps, etc)

Hybrid Components (75%+ of the full 30% credit)
(e.g. All Other Central Plant Equipment and District Piping and Building Connections)

Could be Upwards of $80 Million
Depending on time of phasing.

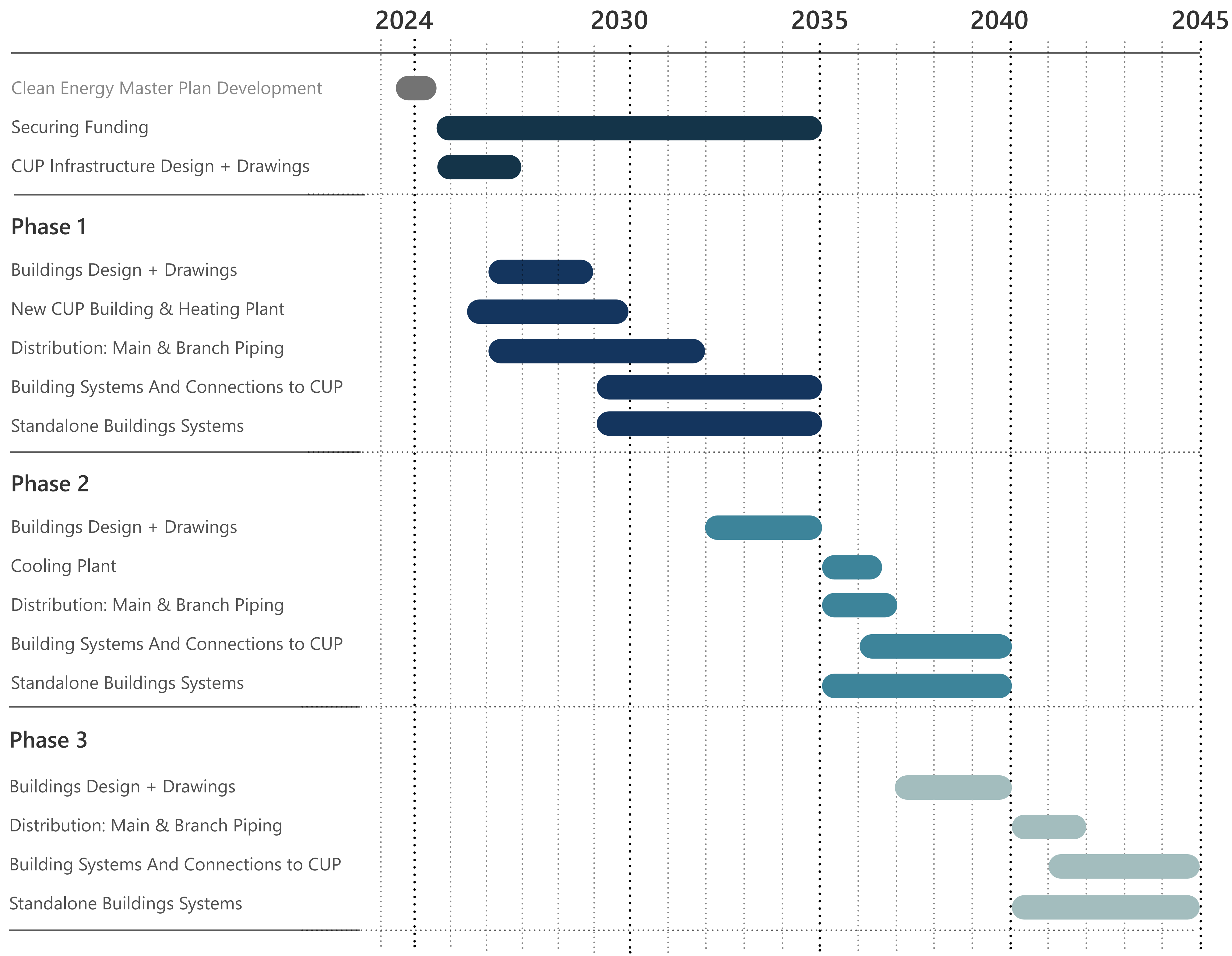
In order to best position UCSB for securing this cash payment, we recommend working with a tax specialist who is experienced with ITC submissions and the IRA. There are many such firms available.

Prioritization and Phasing

As UC Santa Barbara starts its transition to achieve 90% reduction in Scope 1 emissions from fossil gas use in campus energy systems by 2045, it will need to consider phased design and implementation. This will primarily help to align with progressive funding opportunities, avoid high deferred maintenance costs, limit interruptions to access during construction for long periods of time, and allow for more efficient and sustainable staff resourcing.

Phasing suggested herein considers 1) Priority Infrastructure, 2) Heating and Cooling Loads, 3) Carbon Emissions Reduction, 4) Avoided Deferred Maintenance Costs, and 5) Building Prioritization. Other factors that will indirectly impact the phasing include Operations & Maintenance (O&M) Cost Savings, Avoided Labor Costs and Equitable Access. While the final implementation will vary based on actual availability of funding, it is highly suggested that the university follow the components in each phase as closely as possible to minimize disruptions, maximize savings and cost-effectiveness, and to allow for all new buildings and major upgrades to have access to the highly efficient new central utility plant and infrastructure immediately, avoiding redundancies and high costs and saving time and labor.

Securing funding is a critical component governing implementation. This must be prioritized and pursued immediately to ensure timely construction of central plant infrastructure and main distribution to serve the existing and upcoming new developments as early as 2027. A detailed exercise to understand all available funding opportunities such as the IRA tax credits, Energy Savings Performance Contracting (ESPC), green revolving funds, etc. must be conducted to inform the extents of execution in each phase. Living Lab opportunities – existing and new, may be leveraged to engage potential donors and alumni.



It is highly recommended that equipment replacement plans be used to inform and modify the suggested phasing, as needed. Such alignment will save time and money. For example, as a building-level chiller approaches end of life, branch piping to this building may be prioritized to connect to the district system and avoid installing a new building-level chiller. Alternatively, a new chiller may be selected that is equivalent to one needed in the new CUP and relocated there when the piping distribution is in place.

Other Determining Factors

Building Prioritization

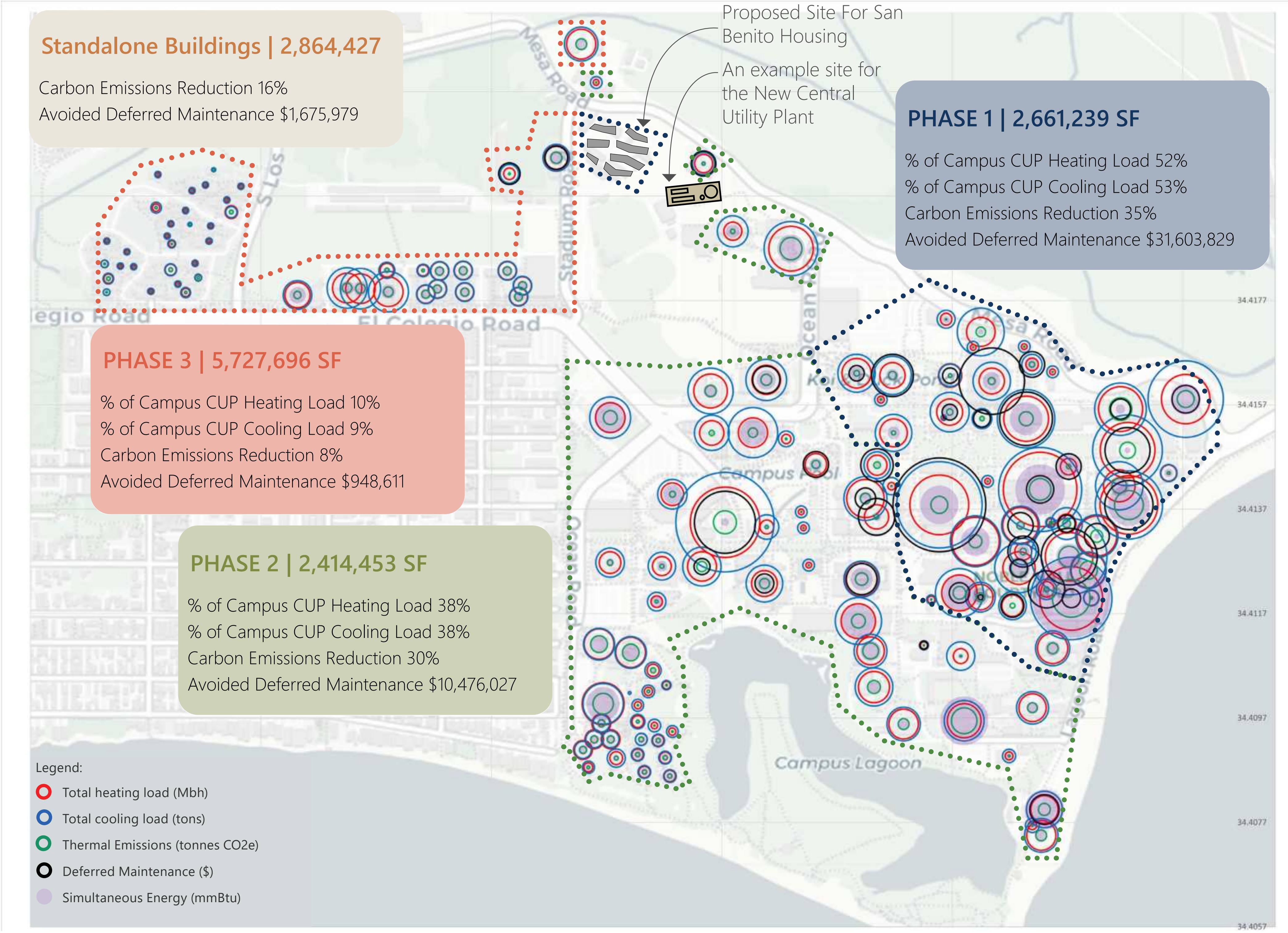
Recommendations around building prioritization consider 1) total heating and domestic hot water loads, 2) total cooling load, 3) potential for simultaneous heating and cooling, 4) potential to avoid deferred maintenance costs (as seen in 2024) and 5) total absolute carbon emissions for each building. The goal would be to focus on buildings with high energy use intensities and absolute carbon emissions.

Buildings should also be prioritized based on proximity to each other allow for faster and cost-effective construction schedules with minimum disruption.

Buildings not connected to the Central Plant should be phased to align with equipment replacement plans, capital planning as well as emissions reduction potential.

Electrification of suggested buildings (CUP and standalone) have the potential to reduce the campus scope 1 emissions by 47%* at the completion of Phase 1.

*compared to 2019 baseline



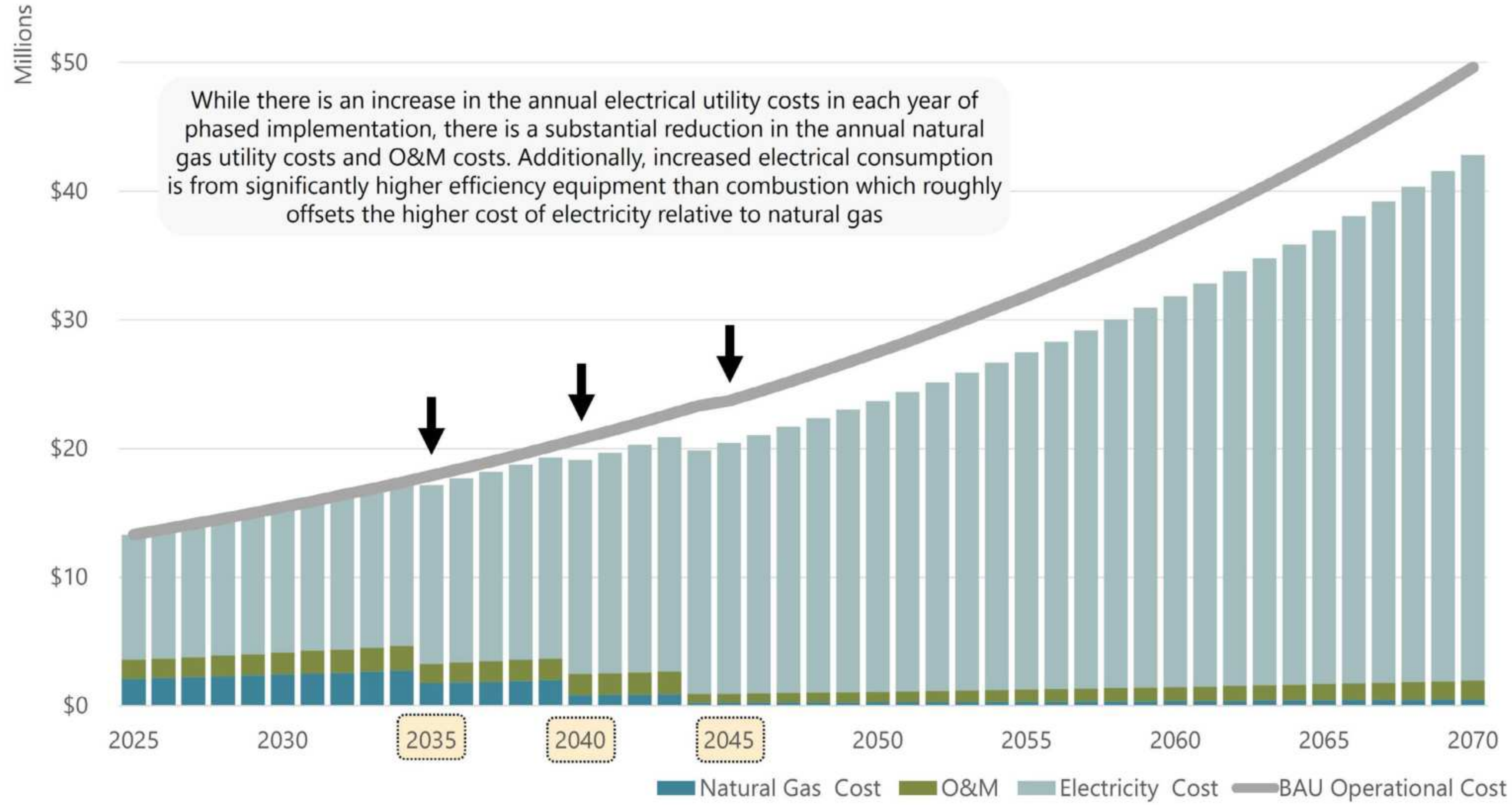
Standalone buildings not shown on this map

Other Determining Factors

Central Utility Plant

Implementing the New Central Utility Plant (CUP) building will be the first step towards the transition away from fossil fuel-based space heating and hot water heating. Prioritizing this along with the main campus thermal loop (heating hot water and chilled water distribution piping mains) will allow for any existing building to be electrified and connected to the plant. This will also ensure additional capacity for any new campus developments or major building renovations in the pipeline, as long as these are in close proximity to the campus thermal loop. The plant provides the benefit of higher efficiency equipment and therefore, higher operational savings; leverages coincident heating and cooling loads across campus for heat recovery; and enables for all new additions on campus to be all-electric.

When implementation is done in phases with the Central Utility Plant being implemented early on, there is a proportional increase in the returns on investments, thus making it more cost effective over time and reducing the overall total cost of ownership.



Not all central plant equipment needs to be installed on Day 1. Any equipment serving spare or future capacity may be installed later. Similarly, future equipment replacements can be made for higher capacities, however, the plant building itself must be sized for adequate space and clearance for additional/ larger equipment and connections.

Other Determining Factors

Campus Thermal Piping Distribution

The main campus thermal loop consisting of the heating hot water and chilled water distribution piping should be done in parallel with the CUP implementation. Prioritizing piping distribution will be key to accessing the high equipment efficiencies and emissions reduction that come from connecting to the all-electric CUP. Once the CUP and piping are in place, building conversions including connections to buildings and building level equipment upgrades can be initiated. Piping loop distribution should be implemented in several phases to align with funding and offer flexibility in construction schedules, thus minimizing disruptions around campus. In this case, main piping should be prioritized with the CUP, and branch piping in parallel with building upgrades informed by building prioritization. **See following pages for recommended phased chilled water and hot water pipe distribution and pipe sizing.**

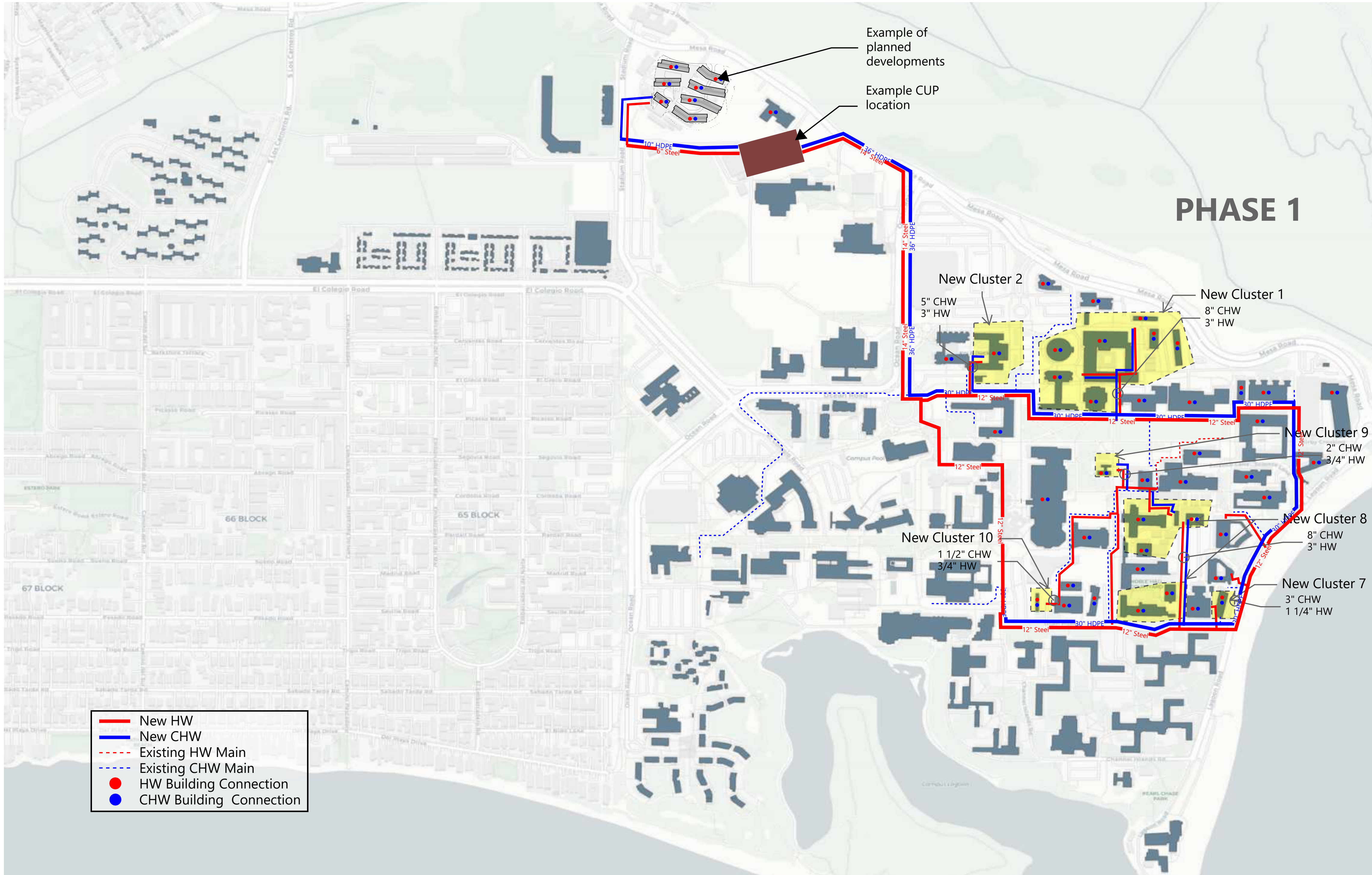
Reliability and Redundancy

It is recommended that existing systems be kept in place for a minimum of one year in newly decarbonized buildings to ensure reliability and a smooth transition prior to decommissioning natural gas service to the buildings. Similarly, equipment serving current campus loop (chillers and cooling towers) is recommended to be maintained as the campus transitions to all-electric systems and installs new central plant equipment. This would ensure sufficient capacity and occupant comfort until all equipment comes online in 2045.

New Buildings & Renovations on Hydronic Heating Only

Current UCSB design guidelines ask for all new construction to be all-electric. Design guidelines should be updated to include that all new construction and major upgrades on campus should have hydronic based heating and should connect to the central loop, when possible. Electric resistance should not be allowed as this is a much less efficient system and will not be a cost-effective solution.

Phase 1

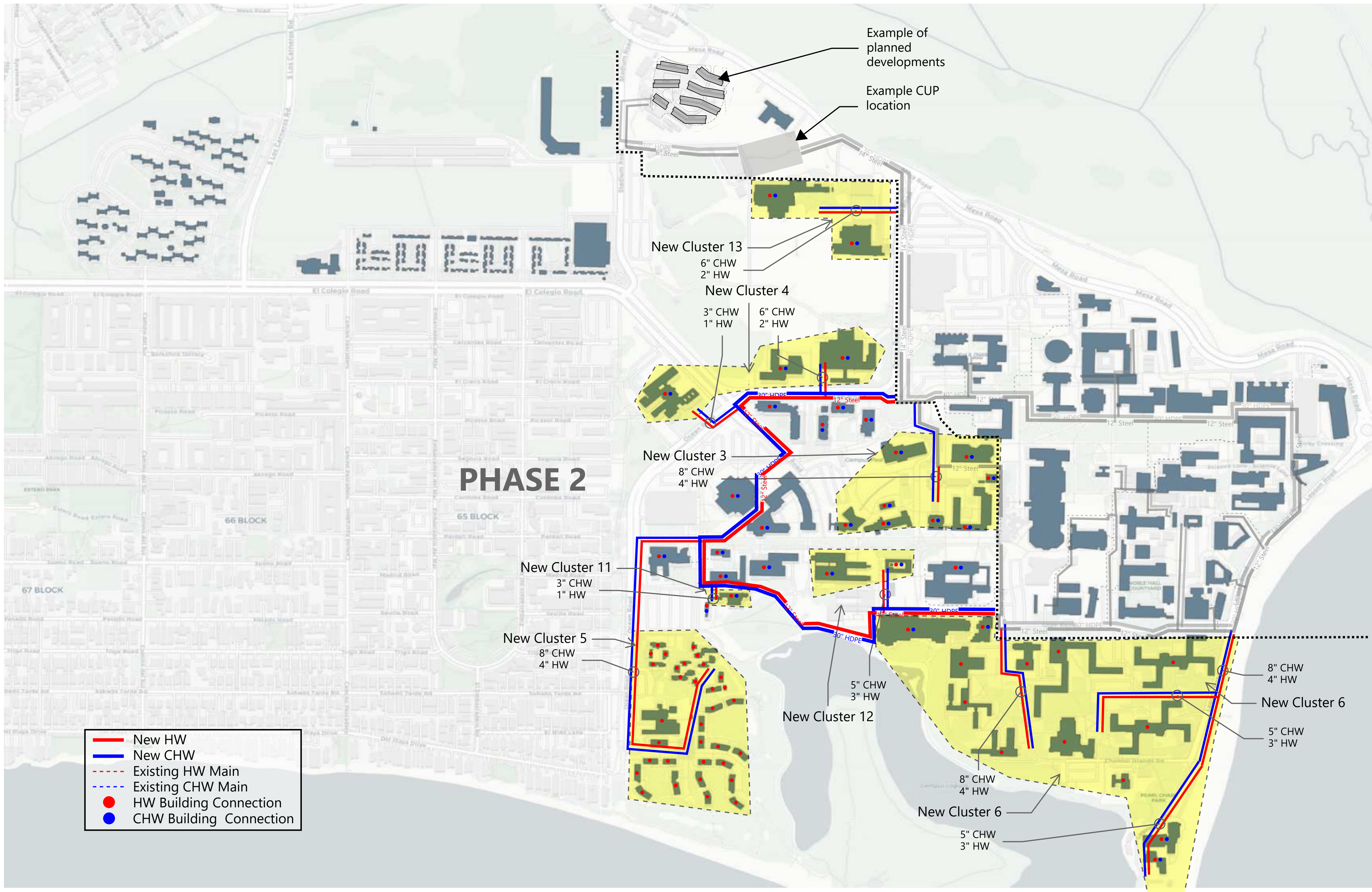


Phase 1 involves the following main components

- Building the Central Thermal Plant building
- Installing the Heating Equipment in the Central Plant
- Running Pipe Main Distribution for Hot and Chilled throughout Campus
- Connecting Phase 1 Buildings

This first step gets the new central plant heat pumps, electric boilers, and hot thermal storage online so they can serve all heating needs for the Phase 1 buildings and also contribute to the existing campus chilled water system via cooling from simultaneous production. This approach allows the existing fossil fuel based heating to be gradually taken offline as the system is commissioned and any kinks are worked through. Additionally, the existing campus chilled water system chillers can continue to provide cooling, with some taken out of service at end of life as desired, since the new central plant heat pumps can operate in cooling only. These critical first steps support the next infrastructure in Phase 2.

Phase 2

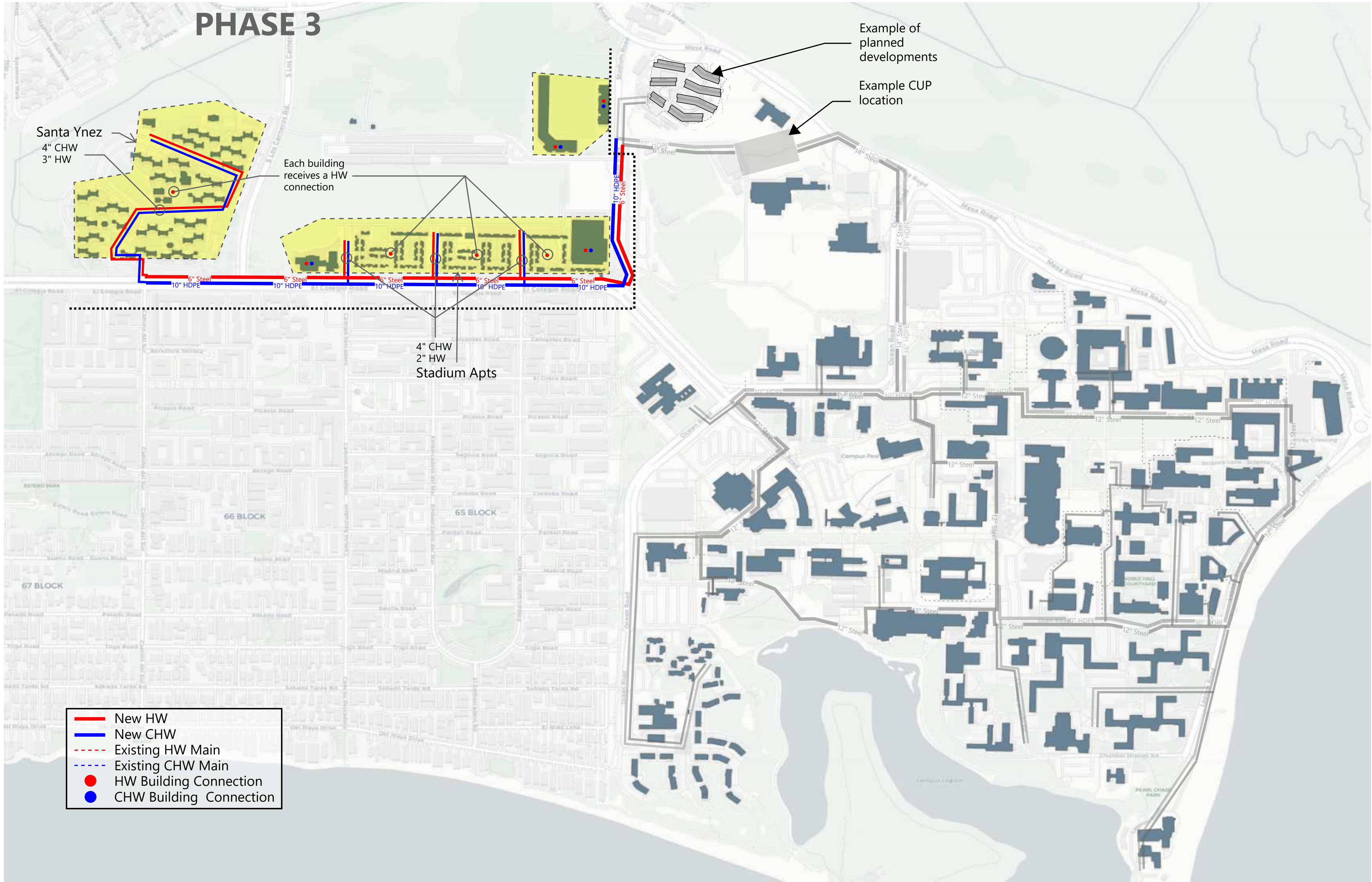


Phase 2 involves the following main components

- Installing the Cooling Equipment in the Central Plant (completing plant)
- Running Pipe Main Distribution for Hot and Chilled throughout more of Campus
- Connecting Main Campus Distribution into a Loop for service flexibility
- Connecting Phase 2 Buildings

This next step gets the new central plant chillers, cooling towers, and cold thermal storage online so they can serve all the cooling needs for Phase 1 and 2 buildings (as well as any future loads). This approach allows the existing campus chilled water system chillers to be gradually taken out of service at end of life as desired, since the new central plant heat pumps can provide full cooling. This critical step marks the completion of installation and initializing operation for most of the campus infrastructure.

Phase 3

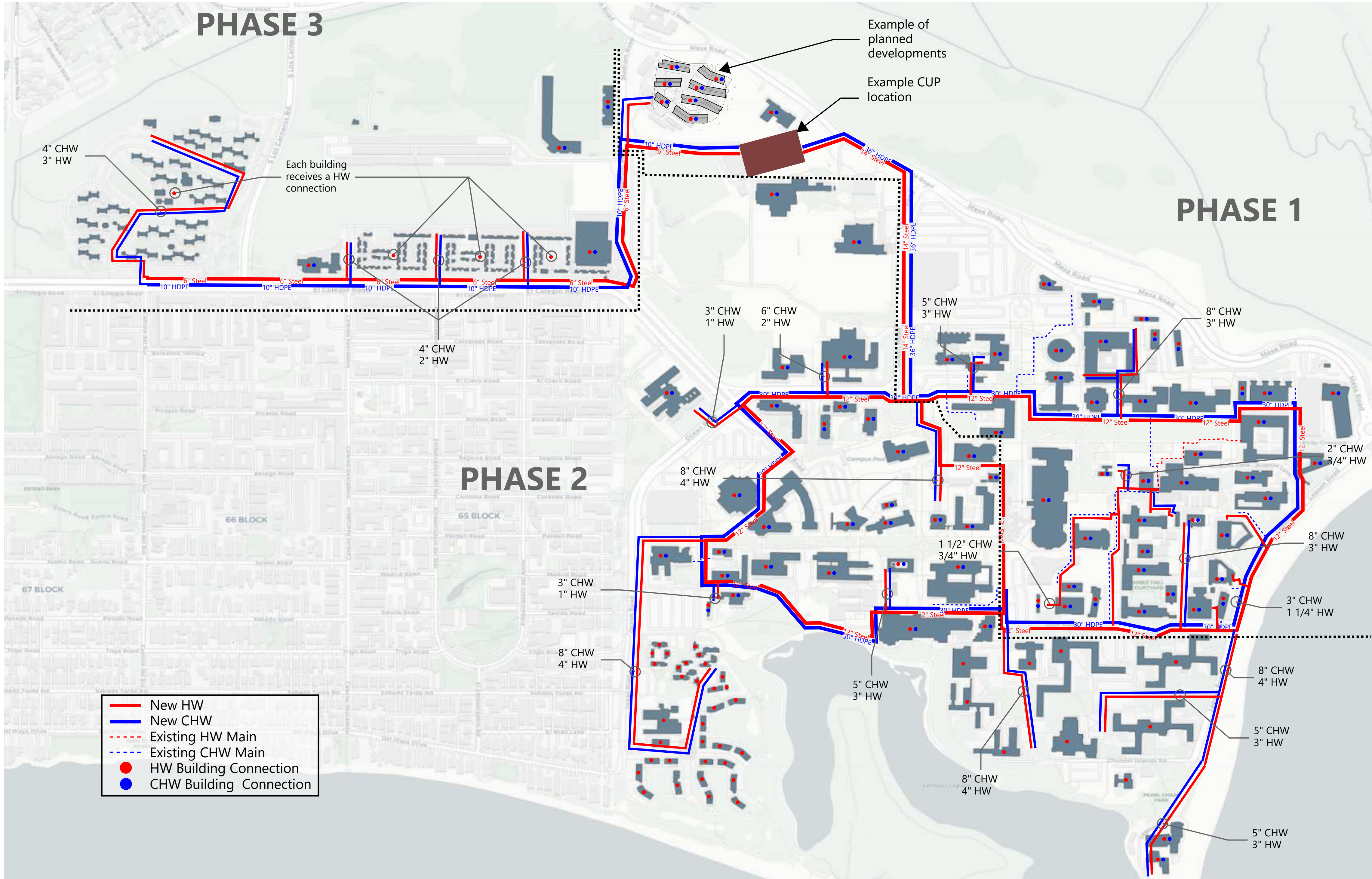


Phase 3 involves the following main components

- Running Pipe Distribution for to Phase 3 region buildings
- Connecting Phase 3 Buildings
- Installing Standalone Heat Pumps at Off-Campus Buildings
- Successful completion of electrifying all UCSB heating and hot water

This last step connects the remaining buildings to the new campus district system. Additionally, all off-campus buildings switch to heat pump based heating and hot water. This effort can be done earlier than Phase 3, and is the last aspect to be completed before the 2045 deadline. This final step marks the completion decarbonizing all UCSB heating and hot water and full operation of a new efficient and resilient campus district heating and cooling plant.

All Phases Together



All Phases Together involves the following main components

- Campus Central Plant (provides all heating and cooling)
- Hot and Cold Pipe Distribution throughout Campus
- Main Campus Buildings connected to New District System
- Off-Campus Buildings served by Standalone Heat Pumps

By the completion of Phases 1, 2, and 3, UCSB will have a new efficient and reliable heating and cooling infrastructure throughout main campus supporting the university's reliable operation, academic goals, budget, and environmental mission. This infrastructure will position UCSB for decades to come with room for growth as climate and needs evolve.

Summary of Recommended Phasing

Phase 1

2030

- Central Utility Plant Building
- Central Plant Heating Equipment
- Piping Main Distribution across Campus and Branch Piping to Phase 1 Buildings
- Phase 1 Building Systems Infrastructure and Building Connections
- Standalone Buildings Infrastructure

Phase 2

2040

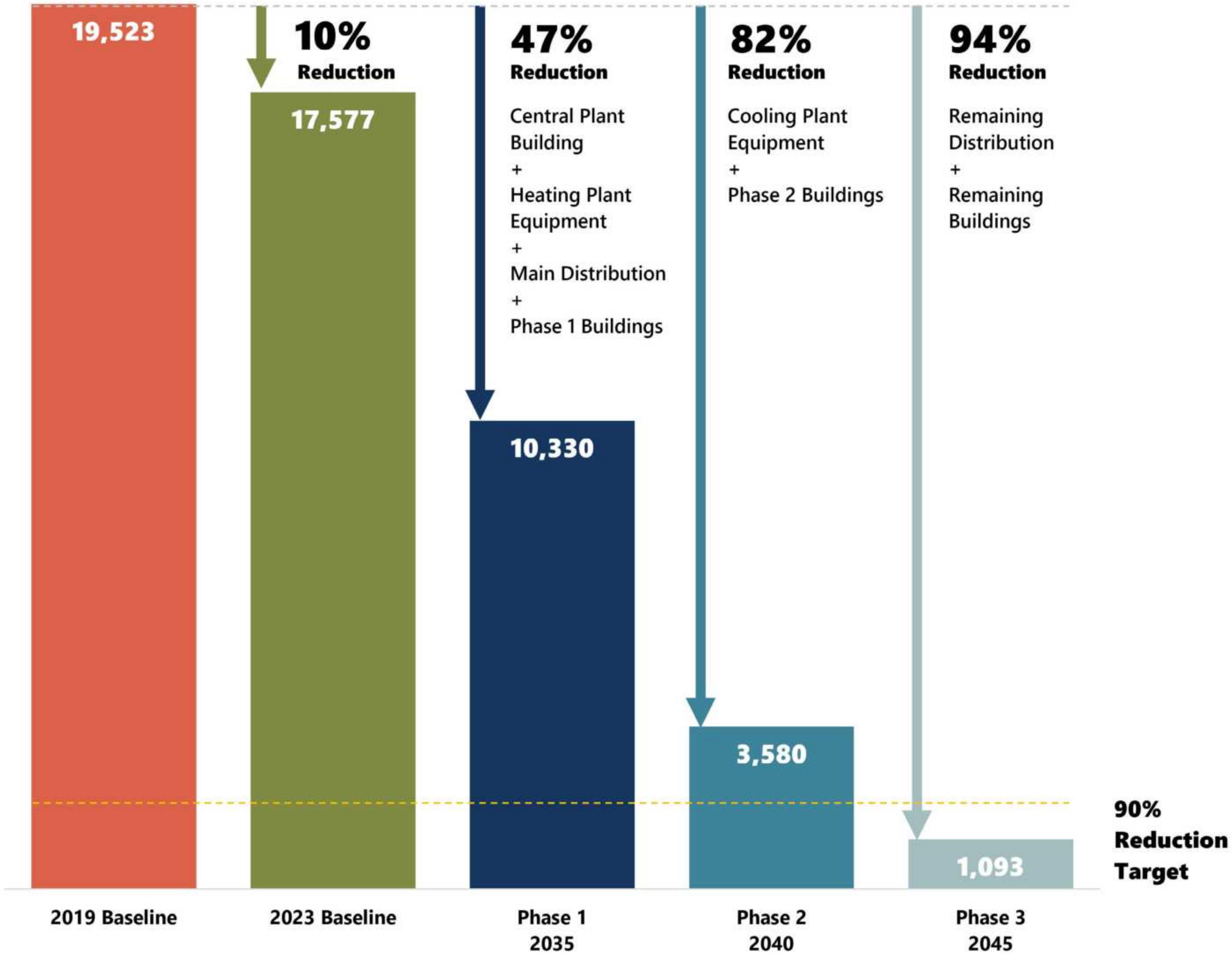
- Central Plant Cooling Equipment
- Branch Piping Distribution to Phase 2 Buildings
- Phase 2 Building Systems Infrastructure and Building Connections
- Standalone Buildings Infrastructure

Phase 3

2045

- Branch Piping Distribution to Phase 3 Buildings
- Phase 3 Building Systems Infrastructure and Building Connections
- Standalone Buildings Infrastructure

Phased Natural Gas Emissions Reduction (MTCO2e)



Future Developments

All heating and cooling equipment for the New Central Utility Plant has been sized to accommodate future growth and changes in usage. Cooling plant equipment has been sized for an Outdoor Air Dry Bulb (OADB) design temperature of 97°F to allow for spare capacity as well as address the increasing frequency and duration of warmer temperatures in future.

Heating equipment, designed for OADB design temperature of 33°F, has been sized for an additional 25% spare capacity for the systems to be conducive to load shifting, storage, and redundancy. However, this additional capacity is also available to serve all future expansions and new loads.

Similarly, cooling plant equipment in conjunction with thermal storage (chilled water) can provide an additional 40% in spare capacity beyond that 97°F design condition, depending on the peak instantaneous campus cooling load.

Thermal storage must be installed at the same time as the rest of the cooling equipment to allow for maximum operational savings as well as the spare capacity.

All new campus piping mains have been sized to serve increased load capacity, along with any existing pipe mains that will be used.

In summary, all equipment sizing reflects a healthy buffer capacity for adapting to future loads and climate conditions. Additionally, the central plant building has been sized with some spare room for future plant equipment replacements with larger sizes.

Rendering for the in progress UCSB San Benito Student Housing development on the northwest corner of the main UCSB campus

UCSB Clean Energy Master Plan

Saves

432,500 MTCO2e
in GHG Emissions

$120M
in Operational Cost

through 2070

Electrify all Heating and Hot Water
Eliminate 94% of UCSB Scope 1 Emissions

Centralized Campus Thermal Plant
Provides Cooling, Heating, and Hot Water

Thermal Energy Storage Tanks
~50% of all Thermal Work made Simultaneously

High-Temp Heat Pump Chillers
Allows for just Pumps and Valves at each Building

Air-Source CO2 Type Heat Pumps
Save ~20% Electricity Leveraging Mild Climate

Optimized Size and Operation
Minimize Energy Cost, Balanced with Investment

Battery Backup Power
Use Tanks as Batteries, and Backup Pumps

Reclaimed Water and Treatment
Reduce Potable Water Use for Cooling Towers

Prioritize Building Plant and Distribution
Central Backbone and Main Piping

Phase by Emissions, Proximity, Maintenance
Accelerate Impact and Avoid Repairing Abandoned Assets

EXISTING CONDITIONS
CAMPUS DECARBONIZATION OPPORTUNITIES
TOOLKIT: TECHNOLOGIES & COMPONENTS
SOLUTIONS
EVALUATION CRITERIA
OPTIONS COMPARISON
RECOMMENDATIONS

NEXT STEPS

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 The California Environmental Quality Act (CEQA) and required analysis.

Dimensions and access clearances required for the different Central Plant components (equipment and accessory equipment) to support spatial planning and sizing at any other site on campus, should it be determined that the Eucalyptus Grove is not feasible site for the CUP, have been provided.

Additional contingency has been assumed for the Central Plant construction costs (as part of the Capital Costs) to allow for the additional seismic mitigation for each scenario with a Central Plant.

CUP will be designed to be resilient to flooding. Electrical and mechanical equipment being upgraded during electrification should be designed to be protected from stormwater ingress and flood damage.

