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Can universities catalyze social innovation to support their own rapid decarbonization? Assessment of community and governance readiness at the University of California

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Universities aspire to lead on sustainable energy transitions, yet progress toward reducing their own emissions has been challenging. We assessed barriers and opportunities for engagement of University of California (UC) campus communities in stimulating more deliberate and rapid campus energy transformation, and our findings highlight the complexity of the socio-technical and governance systems that limit potential for transformative change for decarbonization. Through surveys, interviews, focus groups, and content analysis, we found strong interest among students, faculty, and staff in advancing decarbonization. We found a preference for local and on-campus solutions such as energy efficiency, behavioral change, renewable-energy production, and electrification, and much less support for market offsets and non-local investments. We also found that students and faculty had limited knowledge and sense of agency regarding campus-based decarbonization programs and options, which is consistent with the limited availability of data and information about these programs beyond the few who are directly involved. Weaving our findings with insights from social-innovation theory, we propose an action research agenda that conceives of university operations and governance systems as loci for socio-technical energy transition experiments. In alignment with higher education's long-standing commitments to catalyzing social innovation, opening university energy operations and governance to inclusive, community-led collaborative experimentation has strong potential to create the conditions necessary to produce the social innovation so desperately needed for energy system transformation within universities and beyond.

KEYWORDS

social innovation, third mission, decarbonization, energy transition, collaboratory, living laboratory, sustainability

Introduction

For decades, universities and other institutions of higher education have been looking to discover, design, and lead society along pathways to a sustainable future. Motivated by an ever-advancing understanding of dangerous climate warming, growing inequality, demographic pressures, biodiversity loss, biogeochemical interference (Steffen et al., 2011; Wiedmann et al., 2020; Dasgupta, 2021), and a desire to be centers for problem solving

and innovation, university leaders have initiated and collaborated on agreements and commitments to address climate change through actions by their institutions. Nevertheless, progress toward these goals has been slow and uneven, and often lacking in public accountability (Bekessy et al., 2003, 2007). Rapid and deep decarbonization across all sectors, including universities, will require transformation of sociotechnical systems through investments not only in technologies, but also in social change (Geels et al., 2017). This need for social innovation provides an opportunity for colleges and universities to play an important role in the global energy transition. By catalyzing the social innovation necessary to decarbonize their own operations, universities may also contribute scalable pathways to help reduce greenhouse-gas (GHG) emissions in other sectors (Ramanathan et al., 2016), thus fulfilling the desire for a leadership role for higher education in energy transitions.

While efficient and equitable economic and technical pathways to decarbonize the electricity sector have been clearly articulated (e.g., Williams et al., 2021), society's dependence on carbon-based energy necessitates not only technical advances, but also social innovation. A *social innovation* has been defined as a novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions, and is distinguished from business innovation in that the value created from its solution to a problem accrues primarily to society rather than to private individuals (Phills et al., 2008). Furthermore, for an innovation to qualify as a social innovation, it must be virtually impossible to exclude others from the benefits of the new idea, and the marginal cost of an additional person making use of the new idea must be zero (Pol and Ville, 2009). A true social innovation permanently alters the perceptions, behaviors, and structures that give rise to societal challenges, and contributes to changing the defining routines, resource flows, authority, or beliefs of the broader system into which it is introduced (Centre for Social Innovation, quoted in Pol and Ville, 2009).

Pressing societal problems such as global sustainability, rising inequality and associated humanitarian crises, together with universities' reliance on public funding to support many of their education and research programs, has led to growing expectations of universities to play a role in catalyzing or contributing to social innovation (Bayuo et al., 2020). Intentions to catalyze social innovation have recently come to be associated with the notion of a *third mission* for universities, often referred to as a *contribution to society*, and a complement to the core missions of teaching and research (Vorley and Nelles, 2008; Compagnucci and Spigarelli, 2020). While most third-mission activities to date have focused primarily on commercialization of innovations and technology transfer, there are growing demands for universities to fully incorporate social innovation not only into the goals of their third mission, but also in the way they organize resources, incentives and collaboration structures (e.g., Trencher et al., 2014; Fazey et al., 2018; Cinar and Benneworth, 2021).

Research and theory development related to social innovation have engaged a broad array of academic disciplines over the past several decades. While a universally agreed-upon definition of the concept remains elusive, the various disciplinary perspectives have highlighted a variety of important features that are relevant to how universities might play a role in social innovation processes. According to these scholars, an innovation is social when it (i) involves non-material elements such as processes, institutions, social behavioral patterns, and cultural, normative or regulative structures (Heiscala, 2007; Cajaiba-Santana, 2014; Choi and Majumdar, 2015; Howaldt and Schwarz, 2016); (ii) is developed through a process or mechanism that is inherently social (Mulgan et al., 2007; Mulgan, 2012; Grimm et al., 2013); (iii) involves collaboration among diverse participants (Mulgan, 2012; Ceschin, 2014); (iv) satisfies needs not taken on by markets (Pol and Ville, 2009); and (v) aligns with rhetorics of progress and justice (Mulgan, 2012).

