



Using Direct Decarbonization Strategies to Plan for a Resilient and Fossil Fuel-Free Future

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Article Info

Received:

05 June 2024

Accepted:

17 October 2024

Published:

22 October 2024

DOI:

10.14710/jsp.2024.25050

Presented in the 10th International Workshop on UI GreenMetric World University Rankings (IWGM 2024)

Abstract. UC Davis has a vision for a fossil fuel-free future. The university released the Fossil Fuel-Free Pathway Plan (FFFPP) to address the climate crisis by reducing Scope 1 and Scope 2 greenhouse gas emissions. The FFFPP outlines strategies to eliminate 95% of fossil fuel use, based on 2019 levels, from university operations by 2040. The plan includes the Davis campus, UC Davis Health, Aggie Square, Tahoe Environmental Research Center, Bodega Marine Laboratory, and multiple outlying and leased properties. UC Davis has already broken ground on the Big Shift, a fossil fuel-free conversion project that will allow the campus to heat buildings with electricity rather than natural gas and reduce the Davis campus's fossil fuel consumption by 80%. The FFFPP aligns with broader climate goals and initiatives set by the University of California (UC). The Pathways to a Fossil-Free UC Task Force was created to investigate the challenge of accelerating efforts to decarbonize each UC campus. To further support these efforts the UC recently adopted stronger climate action goals that prioritize direct emission reductions. UC Davis participates in the UC President's Bonnie Reiss Leading on Climate Student Fellowship Program, which funds student-generated projects that reinforce the UC-wide climate action goals. UC Davis students in the program are playing an important role in climate resiliency on campus.

Keyword:

Climate, Decarbonization, Environmental, Fossil Fuel Free, Justice, Transition, Resiliency

1. Introduction

The University of California, Davis (UC Davis) has a legacy of climate action catalysed by operational necessity, student activism and system-wide collaboration. In 2023, UC Davis published the UC Davis Fossil-Fuel Free Plan (FFFPP), an ambitious plan identifying a series

of potential solutions to drastically reduce fossil fuel energy consumption on the UC Davis campuses, and has completed Phase I of The Big Shift project, a multi-phase energy infrastructure project that ultimately converts the campus's heating system from steam to hot water and significantly reduces the Davis campus' reliance on fossil fuels [1,2]. This paper explains the pathways by which the need for direct decarbonization at UC Davis was identified and the catalysts that led to the development of the FFFPP. The processes of creating the FFFPP and conducting decarbonization studies are reviewed.

1.1. A Legacy of Climate Action at UC Davis

A brief look at UC Davis campus history demonstrates how the need for expanded operational campus infrastructure, the inertia of student engagement and advocacy, and ambitious University of California (UC) systemwide policies and goals have all combined to produce the right circumstances for notable achievements and leadership opportunities in sustainability for UC Davis.

UC Davis was established as an agricultural extension campus for UC Berkeley in 1908; referred to as the University Farm. In 1959, UC Davis was designated an independent general campus of the University of California system. As UC made this transition and began to quickly expand, its' infrastructural needs began to progressively outstrip the infrastructural capacity of many of the municipal utilities available in the small rural agricultural town of Davis, California. The campus grew faster than the City of Davis creating a clear need for campus owned and operated utilities [3]. Today UC Davis consists of 5 primary facilities, with its largest campuses in Davis and Sacramento, an outlying coastal research station Bodega Marine Laboratory, an alpine research center Tahoe Environmental Research Center, and several other outlying centers, laboratories and properties scattered across California. Due to its size, population, and operational control of multiple utility systems the academic campus located in Davis frequently draws significant parallels to the operational demands of a small- to mid-sized United States city, operating its own wastewater treatment plant, central heating and cooling plant, a large solar farm, and a bus system that services the campus and City of Davis.