An example site for the New Central

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)

ENVIRONMENTAL EQUITY AND JUSTICE

4

Overview - Environmental Equity and Justice

This section provides an overview of contents covered within the environmental equity and justice chapter. Objective 3 identifies environmental justice and equity considerations related to the transition of to fossil fuel free infrastructure. Through extensive research, document review, and community outreach, the project identifies potential concerns and groups that may be impacted, and recommends best practices to ensure that future decarbonization efforts are equitable and inclusive.

Current Context

- Equity & Environmental Justice at UC Santa Barbara
- Climate Justice Principles

Methodology & Findings

- Equity as a Process
- Equity Informing Decarbonization
- Equity Indicators
- Outreach Strategies
- Outcomes and Best Practices

Recommendations

- Overview and Importance
- Equity Performance Metrics
- Community Engagement Plan

Next Steps

- Next Steps
- Future Action

CURRENT CONTEXT
METHODOLOGY AND FINDINGS
RECOMMENDATIONS
NEXT STEPS

Incorporating Environmental & Climate Justice into Climate Action

Scope and Purpose

The original scoping document of this project included an equity component, where the importance of assess labor vulnerability and developing equity indicators was stressed. They also outlined four major climate and environmental justice concepts to be included.

- Procedural: Fairness of the decision-making process
- Recognition: Respecting different values, cultures, opinions and structures within communities
- Distributive: just allocation of resources, benefits, and burdens
- Restorative: responsive to those impacted by the transition

Referencing University of California Framework

The University of California system has created a guide for campuses to follow when creating their climate protection plans. This guide contains environmental justice principles, best practices to see those principles in action, and indicators that can help evaluate the actions. This is to make sure that climate focused actions also consider how the impacts on disadvantaged communities.

Environmental and Climate Justice Principles

COMMUNITY POWER	ECONOMY	HEALTH IMPACTS	WASTE
HOUSING	NATURAL RESOURCES	TRANSPORTATION	FOOD SYSTEMS

Potential Considerations during Implementation Phase and/or Procurement

COMMUNITY EXPERIENCE	WORKFORCE DEVELOPMENT & JUST TRANSITION	LAND & ENVIRONMENTAL STEWARDSHIP

Terminology - Acronyms and Definitions

An **Environmental Equity Approach** recognizes disparities in the distribution of environmental benefits and burdens within and across communities, and seeks to meet individual and community needs.

Climate Action Stepped-up efforts to reduce GHG emissions and strengthen resilience and adaptive capacity to climate impacts and hazards; integrating climate change measures into policies, strategies and planning; and improving education, awareness-raising and human and institutional capacity with respect to climate change mitigation, adaptation, impact reduction and early warning.

Climate Justice insists on a shift from a discourse on greenhouse gasses and melting ice caps into a civil rights movement with the people and communities most vulnerable to climate impacts at its heart. Climate justice acknowledges climate change can have differing social, economic, public health, and other adverse impacts on underprivileged populations. Advocates for climate justice are striving to have these inequities addressed head-on through long-term mitigation and adaptation strategies.

In context of UC Santa Barbara Campus

The following climate justice principles of the UC Framework for Incorporating Environmental & Climate Justice into Climate Action have been identified for an in-depth exploration to ensure an equitable and environmentally just transition away from fossil fuel based thermal infrastructure.

Community	Decarbonization projects should not just take equity into account, but center it as a key goal • "Prioritize solutions for frontline communities as they represent predominantly low-income communities of color that experience the 'first and worst' climate outcomes". Other frontline communities that must be involved are houseless students, undocumented students, public transit-dependent students, disabled students, and others. • Climate action and decarbonization plans on campus will consider equity and access to clean power for neighboring communities or low-income neighbors of the university.
Health Impacts	Decarbonization projects will not negatively impact public health • All campus community shall have a right to a safe work environment • Climate action will improve local environment
Transportation	Maintaining accessible transportation options throughout campus • Minimize disruption to transportation routes around campus in construction and implementation phases during the clean energy transition.
Economy	Decarbonization efforts are inclusive in reducing emissions throughout campus and inclusive of considering impacts to general staff • Campus communities are included in the creation of or transition to high quality green jobs that provide security, and worker representation

CURRENT CONTEXT

METHODOLOGY AND FINDINGS

RECOMMENDATIONS

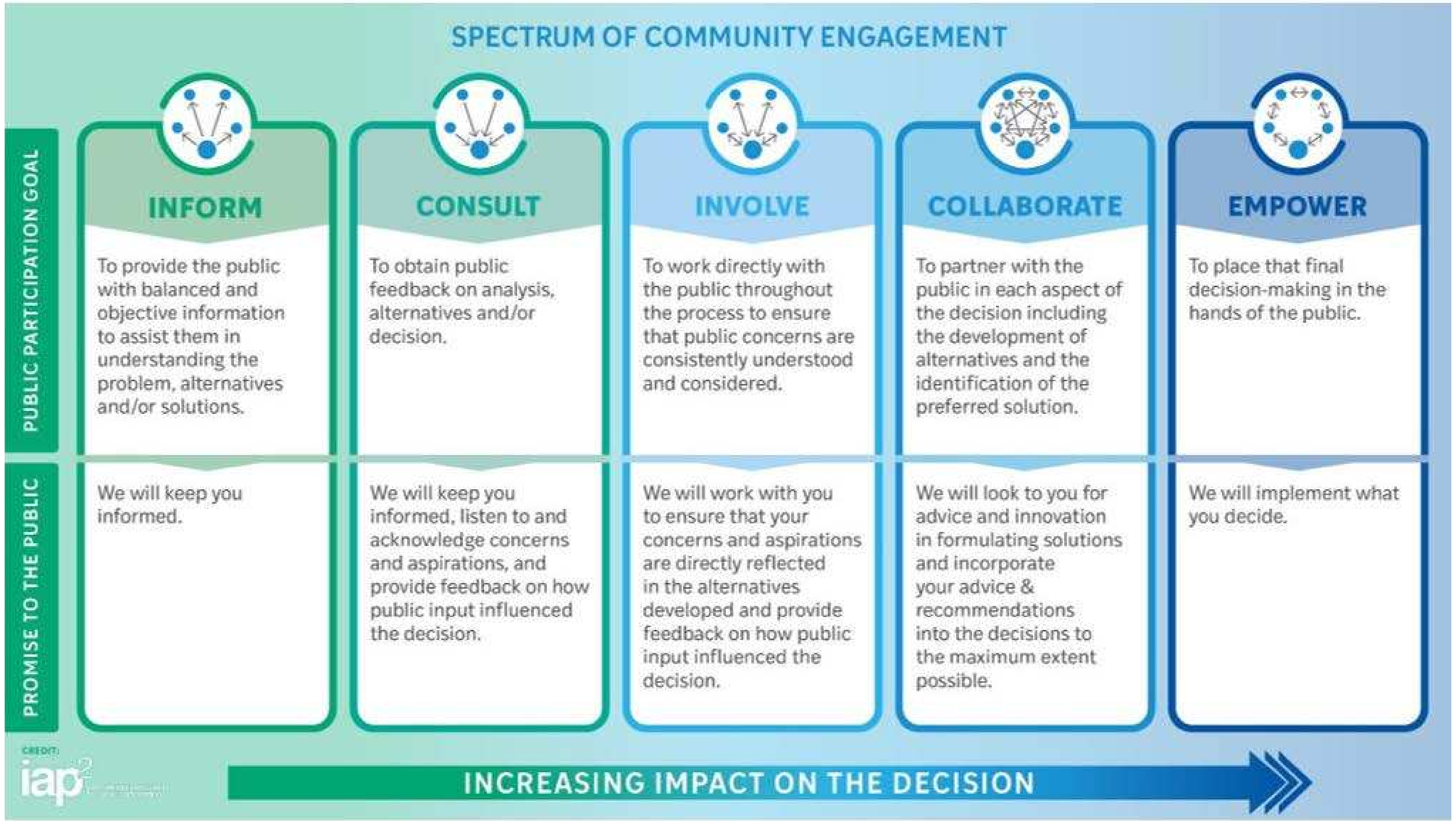
NEXT STEPS

IAP2 Spectrum of Community Engagement

Community input was sought throughout the project development to gauge climate justice concerns and provide clarity regarding project implementation, ecological protection, and equitable accessibility. We have strived to identify and work towards community priorities in climate action.

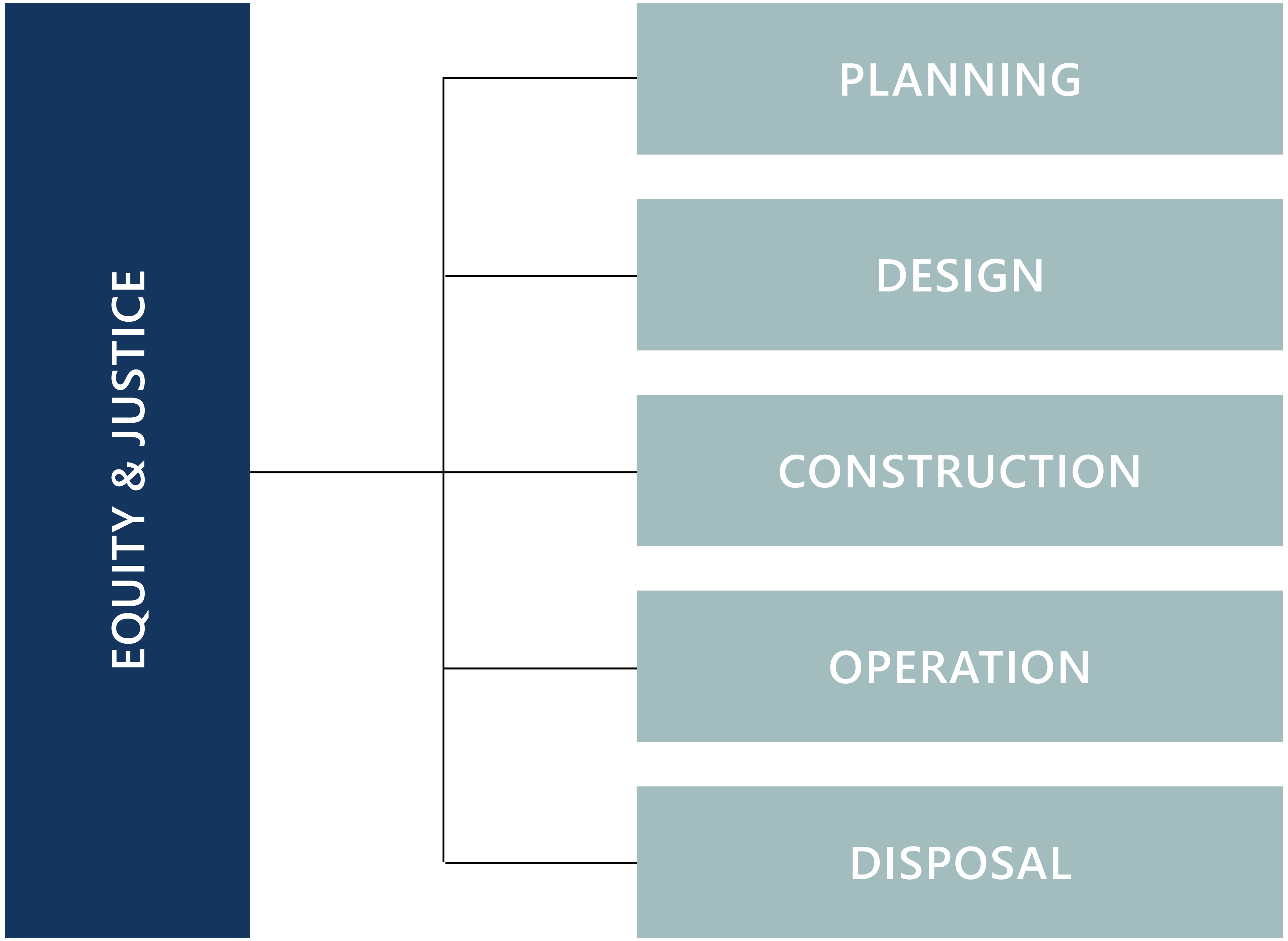
Previous and future strategies can and should include:

- Departmental/student org planning efforts,
- Community-hosted forums,
- Collaborative partnerships, coalitions,
- Policy development and advocacy,
- Community surveys,
- Newsletters and Townhalls, and
- Facilitation opportunities



Equity and Justice should be considered and integrated at each phase of the project.

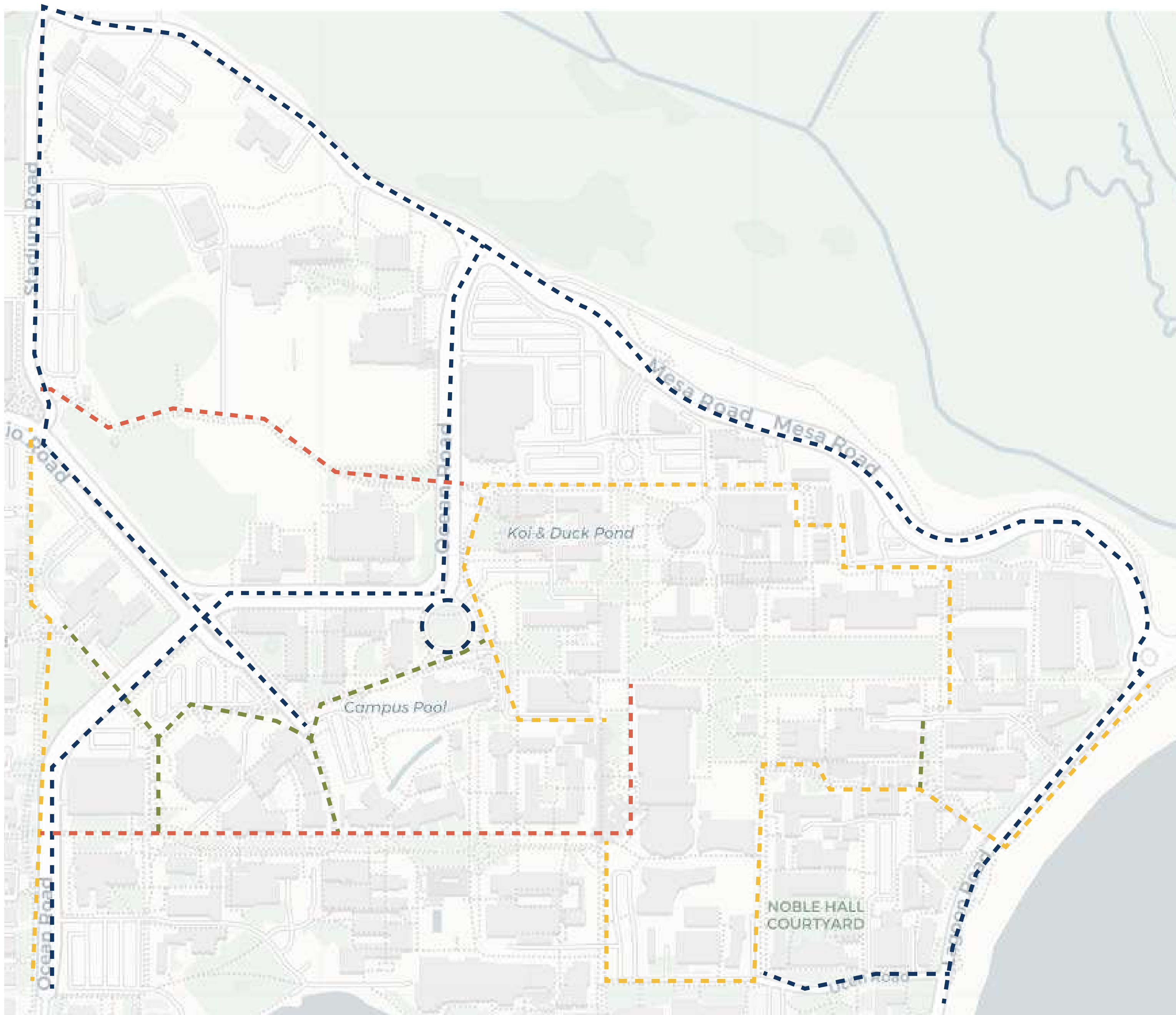
- Documented outreach to address concerns is critical to have positive community involvement, participation and ownership
- Evidence that negative impacts are addressed early and diligently by creating transparent action plan and mitigation strategies such as evaluating minimal disturbance of sacred land or construction impacts
- Active implementation of Campus Sustainability Plan and gathering of metrics
- Acknowledgment of support from the impacted community
- Determination that the project represents smart long-term investment for community future and quality of life will improve
- Documentation of organizational policies and commitments concerning equity and social justice during each phase of the plan (need reference to one)
- Involvement of leadership who is committed to create, implement and update Clean Energy Master Plan
- Skill and capability gaps of local workforce are considered, and training programs are established in use of new technologies and best practices
- Whole-systems design approach is taken when considering options to maximize achievement



Equity: Influences, Impacts, and Actions

Listed are project-specific best practices related to tangible actions the UC Santa Barbara can incorporate into climate action planning and other sustainability activities to promote greater equity. Electrifying and decarbonizing the thermal infrastructure further reinforces the benefit of the university's access to UC Clean Power Program for all their energy needs. Eliminating reliance on natural gas protects UCSB against future variations in utility costs providing financial resiliency.

Action / Consideration	Equity Influences / Impact
Pipe routing options that minimizes ecologic disturbance and quality of life impacts	• Area of disturbance: Campus Mobility, Housing, Building Accessibility, Land use. Pipe routing for the main distribution for the newly proposed Central utility Plant (CUP) considers all major disruptive pathways to ensure access and minimize disruption during construction.
Effects to Workforce	• Electrification jobs training that transitions skillsets for existing staff • Grow partnerships with local institutions (such Santa Barbara City College and Allan Hancock College) to offer vocational trainings
Prioritization of buildings to be transitioned/decarbonized	• Buildings where existing systems may need most attention (e.g. Building renewals, indoor dining, non-functioning HVAC) . Buildings with higher cooling and heating needs and that have high deferred maintenance needs have been prioritized to ensure that all campus occupants have equitable access to thermal comfort, especially during extreme weather events.
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 • Identify co-benefits from decarb investments • Build transparency and trust in decision making



Campus Foot/Bike Traffic
- Major disruption, high traffic
- Major disruption, other paths available
- Minor disruption, other paths available
- Motor Vehicle Road

Determining Measures and Markers for Equity

In recognition of the work done by UCOP, a series of equity indicators was adopted based on UCOP interviews, listening sessions, and experiences across all UC campus, including this team. They are categorized around the following categories:

Procedural: fairness of the decision-making process

Recognition: respecting different values, cultures, opinions, and structures within communities

Distributive: just allocation of resources, benefits, and burdens

Restorative: Responsive to those impacted by the transition

Indicators measure the success of Impact.

As described by the Framework for Incorporating Environmental & Climate Justice into Climate Action, Evaluating Equity Impacts includes recommendations for evaluating the impact of climate actions in addressing equity. Evaluating the equity impacts of these climate actions is necessary to ensure progress is made and the goals of the action are being met. Listed on the right are indicators that should be considered during the clean energy transition.

Identify and measure progress on **economic, social, health, and environmental** issues

- Workforce Training and low displacement of operations and maintenance jobs and general staff
- Operational energy, cost, and water use goals
- Ecological protection

Identify **quantitative** long-term impact

- Quantifying the long-term avoided energy and water costs
- Improved environmental air quality (indoor and outdoor)
- Baseline survey for campus/community awareness and support

Identify **qualitative** long-term impacts

- Occupant thermal comfort
- Energy resilience
- Community/student awareness and relationships
- Accessibility plan during construction

Community Engagement

During the Master Plan process, we utilized a carefully managed and intentional approach to engage stakeholders. We hosted several town halls, conducted progress meetings with the UC Santa Barbara Decarbonization Committee, and consulted a variety of stakeholders, community leaders, and experts. Combined with our collective observations and integrating community voices, the outcome resulted in identifying key equity recommendations to consider for the coming decade of the clean energy transition.

Outreach efforts can be summarized as follows:

1. **Town Halls for Information Presentation and Public Input**

- Focus – What are issues, concerns, observations, and opportunities? Who is affected?
- Vision – Who benefits? Where are the needs? What are the Outcomes?
- Action – next steps, and development of the equity approach and climate justice outcomes driven by the UC Santa Barbara Clean Energy Master Plan

2. **UC Santa Barbara Decarbonization Committee Meetings**

- Potential noise disturbances
- Community groups
- Cost-benefit analysis
- Identifying social and vulnerable categories
- Labor Unions
- Equity Tradeoffs
- Request for a follow up Equity Committee Focus group

3. **Community Group Outreach:**

- Associated Students Environmental Affairs Board (EAB)
- Graduate Students Association (GSA)
- Chumash & other Indigenous communities
- Disabled Students Association (DSA)

Community Feedback- Top Responses and Questions from Outreach

Community Engagement

- Expanding campus groups / organizations to contact
- Building & strengthening of relationships between UC Santa Barbara and community groups
- Decisions that protect campus
- Incentivizing student, staff and faculty engagement
- Providing project materials in Spanish and other locally used languag-es

Transparency

- Accessibility of information related to the project
- Opportunity for input, as a stakeholder
- Explain how carbon offsets will be utilized in this project

Resources to Adapt

- Existing UC Santa Barbara Staff is trained and effectively job transi-tioned
- Construction effects of noise and campus accessibility

Environmental Impact & Protection

- Ground disturbance and ensuring that we avoid cultural deposits as much as possible
- Properly assessing heating and cooling needs building by building (some are over air-conditioned; some do not have adequate cooling)
- Construction during the summer when there is less bike traffic

CURRENT CONTEXT
METHODOLOGY AND FINDINGS
RECOMMENDATIONS
NEXT STEPS

Recommendations

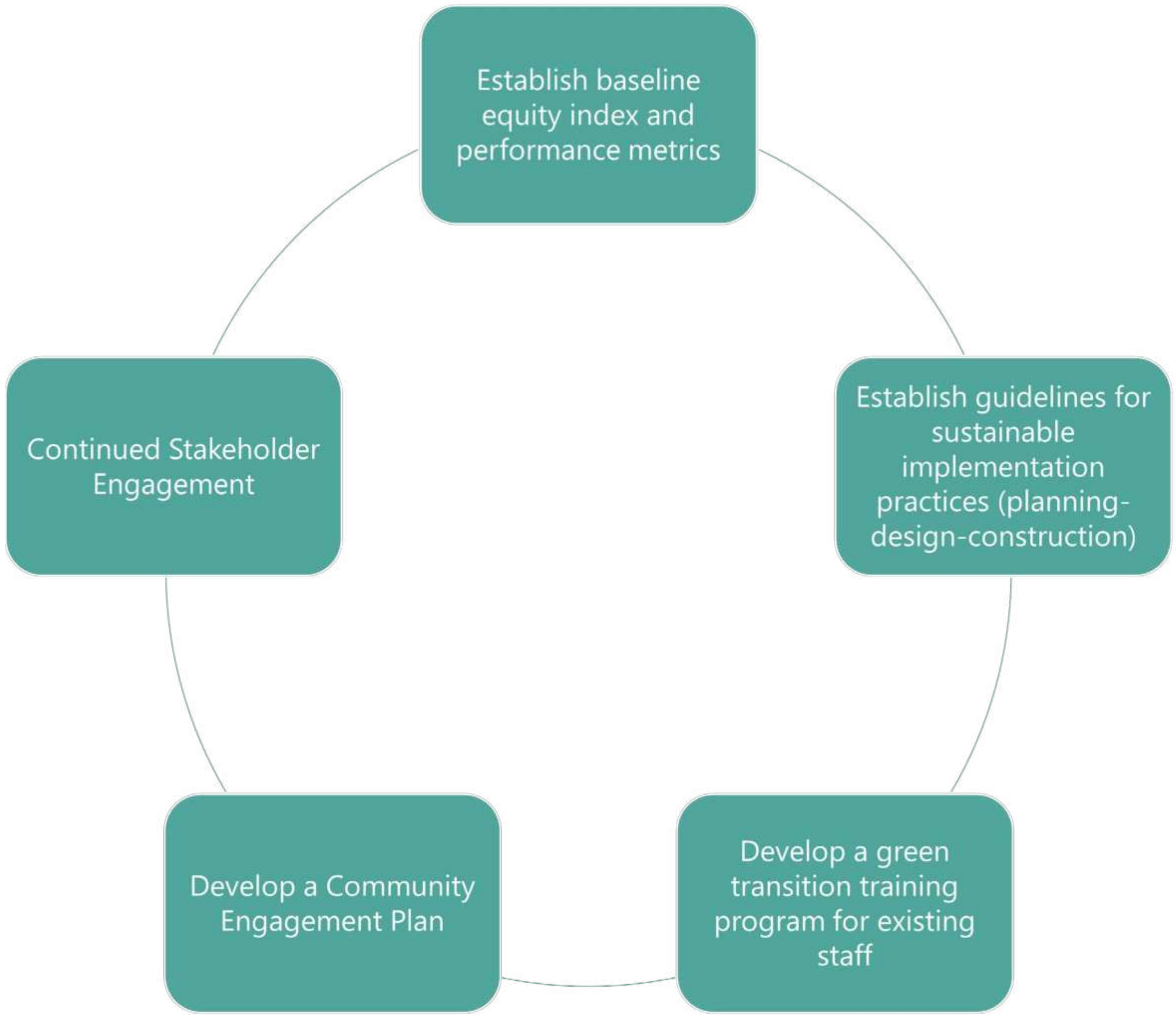
In addition to informing prioritization of buildings for phasing recommendations and informing layout of main piping distribution for the new thermal network on campus, roadmap for implementation was categorized into five focus areas of recommendations.

Recommendations of each area are designed to build on the foundation necessary to continue centering climate equity and just outcomes.

These initiatives will equip UC Santa Barbara with the educational, procedural, and developmental resources imperative to improving overall resiliency and quality of life for all.

Many of the strategies in this plan have benefits outside of their main objectives, and these are called co-benefits.

Co-benefits can strengthen vulnerable populations, enhance relationships and promote educational awareness, improve air quality, and protect our natural resources.



Strategy Focus Areas

Measuring Impacts

Establish qualitative and quantitative baseline equity performance metrics regarding impacts of decarbonization on public health and general quality of life.

This should include:

- Identifying campus groups and communities who will benefit or be burdened by a given decision. Demographic data on vulnerable groups include: accessibility, income, limited-English speakers, commuting students.
- Quantifying decarbonization performance impact on air quality of building systems.
- Indexing environmental health indicators: air quality (ozone/particulate matter), current buildings with lack of proper ventilation, maintained access to bike/walk infrastructure, proximity and duration of construction disturbance
- Factoring in prioritization rankings for weighted impacts and the order of buildings in the clean energy transition plan.
- Framework for successful implementation and evaluation of impact. Examples: Envision, LEED, UCSB Sustainability Plan KPIs

Mobility and Accessibility

Establish guidelines for sustainable construction practices, minimizing risks and impacts to health, mobility and accessibility during construction.

- UC Santa Barbara's construction management plan already incorporates equity considerations and mitigation practices into design practices.
- Consider "Cradle to Grave" philosophy and End of Life cycle

This should include:

- KPIs (construction waste management, energy use, planning/design, quality of life);
- Envision Certification;
- Mitigating risks and impacts to health, mobility, and accessibility during construction;
- Referencing Section 106 of International Existing Building Code and of the National Historic Preservation Act: sustainable building reuse, and available mapping of cultural resources under the ground to be mindful of in the construction process;
- Adapting ideas for Sustainable Energy Procurement from Environmental & Climate Justice Framework.

A robust construction management plan should address the concerns from community about disturbances:

- **Traffic** – Traffic will be generated from the construction workers and street closures, generating concerns of delays and lack of parking. Additionally, access for disabled community might be problematic.
- **Pollution –** Pollution due to increased traffic and dust construction/ dust will have to be mitigated.
- **Construction disturbances –** noise, vibration, and light; construction water and energy consumption.
- **Skilled labor** that can perform specialized installation for renewable energy.

Training Existing Staff

Develop a green transition job training program with partners for existing operations & maintenance staff, minimizing displacement of current operations and maintenance jobs.

Ideas include, but are not limited to:

- Establishing training/vocational programs with local community colleges and/or technical high schools, such as long-term plan in partnership with local institutions such as Allan Hancock College and Santa Barbara City College (SBCC).
- Establishing certificate program and apprenticeships.
- Potentially creating a standing UC Santa Barbara or community college course or program for grad/undergrad students, to create a long-lasting green transition.
- Updated job descriptions + grades/levels.
- Unions.

Engagement Strategies

Recommend publishing a Community Engagement Plan that includes:

- Identification of in-person and online engagement strategies and information document repositories for accessibility, transparency, and for comment.
- Campus-wide education campaign on the Clean Energy Master Plan.
- Methods to inform students on scheduled construction disturbances and considering input on ideal timeframes.

CURRENT CONTEXT
METHODOLOGY AND FINDINGS
RECOMMENDATIONS
NEXT STEPS

Continued Community Engagement

Drawing from community outreach, workshops, and discussions conducted throughout the Clean Energy Master Plan process, we recommend the following best practices for future engagement:

- Reach out to community groups early and often.
- Connect with as many diverse community groups as possible; the more engagement, the better.
- Establish and maintain relationships with these groups, ensuring an ongoing conversation between the school and these groups to continuously incorporate equity into the project throughout the process.
- Acquire feedback from the expanded list of campus community organizations to identify specific communities as it relates to on-campus carbon emissions

It is additionally recommended to consider developing a committee or group of Campus Leaders, Community Organizations, Students, Staff And Residents that will monitor and ensure continued stakeholder engagement and the overall progress of the Master Plan.

This group would continue to act as a guiding force throughout the decision-making and implementation stages of the project to ensure continued community engagement with key and diverse stakeholders.

This recommendation is based on stakeholder input to-date, and best practices and research from the Master Plan consultant team.

Groups for Future Engagement - Tier 1

Community groups for future engagement are categorized into a tier system, ranging from tier 1 to tier 3, based on the recommended order of outreach and scale of importance.

Community group descriptions and contact information for future engagement starting with tier 1 are listed to the right and continue for the next three pages.

Tier 1		
Bren Environmental Justice Club	Working on active projects on campus environmental impacts, could have informative insights for our project.	https://www.instagram.com/brenejclub/ https://bren.ucsb.edu/bren-student-activities
Chumash Representation	Traditional stewards of the land, have indigenous knowledge that is necessary to take into account when working on projects that could have environmental impacts on the land.	Santa Ynez Chumash Tribe, ask for representative Santa Ynez Band of Chumash Indians
Disabled Students Representation	Disabled people on campus could be affected by construction differently than able bodied people, so critical pathways must be accessible to everyone.	Home | Disabled Students Program (ucsb.edu)
Community Affairs Board	This student group should be reached out to to make sure that community bodies outside of UC Santa Barbara's campus are taken into account for this project.	cab.ucsb@gmail.com Community Affairs Board (ucsb.edu)
Commission On Disability Equality	Disabled people on campus could be affected by construction differently than able bodied people, so critical pathways must be accessible to everyone.	code@as.ucsb.edu Commission on Disability Equality – Committee On Committees (ucsb.edu)
Environmental Justice Alliance	Will have insights that align with what we are trying to discover- which groups are most vulnerable, how will different groups be impacted by this project.	as-environmentaljustice@ucsb.edu Environmental Justice Alliance at UCSB – system change, not climate change

Groups for Future Engagement - Tier 1

Community group descriptions and contact information for future engagement are listed to the right and continue for the next two pages.

Tier 1 Continued		
Graduate Student Representation	Will have different concerns than the rest of the student body; many are also employed by the university. A key group on campus that will be important to keep involved in this project.	Home | Graduate Student Association (ucsb.edu)
Public And Mental Health Commission	Construction comes with health concerns both physical and mental, and this commission could help provide us with some expertise on how best to manage that.	pmhc-cochair@as.ucsb.edu pmhc-cochair2@as.ucsb.edu UCSB's A.S. Public & Mental Health Commission – A.S. P.M.H. Commission – UCSB Associated Students
Public Safety Commission	Construction comes with individual and group health concerns, and this commission could help provide us with some expertise on how best to manage that.	publicsafety@as.ucsb.edu A.S. Commission On Public Safety – Safety First (ucsb.edu)
Resident Halls Association	The students that live on campus will be more impacted by this project than almost any other group – as the construction will be both where they live and where they go to school.	rhapresident@housing.ucsb.edu UCSB Residential Housing Association (rhaucsb.com)
Transportation Services/ Santa Barbara Metropolitan Transit District	The transit system for the larger Santa Barbara area will all be affected during the construction, so it is important to involved MTD to make sure that they are equipped to handle the potential disruptions.	clerk@sbmtd.gov Santa Barbara MTD – Enhancing the Mobility of the South Coast (sbmtd.gov)

Groups for Future Engagement - Tier 2

Community group descriptions and contact information for future engagement are listed to the right and continue for the next page.

Tier 2		
UCSB Budget and Planning	This will be important when analyzing if the costs of the project will be pushed to students, and how the decarbonization itself will affect the cost of utilities on campus.	Home | Office of Budget & Planning (ucsb.edu)
Environmental Affairs Board	As part of our analysis of the project we also need to consider the ecosystems that this campus is a part of. This group could have more expertise on the fragility of the environment we are working in.	eab@as.ucsb.edu Environmental Affairs Board | Your Starting Point for Environmentalism at UCSB
Commission On Student Well Being	Construction comes with individual and group health concerns, and this commission could help provide us with some expertise on how best to manage that.	as-coswb-cochair1@ucsb.edu as-coswb-cochair2@ucsb.edu A.S. Commission on Student Well-Being
Commission On Culture, Arts, And Joy Justice	Construction comes with health concerns both physical and mental, and this commission could help provide us with some expertise on how best to manage that.	https://ccajj.as.ucsb.edu/
SB City College Representation	A community college closely affiliated with UC Santa Barbara, will have students impacted by the project, and might be involved in job retraining as well.	Homepage - Santa Barbara City College (sbcc.edu)
Allan Hancock	A community college closely affiliated with UC Santa Barbara, will have students impacted by the project, and might be involved in job retraining as well.	Allan Hancock College | Community College on the Central Coast of California

Groups for Future Engagement - Tier 3

Community group descriptions and contact information for future engagement are listed to the right (cont.).

Tier 3		
Student Commission On Racial Equality	Race is one of the key social groups that must be involved to promote climate justice and equity.	score.chairs@as.ucb.edu A.S. SCORE- Student Commission on Racial Equity – Ready, set, and S.C.O.R.E! (ucsb.edu)
Trans And Queer Commission	Gender and sexuality are one of the key social groups that must be involved to promote climate justice and equity.	tqcomm@as.ucsb.edu Queer Commission (ucsb.edu)
Black Women's Health Collaborative	Race and gender, as well as intersectionality are all key social groups that must be involved to promote climate justice and equity.	AS Black Women's Health Collaborative (ucsb.edu)
Commission For Marginalized Genders	Gender and sexuality are one of the key social groups that must be involved to promote climate justice and equity.	cmg@as.ucsb.edu Commission for Marginalized Genders (ucsb.edu)

Envision

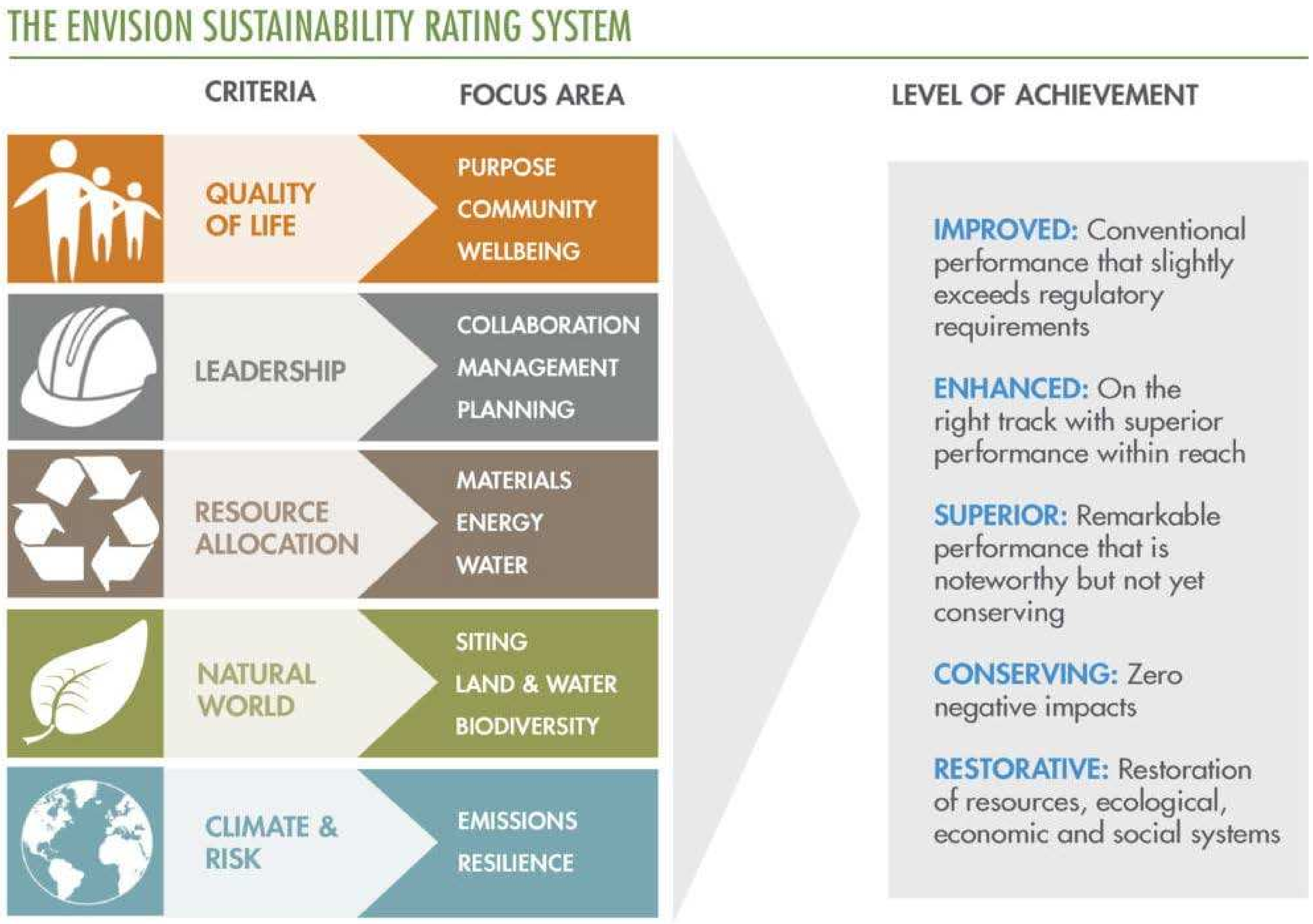
The Envision sustainability framework was designed to help infrastructure stakeholders implement more sustainable, resilient, and equitable projects. The framework provides the guidance needed to initiate this systemic change in the planning, design and delivery of sustainable and resilient infrastructure.

Envision provides industry-wide sustainability metrics for all types and sizes of infrastructure projects to help users assess and measure the extent to which their project contributes to conditions of sustainability across the full range of social, economic, and environmental indicators.

Envision includes 64 sustainability and resilience indicators, called 'credits', organized around five categories: **Qualify of Life, Leadership, Resource Allocation, Natural World and Climate & Resilience.**

Using the Envision project assessment checklists as a resource during planning/design/implementation could offer UC Santa Barbara a valuable tool to better **measure project impact** from equitable energy climate action planning and clean transition implementation, and enhance UCSB's existing sustainability plan as well as general sustainable construction practices. Measure impact from an implementation standpoint. Maximizing impacts from project.

Learn more about Envision at: https://sustainableinfrastructure.org/envision/use-envision/



Strategies for Advancing the Clean Energy Master Plan

Advancement of the Clean Energy Master Plan requires continued reflection, exploration, and questions to consider when incorporating elements of climate action into community projects and policies.

Continual Reflection and Exploration

- Considerations for how to prioritize the Focus Areas and Recommendations.

Engagement

- Continue to engage campus community and identify impacted groups.
- Are there additional partners or perspectives we can include in the project?
- Will the project(s) engage its participants in the beginning, middle, and end of the project?

Encouraging Ideas and Conversations

- Spur ideas and conversations from the Clean Energy Master Plan.
- Utilize Campus Living Lab as placemaking hub.
- How can the findings from this Master Plan serve as a resource or foundation for future projects?

Transparency and Reporting

- Maintain transparency on progress through an annual committee report (standalone or part of another campus annual report) and hold regular town halls.

Resource Allocation and Oversight

- Appropriately resource staff members of a long-term Decarbonization Implementation Committee and identify those responsible for overseeing project/initiative/policy implementation over the next decade, in coordination with Community Stakeholders.

UC SANTA BARBARA

CLIMATE ACTION PLANNING GAP ANALYSIS

5

Objective - Climate Action Planning Gap Analysis

This section provides an overview of contents covered within the Climate Action Planning Gap Analysis chapter as it relates to campus Net-Zero and Climate Resilience Planning. Objective 4 performs an in-depth gap analysis to assess UC Santa Barbara's current climate transition preparedness and documents any current knowledge gaps that point to areas for improvement and potential methods to incorporate new practices. The chapter will also outline subsequent analyses to support comprehensive climate action planning that addresses both net-zero and climate resilience goals.

Context

- UC Santa Barbara Climate Action Planning Context

Methodology

- Methodology Overview
- Process & Workshops
- Criteria, Scoring, & Equity

Gap Analysis Findings

- Net-Zero Gap Analysis Findings
- Climate Resilience Gap Analysis Findings

Roadmap for Future Success

- Recommended Future Analyses & Practices
- Supporting a New Climate Action Plan
- Roadmap for Future Success

CONTEXT

METHODOLOGY
GAP ANALYSIS FINDINGS
ROADMAP FOR FUTURE SUCCESS

UC SANTA BARBARA

Current Situation

UCSB is already recognized as a leader in climate action and resilience planning. For example, in the last decade, UCSB has reduced its GHG emissions by two thirds, resulting in the lowest GHG emissions of any UC campus. UC has initiated various net zero and climate resilience-related planning efforts in the past, including but not limited to, the Campus Sustainability Plan, Green Lab Action Plan, Sea Level Rise Adaptation Strategy, and participating in the UC Framework for J.E.D.I.-Centered Climate Resilience Planning. However, with updated emission reduction targets and a growing need to prepare for and adapt to a changing climate, there is more work to be done.