The clear need to complement the technical innovations emerging from research with social innovations is thus both an opportunity and challenge for research universities (Miller et al., 2015; Geels et al., 2017; Hoppe and De Vries, 2018). Using the ten research universities that make up the University of California (UC) system as a case study, we examine opportunities to catalyze social innovation to support decarbonization of UCs energy use. In particular, we assess community and governance readiness for creating the types of institutional structures and changes that are likely to lead to the emergence of social innovation.

Study domain and context

Our study domain was the 10 universities in the University of California (UC) system. Recognizing the potential of universities to lead on sustainability, the UC president signed the American College and University Presidents Climate Commitment (ACUPCC) in 2007 on behalf of the 10 chancellors. With this pledge, universities across the United States and internationally pledged action on climate change, while promising to prepare students through research and education to "solve the challenges of the twenty-first century" (Dyer and Dyer, 2017). In 2013, UC launched the Carbon Neutrality Initiative (CNI), with a goal of achieving net-zero greenhouse-gas emissions for on-campus operations and purchased energy (Scopes 1 and 2 emissions) by 2025. The plan to meet the CNI goal relied heavily on offsets and biogas procurement, with continued energy efficiency, electrification, and renewable-electricity use (see Figure 1). By 2019, when our research was completed, nearly all of the campuses reported emissions that were still quite far from the goal (see Figure 2). In 2023, due to challenges with finding or creating suitably verifiable and cost-effective emissions reductions projects to generate the carbon offsets that would be needed to meet the CNI goal, UC pivoted strategy toward direct campus decarbonization and committed to invest in on- or near-campus decarbonization infrastructure and climate justice projects. Current UC goals are focused on Scope 1, Scope 2, and identified Scope 3 emissions for all campuses to 90% below 2019 levels by 2045. Since 2019 UC has been making its investment portfolios fossil free, given the financial risk associated with fossil-fuel assets (Bacher, 2019; https://www.ucop.edu/investment-office/).

Throughout UC efforts to reduce emissions, each campus has been largely responsible for defining its own path to

meeting emissions reduction goals. Decarbonization strategy and implementation on most UC campuses involves campus administrators, facilities, and sustainability staff, and engaged members of the faculty, staff and student communities. At the systemwide level, UCs Global Climate Leadership Council (GCLC), appointed since 2014 by the UC President, has been charged with increasing awareness of and engagement with campus emissions-reduction goals and programs. Comprised of administrative leaders from across the UC system, faculty, and student representatives, and outside advisors, the GCLC advises on achieving emissions reduction while also providing guidance for aligning decarbonization and other sustainability goals with UCs teaching, research, and public-service mission. Since 2022, a Task Force on Pathways to a Fossil Free UC has worked under the purview of the GCLC to advise the President and the 10 university Chancellors on accelerating progress toward decarbonizing the UC campus and medical-center operations, and with developing programs and recommendations that can overcome key structural, technical, resilience, organizational, financial, operational, land use, cultural, and legal barriers.

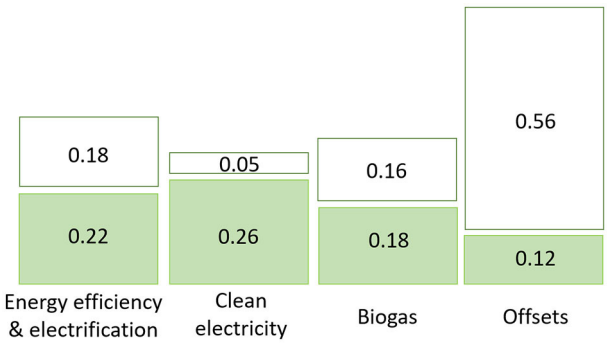

FIGURE 1
Emissions-reduction and offset projects completed since 2009 (shaded areas), and those planned through 2025 (open areas). Units are million metric tons CO_2 equivalent, aggregated across all UC campuses, and relative heights of boxes represent percent contribution to total reduction. Adapted from University of California Office of the President (2020). Note that in July 2023 the strategy and goals were updated, reducing use of offsets in favor of increasing near-term investments in direct campus decarbonization projects, with a goal of 90% reduction in Scope 1, 2, and 3 emissions by 2045.

Methods

We used mixed methods, collecting both qualitative and quantitative data through interviews, surveys, and content analysis, to gain insight into how the UC community perceives the issue of decarbonization, and what governance steps might be taken to better engage these campus communities in helping to achieve that goal. Data and details of questions and statistical analysis are available elsewhere (Bales et al., 2018).

