UC Berkeley Clean Energy Campus

Integrated Resource & Activation Plan

May 2024

Prepared by the Administration Division's Facilities Services Department and the Office of Sustainability & Carbon Solutions

The UC Berkeley Clean Energy Campus

UC Berkeley is on course to decarbonize its energy system.

This document, the **Integrated Resource & Activation Plan**, provides an overview of why Berkeley is taking action now, the engagements undertaken to identify the clean energy and carbon reductions strategy required and a rapid implementation scheme to realize a full utility infrastructure transformation.

Over the next decade the Berkeley Clean Energy Campus effort includes the design and construction of a set of solutions that will transform Berkeley's current campus heating, cooling, and power system into an electrified and renewable energy microgrid. This 21st century system will largely eliminate fossil fuel combustion and related on-campus carbon emissions. The new system will enable reliable and resilient energy capacity that will support campus operations, research and enrollment into the future.

The Berkeley Clean Energy Campus supports the State of California and the University of California's priority to address the climate crisis and will demonstrate how rapid, large-scale reduction of greenhouse gas emissions is possible. Berkeley's longstanding leadership in climate-solution technology and policy research positions it to pioneer this transition to a benchmark-setting energy system characterized by sustainability and resilience, setting a precedent for public institutions worldwide.

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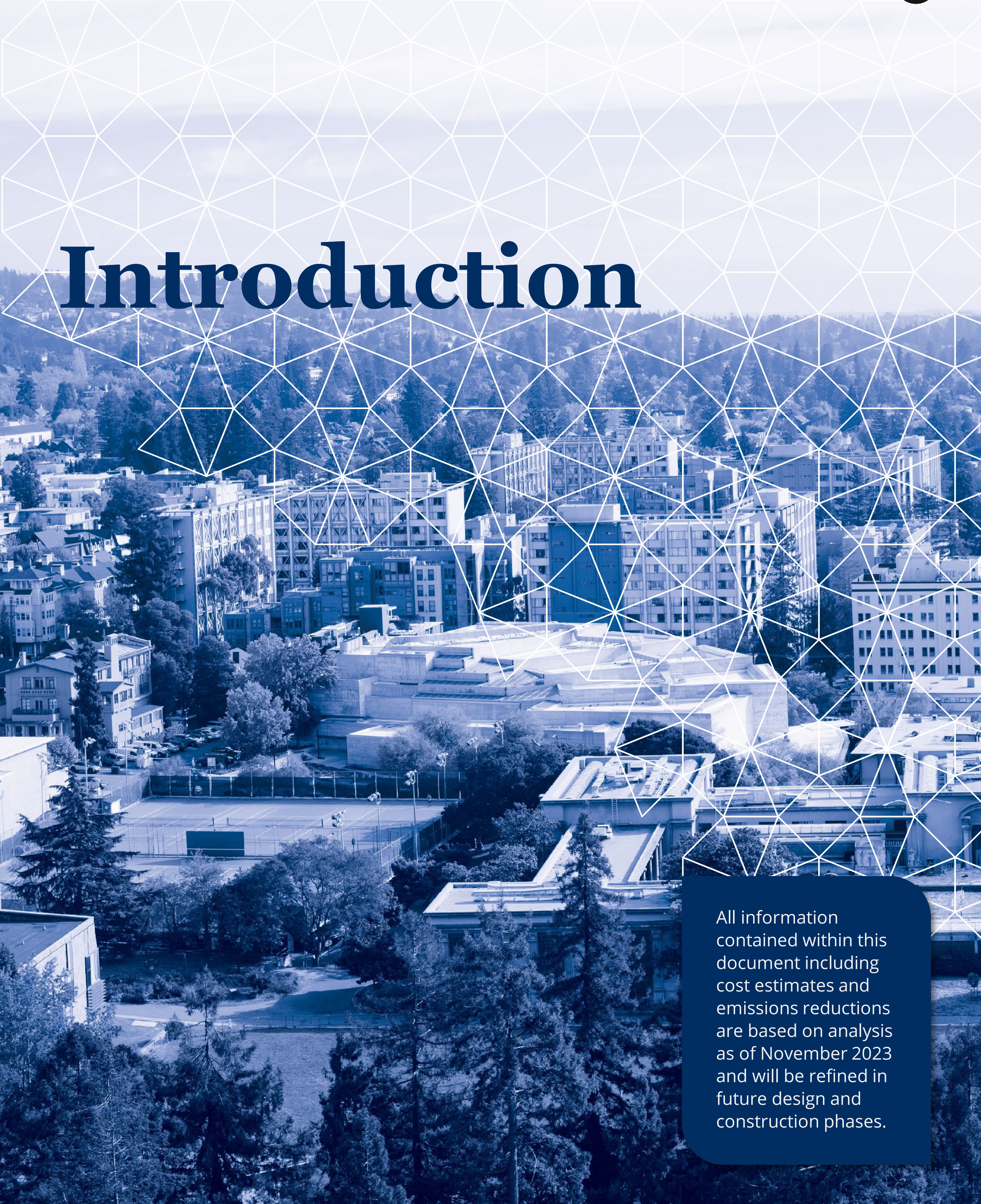


All information contained within this document including cost estimates and emissions reductions are based on analysis as of November 2023 and will be refined in future design and construction phases.

Introduction

The University of California (UC) is fighting climate change and implementing various initiatives and policies with the goal of reducing its carbon emissions by 90 percent before the year 2045.

UC Berkeley has a plan to **reduce its building energy carbon emissions by 85 percent by 2035.** With this reduction in emissions the campus will have achieved an overall operational carbon reduction of 60% or more – well on course to meet the UC 2045 target.

Climate Action Targets

2045

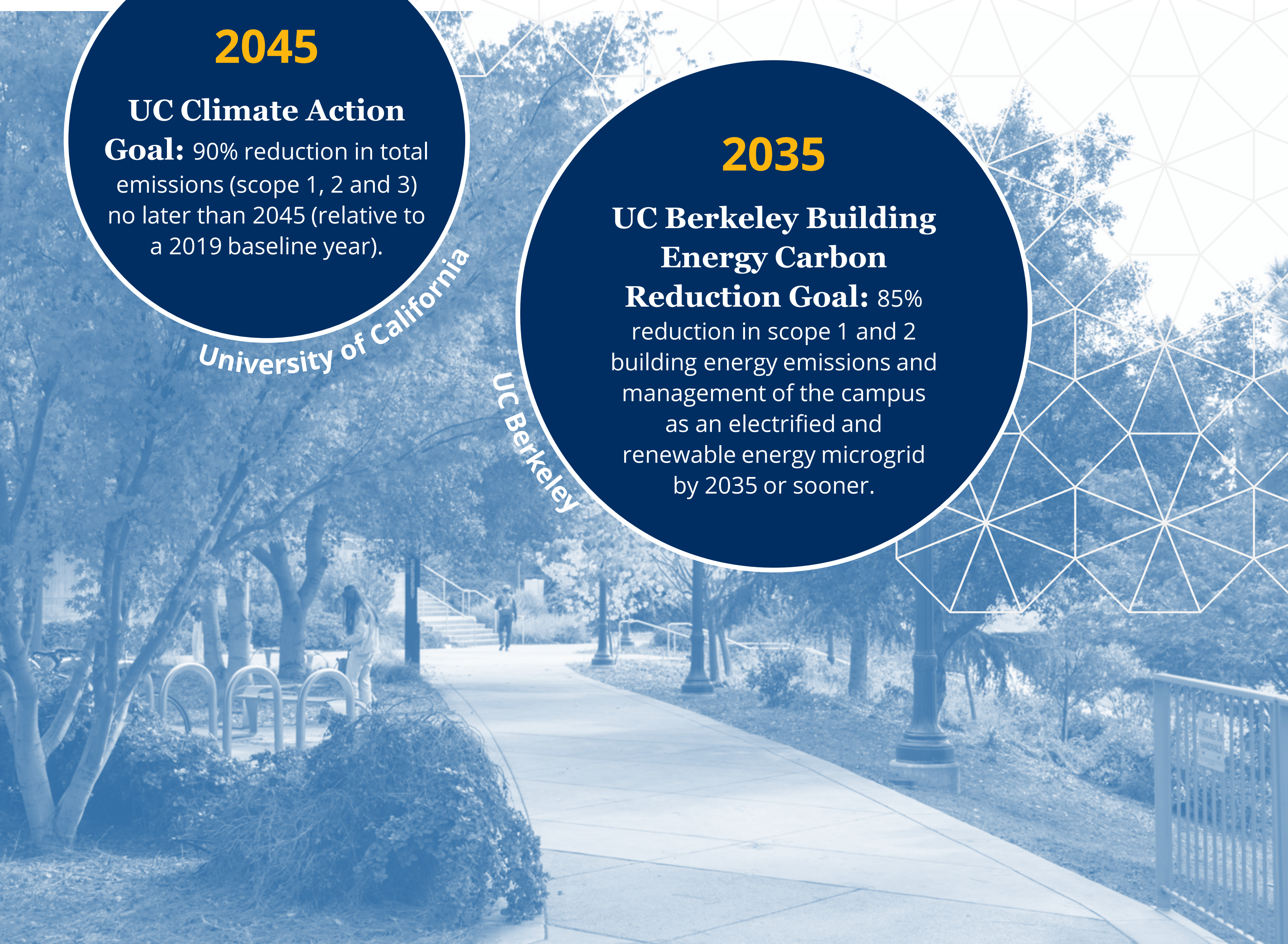
UC Climate Action Goal: 90% reduction in total emissions (scope 1, 2 and 3) no later than 2045 (relative to a 2019 baseline year).

University of California

2035

UC Berkeley Building Energy Carbon Reduction Goal: 85% reduction in scope 1 and 2 building energy emissions and management of the campus as an electrified and renewable energy microgrid by 2035 or sooner.

UC Berkeley



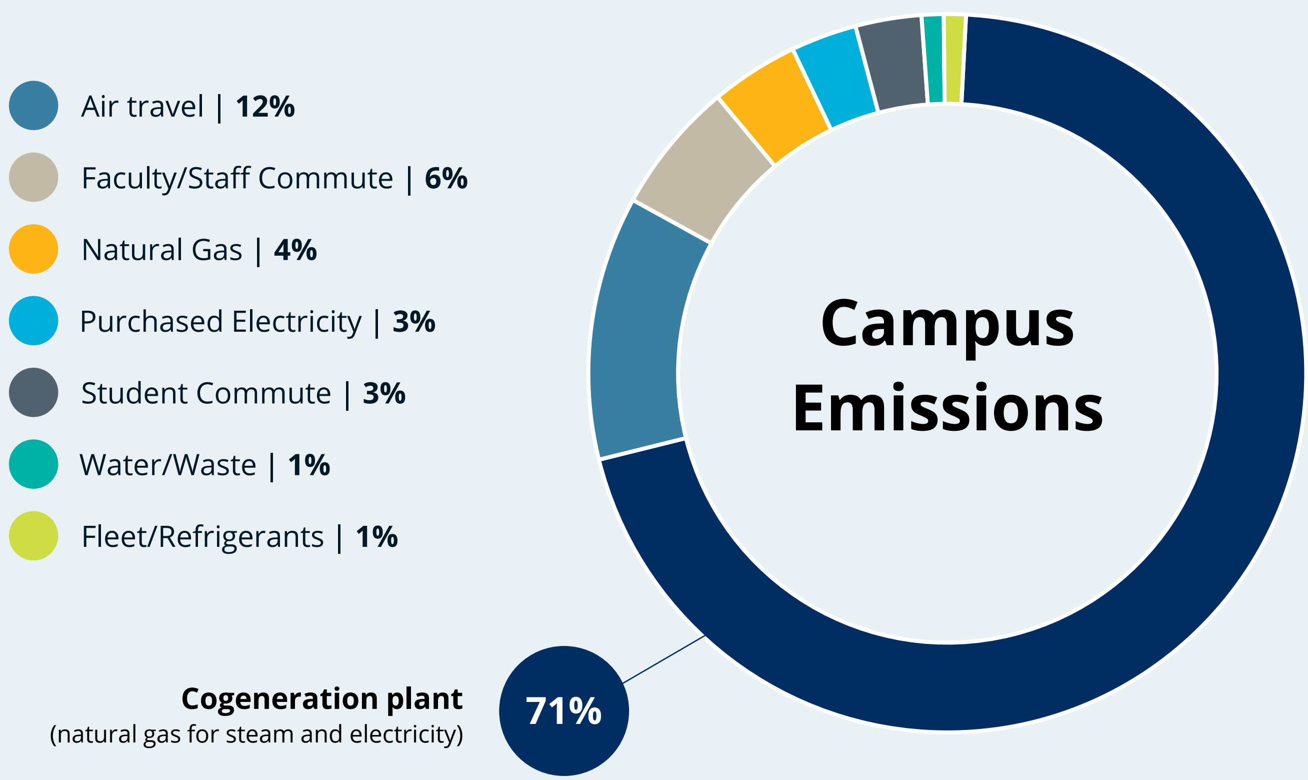
Introduction

Combatting the dire threat of **climate change** means addressing its primary cause—the burning of fossil fuels.

At UC Berkeley, the majority of operational **scope 1, 2, and 3**[1] **greenhouse gas/carbon (GHG) emissions** are associated with building energy consumption. In 2019 the campus emissions were 190,000 metric tons with 71 percent of these emissions coming from the natural gas combusted in the campus **cogeneration plant**. This plant provides most of the main campus electricity and the steam for heating. The plant and steam distribution system to buildings is nearing the end of its lifecycle and replacement with a low carbon solution is imperative to meeting campus needs.

Achieving rapid carbon reduction at UC Berkeley necessitates decisive action and a radical transition from fossil fuels to all-electric solutions supported by clean energy sources. As such the campus is implementing the Berkeley Clean Energy Campus initiative focused on a rapid transformation of the energy system.

UC Berkeley Greenhouse Gas/Carbon Profile Today



[1] Emissions tracked by UC Berkeley include scope 1 (e.g. natural gas combustion on campus), scope 2 (e.g. purchased electricity), and scope 3 (e.g. emissions from commuting and business air travel).

Introduction

Berkeley Clean Energy Campus (BCEC)

The campus has completed numerous studies to determine the most ecologically responsible and financially prudent path forward. The latest, the Integrated Resource and Activation Plan (IRAP), defines the technical, financial, learning and research opportunities for campus decarbonization. Now called the Berkeley Clean Energy Campus (BCEC) initiative, this transformative effort will phase out fossil fuel use for powering, heating and cooling campus buildings by 2035 or sooner. The natural gas-powered cogeneration plant will be decommissioned by 2030 and replaced with a new clean, efficient and resilient energy system that will demonstrate state-of-the-art technologies. It will also exemplify creative financing as a model for other cities and institutions to replicate.