Looking Ahead

The UC Policy on Sustainable Practices requires each UC location to prepare an updated Climate Action Plan (CAP) to establish and achieve GHG emission reduction goals, ultimately resulting in a 90% reduction in total emissions (Scopes 1, 2, and 3) by 2045. In addition, the CAP should integrate adaptation and resilience considerations and must incorporate the UC Framework for Incorporating Environmental & Climate Justice into Climate Action.

The updated CAP must be completed prior to 2026, with implementation to begin immediately. The outcomes of this Climate Action Planning Gap Analysis are intended to help inform the development of the CAP.

CONTEXT

METHODOLOGY

GAP ANALYSIS FINDINGS

ROADMAP FOR FUTURE SUCCESS

Approach

Approach

The Climate Action Planning Gap Analysis is intended to act as a foundation to guide future climate action planning by UCSB. By documenting existing strengths, as well as gaps and opportunities for improvement, the analysis helps to identify broader strategies to meet emission reduction targets, including decarbonization strategies that are resilient to future climate.

Introba took an interconnected and streamlined approach by carrying out net zero and climate resilience analyses in parallel recognizing the strong interconnectedness between the two concepts and decarbonization planning. The analysis took a strength-based approach to identify and build on existing programs and policies so that UCSB can build on its strengths and fill critical gaps.

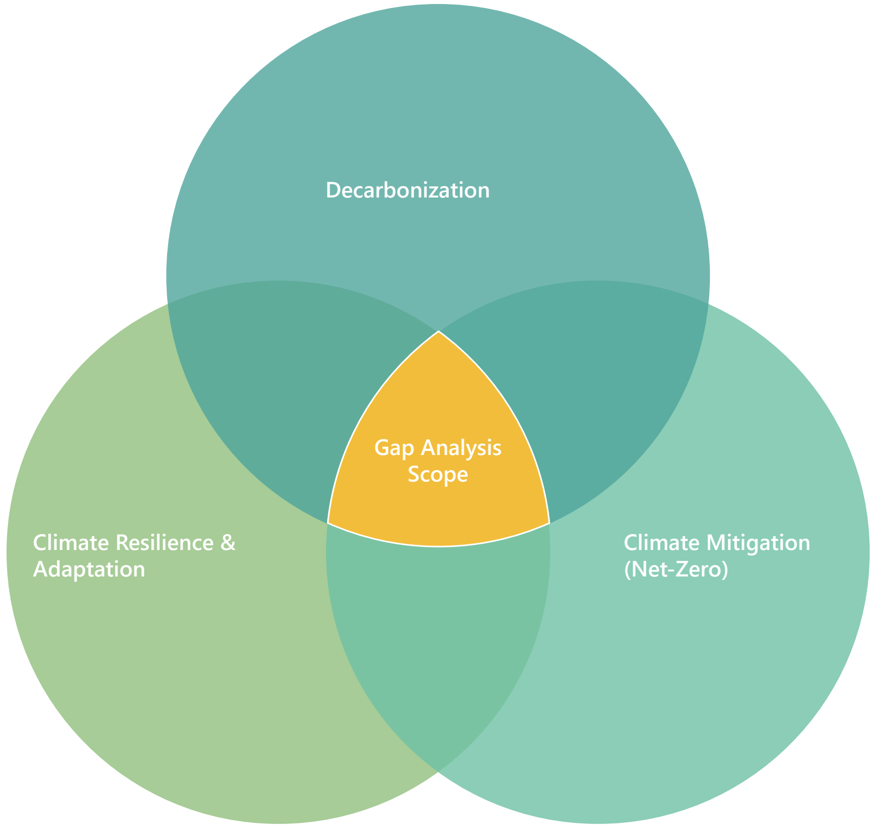
The gap analysis framework was developed based on documented best practices in climate action planning by other higher education institutions across North America, including Ivy League schools and others in the UC system. It was further developed based on the outcomes of a stakeholder engagement workshop and project committee review.

Linkages between the Climate Action Planning Gap Analysis and the Decarbonization Strategy (Deliverable 1) were specifically identified to assist in the prioritization of recommended next steps related to the Clean Energy Master Plan.

Document Review

The list below includes a sample of the major documents reviewed for the gap analysis to identify existing and planned actions to address net zero and climate resilience goals. The document review, along with engagement, ensured a robust and comprehensive evaluation:

- UC Policy on Sustainable Practices (2024)
- UCSB Climate Action Plans (multiple, including drafts)
- Campus Sustainability Plan (2018)
- Green Lab Action Plan (2019)
- Water Action Plan (2017)
- Zero Waste Plan (2020) and Waste Diversion Plan (2013)
- Sea Level Rise Adaptation Strategy (2022)
- Long Range Development Plan (2010)
- Emergency Operations and Emergency Management Plans (2024)
- Sustainable Procurement and Use Practices (2012)
- Green Building Design, UC Sustainable Practices (2024)
- UCOP Framework for Incorporating Environmental & Climate Justice into Climate Action (2022)
- UCOP Framework for J.E.D.I.-Centered Climate Resilience Planning (2021)



Summary of Engagement

The primary form of engagement for the gap analysis was the Net Zero & Climate Resilience Ambition and Existing Practices Workshop, which was held in person on November 16, 2023. The workshop included a series of presentations on the gap analysis scope followed by structured activities and discussion.

The objectives of this workshop included:

- Share what UCSB is already doing to be a net zero and climate resilient campus
- Identify key campus initiatives related to net zero and climate resilience planning
- Identify gaps or issues that existing initiatives do not address
- Identify other strengths and partnership opportunities
- Inform the gap analysis framework and its inputs (e.g., the list of best practices by which to evaluate current initiatives against)

The methodology was further refined through the Net Zero & Climate Resilience Gap Analysis Framework Review Meeting held with the project committee on January 29, 2024. This meeting gathered feedback on updates made to the framework following the November workshop and sought buy-in on the best practices and scoring criteria used, as well as the outputs from the analysis.

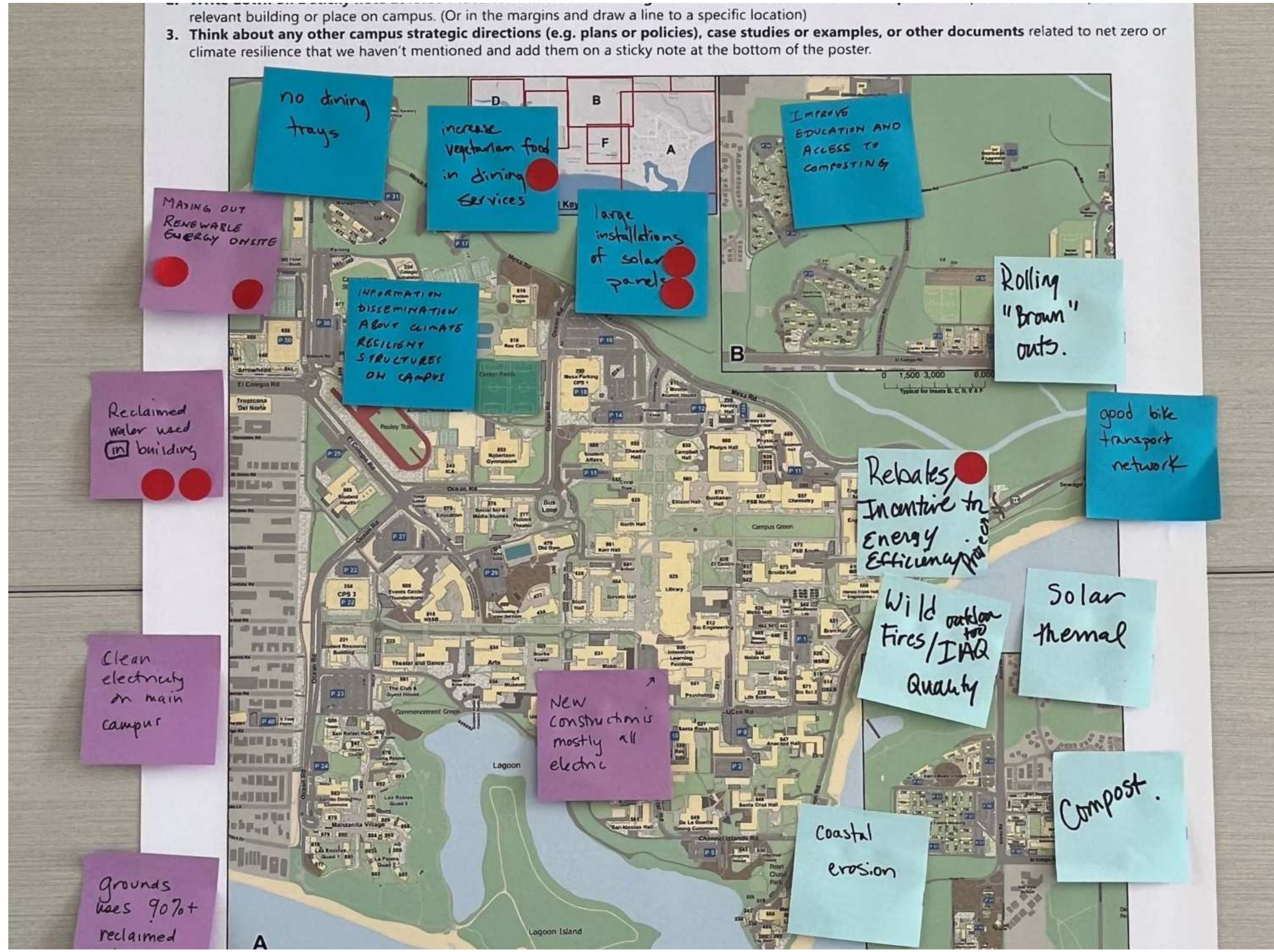


Image: a poster used to collect input during the November 2023 workshop

Gap Analysis Criteria & Evaluation

The gap analysis matrix listed over XX emissions reduction and resilience best practices and documented policies and programs UCSB already has in place that align with these practices. The gap analysis score and corresponding rationale are based on how well UCSB is performing against the demonstrated best practices in each category. The score, along with the existing strengths and gaps identified, informs a set of additional measures or next steps recommended for future climate action planning.

The evaluation criteria for the gap analysis score are as follows:

Gap Analysis Score = 1

UCSB is underperforming compared to best practices in this action category

Gap Analysis Score = 2

UCSB is partially meeting best practices in this action category, but there are opportunities for improvement

Gap Analysis Score = 3

UCSB is meeting or exceeding best practices in this action category

Snippet from UCSB Gap Analysis

SAMPLE MATRIX

Action Category	Best Practices	Gap Analysis Score (status)	Score Rationale	Additional Measures or Next Steps Recommended
Climate Mitigation Assessment and Planning	Complete a Climate Action Plan with a clear path to net zero emissions	2	Developed original Climate Action Plan with proposed pathways to net zero. Additional scoping needed for new CAP with updated emissions reduction targets per UC Policy on Sustainable Practices.	Continue to regularly revisit CAP and update as needed. Update for alignment with Clean Energy Master Plan.
	Make public commitments and join challenge programs	2	Multiple public goals, though some outdated. Opportunity for more challenge programs.	Update public commitments in line with UC Policy and other opportunities (see implementation examples) as appropriate. Engage in more campus challenge programs.
	Apply a climate justice lens to ensure equity, inclusion, diversity, and accountability are integrated into planning	2	Participation in the 2024 UC Equity-centred Climate Resilience process focuses on DEI. Vulnerable groups identified and included in planning. Equity lens not yet applied to [illegible] ut [illegible] for 2025	Opportunity to build on processes and outcomes from the 2024 UC Equity-centred Climate Resilience to inform climate action plan development
University as a Living Laboratory	Build staff and student awareness about climate change mitigation and planning	3	[illegible] garding [illegible] ss across campus. Steering committee involved in Clean Energy Master Plan is one example of how students and staff are being integrated into planning process.	Track/survey for progress.
	Integrate climate change within course curricula and provide "living laboratory" opportunities for learning	2	UCSB has many climate change focused courses, and creates living lab opportunities through the Sustainability Internship Program	Monitor/survey students to gauge awareness. Integrate new content into relevant courses that use UCSB Clean Energy Plan and capital works as a case study for learning (e.g. environmental engineering programs)

CONTEXT
METHODOLOGY
GAP ANALYSIS FINDINGS
ROADMAP FOR FUTURE SUCCESS

Analysis Findings

Existing Areas of Strength & Knowledge

UCSB is already a leader in net zero planning, both within the UC system and nationally. Some specific strengths that rose out of the gap analysis are summarized below. A complete list of existing strengths in net zero planning can be found in Appendix 3-1 Climate Action Gap Analysis Results Summary.

Renewable Energy
UCSB already purchases 100% clean electricity and is a leader in onsite renewable energy generation with many solar installations across campus currently generating 15% of power needs.

Existing Building Efficiency
UCSB actively pursues ongoing efficiency upgrades (e.g., lighting) and prioritizes energy efficiency through its preventative maintenance programs. The Green Labs program is an example of an effective initiative that promotes efficiency in the most energy- and resource-intensive spaces on campus.

Design and New Construction
The UC Policy on Sustainable Practices includes provisions for all-electric buildings. UCSB already has green building design standards in place and there are multiple LEED Platinum buildings on campus, such as Bren Hall, BioEngineering, and KITP Residences.

Opportunities for Future Investigation

Despite the progress made toward a net-zero future, opportunities exist to further reduce emissions (Scopes 1, 2, and 3). Some specific gaps that were identified in the gap analysis are summarized below. A complete list of gaps in net zero planning for future investigation can be found in Appendix 3-1 Climate Action Gap Analysis Results Summary.

Refrigerant Leakage
Refrigerant emissions are tracked within campus Scope 1 emissions, but there are no clear goals for addressing these emissions through refrigerant leakage strategies.

University Fleet
The UC Policy on Sustainable Practices includes clear targets for the acquisition of zero-emission and other clean vehicles, however there is opportunity to go beyond UC targets to transition to a 100% zero emissions fleet sooner in support of a net-zero goal.

Air Travel
Tracking and reporting of business travel emissions has begun, along with a pilot air travel assessment guide, but a clear strategy is needed to reduce air travel and offset remaining emissions (Scope 3).

Analysis Findings

Existing Areas of Strength & Knowledge

UCSB has made great strides toward incorporating climate resilience into its climate action planning efforts in recent years. Some specific strengths that rose out of the gap analysis are summarized below. A complete list of existing strengths in climate reslience planning can be found in Appendix 3-1 Climate Action Gap Analysis Results Summary.

Climate Justice Lens

UCSB has participated in the JEDI Resilience Program (2021-2022) and ongoing Equity-centered Climate Resilience Initiative (2024-2025) to develop its vulnerability assessment, conduct campus community engagement, and develop preliminary strategies for integrating equity, diversity, and inclusion into planning.

Multi-Hazard Action

UCSB has enabled broad campus resilience by enhancing multi-modal connectivity to campus with a robust pedestrian, cycling and wheelchair accessible system.

Managing Power Outage & Energy Resilience

Energy efficiency measures and backup power mitigate power outages while renewable energy provides redundancy.

Managing Rainfall Flooding

UCSB has implemented a range of measures including nature-based restoration projects and strategies to minimize impervious surfaces on campus.

Managing Sea Level Rise, Coastal Flooding, & Erosion

A Sea Level Rise Adaptation Strategy and Shoreline Vulnerability Assessment have been completed and are available to guide campus planning decisions.

Managing Drought / Water Insecurity

UCSB employs water conservation and demand management strategies, prioritizing drought tolerant landscaping and water reuse for irrigation and other non-potable water needs.

Opportunities for Future Investigation

Despite the progress made toward a climate resilient campus, opportunities exist to further prepare for the current and future impacts of a changing climate. Some specific gaps that were identified in the gap analysis are summarized below. A complete list of gaps in climate resilience planning for future investigation can be found in Appendix 3-1 Climate Action Gap Analysis Results Summary.

Managing Extreme Heat

There is a need for mechanical cooling (especially in residences) and campus cooling centers to respond to extreme heat events, along with passive or nature-based approaches such as shading.

Managing Poor Air Quality

There is no clear tracking or prioritization of advanced air filtration for sensitive areas and populations. There are also no identified campus refuge spaces or clean air shelters (can be combined with cooling) to respond to poor air quality events.

Managing Wildfire

There is a need to address wildfires, including through strategic landscape management particularly along the wildland urban interface.

Incorporating Resilience into Design

While there is a clear prioritization for energy and emissions in campus standards, there is a need to incorporate strategies for mitigating climate hazards and future conditions into design standards and guidelines for new construction, retrofits, and asset management planning. This includes developing and tracking metrics for success.

Community Partnerships

UCSB can benefit by collaborating more with government and community organizations on climate adaptation committees and initiatives.

https://www.state.gov/dipnote-u-s-department-of-state-official-blog/science-speaks-sea-level-rise/

CONTEXT
METHODOLOGY
GAP ANALYSIS FINDINGS
ROADMAP FOR FUTURE SUCCESS

Capacity Building Opportunities

The gap analysis helped to identify subsequent studies and analyses needed to conduct climate action planning across the following topics:

Setting interim emission reduction targets. While the Clean Energy Master Plan will help UCSB address the majority of Scope 1 emissions in the built environment, UCSB should develop a fleet electrification strategy that supports and ideally exceeds the provisions for Sustainable Transportation set in the UC Policy on Sustainable Practices. Scope 2 emissions targets are not needed, but Scope 3 emission reduction targets can be set to align with a comprehensive transportation plan that addresses commuting and a business travel reduction strategy that addresses air travel emissions.

Analysis of all fossil fuel uses and setting an institutional boundary. Fossil fuel is covered through existing reporting and will largely be guided through the outcomes of the Clean Energy Master Plan. UCSB has already set an institutional boundary through the AASHE STARS certified reporting process and should continue to keep this boundary the same for all facets of reporting.

Integrating equity-centered climate resilience. UCSB should continue to participate in the ongoing Equity-centered Climate Resilience Initiative, including completing stakeholder mapping and engagement with the broader community. This includes understanding what campus groups and departments are leading climate resilience work, what community partners are operating in this space, and what regional groups UCSB can get involved in to stay connected, nurture and build resilience partnerships.

Minimizing institutional risks. UCSB should conduct a more detailed campus resilience assessment as part of the Equity-centered Climate Resilience Initiative to identify buildings in high-risk areas, document issues experienced during recent climate-related events, and identify what adaptation measures are already in place. A backup power study should also be completed to explore how existing and planned renewable energy could serve as redundant power in case of outages or grid power disruption. Further, UCSB can identify opportunities for support and collaboration with external community and governmental organizations that build resilience within campus and the surrounding community.

https://news.ucsb.edu/2015/016117/striking-bicycle-gold

Immediate Next Steps (through 2025)

In addition to the following the recommendations of the Clean Energy Master Plan, UCSB can address key gaps identified in this analysis and support the development of a new Climate Action Plan by the end of 2025 through the following actions:

- Identify clear emission reduction targets and propose long-term strategies beyond those set in the Clean Energy Master Plan, including addressing additional Scope 1 emissions (e.g., fleet) and Scope 3 emissions (e.g., commute and business travel)
- Develop a strategy for 100% zero emission fleet that supports and ideally exceeds the provisions set in the UC Policy on Sustainable Practices – Sustainable Transportation
- Incorporate refrigerant leakage strategies into the updated CAP and implement a policy for low GWP refrigerants
- Use the results of a detailed campus resilience assessment to identify highest priority buildings and areas for adaptation measures
- Designate at least one refuge space on campus with cooling, advanced air filtration, and backup power, with careful consideration for how to best serve key vulnerable populations
- Ensure equity is embedded throughout an updated CAP by drawing on the outcomes of Deliverable 3 and by continuing to participate in the ongoing Equity-centered Climate Resilience Initiative

Note that UCSB should refer back to Appendix 3-1 Climate Action Gap Analysis Results Summary for a full list of additional measures and next steps for consideration during the climate action planning process.

https://freesetsmk.best/product_details/12672594.html

Long-Term Opportunities (beyond 2025)

Beyond the immediate next steps to inform a new Climate Action Plan, UCSB should consider the following actions to support a net zero and climate resilient campus:

- Develop and implement a comprehensive policy for the electrification of exiting buildings not tied to the central utility plant
- Gather and update current policies, goals, and other initiatives for compilation into a comprehensive transportation plan that supports the transportation related goals and targets of an updated CAP
- Establish a business travel reduction strategy and value-aligned offset program for air travel
- Consider the impact of leased facilities for tracking and reporting and develop leased facility sustainability guidelines to broaden the reach of UCSB sustainability initiatives
- Update campus planning and policy documents to consider climate resilience, including incorporating provisions for sea level rise, wildfire, and extreme heat into design guidelines for buildings and landscape, asset management systems, and capital planning.
- Retrofit existing critical and high-risk facilities to be resilient to future climate change conditions
- Track the implementation and impacts of climate adaptation actions on campus
- Identify opportunities for UCSB to collaborate with external and governmental organizations to identify existing programs that could support on campus resilience, and consider what role UCSB could play in supporting resilience in the surrounding community

https://hdae.ucsb.edu/

LIVING LABORATORY FOR CLIMATE ACTION AND SUSTAINABILITY

6

Objective - Living Laboratory for Climate Action and Sustainability

This section provides an overview of contents covered within the Living Laboratory for Climate Action and Sustainability chapter. Objective 5 aims to assess current climate-related living lab initiatives against emerging best practices, identify new opportunities for student, faculty, and staff involvement in climate action through research and education, and outline realistic next steps to advance the campus as a living laboratory for climate action and sustainability.

Existing Practices

- Existing Campus Living Laboratory Initiatives

Living Laboratory Opportunities

- Roadmap for a Future Living Laboratory

Next Steps

- Next Steps for Campus as a Living Laboratory

EXISTING PRACTICES

LIVING LABORATORY OPPORTUNITIES

NEXT STEPS

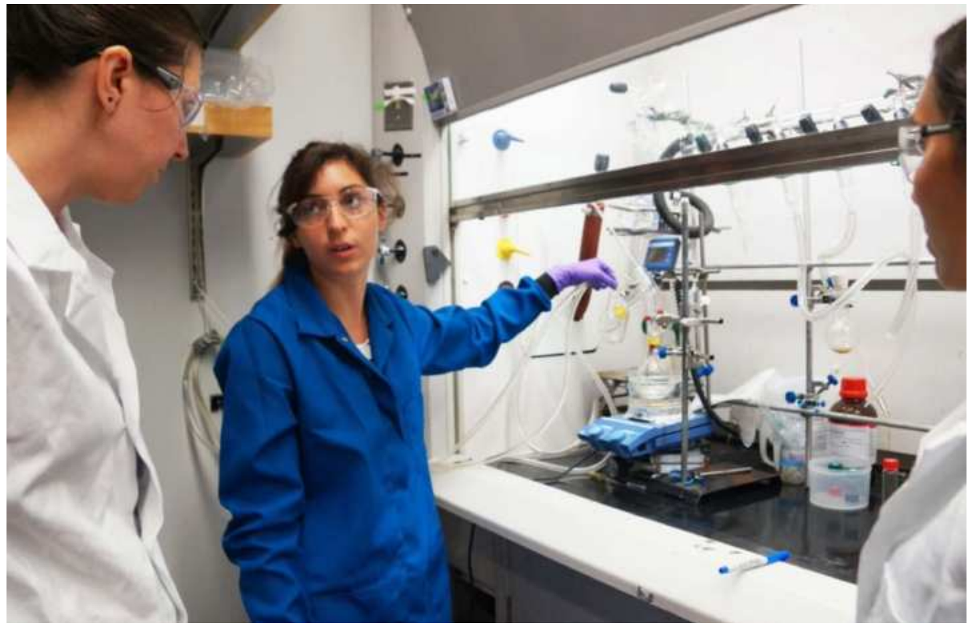
Current Programs

UCSB has made great strides in establishing its campus as a living laboratory for student and staff research and applied learning. Some specific strengths that rose out of the gap analysis are summarized below. Additional strengths are embedded throughout Appendix 3-1 Climate Action Gap Analysis Results Summary.

Clean Energy Master Plan
The Clean Energy Master Planning process has emphasized student and staff involvement and collaboration, including through the project's Steering Committee and paid student internships.

2024 UC Equity-Centered Climate Resilience Initiative
This ongoing initiative establishes a clear directive for engagement and includes funding and participation for Resilience Fellows who play an active role in analysis, engagement, and planning.

Green Labs & LabRATS
These programs specifically engage students and staff for improving sustainable operations of research labs.



https://sustainability.ucsb.edu/sustainability-built-environment

Curriculum
Sustainability and climate course are being taught across multiple campus departments, however relatively few are climate-resilience focused.

Research
The UCSB Institute for Energy Efficiency is a leader in research and innovation in energy efficiency, however research on climate resilience across campus is less common/visible.

Sustainability Internships
The UCSB Sustainability Internship Program offers applied learning opportunities for undergraduate and graduate students.

AASHE STARS
Tracking and reporting of Campus as a Living Laboratory – including through curriculum, research, and engagement and awareness initiatives – already occurs through routine AASHE STARS reports.

A key gap that was identified as part of this analysis is that there is more emphasis on sustainability and decarbonization planning than resilience in current courses and applied learning opportunities.

EXISTING PRACTICES

LIVING LABORATORY OPPORTUNITIES

NEXT STEPS

Additional Opportunities

In addition to identifying existing strengths, the Climate Action Gap Analysis identified many opportunities for future collaborative involvement of students, faculty, and staff in climate action and sustainability efforts on campus. Some of the key recommendations are listed below. Additional opportunities are embedded in the next steps listed in **Appendix 3-1 Climate Action Gap Analysis Results Summary.**

Educational Opportunities

- Create specific opportunities for resilience-focused learning (e.g., nature-based engineering, risk and vulnerability studies)
- Leverage the Clean Energy Master Plan as part of course material and as a case study for learning (e.g., in engineering courses)

Research Opportunities

- Seek opportunities to profile decarbonization and resilience-related research and innovation via the UCSB Environment Hub and Sustainability Research List
- Continue to publish and share out research to showcase the positive work on campus (e.g., Clean Energy Master Plan) and promote cross-sharing and collaboration

Other Pathways

- Create opportunities (e.g., committee participation, internships, public forums) to support the design and implementation of the Clean Energy Master Plan and updated Climate Action Plan
- Increase student and researcher involvement in sustainable food and dining programs on campus (e.g., ensuring that community gardens are leveraged for student use and education opportunities, paid or volunteer support for zero-waste efforts)

https://www.burohappold.com/projects/university-of-california-santa-barbara-institute-for-energy-efficiency/

EXISTING PRACTICES
LIVING LABORATORY OPPORTUNITIES
NEXT STEPS

Future Processes

UCSB already has many systems in place to ensure its campus serves as a living laboratory for students, staff, and researchers to apply opportunities for climate action and sustainability. However, more can be done, specifically to embed climate resilience into curriculum and research and to formalize an overall strategy for Campus as a Living Laboratory. Given the time and resource constraints of the Climate Action Gap Analysis, this study served to lay the groundwork for future planning rather than provide a full action strategy. Still, the below summarizes some reasonable and actionable next steps to expand upon this study.

Complete a Living Laboratory Assessment
A more robust study should identify specific opportunities for expanding the campus as a hub for climate action and sustainability, as well as identify opportunities for organizing and streamlining existing initiatives.

Leverage Current Initiatives for Continued Learning
Continue to involve the campus community (i.e., students, staff, faculty) in the Clean Energy Master Plan, the UC Equity-Centered Climate Resilience Initiative, and other efforts through ongoing engagement and by integrating into course material (e.g., case study projects).

Put Systems in Place for Future Involvement
The forthcoming Climate Action Plan, as well as other subsequent studies and analyses recommended as part of Deliverable 4, represent excellent opportunities to include the campus community in engagement efforts, working groups or steering committees, and in the implementation of future climate action and sustainability efforts.

Develop a Strategy for Climate Resilience Curriculum
Create a clear plan for building up climate resilience in curriculum, research, and other opportunities (e.g., internships). This can be done by including Campus as a Living Laboratory as a specific content area in a more detailed campus climate resilience assessment.

https://hdae.ucsb.edu/

UC SANTA BARBARA

APPENDICES

1-1 – CURRENT CAMPUS USE

1-2 – ENERGY & CARBON ANALYSIS
1-3 –THERMAL EQUIPMENT MODELING
2-1 – FINANCIAL ANALYSIS & ASSUMPTIONS
3-1 – CLIMATE ACTION GAP ANALYSIS RESULTS SUMMARY

Building Data Received

The facility's team at UCSB provided Introba with several key datapoints on all of the campus buildings that were to be part of the Clean Energy Master Plan. This includes every building – leased or owned, on or off campus – that UCSB has operational control over, as these buildings will contribute to Scope 1 and 2 emissions. Data such as gross square footage, number of beds (residential) or kitchens, and information on building energy meters and thermal equipment were used to inform the calibration process and engineering model. Other data, such as building age, location (address, latitude, longitude), occupancy date, number of floors, utility service info, and campus region were used for a number of purposes, from phasing strategies to quality control checks. Finally, the facility's team was able to answer inquiries about the state of thermal mechanical equipment, periods of extended vacancy or other abnormal occupancy patterns, and historical program changes.

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8941	Embarcadero Hall	Academic/ Classrooms	12,963	N	N	N	1970	IV	Phase 1, 2, or 3	SCE	SCG	700345000000	176 214 9960 1
8945	El Dorado Apartments	Residences/ Dorms	41,936	N	N	N	1963	IV	Phase 1, 2, or 3	SCE	SCG	700346000000	174 114 9200 6
8947	Westgate Apartments	Residences/ Dorms	26,029	N	N	N	1962	IV	Phase 1, 2, or 3	SCE	SCG	700126000000	155 214 9200 7
8948	Isla Vista Theater	Academic/ Classrooms	11,385	N	N	N	1970	IV	Phase 1, 2, or 3	SCE	SCG	700268000000	186 714 9900 4
8949	Pardall Center	Office/ Administrative	3,045	N	N	N	1973	IV	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8950	IV Community Resources Bldg	Office/ Administrative	1,264	N	N	N	1970	IV	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8970	910 Embarcadero	Office/ Administrative	4,345	N	N	N	1960	IV	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8200	The Reef	Academic/ Classrooms	1,034	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8205	Filter / Reservoir House	Office/ Administrative	4,118	N	N	N	2001	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8221	Student Resource Building	Office/ Administrative	67,427	Y	N	N	2007	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8223	Theater & Dance West	Academic/ Classrooms	32,749	Y	N	N	2007	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8225	Engineering Science	Labs	87,957	Y	N	N	2004	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8226	Henley Hall	Labs	49,908	Y	N	N	2020	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8232	Building 232	Office/ Administrative	2,160	N	N	N	2003	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8235	Life Sciences	Labs	77,526	Y	N	N	2003	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8243	Intercollegiate Athletics	Gymnasium/ Athletic	44,213	N	N	N	2005	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8245	Arnhold Tennis Center	Gymnasium/ Athletic	1,948	N	N	N	2021	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8250	Mesa Parking	Other	312,746	N	N	N	1998	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8251	Psychology East	Labs	31,882	Y	N	N	2006	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8252	Parking II	Other	218,698	N	N	N	2006	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8254	Parking III	Other	346,432	N	N	N	2007	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8266	Elings Hall	Labs	111,774	Y	N	N	2006	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8275	Education Building	Academic/ Classrooms	93,893	Y	N	N	2009	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8276	Social Sciences & Media Stds	Academic/ Classrooms	92,769	Y	N	N	2009	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8277	Pollock Theater	Other	14,505	Y	N	N	2009	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8300	CLAS	Office/ Administrative	2,160	N	N	N	1989	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8322	Relocatable 322	Office/ Administrative	710	N	N	N	1998	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8324	Bike Shop	Other	1,200	N	N	N	2010	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8334	MSI Trailer 334	Office/ Administrative	520	N	N	N	1965	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8335	Student Resident Life Trailer	Office/ Administrative	1,800	N	N	N	2002	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8336	Central Garage Office	Other	320	N	N	N	1969	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8338	MSI Trailer 338	Office/ Administrative	696	N	N	N	1971	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8342	MSI Trailer 342	Office/ Administrative	1,488	N	N	N	1978	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8347	FM Storage 347	Office/ Administrative	319	N	N	N	1984	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8348	FM Storage 348	Office/ Administrative	319	N	N	N	1984	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8349	FM Storage 349	Office/ Administrative	319	N	N	N	1987	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8370	FM Trailer 370	Office/ Administrative	2,880	N	N	N	1990	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8371	FM Trailer 371	Office/ Administrative	2,916	N	N	N	1978	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8373	FM Storage 373	Office/ Administrative	320	N	N	N	1984	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8375	Transportation Services	Office/ Administrative	1,440	N	N	N	1989	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8380	Engineering Trailer 380	Office/ Administrative	1,440	N	N	N	1985	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8381	Parking Services	Office/ Administrative	1,617	N	N	N	1985	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8383	Modular Building 383	Office/ Administrative	1,440	N	N	N	2018	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8384	Engineering Trailer 384	Office/ Administrative	1,434	N	N	N	2004	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8387	Modular Classroom	Academic/ Classrooms	2,808	N	N	N	1998	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8388	Parking Services 2	Office/ Administrative	2,130	N	N	N	1991	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8400	San Rafael Pool Dressing Room	Residences/ Dorms	418	N	N	N	1971	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8402	Building 402	Office/ Administrative	5,040	N	N	N	1943	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8406	Chicano Students Center	Office/ Administrative	6,766	N	N	N	1943	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8415	FM Storage 415	Office/ Administrative	144	N	N	N	1977	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8434	Building 434	Office/ Administrative	14,272	N	N	N	1943	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8437	FM Building 437	Office/ Administrative	6,239	N	N	N	1943	MAIN	to be demolished	UCOP	SCG	UCOP Main	SCG Main
8439	FM Building 439	Office/ Administrative	6,280	N	N	N	1943	MAIN	to be demolished	UCOP	SCG	UCOP Main	SCG Main
8442	Greenhouse 442	Academic/ Classrooms	758	N	N	N	2013	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8443	Greenhouse 443	Academic/ Classrooms	2,770	N	N	N	2013	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8451	Building 451	Office/ Administrative	4,489	N	N	N	1943	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8465	Aquarium Facility	Labs	5,025	N	N	N	1943	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8477	Building 477	Office/ Administrative	3,703	N	N	N	1943	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8479	Old Gym And Pool	Gymnasium/ Athletic	22,809	N	N	N	1944	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8489	Building 489	Office/ Administrative	9,058	N	N	N	1944	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8494	Creative Studies	Academic/ Classrooms	18,260	N	N	N	1944	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8500	Emergency Generator Station	Other	103	N	N	N	1989	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8501	Arbor Convenience Store	Other	4,606	N	N	N	2005	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8502	Beach Pump	Other	1,552	N	N	N	1975	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8503	Engineering II	Labs	145,155	Y	Y	N	1986	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8504	Bio Sci Instruction Facility	Labs	14,006	N	N	N	1985	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8505	Events Center	Gymnasium/ Athletic	64,197	Y	N	N	1980	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8506	Interactive Learning Pavilion	Academic/ Classrooms	95,000	Y	N	N	2023	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8510	Central Garage Storage	Other	168	N	N	N	1942	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8511	Multi-Activity Center	Gymnasium/ Athletic	53,197	N	N	N	2005	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8512	Bioengineering Building	Labs	85,566	Y	N	N	2017	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8514	OSEB	Office/ Administrative	17,021	N	N	N	2010	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8515	Humanities And Soc Sci Bldg	Academic/ Classrooms	154,547	Y	N	N	1996	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8516	Recreation Center	Gymnasium/ Athletic	66,130	N	N	N	1994	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8517	Mosher Alumni House	Office/ Administrative	23,929	Y	N	N	2007	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8519	Marine Science Utility Bldg	Labs	1,167	N	N	N	2005	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8520	Marine Science Building	Labs	58,881	Y	N	N	2004	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8521	Bren Hall	Labs	82,972	Y	N	N	2002	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8524	Electrical Sub-Station	Other	2,497	N	N	N	1942	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8525	Davidson Library	Library	409,922	Y	N	N	1952	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8526	Webb Hall	Labs	43,449	Y	N	N	1952	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8527	Santa Rosa Residence Hall	Residences/ Dorms	84,495	N	N	N	1954	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8528	South Hall	Academic/ Classrooms	131,668	N	N	N	1969	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8529	Main Sewer Pump	Academic/ Classrooms	2,094	N	N	N	1952	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8530	Centennial House Conf Facil	Office/ Administrative	985	N	N	N	1968	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8531	Music	Academic/ Classrooms	80,924	Y	N	N	1954	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8532	Coral Tree Cafe	Other	2,494	N	N	N	1996	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8533	Robertson Gym	Gymnasium/ Athletic	79,276	N	N	N	1957	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8534	Arts	Academic/ Classrooms	83,683	N	N	N	1957	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8535	North Hall	Academic/ Classrooms	66,119	Y	N	N	1960	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8537	Recreation Storage 537	Gymnasium/ Athletic	486	N	N	N	1959	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8538	Campbell Hall	Academic/ Classrooms	14,491	N	N	N	1961	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8539	Bio Sciences Annex	Labs	1,391	N	N	N	1958	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8540	Greenhouse 540	Academic/ Classrooms	6,082	N	N	N	1960	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8541	Greenhouse 541	Academic/ Classrooms	1,826	N	N	N	2010	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8542	Ortega Dining Commons	Dining Hall	23,416	N	N	N	1956	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8543	University House	Residences/ Dorms	5,243	N	N	N	1964	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8544	Noble Hall	Labs	44,006	Y	N	N	1958	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8545	Recreation Restroom & Storage	Gymnasium/ Athletic	826	N	N	N	1957	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8546	Woodhouse Lab	Labs	10,894	N	N	N	1962	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8547	Anacapa Residence Hall	Residences/ Dorms	78,113	N	N	N	1958	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8548	Santa Cruz Residence Hall	Residences/ Dorms	78,114	N	N	N	1958	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8549	De La Guerra Dining Commons	Dining Hall	32,027	N	N	N	1958	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8550	Beach Pump House	Other	1,100	N	N	N	1961	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8551	Psychology	Labs	48,027	Y	N	N	1963	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8552	Cheadle Hall	Office/ Administrative	68,143	N	N	N	1963	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8553	San Miguel Residence Hall	Residences/ Dorms	85,414	N	N	N	1962	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8554	Theater & Dance East	Academic/ Classrooms	33,945	N	N	N	1963	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8555	Marine Biotechnology Lab	Labs	36,825	N	N	N	1963	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8556	Harold Frank Hall	Labs	100,067	Y	N	N	1965	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8557	Chemistry	Labs	99,298	Y	N	N	1964	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8558	University Center	Other	159,040	N	N	N	1964	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8559	North Sewer Pump Station	Other	895	N	N	N	1969	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8560	Phelps Hall	Academic/ Classrooms	134,893	N	N	N	1965	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8561	San Nicolas Residence Hall	Residences/ Dorms	84,950	N	N	N	1964	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8562	Carrillo Dining Commons	Dining Hall	23,346	N	N	N	1967	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8563	Ellison Hall	Academic/ Classrooms	114,144	N	N	N	1967	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8564	Girvetz Hall	Academic/ Classrooms	48,871	N	N	N	1955	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8565	Environmental Health & Safety	Office/ Administrative	15,013	N	N	N	1992	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8567	Kohn Hall	Academic/ Classrooms	38,038	Y	N	N	1994	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8568	Student Affairs & Admin Svs	Office/ Administrative	77,755	Y	N	N	1996	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8569	Biology Research Lab	Labs	8,184	N	N	N	1964	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8570	Chemistry Annex	Labs	6,130	N	N	N	1964	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8571	Biological Sciences II	Labs	129,364	Y	N	N	1966	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8572	Broida Hall	Labs	150,363	Y	Y	N	1967	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8573	Buchanan Hall	Academic/ Classrooms	18,639	N	N	N	1967	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8575	Cloud Research Lab	Academic/ Classrooms	3,004	Y	N	N	1969	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8577	Baseball Lockers	Gymnasium/ Athletic	1,798	N	N	N	2005	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8579	South Sewer Pump Station	Other	462	N	N	N	1965	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8581	The Club	Residences/ Dorms	29,825	N	N	N	1967	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8584	FM Storage 584	Office/ Administrative	8,522	N	N	N	1967	MAIN	to be demolished	UCOP	SCG	UCOP Main	SCG Main
8586	San Rafael Tower	Residences/ Dorms	61,473	N	N	N	1967	MAIN	Phase 2	UCOP	SCG	UCOP Main	0
8587	San Rafael Cluster	Residences/ Dorms	48,012	N	N	N	1967	MAIN	Phase 2	UCOP	SCG	UCOP Main	0
8588	Student Health	Other	39,225	N	N	N	1968	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8589	Storke Publications	Office/ Administrative	9,223	N	N	N	1968	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8591	Kerr Hall	Academic/ Classrooms	43,678	N	N	N	1975	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8592	Molten Metal Lab	Academic/ Classrooms	1,697	N	N	N	1974	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8594	FM Shop	Office/ Administrative	6,040	N	N	N	1974	MAIN	to be demolished	UCOP	SCG	UCOP Main	SCG Main
8595	Central Garage	Other	3,870	N	N	N	1974	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8597	First Aid Hostel	Other	336	N	N	N	1989	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8598	Flammable Storage 598	Other	884	N	N	N	1975	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8599	Student Services	Office/ Administrative	15,506	N	N	N	1984	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8615	Materials Research Lab	Labs	37,109	Y	N	N	1997	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8657	Physical Sciences North	Labs	93,317	Y	N	N	1994	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8672	Physical Sciences South	Labs	23,457	Y	Y	N	1994	MAIN	Phase 1	UCOP	SCG	UCOP Main	SCG Main
8697	Engineering Trailer 697	Office/ Administrative	727	N	N	N	1991	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8698	Engineering Trailer 698	Office/ Administrative	1,434	N	N	N	1991	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8699	Engineering Trailer 699	Office/ Administrative	1,432	N	N	N	1991	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8875	De Anza Residence Hall	Office/ Administrative	10,813	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8876	Loma Pelona Multipurpose Ctr	Office/ Administrative	7,076	N	N	N	2009	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8877	Tecolote Residence Hall	Residences/ Dorms	10,193	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8878	Cienega Residence Hall	Residences/ Dorms	14,777	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8879	Jalama Residence Hall	Residences/ Dorms	11,378	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8880	Arguello Residence Hall	Residences/ Dorms	11,859	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8881	Miranda Residence Hall	Residences/ Dorms	14,202	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8882	Gaviota Residence Hall	Residences/ Dorms	10,110	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8883	Condor Residence Hall	Residences/ Dorms	10,622	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8884	La Cumbre Residence Hall	Residences/ Dorms	11,696	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8885	Montecito Residence Hall	Residences/ Dorms	10,197	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8886	Tepusquet Residence Hall	Residences/ Dorms	11,027	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8887	Rincon Residence Hall	Residences/ Dorms	10,112	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8888	Zaca Residence Hall	Residences/ Dorms	10,246	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8889	Camuesa Residence Hall	Residences/ Dorms	11,343	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8890	Pendola Residence Hall	Residences/ Dorms	13,141	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8891	Cuyama Residence Hall	Residences/ Dorms	13,935	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8892	Madulce Residence Hall	Residences/ Dorms	10,727	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8893	Figueroa Residence Hall	Residences/ Dorms	10,111	N	N	N	2002	MAIN	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8935	Engineering Trailer 935	Office/ Administrative	1,440	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8936	Engineering Trailer 936	Office/ Administrative	1,440	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8937	Trailer 937	Office/ Administrative	2,160	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8939	Trailer 939	Office/ Administrative	2,160	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8942	Trailer 942	Office/ Administrative	1,440	N	N	N	2001	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8972	FM Trailer 972	Office/ Administrative	2,860	N	N	N	1994	MAIN	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8284	Sedg Modular Residence II	Residences/ Dorms	1,166	N	N	N	2017	NATRES	Phase 1, 2, or 3	UCOP	SCG	4926667344-8	SCG Main
8285	Sedg Tipton Meeting House	Office/ Administrative	3,778	N	N	N	2011	NATRES	Phase 1, 2, or 3	UCOP	SCG	4926667344-8	SCG Main
8288	Sedg Directors Residence	Residences/ Dorms	1,192	N	N	N	2009	NATRES	Phase 1, 2, or 3	UCOP	SCG	4926667344-8	SCG Main
8329	Santa Cruz Isle Mgrs Res	Other	1,684	N	N	N	1964	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8391	Santa Cruz Isle Stwrd House	Other	322	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8392	Santa Cruz Isle Facility 2	Other	2,285	N	N	N	1967	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8393	Santa Cruz Isle Facility 3	Other	1,160	N	N	N	1967	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8394	Santa Cruz Isle Facility 4	Other	441	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8395	Santa Cruz Isle Facility 5	Other	426	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8396	Santa Cruz Isle Facility 6	Other	426	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8397	Santa Cruz Isle Facility 7	Other	426	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8398	Santa Cruz Isle Facility 8	Other	644	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8399	Santa Cruz Isle Facility 9	Other	192	N	N	N	1983	NATRES	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8951	SNARL Lab	Labs	4,166	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8952	SNARL Residence 1	Residences/ Dorms	1,312	N	N	N	1938	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8953	SNARL Residence 2	Residences/ Dorms	2,399	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8954	SNARL Residence 3	Residences/ Dorms	674	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8955	SNARL Residence 4	Residences/ Dorms	730	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8956	SNARL Residence 5	Residences/ Dorms	424	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8957	SNARL Storage	Other	175	N	N	N	1940	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8958	SNARL Container Residence	Other	629	N	N	N	2020	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8960	SNARL Fish Lab	Labs	1,106	N	N	N	1965	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8961	SNARL Green Church	Other	1,304	N	N	N	1954	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8962	SNARL Classroom	Academic/ Classrooms	2,696	N	N	N	2015	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8963	SNARL Dormitory	Residences/ Dorms	1,984	N	N	N	1985	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8964	SNARL Headquarters	Office/ Administrative	3,063	N	N	N	1935	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8965	SNARL Garage	Other	2,400	N	N	N	1998	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8966	SNARL Animal Quarters	Other	292	N	N	N	1954	NATRES	Phase 1, 2, or 3	SCE	SCG	700269000000	SCG Main
8982	VALENTINE University Cabin	Other	1,259	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8983	VALENTINE Old Cabin	Other	1,138	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8984	VALENTINE Cookhouse	Other	739	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8985	VALENTINE Caretaker's Cabin 985	Other	721	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8986	VALENTINE Caretaker's Cabin 986	Other	403	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8987	VALENTINE Kohler Shed	Other	360	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8988	VALENTINE Wood Shed	Other	203	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8989	VALENTINE Ed Center	Other	918	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8990	VALENTINE Private Cabin	Other	1,979	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8991	VALENTINE Storage Shed	Other	176	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8992	VALENTINE Dining Shed	Other	280	N	N	N	1920	NATRES	Phase 1, 2, or 3	SCE	SCG	700267000000	SCG Main
8929	NCOS Gator Barn	Other	1,564	N	N	N	2019	NORTH	Phase 1, 2, or 3	SCE	SCG	700125000000	SCG Main
81120	Sierra Madre Recreation Center	Other	3,343	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81121	Sierra Madre Laguna Village	Residences/ Dorms	26,670	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81122	Sierra Madre Berryessa Village	Residences/ Dorms	31,358	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81123	Sierra Madre Toluca Village	Residences/ Dorms	31,275	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81124	SierraMadre Nacimiento Village	Residences/ Dorms	30,961	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81125	Sierra Madre Havasu Village	Residences/ Dorms	31,333	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81126	Sierra Madre Miramar Center	Residences/ Dorms	6,295	N	N	N	2015	NORTH	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81127	Sierra Madre Apartments	Residences/ Dorms	45,353	N	N	N	2016	NORTH	Phase 1, 2, or 3	SCE	SCG	700543000000	176 377 1652 7
8240	Lake Hemet MWD (ERI)	Other	80	N	N	N	2002	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8895	6789 Navigator Way Bldg. 5 (DFSS)	Office/ Administrative	26,621	N	N	N	2021	OFFSITE	Phase 1, 2, or 3	SCE	SCG	700756000000	165 797 9924 4
8896	6765 Navigator Way Bldg. 6 (DFSS)	Office/ Administrative	17,072	N	N	N	2021	OFFSITE	Phase 1, 2, or 3	SCE	SCG	700796000000	046 051 2215 1
8897	6759 Navigator Way Bldg. 7 (DFSS)	Office/ Administrative	36,848	N	N	N	2021	OFFSITE	Phase 1, 2, or 3	SCE	SCG	700756000000	020 868 8696 3
8924	Anacapa Street (NCEAS)	Office/ Administrative	36,820	N	N	N	2000	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8925	Castilian Drive (A&L Admin)	Other	5,378	N	N	N	1996	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8932	Garden Street (MAT)	Office/ Administrative	400	N	N	N	2016	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8933	Aston Avenue (MSI SONGS)	Other	5,962	N	N	N	2001	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8934	Fairview Ave (UCEAP)	Gymnasium/ Athletic	10,840	N	N	N	2008	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	Unknown	Unknown
8944	Cachuma Boat House	Gymnasium/ Athletic	2,250	N	N	N	1982	OFFSITE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8317	Police 317	Office/ Administrative	1,456	N	N	N	1966	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8339	Green Barn Storage	Other	848	N	N	N	1935	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main