Editorial content analysis

To understand what had been communicated to the UC community about decarbonization, we analyzed the content of online campus news stories that focused on energy, sustainability,

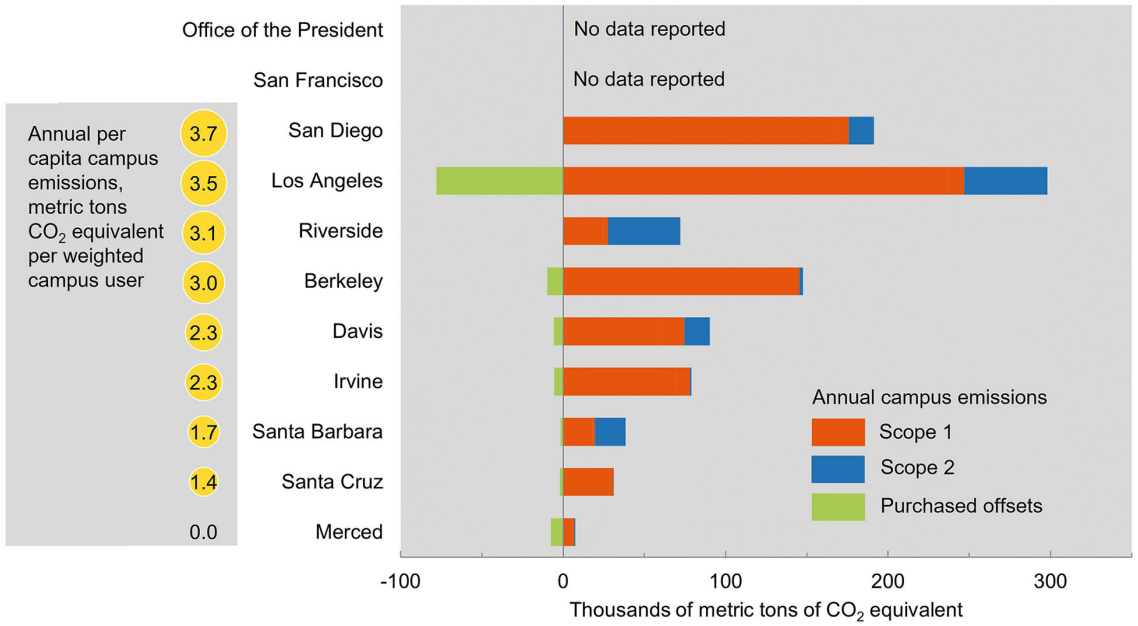

FIGURE 2
Most recent self-reported annual Scope 1 and Scope 2 greenhouse gas emissions for UC campuses (2018–2019). Note that Los Angeles, San Diego, Davis, and Irvine include medical centers. Data source: The Sustainability Tracking, Assessment and Rating System (STARS), Association for the Advancement of Sustainability in Higher Education. Data are for 2018 (Los Angeles, Davis) and 2019 (other campuses), https://reports.aashe.org/institutions/participants-and-reports/ (accessed November 25, 2022).

and decarbonization. This indicated how UCs Office of the President (UCOP) and the 10 universities within the system have communicated about decarbonization, and how UC communities may have been informed about the topic. Our search for news stories and press releases focused on collecting all online stories with themes relevant to decarbonization that were published between January 2016 and March 2017 by campus-based sustainability offices and public-communication offices. Our initial search using potentially relevant index terms yielded 1,058 sustainability-centered articles, from which we found 356 unique articles. Of these, 240 were randomly selected and analyzed to identify the main, overarching categories using an open-coding process (Rubin and Rubin, 2005).

Administrator interviews

We conducted semi-structured interviews with 30 decision makers across campuses, including high-level staff and administrators in sustainability, facilities, utilities, energy management, and capital planning, to gain insight into their perceptions of costs and benefits of implementing decarbonization goals, thoughts on effective communication and engagement, and opinions about the ideal role that UCOP should have in helping each campus achieve their decarbonization goals. Questions focused on eliciting interviewees' views on: (i) competing priorities and other barriers to achieving decarbonization as well as key opportunities for progress; (ii) existing organizational structure, roles, and internal communication relevant to decarbonization; (iii) promising decarbonization strategies and tradeoffs associated with those strategies; (iv) prevailing attitudes toward decarbonization among campus stakeholders; (v) current and previous communication and outreach efforts focused on decarbonization; and (vi) burden of responsibility for action, as well as resources that could support effectiveness of their own actions.

Faculty surveys and interviews

We did in-depth and broad-scale research on faculty opinions and perceptions through a survey. Questions were designed to elicit information about decarbonization-relevant attitudes, behaviors, and values, willingness to accept trade-offs to achieve decarbonization, and preferences for possible strategies their campuses could pursue to achieve the goal. We complemented this with a small number of semi-structured interviews to explore the context for faculty attitudes and preferences, and engaged interviewees in conversation about university decision making. We estimate that the invitation to participate reached over 44,000 email addresses via campus listservs, with 3,396 faculty members choosing to participate and 2,427 finishing the entire survey. The survey solicited information across a broad range of topics divided into 10 blocks, with each participant randomly assigned to complete five blocks, plus the demographic information, creating an ∼10-min survey for most participants. Our self-selected sample was reasonably reflective of the gender and disciplinary focus of UC faculty, but substantially more White/European American than the UC system overall (77 vs. 58%, respectively).