The BCEC Initiative

puts the campus on track to meet its climate reduction goals as well as **provides multifaceted benefits for the campus and beyond, including:**

1

85% Reduction in Carbon Emissions: By replacing the aging and inefficient cogeneration plant with an all-electric system supplied with clean energy, the campus will achieve an 85 percent reduction in building energy GHG emissions while also improving local air quality and contributing to UC Berkeley's environmental commitments.

2

Increase Energy Resilience: The campus will enhance its ability to operate continuously and support campus growth, even in the face of changing conditions such as extreme heat events, wildfires, and power outages.

3

Millions of Dollars in Long-Term Cost Savings: The fully realized Berkeley Clean Energy Campus initiative is estimated to save the campus hundreds of millions of dollars. These savings are generated by lower maintenance and operational costs as compared to the existing energy system.

4

Living Lab: This project will create valuable learning and research opportunities, activating UC Berkeley's brain-trust and fostering collaborative partnerships with government and industry stakeholders.

Introduction

5

Accessibility and Landscape Improvements: The new underground energy distribution network will provide for a generational opportunity for campus-wide renovations of walkways and landscape, including the addition of non-potable (recycled) water piping for irrigation and other uses.

6

Restore and Activate Campus Space: The new plant will be built on the current North Field, an underused recreation field in the central campus. The plant will be one-story, placing most of its core thermal energy systems underground, and will replace the playing field on the roof.

7

Just Transition: Decarbonizing the campus energy systems will require upskilling of existing jobs and will create new positions and opportunities for workers. UC Berkeley is dedicated to ensuring that there is a net gain for employment opportunities resulting from the implementation of the BCEC and that those opportunities are equitably distributed.

8

Stimulates the Regional Economy: The initiative will create and retain full-time jobs, generate hundreds of regional construction jobs, and stimulate tens of millions of dollars into the California economy, bolstering economic growth.

9

Leading Edge Example: The BCEC will serve as a replicable and scalable clean energy model not only for public institutions but also for other sectors. It will demonstrate that meeting University, State, and Federal energy and carbon goals is both achievable and sustainable.

For decades, UC Berkeley has led the world in climate solution technology and policy research. **Now, the campus will build an energy system that sets a standard in sustainable, resilient building energy infrastructure.**

Background

Background

Climate Action to Date

UC Berkeley has made extensive efforts to reduce its greenhouse gas emissions by expanding procurement of green power, reducing energy use through building level energy efficiency, curbing growth-related emissions through electrification and green building practices, and increasing green fleet vehicles. However, most of the reductions in emissions have only just kept pace with campus growth. Emissions from the fossil fuel used in the cogeneration plant system contribute to the majority of the campus' scope 1 greenhouse gas emissions and remain the biggest challenge to achieving the university's 2045 goal of reducing emissions by 90 percent.

Originally designed to power the entire campus and constructed over 30 years ago, the cogeneration system is now inadequate to meet the campus' growing energy needs and incurs increasing operating costs under California's **cap-and-trade** regulatory framework. As a result, the campus has increasingly relied on the local utility for additional power to keep up with growth. With the cogeneration plant and steam distribution system nearing the end of its useful life, maintenance and needed upgrades have become increasingly disruptive and cost prohibitive.

UC Berkeley will meet California state carbon reduction targets

California Cap-and-Trade

In a similar manner to UC Berkeley's efforts, the State of California has been implementing various initiatives and policies to combat climate change. The state has set ambitious emission reduction targets, aiming to reach 40 percent below 1990 levels by 2030 and achieve carbon neutrality by 2045. As part of these efforts, California implemented a cap-and-trade program, managed by the California Air Resources Board, establishing a market-based approach to put a price on carbon to motivate the reduction of greenhouse gas emissions from major industries, including emissions from cogeneration plants like UC Berkeley's. The costs of California's cap-and-trade program are expected to increase over time, representing a financial and reputational risk to UC Berkeley if the cogeneration plant continues to operate. It is estimated that between 2025 and 2050, UC Berkeley could spend $250 million on Cap & Trade carbon costs.

Background

Integrated Resource and Activation Plan Overview

The combination of aging infrastructure, increasing maintenance and operations costs, limited low carbon alternatives to natural gas, and the imperative to achieve climate goals led to the development of the Integrated Resource and Activation Plan (IRAP) to implement the Berkeley Clean Energy Campus Initiative.

Launched in 2021, the two-year Integrated Resource and Activation Plan (IRAP) study included comprehensive engineering and financial studies to create a roadmap for the design of a new campus energy system to replace the aging cogeneration and steam system. Multiple studies involved collaborative partnerships with consultants, campus government relations, researchers, donor services, faculty experts, students and the UC Office of the President.

As a major part of the IRAP, Affiliated Engineers, Inc. (AEI) conducted a comprehensive review of alternatives for retiring the cogeneration plant, ultimately selecting a centralized Electric Heating and Cooling Plant (EHCP) paired with onsite clean energy systems (otherwise known as distributed energy resources) as the optimal solution. The EHCP will incorporate advanced technologies, including geothermal and thermal energy storage, powered by 100 percent clean electricity. Distributed energy resources (DERs) such as fuel cells, solar photovoltaics, and battery energy storage systems will provide onsite clean energy production and power resilience to manage the campus microgrid. A microgrid can operate independently or in coordination with the main power grid, allowing the campus to power critical systems in a blackout.

Key Milestones in the Development of the Berkeley Clean Energy Campus

2015 – 2020

Campus conducts several studies to identify options for upgrading the campus energy infrastructure and reducing energy related emissions.

July 2021

UC Berkeley launches the Berkeley Clean Energy Campus (BCEC) Initiative and initiates the Integrated Resource & Activation Plan (IRAP).

June 2022

The State of California commits $249 million to the Clean Energy Campus.

July 2023

The University of California Board of Regents approves the initiative for pre-construction designs.

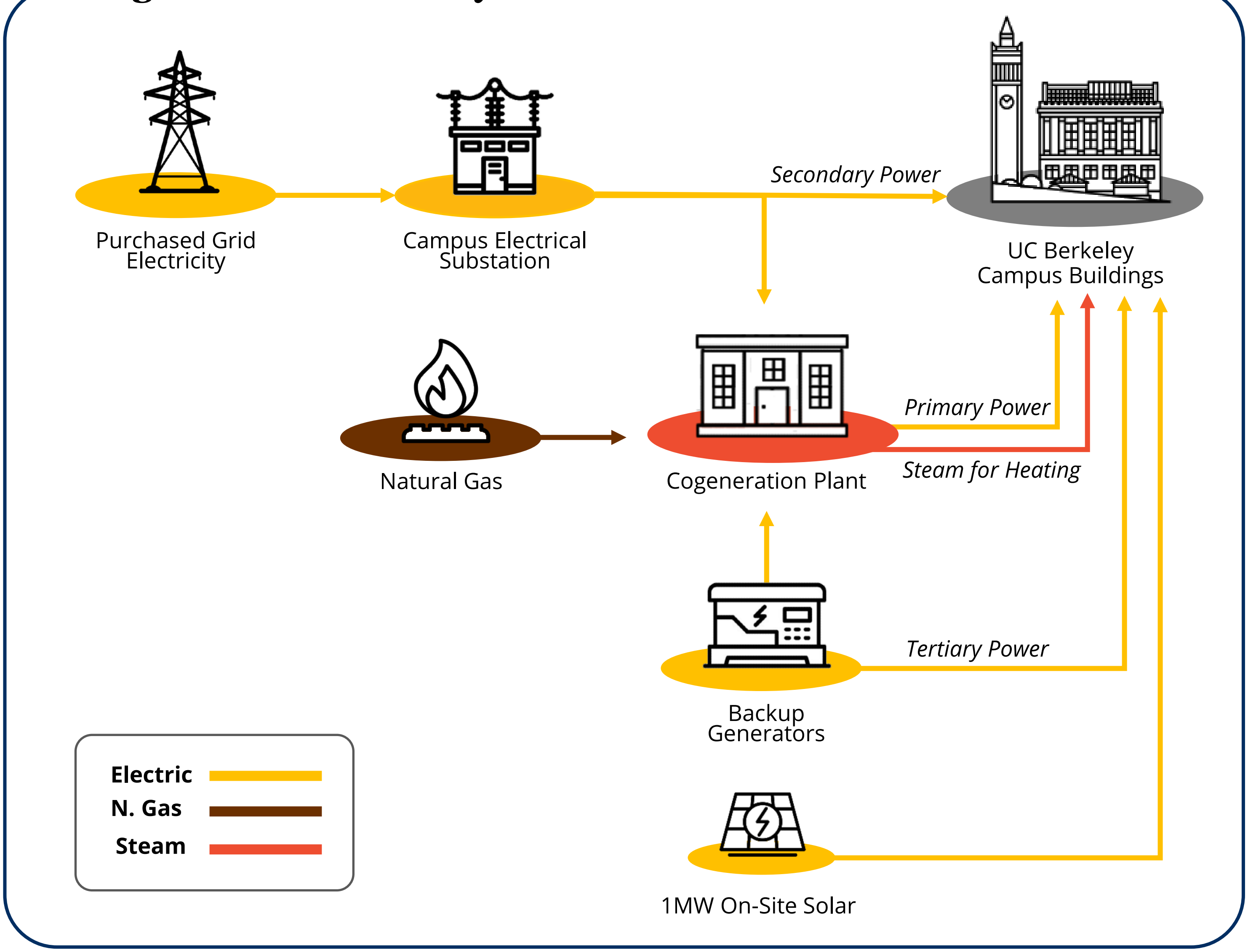
Background

Current System

At the center of Berkeley's current energy system is a gas-fired cogeneration plant, which is the primary source for electricity and heating for campus buildings. When it was first built in 1987, the cogeneration plant was state of the art facility, efficiently producing both electricity and steam. However, 36 years later, the aging and inefficient plant and steam distribution system is nearing the end of its life cycle and unable to keep up with the demands of a rapidly growing campus.

Berkeley's Cogeneration plant

Diagram of Current System



Background

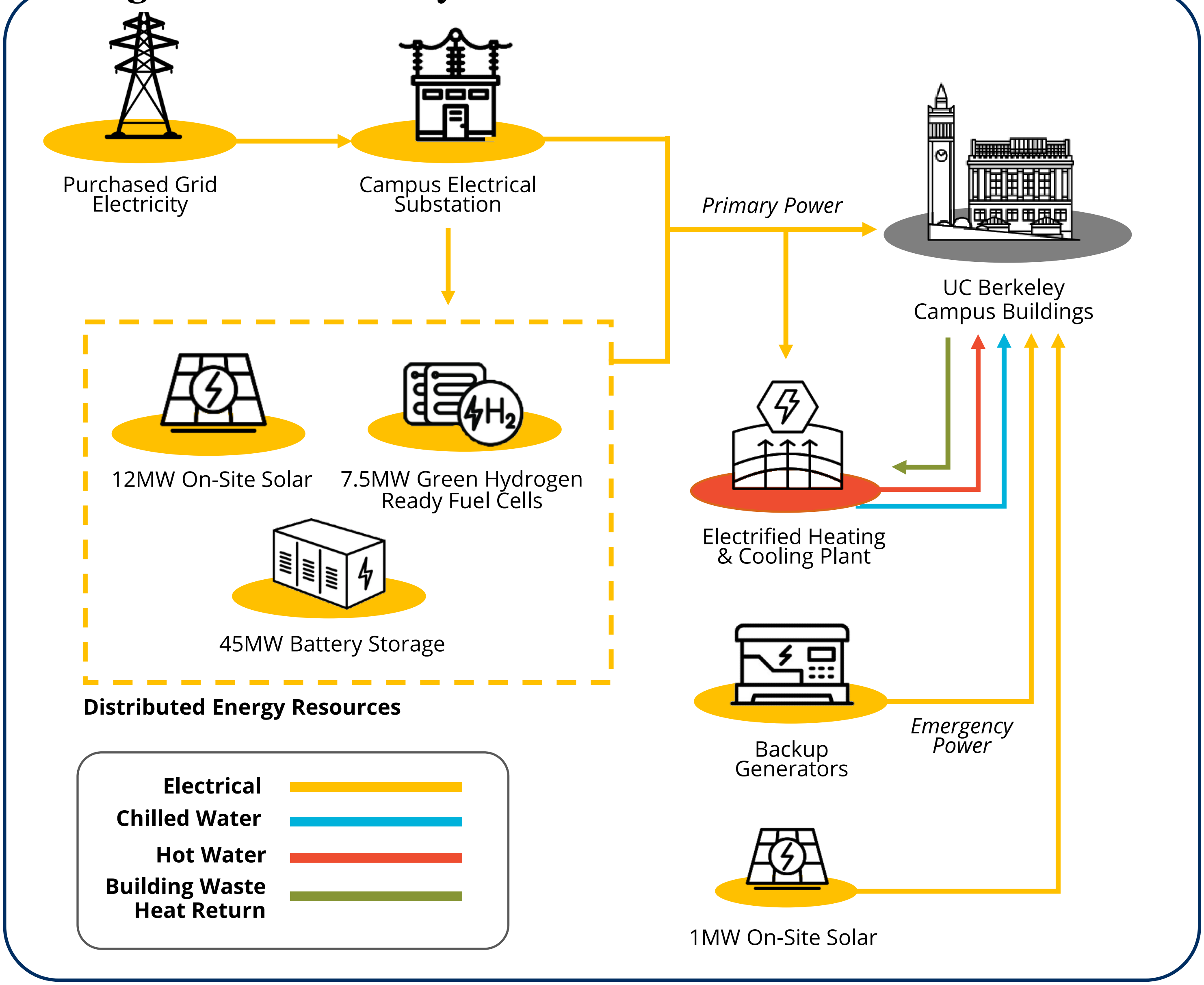
Future System

The new clean energy microgrid will be a localized energy system that integrates multiple distributed energy resources (DERs) such as solar photovoltaics, fuel cells and battery energy storage. Distributed energy resources will help with demand management, generate clean energy, and provide resilient power in emergencies. The microgrid will operate independently or in connection with the main utility electrical grid providing 100% clean power. The system will be controlled and monitored through a central management system. Microgrids provide a more resilient and sustainable energy solution by optimizing the use of renewable energy sources, reducing reliance on the main grid, and providing backup power during grid outages.