Students have shaped the campus and its sustainability policies while utilizing the campus as a living laboratory. The UC Davis Arboretum, a 100-acre area along the Putah Creek Riparian Reserve with over 22,000 species of trees and plants, was initially established to assist the University's mission of teaching and research. In the 1930s UC Davis students planted the first redwood trees in the arboretum, and now students can acquire hands-on leadership experience and an understanding of environmental sustainability by participating in the Arboretum and Public Garden's Learning by Leading program [5, 6]. Students helped form Unitrans, the campus and city bus system and to this day many of buses ridden every day are driven by student-employee bus drivers [7]. An initiative led by UC students and the California Student Sustainability Coalition resulted in the creation of the first iteration of the UC system-wide sustainability policy, establishing a plan adopted by all of UC that tackles many areas, including energy efficiency, climate action, waste reduction, and sustainable procurement [8]. Most recently, UC Davis students voted to continue dedicating a portion of their student fees to The Green Initiative Fund, a sustainability funding program to provide financial support for sustainability related projects on campus [9]. Student involvement and advocacy have contributed significantly to creation of learning opportunities and sustainability progress on our campus.

As one of the ten campuses making up the UC system, UC Davis is governed by the UC-

wide sustainable practices policy, whose origin is partially the result of agitation by UC students. The policy, referred to as the UC Sustainable Practices Policy, is robust, ambitious, and continually revised and updated with best practices that reflect current research and thinking on climate change mitigation [10]. Each UC campus plays a role in policy revision and approval from each campus is required before policy updates are able to move forward. The UC policy on climate action was first added in 2006 and has gone through several iterations since. In a prime example of how this Policy continues to evolve in response to current research, best practices, and acknowledgement of the state of the climate crisis, prior to the most recent update in 2023 the climate action section previously prioritized net zero greenhouse gas emission strategies. The climate action policy called for all campuses to “maintain greenhouse gas emissions at or below 1990 levels”, “achieve climate neutrality from scope 1 and 2 sources by 2025,” and “achieve climate neutrality from specific scope 3 sources” [12]; goals that relied heavily on the acquisition of carbon offsets to be successful. These climate action targets aligned with the UC Carbon Neutrality Initiative (CNI), a commitment by the UC to produce net zero carbon emissions for Scope 1 and Scope 2 sources. Discussed in more detail later in this paper, today the policy has markedly migrated away from offsets as a solution and climate neutrality as a goal. The UC-wide approach and commitment to climate targets has allowed for system level support from the UC Office of the President to aid in climate efforts on each individual UC campus.

Table 1. Priorities Contributing to Impactful Climate Solutions at UC Davis: Then and Now

Priority Area	Historical Priorities (1908-2022)	Current Priorities (2023-2024)
Operational Needs	The UC Davis campus grew faster than local City of Davis infrastructure could support resulting in the need for campus owned and operated infrastructure, as well as strategic campus/city partnerships.	Aging and inefficient steam-heating system reaching end of life, in need of repair or replacement with more sustainable efficient system.
Student-Led Activism	UC Students lobbied for creation of system-wide sustainability guidelines, ultimately leading to UC Sustainable Practices Policy.	UC Green New Deal, a student led movement lobbied against carbon offset over-reliance and called for a greater focus on direct decarbonization.
Institutional Initiatives	UC campuses worked collaboratively to create the UC Sustainable Practices Policy including specific targets on climate action; continually updating and refining policy to reflect evolving research and best practices	UC campuses worked together to revise the climate action section of the policy to reflect new emphases on direct decarbonization
Climate Action Results	#1 Greenest University in the U.S. & 24% reduction in GHG emissions from 2009-2022	Fossil-Fuel Free Pathway Plan & completion of Phase I of The Big Shift

These unique historical characteristics have allowed UC Davis to assume a leadership role in climate action and sustainability within the higher education. The campus maintains a gold-rating in the Sustainability, Tracking, Assessment, and Rating System (STARS) and is acknowledged as the #1 Greenest University in the U.S. (#5 in the world) by the GreenMetric World University Rankings [13]. Greenhouse gas emissions from university operations have been cut by 24% compared to 2009 [14]. Overlap of three priorities – operational need, student-led activism, and institutional initiatives – have contributed to this leadership role.