Student surveys, workshop, and focus groups

We gathered data on UC students' knowledge, attitudes, and behaviors toward decarbonization through: (i) a general survey on knowledge, attitudes, and willingness to engage with decarbonization, (ii) a survey of members of the Associated Students of the University of California government group to uncover barriers to action through a student-government resolution, (iii) focus groups with environmentally engaged students at two campuses to explore student identities, values, attitudes, and motivations, and (iv) a workshop for carbon-neutrality student fellows and interns that provided insights on the kinds of support these highly engaged students were looking for as they worked to become successful agents for change. Because the response rate for the survey was very low, and we received considerably more responses from some campuses than others, results may not be representative of the typical student across the UC system or within any individual campus. Rather, results may reflect those students who are most likely to be involved with on-campus efforts to achieve decarbonization. Our other research methods also focused on student activists and leaders whose level of involvement in the issues under consideration may be quite different from the average student.

Results

Each study component was designed to explore specific aspects of campus decarbonization with different segments of the campus community. In this section, we summarize results, contrasting and integrating perspectives across different segments of the campus communities. These results provide insights into key institutional challenges for UC as well as community and governance readiness for energy system transformation.

Finding 1: existing institutional commitments are perceived to pose significant challenges for campus decarbonization

Existing carbon-based energy infrastructure

As reflected in UCs campus-based Climate Action Plans, achievement of the 2045 decarbonization goal will require phaseout of most campus combustion of natural gas (Figure 2). Replacing natural-gas cogeneration plants before the end of their useful life, e.g., through electrification, will require significant capital investments, retiring of facilities campuses are still paying for, and rethinking heating, cooling, and electricity use.

Many of the faculty we interviewed expressed concern about how campus facilities and operations are currently managed, and they expressed little confidence that changes to campus operations would be done in an efficient and productive manner. They felt that better organization and communication are essential if any changes to campus infrastructure are to be made. Campus energy managers, sustainability officers, and administrators we interviewed generally

did not consider technical issues to be the primary barriers to achieving carbon neutrality. Nonetheless, campus dependence on cogeneration plants and the need to work with outdated and inefficient infrastructure were identified as significant challenges.

Competing priority: primary and secondary missions of the university

Research participants across all groups voiced concern that the relationship between decarbonization efforts, existing decarbonization programs, and the UC mission and values was poorly defined. To these respondents, clear and transparent communication with campus stakeholders about the synergies and tradeoffs between emission-reduction goals and UCs mission is considered fundamental to broad engagement and support. Alignment of emissions-reduction efforts with the institutional missions of research, education, public service, and patient care (for campuses with medical schools) is considered critical. Faculty placed high value on the education and research missions of the university and indicated that they would be less likely to support actions they perceive as diminishing support for those core missions. Further, when asked about actions they were willing to personally take, they were most willing to take actions that align with the missions of research and education. This suggests that to gain faculty support, campus actions to address climate change and reduce emissions must be supportive of education and research, rather than detracting from them.

Competing priority: education affordability

When faculty-survey respondents were asked to rank four values—diversity, affordability of education for students, conducting research that benefits society, and eliminating environmental impact—the affordability item was ranked the highest, while the environmental-impact item received the lowest ranking (Figure 3). Like faculty, students who participated in our research were generally very supportive of actions to lower campus carbon emissions; however, this support diminished somewhat when potential tradeoffs were suggested. Students who participated in our research were split on whether a student fee should help fund energy sustainability initiatives on campus, reflecting the high priority many students place on education affordability.

Competing priority: campus growth

The high priority placed on campus growth—in particular, expansion of the research and patient-care infrastructure—is seen as a barrier to achieving decarbonization. Capital planning was identified as a key locus of activity to ensure that campus growth does not magnify challenges to reducing emissions. Campus energy managers, sustainability officers, and administrators perceived decarbonization programs to be especially vulnerable to budget constraints, with budget shortfalls easily leading to loss of the staff and know-how critical to implementing emission-reduction projects. These findings suggest that competing priorities will continue to be a challenge for reducing university carbon emissions. Aligning decarbonization programs with the university's core mission would provide opportunities to not only harness the creativity of the campus community, but also elevate decarbonization as a priority for campus investments, extramural-research support, and donor giving.