What is a microgrid?

A localized and independent electrical system that can operate autonomously or connect to the larger power grid, incorporating renewable energy sources, energy storage, and advanced control technologies to provide reliable and efficient power.

Diagram of Future System



Background

The project will be implemented in two primary phases. The strategic phasing and timing of the project studied in the IRAP results in efficient cost savings and long-term operability.

Phase 1 2028

- Design and build the centralized electric heating and cooling plant (EHCP).
- Construct the heating and cooling distribution piping to north side of campus.
- Convert 50% of campus buildings, with a primary focus on academic buildings that have high steam and power consumption, such as engineering and science buildings on the north side of campus. This will lay the foundation for increasing energy efficiency of the plant as well as those buildings connected to it.
- Install 15 megawatts (MW) of Distributed Energy Resources.
- Shutdown and decommission the cogeneration plant.

Phase 2 by 2035

- Connect remaining campus buildings to the new thermal system, gradually transitioning them from steam to the EHCP.
- Build out equipment system capacity at the electric heating and cooling plant.
- Expand campus electrical capacity.

2028

Berkeley Clean Energy Campus (BCEC)

PHASE 1 GOAL: Develop an efficient, electrified campus heating and cooling system, increase use of clean electricity in campus buildings resulting in a 70% reduction in building energy carbon emissions as early as 2028.

Phase 1 Benefits

Realized in 2028

70%
Reduction in carbon emissions from campus buildings

75%
Campus building thermal needs facilitated by the new central plant

100%
Fully-operational central plant with capacity for all buildings

$200M
In avoided costs from upkeep of existing systems

BY 2035

Berkeley Clean Energy Campus (BCEC)

PHASE TWO GOAL: Achieve 85% carbon-free building energy use

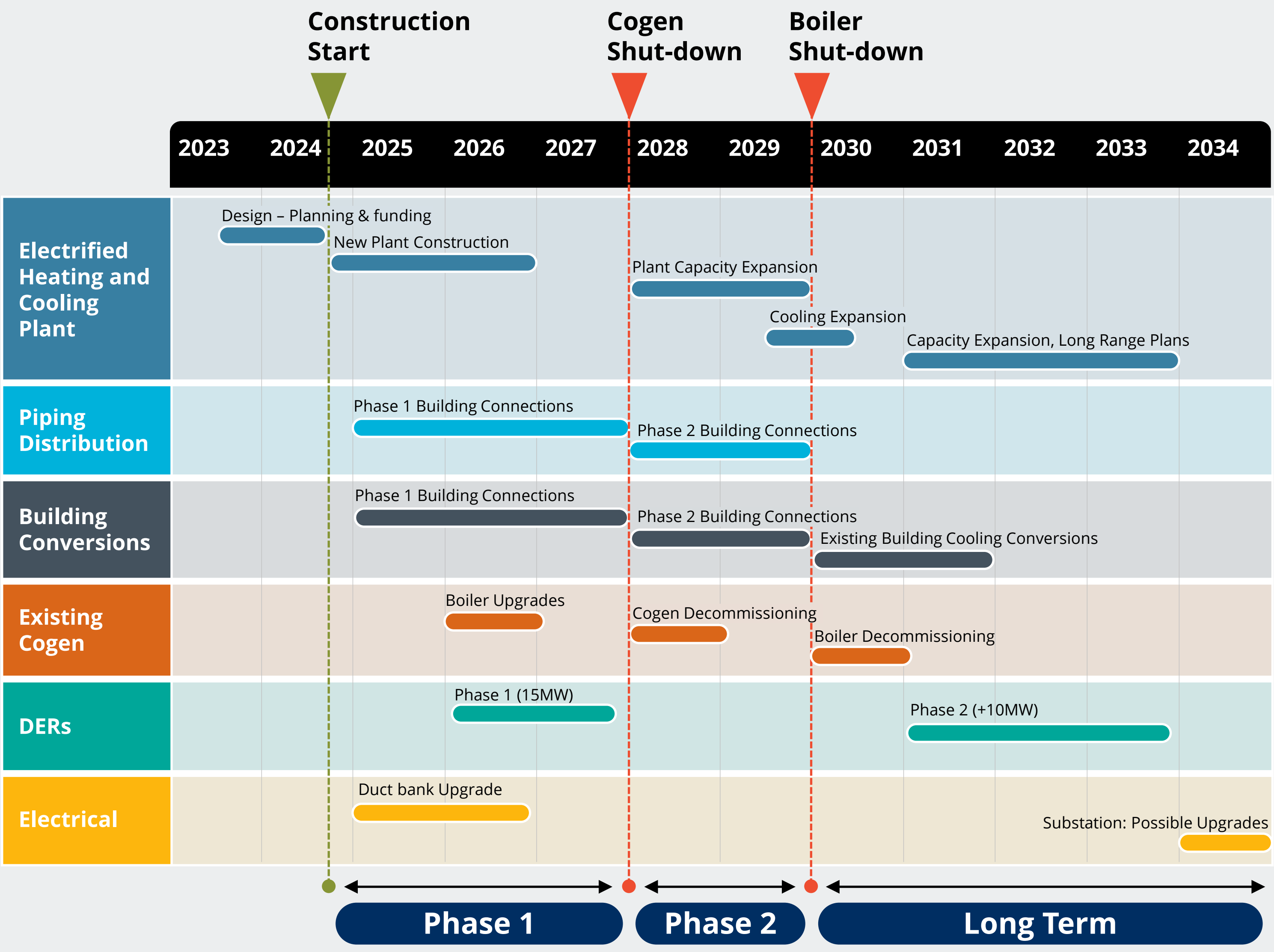
Long Term

- Add an additional 10 megawatts (MW) of clean on-site Distributed Energy Resources.
- Connect new buildings planned for in the campus Long Range Development Plan/ Master Plan and electrical system upgrades.

Background

Collectively, the engineering, financial, and renewable energy studies included in the IRAP have served as key pillars in the development of the Berkeley Clean Energy Campus roadmap and played a pivotal role in defining the project scope for this complex endeavor. With the initial blueprint development completed, the project has moved into preliminary design with a target to begin construction in 2025.

While this plan addresses the majority of UC Berkeley's scope 1 and 2 emissions, additional carbon reduction strategies will be required. The campus will be drafting a revised climate action plan by 2026 outlining its plans to further reduce emissions from buildings not on the new energy system as well as other emissions sources such as fleet vehicles, commuting and business air travel.

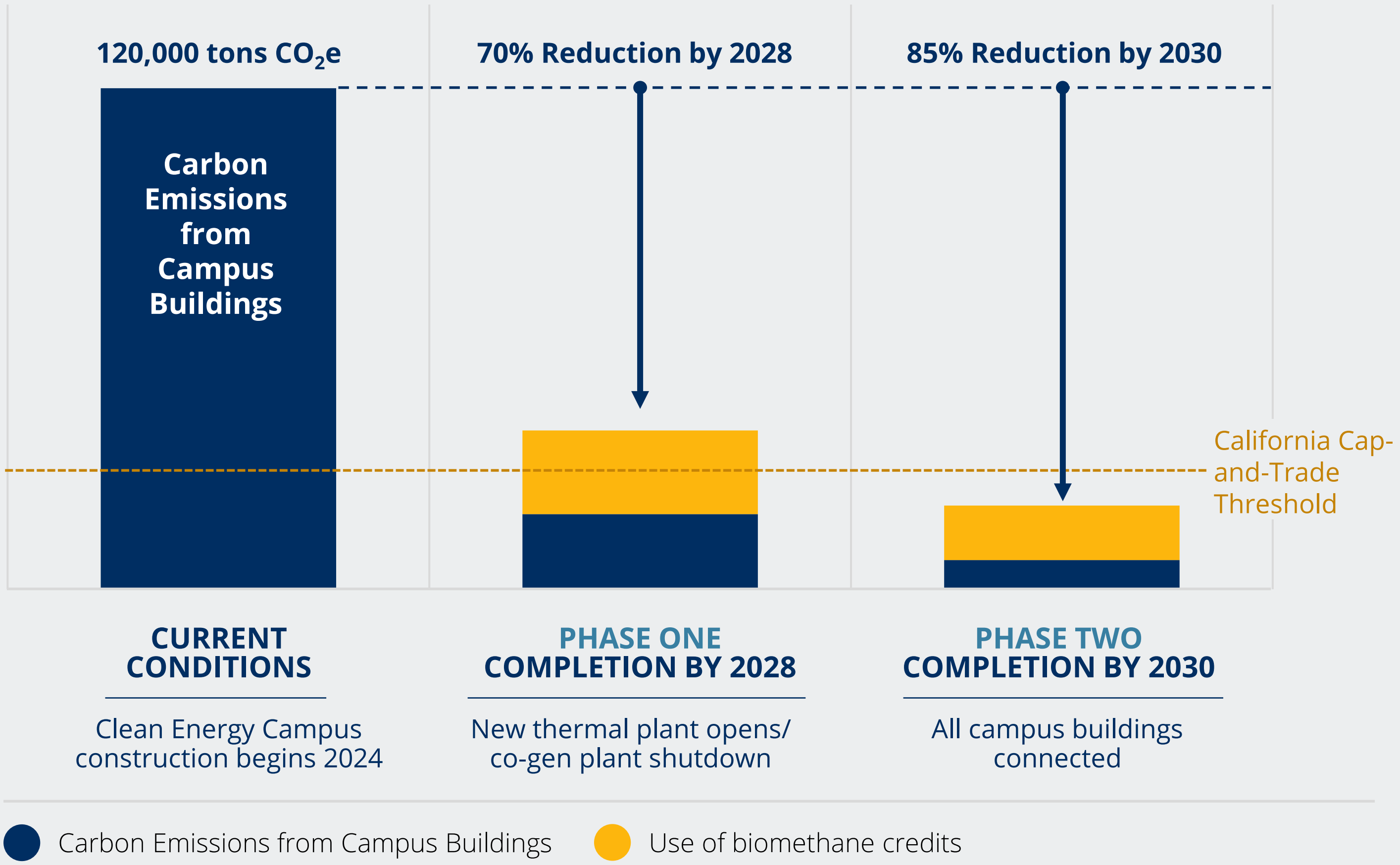


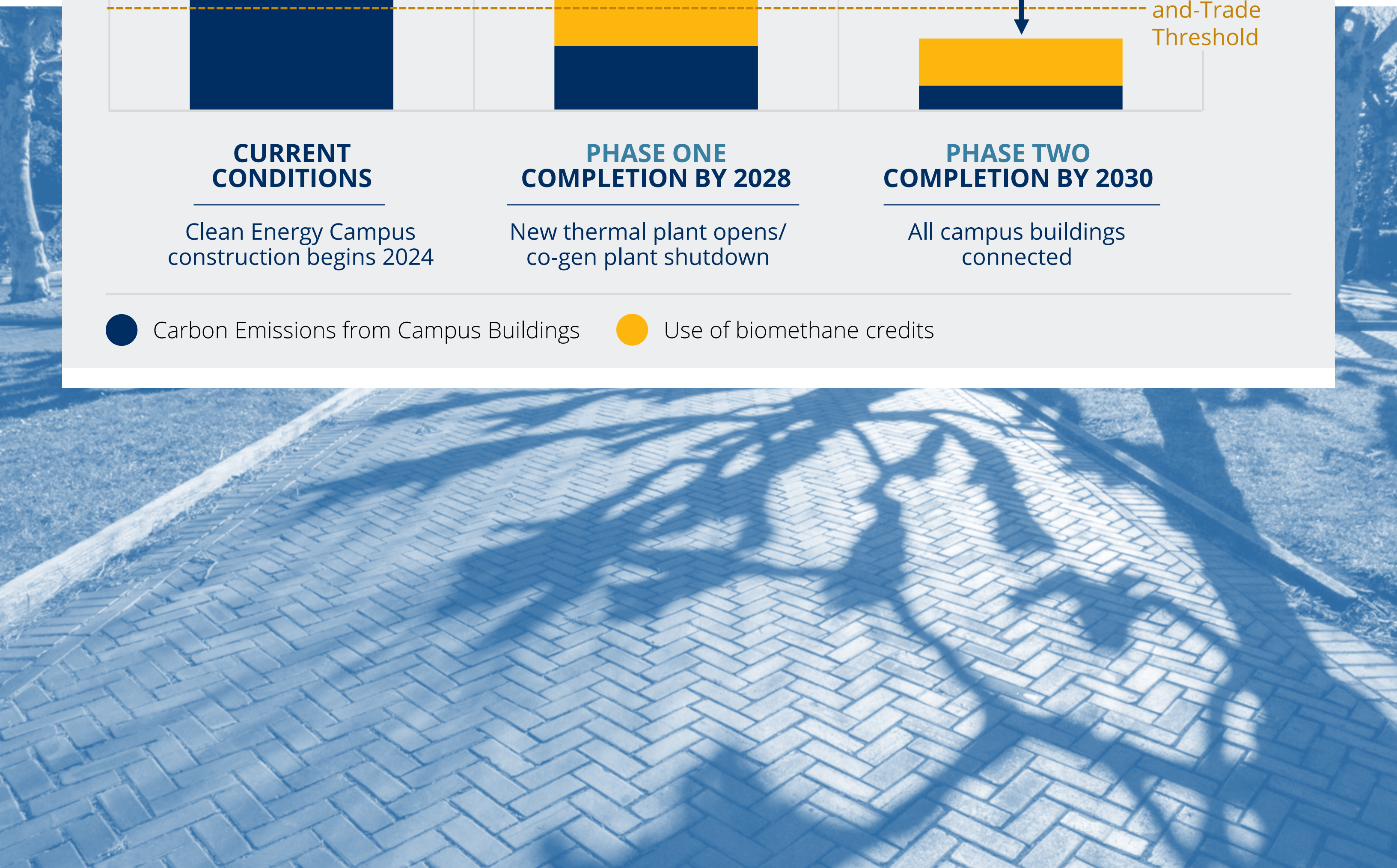
See AEI Berkeley Clean Energy Campus Integrated Resource & Activation Plan (IRAP) in the appendix for more detail.