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Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8340	FM Building 340	Office/ Administrative	1,926	N	N	N	1972	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8343	Flammable Storage 343	Other	406	N	N	N	2008	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8376	Police Trailer	Office/ Administrative	919	N	N	N	2001	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8378	Communication Trailer	Office/ Administrative	1,440	N	N	N	1993	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8379	Communication Trailer 2	Office/ Administrative	1,440	N	N	N	1990	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8507	Central Storehouse	Other	20,926	N	N	N	1980	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8518	Student Greenhouse	Academic/ Classrooms	891	N	N	N	1980	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8574	Public Safety	Office/ Administrative	15,858	N	N	N	1967	STORKE	Phase 2	UCOP	SCG	UCOP Main	SCG Main
8578	Harder Office	Office/ Administrative	11,500	N	N	N	2004	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8580	Harder Stadium	Gymnasium/ Athletic	32,825	N	N	N	1966	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8583	Bird Aviary	Academic/ Classrooms	1,493	N	N	N	1993	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8585	North Water Pump Station	Other	2,400	N	N	N	1968	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8758	Storke Apartments 758	Residences/ Dorms	4,093	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8759	Storke Apartments 759	Residences/ Dorms	9,026	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8760	Storke Apartments 760	Residences/ Dorms	6,583	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8761	Storke Apartments 761	Residences/ Dorms	9,855	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8762	Storke Apartments 762	Residences/ Dorms	8,217	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8763	Storke Apartments 763	Residences/ Dorms	8,217	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8764	Storke Apartments 764	Residences/ Dorms	8,217	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8765	Storke Apartments 765	Residences/ Dorms	8,205	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8766	Storke Apartments 766	Residences/ Dorms	9,827	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8767	Storke Apartments 767	Residences/ Dorms	9,839	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8768	Storke Apartments 768	Residences/ Dorms	9,815	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8769	Storke Apartments 769	Residences/ Dorms	9,839	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8770	Storke Apartments 770	Residences/ Dorms	9,815	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8771	Storke Apartments 771	Residences/ Dorms	7,413	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8772	Storke Apartments 772	Residences/ Dorms	2,463	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8773	Storke Apartments 773	Residences/ Dorms	7,413	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8774	Storke Apartments 774	Residences/ Dorms	3,272	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8775	Storke Apartments 775	Residences/ Dorms	7,396	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8776	Storke Apartments 776	Residences/ Dorms	4,093	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8777	Storke Apartments 777	Residences/ Dorms	8,205	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8778	Storke Service 778	Office/ Administrative	1,061	N	N	N	1972	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8779	Storke Apartments 779	Residences/ Dorms	6,563	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8780	Storke Apartments 780	Residences/ Dorms	9,034	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8781	Storke Apartments 781	Residences/ Dorms	9,034	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8782	Storke Apartments 782	Residences/ Dorms	7,392	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8783	Storke Apartments 783	Residences/ Dorms	7,392	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8784	Storke Apartments 784	Residences/ Dorms	9,055	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8785	Storke Apartments 785	Residences/ Dorms	7,396	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8786	Storke Service 786	Office/ Administrative	1,438	N	N	N	1972	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8787	Storke Apartments 787	Residences/ Dorms	8,205	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8788	Storke Apartments 788	Residences/ Dorms	6,563	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8789	Storke Apartments 789	Residences/ Dorms	6,563	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8790	Storke Apartments 790	Residences/ Dorms	3,272	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8791	Storke Apartments 791	Residences/ Dorms	3,272	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8792	Storke Apartments 792	Residences/ Dorms	6,600	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8793	Storke Apartments 793	Residences/ Dorms	4,073	N	N	N	1972	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8794	Storke Apartments 794	Residences/ Dorms	7,028	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8795	Storke Apartments 795	Residences/ Dorms	7,028	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8796	Storke Apartments 796	Residences/ Dorms	5,278	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8797	Storke Apartments 797	Residences/ Dorms	10,519	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8798	Storke Apartments 798	Residences/ Dorms	7,028	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8799	Storke Apt Community Bldg	Other	1,205	N	N	N	1982	STORKE	Phase 1, 2, or 3	SCE	SCG	700027000000	116 284 2356 5
8802	Storage Bunker 802	Other	1,352	N	N	N	1942	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8805	Santa Ynez Apartments 805	Residences/ Dorms	7,156	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8806	Santa Ynez Apartments 806	Residences/ Dorms	7,832	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8807	Santa Ynez Apartments 807	Residences/ Dorms	7,156	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8808	Santa Ynez Activities 808	Residences/ Dorms	1,205	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8809	Santa Ynez Apartments 809	Residences/ Dorms	2,619	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8810	Santa Ynez Apartments 810	Residences/ Dorms	10,734	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8811	Santa Ynez Apartments 811	Residences/ Dorms	6,197	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8812	Santa Ynez Apartments 812	Residences/ Dorms	9,167	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8813	Santa Ynez Apartments 813	Residences/ Dorms	7,764	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8814	Santa Ynez Apartments 814	Residences/ Dorms	7,764	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8815	Santa Ynez Activities 815	Residences/ Dorms	1,205	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8816	Santa Ynez Apartments 816	Residences/ Dorms	8,050	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8817	Santa Ynez Laundry	Residences/ Dorms	1,991	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8818	Santa Ynez Office Shop	Residences/ Dorms	2,757	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8819	Santa Ynez Apartments 819	Residences/ Dorms	9,843	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8820	Santa Ynez Apartments 820	Residences/ Dorms	9,775	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8821	Santa Ynez Apartments 821	Residences/ Dorms	10,734	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8822	Santa Ynez Apartments 822	Residences/ Dorms	5,589	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8823	Santa Ynez Activities 823	Residences/ Dorms	1,205	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8824	Santa Ynez Apartments 824	Residences/ Dorms	11,410	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8825	Santa Ynez Apartments 825	Residences/ Dorms	11,342	N	N	N	1980	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8826	Santa Ynez Apartments 826	Residences/ Dorms	7,156	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8827	Santa Ynez Apartments 827	Residences/ Dorms	11,410	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8828	Santa Ynez Apartments 828	Residences/ Dorms	9,167	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8829	Santa Ynez Apartments 829	Residences/ Dorms	10,734	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8830	Santa Ynez Apartments 830	Residences/ Dorms	6,197	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8831	Santa Ynez Activities 831	Residences/ Dorms	1,205	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8832	Santa Ynez Shop 832	Residences/ Dorms	3,152	N	N	N	1986	STORKE	Phase 3	SCE	SCG	600001000000	059 697 2663 6
8834	Charles T. Munger Physics Residence	Residences/ Dorms	78,117	N	N	N	2017	STORKE	Phase 3	UCOP	SCG	UCOP Main	178 377 4209 1
8839	San Clemente Parking IV	Other	268,168	N	N	N	2008	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8840	Arrowhead 840	Residences/ Dorms	9,699	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8841	Arrowhead 841	Residences/ Dorms	50,824	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8842	Bradbury 842	Residences/ Dorms	53,250	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8843	Castaic 843	Residences/ Dorms	33,230	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8844	Donner 844	Residences/ Dorms	53,250	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8845	Encino 845	Residences/ Dorms	37,953	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8846	Donner 846	Residences/ Dorms	17,326	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8847	Castaic 847	Residences/ Dorms	10,953	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8848	Castaic 848	Residences/ Dorms	2,491	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8849	Bradbury 849	Residences/ Dorms	17,335	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8850	Arrowhead 850	Residences/ Dorms	18,919	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8851	Castaic 851	Residences/ Dorms	16,232	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8852	Encino 852	Residences/ Dorms	16,232	N	N	N	2008	STORKE	Phase 3	UCOP	SCG	UCOP Main	SCG Main
8860	Santa Catalina Res Hall	Residences/ Dorms	251,100	N	N	N	1966	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81861	Portola Dining Commons	Dining Hall	33,961	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81862	SJ Tenaya South #1862	Residences/ Dorms	48,884	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81863	SJ Tenaya South #1863	Residences/ Dorms	1,252	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81864	SJ Tenaya North #1864	Residences/ Dorms	41,764	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81865	SJ Elsinore Court #1865	Residences/ Dorms	11,485	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81866	SJ Elsinore Court #1866	Residences/ Dorms	8,308	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
81867	SJ Elsinore Court #1867	Residences/ Dorms	12,555	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81868	SJ Calaveras Court #1868	Residences/ Dorms	10,450	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81869	SJ Calaveras Court #1869	Residences/ Dorms	10,014	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81870	SJ Calaveras Court #1870	Residences/ Dorms	9,354	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81871	SJ Calaveras Court #1871	Residences/ Dorms	1,391	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81872	SJ Calaveras Court #1872	Residences/ Dorms	1,481	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81873	SJ Calaveras Court #1873	Residences/ Dorms	11,072	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81874	SJ Malibu Court #1874	Residences/ Dorms	10,680	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81875	SJ Malibu Court #1875	Residences/ Dorms	11,014	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81876	SJ Malibu Court #1876	Residences/ Dorms	8,084	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81877	SJ Malibu Court #1877	Residences/ Dorms	11,058	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81878	SJ Ramona Court #1878	Residences/ Dorms	1,297	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81879	SJ Ramona Court #1879	Residences/ Dorms	10,830	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81880	SJ Ramona Court #1880	Residences/ Dorms	6,982	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81881	SJ Ramona Court #1881	Residences/ Dorms	1,000	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
81882	SJ Ramona Court #1882	Residences/ Dorms	11,228	N	N	N	2018	STORKE	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	079 714 6007 1
8351	Building 351	Office/ Administrative	3,853	N	N	N	1954	WEST	Phase 1, 2, or 3	UCOP	SCG	UCOP Main	SCG Main
8352	West Art 352 - Child Care	Other	1,365	N	N	N	1948	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8353	West Recreation Ath	Other	1,084	N	N	N	1956	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8354	West Creative 354	Academic/ Classrooms	2,021	N	N	N	1956	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8355	Orfalea Family Children's Ctr	Other	13,373	N	N	N	1965	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8358	West Leisure Service-Red Barn	Other	5,168	N	N	N	1921	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8360	West Animal Compound	Other	1,059	N	N	N	1921	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8361	West Creative 361	Academic/ Classrooms	1,295	N	N	N	1965	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8362	West Cliff House	Academic/ Classrooms	2,842	N	N	N	1954	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8363	Coal Oil Point Reserve Office	Office/ Administrative	448	N	N	N	1948	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8366	Coal Oil Point Staff Trailer	Office/ Administrative	1,350	N	N	N	1997	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8367	West Storage 367	Other	542	N	N	N	1960	WEST	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
8701	West Apartment 701	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8702	West Apartment 702	Residences/ Dorms	2,942	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8703	West Apartment 703	Residences/ Dorms	8,200	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8704	West Apartment 704	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8705	West Apartment 705	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8706	West Apartment 706	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8707	West Apartment 707	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8708	West Apartment 708	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8709	West Apartment 709	Residences/ Dorms	2,942	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8710	West Apartment 710	Residences/ Dorms	4,413	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8711	West Apartment 711	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8712	West Apartment 712	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8713	West Apartment 713	Residences/ Dorms	2,942	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8714	West Apartment 714	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8715	West Apartment 715	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8716	West Apartment 716	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8717	West Apartment 717	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8718	West Apartment 718	Residences/ Dorms	4,413	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8719	West Apartment 719	Residences/ Dorms	4,413	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8720	West Apartment 720	Residences/ Dorms	4,413	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8721	West Apartment 721	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8722	West Apartment 722	Residences/ Dorms	2,942	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8723	West Apartment 723	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8724	West Apartment 724	Residences/ Dorms	8,200	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8725	West Apartment 725	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8726	West Apartment 726	Residences/ Dorms	2,942	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8727	West Apartment 727	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8728	West Apartment 728	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8729	West Apartment 729	Residences/ Dorms	2,222	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8730	West Apartment 730	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8731	West Apartment 731	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8732	West Apartment 732	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8733	West Apartment 733	Residences/ Dorms	4,100	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8734	West Apartment 734	Residences/ Dorms	8,200	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8735	West Apartment 735	Residences/ Dorms	3,672	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8736	West Office and Laundry	Residences/ Dorms	1,400	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8737	West Laundry	Residences/ Dorms	1,120	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8738	West Electrical 738	Other	400	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8739	West Electrical 739	Other	144	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8740	West Heater 740	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8741	West Heater 741	Other	178	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8742	West Heater 742	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7

Appendix 1-1 – Current Campus Use

Building ID CAAN	Building Name	Building Use Type	Building Area (GSF)	Current District Cooling Y/N?	Current District Heating Y/N?	Current District Hot Water Y/N?	First Year Active	Region	Decarbonization Phase	Electricity Utility Provider	Gas Utility Provider	Electric Utility Billing Group	Gas Utility Billing Group
8743	West Heater 743	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8744	West Heater 744	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8745	West Heater 745	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8746	West Heater 746	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8747	West Heater 747	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8748	West Heater 748	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8749	West Heater 749	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8750	West Heater 750	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8751	West Heater 751	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8752	West Heater 752	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8753	West Heater 753	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8754	West Heater 754	Other	178	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8755	West Heater 755	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8756	West Heater 756	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
8757	West Heater 757	Other	96	N	N	N	1961	WEST	Phase 1, 2, or 3	SCE	SCG	700121000000	005 613 9882 7
87000	West 7000	Other	1,885	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87015	DEV7015	Other	1,301	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87020	DEV7020	Other	8,500	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87040	DEV7040	Other	5,471	N	N	N	1949	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87045	DEV7045	Other	9,438	N	N	N	1980	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87050	West Conference Center	Other	3,560	N	N	N	1980	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87055	DEV7055	Other	24,399	N	N	N	1925	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87060	COPR Nature Center	Other	5,480	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87085	DEV7085	Other	4,718	N	N	N	1969	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87095	West Cottage 7095	Other	4,419	N	N	N	1998	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87097	West Cottage 7097	Other	4,419	N	N	N	1998	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87905	DEV7905	Other	5,397	N	N	N	1965	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87935	West 7935	Other	1,320	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87940	West House 7940	Other	1,649	N	N	N	1935	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87945	West 7945	Other	1,749	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87950	West 7950	Other	3,914	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87955	West 7955	Other	3,726	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87961	DEV7961	Other	11,353	N	N	N	1960	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87965	West 7965	Other	3,547	N	N	N	1998	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1
87966	West 7966	Other	3,547	N	N	N	1998	WEST-D	Phase 1, 2, or 3	SCE	SCG	700268000000	130 114 6074 1

Data Sorting and Assumptions

There were many cases where shared meters or submeters resulted in aggregated data across several buildings. For our analysis, these would need to be disaggregated down to the building level to understand the real heating, cooling, and domestic hot water loads, as well as electricity consumption, for each building. All meters provided had some level of disaggregation required to get to this point, and in some cases there were many different layers of disaggregation needed for the same building. The general process is laid out below and explained in detail on the following pages.

Complete monthly data available

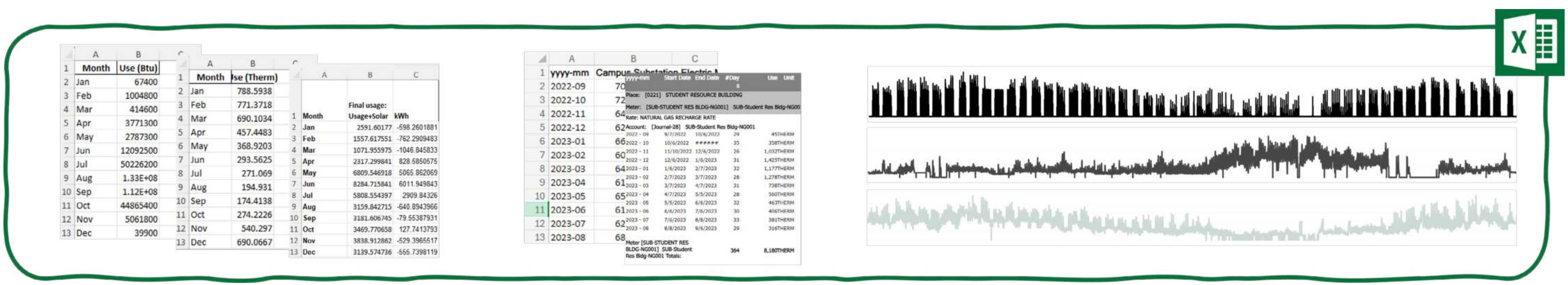
Buildings were categorized as “ready for calibration” if they had 12 months of data for each applicable utility or hourly (8760) profiles for one or more utilities or both.

Shared/Aggregated metered data

Some campus buildings share a meter i.e. a single meter reports energy use for multiple buildings, resulting in combined usage readings being provided. For a successful calibration, each building must have a monthly profile for the relevant utilities. For this reason, energy use for the shared meters was disaggregated into its individual components based on their program and areas, as well as UCSB’s documented mean energy use intensity for each program.

Incomplete/Missing utility data

For unmetered buildings or buildings with missing utility data, usage was estimated based on the total campus meter reading and usage patterns of similar building types. Program types, areas, and UCSB’s documented mean energy use intensity per program were used as reference.



Shared/Aggregated Metered Data

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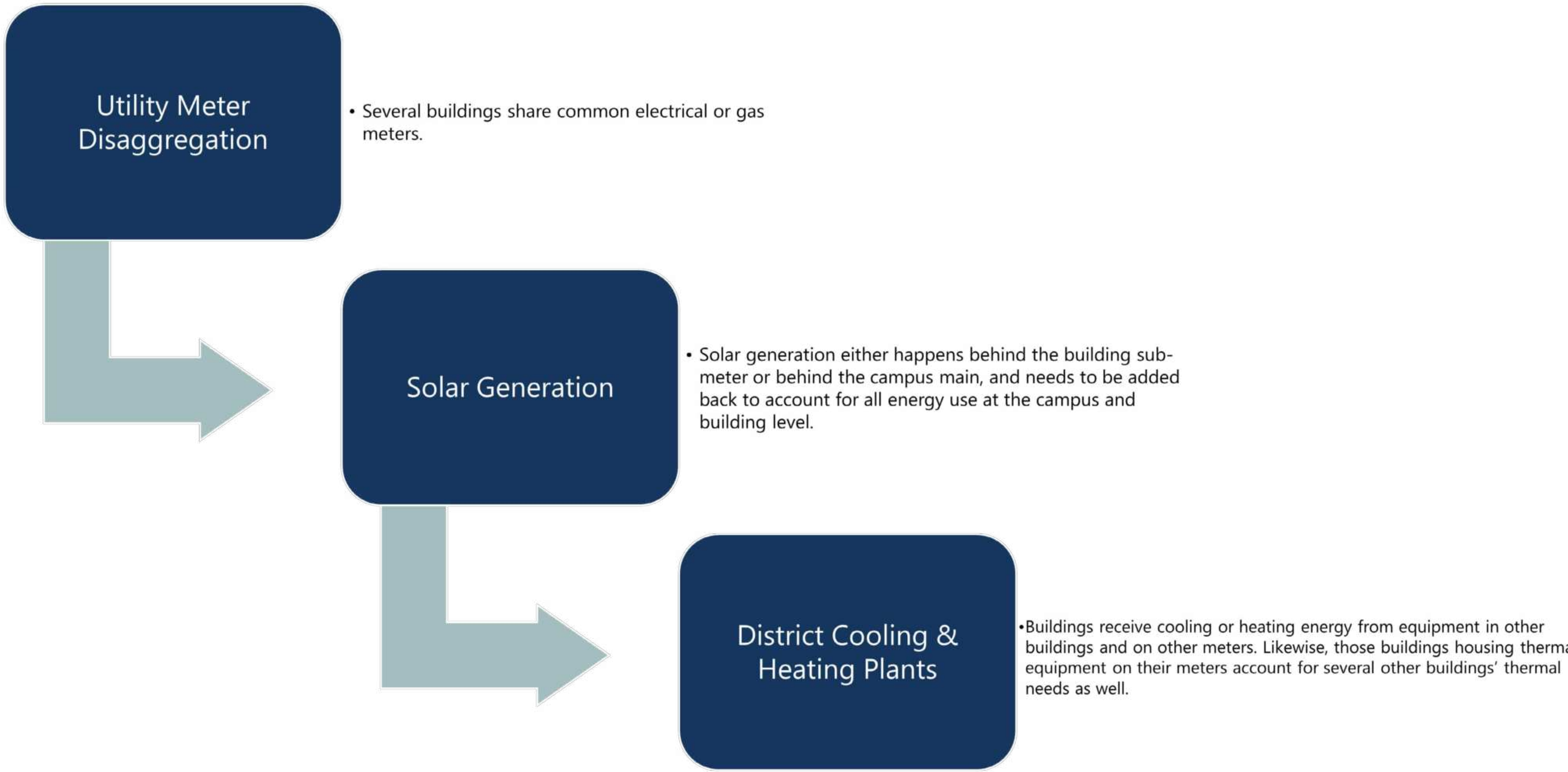


Shared/Aggregated Metered Data

To start, buildings that shared electric or gas sub-meters were dealt with to establish a base list of building and utility accounts for which to further aggregate or disaggregate data. Our team produced a set of conditions for which a specific strategy was used to obtain building specific utility meter data. This was done first to provide a consistent method across the entire campus portfolio of buildings. To supplement received energy data, energy use intensity (EUI) benchmarks were developed based on campus building energy use profiles which fell under conditions 01, 02, or 03. Additionally, the Building Performance Database (BPD) was also used to generate EUI benchmarks where no campus data was available for specific building types.

	Electric	Gas	Strategy
Condition 01	Single building meter, not shared	Single building meter, not shared	No further action necessary, energy is already building specific.
Condition 02	Multiple meters, not shared	Single building meter, not shared	No further action necessary, energy is already building specific.
Condition 03	Single building meter, not shared	Multiple meters, not shared	No further action necessary, energy is already building specific.
Condition 04	Single/multiple meters, shared between same buildings as gas meter(s)	Single/multiple meters, shared between same buildings as electric meter(s)	1) If all buildings are of the same use type (e.g. all are offices), they can be modeled as one building OR energy can be disaggregated proportionally according to building area.2) For two or more building types, energy use should be disaggregated proportionally according to benchmarked EUI and building area.
Condition 05	Single/multiple meters, shared between buildings different than gas meter(s)	Single/multiple meters, shared between buildings different than electric meter(s)	1) If all buildings are of the same use type (e.g. all are offices), they can be modeled as one building OR energy can be disaggregated proportionally according to building area.2) For two or more building types, energy use should be disaggregated proportionally according to benchmarked EUI and building area (preferred).
Condition 06	No electric meter, campus general service	No gas meter, campus general service	Total leftover unmetered buildings = Campus meter - data received Buildings disaggregated further according to either Strategy 1 or 2 in Condition 04.
Condition 07	Master Metered SCE Service	Master Metered SCE Service	Same as Condition 06

Shared/Aggregated Metered Data

To some extent, solar generation presents a challenge when actual building electricity use is needed. The campus essentially has three types of solar arrays; PPA solar arrays, owned arrays "behind" the meter, and owned arrays "in front of" the meter. For any building that had solar arrays "behind" the meter, solar generation can mask building energy use during hours the sun is shining. To fix this, solar generation needs to be first added back to the building (to get the true building energy use) and then subtracted out again when calculating electricity costs. Meanwhile, though all of the PPA arrays and some of the owned meters were "in front of" building sub-meters, but they were behind the campus meter. This means that electricity usage for any solar array that was "in front of" the meter still needs to be added back into the campus meter. Hourly data was received for most of the PPA solar arrays, while most of the owned arrays had monthly data provided. None of the arrays behind the meter had generation profiles provided, monthly or hourly. Since hourly would be needed to add back to building profiles, the PPA data provided the base hourly profile for the rest of the arrays. Any of the arrays with monthly generation data were converted to hourly by calculating the hourly % of full capacity generated for each of the hourly profiles, and then applying that percentage to the capacity of the non-hourly arrays.

After this analysis had been done, our team noticed the PPA production amounts were far exceeding what was normal for non-tracking arrays for the Santa Barbara location. To fix this, PPA hourly generation data was scaled based on a calculated kWh/kW factor which was generated by PVWatts.

Array Location	Building ID	Rated Capacity	PPA or Owned	Notes
Harder Stadium	8578	10	Owned	
Rec Center II	8511	135	Owned	
Bren Hall	8521	47	Owned	
Parking Structure 22		425	Owned	
Henley Gate		2	Owned	
	8951	15	Owned	Behind building sub-meter
	8929	25	Owned	Behind building sub-meter
	8288	60	Owned	Behind building sub-meter
UCSB Theater	8223	173	PPA	
Sierra Madre	81120	155	PPA	
Kerr	8591	216	PPA	
Davidson	8525	217	PPA	
Cheadle	8552	199	PPA	
Athletics	8243	167	PPA	
Arts	8534	187	PPA	
San Clemente	8839	796	PPA	
Mesa Parking	8250	988	PPA	
Elings Hall	8252	592	PPA	
UCSB Lot 38	8834	1931	PPA	
Robertson Gym	8533	494	PPA	

Shared/Aggregated Metered Data

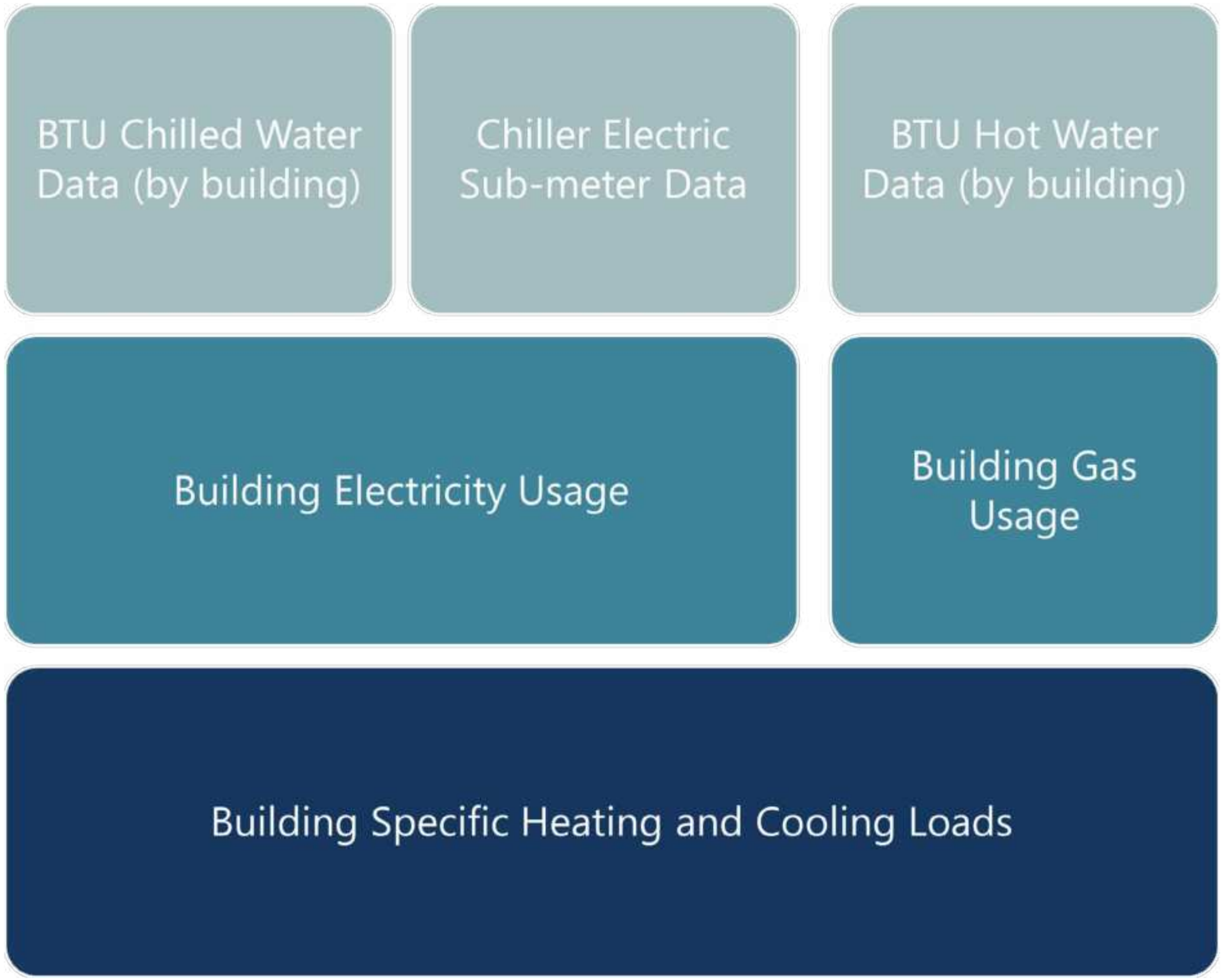
The existing district chilled water and hot water use would also need to be accounted for in each building specific of the shared cooling and heating loops. Currently, there are 14 chillers located in 10 buildings, which together serve X buildings on a shared cooling loop. Likewise, there is a single boiler in a building that serves 3 buildings for space heating. Many buildings had their own sub-meters for chilled and hot water data; additionally, the chillers all included electrical sub-meters which isolated them from the buildings which they were located in.

Our team used the BTU chilled and hot water meter data provided to understand cooling and heating loads for the associated buildings. For buildings on the district heating or cooling loops that did not have BTU meters, average heating and cooling loads were taken from similar buildings on campus, and these were scaled by square footage to fill in the gaps for the missing meter data. So the loads were now known, but the energy use for these loads were on the meters of the buildings that housed the heating or cooling equipment. This would increase the electrical or gas consumption for buildings that housed thermal equipment in proportion to the loads they served for that year.

Our approach to this issue was to use the chiller electrical sub-meter data, and the building specific cooling and heating loads to reassign the electrical usage. Having already assigned electric sub-meters to buildings, the total building electricity consumption was known. If the building has a chiller, the chiller electrical consumption was read from the sub-meter and subtracted from the building's total electric meter. The result was the total electricity consumption for the building, minus any energy for cooling. The cooling was instead accounted for in the form of chilled water usage from a district plant.

The boiler process was similar, except that there were no gas sub-meters to isolate boiler gas usage from the building the boiler was housed in. Instead, the heating loads of the 3 buildings on the heating loop were summed, and an assumed efficiency factor was used to convert the loads to approximate gas consumption, which was then subtracted from the building gas meter.

Now we have the total building energy consumption – electricity for all non-cooling applications, chilled water consumption for all cooling, and natural gas for any heating or domestic hot water. All of the electricity and gas was assigned to a "District Building" on campus, replicating a central plant of sorts to account for all the heating and cooling energy for emissions calculations.



Shared/Aggregated Metered Data

After building specific energy use data was determined for every building, we employed a series of quality assurance/control measures to scrub the data for any potential errors. These "Scrubs" were applied to the building utility data to flag potential issues, and certain flags were given a weight to reflect how sensitive the analysis would be to any given flag. In some cases, not only did this process catch potential errors during the disaggregation process, but was also able to detect the presence of faulty meter readings (in the case of some solar data) or unoccupied buildings that were not previously noted (for instance in the Devereux region).

Scrub No.	Description	Weighting (0-1)	Weighting Justification	Action
Scrub.1 – Outlier (high)	EUI greater than x1.5 the IQR (inter-quartile range).	0.8	Should flag only small number of buildings. Doesn't necessitate an error but should warrant inspection.	Check square footage and energy data for errors. Ensure building is not mis-categorized, or study operation.
Scrub.2 – Outlier (low)	EUI less than x1.5 the IQR (inter-quartile range).	0.8	Same as above.	Same as above.
Scrub.3 – Abnormal EUI (high or low)	EUI outside IQR by less than 1.5 +/-	0.75	Same as above, but less critical due to less difference than IQR.	Same as above.
Scrub.4 – Unusual process gas	For gas heating, higher gas consumption in summer (May-Oct) than in winter (Nov-Apr).	0.8	Less than 1 because a flag is possible and doesn't necessarily imply an error. Given students are gone in the summer and the only real gas usage would be DHW, a flag should be highly unlikely.	Look at base load gas compared to heating load. Consider building use type and if there would be any type of summer only gas heat (e.g. there is an indoor pool, lots of cooking, etc.)
Scrub.5 – Mixed heating (electric and gas)	For gas heating, higher electric in winter (Nov-Apr) than in summer (May-Oct).	0.25	Given campus chilled water for cooling, summer electric consumption could still be low. We may still want to check these on a case by case basis.	Make sure winter electricity usage is not drastically bigger than in summer. If it is, consider occupancy schedule of the building as possible explanation.
Scrub.6 – Spike in monthly usage	Very different (x2 before or after) month EUI within a Building.	0.5	Carbon Signal accounts for outlier months and will try to fix the calibration.	Check for errors in utility data. Is month preceeded or followed by zeros? It could be 2 months of usage allocated into 1 month by mistake. Can anomaly be explained by campus event, e.g. construction?
Scrub.7 – Negative or 0 monthly energy	Less than or equal to zero EUI in a month for electric, gas, or chilled water.	0.8	Given hourly data for most and reliable monthly data, 0's should not exist in the data. Additionally, subtracting meters (solar, chiller) sometimes produces negative results, and this could indicate faulty readings or assumptions.	Anything 0 or less should be considered an error. Check the data, meter splitting, and sub-metering techniques. (check is for electric, gas, and chilled water. HW is only 3 buildings).
Scrub.8 – Negative or 0 annual energy	Less than or equal to zero EUI for the year.	1	Very unlikely. This would almost certainly indicate an error.	Same as above.
Scrub.9 – Abnormally high gas use (relative to total energy)	For fossil fuel heated, abnormally high % (80% or greater) of Annual EUI.	0.8	This would imply the building is heating only. Carbon Signal requires a different calibration strategy for heating only buildings.	Ensure all meters and EUI values are summing correctly. Ensure meter splitting was done correctly. Compare the electric and gas profiles – does it look like there is still cooling? If not, consider the building is heating only.
Scrub.10 – Abnormally low gas use (relative to total energy)	For fossil fuel heated, abnormally low % (20% or less) of Annual EUI.	0.25	Given the climate, this is likely to be very common, and will not impact Carbon Signal analysis. Check and any action can be considered on a case-by-case basis.	Ensure all meters and EUI values are summing correctly. Ensure meter splitting was done correctly. Check building type – some will be expected to have lower gas heating values than others. Consider the building may have gas-heat as a secondary form of heating.
Scrub.11 – Abnormally high chilled water (relative to total energy)	For campus chilled water, abnormally high % (60% or greater) of Annual EUI.	0.8	This would indicate something wrong with data, since a building that has cooling should also have a decent amount of electric cooling load.	Ensure all meters and EUI values are summing correctly. Ensure meter splitting was done correctly.
Scrub.12 – Abnormally low chilled water (relative to total energy)	For campus chilled water, abnormally low % (10% or less) of Annual EUI.	0.8	A building that has CW cooling should expect to see a significant portion of energy associated with its cooling.	Ensure all meters and EUI values are summing correctly. Ensure meter splitting was done correctly. Check electricity profile for signs of additional cooling (e.g. increased consumption in summer months).