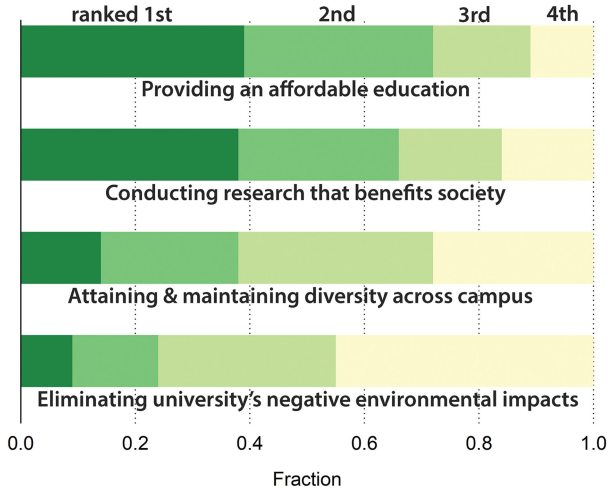

FIGURE 3
Faculty ranking of values for the UC system. Response to question: Please tell us how you prioritize the following set of values for the UC system as a whole by ranking these items such that 1 = the most-important priority and 4 = the least-important. Mean rank values shown here transformed by 1−response/4, so 0 is least important and 1 is most important. Adapted from project report (Bales et al., 2018).

Finding 2: campus communities desire transformative change in campus energy systems, but often lack critical information and sense of agency

Desire to act on climate change

Ninety-two percent (92%) of the UC faculty who participated in our study were very concerned about global warming, vs. about 62% of a representative U.S. sample at the time. Across a broad spectrum of issues related to decarbonization and sustainability, faculty who responded to the survey expressed willingness for the UC system to take actions to become more sustainable. When asked about how important it is for the UC campuses to play a leading role in moving the state of California toward carbon neutrality (Figure 4), 49% of respondents reported finding it extremely important, and an additional 40% found it somewhat or quite important. While in the minority, 5% of respondents indicated that taking this kind of leadership role was not at all important.

Preference for more transformative emissions reduction approaches

Faculty who were already knowledgeable about campus emissions reductions often had specific strategies in mind, including technology upgrades, power-purchase agreements, and investments in renewable energy. Of note is the strong

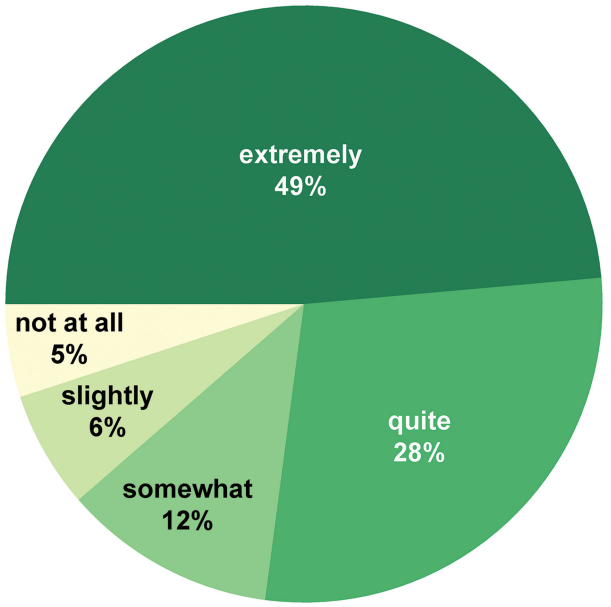

FIGURE 4
Faculty support for UC leadership moving the 10 campuses, including medical centers, toward carbon neutrality. Response to question: How important is it for UC campuses to play a leading role in moving the State of California toward carbon neutrality?

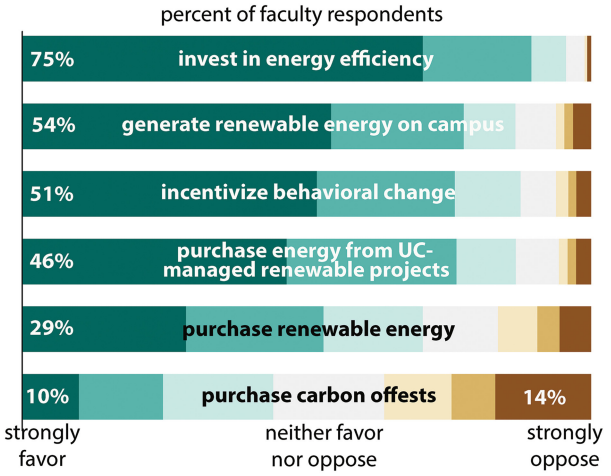

FIGURE 5
Degree of faculty support for new energy-policy approaches. Responses to the question: New energy policies within the UC system might take any number of approaches. To what degree would you support or oppose adoption of the following approaches on your campus? Adapted from project report (20).

preference for on-campus solutions that change the way energy is generated or used locally (Figure 5). Across the UC System, the support for energy efficiency, incentives for behavioral changes, and renewable-energy generation was higher than support for purchasing renewable-energy certificates and carbon offsets, and we encountered some opposition to use of offsets to achieve carbon-neutrality goals.