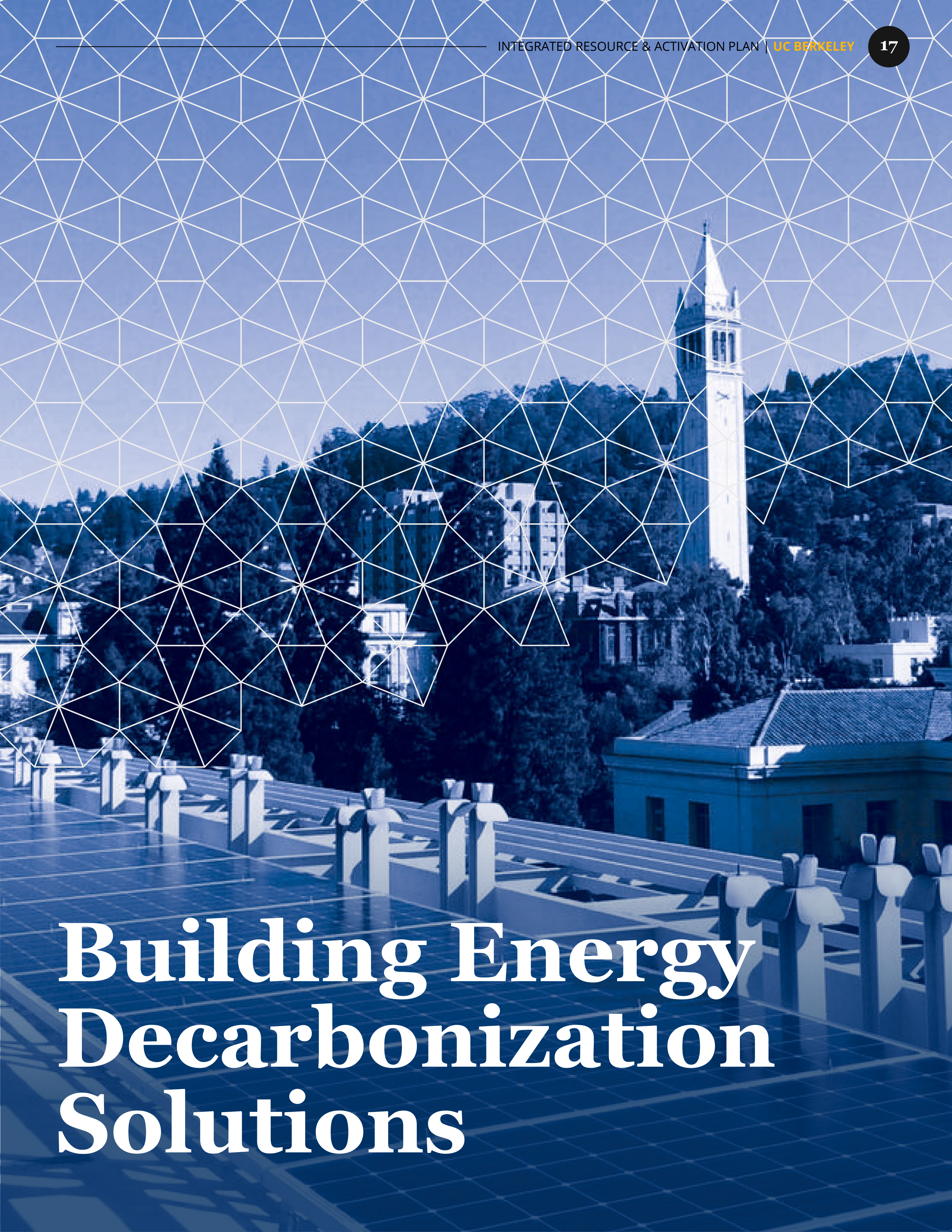
Background

The Berkeley Clean Energy Campus is estimated to reduce emissions by 70% in the first phase. With the additional procurement of biomethane credits, represented by the yellow bars, to offset natural gas, UC Berkeley will be able to lower its emissions sufficiently enough to be under California's Cap-and-Trade requirements (>25K tons of carbon) in Phase 1. Phase 2 will eliminate additional fossil use achieving an 85% reduction in carbon emissions. The biomethane contract expires in 2039.

Clean Energy Campus: Carbon Reductions







Building Energy Decarbonization Solutions

Building Energy Decarbonization Solutions

The technical solutions developed in the **Integrated Resource and Activation Plan (IRAP)** address two primary campus needs:

1. How to deliver decarbonized and energy efficient heating and cooling to buildings

2. How to provide onsite clean energy backup systems to increase resilience

The specific goals of the IRAP include:

- Greatly reduce fossil fuels use and carbon emissions and achieve University, State and Federal climate change goals.
- Renew and upgrade aging infrastructure.
- Transition to a resilient microgrid fed by on-site renewable energy.
- Optimize life-cycle costs, leveraging state funding and federal tax credits as well as innovative financing.
- Optimize land-use and contribution to community benefits.
- Leverage UC Berkeley's brain-trust and provide unique **living lab** opportunities within the university, building collaborative relationships with government and industry.

Building Energy Decarbonization Solutions

Affiliated Engineers, Inc. (AEI) built on previous studies that looked at different central plant and distributed (nodal) plant solutions. The optimal solution was determined to be a centralized Electric Heating and Cooling Plant (EHCP) and a new thermal distribution system paired with onsite clean energy systems (called Distributed Energy Resources or DERs).

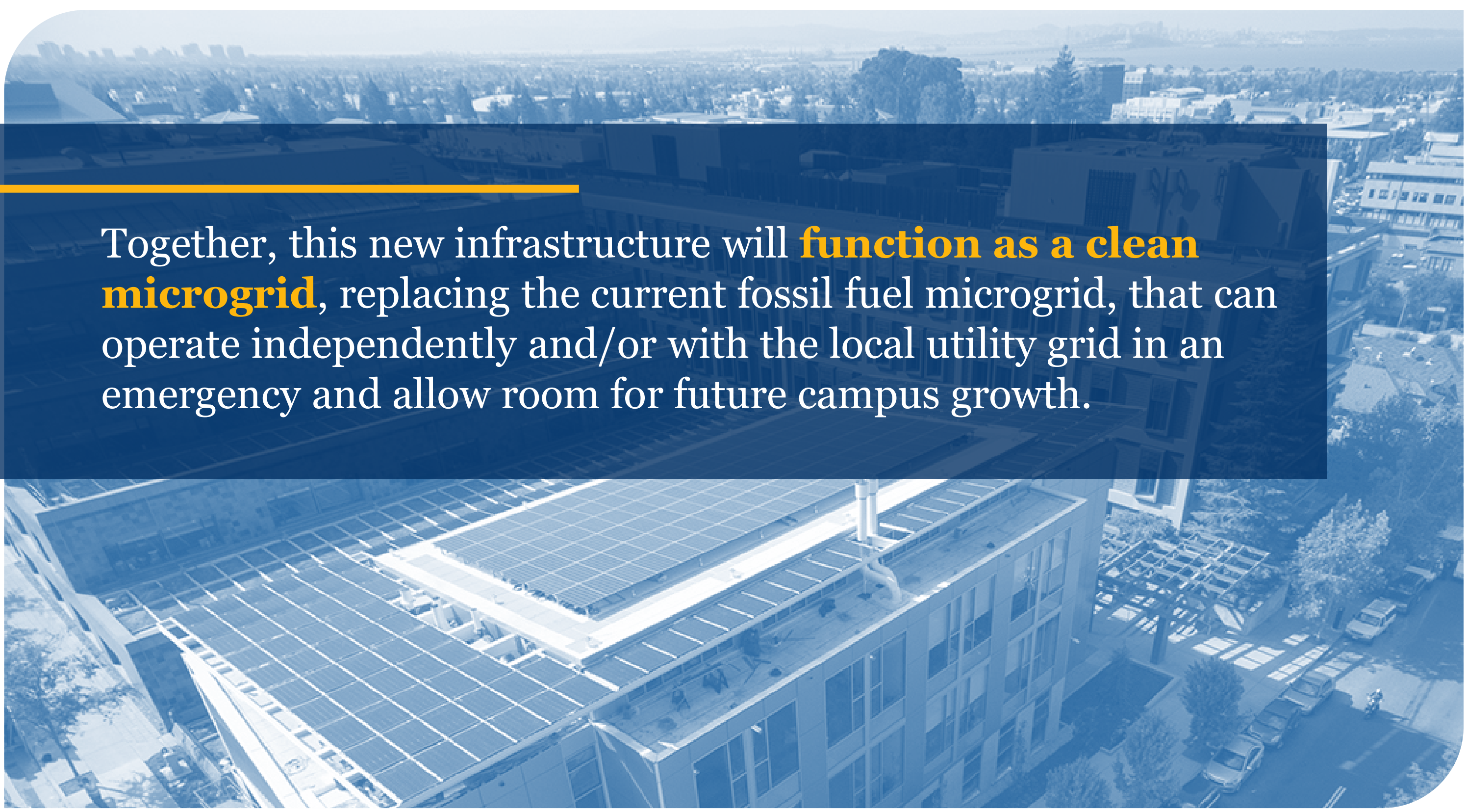
The Electrified Heating and Cooling Plant will be a state-of-the-art facility accommodating advanced, energy efficient technologies including **heat recovery chillers** and thermal energy storage supported by an underground **geothermal heat exchange** system. This plant will provide heating and cooling to existing and new campus buildings through efficient hot and chilled water distribution piping and will be powered by 100 percent clean electricity.

Distributed Energy Resources (DERs) include **green hydrogen** ready fuel cells, **solar photovoltaics** and battery energy storage systems to provide onsite clean energy production efficiently that will also provide resilience for **critical loads** in emergencies and power outages.

Together, this new infrastructure will function as a clean microgrid, replacing the current fossil fuel microgrid, that can operate independently and/or with the local utility grid in an emergency and allow room for future campus growth. The DERs will also greatly reduce carbon emissions in a way that current infrastructure cannot.

The project will be strategically divided into phases to ensure efficient capital planning and to maximize long-term cost savings associated with operation and maintenance.

The following section provides more technical details on each of the solutions identified as part of the IRAP and more information can be found in the appendix.



Together, this new infrastructure will **function as a clean microgrid**, replacing the current fossil fuel microgrid, that can operate independently and/or with the local utility grid in an emergency and allow room for future campus growth.

Building Energy Decarbonization Solutions

Decarbonizing Heating, Expanding Cooling

UC Berkeley currently operates a steam distribution system that provides most campus buildings with heating and hot water as well as supporting some lab processes. Steam is generated at the cogeneration plant and distributed through an increasingly deteriorating piping and tunnel network to buildings. Cooling is provided for a portion of primarily academic buildings by distributed stand-alone equipment (i.e. rooftop air conditioners). As climate change increases the number and severity of extreme heat days, the demand for cooling in all campus buildings is likely to increase. As such, the IRAP sought to identify solutions that would not only decarbonize heating but also provide opportunities to expand cooling to increase campus resilience and occupant comfort in an efficient manner.

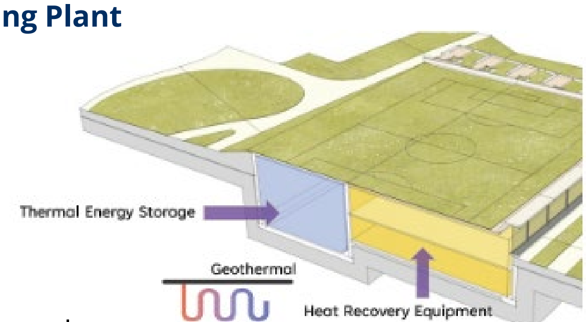
Redesigning the entire campus thermal system is a complex undertaking involving many interrelated systems. The following describes the proposed solutions for five key components of the new system: the new Electrified Heating and Cooling Plant (EHCP), thermal distribution systems, building conversions, advanced utility controls, and electrical upgrades.

Electrified Heating and Cooling Plant (EHCP)

Located on North Field, the new Electrified Heating and Cooling Plant (EHCP) will incorporate innovative technologies to optimize heating and cooling processes while increasing efficiency for campus buildings. The EHCP will capture waste heat from across the campus and from the ground (geothermal) and store and distribute this heat to meet the campus heating and hot water demands. Using advanced heat recovery technologies coupled with thermal energy storage, the EHCP will operate with a combined overall heating efficiency greater than 300 percent. By comparison, the existing steam heating and distribution system operates with an estimated overall heating efficiency less than 60 percent when accounting for distribution losses from the aging steam pipes.

The geothermal system will consist of boreholes drilled below the North Field site to store heat seasonally. Phase 1 will include about 150 boreholes drilled 400 feet deep beneath the plant building. **Water-to-water heat pumps** specifically designed to utilize this underground resource will provide simultaneous heating and cooling capabilities by pulling heat from or rejecting heat to the ground. By tapping into the relatively constant underground temperature and leveraging this with thermal energy storage, the EHCP can harness free and lower cost heating and cooling for buildings.