UC SANTA BARBARA

1-1 – CURRENT CAMPUS USE

1-2 – ENERGY & CARBON ANALYSIS

1-3 –THERMAL EQUIPMENT MODELING

2-1 – FINANCIAL ANALYSIS & ASSUMPTIONS

3-1 – CLIMATE ACTION GAP ANALYSIS RESULTS SUMMARY

Shared/Aggregated Metered Data

Monthly energy use data, program type, location, and square footage are the parameters needed to calibrate each building and pick an energy model that is approximately representative of the building's characteristics and operation, thereby serving as a digital twin of sorts. Having an energy model associated with each building allows for disaggregation of the building's energy by end-use. These planning-level models are a quick and efficient way of design-assist for concept engineering and are not intended to replace detailed engineering calculations. Depicted below are sample calibrations for 6 of the buildings included in the study across several building types and sizes.

Elison Hall

Electricity

Monthly utility data in kBtu/ft²

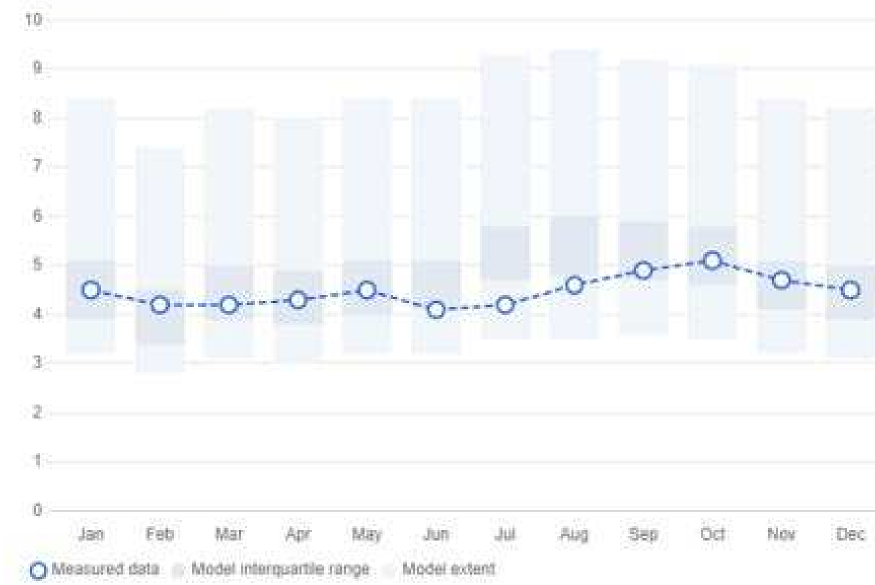
Natural Gas

Monthly utility data in kBtu/ft²

Harder Office

Electricity

Monthly utility data in kBtu/ft²



Natural Gas

Monthly utility data in kBtu/ft²

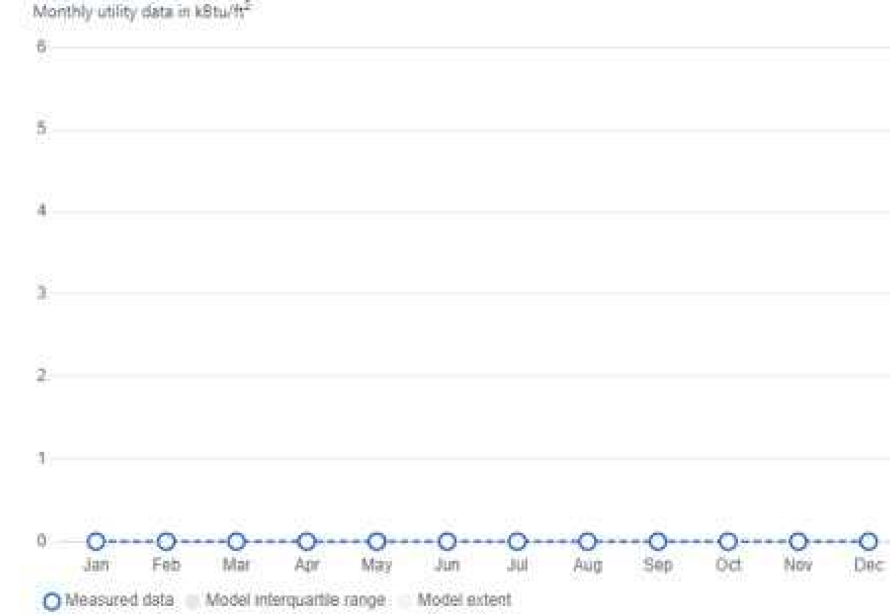
Student Resident Life Trailer

Electricity

Monthly utility data in kBtu/ft²

Natural Gas

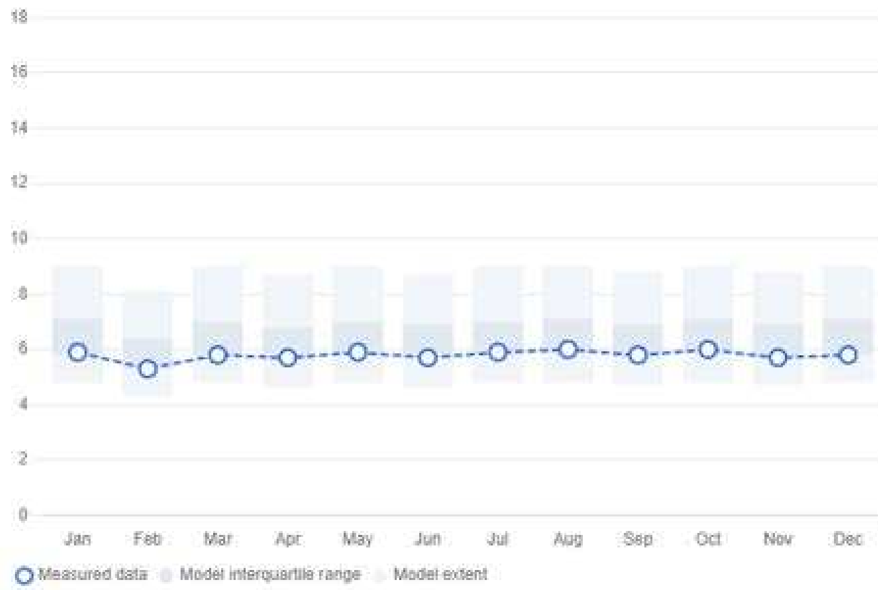
Monthly utility data in kBtu/ft²



Noble Hall

Electricity

Monthly utility data in kBtu/ft²



Natural Gas

Monthly utility data in kBtu/ft²

University Center

Electricity

Monthly utility data in kBtu/ft²

Natural Gas

Monthly utility data in kBtu/ft²

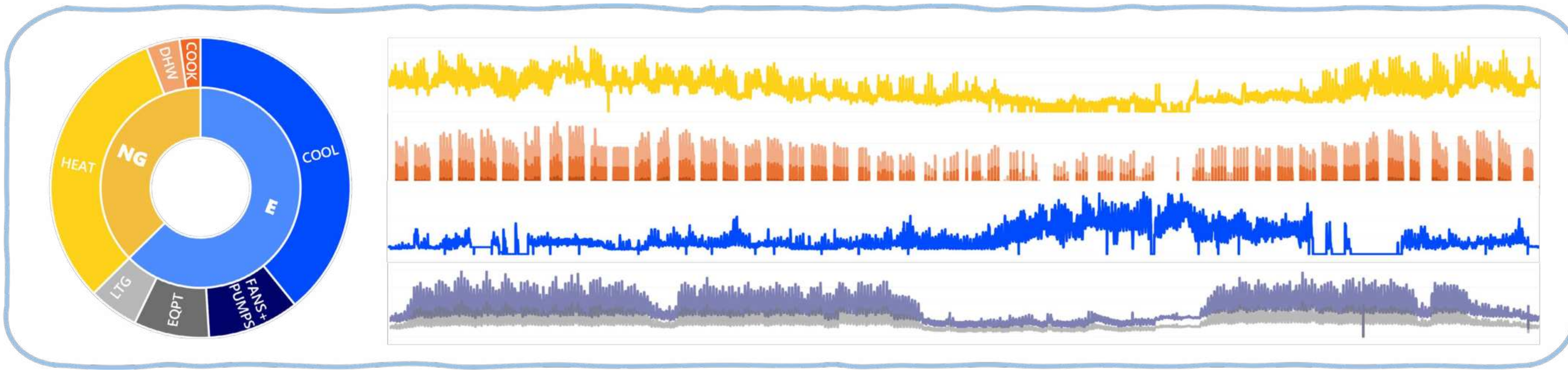
Disaggregating Hourly Loads by End Use

Sizing of equipment and estimating of energy cost and GHG emissions requires an analysis with hourly or sub-hourly resolution for higher fidelity. The benefit of having an energy model as a digital twin is the ability to extract hourly load profiles for each end-use that can be leveraged as inputs to the engineering models. Hourly (8760) profiles disaggregated by end-use and utility into building loads and process loads. Process loads are defined as those driven primarily by occupant behavior with limited impact on heat transfer dynamics within the building.

The process of disaggregating process loads into the relevant components involved identifying typical usage patterns for cooking, laundry, and service hot water for different program types (food service, residences, hotel, athletics) based on the applicable PNNL prototype models.

Hourly profiles have been extracted for the following end-use components:

- Building Cooling
- Building Heating
- Domestic Water Heating
- Cooking/Laundry
- Non-Thermal Electricity



1-1 – CURRENT CAMPUS USE
1-2 – ENERGY & CARBON ANALYSIS
1-3 –THERMAL EQUIPMENT MODELING
2-1 – FINANCIAL ANALYSIS & ASSUMPTIONS
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Modeling Approach

Disaggregated hourly load profiles were extracted using the above process to obtain space cooling, space heating, and domestic hot water loads for every building on campus, for the purpose of modeling the proposed central plant and building independent heating and cooling systems. The modeling was done using a combination of custom-made Excel, Streamlit (Python), and Jupyter Notebooks (Python) programs for the following pieces of equipment:

- Heat Recovery Chillers
- Heat Pump Chillers (CO2)
- Centrifugal Chillers
- Electric Boilers
- Thermal Energy Storage tanks
- Air-Source Heat Pumps (CO2, building independent)
- Domestic Water Heat Pumps (CO2, building independent)
- Cooling Towers
- Geothermal wellfield
- Ocean heat exchange loop

Generally, our modeling process involved summing the hourly loads from campus buildings to arrive at return water temperatures and flows while factoring in any mixing at the building level between different heating end uses (space and hot water). Next, heating and cooling loads as seen by central plant equipment were calculated, along with any additional energy to charge thermal energy storage tanks. Equipment efficiency curves were generated for all mechanical equipment using manufacturer's operating points and multi-dimensional regressions to calculate electricity consumption. The process for building independent heat pumps was the same, with the exception that building mixing was not necessary. Finally, electricity was summed by utility account number for the electricity of the proposed thermal systems, along with the existing electricity of non-thermal systems to arrive at new utility costs. Similarly, gas consumption for non-thermal, cooking, and laundry processes were retained from the calibration piece, and gas costs were recalculated by account after subtracting out the gas consumption from the thermal systems.

- Non-thermal loads and energy
- Non-thermal energy costs
- Building Independent Loads
- Building Independent Equipment Energy
- Building Independent Electricity
- Building Independent Energy Costs
- All thermal equipment COPs (regression)

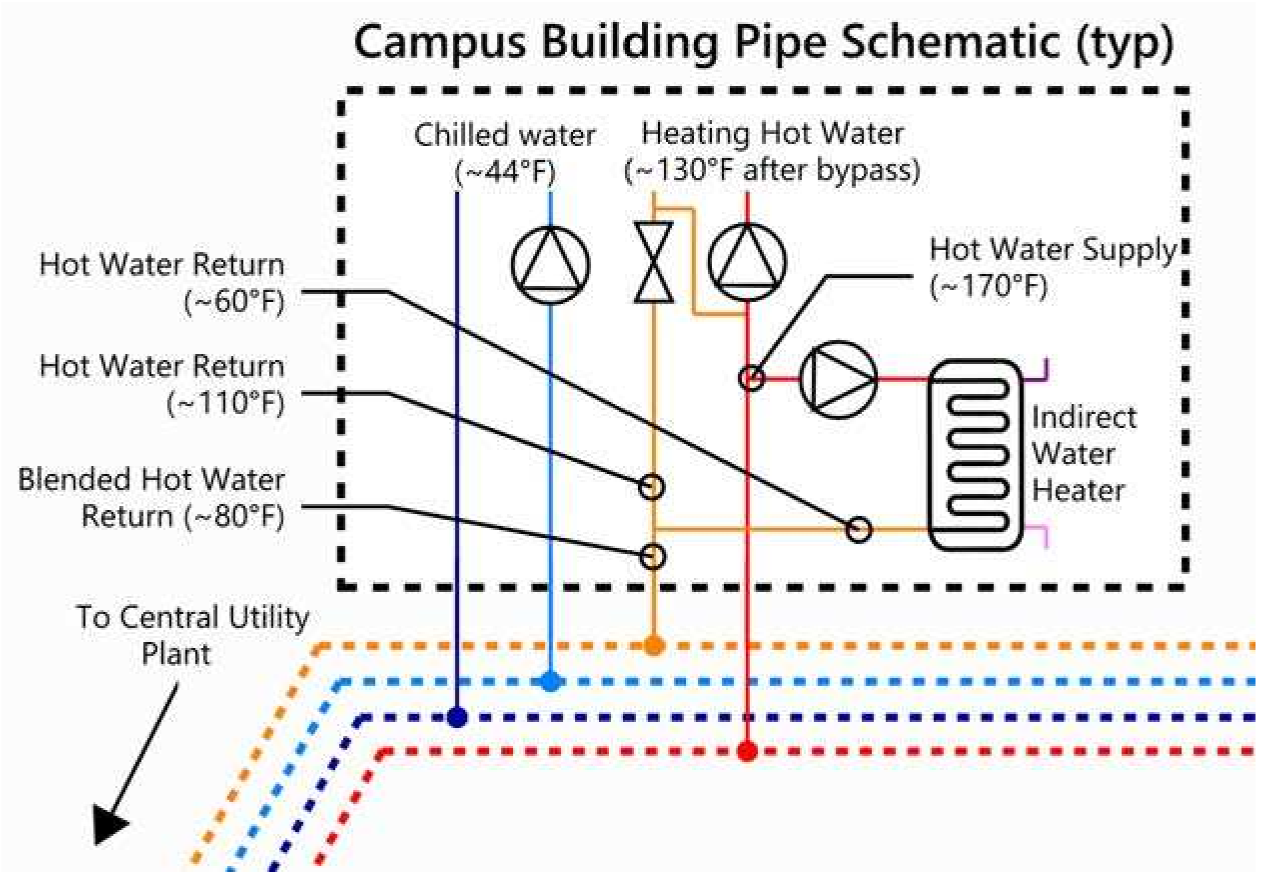
- Central Utility Plant Loads
- Central Plant Equipment Energy
- Heat Rejection/Extraction Loads & Energy
- Central Utility Plant Electricity
- Central Utility Plant Energy Costs
- Central Plant Equipment Sizing
- Central Plant Equipment Sensitivity Analysis

Modeling Approach

Buildings fell into one of two categories for the purposes of thermal equipment modeling – either they would be connected to a future central utility plant to provide all heating, hot water, and cooling energy; or, they would utilize independent systems. Buildings on their own independent systems were able to approached in a more straightforward manner. Heating and cooling loads were pulled from the calibration models, and the loads and outside air temperatures were analyzed each hour and paired with points on equipment efficiency curves to obtain equipment electricity consumption.

Central plant buildings, on the other hand, can't be analyzed in isolation since they are all feeding into a common supply and return water pipe. Furthermore, high temperature hot water from the central plant would be used both for space heating (at 130°F to 150°F) and domestic water heating (at 170°F), so return water temperature from the building would need to be mixed with incoming supply, and all of the return water flows and temperatures would be mixed at the end to yield a blended hot water return temperature.

Fortunately, since central plant equipment will only ever see the final mixed temperature in all cases, individual building loads are still able to be aggregated, and this process is only needed to be performed once. So, all hourly loads for buildings to be on the central plant were extracted from the calibration models, their chilled water, heating hot water, and domestic hot water loads were summed to obtain one hourly profile for each; next, the blended heating hot water return, heating hot water bypass, and domestic hot water return were calculated to yield the blended hot water return temperature and flow, which would be used in central utility plant heating calculations.



Central Utility Plant Equipment Modeling

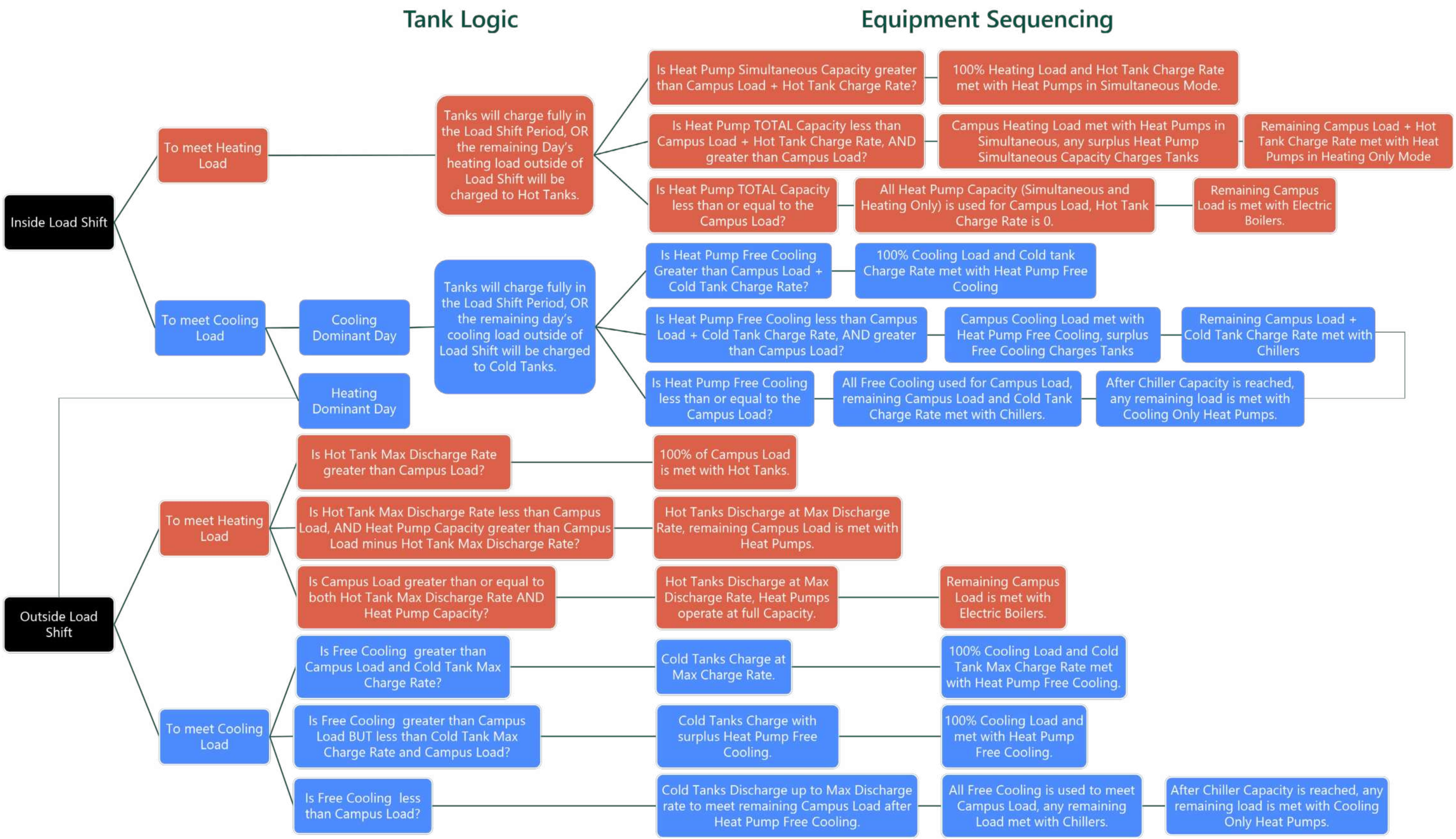
After campus loads are aggregated, they are ready to be fed into the thermal equipment model. Equipment was simulated in the modeling environment hourly for the chosen simulation year. Various different operating parameters and the different equipment scenarios were tested by controlling a wide variety of inputs for each modeled piece of equipment. The purpose of this step in the modeling process was to obtain the following hourly points on each piece of equipment:

- Return water temperatures (°F; hot and chilled)
- Supply water temperatures (°F; hot and chilled)
- Flow rates (gallons per minute; supply, return, hot, and chilled)
- Thermal energy (Btus; heating, cooling, heat rejection, heat extraction)

Equipment was allocated load from the campus based on a sequence of operations ensuring the most efficient equipment would meet the load first, and once its capacity was reached the surplus load would be passed on to the next most efficient piece of equipment. These sequences were outlined in the main body of the report and were developed by the Introba engineering team. They are explained in further detail on the next page.

	A	B	C	D	E	F	G	H
1	**CUP User Inputs**					**TES Tank User Inputs**		
2	**Setpoints**					**Initial Conditions**		
3	Hot Water Supply	170	F			Starting TES Hot Charge	90%	
4	Supply Losses	-5	F			TES Hot Tank Upper Tank Temp	170	F
5	Return Losses	-3	F			TES Hot Tank Lower Tank Temp	80	F
6	Chilled Water Supply	44	F			TES Hot Tank Upper Tank Volume	593,700	Gal
7	Supply Losses	2	F			TES Hot Thermocline thickness	2	feet
8	Return Losses	0	F			TES Hot Thermocline volume	22,747	Gal
9	**Heat Pumps**					TES Hot Tank Lower Tank Volume	65,967	Gal
10	Heating Capacity	54,000,000	btu/h			Starting TES Cold Charge	90%	
11	Cooling Capacity	41,538,462	btu/h			TES Cold Tank Upper Tank Temp	60	F
12	Water-Source Only %	0%				TES Cold Tank Lower Tank Temp	44	F
13	Air-Source + Water Source %	100%				TES Cold Tank Upper Tank Volume	490,661	Gal
14	**Electric Boilers**					TES Cold Thermocline thickness	2	feet
15	Max Capacity	26,000,000	btu/h			TES Cold Thermocline volume	169,194	Gal
16	Boiler Efficiency	99%				TES Cold Tank Lower Tank Volume	4,415,953	Gal
17	Hot Water Setpoint	170	F			**Tank Properties**		
18	**Electric Chillers**					TES Hot Wall-Losses	3%	
19	Max Capacity	70,000,000	btu/h			TES Hot Thermocline/other-Losses	19%	
20	Max Lift	42	F			TES Cold Wall-Losses	2%	
21	Min Lift	15	F			TES Cold Thermocline/other-Losses	2%	
22	Capacity for Min Lift	21,000,000	btu/h			TES Hot Diameter	44	feet
23	Factor for Compressor Energy	13				TES Hot Height	60	feet
24	**Heat Source/Sink**					TES Hot Tank Volume	682,414	Gal
25	Ground-source Capacity	-	btu/h			TES Cold Diameter	120	feet
26	Ocean Capacity	-	btu/h			TES Cold Height	60	feet
27	Cooling Tower Capacity	174,200,000	btu/h			TES Cold Tank Volume	5,075,808	Gal
28	Delta T (for HPs; CT & Ocean Only)	10	F			**Tank Charging Characteristics**		
29	Delta T (for Cent. Chillers; CT & Ocean Only)	15	F			TES Hot Capacity	512,220	kBtu
30						TES Cold Capacity	677,316	kBtu
31	**Building Level User Inputs**					TES Hot Max % of Total Tank Volume moved in	8%	
32	**Heating Hot Water**					TES Cold Max % of Total Tank Volume moved i	8%	
33	Max Load	68,907	btu/h			TES Hot Max Flow	910	gpm
34	Delta T @ Max Load	30	F			TES Cold Max Flow	6,770	gpm
35	Delta T @ Min Load	25	F			Fraction of Thermocline to discharge	50%	
36	**Return HHW Temps given Supply Ten** delta T					Stop Charging tank at ____ Capacity	98%	
37	110	15	F			**Conversion Rates**		
38	130	20	F			CUF to GAL	7.48	
39	160	30	F			GAL to Lbs	8.34	
40	180	40	F					
41	**Chilled Water**							
42	Max Load	66,334	btu/h					
43	Delta T @ Max Load	16	F					
44	Delta T @ Min Load	8	F					
45	**Domestic Hot Water**							
46	Max Load	8,049	btu/h					
47	Max Approach	20	F					
48	Min Approach	5	F					
49	Load @ Min Approach	2,093	btu/h					

Appendix 1-3 – Thermal Equipment Modeling of Proposed Systems



Central Utility Plant Equipment Details

The central utility plant was modeled as distinct pieces of equipment depending on type, mode of operation, and heat source or sink. As such, there were 22 unique pieces of equipment to model.

Heat Pumps/Heat Recovery Chiller – Simultaneous

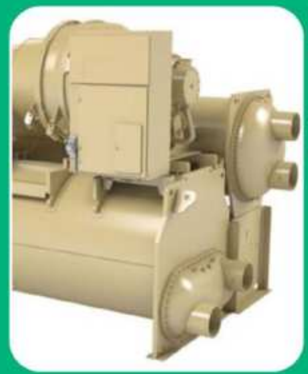
- Heat pump and heat recovery chiller in this mode were modeled identically.
- Supply temperatures were assigned on the input page; entering water temperatures and flow rates on heating and cooling sides were calculated from campus loads for that hour; this info was used to calculate a heat to cool ratio based on manufacturer data.
- Efficiency for this (and all other heat pump modes) came from manufacturer supplied operating points.

Heat Pumps/Heat Recovery Chiller – Heating Only

- Heat pump and heat recovery chiller in this mode were modeled identically, except that the heat recovery chiller was not given a heat extraction source.
- Entering and leaving temperatures and flows calculated similarly to above, but a heat extraction source provides the heating energy, instead of return chilled water. Air-source capacity via gas coolers was controlled as percentage of installed HP capacity; Ground and ocean source were controlled by user input.
- Air-source operation was dictated by an ambient dry-bulb input; ground source operation used predicted water temperatures from a ground-loop; ocean source operation used ocean temperatures (from hourly surface water temps) for the return water temperature.

Heat Pumps/Heat Recovery Chiller – Cooling Only

- Heat pump and heat recovery chiller in this mode were modeled identically.
- Entering and leaving temperatures and flows calculated similarly to above, but a heat rejection source provides the cooling energy, instead of return hot water. Air-source capacity via gas coolers was controlled as percentage of installed HP capacity; Ground, ocean, and tower source were controlled by user input. Compressor energy was added to the heat rejection in each case.
- Ground and ocean source operations were modeled identically to heating only mode; cooling tower operation was dictated by ambient mean coincident wet-bulb temperatures and a stepped cooling tower approach temperature based on typical design parameters.

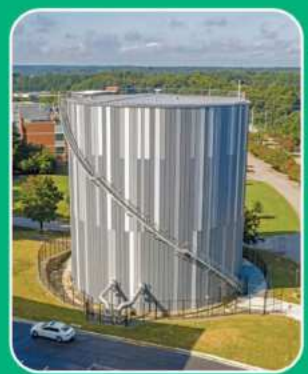


Centrifugal Chiller

- Supply temperatures were assigned on the user input page; entering water temperatures and flow rates were calculated from campus loads for that hour.
- Efficiency curves were based on manufacturer supplied operating points.
- Ground, ocean, and tower source were controlled by user input. Ground source operation used predicted water temperatures from a ground-loop; ocean source operation used ocean temperatures (from hourly surface water temps) for the return water temperature; cooling tower operation was dictated by ambient mean coincident wet-bulb temperatures and a stepped cooling tower approach temperature based on typical design parameters

Electric Boiler

- Supply temperatures were assigned on the user input page; entering water temperatures and flow rates were calculated from campus loads for that hour.
- Efficiency curves for the electric boiler plant were held at a constant 0.98 COP, based on equipment manufacturer ratings. This COP could fluctuate over time to lower values, but our value is intended to be conservative.



Thermal Energy Storage

- Hot and cold tanks have three thermal zones which needed to be modeled; supply side (top of tank for heating, bottom of tank for cooling); return side (opposite of supply); and the thermocline. The thermocline is the boundary layer between supply and return sides of the tank, and where the temperature abruptly changes between the two without mixing.
- Each hour, a starting volume of water was carried over from the previous hour. Charging allowed the return side of the tanks to decrease, while the supply side temperature and volumes were calculated by mixing supply temperature water at a certain rate with the starting volume (the same is true in reverse for discharging).
- The thermocline was held at a constant volume during charge and discharge, to assume appropriate design conditions for maximum flow rates are met. Each hour, the volume of the thermocline was allowed to increase, representing tank losses.

Standalone Equipment and Non-Thermal Loads Modeling

Most of the data processing work done in the energy and carbon analysis phase was supported by various Python tools – for data cleanup, disaggregation, and grouping buildings. Since all of the standalone equipment and non-thermal loads could be modeled independent of one another, this modeling stream was continued.

Our energy analysis resulted in energy end-use breakdowns for every building, both thermal (cooling, heating, domestic hot water, cooking, and laundry) and non-thermal (lighting, fans, pumps, plug loads, and other processes). Since our team only entertained one option for standalone buildings (building independent heat pumps for all cooling, heating, and domestic hot water), and since non-thermal loads were held constant, only one scenario needed to be modeled for these buildings.

After all loads were determined for each building, the cooling, heating, and domestic hot water loads were isolated and assigned to their standalone systems – CO2 standalone heat pumps for heating and cooling, and CO2 heat pump water heaters for domestic hot water. Efficiency curves were generated for each equipment type based on manufacturer provided operating points, and hourly ambient outside air temperatures were used along with heating and cooling loads to simulate energy usage. Cooking, Laundry, and all other non-thermal loads were kept constant between the baseline and proposed scenarios. Energy was calculated for each end use and was summed for each hour of the simulation at the building level.

The next step in the process was the calculate energy costs for electric, gas, and PPA solar. Once the building energy use was known (for baseline and proposed cases), energy use was summed hourly (for electric) or monthly (for gas) for all buildings on the same utility account.

1-1 – CURRENT CAMPUS USE
1-2 – ENERGY & CARBON ANALYSIS
1-3 –THERMAL EQUIPMENT MODELING
2-1 – FINANCIAL ANALYSIS & ASSUMPTIONS
3-1 – CLIMATE ACTION GAP ANALYSIS RESULTS SUMMARY

Assumptions

The financial analysis was developed to understand the overall cost of ownership for phased implementation from 2025 through 2070 (25 years beyond 100% implementation), and ultimately to inform decision-making between the several system options based on reliable and robust cost estimates as the campus transitions towards fossil fuel-free thermal infrastructure.The financial model includes Capital Costs, Replacement Costs, Operations and Maintenance Costs, Staffing Costs, Soft Costs for Replacements and New Construction, Utilities Costs and the Social Cost of Carbon.

Majority of the assumptions used for the financial modeling, including natural gas costs, electricity costs, social cost of carbon and escalation rates, come directly from four main sources:

- UC Decarbonization Studies Assumptions File (Apr 2024)
- UCSB TOU Gen Value Projections (Apr 2024)
- UCSB Existing Utility Rate Structures (Apr 2024)
- UCSB Deferred Maintenance Data (ICAMP) (Oct 2023)

Cost data for capital costs and maintenance costs for each system is based on detailed estimates prepared by Currie and Brown. Costs are based in 2024 (present value) and have been escalated for future years.

First costs and replacement costs are based on cost of equipment, materials and labor for construction in 2024. All costs have been escalated at a rate of 3% per UCOP Decarbonization Study Assumptions guidance. All first costs include General Contractor markup. Costs reflect installed unit cost including equipment, labor, contingency and overheads. Equipment costs include pumps, valve, vibration isolation, hydronic accessories and piping connections to header mains. Equipment with high exposure to marine environment has been priced for 304SS grade, as applicable. Costs include Building Automation System costs for each piece of equipment based on complexity and number of points being monitored.

Soft Costs for new (35%) and renovation (10%) design and construction projects has been added to the first costs, where applicable.

Escalation Rates	
Escalation Rate (%)	3%
Cost of Carbon Escalation Rate (%)	1.5%
Carbon	
Cost of Carbon 2024 ($/MTCO2e)	$261.10
Current Campus Scope 1 Emissions (MTCO2e)	17,461
Current Scope 1 Non-Thermal Emissions eg. cooking, laundry (MTCO2e)	1,093
Current Energy Usage and Utility Costs	
Annual Electric Utility Cost	$ 9,457,089
Annual NG Utility Cost	$ 2,032,468
Electrical Usage (kWh)	81,056,742
Gas Usage (therms)	3,290,765

Operations and Maintenance costs include the following:

- Supplies and Expenses (S&E) Charges
- Utility Charges

S&E charges include annual servicing by technicians, materials and parts. Majority of the ongoing maintenance services during the year that would classify as "labor" are provided by salaried UCSB operations & maintenance staff professionals. As the base number of O&M staff members will be the same across all system options, only salary for additionally required O&M staff is considered in the cost analysis.

Utility costs are primarily based on UCOP Decarbonization Study Assumptions. Electricity rates use UCOP TOU Gen Value Projections rates for commodity/ generation charges, and current Southern California Edison (SCE) tariff structure TOU-8-STANDBY for transmission and distribution charges. The university also pays departing load charges to SCE which is applied to all scenarios.

Natural gas rates use UCOP recommended rates for Southern California Edison. Escalation is assumed at 3% per UCOP guidelines for both utilities.

Equipment Replacement Life is assumed to be as follows:

Air Source Heat Pumps (Building Independent)	15 years
Centrifugal Chiller, CO2 Heat Pump Chiller, Heat Recovery Chiller	25 years
Cooling Towers	25 years
Electric Resistance Boiler	25 years
Dry Gas Cooler	25 years
Heat Exchangers and Manifold Assemblies	25 years

Assumptions: Unit Costs

Unit Cost Rates

Central Plant Equipment	Unit	Rate
Centrifugal Chiller	$/ton	1,455
Cooling Towers	$/ton	590
Cooling Tower Water Treatment	$/ton	250
CO2 Heat Pump Chiller Assembly (6-Pipe)	$/ton	3,125
Dry Gas Cooler	$/ton	1,810
Heat Recovery Chiller	$/ton	1,382
Electric Resistance Boiler	$/MBH	52
Thermal Storage Tanks	$/gallon	3
Geoexchange Borefield	$/ft	80
Manifold Assemblies	$/ea	195,000
Electrical Labor	$/ea	100,000
Central Utility Plant	**Unit**	**Rate**
Central Utility Plant Building	$/sf	200
Building Connection piping 10" Sch 40 Gal Steel	$/ft	537
Building Connection piping 18" Sch 40 Gal Steel	$/ft	1,009
Building Connection piping 24" Sch 40 Gal Steel	$/ft	1,338

Distribution	Unit	Rate
Large Trench (9ft wide by 6 ft deep) for (2) 24" PE 4710 DR11 Pipes	$/ft	1,781
Medium Trench (7ft wide by 5 ft deep) for (2) 16" PE 4710 DR11 Pipes	$/ft	1,121
Small Trench (5ft wide by 3ft deep) for (2) 12" PE 4710 DR11 Pipes	$/ft	563
6" PE4710 DR11 Direct Buried piping with insulation	$/ft	147
6" PE4710 DR11 piping without insulation; for submersion in lagoon or seawater	$/ft	143
Heat Exchanger for Lagoon Water HX	$/ea	1,000
Heat Exchanger for Seawater HX	$/ea	10,000
Building Equipment	**Unit**	**Rate**
Building Connections- 3/4" Copper	$/ft	54
Building Connections- 1" Copper	$/ft	62
Building Connections- 1-1/2" Copper	$/ft	83
Building Connections- 2" Copper	$/ft	106
Building Connection piping 3" Sch 40 Gal Steel	$/ft	210
Building Connection piping 4" Sch 40 Gal Steel	$/ft	238
Building Connection piping 6" Sch 40 Gal Steel	$/ft	282
Building Independent ASHP (Htg/Clg)	$/ton	3,064
Building DHW Heat Pump	$/MBH	1,517
Electrical Panel Upgrades	$/ea	50,000

Notes:
- All piping costs assume 2" insulation with ASJ
- All costs include General Contractor markup
- Costs are total installed cost
- Equipment costs include pumps, valve, vibration isolation, hydronic accessories and piping connections to mains (up to 15ft unless otherwise noted)
- Assumes 314 or 316 SS for exposed external equipment where available, inlcuding Air Source Heat Pumps, Cooling Towers, Gas Coolers
- Includes BAS costs for each piece of equipment based on complexity and number of points being monitored

Assumptions: Quantities

Quantity Totals	Unit	Option 0 (No Central)	Central 1 (HRC)	Central 2 (HRC + TES)	Central 3 (Air + TES)	Central 4 (Geo + TES)	Central 5 (Sea + TES)	Central 6 (Multi + TES)
Central Plant Equipment								
Centrifugal Chiller	tons	0	8,000	6,000	6,000	6,000	6,000	6,000
Cooling Towers	tons	0	9,000	9,000	9,000	6,500	0	0
Cooling Tower Water Treatment	tons	0	9,000	9,000	9,000	6,500	0	0
CO2 Heat Pump Chiller Assembly (6-Pipe)	tons	0	0	0	4,500	4,500	4,500	4,500
Dry Gas Cooler	tons	0	0	0	4,500	0	0	4,500
Heat Recovery Chiller	tons	0	1,500	3,500	0	0	0	0
Electric Resistance Boiler	MBH	0	72,000	72,000	30,000	30,000	30,000	30,000
Thermal Storage Tanks	gallons	0	0	5,759,773	5,759,773	5,759,773	5,759,773	5,759,773
Geoexchange Borefield	ft	0	0	0	0	950,000	0	950,000
Manifold Assemblies	ea	0	0	0	0	4	1	5
Electrical Labor	ea	0	1	1	1	1	1	1
Central Utility Plant								
Central Utility Plant Building	sf	0	20,000	20,000	20,000	20,000	20,000	20,000
Building Connection piping 10" Sch 40 Gal Steel	ft	0	5,800	3,600	5,800	5,800	4,200	4,200
Building Connection piping 18" Sch 40 Gal Steel	ft	0	400	600	600	600	200	200
Building Connection piping 24" Sch 40 Gal Steel	ft	0	2,400	2,400	2,400	2,400	2,400	2,400
Distribution								
Large Trench (9ft wide by 6 ft deep) for (2) 24" PE 4710 DR11 Pipes	ft	0	20,200	20,200	20,200	22,600	25,000	25,000
Medium Trench (7ft wide by 5 ft deep) for (2) 16" PE 4710 DR11 Pipes	ft	0	6,100	6,100	6,100	6,100	6,100	6,100
Small Trench (5ft wide by 3ft deep) for (2) 12" PE 4710 DR11 Pipes	ft	0	2,000	2,000	2,000	2,000	2,000	2,000
6" PE4710 DR11 Direct Buried piping with insulation	ft	0	0	0	0	0	0	0
6" PE4710 DR11 piping without insulation; for submersion in lagoon or seawater	ft	0	0	0	0	0	144,000	12,000
Heat Exchanger for Lagoon Water HX	ea	0	0	0	0	0	0	960
Heat Exchanger for Seawater HX	ea	0	0	0	0	0	960	0
Building Equipment								
Building Connection piping 3" Sch 40 Gal Steel	ft	20,000	38,100	38,100	38,100	38,100	38,100	38,100
Building Independent ASHP (Htg/Clg)	tons	24,000	5,000	5,000	5,000	5,000	5,000	5,000
Building DHW Heat Pump	MBH	144,000	12,000	12,000	12,000	12,000	12,000	12,000
Electrical Panel Upgrades	ea	200	0	0	0	0	0	0

See information on following pages for costs breakdown by system.