1.2. Distinct and Intersecting Priorities Catalyze Climate Action

The historical and systematic context of climate action at UC Davis in parallel with more recent on-campus climate actions demonstrates how strategic prioritization efforts have catalyzed impactful climate solutions in place today. Table 1 displays historical climate actions alongside climate actions currently in place to emphasize the distinct role each priority plays and how they cooperate to contribute towards greenhouse gas emission reductions strategies, including an emphasis on direct decarbonization and the recently published Fossil Fuel Free Pathway Plan.

2. A Case for Direct Decarbonization

To understand how the need for direct decarbonization led to the development of the FFFPP, it is important to first recognize how direct decarbonization aligned with other operational, cultural, and strategic priorities. A discussion of the current scenario involving (1) an aging campus steam-heating infrastructure, (2) student climate advocacy for ending reliance on carbon offsets, and (3) development of a new UC-wide climate policy will examine how these three priorities led to direct decarbonization as a solution and the FFFPP process.

2.1. Operational, Student-Led and Institutional Initiatives Intersect to Catalyze Results

UC Davis owns and operates the Central Heating and Cooling Plant (CHCP), which is located on the core campus and distributes energy to buildings across campus. Natural gas is used to fuel boilers in the CHCP to create steam. The steam generated by the boilers travels through underground pipes across campus in order to heat buildings [15]. With some sections being as much as 75 years old, the steam-heating system had been approaching the end of its useful life cycle for some time. Many pipes in the system leaked significant amounts of steam resulting in poor performance and highly inefficient heating and cooling systems, particularly in older buildings and areas of campus furthest from the steam boilers. Internal evaluation by UC Davis' Facilities Management engineers and utility managers yielded the clear decision that the existing heating system would need to be renewed and initiated an evaluation of a series of strategies for renovation or replacement of the heating system.

This investigation conducted by both internal operational partners and external independent consultants determined that among all the evaluated solutions, the most viable solution was both the second most cost effective and would facilitate an eventual conversion from a natural gas-powered system to a fully electrified system. This strategy allowed a full conversion of the heating system from using steam to using low-temperature hot water but would ultimately demand less fuel and water to operate and ultimately save on long-term maintenance costs as well [16].

Such a construction project would be messy, requiring the campus to dig trenches, rip out old pipes, and install new pipes all while maintaining operations for a campus with over 48,000 daily visitors. To communicate the scale of this infrastructure overhaul to the campus community, the project became known as the Big Shift. More information about the Big Shift can be found at <https://bigshift.ucdavis.edu/>. The Big Shift represents one of three initiatives described in this scenario.

The second initiative reflects appeals presented to campus leaders as a result of student climate advocacy for ending reliance on fossil fuels. Students have long been encouraging and demanding advancements in UC climate work. They played a role in the establishment of the system-wide sustainability policy and continue to participate as agents of change in programs like the UC President's Bonnie Reiss Climate Action Fellowship program, which financially supports projects aligned with UC climate goals carried out by students [17]. The Climate Action Fellowship program was born out of the UC Carbon Neutrality Initiative (CNI), an initiative established by the UC Office of the President committing the UC to carbon neutrality for Scope 1 and Scope 2 emissions.

In 2020 the UC Green New Deal (UC GND) coalition, made up of UC students and faculty, was established to organize campaigns urging the UC to move away from the use of fossil fuel and carbon offsets [19]. One of the first actions of the coalition was to create a petition for UC to take action on the UC GND platform. At UC Davis, in addition to the UC Green New Deal and other organizations, the Fossil Free UCD, a coalition of students, staff, and faculty has continuously advocated strongly for several goals, including a commitment from UC Davis leadership to divest both financially and operationally from the use of fossil fuels [18].

The third initiative exists in the form of an institutional effort to adopt stronger, science-backed targets for mitigating climate change. In July 2023 the UC announced new climate action goals that focus on direct decarbonization and severely curtail the use of carbon offsets. This update to the UC Sustainable Practices Policy was the result of a process occurring across several months and involving UC climate experts, sustainability officers, campus leadership and forums to facilitate stakeholder feedback. Under the updated policy, UC campuses are required to "reduce total greenhouse gas emissions by 90 percent by 2045, with 2019 emission levels as a baseline, and negate any residual GHG emissions through investments in carbon removal projects". The 2045 emissions targets override and supersede the goals previously outlined in the UC Carbon Neutrality Initiative for which the UC would have had to rely on a significant amount of purchased carbon offsets to achieve carbon neutrality by 2025 [20]