Concept of the new Centralized Heating & Cooling Plant



The new plant will utilize an underused field in the central campus and a majority of the core energy systems will be underground, including plant equipment, thermal energy storage tanks, and geothermal systems. A new recreation field will be installed on the roof

The new plant will provide views into the inner workings of the facility and offer community learning

Provided by AEI

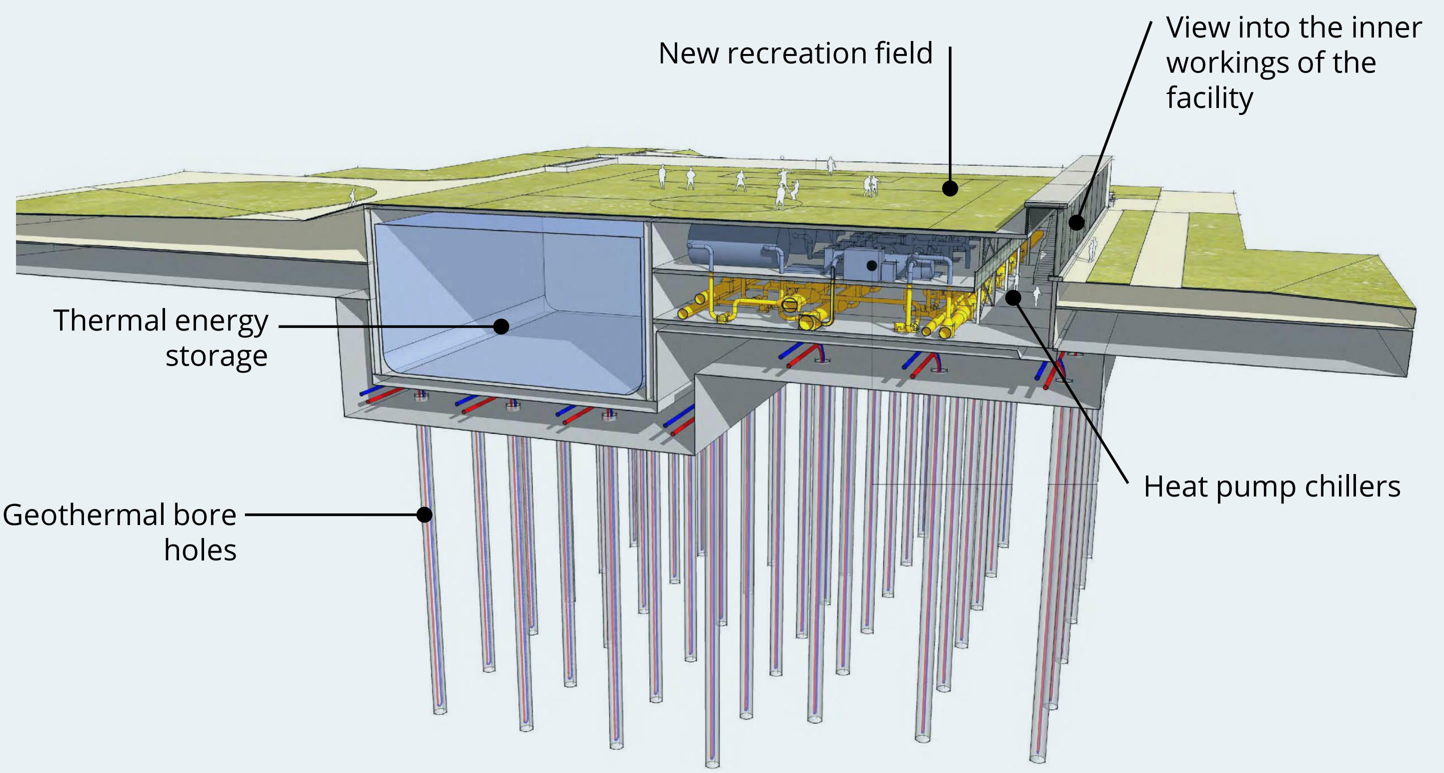
Building Energy Decarbonization Solutions

The thermal energy storage (TES) system consists of two large water tanks totaling over 6 million gallons that will capture excess heat during periods of low demand and store it for periods of high demand. By incorporating TES, the EHCP can satisfy 80 percent of the campus heating energy currently provided by steam, by capturing and reusing waste heat from across the campus. As demand grows and space becomes available, expansion can be accommodated.

When the cogeneration plant is decommissioned at the latter part of phase 1 construction, the electrified heating and cooling plant will take over for about 75 percent of campus heating and cooling needs. Electricity will be provided by the local utility and the distributed energy resources. The remaining buildings to be added in phase 2 will continue to operate on steam until transitioned to the EHCP.

The new plant will not only serve as a centralized energy hub but also a living laboratory. Campus affiliates and visitors will have the opportunity to study and experience sustainable energy solutions firsthand.

Concept diagram of the new Electrified Heating and Cooling Plant



Provided by AEI

Building Energy Decarbonization Solutions

Thermal Distribution Systems

The implementation of the new state-of-the-art thermal distribution system will revolutionize the heating and cooling capabilities of the campus, replacing the inefficient high-maintenance steam system. The new network of heating hot water and chilled water supply and return pipes will be connected to the electrified heating and cooling plant, forming a series of loops that will efficiently serve all campus buildings.

The upgraded system will significantly improve the distribution of thermal energy to buildings as compared to the current steam system, minimizing energy losses during distribution and enhancing the system's redundancy. This will result in greater overall efficiency and cost savings. Moreover, the new system will eventually eliminate the need for distributed cooling equipment units (e.g. rooftop air conditioners), reducing maintenance requirements. As a result of the new system, more campus buildings will have access to cooling capabilities, providing a more comfortable environment for occupants.

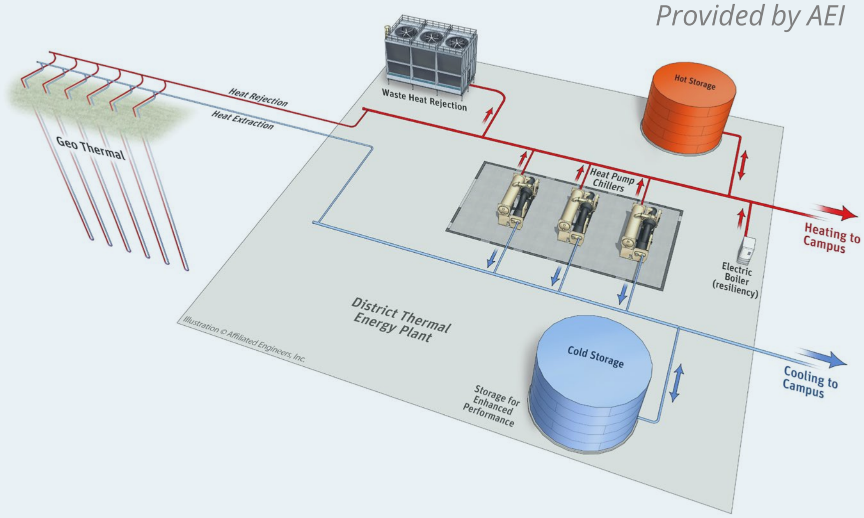
The distribution and phasing plan developed by AEI for the campus takes into account steam system deferred maintenance priorities to avoid significant costs by replacing those areas of campus most in need of repair first. To initiate the project, the campus will prioritize connecting the most energy-intensive buildings (about half of the campus) to the new system, effectively shifting approximately 75 percent of the thermal energy load to the electrified heating and cooling plant. Subsequently, other campus facilities will be sequentially connected to the distribution network as it expands in phase 2.

In addition, the first phase will leverage existing cooling assets distributed around campus to supplement the cooling provided by the Electrified Heating and Cooling Plant (EHCP) and reduce the need for additional centralized cooling towers at the beginning. These existing water-cooled chillers still have useful service life and will be integrated into the new chilled water distribution, effectively operating as satellite peaking-plants. Integrating the existing equipment into a new chilled water distribution system is a cost-effective solution compared to installing new water-cooled chillers in the EHCP at the outset. The existing equipment will continue to operate until it reaches the end of its useful service life, at which point it will be replaced with new centralized cooling equipment in the EHCP. This phased approach will allow for a seamless transition while optimizing cost-efficiency.

Diagram of the Electrified Heating and Cooling Plant

The EHCP will capture waste heat from across the campus and from the ground (geothermal) and store and distribute this heat to meet the campus heating and hot water demands.

Provided by AEI



Building Energy Decarbonization Solutions

Building Conversions

The conversion of existing buildings from steam to hot and chilled water will align with the phasing of the distribution plan. There are four primary ways in which buildings will be adapted to the new system:

- Existing buildings connected to steam will be retrofitted to accept hot water instead of steam for heating through the addition of new and emerging **heat pump** and **heat recovery technologies**.
- Process steam loads (e.g. for sterilization processes) will be shifted to building-based electric steam generators.
- Existing distributed cooling systems (e.g. rooftop air conditioning units) will be converted and transitioned to the new centralized chilled water system.
- Existing buildings that currently do not have cooling will be provided with a connection to the central chilled water system for future use.

This upgrade will enhance energy efficiency and reduce reliance on outdated steam systems. Furthermore, both existing buildings with cooling requirements and those without will be connected to the new chilled water system, bolstering the campus' ability to adapt to climate change and provide optimal comfort. Significantly, most of the heat needed for campus buildings will come from the buildings themselves, by recapturing heat currently thrown away via existing building level **cooling towers**.

Most of the buildings to be converted are on the core campus or immediately adjacent and already connected to the existing steam system. Other university buildings located further from the core campus and unconnected to the existing cogeneration and steam system, will be addressed through future decarbonization planning. These other university buildings represent a much smaller energy use and carbon footprint than the buildings that are part of the new campus system. To facilitate a smooth transition, all new facilities planned and constructed prior to the full operation of the electrified heating and cooling plant or distribution network will be designed to seamlessly integrate with the new system.

Advanced Utility Controls

Advanced utility controls will guide the campus-wide flow of heating, cooling, and electricity through the new energy distribution network–what is known as a microgrid. These controls will include sensors, software, and monitoring equipment that ensure sufficient energy is available and shared among campus buildings. Each building is essentially "tuned for maximum efficiency." The advanced utility controls will also be vital when responding to future unplanned outages, as they will allow the campus to specifically direct energy resources to the buildings where it is most needed to maintain critical operations. The microgrid system will monitor both the Distributed Energy Resources and the campus electrical distribution system and provide intelligent monitoring and controls based on campus usage and available DERs. Availability of power from DERs varies with time of day, season, weather, battery capacity and other factors. To assure the system operates smoothly, the microgrid system's programming will consider all incoming, historical, and forecasted data while providing automated control and streamlined monitoring to all systems on campus.

Electrical Upgrades

UC Berkeley currently relies on the existing cogeneration system for 90 percent of its electricity needs, with the rest being supplied by the local utility. Diesel generators are installed in strategic locations throughout campus to provide backup power in the case of an outage. As the campus transitions from the natural gas cogeneration facility and onto to the Electrified Heating and Cooling Plant (EHCP), it will rely on the local utility and newly installed onsite clean energy installations (see Clean Energy: Distributed Energy Resources

Building Energy Decarbonization Solutions

section) to provide power. The new systems, such as electric heat pumps, will increase the overall electrical load of campus and will require upgrades to existing infrastructure. While this can be a significant cost barrier for electrification, the design team determined a flexible approach that could be phased over time to reduce the immediate need for expensive upgrades.

Electrical infrastructure upgrades will be phased to align with the projected electrical load growth from the EHCP as well as the installation of distributed energy resources. Upgrade of the existing utility service capacity serving the campus (Hill **Substation**) is not anticipated to be required during phases 1 and 2 implementation but is likely required to support future campus growth. Supplemental on-site clean Distributed Energy Resources will also be required to support growth.

Currently, the campus distribution system is limited to 48 Mega Volt Amp (MVA) due to existing feeders to the Hill substation. To expand capacity, the campus plans to implement various electrical system upgrades including additional switchgear and conductors from the Hill Substation. These upgrades will increase the system capacity to 55 MVA, allowing for the accommodation of the Phase 1 and Phase 2 heating and cooling distribution without the need for immediate electrical utility service improvements at the Hill Substation. This solution ensures that the campus can effectively meet its electrical needs while optimizing resources and minimizing near-term expenditures. An eventual expansion of electrical capacity at the Hill Substation will be needed to accommodate future growth, unless the campus can keep loads below 55 MVA; as this type of expansion has long lead-times. The planning for this is already underway.

Electrification is Energy and Water Efficient

The electrification of thermal systems at UC Berkeley requires an additional 30,000 megawatt-hours (MWh) of power per year, which amounts to a 16 percent increase compared to the current campus energy usage. According to the IRAP analysis, the anticipated annual energy consumption at the new Electrified Heating can Cooling Plant (EHCP), once fully built, will be 72,000 MWh. However, due to the removal of cooling building level equipment and other measures, the building electrical loads will decrease by 47,000 MWh. The incredible efficiency gains are in part due to the capture of waste heat, which is currently being discarded across campus. The new heat recovery equipment and thermal energy storage tanks at the EHCP will be able to capture 90 percent of the annual campus heating requirements from waste heat.

In addition to being highly energy efficient, capturing waste heat through systems like geothermal and thermal energy storage (TES) results in significant water savings due to the reduction in the number of cooling towers needed to reject waste heat. Moreover, geothermal systems are eligible for rebates through the federal Inflation Reduction Act, providing further incentives for its implementation (see Financial Analysis section).

47,000 MWh **decrease in building electrical loads** according to the study analysis with the new Electrified Heating and Cooling Plant

Building Energy Decarbonization Solutions

Water Savings & Recycled Water

The implementation of the Berkeley Clean Energy Campus presents an opportune moment to save water and to leverage the trenching activities required for the new hot and cold water distribution system to connect to the regional recycled water supply when it becomes available. By planning for this future connection, central cooling towers for the electrified heating and cooling plant and future buildings can benefit from the use of recycled water as well as for irrigation purposes. Whether recycled water is used or not, the BCEC is projected to reduce campus water use by 20 percent in the energy use system with the efficiencies gained from the new thermal systems.

20% Reduction BCEC to reduce campus water use in the energy use system by 20% and the option to use recycled water

On-Site: Distributed Energy Resources (DERs)

After the decommissioning of the existing cogeneration plant at the end of Phase 1, the campus will rely on electricity from the utility and onsite clean energy resources. One of the significant challenges of transitioning to an all-electric system is ensuring energy resiliency during utility outages and other events such as high winds, wildfires, and potential earthquakes.

The campus recognizes the importance of maintaining and improving reliable energy sources to meet critical campus safety needs and safeguard sensitive laboratory research.

Implementing Distributed Energy Resources **(DERs) can enhance energy resiliency**, providing a reliable backup of clean energy during utility outages.

Building Energy Decarbonization Solutions

Identifying Critical Loads

A key objective of the project was to provide on-site sources of power to support critical campus operations during a utility outage. Identifying those critical operations and their associated loads is a complex process. To identify critical operations, UC Berkeley assembled a group of campus stakeholders who represented key functions such as research and student life. The group identified and prioritized particular functions to be supported with an emphasis on student safety and research. These included specific research needs, residential housing and dining, security (including lighting, health services, emergency operations center, and the campus police department), and essential data. The evaluation assumed managing critical loads in an outage would include shutting down buildings without critical functions, having non-essential employees work remotely and, depending on circumstances, move classes to a remote format and cancel events. The engineers then identified the needed load to support those functions which provided the basis for the design of resiliency measures. Aligning operations to those loads during an outage will be an ongoing challenge and will require sophisticated controls to maintain.

DERs: Solar, Batteries and Fuel Cells

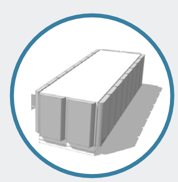
AEI studied a range of Distributed Energy Resource (DER) options that can power the campus for up to five days as well as supplement utility-provided energy during normal operational times. Factors considered included:

- Cost competitiveness
- Feasibility of funding and constructability
- Ability to connect to UC Berkeley's electrical grid
- Ability to provide clean, low-carbon energy
- Ability to provide resilient power for up to 5 days of utility outage
- Phasing and growth potential
- Attractiveness for potential partners and external funding opportunities

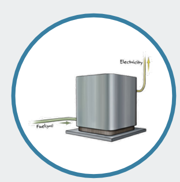
Technical maturity and ability to meet demand DER technology assessed included solar photovoltaic, fuel cells, modular nuclear, deep geothermal power, wind turbines, and pumped hydro power. Using AEI's optimization tool and evaluating other qualitative benefits, the team determined a preferred approach combining a mix of technologies which includes fuel cells, solar photovoltaics and battery energy storage.