Life Cycle Cost Results - Capital Costs

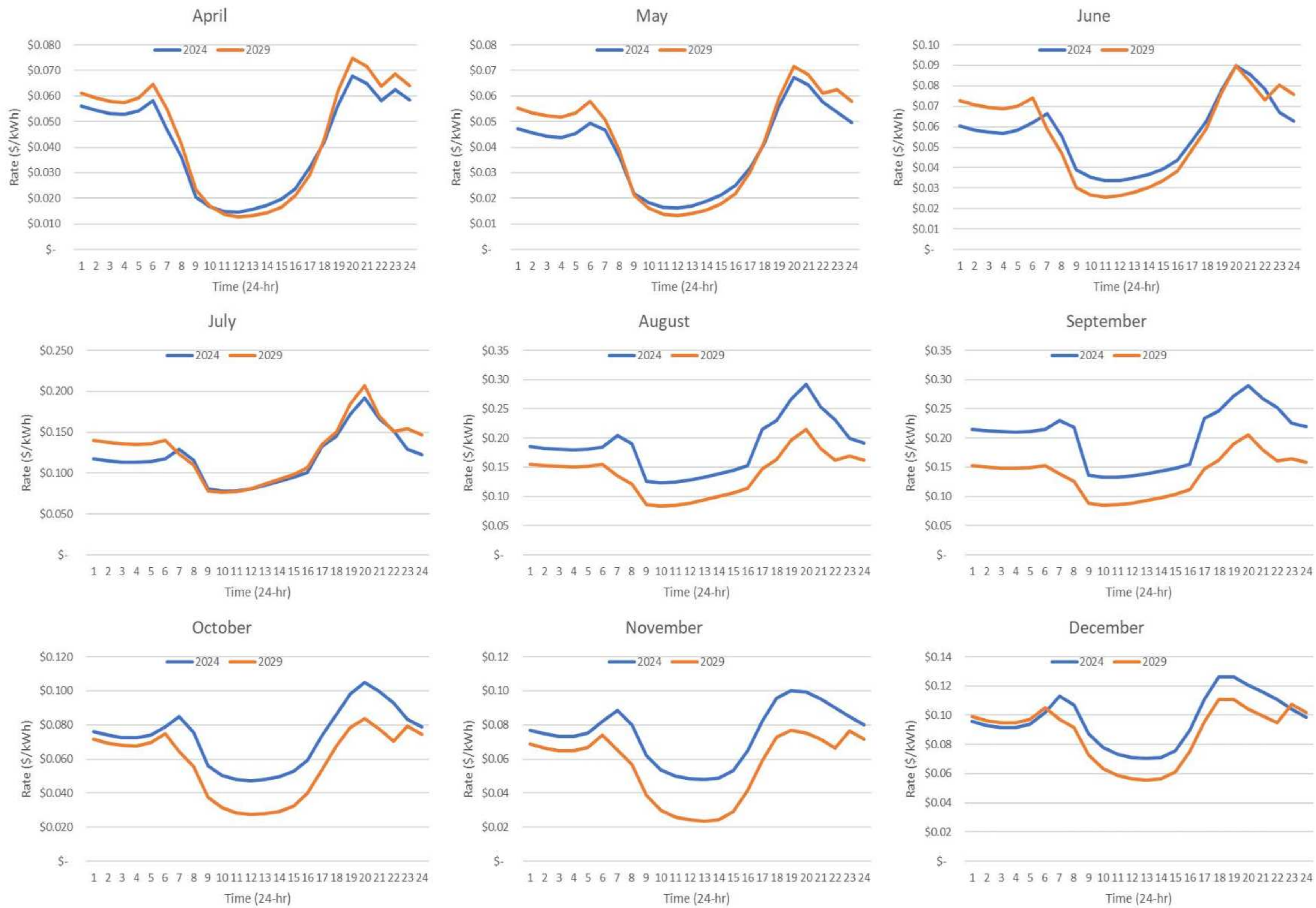
Capital Costs	**BAU (Current Equip)**	**Option 0 (No Central)**	**Central 1 (HRC)**	**Central 2 (HRC + TES)**	**Central 3 (Air + TES)**	**Central 4 (Geo + TES)**	**Central 5 (Sea + TES)**	**Central 6 (Multi + TES)**
Heat Pump Chillers	$0	$0	$0	$0	$25,398,439	$25,398,439	$25,398,439	$25,398,439
Heat Recovery Chillers	$0	$0	$3,744,069	$8,736,160	$0	$0	$0	$0
Chillers	$0	$0	$21,023,135	$15,767,351	$15,767,351	$15,767,351	$15,767,351	$15,767,351
Electric Boilers	$0	$0	$6,762,080	$6,762,080	$2,817,534	$2,817,534	$2,817,534	$2,817,534
Storage Tanks	$0	$0	$0	$31,208,374	$31,208,374	$31,208,374	$31,208,374	$31,208,374
Cooling Towers	$0	$0	$13,654,201	$13,654,201	$13,654,201	$9,861,367	$0	$0
Air-Source	$0	$0	$0	$0	$14,710,776	$0	$0	$14,710,776
Geo-Source	$0	$0	$0	$0	$0	$137,264,454	$0	$137,264,454
Sea-Source	$0	$0	$0	$0	$0	$0	$54,530,110	$4,833,154
Central Plant Equipment	$0	$0	$45,183,485	$76,128,167	$103,556,675	$222,317,519	$129,721,808	$232,000,082
Central Plant Piping & Electrical Cost	$0	$0	$12,334,894	$10,564,737	$12,699,268	$12,699,268	$10,418,135	$10,418,135
Central Plant Building	$0	$0	$7,224,445	$7,224,445	$7,224,445	$7,224,445	$7,224,445	$7,224,445
Campus Distribution	$0	$0	$79,361,069	$79,361,069	$79,361,069	$88,489,878	$95,153,345	$96,562,112
Building Connections	$0	$7,596,793	$14,471,890	$14,471,890	$14,471,890	$14,471,890	$14,471,890	$14,471,890
Building Independent Heat Pumps	$0	$545,416,695	$60,548,073	$60,548,073	$60,548,073	$60,548,073	$60,548,073	$60,548,073
Total First Costs (excluding soft costs)	**$0**	**$553,013,488**	**$219,123,857**	**$248,298,382**	**$277,861,420**	**$405,751,073**	**$317,537,696**	**$421,224,736**
Total Replacement through 2070 (w/o soft costs)	**$1,611,407,133**	**$1,241,010,999**	**$608,344,292**	**$607,792,179**	**$665,221,385**	**$626,478,935**	**$605,831,422**	**$636,632,520**
Soft Costs for First Costs (35% addition)	**$0**	**$193,554,721**	**$76,693,350**	**$86,904,434**	**$97,251,497**	**$142,012,876**	**$111,138,194**	**$147,428,658**
Soft Costs for Replacement (10% addition)	**$161,140,713**	**$124,101,100**	**$60,834,429**	**$60,779,218**	**$66,522,138**	**$62,647,894**	**$60,583,142**	**$63,663,252**
Total Capital Costs (including soft costs)	**$1,772,547,846**	**$2,111,680,308**	**$964,995,928**	**$1,003,774,212**	**$1,106,856,441**	**$1,236,890,778**	**$1,095,090,454**	**$1,268,949,166**

Energy Costs Assumptions

Costs were calculated at the utility account level for our baseline and proposed scenarios. Electrical utility rates were obtained from UCOP for 2024-2029 showing hourly rates across the year. Gas rates used were obtained from Southern California Gas for the current year (2024) and these were used in all scenarios. PPA rates were obtained from the campus as well. To simplify the cost calculations and provide an apples-to-apples comparison, only one set of rates were used for each utility. For future years, a 3% escalation was applied to account for escalating utility rates.

UCOP has defined hourly rates from 2024 through 2029 – however, the escalation derived from these profiles was not consistent and therefore our team opted to use the 3% escalation. However, the general trend from UCOP appears to show increases in electricity rates during peak times (outside solar generation hours) and decreases in rates during off-peak times (during solar generation hours). Aside from winter hours, this trend continues throughout the year.

See information on following pages for costs breakdown by system.



Annual Energy Use Results

Annual Electricity Use (kWh)	BAU (Current Equip)	Option 0 (No Central)	Central 1 (HRC)	Central 2 (HRC + TES)	Central 3 (Air + TES)	Central 4 (Geo + TES)	Central 5 (Sea + TES)	Central 6 (Multi + TES)
Central Plant Thermal	0	0	37,792,206	34,205,767	17,259,196	17,065,366	16,079,823	16,279,046
Building Level Thermal	9,274,567	31,406,607	5,570,352	5,570,352	5,570,352	5,570,352	5,570,352	5,570,352
UCSB Thermal Total Use (Cooling, Heating, Hot Water)	9,274,567	31,406,607	43,362,557	39,776,118	22,829,548	22,635,718	21,650,175	21,849,397
UCSB Non-Thermal Total Use (Every Other Use)	82,456,213	82,456,213	82,456,213	82,456,213	82,456,213	82,456,213	82,456,213	82,456,213
UCSB Total Electricity Use	**91,730,780**	**113,862,820**	**125,818,771**	**122,232,332**	**105,285,761**	**105,091,931**	**104,106,388**	**104,305,611**
Solar PV Generation	10,674,038	10,674,038	10,674,038	10,674,038	10,674,038	10,674,038	10,674,038	10,674,038
UCSB Total Net Electricity Use	**81,056,742**	**103,188,781**	**115,144,732**	**111,558,293**	**94,611,723**	**94,417,893**	**93,432,349**	**93,631,572**
% Change from Current	**-**	**+27%**	**+42%**	**+38%**	**+17%**	**+16%**	**+15%**	**+16%**

Annual Natural Gas Use (therms)	BAU (Current Equip)	Option 0 (No Central)	Central 1 (HRC)	Central 2 (HRC + TES)	Central 3 (Air + TES)	Central 4 (Geo + TES)	Central 5 (Sea + TES)	Central 6 (Multi + TES)
UCSB Thermal Total Use (Heating and Hot Water)	3,084,764	0	0	0	0	0	0	0
UCSB Non-Thermal Total Use (Cooking, Laundry, Other)	206,001	206,001	206,001	206,001	206,001	206,001	206,001	206,001
UCSB Total Natural Gas Use	**3,290,765**	**206,001**	**206,001**	**206,001**	**206,001**	**206,001**	**206,001**	**206,001**
% Change from Current	**-**	**-94%**	**-94%**	**-94%**	**-94%**	**-94%**	**-94%**	**-94%**

A look at the energy use for system types before diving into the operational costs.

Life Cycle Cost Results - Operational Costs

Operational Costs	**BAU (Current Equip)**	**Option 0 (No Central)**	**Central 1 (HRC)**	**Central 2 (HRC + TES)**	**Central 3 (Air + TES)**	**Central 4 (Geo + TES)**	**Central 5 (Sea + TES)**	**Central 6 (Multi + TES)**
2045 Costs								
Natural Gas	$3,780,989	$236,794	$236,794	$236,794	$236,794	$236,794	$236,794	$236,794
Electricity	$17,592,972	$21,419,627	$23,695,258	$22,354,618	$19,510,749	$19,460,685	$19,237,019	$19,300,054
Utilities (Electricity and Natural Gas)	$21,373,961	$21,656,421	$23,932,052	$22,591,412	$19,747,543	$19,697,479	$19,473,813	$19,536,848
Additional O&M Staff	$2,080,640	$1,071,530	$535,765	$535,765	$535,765	$535,765	$595,294	$535,765
Total Costs now through 2070								
Natural Gas	$202,020,204	$61,939,735	$61,939,735	$61,939,735	$61,939,735	$61,939,735	$61,939,735	$61,939,735
Electricity	$940,001,588	$1,091,245,981	$1,181,187,830	$1,128,200,487	$1,015,799,648	$1,013,820,922	$1,004,980,766	$1,007,472,156
Utility Costs (Electricity and Natural Gas)	**$1,142,021,791**	**$1,153,185,716**	**$1,243,127,565**	**$1,190,140,222**	**$1,077,739,382**	**$1,075,760,657**	**$1,066,920,501**	**$1,069,411,891**
Additional O&M Staff	$111,169,679	$71,285,681	$50,110,157	$50,110,157	$50,110,157	$50,110,157	$52,462,993	$50,110,157
Supplies and Expenses O&M	$18,256,724	$96,347,548	$16,352,593	$17,931,199	$19,047,325	$17,834,144	$19,694,355	$18,951,741
O&M Costs	**$129,426,403**	**$167,633,229**	**$66,462,749**	**$68,041,355**	**$69,157,482**	**$67,944,301**	**$72,157,348**	**$69,061,898**
Total Operational Costs (now through 2070)	**$1,271,448,194**	**$1,320,818,945**	**$1,309,590,314**	**$1,258,181,577**	**$1,146,896,864**	**$1,143,704,958**	**$1,139,077,849**	**$1,138,473,789**
Total Cost of Carbon (now through 2070)	$297,292,391	$111,507,231	$111,507,231	$111,507,231	$111,507,231	$111,507,231	$111,507,231	$111,507,231
Total with Cost of Carbon (now through 2070)	**$1,568,740,585**	**$1,432,326,176**	**$1,421,097,545**	**$1,369,688,808**	**$1,258,404,095**	**$1,255,212,189**	**$1,250,585,079**	**$1,249,981,020**

Life Cycle Cost Results - Total Costs Of Ownership

Total Cost of Ownership	BAU (Current Equip)	Option 0 (No Central)	Central 1 (HRC)	Central 2 (HRC + TES)	Central 3 (Air + TES)	Central 4 (Geo + TES)	Central 5 (Sea + TES)	Central 6 (Multi + TES)
Capital Costs	$1,772,547,846	$2,111,680,308	$964,995,928	$1,003,774,212	$1,106,856,441	$1,236,890,778	$1,095,090,454	$1,268,949,166
Utility Costs	$1,142,021,791	$1,153,185,716	$1,243,127,565	$1,190,140,222	$1,077,739,382	$1,075,760,657	$1,066,920,501	$1,069,411,891
O&M Costs	$129,426,403	$167,633,229	$66,462,749	$68,041,355	$69,157,482	$67,944,301	$72,157,348	$69,061,898
Total Cost of Ownership (now through 2070)	**$3,043,996,040**	**$3,432,499,253**	**$2,274,586,242**	**$2,261,955,790**	**$2,253,753,305**	**$2,380,595,736**	**$2,234,168,303**	**$2,407,422,955**

Recommended System:
Air-Source Heating/ Cooling with Thermal Storage
Quantities and Costs by Phase

Recommended Option - Quantities By Phase

Quantities by Phase for Recommended Option	Unit	Phase 0A	Phase 0B	Phase 1	Phase 2	Phase 3	Total
Central Plant Equipment							
Centrifugal Chiller	tons	0	0	0	6,000	0	6,000
Cooling Towers	tons	0	0	0	9,000	0	9,000
Cooling Tower Water Treatment	tons	0	0	0	9,000	0	9,000
CO2 Heat Pump Chiller Assembly (6-Pipe)	tons	900	1,350	4,500	0	0	4,500
Dry Gas Cooler	tons	900	1,350	4,500	0	0	4,500
Electric Resistance Boiler	MBH	10,000	20,000	30,000	0	0	30,000
Thermal Storage Tanks	gallons	682,598	0	5,759,773	0	0	5,759,773
Electrical Labor	each	0.10	0.15	0.50	0.50	0.00	1.00
Central Utility Plant							
Central Utility Plant Building	sf	20,000	0	20,000	0	0	20,000
Building Connection piping 10" Sch 40 Gal Steel	ft	700	700	2,600	3,200	0	5,800
Building Connection piping 18" Sch 40 Gal Steel	ft	600	0	600	0	0	600
Building Connection piping 24" Sch 40 Gal Steel	ft	600	600	1,200	1,200	0	2,400
Distribution							
Large Trench (9ft wide by 6 ft deep) for (2) 24" PE 4710 DR11 Pipes	ft	250	2,500	8,000	4,000	0	12,000
Medium Trench (7ft wide by 5 ft deep) for (2) 16" PE 4710 DR11 Pipes	ft	50	2,500	8,000	4,000	0	12,000
Small Trench (5ft wide by 3ft deep) for (2) 12" PE 4710 DR11 Pipes	ft	1,200	2,000	3,647	3,351	9,194	16,192
Building Equipment							
Building Connection piping 3" Sch 40 Gal Steel	ft	0	0	11,381	15,586	11,133	38,100
Building Independent ASHP (Htg/Clg)	tons	0	0	0	0	5,000	5,000
Building DHW Heat Pump	MBH	0	0	0	0	12,000	12,000

Recommended Option - Capital Cost By Phase

Capital Costs by Phase	**Phase 0A**	**Phase 0B**	**Phase 1**	**Phase 2**	**Phase 3**	**Total**
Heat Pump Chillers	$2,983,781	$4,748,240	$19,465,789	$0	$0	$25,398,439
Heat Recovery Chillers	$0	$0	$0	$0	$0	$0
Chillers	$0	$0	$0	$14,009,087	$0	$15,767,351
Electric Boilers	$551,668	$1,170,529	$2,159,405	$0	$0	$2,817,534
Storage Tanks	$2,172,505	$0	$23,918,620	$0	$0	$31,208,374
Cooling Towers	$0	$0	$0	$12,131,581	$0	$13,654,201
Air-Source	$1,728,206	$2,750,181	$11,274,585	$0	$0	$14,710,776
Geo-Source	$0	$0	$0	$0	$0	$0
Sea-Source	$0	$0	$0	$0	$0	$0
Central Plant Equipment	$7,436,160	$8,668,950	$56,818,399	$26,140,668	$0	$103,556,675
Central Plant Piping & Electrical Cost	$1,903,091	$1,343,420	$5,062,276	$5,414,570	$0	$12,699,268
Central Plant Building	$4,243,600	$0	$5,536,935	$0	$0	$7,224,445
Campus Distribution	$1,248,573	$9,432,889	$34,978,621	$21,655,273	$9,629,164	$79,361,069
Building Connections	$0	$0	$3,313,045	$5,260,127	$4,355,663	$14,471,890
Building Independent Heat Pumps	$0	$0	$0	$0	$62,364,515	$60,548,073
Total First Costs (excluding soft costs)	**$14,831,424**	**$19,445,260**	**$105,709,276**	**$58,470,637**	**$76,349,342**	**$277,861,420**
Soft Costs for First Costs (35% addition)	**$5,190,998**	**$6,805,841**	**$36,998,247**	**$20,464,723**	**$26,722,270**	**$97,251,497**
Total Capital Costs (including soft costs)	**$20,022,423**	**$26,251,100**	**$142,707,523**	**$78,935,360**	**$103,071,612**	**$375,112,918**

Notes:
- Phases 0A and 0B are immediate actions that would be taken first as part of Phase 1, and thus the totals for Phase 1 are inclusive of Phase 0A and 0B.
- Phase 0A is assumed to be constructed by 2026 and therefore $ are shown as if expense occurred in 2026, using inflation at 3%/yr to 2026 dollars.
- Phase 0B is assumed to be constructed by 2028 and therefore $ are shown as if expense occurred in 2028, using inflation at 3%/yr to 2028 dollars.
- Phase 1 is assumed to be constructed by 2035 and therefore $ are shown as if expense occurred in 2035, using inflation at 3%/yr to 2035 dollars.
- Phase 2 is assumed to be constructed by 2040 and therefore $ are shown as if expense occurred in 2040, using inflation at 3%/yr to 2040 dollars.
- Phase 3 is assumed to be constructed by 2045 and therefore $ are shown as if expense occurred in 2044, using inflation at 3%/yr to 2044 dollars.
- Total refects of all actions were taken in 2044, matching the options comparison section.

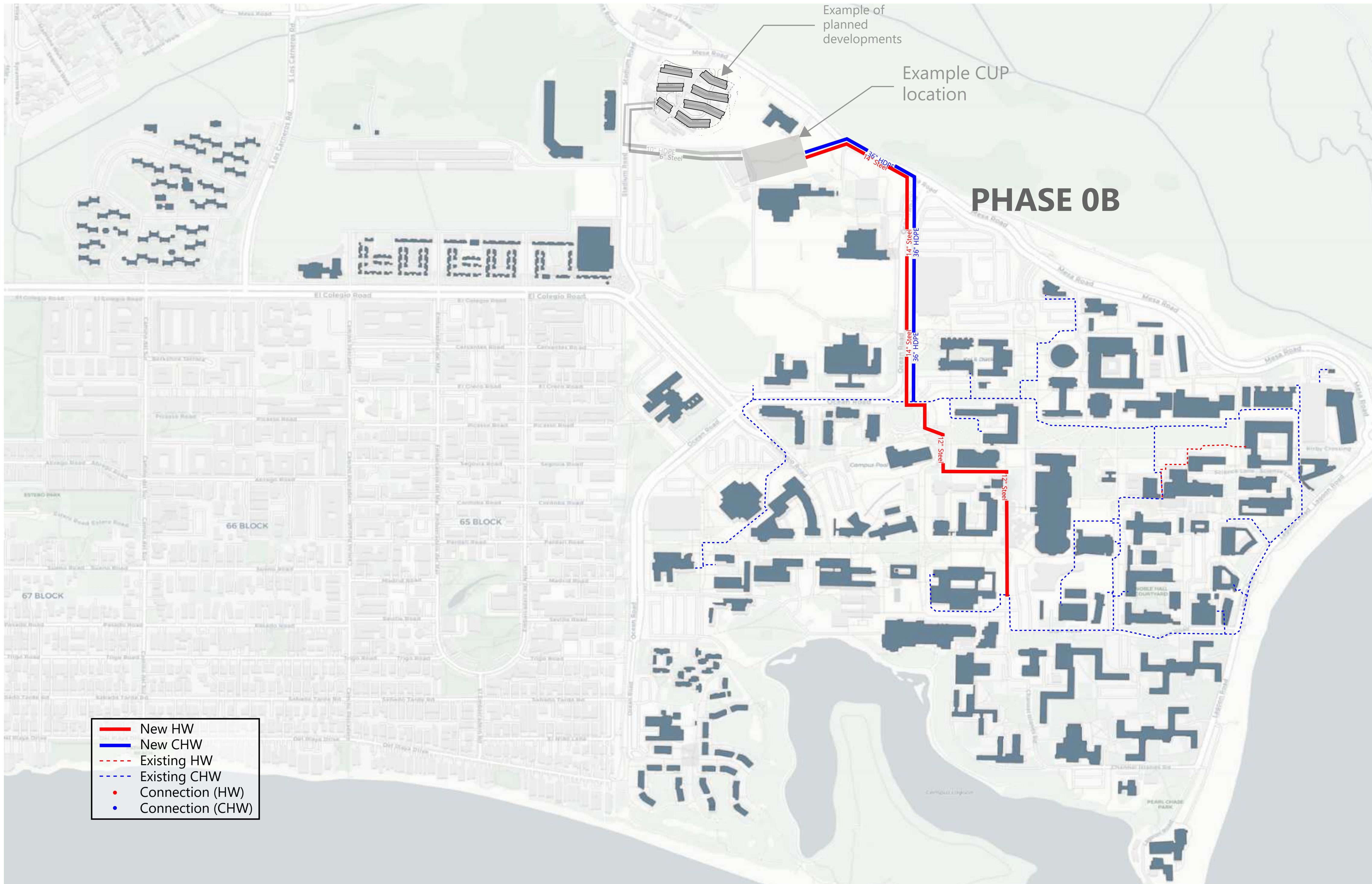
Phase 0A

Phase 0A involves the following main components

- Building the Central Thermal Plant building
- Installing First Part of Heating Equipment in the Central Plant
- Running Pipe Main to San Benito location

Phase 0A exists as an accelerated first step in Phase 1 to ensure a new central heating plant can provide heat to the new San Benito housing in time for it's opening. This first step gets the new central plant building built with 20% of Heat Pumps, 33% of Electric Boilers, and 100% of the Hot Thermal Storage installed and operational. This approach allows full 10,000 MBH capacity from electric boilers, enough for all San Benito heating and hot water needs, in case there are any kinks in getting the heat pumps operating in time for San Benito's opening.

Phase 0B



Phase 0B involves the following main components

- Installing More Heating Equipment in the Central Plant
- Running Pipe Main Distribution for Hot and Chilled to the closest existing pipe main
- Connecting New Chilled Water Main to Existing Chilled Water Main
- Running New Hot Pipe directly to the location of the future Southeast Housing and Dining Commons

Phase 0B is a second accelerated step in Phase 1 to ensure a new central heating plant can provide heat to the future Southeast Housing and Dining Commons in time for it's opening. This step adds capacity to get a total installed at the central plant of 50% of Heat Pumps, 100% of Electric Boilers installed and operational. This approach allows 30,000 MBH capacity from electric boilers, enough for all San Benito and Southeast Housing and Dining Commons heating and hot water needs, in case there are any kinks in getting the heat pumps operating in time for their openings. Additionally, the heat pumps can send free simultaneous chilled water production through the new main into the existing campus CHW loop, offsetting some of the existing chiller production until the full new chilled water system is built and operational (by end of Phase 2).

1-1 – CURRENT CAMPUS USE
1-2 – ENERGY & CARBON ANALYSIS
1-3 –THERMAL EQUIPMENT MODELING
2-1 – FINANCIAL ANALYSIS & ASSUMPTIONS

3-1 – CLIMATE ACTION GAP ANALYSIS RESULTS SUMMARY

Climate Action Gap Analysis - Net Zero Results Summary

Action Category	Best Practices	Implementation Examples	Relevant UC Santa Barbara Climate Goals & Targets (high-level policy goals/commitments from existing plans & strategies)	Existing, Planned, or Proposed Actions (from existing plans & strategies)	Gap Analysis Score (status) (1 - underperforming BP; 2 - partially meeting BP, some action taken but more required; 3 - meeting or exceeding basic BP)	Score Rationale (assumes proposed/planned actions have been implemented)	Additional Measures or Next Steps Recommended	How Closely Does the Recommendation Relate to the Clean Energy Master Plan & UCSB Decarbonization Goals? (1 - not related closely to Clean Energy Master Plan; 2 - somewhat related to Clean Energy Master Plan; 3 - very relevant to Clean Energy Master Plan)	Other Notes on Future Campus Clean Energy Plan Implementation
Climate Mitigation Assessment and Planning	**Complete a Climate Action Plan with a clear path to net zero emissions**	- Set a target date for achieving net-zero and interim target dates for meeting milestones leading to net zero (Second Nature Commitments). E.g., Princeton University's net-zero target is 2046 with an interim 30% reduction target by 2026 (Princeton University Sustainability Action Plan) - Develop mechanisms and indicators for tracking progress (Second Nature Commitments) - Describe mitigation strategies the institution intends to use to achieve net zero (Second Nature Commitments) - Identify measurable sustainability objectives and their accountable staff position or unit (AASHE STARS 3.0)	**Previous Draft UCSB 2016 Climate Action Plan -** Goal of carbon neutrality by 2025	**UC Policy requires UCSB to produce an updated climate action plan by January 2025 addressing a 2045 net zero target date**	2	Developed original Climate Action Plan with proposed pathways to net zero. Additional scoping needed for new CAP with updated emissions reduction targets per UC Policy on Sustainable Practices.	Continue to regularly revisit CAP and update as needed. Update for alignment with Clean Energy Master Plan.	2	
	Make public commitments and join challenge programs	- Join the UN Race to Zero - Join the Second Nature University Climate Change Coalition (UC3) - Sign Second Nature's Presidents' Climate Leadership Commitments - Publish a statement, policy, or plan that outlines the institution's guiding vision or goals for sustainability (AASHE STARS 3.0)	UC Policy requires UCSB to produce an updated climate action plan addressing a 2045 net zero target date UCSB 2016 CAP includes goal of carbon neutrality by 2025 UC signatory of Presidents Climate Commitments	UC Policy requires UCSB to produce an updated climate action plan addressing a 2045 net zero target date **UCSB CSP** - engages in Cool Campus Challenge (created for UC's, focuses on energy/waste reduction)	2	Multiple public goals, though some outdated. Opportunity for more challenge programs.	Update public commitments in line with UC Policy and other opportunities (see implementation examples) as appropriate. Engage in more campus challenge programs.	1	
	Apply a climate justice lens to ensure equity, inclusion, diversity, and accountability are integrated into planning	- Support programs, initiatives, or networks designed to address the specific needs of students or employees with disabilities, students or employees that identify as members of marginalized racial, ethnic, and/or Indigenous groups, LGBTQ+ students or employees, low-income and/or first-generation students or employees, refugees, asylum seekers, internally displaced, and/or undocumented students or employees and students or employees from one or more additional underrepresented groups (AASHE STARS 3.0) - Ensure that marginalized racial and ethnic groups, Indigenous peoples, women, and individuals with other marginalized gender identities are represented among students and employees (AASHE STARS 3.0) - Ensure that education programs are affordable to and inclusive of low-income and first-generation students (AASHE STARS 3.0)	**2023 UC Report on Sustainable Practices** - new section in 2023 focusing on intersection of sustainable practices with anti-racism, diversity, equity, and inclusion 2023 UC Report on Sustainable Practices - new section in 2023 focusing on intersection of sustainable practices with anti-racism, diversity, equity, and inclusion UC framework created from JEDI centered climate resilience SB CAP 2012 - update evacuation plans addressing special needs of people with disabilities UC Framework for EJCJ - part of principles section: views and perspectives from BIPOC, low-income, and communities impacted by climate change are essential in shaping policy addressing climate change Future policy decisions shall rebuild communities in nature and honor the cultural integrity of all BIPOC communities	**UC Sustainable Policy** - DEIJ assessment will be completed of existing sustainability policy to identify what is missing. Goals to be developed that incorporate principles of anti-racism, diversity, equity, and inclusion by 2025. UC Resilience & Equity Program- includes a strong focus on equity-centered planning and identifying key vulnerable groups on campus 2021 Location-specific workshop Slides UCSB - identified vulnerable groups at risk	2	Participation in the 2024 UC Equity-centered Climate Resilience process focuses on DEI. Vulnerable groups identified and included in planning. Equity lens not yet applied to mitigation planning, but opportunity to do so for 2025 Climate Action Plan	Opportunity to build on processes and outcomes from the 2024 UC Equity-centered Climate Resilience to inform climate action plan development	2	
	Build staff and student awareness about climate change mitigation and planning	- Assess and track sustainability literacy of students (AASHE STARS 3.0) - Involve staff in developing or adopting the methodology to assess sustainability literacy (AASHE STARS 3.0) - Increase number of student climate and sustainability groups and representatives on campus. E.g., Princeton University has 10+ student sustainability groups and 100+ student EcoReps	**UCSB 2016 CAP** - CNI Faculty Education Committee set a goal across UC system to ensure every UC graduate is literate in sustainability by 2025	**UCSB 2016 CAP** - Programs on campus focus on behavioral change such as LABRats, PACES, and residence hall energy efficiency competition. Encouragement for relevant classes to include climate change within curriculum. Goal is to increase 75% of UCSB departments to offer at least one course related to sustainability by 2025. Energy Awareness campaign as a goal to include in academic and residence hall to encourage further behavior change	3	Quantitative goals regarding sustainability awareness across campus. Steering committee involved in Clean Energy Master Plan is one example of how students and staff are being integrated into planning process.	Track/survey for progress.	2	

3-1 – Climate Action Gap Analysis Results Summary

University as a Living Laboratory	**Integrate climate change within course curricula and provide "living laboratory" opportunities for learning**	- Include actions to make carbon neutrality a part of the curriculum and other educational experiences for all students (Second Nature Commitments Implementation Handbook) - Offer courses with a campus-as-lab (CAL) focus, activity and/or course projects. E.g., 109 course-based CAL experiences offered at Princeton University (Princeton University Sustainability Action Plan)	**UCSB 2016 CAP** - CNI Faculty Education Committee set a goal across UC system to ensure every UC graduate is literate in sustainability by 2025	**UCSB CSP - 50.8% of departments offer courses related to sustainability** (e.g., "Campus as a Living Lab" course) **UCSB 2016 CAP** - Programs on campus focus on behavioral change such as LABRats, PACES, and residence hall energy efficiency competition. Encouragement for relevant classes to include climate change within curriculum. Goal is to increase 75% of UCSB departments to offer at least one course related to sustainability by 2025. Energy Awareness campaign as a goal to include in academic and residence hall to encourage further behavior change **UCSB Sustainability Internship Program** offers living lab opportunities for undergraduate and graduate students	**2**	UCSB has many climate change focused courses, and creates living lab opportunities through the Sustainability Internship Program	Monitor/survey students to gauge awareness. Integrate new content into relevant courses that use UCSB Clean Energy Plan and capital works as a case study for learning (e.g. environmental engineering programs)	**2**	Opportunity to create living lab projects to support design and implementation of the Clean Energy Master Plan
	Leverage, strengthen and share out on climate mitigation-related academic research, innovation and leadership at the University	- Conduct on-the-ground work across disciplines to generate new ideas and discoveries that can be replicated at other institutions. E.g., Harvard Living Lab: Sustainability accelerator (Harvard Sustainability Action Plan) - Encourage campus as a lab (CAL) faculty research initiatives and independent student research projects (Princeton University Sustainability Action Plan) - Join a larger network of universities conducting and sharing climate mitigation related research. E.g., Second Nature University Climate Change Coalition (UC3), International Universities Climate Alliance)	**SB Coastal LUP** - Sea level rise scenarios developed by UCSB have been used to prepare several preliminary vulnerability assessments. Helped inform campus hazard vulnerability assessment	**UC Framework for EJCJ** - Provide research support to economic development strategies to promote a green economy and to statewide agency efforts to increase renewable electricity procurement. The UCSB Institute for Energy Efficiency (IEE) is a leader in research and innovation for energy efficiency. UCSB shares out on new research through the **UC Santa Barbara Environment hub** and hosts a **sustainability research list** at sustainability.ucsb.edu, which is updated every three years	**2**	UCSB contributions to climate research mentioned in various city and regional planning documents. UCSB has an online database of sustainability-related research, though resilience is not a large portion More work could be done to profile climate mitigation initiatives and research currently underway	Continue to publish research regarding local climate mitigation efforts. Host a climate mitigation forum that showcases the climate mitigation work and research being done on campus, inviting sister institutions to promote cross-sharing and collaboration.	**2**	There is an opportunity to draw on the sustainability and climate leadership among UCSB researchers into implementation of the Clean Energy Master Plan and Climate Action Plan
Existing Building Efficiency	**Benchmark energy use of all buildings and disclose data online**	- Track energy use and emissions of all buildings, and compare annually to both historical baselines and national benchmarks from ENERGY STAR (ENERGY STAR Guidelines for Energy Management) - Report and publicly disclose benchmarking data online - Create greenhouse gas inventory baseline and annual progress evaluations (Second Nature Commitments Implementation Handbook)	**County of SB ECAP** - Benchmarking Policy uses ENERGY STAR Portfolio manager, requires the county to benchmark yearly.	**UCSB Climate Action Plan** - campus buildings have been benchmarked according to building type for the purpose of action plan **UCSB CSP** - energy dashboard was created for occupants to see building energy use	**2**	Unclear if all buildings are disclosed on the UCSB CSP, or just residential.	Disclose all building data online.	**2**	
	Conduct ongoing energy efficiency retrofit program	- Conduct regular retrocommissioning or "tune-ups" of all buildings every 5 years to improve building controls, set points, and operations (US EPA ENERGY STAR) - Complete lighting retrofits. E.g., convert all lights to LEDs (US EPA ENERGY STAR) - Upgrade and maintain heating and cooling equipment to be more energy-efficient (US EPA ENERGY STAR) - Plan systematic building upgrades using the 5-stage approach in EPA's Building Upgrade Manual (US EPA ENERGY STAR)		Preventative maintenance program, ongoing lighting upgrades and energy efficiency projects. On a case-by-case project basis, deferred maintenance initiatives receive supplemental funding from projected energy efficiency savings. Related - each campus will seek to certify as many buildings through LEED O+M as possible **UC Integrated Capital Asset Management Program (ICAMP)** - includes formalized approach for prioritizing projects.	**2**	Existing prioritization of projects with demonstrated energy efficiency savings, with some guidance for deferred maintenance through UC Integrated Capital Asset Management Program (ICAMP). Goal of certifying buildings through O+M (or another internal/external standard) should be included as required policy rather than encouraged.	Formally integrate energy efficiency upgrades into UCSB deferred maintenance plan If O+M is too difficult to complete campus wide, recommend implementing a energy specific retrofit program campus wide.	**1**	
	Implement Green Labs Programs	- Obtain My Green Lab Certifications for lab spaces (My Green Lab Certification) - Create a Green Lab committee comprising lab representatives, university staff, operations manager, and directors to plan and oversee actions (Trinity College Dublin) - Examples of sustainability measures taken: optimizing turning off and on lab equipment, defrosting freezers and lowering their operating temperatures, reducing plastic and packaging waste, sharing materials between labs. (Trinity College Dublin) - Second Nature examples: Design experiments to minimize electricity and water usage, purchasing green supplies, using green chemistry practices, sharing lab space and equipment (Second Nature Green Labs)	**Green Lab Action Plan**: Commitment in UC Policy on Sustainable Practices that all locations shall complete a UC Green Laboratories Action Plan to determine strengths and areas for improvement within the operations of research laboratories in respect to sustainability and carbon neutrality.	**Green Lab Action plan** - implementation strategies for HVAC, Water, Waste reduction and Engagement. Program was created (LabRATS) which works directly with lab occupants to assess and reduce environmental impact. 19.7% of wet labs have been assessed to date.	**3**	Clear Green Lab program action plan and program.	Continue to track lab efficiency and partner with on campus group LabRATS.	**1**	

3-1 – Climate Action Gap Analysis Results Summary

New Construction and Major Renovations	**Establish standards for all new buildings to be all-electric**	- Mandate new building constructions to be all-electric. E.g., New York State All-Electric Buildings Law. Starting in 2026, most new buildings in New York must use electric heat and appliances. (New York State All-Electric Buildings Law) - Include provisions for kitchens and dining. E.g., UCLA Health to include new all-electric kitchen at new neuropsychiatric facility (UCLA Health)	**UC Policy on Sustainable Practices** - new building or major renovations must not use combustion for space and water heating If NC uses on-site fossil fuel combustion, requires estimate of electricity/gas use, explanation why fossil fuels are required, analysis of why it is most cost effective, and plan for mitigation	**UCSB Sustainable Design Requirements** - new construction must not use onsite fossil fuel combustion for space and water heating (except those projects connected to an existing campus central thermal infrastructure) Note that the UCSB Clean Energy Master Plan will provide a path to an all-electric CUP for connected buildings. Plans to approve a new all-electric kitchen on campus	3	UC Policy for all-electric buildings requires buildings to not use onsite fossil fuel combustion for space/water heating unless connected to central system.	Opportunity to go above and beyond by extending the requirement to other combustion uses (e.g., kitchens)	2	Much depends on electrification of new district system - provisions should be clear for buildings not connected.
	Establish energy efficiency standards for all new buildings	- Establish Energy Use Intensity (EUI) and Thermal Energy Demand Intensity (TEDI) targets for all new buildings, by building type. E.g., Cornell University new buildings to limit energy usage to 50% of the industry standard baseline (Cornell University Climate Action Plan) - Establish a well defined energy modeling protocol (Cornell University Climate Action Plan) - Mandate earning EPA's Designed to Earn the ENERGY STAR recognition for new constructions (ENERGY STAR Design Guidelines)	**UCSB Sustainable Design Requirements** - Locations will achieve a 90% reduction in total emissions (Scope 1-3) no later than 2045 relative to 2019 baseline County of SB ECAP - 25% electricity reduction goal by 2020. Ongoing goal to increase energy efficiency standards above Title 24.	**UCSB Sustainable Design Requirements** - all new building projects must outperform the California Building Code energy-efficiency standards by at least 20% or meet prescriptive requirements. Stretch goal is 30%. Meet LEED Gold at a minimum, strive for Platinum. **SB CAP 2012** - new buildings must be 10-20 percent more efficient than 2005 Title 24	3	Clear energy efficiency standards for all new buildings.	Implement measures to verify energy efficiency goals are being met for existing buildings.	1	
	Measure and limit embodied carbon in building projects	- Require new construction projects to estimate and limit "embodied carbon" lifecycle emissions. E.g., Harvard committed to reduce embodied carbon in the primary materials used in new construction and major renovations by a minimum of 20% by 2024, compared to conventional buildings (Harvard Sustainability Action Plan) - World Green Building Council Vision: By 2030, all new buildings, infrastructure and renovations will have at least 40% less embodied carbon. By 2050, new buildings, infrastructure and renovations will have net zero embodied carbon (World Green Building Council) - Earn LEED credits for low carbon building materials (LEED Credits)		Current Buy Clean CA requirement for at least four products, GWP threshold, and reporting requirement for projects	2	Current practices underway, but missing clear guidance for embodied carbon in design standards/CAP.	Require life cycle assessment for new buildings. Expand and make clear provisions to choose building materials with lower GWP and Buy Clean California Act (UCSD Standard).	1	
Renewable Electricity	**Purchase off-site renewable electricity sufficient to meet all electrical demand**	- Mandate the procurement of fossil-fuel free energy sources. E.g., Harvard to procure 100% of required electricity from fossil fuel-free sources. (Harvard Sustainability Action Plan) - As a bridging strategy, contribute to renewable energy projects to become fossil fuel-neutral (Harvard Sustainability Action Plan) - Join the EPA's Green Power Partnership (Green Power Partnership)		**UCSB is already purchasing 100% clean energy**	3	Already procuring 100% clean electricity	To build on this by looking at grid resilience and onsite renewable generation and storage for backup	2	Closely tied to grid capacity & supply
	Increase onsite renewable energy generation	- Install renewable energy on existing and new buildings, especially those with larger roof areas. E.g., Harvard University installed 3MW of solar panel capacity as of 2022 with many arrays being on campus roofs (Harvard Sustainability Action Plan) - Support the development of clean and renewable energy sources, aiming for 100% of total electricity consumption to come from onsite renewable energy generation (AASHE STARS 3.0) - Earn LEED credits for onsite renewable electricity generation (LEED Renewable Energy Credits) Note: Onsite renewable energy would yield more LEED credits than the equivalent amount of purchased offsite renewable energy	**UCSB Sustainable Design Requirements** - Campuses and health locations will install additional on-site renewable electricity supplies and energy storage systems whenever cost effective/in support of Climate Action Plan. **UCSB 2016 CA**P - On-site solar was included as one of the strategies to achieve net zero emissions by 2025.	**UC annual report on sustainable practices** - UC signed wind energy contract as well as utility scale batteries to SoCal solar project UC Sustainable Policy - In lieu of purchasing voluntary offsets, in 2025-2030 each campus will allocate funds equal to 25$/MTOCO2e for remaining scope 1 and 2 emissions **SB CAP 2012** - for commercial projects, provide a minimum of 5 kW of photovoltaic panel systems for every new sqft of building net floor area, or a system sized to meet 30% of energy demand (whichever is lower) Added 6 MW of on-campus solar between 2017-2019; currently generating 15% of UCSB power needs onsite	3	Clear leader in this space with further intention in policy to increase onsite renewable energy generation. Currently generating 15% of UCSB's power needs onsite.	Ample opportunity to pair with living laboratory goals	2	Onsite generation to be considered in overall capacity / needs of district system
	Install batteries for backup power where feasible	- Create reliable and redundant backup energy systems (Second Nature Climate Resilience Background) - E.g., Princeton's innovative microgrid includes battery storage for backup power (Second Nature Smart Infrastructure)		No battery storage for existing solar installations.	1	No current battery storage for existing solar installations.	Assess possibility of installing batteries for backup power and implement where feasible, cost-effective	2	Potential to use battery backup during peak electric demand