Operational, student-led and institutional priorities all point to direct decarbonization as the most effective solution for climate emissions reduction. The Big Shift construction project would reduce fossil fuel consumption on the Davis campus by 80% and cost less over time than completing the necessary repairs to maintain the current steam-heating system [21]. After UC Green New Deal coalition campaigns and the allocation of state resources towards the exploration of decarbonization solutions, the UC Office of the President designated \$10 million to be distributed across all UC campus for the development of electrification plans and founded the Pathways to a Fossil Free UC Task Force in October 2022 [19]. The purpose of this task force is to analyze challenges related to campus decarbonization by developing recommendations for next steps to eliminate fossil fuel use that consider both operational and climate justice and equity goals [22]. The new UC climate action policy requires UC campuses to fully decarbonize by 2045 and allows the UC to utilize

funds that would have gone towards carbon offsets (\$20-\$30M per year system wide) for campus efforts to cut carbon emissions [20]. Direct decarbonization was identified as the most impactful solution for real greenhouse gas reduction in university operations.

2.2. Understanding How to Decarbonize

Once direct decarbonization was collectively established as the way forward, the remaining challenge is to figure out what solutions best combine to achieve this goal. In 2021 the UC Davis Chancellor established the Campus Advisory Committee on Sustainability (CACS) and charged the committee to prepare a plan for how UC Davis could potentially end fossil fuel use on our campuses [23]. The CACS embarked on a multi-year process to fulfill the charge, publishing the final version of the FFFPP in December 2023.

Although the Chancellor's directive came prior to the UC Green New Deal 2022 campaign and the new UC climate action targets, the entire process of the FFFPP creation was an iterative one. Student activism and institutional priorities helped solidify and shape the plan along the way. UC Davis has had the privilege and the burden of defining how to decarbonize university operations and serve as a model for similar efforts at many other higher education institutions.

In addition to the UC Davis Chancellor's charge, the Pathways to Fossil Free UC Task Force, directed by the UC Office of the President, developed instructions for conducting state-funded decarbonization studies in order to further investigate how all UC campuses can transition to fossil free. All UC campuses are required to complete a set of deliverables as a part of the process. For UC Davis, the FFFPP fulfills a large portion of the deliverables required.

The FFFPP was released by UC Davis to address Scope 1 and Scope 2 greenhouse gas emissions. The document outlines strategies to eliminate 95% of fossil fuel use, based on 2019 levels, from UC Davis operations by 2040. Covering all 6 UC Davis locations, including the Davis campus, the UC Davis Health campus in Sacramento, Aggie Square, Tahoe Environmental Research Center, Bodega Marine Laboratory, and outlying campuses; the FFFPP is the earliest plan for a multi-campus UC [21].

UC Davis has already begun work on implementing strategies from the FFFPP. Phase I of the Big Shift project reached completion in early 2023 and the campus committed \$55.5 million to the next phase of the construction project [26]. Although a pathway for financing the completion of the Big Shift in its entirety remains to be identified, the initial phases of the project serve as a model for other fossil fuel-free conversion projects.

3. Building a Pathway to Fossil Free

The published FFFPP contains a series of stacked solutions that if fully implemented in aggregate would allow UC Davis the potential to eliminate 95% of greenhouse gas emissions from fossil fuel usage by the year 2040. This pathway plan addresses primarily technical solutions associated with decarbonization implementation. In contrast, the completion of the UC Davis state-funded decarbonization study will address several other additional key considerations necessary for evaluating the implications of the full decarbonization transition. This section will review the process of creating the FFFPP and conducting the decarbonization studies.

3.1. The Five Deliverables

As a part of state-funded decarbonization studies, the Pathways to a Fossil Free UC Task Force defined the scope of work required by each UC campus for completion of individual campus decarbonization studies. This guidance outlines five deliverables necessary to accomplish the goal of examining the feasibility and strategies necessary for evaluating how to electrify campus operations. For UC Davis, the FFFPP accomplishes a large proportion of the deliverable goals. Table 2 summarizes all five deliverables and identifies the portion of each accomplished by the FFFPP. Since the development of the FFFPP coincided with the creation of the scoping guidance, there was no model in place for UC Davis to follow in the creation of the plan. Instead, UC Davis has had the privilege of serving as a model for other campuses.