Ultimately, AEI recommended a three-part system of DERs: 7.5 megawatts (MW) of fuel cells capable of operating on green hydrogen; 10-12 megawatts (MW) of solar generation on campus rooftops and parking garages; and, 45 megawatt-hours (MWh) of battery energy storage.

Three-part system of DERs



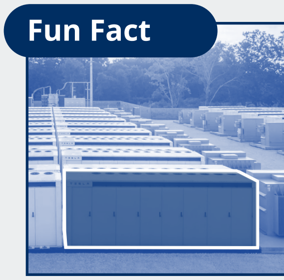
45 MWh Battery Energy Storage



7.5 MW Fuel Cells

10-12 MW Solar PV

Fun Fact



The Battery Energy Storage System occupies an area equivalent to **250 Refrigerators**

Building Energy Decarbonization Solutions

Distributed Energy Resources Profile

Campus Critical Loads

- Research
- Student Residential Housing
- Data
- Safety

Recommended Technology Mix

- Solar Photovoltaics
- Solid Oxide Fuel Cell
- Battery Energy Storage

Energy Sources

- Solar (renewable energy)
- Biomethane for fuel cell (short-term)
- Green Hydrogen for fuel cell (long-term)

AEI also estimated that an additional 10 MW of additional DERs would need to be added in subsequent years to meet growing campus energy resiliency needs.

The University of California (UC) has explored other strategies to reduce emissions while maintaining existing infrastructure including the procurement of biomethane to replace natural gas. Biomethane, also known as renewable natural gas (RNG), is a type of biogas produced from organic waste materials, such as agricultural waste, food waste, wastewater, and landfill waste. Considered a carbon neutral alternative to natural gas, the UC system has invested in biomethane as a transition fuel to aid campuses in reducing emissions through 2040. UC Berkeley plans to use its biomethane allocation from the UC system to reduce the Cap-and-Trade emissions associated with the fuel cells through this time period. This allows UC Berkeley to ramp down natural gas use emissions while more DERs are implemented as well as avoid Cap-and-Trade costs.

Possibility for Solar PV and Storage for Future Growth

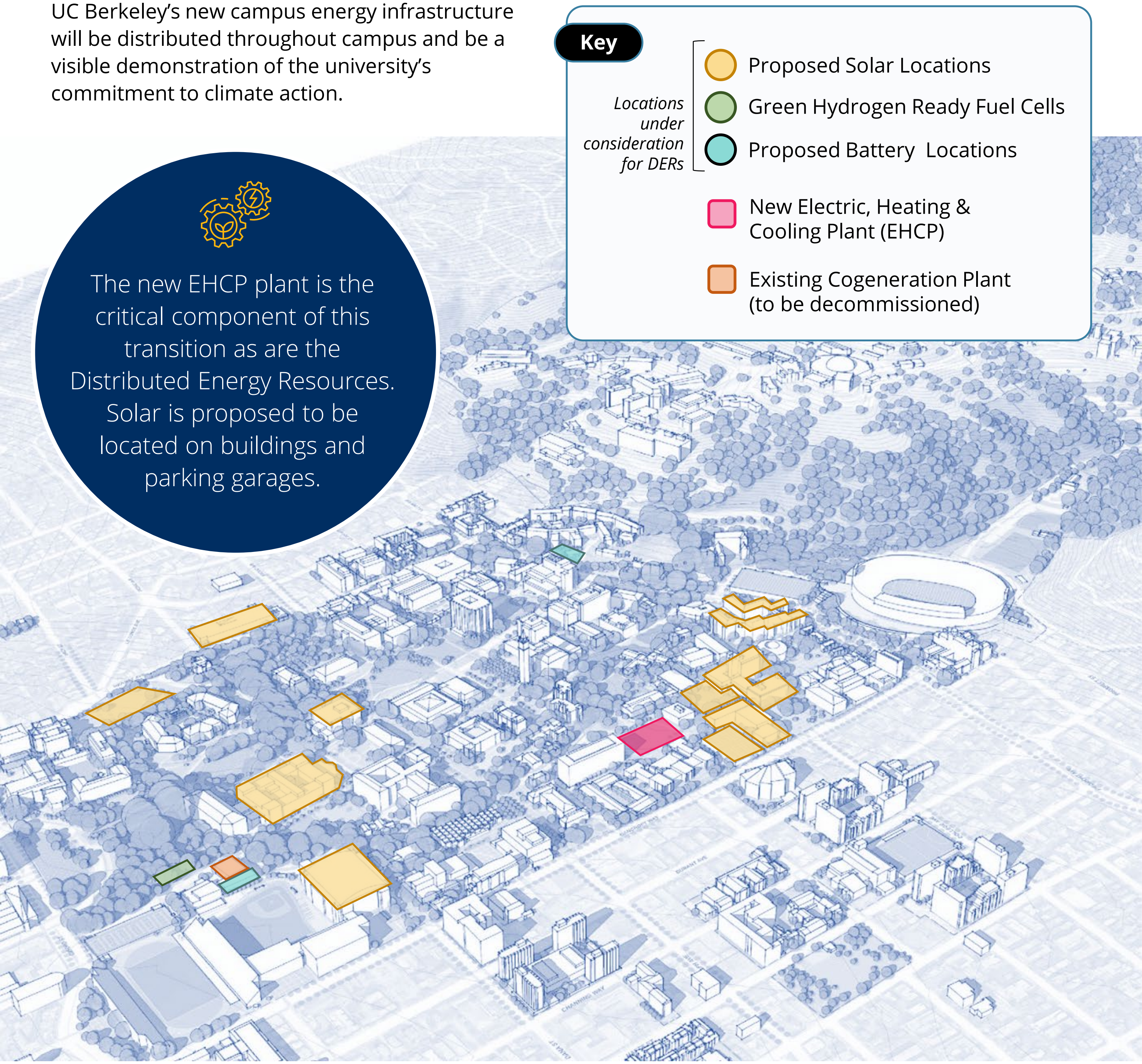
A study conducted by Burns & McDonnell in 2022 assessed the potential for clean energy generation on UC Berkeley's Hillside Campus through solar PV and battery energy storage systems. Despite challenges such as steep slopes, extensive vegetation, existing buildings, and limited infrastructure accessibility, five clusters of sites were identified for potential solar development. Of those five, three sites on the campus hillside totaling 12-15 MW were identified as the most feasible installation options for maximizing solar while minimizing the impact on existing trees, structures and other obstacles. The three sites identified as most feasible for solar will continue to be evaluated for installation during later phases of the energy system construction. The campus will first focus on rooftop and carport solar PV installations on the main campus.

Introduction

Overview of Berkeley Clean Energy Campus Plan

UC Berkeley's new campus energy infrastructure will be distributed throughout campus and be a visible demonstration of the university's commitment to climate action.

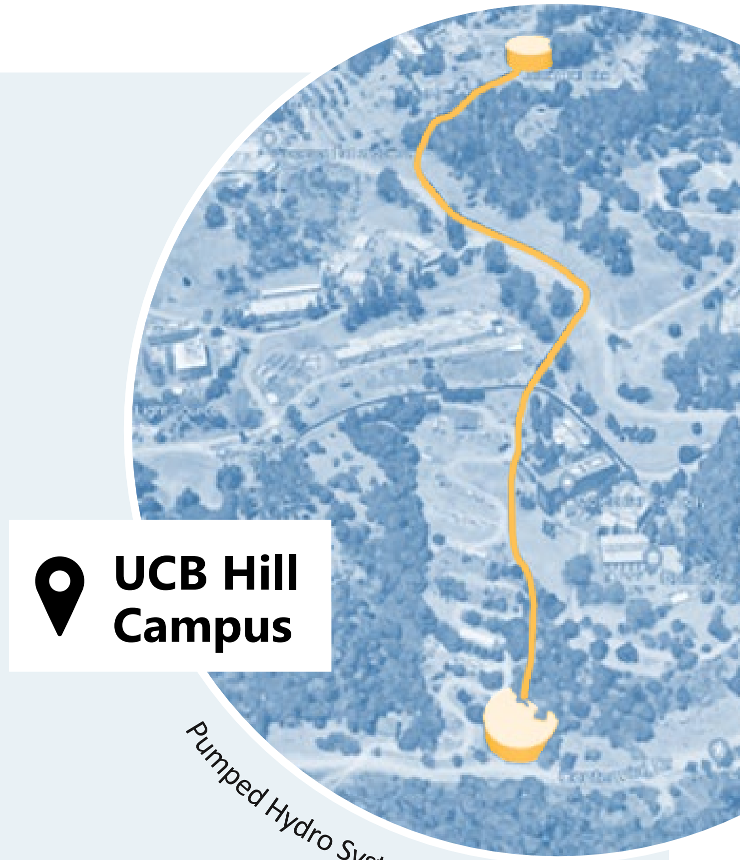
The new EHCP plant is the critical component of this transition as are the Distributed Energy Resources. Solar is proposed to be located on buildings and parking garages.



Building Energy Decarbonization Solutions

Exploring Pumped Storage Hydropower

Prompted by input from UC Berkeley Mechanical Engineering faculty, AEI conducted a study on the potential of closed-loop pumped storage hydropower on campus. Leveraging UC Berkeley's unique geography and steep slope on the hill campus, the IRAP explored the possibility of a closed-loop pumped storage hydropower system as an alternative or supplement to electrochemical batteries that rely on rare earth metals. This innovative approach involves pumping water to an upper storage tank during periods of abundant and clean power, and then utilizing a hydropower turbine and gravity to generate additional power as needed during outages or peak hours, while reducing dependence on the utility.



Pumped Hydro System Concept

A pumped storage hydropower scheme could have a lifespan of

60+ years

Compared to lithium-ion batteries that require replacement every

7-10 years

making pumped storage hydropower a more sustainable and lower embodied carbon solution

By identifying feasible sites with 20 million gallons of upper and lower storage volumes, this system can provide up to 15 megawatt-hours (MWh) of energy, with a turbine output of around 3.5 megawatts (MW), for a duration of 4.75 hours. An additional 30 MWh of battery storage would still be needed to supplement pumped storage hydropower in meeting the critical loads of the campus.

Initially, the capital cost of implementing the pumped storage hydropower system far surpasses that of a battery system of similar size. However, over the system's lifespan, the replacement costs for batteries make the battery capital costs more expensive.

Financial Evaluation

Financial Evaluation

The State of California has committed $249 million towards the project and the funding for the Integrated Resource Activation Plan (IRAP) itself was made possible by the support of generous donors;

however, the total capital cost of the BCEC project is estimated to be **$700 to $800 million,** requiring strategic financial planning. Under the IRAP, consulting firm Ernst & Young (EY) conducted a financial analysis that examined various financing options and developed a financial roadmap for the project's first phase under these funding scenarios. The analysis considered potential funding sources such as the federal **Inflation Reduction Act (IRA)** tax credits, **power purchase agreements (PPA)**, short- and long-term financing, green bonds, grants, and state and federal grants. State funds are envisioned to be used to design the BCEC and cover some of the construction costs of the thermal system transformation. The Distributed Energy Resources (DERs) have been modeled to be delivered through public-private energy service contracts (i.e. power purchase agreements). delivered through public-private energy service contracts (i.e. power purchase agreements).

Ernst & Young developed a flexible financial modeling tool that incorporated cost estimates developed by AEI. The inputs included the state-sponsored funding coverage and debt to fill the financial gap for design and construction of phase 1 of the project. Ernst & Young's discounted cash flow analysis assumed a 4.25 percent tax-exempt financing interest rate with the guidance of the UC system Capital Markets Finance. EY also determined that the campus could take advantage of new "direct pay" provisions under the federal Inflation Reduction Act (IRA), which for the first time can directly transfer clean energy tax credits to non-profit institutions such as universities.

Financial Evaluation

Leveraging funds for the first phase of the Clean Energy Campus

The $249 million in State Funds not only provide significant investment in the BCEC implementation,
it is a funding and saving catalyst. It is offering the BCEC numerous opportunities, including:

- Completion of designs and technical schematics for the entire new system, including new plant, distribution, and distributed energy resources.
- Funds a portion of the Phase 1 construction.
- Implements essential make-ready projects to accommodate increased campus-wide electrical demand and central cooling towers.

The Inflation Reduction Act (IRA)

The IRA will play an important role in funding the Berkeley Clean Energy Campus. The campus is identifying how the IRA can significantly leverage funding allocated by the State.

Catalyst for Savings

The faster the Clean Energy Campus can be completed, the greater the savings that will be realized, and the quicker UC Berkeley can move significantly away from fossil fuel combustion and demonstrate for others rapid large-scale decarbonization.

Green Bonds

Green bonds and green bank financing instruments provide discounted interest rates for eligible "green" projects. The availability, financing rates and size of any potential loan vary by project type and issuer. Green bonds offer potentially 10-45 basis points (bps) lower than traditional bonds. Green banks such as California IBank provide infrastructure loans at rates lower than the market and up to $60 million. As UC Berkeley roles out specific projects, these financing mechanisms may prove to be a viable solution.

What is a PPA?

- PPAs (power purchase agreements) offer UCB the ability to receive energy from resources such as solar and battery storage from a third-party developer without capital costs.
- In a typical direct PPA structure,
  a project developer owns and operates the renewable energy provided to UCB, who receives and takes legal title to the energy based on a negotiated contract at a fixed price.

Tax Credits in a PPA

- Tax ownership of the DER assets (solar, battery storage and fuel cell) transfers to developer, therefore UCB will not be eligible for the associated tax credits.
- Although the developer retains the credit, the benefits of the credit should be shared with UCB and reflected in a reduced fixed price ("strike price").

Provided by EY

Financial Evaluation

Phase 1 | Tax Credit Estimates

$54 million
Low Case

$71 million
High Case

The financial model estimated eligible tax credits to be $47 million to $71 million from clean energy resources such as battery storage, fuel cells, geothermal energy, piping, and the EHCP for Phase 1. EY's findings reveal that under the IRA, the Federal government could provide rebates ranging from 10 percent to 20 percent of the total project costs upon completion. As an example, including a geothermal heat exchange system beneath the main plant enhances the campus' thermal infrastructure while also increasing the likelihood of securing higher rebates.