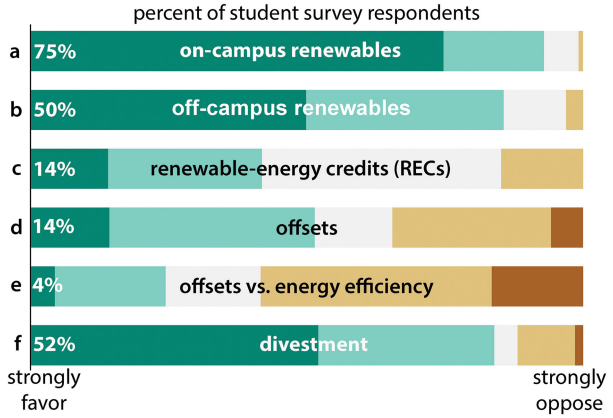

FIGURE 6
Student preferences for decarbonization strategies. Student responses (percent of respondents) to the questions: **(a–c)** "How do you feel about different ways to acquire low-carbon energy?" **(d)** "Would you say it is important for your campus to reach carbon neutrality by 2025, even if it means buying carbon offsets?" **(e)** "Do you support the purchase of carbon offsets to allow the UC to reach carbon neutrality by 2025, even if it means investing less in long-term energy efficiency projects and improvements?" **(f)** "How important do you think it is for the UC to divest from fossil fuel companies?"

Students expressed strong support for UC further developing renewable energy to serve campuses. Their support for campus-based renewables was much greater than their support for offsets, and even greater than their support for divestment of campus investments from fossil-fuel companies (Figure 6).

Staff involved with campus-level emissions-reduction activities saw energy efficiency and on-campus renewables as the most-important opportunities for making progress toward decarbonization. At campuses with natural-gas-fueled central-heating and power plants (also called cogeneration plants) there was concern about challenges involved with transitioning away from such systems. Changes to space use, fuel procurement, and transportation were only suggested by a few of those interviewed.

Most faculty interviewees did not see market-based offsets as a viable strategy for campus decarbonization because they would divert funds from efficiency or renewables-focused projects. Interviewees did, however, support offsets if they were a funding mechanism for on-campus projects, or if purchased locally. All those interviewed agreed that while offsets might be an inexpensive "easy fix," they were not the best use of funds for meeting long-term sustainability and development goals on campus. Most would rather spend money investing in campus infrastructure, such as energy-efficiency projects, to receive long-term savings, rather than spending money each year on offsets. If offsets are needed, respondents noted that they would need to be chosen with the teaching and research missions of the university in mind. Further, to satisfy students and California taxpayers, they felt that offsets should be purchased locally, or at least from California.

Desire for action, but (perceived) lack of agency

Faculty and students who participated in our research saw campus and systemwide administrators as bearing the primary

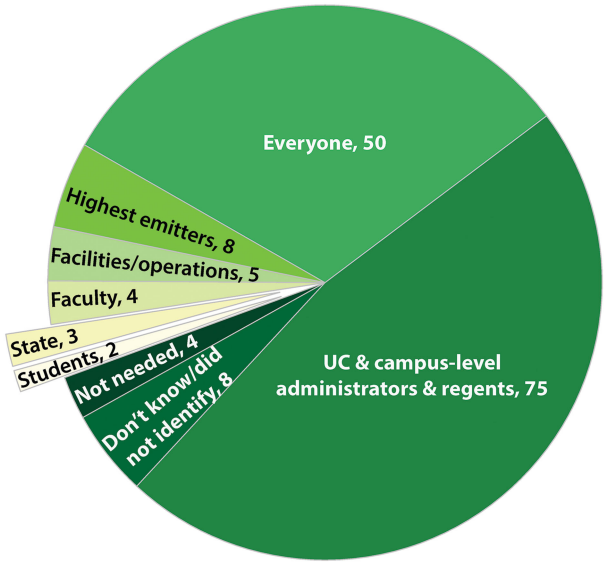

FIGURE 7
Faculty attitude toward who is primarily responsible for UCs carbon footprint reduction. Response to the question: Who do you think should bear primary responsibility for reducing the carbon footprint on your campus and why? Values in pie chart indicate number of times mentioned (159 total).

responsibility for decarbonization actions on campuses (Figure 7). Because of the type and scale of projects and actions needed to decarbonize campuses, participants in our research saw high prioritization by leadership as necessary for enabling and reinforcing higher prioritization by others on campus. Overall, research participants expected administrators to: (i) promote sharing of data and information about campus-energy use and decarbonization strategies, (ii) help with acquiring funding and partnerships needed to reduce campus emissions, (iii) provide coordination support for inter-campus collaboration, and (iv) have a structured system for chancellor-level reporting on progress.