Table 2. UC Davis Deliverables for the Decarbonization Studies Addressed by the FFFPP

#	Deliverable	FFFPP Accomplishes
1	Strategy for >90% reduction in Scope 1 from fossil fuels	Fully accomplished
2	Estimates of total capital & operational costs/savings	Fully accomplished
3	Identify just transition of impacted workforce & equity considerations	Partially accomplished
4	Document gaps/studies needed & establish net-zero benchmark goals	Partially accomplished
5	Identify opportunities for aligning academic mission and operational goals	Not accomplished

3.2. Creation of the Fossil-Fuel Free Pathway Plan

By leveraging the institutional expertise of UC Davis staff and faculty, the FFFPP was able to be completed almost entirely without outside support. UC Davis did not enlist external consultants to develop the solutions and strategies articulated in the FFFPP. This unique opportunity to leverage internal subject matter experts allowed the true resident experts to share their deep institutional knowledge at all stages of the FFFPP development and writing process. This unique approach allowed for an unprecedented level of detailed familiarity among operational staff and stakeholders and has resulted in several instances of early implementation of strategies and solutions articulated in the plan. The plan was written internally by a team of campus subject-matter experts and planners, both staff and faculty, and its completion has positioned UC Davis as a leader in the UC and higher education decarbonization movement.

Development of the plan began in 2021 with the charge letter from Chancellor May assigning the CACS the role of spearheading the process [1]. Early parts of the process included the convening of stakeholders and enlisting operational and sustainability expertise. The first step of the process was to define a scope, creating a definition for what a fossil fuel-free future at UC Davis could look like, and developing a vision statement based on consensus from campus experts and stakeholders. Part of finalizing the scope of the FFFPP involved campus outreach in the form of town halls, tabling, workshops, film screenings, and publicly posted communication online and through email. In this way the

CACS was able to educate and collect feedback at multiple phases of the plan development process. Ultimately, the solutions articulated in the plan allow the authors to identify a target of "95% no fossil fuel use as measured annually for all UC Davis operations (Scope 1) and all UC Davis purchased utilities (Scope 2), against a baseline of 2019 fossil fuel use." As part of the scope, the plan would acknowledge the role of Scope 3 emissions for commuting and air travel and the need to develop improved tracking for other Scope 3 sources [1]. The following is the publicly posted vision statement on the FFFPP website [1]:

The UC Davis Campus Advisory Committee on Sustainability (CACS) envisions the Fossil Fuel-Free Pathway Plan for UC Davis will offer scenarios for tangible actions, with proposed dates and measurable goals, to achieve our definition of fossil fuel-free. The plan will thread equity and climate justice, and habitat health throughout our scenarios and planned actions to do right by the local and global communities we serve; will be adaptable and position the university for resiliency and to reduce financial, operational and reputational risk of continued dependence on fossil fuel-based energy systems. The technologies to electrify and decarbonize exist now and the CACS envisions a phased planning process that retains the flexibility to incorporate new scientific insights and technological advances; and reflects applicable laws and policies, and established global commitments and social and cultural shifts around the climate emergency. This plan will continue to evolve with these new inputs and information.

From 2022-2023 the CACS conducted analyses of available data from climate research and inventories on campus energy and natural gas usage. Shifts in technology, operations and management were considered. Specific chapters were assigned to relevant campus experts. By mid-2023 a draft was finalized and shared with the campus and larger community as part of a public comment period lasting just over three months. Feedback was submitted through an online form and over 180 submissions from the community were collected. The CACS reviewed and incorporated community feedback prior to sharing the FFFPP with Chancellor May for review at the end of 2023.

In December 2023, a little over two years after the Chancellor's initial charge letter, the final version of the FFFPP was posted [21]. The plan contains a robust collection of solutions developed by the campus experts and individuals who would be ultimately responsible for implementing these solutions, allowing for increased alignment between what is possible and what is probably. The FFFPP truly articulates a viable pathway for UC Davis to become 95% fossil fuel-free and continue to make strides in the elimination of fossil fuels.