Inflation Reduction Act (IRA) Tax Credits

Mitigating Risks

UC Berkeley has the unique opportunity to leverage the Inflation Reduction Act (IRA) tax credits for implementation of the Berkeley Clean Energy Campus (BCEC). While there is a risk that a new administration could undermine the tax benefits, historical trends suggest that these credits have generally been extended rather than revoked. The current Clean Energy Tax Credit program, provided under the IRA, is authorized until 2032. To mitigate this risk, UC Berkeley can complete its project and secure the tax credits prior to the expiry of the current authorization in 2032.

Another potential challenge with leveraging the IRA is the reliability of the tax credit amount. Initially projected based on cost estimates and interpretation of the tax credit applicability, the final determination of the credit amount will be made by the IRS after project completion. This risk is common for renewable energy projects, but insurance products are available in the marketplace to underwrite this risk and provide some certainty to the university for a premium.

Another consideration is the direct pay process, which is newly established under the IRA. While tax credits for renewable energy are not new, the full process and requirements for the direct pay process are still being clarified through federal administrative guidance. However, initial federal guidance has been issued, confirming the eligibility of public universities for the direct pay process. It is essential for UC Berkeley to remain up to date with federal guidance to ensure compliance with the requirements.

Overall, by strategically planning and taking advantage of the IRA tax credits, UC Berkeley can benefit from financial incentives to enable the BCEC. While there are potential risks, various measures can be taken to mitigate them and ensure a successful utilization of the tax credits.

Financial Evaluation

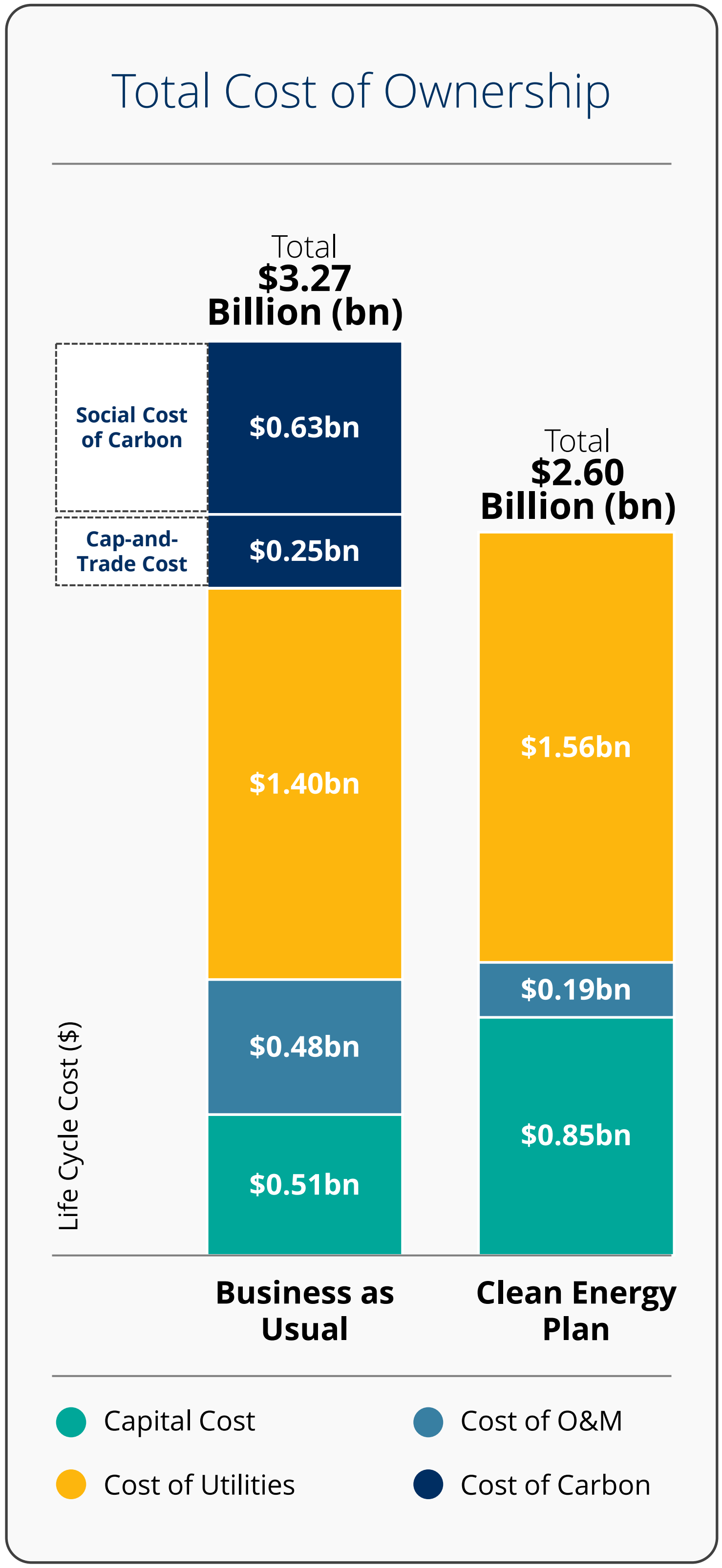
Total Cost of Ownership

A large infrastructure transformation that will serve the campus for many years cannot be considered just in terms of upfront capital cost but in terms of total cost of ownership.

For the IRAP, the life cycle cost analysis included the following considerations over a 25-year period:

- Campus utility costs (electricity, natural / biomethane gas and water)
- Operation and Maintenance (O&M) costs
- Carbon emissions costs (cap & trade and **social costs**)
- Capital Expenditure costs (including deferred maintenance and avoided costs)

The new decarbonized system costs have been compared against the Business-as-Usual case, which is defined as the campus refurbishment of the cogeneration plant and steam distribution system and making the repairs to the system for it to be functional and operational. **The total cost of ownership over a 25-year life cycle resulted in a cost of $2.6 billion for the new Clean Energy Plan** compared to the cost of $2.63 billion for the Business-as-Usual case (excluding social cost of carbon). The inclusion of the social cost of carbon increases the cost of the Business-As-Usual case to $3.31 billion.



Financial Evaluation

Social Cost of Carbon

The social cost of carbon is the monetary value of the net harm to society from climate change associated with adding carbon to the atmosphere each year.

The impacts of climate change include but are not limited to net agricultural impacts, human health effects, increased flood risk damages, environmental migrations, and changes in the value of ecosystem services. The social cost of carbon is a value of the future cost of climate change and can be used to weigh the benefits of reduced consequences against the costs of cutting emissions. UC Berkeley experts have been consulted and have estimated the equity weighted social cost of carbon for the UC system to be approximately $246 per ton of greenhouse gas emissions. This cost will continue to escalate over time.

The financial analysis (shown in the graph on the previous page) provides a conceptual cost and revenue foundation for completing the project's first phase. Moving forward, project financing is largely dependent upon variables such as potential future state investments, partnerships with private entities and philanthropic interest, all of which the university continues to explore. Despite the significant initial investment, the long-term financial savings illustrate the financial viability of a clean energy transition.

UC System equity weighted

Social Cost of Carbon

$246

Per ton of greenhouse gas emissions

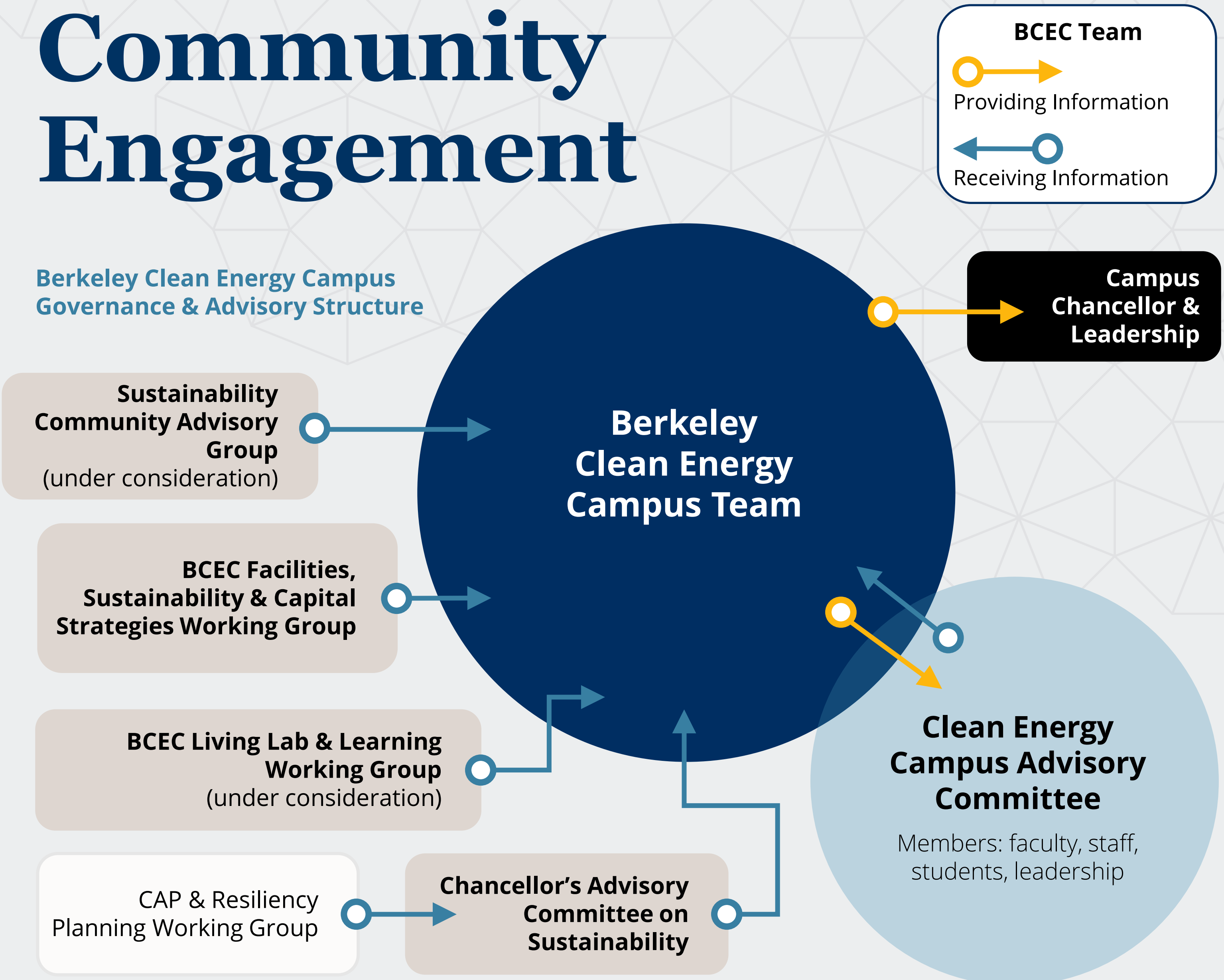
State Advocacy and Funding Outcome

UC Berkeley's campus leaders prioritized the BCEC and collaborated with the campus Office of Government, Community Relations, the Office of Sustainability, and Facilities Services to advocate for the Berkeley Clean Energy Campus, elevating it as its top capital funding request to the state in 2022. Their advocacy efforts encompassed engagements with state legislators, the Governor's Office, the UC Board of Regents, and other decision-makers. To present the project as a model decarbonization capital investment, Chief Sustainability Officer Kira Stoll and Director of Advocacy and Institutional Relations Michelle Moskowitz personally traveled to Sacramento multiple times in 2022 and 2023. In over 30 presentations, they emphasized the project's potential to reduce campus greenhouse gas building energy emissions by 85 percent , which would support the state's ambitious greenhouse gas reduction goals and serve as a prominent demonstration project for other campuses and small cities.

To increase project visibility, over 100 students also reached out to lawmakers, urging immediate action on climate change and advocating for the state's financial investment. These collective efforts yielded incredible results, with the **state approving $249 million in state-backed debt for the Berkeley Clean Energy Campus**, acknowledging its significance and potential impact.

Community Engagement

Community Engagement



The Berkeley Clean Energy Campus (BCEC) project has prioritized engaging various stakeholders, including administrators, faculty, researchers, and students, in an inclusive and campus-wide conversation.

To facilitate effective guidance, activities and structures have been developed to provide recommendations on the initiative to the Chancellor and other campus leadership that factor in a diverse set of stakeholder input.

One avenue for this engagement has been the establishment of a BCEC Advisory Committee. The Advisory Committee includes faculty, staff, students, and campus administrators who provide a broad range of expertise and perspectives. This committee has actively reviewed the financial and engineering study outcomes, while also exploring research opportunities associated with the project. Moreover, the project has sought the expertise of student groups like BEACN, an undergraduate consulting firm affiliated with the Haas School of Business, to assess the feasibility of using renewable hydrogen for backup power. The project leads have been in close contact with the UC Berkeley Green New Deal

Community Engagement

student advocates, who have voiced their support for the expedited closure of the cogeneration plant. The group holds student representatives on the advisory committee and several members have been instrumental in project advocacy with the State.

Attention to faculty and researcher engagement has been front and center. This has included presentations and discussions with the Academic Senate and about 80 faculty members have been invited to meetings updating them on the initiative and soliciting their feedback. The breadth of engagement from expert faculty has been impressive. For example, Serverin Borenstein and Nancy Wallace - faculty with the Haas School of Business - advised on marginal costs and financial structures; Dan Kammen faculty with the Energy and Resources Group/Goldman School of Public Policy has suggested resources to examine technologies including geothermal, hydrogen, and long-duration batteries; and Ramamoorthy Ramesh faculty with Physics and Materials Science and Engineering and founding director of DOE's SunShot initiative has identified the value and purposes of the data that could be generated by the project.

Strategic meetings are also on-going with leaders and staff of regional and state agencies, to both inform and explore potential partnerships. Meetings with the General Managers of Bay Area Rapid Transit (BART) and water utility, East Bay Municipal Utility District and the CEO of Pacific Gas & Electric (PG&E) have highlighted mutual interests and potential shared opportunities.

Finally, the energy system team has created a dedicated website for the project that will be continually updated as design and construction progresses.

Click here to

check out our clean energy website

cleanenergycampus.berkeley.edu

Community Engagement

Living Lab

From the outset, it has been recognized that the Berkeley Clean Energy Campus initiative is not only a transformative infrastructure project but also a profound opportunity for research and learning

Berkeley's new clean energy system presents a unique opportunity for students, faculty, and other researchers to both contribute and advance their knowledge in renewable energy, project finance, and other fields. The initiative is focused on including the campus brain-trust in the system design and continued discovery during the entire lifespan its operations. The intention of a BCEC living lab is to build mutually beneficial project partnerships between the energy operations and the research and teaching enterprises.