3-1 – Climate Action Gap Analysis Results Summary

Electrification	**Replace in-building fossil fuel equipment with electric alternative**	- Replace in-building gas-fired heating equipment with heat pumps / heat recovery chillers (US DOE Better Buildings HVAC) - Replace gas-fired Domestic Hot Water (DHW) / Service Hot Water (SHW) heaters with heat pump water heaters (US DOE Better Buildings HVAC)	Example of current approach underway: https://energized.edison.com/stories/fighting-climate-change-through-higher-education	**Watts Up Report** - site surveys taken of dining/housing facilities (sample of 4 buildings) to take inventory of all-natural gas-fueled equipment and model developed based on electrified replacement options/cost savings. Plans for first all-electric kitchen on campus.	2	Some effort in terms of replacement research, but no direct policy for replacing fossil fuel equipment. Majority focus is on new central utility plant.	Implement a more comprehensive policy for electrification of existing buildings not tied to district energy system. The campus should consider additional on-site solar and battery storage in conjunction with demand reduction from proposed central plant load shifting strategies to lower operating costs and make upgrades like kitchen electrification financially feasible	3	
	Conduct feasibility study for campus decarbonization	- Explore feasibility of electrification with 100% renewable electricity procurement, green hydrogen, or other future technology solutions (Harvard Sustainability Action Plan)	**UC Policy on Sustainable Practices** - 90% reduction in scope 1 emissions from fossil gas use in campus energy systems from a 2019 baseline	Clean energy master planning process underway Older: UCSB Climate Action Plan - recommended to conduct feasibility study focused on eliminating use of natural gas for heating and cooling per 2015. To achieve net zero, 50% of boiler systems will need to be replaced, no feasibility update per 2015 if study has been conducted. Watts Up report - study conducted of sample few dining/housing facilities to understand the costs/savings of electrification	3	Robust planning effort underway as part of deliverable 1		3	
	Convert district energy system to run on as low-temperature hot water as possible that meets campus needs and prioritizes generation efficiency	- Convert steam powered systems to hot water district energy to reduce water use, reduce waste heat loss, and be more compatible with other sustainable technologies such as waste heat recovery technologies, or geothermal or solar thermal energy sources. (Second Nature Hot Water District Heating)		Clean energy master planning process underway	2	Robust planning effort underway as part of deliverable 1. Implementation to follow.	Implement the recommendations of the Clean Energy Master Plan	3	
	Electrify heating and hot water using mild sources (e.g., geoexchange) and heat recovery (e.g., thermal energy storage)	- Invest in converting or installing geo-exchange technology to phase out non-renewable energy sources. Eg., Princeton University is investing in geo exchange technology to create and convert systems to geo-exchange technology with enough capacity to serve the entire campus (Princeton University Sustainability Action Plan)		Clean energy master planning process underway, with similar proposed strategies Watts Up Report - heat pumps outlined to meet demand for space and water heating much more efficiently and recommended to replace existing building systems. No active policy in place.	2	Robust planning effort underway as part of deliverable 1. Implementation to follow.	Implement the recommendations of the Clean Energy Master Plan	3	
Leased Facilities	**Collect data on energy use and emissions in leased facilities**	- Collect data regarding upstream and downstream leased facilities to include in GHG inventory (AASHE STARS 3.0) - Calculate emissions from upstream and downstream leased assets using GHG Protocol Technical Guidance for Calculating Scope 3 Emissions (GHG Protocol Technical Guidance)		Note that several leased buildings are included in Clean Energy Master Planning, although these are not part of district energy system.	1	Lacking documentation of energy use & emissions for leased facilities.	Collect data on energy use and emissions in leased facilities	1	
	Use green leases to enhance data and cost sharing	- Follow the Building Owners and Managers Association International's Green Lease Guide to craft a green lease and maintain sustainable building operations (Building Owners and Managers) - Join the Green Lease Leaders Program (Green Lease Leaders)			1	No current documents detailing leased facility sustainability guidelines.	Develop leased facility sustainability guidelines prioritizing data transparency and sustainability commitments	1	
	Move to leasing all-electric, energy efficient buildings	- Introduce commitments or mandates to leasing all-electric or energy efficient buildings E.g., mandate all leases to meet certain level of Green Lease Leaders recognition (Green Lease Leaders) - If leasing an office space, lease from organizations that have earned ENERGY STAR Tenant Space designation by the U.S. EPA (ENERGY STAR Tenant Spaces)			1	No current documents detailing leased facility sustainability guidelines.	Develop leased facility sustainability guidelines prioritizing occupation of energy efficient and all-electric buildings where possible	1	
Refrigerants	**Track and reduce refrigerant leakage**	- Introduce effective maintenance procedures to minimize leakage (EDGE Guidance Document for Refrigerant Selection to Reduce Climate Impact) - Implement leak detection systems such as area monitors and leak pin-pointers (EDGE Guidance Document for Refrigerant Selection to Reduce Climate Impact)		**UCSB Climate Action Plan** - refrigerant emissions are tracked within campus Scope 1 emissions data.	2	Refrigerant emissions are tracked but no concrete goals for reduction.	Incorporate refrigerant leakage reduction strategies into updated CAP	2	Implications for electrification of district system
	Establish policy for using low-Global Warming Potential (GWP) refrigerants for heat pumps and cooling equipment	- Implement low GWP alternatives for heat pumps and cooling equipment. For example, for heating-only heat pumps, using HFC-32, HFC-446A, HFC-447A, or HFC452B as low GWP alternatives (https://edgebuildings.com/wp-content/uploads/2022/04/170403-RefrigerantSelection_EDGE_MontrealProtocol.pdf)		UCSB Sustainable Design Requirements - Meet LEED Gold at a minimum, strive for Platinum.	2	Pre-requisite of Fundamental refrigerant management in LEED requires projects to eliminate CFC based refrigerants.	Develop policy beyond LEED requirement for low GWP refrigerants.	2	Implications for electrification of district system

3-1 – Climate Action Gap Analysis Results Summary

Fleet Electrification	**Electrify fleet by replacing all gas or diesel powered university vehicles with zero emission vehicles**	- Replace, through normal capital replacement process, all vehicles with electric vehicles (or other zero emission vehicles for specialty vehicle types where electric vehicles are not available). -Purchase battery-electric or plug-in hybrid electric light duty vehicles for all new light-duty vehicle purchases - Transition all cars, vans, trucks, and buses in its fleet to electric vehicles, i.e., zero emission vehicles and/or plug-in hybrid electric vehicles (AASHE STARS 3.0)	**UCSB Sustainable Design Requirements -** A fleet sustainability implementation plan will be developed by Jan 1st 2022 to document the needs to implement a low-carbon fleet program and reduce emissions by 2025 **UC Sustainable Policy** - Each campus will reduce GHG emissions from fleet ad report annually on progress. County of SB ECAP - 5% of County's fleet to be alt fuel vehicles by 2020, 20% in 2035 County of SB 2030 Plan - increase commercial EV car use to 15% by 2030 and 75% by 2045	**UC Policy on Sustainable Practices** - After July 1 2023, zero-emission vehicles, plug-in hybrid, or dedicated clean transportation fueled vehicles will account for at least 50% of all vehicle acquisitions (including leased) (additional provisions by vehicle type)	2	Good progress to date, but more action needed with opportunity to go above and beyond UCOP targets.	Develop strategy for 100% electric fleet by net zero target year as part of updated CAP	1	
	Electrify transit bus fleet	- Transition all cars, vans, trucks, and buses in its fleet to electric vehicles, i.e., zero emission vehicles and/or plug-in hybrid electric vehicles (AASHE STARS 3.0)	Note related goal from SB MTD to adopt fully zero-emissions fleet by 2040		N/A	UCSB does not own their bus fleet. Plans exist at the city/regional level to electrify transit bus fleet.	UCSB should support regional plans to electrify transit bus fleet and reflect this alignment in updated CAP.	1	
	Install electric vehicle charging infrastructure to support fleet electrification and employee commute via EVs	- Install Level 1 EV Chargers in areas where users are expected to park for long periods—such as staff parking lots and Level 2 EV chargers in areas of high turn-over or more irregular parking schedules (US DOE Workplace Charging) - Take a proactive approach with new parking facility construction by installing features such as conduit and expanded electrical capacity—making these facilities "PEV ready" (US DOE Workplace Charging)	County of SB ECAP - leverage public private partnership and collaboration with local businesses to install 225 publicly accessible chargers needed throughout the county	https://www.tps.ucsb.edu/commuter-options/electric-vehicle-services	2	Charging stations available on campus. Unclear if sufficient charging is available to support both student/faculty use and fleet.	Develop plan to provide sufficient EV charging throughout campus in alignment with EV transition and mode shift targets	1	
Commute and Transit	**Track emissions through commuter surveys**	- Gather data regarding number of trips taken using sustainable modes of transportation (AASHE STARS 3.0) - Gather data regarding the primary mode of transportation used by staff and students (AASHE STARS 3.0)		**UCSB Sustainable Design Requirements** - Annual commuter data including employee and campus-wide mode split and accounting for ZEVs and EVs. UCSB Commuter Mode-Split Data - from 2023, accounts for years from 1969-2023 (with some gaps, mainly between 75-91 and 02-10). Accounts for SOV, motorcycles, carpool, bus, bike, walk, etc.	3	Annual commuter data tracked and included in Climate Action Plan.		1	
	Develop comprehensive transportation plan	- Establish transportation-related objectives, priorities, actions, and evaluation criteria (OSU Transportation, UConn Active Transportation Plan) - Use the US EPA's Guide to Sustainable Transportation Measures to inform performance measure selection and implementation (Guide to Sustainable Transportation Measures) - Publish detailed transportation plan to ensure accountability (OSU Transportation, UConn Active Transportation Plan)	**UCSB Sustainable Design Requirements** - by 2025, goal to reduce single-occupant vehicle (SOV) percentage by 10% relative to 2015, and by 2050, no more than 40% of employees and 30% of employees commuting by SOV County of SB ECAP - meet net zero increase per capita in GHG emissions from passenger vehicles by 2020 City of SB Circulation Plan - high quality public right-of-way infrastructure emphasized for pedestrians and bicycles Bicycle master plan includes working with UCSB to identify current and future needs for bikeways	**UCSB Climate Action Plan** - outlines past accomplishments and future recommendations for improving transit service, including having partnered with SB MTD to expand options for students	1	Transportation included as a category within various plans, but no specific comprehensive transportation plan for campus.	Gather and update current information/policies/goals and compile into comprehensive transportation plan in alignment with updated CAP	1	
	Provide incentives for active and low-carbon commute options such as biking, transit, and EVs	- Improve bus systems, introduce carpool lots, and subsidize public transit (Second Nature Improved Commuting) - Develop a benefits plan for students and employees who commute by public transit, sharing a ride with a colleague, biking, or walking. E.g., Princeton Revise your Ride program	**UCSB Sustainable Design Requirements** - by 2025, at least 4.5% of commuter vehicles ZEV, 2050 as 30% City of SB circulation Plan - considerations for fare subsidies to increase ridership for transit, transit pass program for schools, membership options, giving transit vehicles priority over other vehicles in traffic.	**UCSB CSP** - committee worked with financial aid to provide program that would fund 1/2 the annual membership cost of bike share program **UC Framework for EJCJ** - incentivize public transportation (include reimbursement for biking expenses), provide integrated fare system for public transport **IV 2016 Master Plan** - county + UCSB established car-sharing program to reduce SOV	3	UC Framework provides incentives for public transport, bike share and car-sharing include incentives as well. Robust bike/walking network throughout campus, transit connectivity to surrounding community.	Provide student specific discounts for MTS, host events that encourage/reward biking to class. Include in comprehensive transportation plan.	1	
	Provide EV charging infrastructure to support commute via EVs	- Provide Level 2 EV chargers in areas of high turn-over or more irregular parking schedules (US DOE Workplace Charging) - Take a proactive approach with new parking facility construction by installing features such as conduit and expanded electrical capacity—making these facilities "PEV ready" (US DOE Workplace Charging). E.g., Provide Level 2 EV chargers for 40% of all parking spaces in any new garages, with conduit laid to support charging at 90% of spaces		UCSB rewarded REACH 2.0 grant to install more level 2 charging stations EV charging stations on campus	2	EV Chargers provided and listed on UCSB's websites. Not within policy to provide Level 2 EV chargers for certain % of parking spaces in any new garages.	Incorporate EV charger provisions for future buildings/parking structures. Include in comprehensive transportation plan.	1	
	Partner with Santa Barbara MTD to improve mass transit service	- Scale action beyond the university campus through information-sharing and partnerships with local municipalities (Princeton University Sustainability Action Plan)	**City of SB Circulation Plan** - Actively pursue regional transportation solutions throughout SB to address regional transportation needs City shall cooperate with encouraging regional transit providers to provide express service from Ventura, SB, and Goleta	SBCAG and MTD participate in UCSB Sustainable Transportation Committee and partner to improve transit **Isla Vista 2016 Master Plan** - plans to extend bicycle, pedestrian, and public transit networks in UCSB Increased later transit service including UCSB to at least 11pm weeknights, 2am weekends	2	Regional transit authorities participate in sustainable transportation committee Listed in SB and IV plans to incorporate networks to UCSB, however not currently reflected in UCSB policy.	Partner with Santa Barbara MTD to provide discounts and/or increased service for students during peak hours. Include in comprehensive transportation plan.	1	

3-1 – Climate Action Gap Analysis Results Summary

Air Travel	**Reduce air travel**	- Provide incentives designed to encourage employees to reduce their air travel (AASHE STARS 3.0) - Adopt restrictive measures designed to reduce the GHG emissions associated with its directly financed air travel (AASHE STARS 3.0)		Currently tracking and reporting air travel emissions. Pilot air travel assessment guide: https://sustainability.ucsb.edu/sites/default/files/UCSB%20Business%20Travel%20Assessment.pdf **UC Framework for EJCJ** - reduce carbon footprint with teleconferencing, creating voluntary offset program via GreenTravel encouraging no airplane travel	2	Tracking and reporting has begun, but more strategy needed for reduction - UC Framework participation requires reduction and offset of air travel.	Make clear tracking & reporting of air travel and emissions. Ensure UC Framework is incorporated into specific UCSB policy.	1	
	Offset remaining air travel	- Introduce a program designed to mitigate the GHG emissions associated with its directly financed air travel (AASHE STARS 3.0)			1	UC Framework participating requires reduction and offset of air travel. Strategy needed.	Establish value-aligned offset program for air travel after first working to track & report. Ensure UC Framework is incorporated into specific UCSB policy.	1	
Food Systems	**Develop a strategy to increase sustainable food options on campus**	- Complete inventory on food and beverage (AASHE STARS 3.0) - Prioritize purchasing sustainably and ethically produced products, plant-based foods, and social impact suppliers (AASHE STARS 3.0) - Increase the purchase of local food (Second Nature Sustainable Procurement)	**UCSB Sustainable Design Requirements** - AASHE STARS 2.2 Sustainably and Ethically produced is the standard for campus food sustainability. Campuses encouraged to utilize compostable foodservice packages.	Two community gardens available to students on campus. **UCSB 2016 Annual Food Report** - gap analysis completed with respect to sustainable food procurement. Sustainable seafood selected by Monterey Bay Aquarium Seafood watch guidelines. 55% of the produce purchased must be sustainable (using AASHE STARS 2.2 as guide) Reusable container program for take out meals at Ortega Dining Commons	2	Strategy identified to procure sustainable food as defined by AASHE.	Ensure that community gardens on campus are leveraged for student use and education opportunities. Increase dining programs and options for students. Ample opportunity to pair with living laboratory goals.	1	
	Reduce wasted food and divert organic waste through composting program	- Design food waste reduction methods to align with EPA Wasted Food Scale. From most to least preferred: prevent food waste, donate or upcycle, feed animals or leave unharvested, compost, anaerobic digestion, apply to the land, send down the drain, landfill or incinerate - Expand campus composting programs outside of dining halls (Princeton University Sustainability Action Plan)	SB 2030 CAP - Reduce landfilled organics 80% by 2030 and 100% by 2045. Reduce landfilled inorganic waste by 35% by 2939 and 90% by 2045	**2020 Zero Waste Plan** - composting program within dining area established, also for food vendors. Vendors are required to dispose of all food waste in according bin.	2	Initiatives regarding composting have been/are in place. More tracking/reporting needed.	Establish clear tracking for diversion for organics.	1	
Waste Reduction and Diversion	**Use composting and recycling to increase waste diversion**	- Have or participate in a composting program that accepts compostable alternatives to single-use disposable plastic (AASHE STARS 3.0) - Fulfill LEED requirement by having dedicated areas for the collection and storage of recyclable materials including mixed paper, corrugated cardboard, glass, plastics, metals, and two of: batteries, mercury-containing lamps, and electronic waste (LEED Storage and Collection of Recyclables) - Commit to earning the TRUE Zero Waste certification. TRUE-certified spaces are environmentally responsible and achieve a minimum of 90% waste diversion (TRUE Zero Waste)	**2012 UCSB Waste Diversion Plan** - achieve 75% waste diversion by 2012 and zero waste by 2020. UC Policy on Sustainable Practices requirement is 50% of municipal solid waste by 2008, 75% by 2021, and zero waste by 2020 **UCSB 2012 Waste Diversion Plan** - Departments contributing to diversion goals include A.S. Recycling, Department of Public Worms (vermicomposting program), Environmental Health & Safety, Hazardous Waste, Surplus Chemical, and Facilities. Strategies to achieve Zero Waste include communication of waste management strategies, departmental level collaboration of various departments. **SB CAP 2012** - citywide goal to achieve 75% overall waste diversion by 2020	**Green Lab Action Plan** - LabRATS has completed several waste audits of laboratory buildings and implemented recycling programs. 2020 UCSB Waste Diversion - diversion rate = 62% **2012 Waste Diversion Plan** - analyze waste receptacles at UCSB. Conduct spatial analysis of the outdoor public waste bin and optimize the rearrangement of waste receptacles. MarBorg Industries to provide a formal food compost program for UCSB's main campus. Already occurs via four food waste compactors at each of the H&RS dining commons. Compostable food servicewear to be implemented. Zero Waste Committee will assist UCSB in achieving the 2020 zero waste goal. Alliance will ensure uniformity in waste management. 2020 zero waste goal was not met. **2020 Zero Waste Plan** - UCSB Staff in dining areas required to throw all food scraps and organic material into organic waste receptacle. **2014 Waste Diversion Plan** - campus-wide policy that all food entities leasing space from University Center must provide compostable food serviceware. All events hosted at Bren Hall to incorporate composting. Biodegradable paper towels pilot program. Daily waste audit was conducted for if they were	2	Clear that UCSB prioritizes and encourages composting campus-wide. Recycling/zero-waste goals clearly established and programs in place to achieve.	Conduct yearly waste audits to assist in achieving zero-waste goals. Ample opportunity to align with living laboratory goals.	1	
	Establish standards for reduction and recycling of construction waste	- Divert 90% or more of construction and demolition (C&D) waste from disposal through recovery options (AASHE STARS 3.0) - Earn LEED credits by diverting at least 50% of the total construction and demolition materials from landfills and incineration facilities or by salvaging or recycling at least 50% of demolition debris and utilizing waste minimizing design strategies and construction techniques (LEED Construction and Demolition Waste Management)	**UCSB 2020 Zero Waste Plan** - C&D Waste is mentioned but since this is not considered part of the municipal solid waste stream it does not count towards the University's MSW goals. Reported waste data is reported separately from MSW. **City of SB CAP 2012 -** GP policy PS8.5 2015 - increase monitoring and enforcement of City Unscheduled Hauling Ordinance to ensure most construction debris is recycled	**Standards created in UCSB 2020 Zero Waste Plan** County of SB ECAP - all demo projects require permit to implement recycling plan, maximizing asphalt, concrete, and equipment.	2	Policy for LEED certification and establishing recycling plan for C&D waste, no goals for construction waste established.	Create a clear diversion rate policy for all construction waste. Consider making the C&D waste credit mandatory for new construction.	1	

3-1 – Climate Action Gap Analysis Results Summary

Procurement	**Develop an overarching sustainable procurement strategy**	- Publish a supplier code of conduct that exceeds minimum regulatory compliance in regard to environmental impact, treatment of workers, governance and ethical business practices, advancement of sustainability in the supply chain, or monitoring and review (ASHE STARS 3.0) - Create sustainable procurement policies that select equipment based on both the direct emissions caused by the item's fuel source and efficiency as well as its embodied carbon and longevity (Second Nature Sustainable Procurement) - Focus on local purchasing which can also support local economic development (Second Nature Sustainable Procurement) - Encompass sourcing, manufacturing, packaging, transporting, distributing, retailing, usage, and disposal of products used by the institution in the procurement strategy (Second Nature Sustainable Procurement) - Examples: Prioritizing durability and longevity as opposed to disposability, eliminating the use of plastics, purchasing in bulk (Second Nature Sustainable Procurement)	**UCSB Sustainable Design Requirements** - The University will require all packaging materials to meet the UC Sustainable Procurement Guidelines. **UCSB Sustainable Procurement Guidelines** - Procurement looks to reduce unnecessary purchasing first, then prioritize purchase of surplus or multiple use products, before recyclable, compostable, or otherwise sustainable products.	**2012 UCSB Waste Diversion Plan** - UCSB Procurement Gateway will increase transparency of sustainable products via Procure to Pay System (P2P). Students assembled a list of sustainable product classifications and will add into the P2P product catalogs. New program will permit the evaluation of full life-cycle and environmental impact of procured products. **UCSB Sustainable Procurement Guideline**s - guidance provided encouraging the purchase of products with third-party certifications such as ENERGY STAR, EPEAT, FSC, Cradle to Cradle, EPA Safer Choice, etc. Different levels including required (25% of purchases must meet certifications) and preferred (75%). Healthy material standards similar to LEED (VOC Rule 1168) required for all flooring (including adhesives/sealants) and furniture. Foodware must be either reusable or certified compostable. WaterSense label required for all water appliances/fixtures	3	Sustainable procurement guidelines established with clear thresholds for purchasing.	Continue to track and implement these guidelines.	1	
Offsets	**Develop a plan for value-aligned offsets that remove and sequester carbon**	- Determine method of acquiring carbon offsets. E.g., purchasing, investing in projects, developing projects, producing third-party verified offsets, producing peer-reviewed and innovative offsets (Second Nature Carbon Markets) - Determine offset strategy. E.g., least-cost approach, neutrality first approach, reductions by scope, producing and marketing offsets, targeted reductions (Second Nature Carbon Markets)		**UCSB Sustainable Design Requirements** - only high-quality carbon offsets that represent quantifiable and enforceable emissions reduction or have third-party verification will be used. Accepted organizations are The Verified Carbon Standard, American Carbon Registry, and the Climate Action Reserve.	2	Standards for quality of carbon offsets have been established. Opportunity to further align with university values and priorities, including equity considerations. Other policy document amount of carbon offsets needed compared to different outcomes depending on energy efficiency savings.	Ensure all carbon offsets are tracked and held to the sustainable design requirements standards. Consider updating to include value-based and equity considerations.	1	

Climate Action Gap Analysis - Climate Resilience Results Summary

Action Category	Best Practices	Implementation Examples	Relevant UC Santa Barbara Climate Goals & Targets (high-level policy goals/commitments from existing plans & strategies)	Existing, Planned, or Proposed Actions (from existing plans & strategies)	Gap Analysis Score (status) (1 - underperforming BP; 2 - partially meeting BP, some action taken but more required; 3 - meeting or exceeding basic BP)	Score Rationale (assumes proposed/planned actions have been implemented)	Additional Measures or Next Steps Recommended	How Closely Does the Recommendation Relate to the Clean Energy Master Plan & UCSB Decarbonization Goals? (1 - not related closely to Clean Energy Master Plan; 2 - somewhat related to Clean Energy Master Plan; 3 - very relevant to Clean Energy Master Plan)	Other Notes on Future Campus Clean Energy Plan Implementation
Climate Resilience Assessment & Adaptation Planning	**Complete a climate risk assessment**	- Lead a campus-community resilience & vulnerability assessment (exposure, sensitivity, adaptive capacity of campus assets, people and services) with input from campus and community actors (Second Nature) - Use campus assessment data and local/state/federal/international targets to guide climate action planning (Second Nature Signatory Handbook) - Complete a more detailed climate risk assessment (likelihood and consequence of climate hazards on services and assets) for 2050 and 2080 time horizon for all campus buildings, infrastructure, natural spaces, and leased properties (UC Equity-centered Resilience Planning Process)	**UCOP Sustainable Practices Policy 2023** update requires updated Climate Action Plan by 2025 that integrates adaptation and resilience **UCSB EOP 2022** notes that "Each campus and the Office of the President will maintain a comprehensive and effective program encompassing risk assessment, risk mitigation, emergency preparedness and response, and business recovery to strengthen crisis and consequence management capabilities across the University system." **July EPC Climate Hazards results** - climate related hazards survey was sent out for UCSB to identify biggest climate risks	Climate resilience gap analysis as part of Clean Energy Master Planning Participated as a pilot for the UCOP new **Climate Hazard, Vulnerability Assessment (HVA).** Participated in the **2021 UC Equity-centered Climate Resilience initiative** including educational workshops and initial vulnerability identification Will be participating in the 2024 UC Equity-centered Climate Resilience initiative, which will involve completing an impact (vulnerability) assessment	2	Highest risks (climate hazards) have been identified to UCSB campus through HVA pilot project. - Gap analysis identifies opportunities for resilience, particularly related to decarbonization, but doesn't involve a full assessment of climate risks on campus - Participating in the 2024 UC Equity-centered Climate Resilience initiative	- Continue to carry out an impact assessment as part of the 2024 Equity-centered Climate Resilience Initiative - Lead a more detailed climate risk assessment, as needed, as part of design for systems and aspects of campus found to be highly vulnerable based on 2024 impact assessment. - Integrate a requirement for completing climate risk assessment for new construction, including the new energy system and new/retrofit construction	3	- Identify specific climate risks facing decarbonization strategies, including the new campus energy system. - Prioritize risk mitigation strategies that advance campus decarbonization goals (e.g. enhancing natural assets)
	Identify and implement adaptation strategies to address highest risks	- Carry out a cost-benefit analysis with tangible and intangible considerations to select the most suitable adaptation approaches and to inform implementation timelines and priorities (Second Nature Financing) - E.g., Harvard major capital projects are designed using local and regional data to minimize and manage future climate impacts such as floods, storm surges, increased precipitation, extreme heat, and temperature fluctuations (Harvard Sustainability Action Plan)	**UC Resilience & Equity Framewor**k - includes guidance for developing actions as part of resilience planning, however doesn't list specific actions.	Participating in the **2024 UC Equity-centered Climate Resilience initiative**, which will involve high level identification of resilience actions	2	Highest risks have been identified to UCSB campus through HVA pilot project. Adaptation strategies will begin to be identified as part of UC Equity-centered climate resilience project for 2024.	- Draft tangible and high priority strategies and next steps to address key vulnerabilities as part of the 2024 Equity-centered Climate Resilience Initiative	2	Broader adaptation planning and implementation will come after Clean Energy Master Plan is drafted, but could be incorporated into system design and future Clean Energy Master Plan updates
	Take a climate justice lens to integrate equity, inclusion, diversity, and accountability into planning	- Support programs, initiatives, or networks designed to address the specific needs of students or employees with disabilities, students or employees that identify as members of marginalized racial, ethnic, and/or Indigenous groups, LGBTQ+ students or employees, low-income and/or first-generation students or employees, refugees, asylum seekers, internally displaced, and/or undocumented students or employees and students or employees from one or more additional underrepresented groups (AASHE STARS 3.0) - Ensure that marginalized racial and ethnic groups, Indigenous peoples, women, and individuals with other marginalized gender identities are represented among students and employees (AASHE STARS 3.0) - Ensure that education programs are affordable to and inclusive of low-income and first-generation students (AASHE STARS 3.0) - Ensure that students succeed irrespective of economic status, gender identity, indigeneity, or racial/ethnic identity (AASHE STARS 3.0)	**2023 UC Report on Sustainable Practices** - new section in 2023 focusing on intersection of sustainable practices with anti-racism, diversity, equity, and inclusion UC framework created from JEDI centered climate resilience **SB CAP 2012** - update evacuation plans addressing special needs of people with disabilities **UC Framework for EJCJ** - part of principles section: views and perspectives from BIPOC, low-income, and communities impacted by climate change are essential in shaping policy addressing climate change Future policy decisions shall rebuild communities in nature and honor the cultural integrity of all BIPOC communities	**UC Sustainable Policy -** DEIJ assessment will be completed of existing sustainability policy to identify what is missing. Goals to be developed that incorporate principles of anti-racism, diversity, equity, and inclusion by 2025. **UCOP Equity Indicators -** Set of indicators and performance metrics developed to support the system-wide decarbonization initiative that the UCSB Clean Energy Master Plan is part of. **UC Equity-centered Climate Resilience initiative** includes a strong focus on equity-centered planning and identifying key vulnerable groups on campus. 2021 Location-specific workshop Slides UCSB - identified vulnerable groups at risk	2	Participation in UC Resilience & Equity program in 2024 takes an equity-centered approach to resilience planning. Opportunity to integrate equity-based approaches into climate action implementation and other UCSB programs	- Draw on the UCOP EJCJ and Equity Indicators to inform planning for engagement as part of the 2024 Equity-centered Climate Resilience Initiative	3	Key principles and approaches for equity-centered planning and design are informing the Clean Energy Master Plan development

3-1 – Climate Action Gap Analysis Results Summary

University as a Living Laboratory	**Build staff and student awareness about future climate projections and strategies for improving their own resilience**	- Host an on-campus community resilience building workshop with students and staff to define climate hazards, identify strengths and vulnerabilities, and develop and prioritize actions to build resilience (Second Nature Campus-Community Resilience Assessment) - Provide educational resources & toolkits on at-home and personal emergency preparedness & resilience to climate-related hazards (Second Nature Campus-Community Resilience Assessment, U.S. Gov. Climate Resilience Toolkit) - Add courses and improve curriculum to include sustainability and resilience field work, as well as student-community opportunities for interaction (Second Nature Campus-Community Resilience Assessment) - Include goals related to building awareness about climate impacts in Climate Action Plan. E.g., Princeton CAP includes goal related to building awareness about climate impacts on health and safety (Princeton Climate Action Plan)	**SB CAP 2012** - promote public education on emergency and disaster preparedness **SB Coastal LP** - promote community resilience through risk reduction, public education and emergency response planning and programs **UC Equity-centered Climate Resilience Framework** provides guidance on student and staff engagement and knowledge building around climate resilience.	**Participating in the 2024 UC Equity-centered Climate Resilience initiative** will create opportunities for staff and student engagement **UCSB** has offered Campus Emergency Response Team (CERT) training, and various initiatives to build staff and student awareness including the UCSB residence hall energy competition, cycleMAYnia, PACES, including sustainable Liaison program and sustainability assessments and LABRats.	**2**	UCSB has led a number of initiatives to build staff and student awareness on climate resilience, though more could be done to mainstream awareness more broadly	Develop opportunities to build staff and student awareness of the climate resilience context as part of the 2024 Equity-centered Climate Resilience Initiative Establish ongoing awareness building initiatives such as integrating climate dimensions into other communication materials (e.g. capital planning and budgets)	**1**	Communication and education about resilience elements of Clean Energy Master Planning process supports this
	Integrate climate change within course curricula and provide "living laboratory" opportunities for learning	- Identify actions in Climate Action Plans to expand university research in resilience and make resilience part of the curriculum and other educational experiences for students (Second Nature Examples of Climate Action Plan Structures) - Add courses and improve curriculum to include sustainability and resilience field work, as well as student-community opportunities for interaction (Second Nature Campus-Community Resilience Assessment) - Harvard, Johns Hopkins, and MIT sustainability plans emphasize the importance of integrating on-camps education/research into adaptation solutions (Harvard Sustainability Action Plan, John Hopkins Climate Action and Sustainability Plan, MIT Climate Plan)	**UCSB 2016 CAP** - CNI Faculty Education Committee set a goal across UC system to ensure every UC graduate is literate in sustainability by 2025. Programs on campus focus on behavioral change such as LABRats, PACES, and residence hall energy efficiency competition. Encouragement for relevant classes to include climate change within curriculum. Goal is to increase 75% of UCSB departments to offer at least one course related to sustainability by 2025.	**UCSB 2016 CAP** - 50.8% of departments offer courses related to sustainability (e.g., "Campus as a Living Lab" course) **UC Equity-centered Climate Resilience initiative** - Involves student fellows to create practical learning opportunities. **Clean Energy Master Plan** includes student interns as practical learning opportunities **Climate resilience courses** are being taught by Summer Gray and Ken Hiltner (related to infrastructure and equity) **UCSB Sustainability Internship Program** offers living lab opportunities for undergraduate and graduate students	**2**	UCSB has many climate change focused courses, however more emphasis on sustainability and decarbonization than resilience. also creates living lab opportunities through the Sustainability Internship Program	Investigate how many climate change courses are resilience-focused or include a resilience element. Create specific opportunities for resilience-focused learning opportunities (e.g. resilience classes in engineering and science departments)	**3**	Clean Energy Master Plan includes student interns Could include case studies with student involvement around how to integrate climate resilience into clean energy system planning and design
	Leverage, strengthen and share out on climate adaptation-related academic research and leadership at the University (e.g. climate science and adaptation technology)	- Establish partnerships with other university climate centers to amplify impact. E.g., join the Second Nature University Climate Change Coalition, UC3 (Second Nature UC3) - Harvard, Johns Hopkins, and MIT sustainability plans emphasize the importance of integrating on-camps education/research into adaptation solutions (Harvard Sustainability Action Plan, John Hopkins Climate Action and Sustainability Plan, MIT Climate Plan)	**UC Framework for EJCJ** - Provide research support to economic development strategies to promote a green economy and to statewide agency efforts to increase renewable electricity procurement.	**SB Coastal LUP** - Sea level rise scenarios developed by UCSB have been used to prepare several preliminary vulnerability assessments. **UC Equity-centered Climate Resilience Initiative** that UCSB participated in 2021 involved brining UCSB staff into early climate planning workshops to share knowledge of climate science and resilience UCSB shares out on new research through the **UC Santa Barbara Environment hub** and hosts a **sustainability research list** at sustainability.ucsb.edu, which is updated every three years	**2**	In various city of SB planning documents, UCSB contributions to climate research mentioned.. UCSB has an online database of sustainability-related research, though resilience is not a large portion More work could be done to profile climate resilience initiatives and research currently underway	Consider opportunities to leverage UCSB-led research to inform resilience considerations as part of Clean Energy Master Plan implementation	**1**	There is an opportunity to draw on the sustainability and climate leadership among UCSB researchers into implementation of the Clean Energy Master Plan and Climate Action Plan
	Meaningfully engage with diverse groups as part of climate adaptation planning & action implementation, with a particular focus on understanding and meeting the needs of key vulnerable or equity-seeking groups	- Develop community engagement strategies and engage the community in prioritization and planning (Second Nature Commitments Implementation Handbook) - Organize and execute a community resilience building workshop (Second Nature Campus-Community Resilience Resource)	**UC Equity-centered Climate Resilience Framework** sets a clear focus on building resilience among the most marginalized and at-risk groups	Participation in the **2024 UC Equity-centered Climate Resilience Initiative,** which includes leading equity-centered engagement. Also includes establishing a core team including people who represent key vulnerable groups on campus. UCSB has opted into this initiative to include it as an input to a new 2025 Climate Action Plan.	**2**	Groundwork is in place through participation in the 2024 UC Equity-centered Climate Resilience Initiative, which will involve an equity-centered approach to resilience planning for input to the 2025 CAP.	Develop a clear definition of which on-campus and external groups will be engaged as part of the 2024 Equity-centered Climate Resilience Initiative Develop a list of key vulnerable groups on campus to inform engagement Build on lessons learned through equity-centered engagement on the Clean Energy Master Planning process	**2**	Key principles and approaches for equity-centered planning and design are informing the Clean Energy Master Plan development. Lead ongoing equity centered engagement as part of Plan implementation and system design

3-1 – Climate Action Gap Analysis Results Summary

Community Partnerships	**Collaborate with government & community organizations on climate adaptation committees & initiatives**	- Establish and hold regular calls/meetings with a joint campus-community sustainability and/or resilience task force or committee to guide Climate Action Plan implementation (Second Nature Campus Community Structure) - Coordinate with the City's Resilience Office (Second Nature Campus Community Structure) - Leverage opportunities to build relationships and climate considerations as part of existing joint projects (Second Nature Organizing for Action) - Actively support a joint campus-community task force to ensure alignment of the plan with community goals and to facilitate joint action (Second Nature Commitments Implementation Handbook) - Focusing on inclusive governance that prioritizes equity and justice in adaptation planning and implementation (IPCC AR6 WGII 2022)	**UC Framework for EJCJ** - sets an intent to collaborate with community-based organizations including statewide, tribal, local leaders on issues	**County of SB ECAP** - outreach goals outlined (education of ECAP, providing opportunities for input). Community workshop for ECAP held in 2012 **UC Framework for EJCJ** - Include CEJA and the Greenlining Institute for regular standing meetings.	1	Collaboration mentioned throughout various policy documents, however no direct collaboration with government and community organizations on climate initiatives.	Identify regional fora (e.g. working groups, committees) that UCSB could become involved in on an ongoing basis to stay connected with climate resilience initiatives at the regional scale (e.g. to understand how City/regional initiatives may enhance resilience on campus, what investment may be needed on campus to fill gaps, and to discuss areas where UCSB can offer broader community support)	2	Regional dimensions of energy system transition
Effective Adaptation Action Implementation	**Allocate reliable funding for climate adaptation planning and action**	- Develop funding mechanisms to achieve plan objectives (Second Nature Financing) - Identify incentives or grants that could be taken advantage of for funding (Second Nature Financing) - Perform economic analyses to quantify the potential costs and benefits (Second Nature Financing)		UCSB participation in the **2024 UC Equity-centered Climate Resilience Initiative** provides initial funding for climate resilience action planning, however no funding commitment for implementation. The UCOP-funded initiative covers consultant fees, including direct support hours for each campus location, and also provides $2,000 for each location to hire Resilience Fellows and an additional $1,000 for engagement supports.	2	UCSB participation in 2024 UC Equity-centered Climate Resilience initiative indicates initial funding into climate adaptation planning. Unclear whether funding will/has also been allocated for ongoing planning and implementation	Identify a representative from UCSB leadership to act as a liaison and sponsor throughout the climate resilience planning process. Integrate climate resilience into UCSB program and capital budget processes (e.g. reserve funds, resilience upgrades at asset renewal, investing in resilience planning and implementation)	2	Incorporate funding for resilience considerations as part of energy system design
	Integrate climate change considerations in university policies & decision-making frameworks	- Create internal institutional structures to guide development and implementation of the Climate Action Plan (Second Nature Organizing for Action) - Review (and revise if necessary) the Climate Action Plan every 5 years (Second Nature Examples of Climate Action Plan Structures) - Take an integrated approach to climate planning that aligns and works with other plans, strategic visions, campus master plans, academic plans, development goals, utility master plans, transportation master plans, and other plans and policies (Second Nature Introduction to Sustainability Planning and Climate Action)	Sustainable Design Requirements are currently in place. Campus Design Standards and Guidelines are also in place but do not address future climate conditions	Participation in the **2024 UC Equity-centered Climate Resilience initiative** will include developing further resilience policy and tools for UCSB	2	The Sustainable Design Requirements have strong alignment with climate resilient design best practices. The Campus Design Standards and Guidelines provide more detail but do not directly address future climate. Expect that this will be expanded upon during 2024 Equity-centered Resilience Planning in 2024	Draw on outcomes from this gap analysis to consider how climate resilience could be integrated into existing policy and program documents (e.g. development guidelines)	1	
	Establish indicators for tracking plan implementation progress	- Establish a target date by which defined thresholds of resilience will be met (Second Nature Commitments Implementation Handbook) - Establish mechanisms and indicators for tracking adaptation/resilience action progress, including those that cut across campus-community boundaries (Second Nature Campus-community Resilience Assessment)	**UC Equity-centered Climate Resilience Framework** - indicators/metrics are outlined and example indicators are provided SB CAP 2012 - monitoring/implementation of adaptation planning will be undertaken by various city departments		1	No evidence of ongoing resilience tracking	Create and implement indicators specific to UCSB resilience related goals, drawing on resources that will be developed and provided as part of the 2024 Equity-centered Climate Resilience Initiative	2	Include resilience performance indicators for tracking clean energy master planning progress and outcomes
	Review climate action planning resources every 5 years and update as necessary	- Determine whether new climate data or other information needs to be incorporated (Second Nature Why Review a Climate Action Plan) - Identify if new targets and actions are needed (Second Nature Examples of Climate Action Plan Structures)		Participating in **2024 UC Equity-centered Climate Resilience initiative** will involve a review of resilience planning for this year	1	Currently no indication of commitment for ongoing climate resilience planning and update	Establish a realistic climate resilience planning review and update timeline as context setting for participation in the 2024 Equity-centered Climate Resilience Initiative	1	
	Establish a formal governance & accountability structure for university-wide climate adaptation/action implementation	- Establish a multi-disciplinary task force to discuss Climate Action Plan implementation (Second Nature Organizing for Action) - Evaluate and publicly report on climate action plan progress annually using success indicators (Second Nature Commitments Implementation Handbook) - Establish an Implementation Liaison (Second Nature Implementation Liaison)		**UC Equity-centered Climate Resilience initiative** - includes provisions to create a core team to implement JEDI focused climate initiatives. UCSB initiative is being led through a partnership with the Emergency Manager and Sustainable manager in VCAD, and the Sustainability Department in student affairs.	2	UC Equity-centered Climate Resilience initiative is being led through partnership with UCSB Emergency Management and Sustainability Departments	Identify pathways for collaboration between departments related to ongoing climate resilience planning and long term implementation.	1	