Overall, although many student respondents did not know a lot about campus decarbonization, they expressed willingness to take significant personal action to reduce carbon emissions and strongly supported other issues related to decarbonization (Figure 8). Students indicated willingness to conserve energy by turning off appliances and electronics when not in use, adopting energy-efficient appliances, using less heating, and taking green transit to campus, as well as expressing support for carbon neutrality and undertaking other activities. However, the range of actions they identified was limited by their lack of knowledge about the actions and strategies most capable of producing sizable reductions to their campus' emissions.

Insufficient knowledge of potential campus-decarbonization pathways

Even though the students and faculty who participated in our research were among those already engaged with sustainability and climate issues, their familiarity with, and understanding of, campus decarbonization goals and activities were relatively limited. Most faculty surveyed and interviewed had some understanding of actions that can be taken to reduce campus carbon emissions, and a few had considerable knowledge about this topic. Many were not familiar with UCs Carbon Neutrality Initiative (CNI), and the sources of emissions that the CNI is focused on (on-campus energy generation and purchased energy) were less salient to them than are other categories of campus emissions (e.g., commuter transport).

Among students, even those who were already familiar with the CNI or engaged with environmental issues saw a need for more information; many anticipated a benefit from deeper understanding of campus emission-reduction goals and strategies. For example, while most of the 22 students who participated in our focus groups had heard of the CNI, when they were asked to explain carbon neutrality, many responses involved topics that are only somewhat related, such as divestment and recycling. They were unsure what campus environmental initiatives were aligned with the CNI, and what the campus had done toward reducing carbon emissions. Students in particular saw a need for clear, actionable information about the decarbonization strategies being pursued or considered.

Finding 3: inclusive participatory *governance* of campus energy strategy and investment is seen as critical for transformative change

Decision-making structure, processes, and institutional capacity

As a group, faculty-survey respondents were cautiously optimistic about the effectiveness of their campus' and the UC system's actions to achieve carbon neutrality by 2025. However, a significant minority of faculty were quite pessimistic about reaching this goal (Figure 9). Both faculty and students who participated in our study had expectations for how institutional decisions would be made regarding programs, investments, or incentives to reduce or offset campus emissions. These campus-community members indicated expectations for inclusive, consultative, and deliberative processes. Students indicated the need to feel a sense of ownership, participation in decision making, and confidence that actions will have an impact in order to participate in activities focused on decarbonization. Faculty who were less familiar with campus-decarbonization efforts and plans emphasized the importance of transparency and open sharing of information both within and beyond the campus community.

Limited communication about decarbonization from leadership

In our analysis of sustainability-related campus news, campus-decarbonization goals and strategies to achieve emissions reductions for campus operations did not feature prominently in news stories produced by either campus public-communication or sustainability offices. While public-communication offices generally produced more sustainability-themed news stories than did sustainability offices, news items produced by sustainability offices were more likely to feature information about emission-reduction and decarbonization goals.