During the spring of 2024, UC Berkeley will continue exploring other research and learning opportunities through a series of stakeholder engagement efforts with faculty, staff and students. These initial ideas will be integrated into the design of the infrastructure and plant to help enable future collaborations.

In 2022, a UC Berkeley team led by Civil Engineering professor Kenichi Soga in partnership with the Office of Sustainability applied for U.S. Department of Energy funds to develop campus geothermal energy storage potential that would support the Berkeley Clean Energy Campus project's heating system. While UC Berkeley did not receive the funding, the campus application process developed equity-focused partnerships with campus groups such as the Labor Center Green Economy Program, the Building Efficiency for a Sustainable Tomorrow (BEST) Center, along with scientists and engineers from Lawrence Berkeley National Laboratory that will be utilized in future grant applications.

The thermal properties below campus are well-suited for implementing a Ground Source Heat Pump system

UC Berkeley Civil and Environmental Engineering Professor Kenichi Soga led a research project digging a 400-foot borehole near University House on campus and found that the thermal properties below campus are well-suited for implementing a Ground Source Heat Pump system. The research also found that conducting deep borehole drilling on campus is a relatively straightforward process due to the soil profile.

This research helped lead to the BCEC to include geothermal heat exchange into the design of the new energy system.

Link to Berkeley News article

Community Engagement

Just Transition

UC Berkeley is committed to a **just transition** for the BCEC project, which entails ensuring that the shift to a low-carbon economy is **fair**, **inclusive**, and **equitable** for workers and communities impacted by the transition.

The university recognizes that as certain industries or technologies contributing to climate change are phased out, workers in those sectors may face job displacement. Additionally, communities dependent on these industries may encounter economic hardships.

A just transition approach aims to support affected workers and communities by providing retraining, reskilling, and job placement assistance. It also focuses on creating new economic opportunities in clean energy sectors. This approach ensures that workers and communities can actively participate in and benefit from the emerging green economy. UC Berkeley recognizes decarbonizing the campus energy systems will require upskilling and changes to existing jobs and will create new positions and opportunities for staff. The university is dedicated to ensuring that there is a net gain for employment opportunities resulting from the implementation of the BCEC and that those opportunities are equitably distributed.

Throughout the winter and spring of 2024, UC Berkeley will be assessing the labor and equity impacts of the BCEC through research and stakeholder engagement. Listening sessions and focus groups will be held to hear from staff on the ground most impacted by the transition as well as leaders across the campus engaged in climate and environmental justice issues. Lessons learned from this process will inform equity indicators that will be used to track implementation and ensure goals are met for job creation and community **co-benefits**.

The campus is also committed to promoting and increasing participation of Small Business Enterprises (SBEs) and Disabled Veteran Business Enterprises (DVBEs) in purchasing and contract business, subject to any applicable obligations under state and federal law, collective bargaining agreements, and university policies. The campus regularly communicates with interested contractors and consultants to provide information about finding opportunities to work at the campus and encourages them to respond to the annual announcement soliciting interest to perform services. Providing qualified SBEs with the maximum opportunity to participate will be encouraged with the selected design professionals and contractors to meet 25 percent participation. Additionally, as part of the Inflation Reduction Act tax credit program, construction contracts will include prevailing wage (something the UC system already requires) and contracting with firms that offer apprenticeship programs.

UC Berkeley's commitment to a just transition further reinforces the university's dedication to social responsibility, environmental stewardship, and sustainability. By prioritizing fairness and inclusivity, the project can set an example for other initiatives and contribute to a more equitable and sustainable future for all.

Next Steps

Next Steps

The next steps for the Berkeley Clean Energy Campus initiative will include the following:

- Finalize project design
- Secure funding
- Begin construction on Phase 1
- Install distributed energy resources
- Decommission existing cogeneration plant

Multiple make-ready projects will be undertaken during Phase 1 to accommodate increased electrical demand and eventual central cooling towers. In 2024, the project will enter design to develop a detailed plan for the initial build-out of the BCEC, with construction expected to begin in 2025.

The Berkeley Clean Energy Campus initiative puts the campus on track to meet its carbon reduction goals, while also renewing and increasing the resilience, consistency and efficiency of the energy infrastructure. The multifaceted benefits and solutions of the initiative also include expansion of research and learning opportunities and support for the green labor transition.

Benefits

The benefits of the Berkeley Clean Energy Campus can extend beyond campus:

the initiative will serve as a model, demonstrating the transition to a clean energy system on the scale of a medium-sized city.

In addition, the BCEC will generate hundreds of regional construction jobs at the prevailing wage. The project will also facilitate training programs and apprenticeships for those who are interested in transitioning from traditional infrastructure and building-related trades to segue into skilled green-energy jobs. UC Berkeley intends to share its BCEC journey with others seeking to rapidly decarbonize and to demonstrate to the world that meaningful, large-scale solutions to climate change are doable when a community is committed to the task.

Acknowledgements

Acknowledgements

UC Berkeley would like to recognize the following groups and people for their contribution to the Integrated Resource & Activation Plan (IRAP) for the Berkeley Clean Energy Campus initiative.

With a special thanks to three generous donors who funded the IRAP – in the interest of helping UC Berkeley find the pathways to implement deep and transformational carbon reduction solutions. And to Chancellor Carol T. Christ for her leadership and prioritization of Berkeley's decarbonization efforts.

UC Berkeley

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- Ashok Gadgil, Professor, Civil Engineering
- Ben Hermalin, Executive Vice Chancellor and Provost
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UC Berkeley Chancellor's Advisory Committee on Sustainability - CACS (2022-2024) Link to more info

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This report was prepared by JLL for UC Berkeley as a synthesis of prior reports, research and work that has been put into the Berkeley Clean Energy Campus Integrated Resource & Activation Plan (IRAP)

Appendix

- Glossary
- Affiliate Engineers, Inc. - Berkeley Clean Energy Campus Integrated Resource & Activation Plan (IRAP)

Glossary

Advanced Utility Controls – sophisticated systems that enable precise monitoring and optimization of various utility functions within a building, leading to improved energy efficiency, cost reduction, and occupant comfort.

Battery Energy Storage Systems – the technology of storing electrical energy in batteries, allowing it to be used later and providing backup power during outages or peak demand periods.

Cap-and-Trade – market-based mechanism that aims to reduce greenhouse gas emissions by establishing a cap on the total emissions allowed and enabling the trading of emission allowances between companies to incentivize emission reductions. This is a key component of California's approach to greenhouse gas reduction, which limits emissions from certain industries.

Climate Change – change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and natural climate variability over time.

Co-Benefits – additional positive outcomes that result from implementing actions related to decarbonization planning.

Cogeneration Plant – facility that simultaneously generates electricity and steam for the UC Berkeley community by using natural gas as its fuel source.

Cooling Towers – large structures used in industrial and commercial settings to extract heat from process or HVAC (heating, ventilation, and air conditioning) systems by allowing water to evaporate, thereby cooling the circulating fluid and facilitating efficient heat transfer.

Critical Loads – essential electrical equipment and systems within a facility that must be continuously powered.

Distributed Energy Resources (DERs) – small-scale power generation and storage technologies, such as solar panels, wind turbines, fuel cells, and batteries, that are deployed close to the point of consumption, providing alternative energy sources and a more decentralized and resilient energy system.

Fuel Cells – electrochemical devices that convert the chemical energy from a fuel, such as hydrogen, into electricity through a reaction with oxygen, offering a clean and efficient alternative to traditional combustion-based power generation.

Geothermal – relating to or utilizing the heat of the earth's interior.

Geothermal Heat Exchange – system that utilizes the consistent temperature of the ground or water beneath the Earth's surface to provide heating and cooling for buildings.

Greenhouse Gas (GHG) Emissions – gases in the atmosphere that absorb radiation causing the planet's surface to warm to a temperature above what it would be without its atmosphere. The primary greenhouse gases in Earth's atmosphere are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Green Hydrogen – hydrogen produced through the process of electrolysis using renewable energy sources.

Glossary

Heat Pump – device that transfers heat energy from one location to another by utilizing energy input, typically electricity, to move heat from a colder environment to a warmer one.

Heat Recovery Chillers – HVAC systems that simultaneously provide cooling and utilize waste heat generated from the cooling process for supplemental heating or other applications, improving energy efficiency by recovering and repurposing heat.

Heat Recovery Technologies – systems and processes that capture and reuse waste heat generated by industrial processes, HVAC systems, or other sources, converting it back into useful energy for heating, cooling.

Inflation Reduction Act (IRA) – significant piece of climate legislation, introduced in 2022, offering funding, programs, and incentives to drive and accelerate the clean energy transition.

Just Transition – equitable approach towards greening the economy in a way that is as fair and inclusive to everyone involved, ensuring fair treatment and opportunities for affected workers and communities.

Living Lab – the use of campus as a living laboratory which integrates the academic and operational spheres of the university. This philosophical approach benefits the research and educational mission of the University of California and creates experiential learning and applied research opportunities, while enhancing the campuses' ability to address real world sustainability challenges.

Microgrid – localized and independent electrical system that can operate autonomously or connect to the larger power grid, incorporating renewable energy sources, energy storage, and advanced control technologies to provide reliable and efficient power.

Power Purchase Agreement (PPA) – long-term electricity supply agreement between the power producer and customer in which a third-party developer installs, owns, and operates an energy system on the customer's property.

Scope 1 Emissions – direct emissions generated from the campus cogeneration plant, purchased natural gas, emergency generators, campus fleet, and emissions from refrigerants.

Scope 2 Emissions – indirect emissions, such as purchased electricity.

Scope 3 Emissions – indirect emissions from sources not owned or directly controlled by an institution, but related to the institution's activities, such as business travel and commuting.

Social Cost – comprehensive economic and societal impacts arising from a particular activity or decision, considering not only direct financial costs but also broader considerations such as environmental degradation, public health effects, and social inequalities.

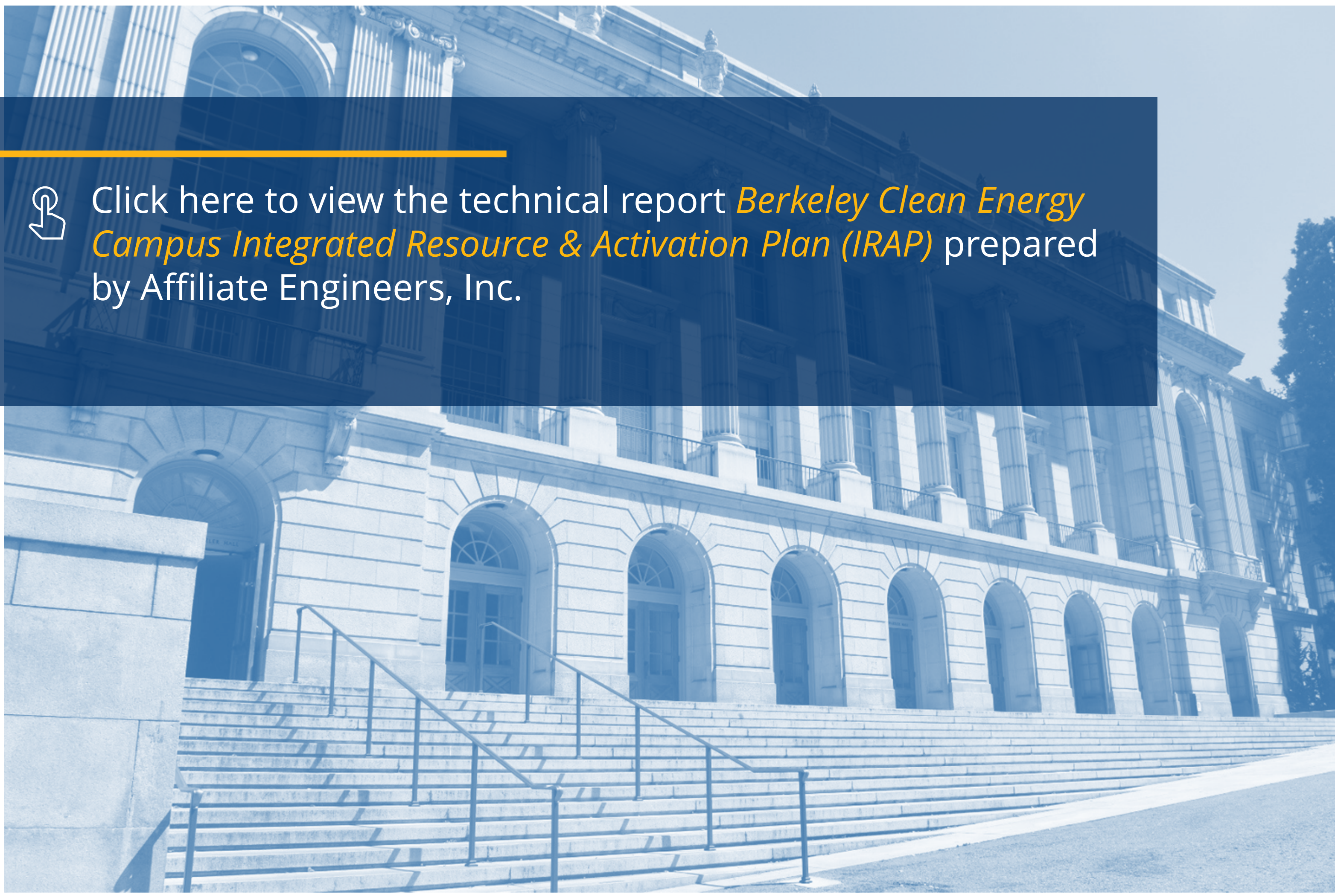
Solar Photovoltaics (PV) – clean energy technology that converts sunlight directly into electricity, commonly in the form of solar panels.

Substation – component of electrical power systems that transforms high-voltage electricity from a transmission system into lower voltages suitable for distribution to consumers.

Thermal Energy Storage – process of capturing and storing thermal energy during times of excess or low demand, and then releasing it when needed for heating, cooling, or other thermal applications.

Water-to-Water Heat Pumps – HVAC systems that transfer heat energy from a water source and use it to provide heating and cooling for buildings or to supply hot water.

Affiliate Engineers, Inc. Report



Click here to view the technical report *Berkeley Clean Energy Campus Integrated Resource & Activation Plan (IRAP)* prepared by Affiliate Engineers, Inc.

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