3.3. The Decarbonization Studies

The FFFPP accomplishes approximately more than half of the five deliverables set forth by the Pathways to a Fossil Free UC Task Force and partially accomplishes the remaining deliverables. Throughout the 2023-2024 academic year, the campus has continued to work on contributing to the remainder of the deliverables as a part of the state-funded decarbonization studies.

Deliverable 3 of the decarbonization studies requires UC campuses to "identify climate justice and equity considerations related to the transition of campus/health system energy systems to fossil fuel free and propose solutions or next steps to identify solutions" [27]. In order to address this deliverable, UC campuses are working with a consultant to develop and evaluate equity indicators on transition impacts and opportunities. These equity indicators will integrate key climate and environmental justice concepts related to decision-making procedures; recognition of different values as they relate to culture, opinions, and

community structures; distribution of resources; and just restoration.

The process for equity indicator identification began with holding campus stakeholder listening sessions to gather input on equity issues. The results of the listening sessions and additional research led to the development of draft equity indicators. The UC Sustainability and DEIJ Working Group as well as other relevant groups reviewed and further refined the draft indicators. The current draft outlines a multi-phased process that emphasizes the importance of establishing an understanding of environmental justice resources in order to build capacity for more successful climate justice action and tracking of progress.

In addition to just transition work, UC campuses have been working on the beginning stages of developing resiliency plans for their individual locations, which will support a component of Deliverable 4 focusing on equity-centered climate resilience. UC Davis is working with student Climate Action Fellows to have them lead the process and learn firsthand about community and stakeholder engagement. Throughout the 2023-2024 academic year the student fellows have been working together to plan, conduct, and analyze community and stakeholder engagement sessions at UC Davis. The sessions seek participant feedback on perceived climate risks and impacts. The student-facilitated sessions gather important data that will lay the groundwork for continued UC Davis resiliency planning. Fellows are also playing the important role of developing processes for community engagement on a topic that is difficult to discuss and historically has not been addressed in operational planning.

3.4. Next Steps

Now that the pathway forward provided by the FFFPP has been established and the initial leg work on addressing the remainder of the deliverables has begun, plans for UC Davis include completing the full scope of decarbonization studies. Feedback gained from the decarbonization study process will assist in the revision of the UC Davis Climate Action Plan by 2026, aligning with the UC Sustainable Practices Policy.

In the meantime, the campus has kept its focus on the implementation of decarbonization solutions, including the Big Shift. At time of publication UC Davis has already invested over \$111 million in the Big Shift, a large-scale construction project that will bring the Davis campus most of the way to ending fossil fuel reliance. The campus has developed a master plan for full campus conversion, district by district, from steam to hot water for the heating system. The first phase of the Big Shift conversion project has recently been completed and is already yielding unanticipated operational savings due to high efficiency improvements yielded by the conversion. UC Davis looks forward to completing Phase II of the project, which is underway. This next phase of the project will update buildings in a district of campus that includes student residence halls and the large campus recreation center. After the completion of Phase II, natural gas usage at the CHCP will be reduced by 10 percent. Natural gas will still be required to produce steam to heat buildings yet to be converted. In order to realize the full benefits of the Big Shift and entirely move away from natural gas for heating buildings, construction for all districts will need to be completed. The Big Shift focuses specifically on the Davis campus, while the FFFPP covers all UC Davis campuses. UC Davis campuses will continue to collaborate and leverage system-wide support to complete climate action plans that incorporate the new UC climate action goals while integrating environmental justice and resilience considerations.

4. Conclusion

The legacy of climate action at UC Davis, built from operational necessity, student-led activism, and institutional initiative, continues to be upheld by the campus's recently published plan that maps out strategies to end fossil fuel use on campus and serves as a model for the UC and other higher education institutions. With continued dedication and prioritization, as well as deeply engaged operational stakeholders invested in pursuing a sustainable future for our campus, the goal of achieving a decarbonized UC Davis is closer than ever.

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