3-1 – Climate Action Gap Analysis Results Summary

	Consider future climate in emergency planning documents & protocols	- Consider how future climate conditions could cause higher magnitude/more frequent hazard events such as flooding, wildfire, power outage, or evacuation (UC Framework for J.E.D.I.-Centered Climate Resilience Planning) - Build flexibility into the planning process, and anticipate that the CAP will need to adapt to changing climate futures (Second Nature How to Report on Resilience Goals) - E.g., Princeton Climate Action Plan Resilience Goals include actions to integrate climate considerations into emergency planning/protocols (Princeton Climate Action Plan)	**SB CAP 2012 -** SB includes American Red Cross and Direct Relief international with plans and resources to respond in community emergencies **GP Policy ER2 target 2015:** incorporate response strategies for emergency preparations regarding climate change	Participated as a pilot for the UCOP new **Climate Hazard, Vulnerability Assessment (HVA).** **July EPC Climate Hazard Results** show survey was sent to identify climate-related hazards at UCSB	2	Climate considerations within July EPC Climate Hazard results and Climate HVA pilot. Unclear how climate considerations have been integrated into emergency planning	Continue to participate in the Climate HVA pilot and find ways to meaningfully integrate results into broader emergency planning and protocols across UCSB	1	
	Enhance multi-modal access to campus	- Improve bus systems, introduce carpool lots, and subsidize public transit (Second Nature Improved Commuting) - Develop a benefits plan for students and employees who commute by public transit, sharing a ride with a colleague, biking, or walking. E.g., Princeton Revise your Ride program	**UCSB Campus Plan** - a coherent system of pedestrian circulation should be well connected, use of bicycles should be enhanced and conflicts should be eliminated. Specifically, north and west campus (housing) should be better linked by stronger framework of pedestrian and bicycle access. **City of SB Circulation Plan** - Design standards: improve design for disabled access by providing more ramps and repair sidewalks. Identify/relocate obstructions to wheelchair users.	Accessible parking map for campus: https://www.vcadmin.ucsb.edu/sites/default/files/docs/UCSB_Accessible_Map.pdf	3	Bike accessible, wheelchair accessible (based on map), access by foot and vehicle.	Integrate awareness of campus multi-modal access routes (and their hazard risk) into emergency and evacuation planning.	2	As it relates to construction impacts on transportation pathways
	Build local resilience by planning for supply chain disruptions & incorporating climate resilience considerations into procurement	- Prioritize local suppliers to build resilience to regional supply chain disruption and support local economic development (Second Nature Sustainable Procurement) - Publish a supplier code of conduct that exceeds minimum regulatory compliance in regard to environmental impact, treatment of workers, governance and ethical business practices, advancement of sustainability in the supply chain, or monitoring and review (ASHE STARS 3.0) - Create and publish a sustainable purchasing guide or set actionable sustainable purchasing objectives that supports climate resilience. (Harvard Sustainable Purchasing Guide, Princeton University Sustainability Action Plan)			1	No information available.	Investigate opportunities for supplier redundancy for critical services in case of catastrophic disruption (e.g. contractors for trucked water, security, etc.)	2	Plan proactively for potential supply chain disruptions as part of energy system procurement and construction
	Consider future climate hazards in staff supports and resource planning	- Establish a post-disaster employee recovery assistance program according to staff needs (WHO Guidelines) - Assess potential workplace hazards that may arise in emergencies, and plan to take measures to reduce those hazards (WHO Guidelines) - Establish plans for handling future climate impacts and extreme events such as an evacuation or transportation plan during an extreme event (WHO Guidelines) - Train facility staff in protecting their health and safety during an emergency situation (WHO Guidelines) - Schedule outdoor work for cooler parts of the day and reduce physical demands during hot days (WHO Guidelines)			1	No information available.	Include climate-related hazards in health and safety protocol for system construction, operation and management that includes PPE requirements, stop-work thresholds, staff redundancy and protocols for work from home during emergencies.	2	Include climate considerations into construction management protocols
	Support & enhance local/on-campus food production	- Create spaces and programming to support on-campus gardens and markets. E.g., Harvard plans to build rooftop gardens to grow food and serve as living labs (Harvard Sustainability Action Plan) - Increase the purchase of local food (Second Nature Sustainable Procurement)	The **UC Sustainable Practices Policy** encourages use of local food sources and plant-based foods. **UC Framework for EJCJ** promotes farm to fork policies that support locally sourced food		2	Campus garden, UC framework promotes local food production.	Continue to fund and care for the campus garden, including creating living lab opportunities with students. Prioritize climate-adapted produce in the campus garden. Establish a policy for on-campus restaurants to encourage use of local food sources.	1	

3-1 – Climate Action Gap Analysis Results Summary

Multi-Hazard Action	**Prioritize nature-based and low-carbon approaches for managing climate risk**	- Use green infrastructure approaches for stormwater management such as collecting rainwater in barrels or cisterns for later reuse, installing porous paving, building green roofs and rain gardens, or planting trees (UNEP Practical Guide). E.g., Princeton's Action Plan prioritizes enhanced stormwater management with a focus on green infrastructure (Princeton Climate Action Plan) - Use natural shading (e.g. trees), thermal mass (e.g. rock) and cross-breezes as passive strategies for cooling buildings and outdoor spaces (UNEP Practical Guide)		**LDRP UCSB (updated 2019)** - restoration projects around campus Lagoon and north bluff included six acres of coastal bluff restoration and a suite of vernal pools and marshes with bio-swales and filters to improve the quality of storm water run-off. County of SB Flood Control District maintains Phelps creek as a floodway and maintenance easement Policy includes minimizing impervious surfaces, design development to increase the area of pervious surfaces. Where pavement is required, use permeable pavement systems where appropriate and feasible.	2	Nature-based approaches for coastal bluff restoration identified. Minimizing impervious surfaces and other design choices identified in LDRP for flood control.	Provide clear guidance and prioritization of lower maintenance and climate-adapted nature-based approaches in university design guidelines. Identify key green and blue-space on campus to protect from development.	2	Identify nature-based approaches to support or complement energy system design (e.g. bioswales to manage stormwater flooding around energy system, shading and material selection to keep system equipment cool)
	Design new buildings and infrastructure to be resilient to future climate change conditions	- Orient structures to reduce solar exposure, leverage passive cooling, and reduce wind tunneling (UNEP Practical Guide) - Avoid building in floodplains or flood-prone areas and locate critical uses above main floor in flood risk areas (UNEP Practical Guide) - Design for permanent back-up power, switching gear and / or power hook-ups and infrastructure for temporary generators to provide power for critical utilities such as HVAC and boilers (LEED Design for Enhanced Resilience) - Incorporate planning for future climate (such as using climate data for future warming trends in energy modelling) in building design (UNEP Practical Guide). E.g., Design new buildings with HVAC systems sized for 2050 design temperatures, and/or with space for future expansion to accommodate more extreme temperatures by end-of-century.	Sustainable Design Requirements are currently in place. Campus Design Standards and Guidelines are also in place but do not address future climate conditions	**LDRP UCSB (updated 2019)** - Development in the Coastal Zone must be approved by the Coastal Commission.	2	The Sustainable Design Requirements have strong alignment with climate resilient design best practices. The Campus Design Standards and Guidelines provide more detail but do not directly address future climate.	Ensure resilience design considerations are written into the future design guidelines.	3	- do not build central utility in projected floodplain (2080/2100), or plan extensive flood protection strategies to ensure continual operation during coastal or pluvial flood event projected under future sea level and climate conditions. - provide cooling for critical system components, including backup power supply - locate critical systems components within enclosures rated for future wind load, flood levels and fire resistance - design ocean cooling loop and vault to be adapted for future ocean temperatures and potential debris and water levels due to storm surge and gradual sea level rise. - Design future cooling capacity for future weather files (team is planning
	Retrofit existing critical and high-risk facilities to be resilient to future climate change conditions	- Install strategies to mitigate building overheating, such as installing exterior shading, improving insulation, installing higher performance glazing, and implementing nature-based solutions (UNEP Practical Guidelines) - Upgrade HVAC systems to lower-carbon alternatives (e.g. heat pumps) with backup power (Better Buildings HVAC) - Incorporate planning for future climate (such as using climate data for future warming trends in energy modelling) in building design (UNEP Practical Guide)	UC Equity-centered Climate Resilience Framework - strategies for climate resilience include collaborative flood risk mapping at campus, city, and regional scales. Restore and enhance ecological infrastructure to reduce and manage increased stormwater events, prevent downstream flooding and reduce runoff. Considerations to go beyond FEMA floodplain maps as properties may be susceptible to flood damage not identified by FEMA. Wildfire risk identified for UCSB with rising temps. Appendix F shows example impacted campus building and systems with wildfire smoke and a possible need for increased air filtration in buildings. Example given in Appendix F of increasing air conditioned buildings to avoid heat and health impacts. Action called out to complete an inventory and condition assessment of campus air filtration systems to identify priority upgrades by 2022, (unsure if this has been fulfilled)		1	Current strategies identify flooding risk, wildfire risk, and air quality. No current policy in retrofitting vulnerable facilities, however risks have been identified across campus.	Identify highly vulnerable facilities as part of 2024 Equity-centered Climate Resilience Initiative and target these for more detailed risk assessment and adaptation retrofit planning.	2	Integrate climate considerations into retrofits of existing buildings to accommodate energy system change
	Integrate climate resilience considerations into asset management planning	- Update asset management strategies to incorporate resilience strategies address resilience at all steps in the asset management process (US DOT Addressing Resilience) - Integrate climate resilience actions into a risk management plan that can become a core component of an asset management plan (FCM Guide)			1	No information available.	Integrate climate resilience considerations into asset management protocols and capital planning (e.g. by incorporating future weather files to inform renewal upgrades).	2	asset management planning and renewal for energy system components
	Establish a clear policy and approach for the role the university will play (if any) in supporting broader external community resilience during an extreme event	- Commit to creating a Community Resilience Center or Resilience Hub to provide a clean air and cooling refuge space (Community Resilience Center, Resilience Hub)			1	No information available.	Begin discussing this as part of the 2024 Equity-centered Climate Resilience Initiative, including during processes for identifying external groups to engage with and considering for a for ongoing collaboration with the City.	2	factor this into energy capacity design and decision-making

	Plan for increased operations & maintenance and staffing redundancy to manage future climate conditions and hazards	- Establish a post-disaster employee recovery assistance program according to staff needs (WHO Guidelines) - Assess potential workplace hazards that may arise in emergencies, and plan to take measures to reduce those hazards (WHO Guidelines) - Establish plans for handling future climate impacts and extreme events such as an evacuation or transportation plan during an extreme event (WHO Guidelines) - Train facility staff in protecting their health and safety during an emergency situation (WHO Guidelines) - Schedule outdoor work for cooler parts of the day and reduce physical demands during hot days (WHO Guidelines)		**City of SB CAP 2012** - additional maintenance and staffing will be coordinated among city departments during an emergency situation	2	Additional staffing mentioned at a high level for emergency situation.	Consider this as part of integrating climate considerations into HR policies Prioritize lower-maintenance systems where possible to reduce burden on staff during extreme events Establish a landscape guidelines including approaches to proactively assesses tree health to reduce maintenance needs during/after extreme wind, rainfall and drought/heat events	2	In terms of energy system maintenance
Managing Extreme Heat	**Provide adequate cooling in critical buildings/spaces to maintain occupant thermal safety under future climate (combination of mechanical & passive strategies) (upsized for more cooling in case of wildfire/heat compound event where people can't open their windows)**	- Design for increased cooling load over time to ensure thermal safety under increased extreme heat (LEED Design for Enhanced Resilience) - Design for future flexibility in cooling systems by providing space for future electrical, water, ductwork, radiant cooling, etc. to be added as needed (LEED Design for Enhanced Resilience) - Design new buildings with operable windows and cross-flow ventilation (LEED Design for Enhanced Resilience, UNEP Practical Guidelines) - Incorporate passive cooling strategies (such as planting shade trees or maximizing natural ventilation) to minimize HVAC loads and increase opportunity for future active cooling systems	Extreme heat identified as hazard in July 13 EPC Climate Hazards Results Climate Change Hazard Overview: extreme heat identified as a potential hazard, especially for those without access to mechanical cooling.		1	No mechanical cooling in residential units but cooling is provided in common areas as spaces of respite. No information about current on-campus cooling centers for extreme heat events.	Develop a list of buildings on campus with mechanical cooling, including information on capacity and system age/condition (could be included as part of a campus-wide or building-specific condition assessments) Update design guides to require mechanical cooling for future temperatures for new buildings Consider designating certain buildings as cooling centers, specifically for residential use when the air quality is too poor to use natural ventilation in resident buildings.	3	factor this into design of energy system components to stay cool, and in terms of potential future energy capacity needs to accommodate expansion of mechanical cooling
	Use nature-based approaches to enhance cooling by shading buildings and reducing the urban heat island effect	- Plant shade trees and other vegetation in strategic locations to shade the building and manage solar exposure and overheating (UNEP Practical Guidance). E.g., Princeton Climate Action Plan includes a goal of implementing a data-driven plan to protect and expand tree canopy (Princeton Climate Action Plan) - Plant vegetation strategically on-site to capture and direct wind flow for natural ventilation (UNEP Practical Guidance) - Update landscaping guidelines to prioritize species that are resilient to extreme heat (UNEP Practical Guidance)	**LRDP UCSB 2019** - Storke Plaza would be benefited by increasing shade with trees along edges, no current direct plan to implement.		1	LRDP mentions reducing heat island effect and shading parking garages, however not clear degree to which these have or are being implemented.	Include guidance for effectively including nature-based and/or passive approaches as part of campus design guidelines.	2	consider shading to keep equipment cool
	Provide refuge spaces with advanced resilience features (e.g. backup power, filtration, cooling) for student & staff	- Identify and publicize community spaces where vulnerable students and staff can access ventilated indoor spaces during smoke or other events (In Pursuit of Clean Air - Stanford) - Create a Community Resilience Center or Resilience Hub to provide a clean air and cooling refuge space (Community Resilience Center, Resilience Hub) - In case of emergencies, extreme heat days, or poor air quality, provide shelter and food services for vulnerable staff, faculty and students who live off campus (UC Framework for J.E.D.I.-Centered Climate Resilience Planning)		No information available on location of refuge spaces	1	No documentation of current cooling centers or refuge spaces on campus. No current guidelines for refuge spaces.	Consider assigning one or more spaces on campus as a refuge for staff, faculty, students and visitors during extreme heat event. Designated refuge spaces should ideally have mechanical cooling sized for future conditions, air filtration, and backup power	2	consider electricity servicing and back up power to areas of refuge

3-1 – Climate Action Gap Analysis Results Summary

Managing Poor Air Quality	**Design new buildings to safeguard occupants from poor air quality in all spaces**	- Create procedures to ensure rapid clean-up and recovery from extreme weather events to avoid indoor air quality problems such as mold growth associated with floods (WHO Guidelines) - Equip facilities with air pollution filters to improve indoor air quality (WHO Guidelines) - Include air filtration for critical spaces in existing and new buildings (WHO Guidelines) - Target minimum MERV 13 filtration, and replace filters more frequently during poor air quality events (ASHRAE Filtration, EPA Clean Room) - When HVAC air cleaning is not sufficient, consider using in-room air cleaners or using in-room air cleansers in conjunction with HVAC filters (ASHRAE Filters) - Equip facilities with air pollution filters to improve indoor air quality (WHO Guidelines)	**EPC June 1** - climate hazard assessed that poor air quality from wildfire smoke will continue to be a concern **UCSB EHS Plans** - control/reduce unhealthy exposure to wildfire smoke through engineering and administrative control. If an individual is exposed to unhealthy levels of wildfire smoke (PM 2.5 AQI > 150), must be provided NIOSH-approved filtering facepiece respirators. **UCSB Resilience Location Specific Report -** fire threatens power source and causes air quality issues, with an example being the Thomas Fire. This fire led to air quality issues, mudslides, road closures, and loss of life. A focus on increasing heat in SB area and fire hazards within report. **2019 CAL/OSHA Standards Board emergency regulation Title 8, Section 5141.1 Protection from Wildfire Smoke** requires employers to establish protections for employees for wildfire smoke (https://www.ehs.ucsb.edu/programs-services/industrial-hygiene/protection-wildfire-smoke)	**UCSB Campus Design Guide** - Division 23 - HVAC specify MERV 13 for air handling units in new construction. No information available on which buildings have filtration or advanced filtration (e.g. MERV 13 or above)	2	Design guide specifies MERV 13 and other air quality provisions for new constructions, with other actions in place to improve air quality.	Document which buildings have air filtration Identify buildings that could benefit from advanced filtration such as spaces with priority populations (e.g. daycares) or uses that may be sensitive to poor air quality (e.g. labs)	2	consider energy capacity needs to accommodate increased filtration
	Host a clean air refuge space in critical buildings	- Target minimum MERV 13 filtration, and replace filters more frequently during poor air quality events (ASHRAE Filtration, EPA Clean Room) - Create a Community Resilience Center or Resilience Hub to provide a clean air refuge space (Community Resilience Center, Resilience Hub)		No information on refuge spaces on campus, including refuge spaces with filtration that can serve as clean air shelters	1	No information available.	Consider assigning one or more spaces on campus as a refuge for staff, faculty, students and visitors during extreme heat event. Designated refuge spaces should ideally have mechanical cooling sized for future conditions, air filtration, and backup power	2	consider energy capacity needs to accommodate increased filtration
Managing Power Outage & Energy Resilience	**Ensure adequate backup power to critical facilities and ensure backup generators are protected from extreme hazards**	- Locate back-up power equipment and infrastructure above the 500 year floodplain (LEED Design for Enhanced Resilience) - Ensure the location of energy backup or renewable energy infrastructure can withstand extreme weather events such as strong winds, hail, floods. E.g., Equipment is sufficiently elevated in areas prone to floods and anchored in areas prone to strong winds (WHO Guidance) - Ensure emergency backup covers at least all critical service areas and equipment (WHO Guidance) - Periodically check emergency backup generators (WHO Guidance)	**County of SB Energy and Climate Plan** - CE-1.7 Energy Assurance Plan: install renewable energy and backup power systems at critical facilities	UCSB has a decentralized diesel genset for emerg. back up power as per code.	3	All critical facilities have dedicated backup power generators (mostly diesel).	Clearly define and document which buildings are classified as critical and have backup power. Identify critical buildings or systems that should be prioritized for back up power upgrades (e.g. enclosures to protect against extreme events), expansion (e.g. for future demand or temperatures), or addition (where no back up power existed before, e.g., chiller plants)	2	consider electricity servicing and back up power to areas of refuge
	Install renewable power sources to build low carbon redundancy to grid power during extreme events	- Install solar + storage resources capable of operating independently during outages and storm events. Design and equip these resources with the appropriate transfer or disconnect switches, a critical load panel, smart inverters, and sufficient control systems, to act as a uniform and reliable distributed resource with islanding capabilities (US DOE Better Buildings Distributed Generation) - Solar energy, wind, biomass, or hydroelectricity and be produced and stored in batteries on-site to reduce reliance on grid power and build redundancy (WHO Guidance)	**UC Sustainable Policy** - In lieu of purchasing voluntary offsets, in 2025-2030 each campus will allocate funds equal to 25$/MTOCO2e for remaining scope 1 and 2 emissions **UCSB Sustainable Design Requirements** - Campuses and health locations will install additional on-site renewable electricity supplies and energy storage systems whenever cost effective/in support of Climate Action Plan. **UCSB Climate Action Plan -** On-site solar is included as one of the strategies to achieve net zero emissions by 2025. Current reduction estimate is 3,787 MT Co2e	**UC annual report on sustainable practices** -UC signed wind energy contract as well as utility scale batteries to SoCal solar project UCSB has existing solar arrays. Offsite arrays administered through PPA.	3	Existing solar arrays on campus contribute significantly to power generation. Includes clear plans and investment in other renewable power sources (e.g. wind power, district energy).	Explore how existing and planned renewable energy could serve as redundant power in case of DEU or grid power disruption	3	consider resilience of any renewable power systems planned
	Design energy-efficient systems to avoid power surges during extreme heat or air quality events	- Prioritize passive cooling systems to avoid overloading electrical systems during heatwaves. E.g., high performance envelopes, exterior shading, mixed-mode cooling systems, cross-ventilation, good insulation (UNEP Practical Guidelines) - Maximize energy efficiency of HVAC and refrigeration and lighting and reducing plug and process loads can help alleviate power surges during extreme events (DOE Better Buildings Efficient Technologies)	**UCSB Sustainable Design Requirements** - Locations will achieve a 90% reduction in total emissions (Scope 1-3) no later than 2045 relative to 2019 baseline. **UCSB Sustainable Design Requirements** - all new building projects must outperform the California Building Code energy-efficiency standards by at least 20% or meet prescriptive requirements. Stretch goal is 30%. Meet LEED Gold at a minimum, strive for Platinum.		3	Strict energy-efficiency standards established in design requirements however information not currently available on how these requirements are being implemented and how climate conditions (e.g. potential power surge demand) is being considered.	Design the DEU to consider and accommodate future energy demand due to increase in mechanical cooling	3	Design the DEU to consider and accommodate future energy demand due to increase in mechanical cooling

3-1 – Climate Action Gap Analysis Results Summary

Managing Rainfall Flooding	**Design buildings to prevent rainwater ingress through rooftops, windows, entryways, vents/louvers, drains, and foundations**	- Implement specific design measures to minimize water ingress into the structure such as raised doorsteps, install roof improvements, installing covers or overhangs above windows, entryways, or exterior walls (UNEP Practical Guidelines) - Design rooftop appurtenances and other potential areas of water leakage to be waterproofed (UNEP Practical Guidelines)			2	Unclear how rooftop and envelope systems are currently protected from rainwater ingress. Note that buildings to be connected to the DEU will have all rooftop mechanical equipment removed. However some buildings will not connect to DEU and will likely have rooftop equipment (e.g. heat pumps).	Update design guidelines to include enhanced roof and envelope measures to reduce rainwater ingress due to more severe rainstorms (e.g. wind-driven-rain) or rainwater volumes (e.g. pooling on roof)	2	Buildings connected to the DEU will have rooftop mechanical equipment removed. Important to mitigate risk of rainwater ingress during rooftop retrofits.
	Install below-grade spaces to manage flood waters, e.g. with backup flow preventers and sump pumps	- Use underground storage systems to detain runoff in underground receptacles and slowly release runoff. underground storage systems are typically designed to store large volumes of runoff and therefore can have A significant impact in reducing flooding and peak discharges. E.g., culverts, engineered stormwater detention vaults, or perforated pipes (EPA Climate Impacts on Water Quality) - Install sump pumps or self-priming pumps that control the level of seepage water (FEMA Dry Floodproof Buildings) - Install backflow (non-return) valves or shutoff valves that prevent floodwater from entering through sewer and drainage pipes (FEMA Dry Floodproof Buildings)			2	Many larger buildings appear to have basement mechanical room but these will be phased out/replaced as part of the DEU transition. Some boiler rooms and chiller rooms are below grade, which will remain with new system. Unsure whether existing buildings within the floodplain have sump pumps.	Consider floodproofing strategies for buildings that will continue to have basement or ground-level mechanical or electrical rooms (e.g. placing equipment on curbs, installing sump pumps). Design buried DEU conduit to be resilient to inflow and infiltration and/or cross-contamination.	2	Buildings connected to the DEU will have basement mechanical rooms removed/replaced. Design buried DEU conduit to be resilient to inflow and infiltration and/or cross-contamination
	Size stormwater management infrastructure for higher rainfall volumes under future climate conditions	- Design rainwater harvesting systems, retention/detention ponds, stormwater mains, ditches and culverts for increased rainfall volumes due to climate conditions (UNEP Practical Guidelines, EPA Climate Impacts on Water Quality)	**UCSB 2017 Water Action Plan** - (based on Post-Construction Stormwater Management Requirements for Development Projects in the Central Coast Region, Resolution No. R-3-2013-0032 permit) - treat the volume of stormwater generated by an 85th percentile rain event, infiltrate the volume of stormwater generated by an 95th percentile rain event, and manage peak stormwater flows from the 2-10 year storm events. LRDP UCSB 2019 - Development must implement LID approach to stormwater to retain runoff from 85th percentile 24-hour design storm. Extensive policy regarding approach/requirements for stormwater management.		2	Current stormwater infrastructure is sized for 85th percentile rain event, however worst case scenario flood conditions are not accounted for in stormwater.	Assess risks for high rainfall volumes and develop implementation plan to adapt overtime to account for excess runoff.	2	as it applies to flood protection of energy system construction and components (operation)
	Use nature-based approaches and increase total permeable area to enhance stormwater management	- Incorporate green infrastructure and nature-based solutions such as the use of porous pavement, green roofs, rainwater collection systems (cistern, barrel, etc., along with bioretention in vegetated swales), constructed wetlands, rain gardens, and planted trees to improve stormwater systems (UNEP Practical Guidelines). E.g., Harvard Sustainability Action Plan includes actions such as building rooftop gardens, planting more trees, and increasing green spaces on campus (Harvard Sustainability Action Plan)	**County of SB Flood Control District** maintains Phelps creek as a floodway and maintenance easement Policy includes minimizing impervious surfaces, design development to increase the area of pervious surfaces. Where pavement is required, use permeable pavement systems where appropriate and feasible. **SB Coastal LUP** - Stormwater Management Program requirements: give precedence to a LID approach to stormwater management. Plan, site, and design development to protect and restore hydrologic features (stream corridors, drainage swales, groundwater recharge areas, floodplains, topographical depressions)	**LDRP UCSB 2019** - restoration projects around campus Lagoon and north bluff included six acres of coastal bluff restoration and a suite of vernal pools and marshes with bio-swales and filters to improve the quality of storm water run-off.	3	Long range development plan clearly states to minimize impervious surfaces and restoration projects have taken place to restore campus lagoon and north bluff.	Develop landscape guidelines to encourage more nature-based approaches for stormwater management (e.g. rain gardens, bio-swales). Prioritize climate-adapted and low maintenance design.	1	as it applies to flood protection of energy system

3-1 – Climate Action Gap Analysis Results Summary

	Floodproof new or existing buildings in coastal flood risk areas	- Consider implementing wetproofing techniques for storage facilities or garages, which intentionally allow floodwater to enter and exit automatically (FEMA Wet Floodproofing) - Implement dry proofing techniques which make a building and attendant utilities and equipment watertight and substantially impermeable to floodwater, with structural components having the capacity to resist flood loads. E.g., Seals that prevent floodwater entrance through utility penetrations, applying paints, membranes, gaskets, or other sealants that reduce water seepage, and installing impermeable panels to cover doors, windows and other openings (FEMA Dry Floodproofed Buildings) - Select building materials that are waterproof or have increased water resistance (UNEP Practical Guide)	**SB Coastal LUP** - new development shall minimize flood risk by increasing elevation of structures, restricting basements, restricting grading, utilizing flood proof materials consistent with local building requirements **UCSB SLR Adaptation Strategy** - site and design new buildings to avoid shoreline hazards. Relocate and remove development as necessary to maximize a natural shoreline at UCSB.	UCSB has a number of older buildings likely slated for replacement the building rather than major upgrades **UCSB SLR Adaptation Strategy** - Three areas identified as at risk for shoreline hazards. Monitoring, adaptation studies, and future adaptation strategies outlined to be implemented if necessary. Relocation of development provisions have been outlined as needed. Public access trails and other amenities also included for relocation as needed. UCSB Sea Level Rise Plan calls for tracking **sea level rise** changes over time but not clear whether funding has been allocated for implementation	2	Planned actions "as needed" to avoid shoreline hazards Unclear if any buildings have been relocated or what specific floodproofing measures have been taken.	Identify floodproofing strategies or investigation next steps for buildings identified during impact assessment (2024 Equity-centered Climate Resilience Initiative) careful consideration of floodproofing energy system components in coastal or coastal flood risk areas	3	careful consideration of floodproofing energy system components in coastal or coastal flood risk areas
Managing Sea Level Rise, Storm Surge, and Coastal Flooding and Erosion	**Ensure critical electrical and mechanical equipment is located above estimated flood depths**	- Primary mechanical and electrical equipment, including HVAC equipment, water heating equipment, electrical panels, and generators, must follow FEMA 55 guidelines and FEMA Technical Bulletins and Advisories for wet and dry flood-proofing (LEED Design for Enhanced Resilience)		Planned action to relocate electrical and mechanical equipment for those buildings in which it is below ground. New centralized plant will include above ground electrical and mechanical equipment.	2	CUP will be designed to be above the FCL or floodproof along with a proposal to do the same for all new electrical and mechanical equipment.	Consider leading a campus flood risk assessment to map flood risk and Identify critical equipment and buildings below the FCL. Develop strategies for moving critical equipment out of the floodplain (where possible) and floodproofing strategies where relocation is not realistic. Locate the new DEU building above the flood construction level (FCL) or, if it must be located below the FCL, ensure the building does not have a basement and is raised on a concrete pad. Floodproof any DEU building connection points located below the	3	Consider how to prevent flood ingress at DEU pipe connections/valves into buildings (e.g. siting connection points above the FCL). The new central system will be a new above-ground building likely located above the FCL. Hot/cold pipes from the central system will be connected to individual buildings, with pipe connection/valve placement depending on the building (some may be below the FCL).
	Identify buildings vulnerable to the impacts of coastal erosion and plan for long-term retreat and/or flood protection	- Use existing tools and data to identify vulnerable areas and buildings based on current and future climate impacts. E.g., USGS Coastal Change Hazards Portal which includes a coastal vulnerability index, coastal change forecasts and an interactive map to identify areas of high vulnerability (USGS Coastal Change Hazards) - Inform resilience planning efforts (such as long-term retreat or flood protection measures) using identified vulnerable areas and coastal change forecasts (USGS Coastal Change Hazards)	**SB Coastal LUP** - City is required to develop SLR plan that identifies vulnerability to sea level rise and for it to be implemented. New development shall not contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area **SB CAP 2012** - sets guidance to conduct periodic sea level rise studies that provide risk analysis indicating probability and magnitude of impact to SB. Future policies to be developed by 2020 to identify funding to relocate away from areas subject to future sea level rise inundation **LRDP UCSB 2019** - within 5 years of certification from the 2010 LRDP, university must prepare a comprehensive sea level rise hazards assessment including identifying most vulnerable areas and conducting risk assessment. **UC Resilience Location Specific Report UCSB** - erosion damage to student housing identified, damage to fencing already observed	**UCSB SLR Adaptation Strategy** - study conducted by UCSB to identify likelihood of sea level rise, flooding, and beach erosion over time. Strategies identified for beach erosion includes strategically-placed permeable sand retention features to create wider beaches to protect bluffs on east campus. **Shoreline vulnerability assessment** completed with areas most at risk identified (Devereux Slough, Coal Oil Point, campus lagoon). Adaptation strategies include monitoring, future planning, and specific retreat actions. Relocation of auto traffic to higher interior location could be beneficial with sea level rise (suggested, but not in action).	3	Vulnerability assessment completed and buildings identified that are susceptible.	Incorporate erosion considerations as part of coastal flood risk assessment (noted above). Coordination with COPR management staff recommended before any development at Coal Oil Point. Hazards to be identified in terms of existing structures. Public access trails to at risk beaches also recommended to be relocated.	3	careful consideration of erosion management around energy system components, particularly the intake pipe at the coast
Managing Severe Storms	**Enhance multi-modal access to campus**	- Improve bus systems, introduce carpool lots, and subsidize public transit (Second Nature Improved Commuting) - Develop a benefits plan for students and employees who commute by public transit, sharing a ride with a colleague, biking, or walking. E.g., Princeton Revise your Ride program	**UCSB Campus Plan** - a coherent system of pedestrian circulation should be well connected, use of bicycles should be enhanced and conflicts should be eliminated. Specifically, north and west campus (housing) should be better linked by stronger framework of pedestrian and bicycle access. **City of SB Circulation Plan** - Design standards: improve design for disabled access by providing more ramps and repair sidewalks. Identify/relocate obstructions to wheelchair users.	Accessible parking map for campus: https://www.vcadmin.ucsb.edu/sites/default/files/docs/UCSB_Accessible_Map.pdf	3	Bike accessible, wheelchair accessible (based on map), access by foot and vehicle.	Integrate awareness of campus multi-modal access routes (and their hazard risk) into emergency and evacuation planning.	2	As it relates to construction impacts on transportation pathways

3-1 – Climate Action Gap Analysis Results Summary

	Design for more frequent windstorms and higher windspeeds under future climate conditions	- Incorporate wind design measures in areas of high wind and windstorms. E.g., FORTIFIED Commercial-High Wind & Hail - Bronze, Silver, or Gold Level (FORTIFIED Commercial-High Wind) or	Hazard identified in July EPC Climate Hazard Results	UCSB has a proactive maintenance program for managing tree health to reduce damage during high wind events	2	This hazard was identified in the July EPC Climate Hazard Results, UCSB tree maintenance program helps to manage this risk.	Document wind resilience design strategies within existing buildings. Include resilient design strategies for future wind loads in design guidelines.	2	as it relates to energy system components (e.g. installing robust enclosures)
	Prioritize low-flow appliances where appropriate	- Mandate that all newly installed toilets, urinals, private lavatory faucets, and showerheads that are eligible for labeling must be WaterSense labeled (LEED Indoor Water Use Reduction) - Install ENERGY STAR or performance equivalent appliances (LEED Indoor Water Use Reduction) - Meet or exceed the minimum criteria for water efficient fixtures, fittings, and equipment specified in a green building standard (AASHE STARS 3.0)	**UCSB 2017 Water Action Plan** - Goal, replace existing single pass cooling systems and constant flow sterilizers and autoclaves in laboratories. Repair pool at old gym on-camps (leaks). Implement and prioritize aerator retrofits. Implement and prioritize toilet/urinal/shower retrofits.	**UCSB Campus Design Guide** - Division 22 - Plumbing calls for fixture standards for new construction & renovations **UCSB 2017 Water Action Plan** -Audit was conducted of on-campus restrooms for number and flow rate of appliances. No significant changes made from results. Challenges identified due to old plumbing. UCSB uses **HR&S plumbing standards** for purchasing fixture standards. All new projects on campus will strive for **Gold LEED Certification.**	3	Design guide contains fixture standards. LEED Gold certification requires lower-flow appliances along with CalGreen requirements.	Update design guidelines to further prioritize low flow fixtures where appropriate	1	Low flow fixtures enhance overall efficiency on campus, reducing hot water use
	Manage water quality of non-potable water on campus	- Implement nature-based solutions such as pervious paving, bioretention, and rainwater collection to help improve water quality and recycle rainwater for on-site use (UNEP Practical Guidelines)	**UCSB 2017 Water Action Plan** - Goal, install a reverse osmosis system on-site at the Commencement Green to raise water quality of recycled water. Conduct annual soil samples to understand quality of recycled water/how it affects landscaping. **SB CAP 2012** - coordination with water, wastewater, and water management agencies/companies regarding debris removal in an emergency event **SB Coastal LUP** - support creek and ocean water quality programs including water monitoring, clean-ups, regulation enforcement for water quality, street sweeping, larger improvement projects. **LRDP UCSB 2019** - new development shall be designed to prevent adverse impacts from stormwater to coastal waters and environmentally sensitive habitat areas. First priority of campus land development shall be prevention of post-construction runoff/additional drainage measurements to slow, capture, treat, infiltrate, and detain runoff. To maximize water quality, prioritize the use of earthen-based runoff treatment facilities such as bioswales or vegetated filter strips. University must monitor maintenance plan of vegetation intended for runoff. Site designs must include source control measures to control		3	Source control measures identified and implemented to manage water quality of non-potable water.	Investigate options for emergency water supply (e.g. trucked water supplier and building hookups) in case of critical water shortage. Find opportunities to increase on-site capture and treatment of stormwater to limit runoff to neighboring environments	1	
Managing Drought / Water Insecurity	**Prioritize drought & extreme-heat tolerant landscaping**	- Incorporate water efficient landscaping principles such as the use of native, low water-consuming species in site landscaping, reducing the use of exotic species and grass lawns, and efficient irrigation system to reduce water consumption (UNEP Practical Guidelines) - Plant drought resistant ground shading plants to retain ground moisture (UNEP Practical Guidelines)	**UCSB 2017 Water Action Plan** - UCSB prioritizes native and drought-tolerant plan species on-campus to limit vegetative water consumption. Goal was to replace 71,101 sqft of under-used turf with drought-tolerant plants. **SB CAP 2012** - requires buildings to be designed to enhance the wildlife corridor network	**LDRP UCSB 2019** - West, North, and Storke Campus have planned or completed restoration projects with a focus on removing invasive exotic plants and restored with native plants, naturalized basins and oaks.	3	Clearly stated in the water action plan that drought tolerant plants are prioritized, actions planned for restoration projects in areas with invasive species.	Update design guidelines to prioritize climate adapted species (e.g. xeriscaping). Incorporate climate considerations into landscape design and management guidelines.	1	as it relates to landscape establishment after energy system construction
	Water capture, storage and re-use where appropriate	- Use underground storage systems to detain runoff in underground receptacles and slowly release runoff. Underground storage systems are typically designed to store large volumes of runoff and therefore can have A significant impact in reducing flooding and peak discharges. E.g., culverts, engineered stormwater detention vaults, or perforated pipes (EPA Climate Impacts on Water Quality) - Implement low-impact development or green infrastructure practices to replicate natural site hydrology processes and retain on site the runoff from regional or local rainfall events (LEED Rainwater Management) - Reuse captured rainwater for landscaping and other on-site water requirements (UNEP Practical Guidelines)	**UCSB Sustainable Design Requirements -** all new buildings will achieve at least 5 points within LEED BD+C Water efficiency and Sustainable Sites: Rainwater Management **UCSB 2017 Water Action Plan -** Graywater is excluded within the plan as practical applications at University level are limited by legal statues (Title 22).	**UCSB 2017 Water Action Plan** - Recycled water is used at the resident halls of Santacruz, Anacapa, part of Santa Rosa, and De la Guerra. Also used for resident halls of San Nicholas and San Miguel in 2007. Recycled water utilized as make-up water for toilets in Tenaya Towers Working with Goleta Water District on extensive planning and permitting process, estimated to save over 600,000 gallons of potable water use a year. 90% of the total water used for irrigation on-campus is recycled water.	3	Recycled water utilized at resident halls, make-up water, and for irrigation on campus. Water capture + reuse may be limited by legal statues, so no reuse plans identified within the Water Action Plan.	Investigate opportunities for water capture and reuse on campus (e.g. for irrigation).	1	

	Use water conservation and demand management strategies	- Introduce sustainable landscaping requirements to reduce water consumption (Harvard Sustainability Action Plan) - Obtain My Green Lab Certifications for lab spaces by incorporating water-saving lab procedures and actions into research activities (My Green Lab Certification) - Apply behavioral science approaches to promote widespread adoption of mindful water use behaviors, including through programs and building design (Princeton University Sustainability Action Plan)	**UCSB 2017 Water Action Plan** - UCOP mandated reduce growth adjusted potable water consumption by 20% in 2020, 36% by 2025 (based on 3yr avg baseline 2005-2008). Has set a goal to continue to evaluate landscape areas for potable water savings. Expand weather-based irrigation control system. **UC Sustainable Policy** requires water action plans from each campus SB CAP 2012 - objective of reducing per capita water use by 20% by 2020	**UCSB 2017 Water Action Plan** - UCSB uses weather based irrigation controllers, using matched precipitation Rotators and drip tubing irrigation where appropriate. Uses Rain Master Oasis weather-based irrigation system that controls 60% of campus irrigation. LabRATS has achieved marked success in reducing lab water use, primarily through equipment replacement, low-cost adaptations to existing equipment, equipment maintenance checks, and education and outreach. Best management strategies outlined and plans for new construction as it pertains to water conservation.	3	Water conservation and demand management strategies are laid out in Water Action Plan. Design requirements include lower-flow fixtures and reduced irrigation.	Consider opportunities to update the Water Action Plan within the next 2 - 3 years (possibly as part of, or following, climate action plan update in 2025).	1	
Wildfire	**Design facilities in wildland-interface areas with non-combustible envelope materials and wildfire protection strategies**	- Prioritize the use of ignition-resistant construction and materials (2024 ICC Wildland-Urban Interface Code) - Consider installing rooftop sprinklers on buildings in high-risk areas that do not have sufficient fire resistance (2024 ICC Wildland-Urban Interface Code) - Demonstrate compliance with ICC's 2012 International Wildland-Urban Interface Code (IWUIC) or 2013 NFPA 1144 (LEED Design for Enhanced Resilience)	**UC Resilience Location Specific Report UCSB** - Wildfire risk identified as being a consideration for future facilities/policy **Climate Hazards at UCSB -** WUI fire threat is low although SB borders area of high heat		1	No current design guidelines, no mention of combustible envelope materials in sustainable design guidelines.	Include provisions for non-combustible envelope materials in future design guidelines. Incorporate nature-based solutions for wildlife in vulnerable areas.	3	consider wildfire safety and resilience as part of system design and construction
	Strategic landscape management to reduce vegetation and fuel near buildings and recreational areas	- Create a vegetation management plan to comply with ICC's 2012 International Wildland-Urban Interface Code including methods and timetables for removing slash, snags, vegetation that may grow into overhead electrical lines, other ground fuels, ladder fuels and dead trees, and thinning of live trees (2024 ICC Wildland-Urban Interface Code) - Plant fire-resistive plants such as plants with high fuel moisture, drought-tolerant plants, and nonresinous plants (2024 ICC Wildland-Urban Interface Code)	**SB Coastal LUP** - existing structures and new development in high fire hazard areas shall provide defensible space. Vegetation within this space must be maintained to provide an effective fuel break by thinning dense vegetation and removing dry brush.		1	SB Coastal Land Use Plan identifies landscape management to reduce fire risk, however this is not a tactic within UCSB's design documents.	Consider including vegetation provisions for wildfire prevention in UCSB's landscape guidelines. Specify which areas would be most vulnerable.	2	as it relates to landscape establishment after energy system construction, particularly in areas around the central DEU building

UC **SANTA BARBARA**

Clean Energy Master Plan