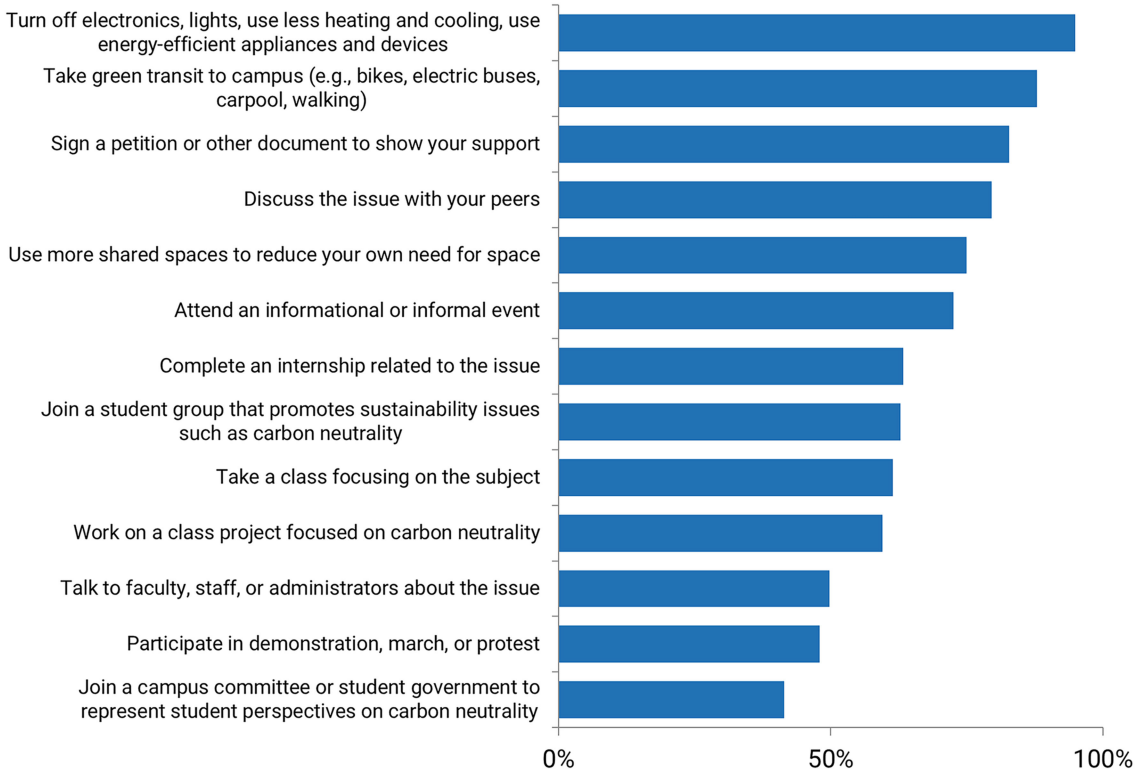

FIGURE 8
Student willingness to take specific actions to help achieve carbon neutrality. Student responses (percent of respondents) to the question, "Which actions would you be willing to take to help achieve carbon neutrality on your campus?"

Thematic analysis of the campus news stories that mentioned carbon neutrality provided limited and sometimes ambiguous information about steps campuses can take to achieve emissions reduction. Among stories that did cover strategies for campus carbon neutrality, renewable energy and energy efficiency or conservation featured prominently; meanwhile, market-based mechanisms such as renewable-energy credits, cap and trade, and carbon-offset programs very rarely appeared, and were entirely absent in sustainability-themed news at many of the UC campuses. This lack of information and communication around market-based programs results in a lack of awareness of these programs, and in turn prevents community-wide dialog and deliberation about the full suite of possible pathways to emissions reduction.

Lack of transparency and accountability regarding emissions and expenditures

While UCs Office of the President provides aggregated annual Scope 1–2 emissions data for each campus through its sustainability website, there exists no centralized accessible source for timely, disaggregated data about UC carbon emissions, energy sources and use, and emission-reduction activities or projects. A few UC campuses provide somewhat more-detailed information on their sustainability websites, but even in these cases the data are generally aggregated on an annual basis for the whole campus. For only one campus (UC Santa Barbara) were we able to find a data dashboard that offered deeper insights into projected costs, savings, and emission-reduction potential for different campus-energy strategies. Scope 3 emissions are poorly accounted for in publicly available data about UC emissions, with only a few campuses providing even partial estimates. Such data, updated frequently and in a form that could be used to inform research projects, educational activities, communication campaigns, or community-led deliberation processes, was identified as an important component of campus-community involvement in decarbonization.

Both faculty and students expected data on decarbonization-related expenditures and their effectiveness to be provided in the context of a deliberative decision-making process that includes faculty, staff, and student priorities and concerns. At the same time, some administrators—plus those responsible for implementing decarbonization actions—expressed concerns about presentations of energy use and emissions data that might encourage comparisons that are inaccurate or unfair. We observed that the administrators we spoke with appeared to feel responsible for maintaining their campus's outward-facing reputation as a leader in sustainability.

Discussion

Opportunities and challenges

Our findings are consistent with studies of other higher-education institutions, which have also found a lack of

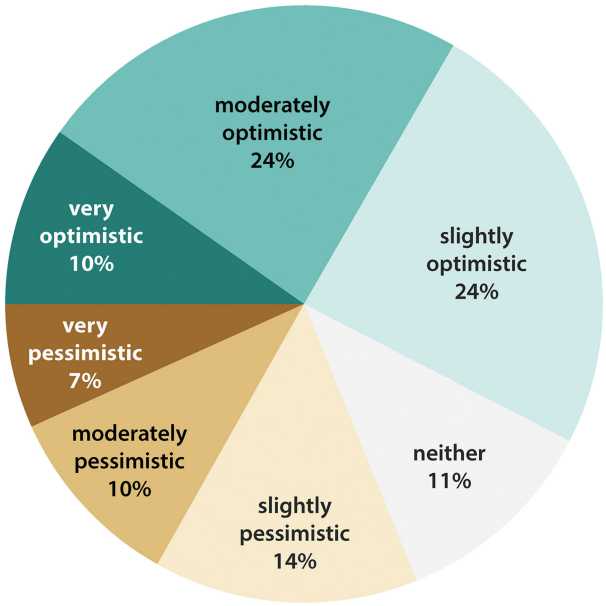

FIGURE 9
Faculty degree of optimism or pessimism that UC can become carbon-neutral by 2025. Responses to the question: How optimistic or pessimistic are you that the campus operations across the UC-system can become carbon neutral by 2025?

awareness and knowledge across campus communities, as well as no clearly designated group to implement solutions to sustainability challenges (Verhulst and Lambrechts, 2015; Filho et al., 2017; Hueske and Guenther, 2021). Many of the tensions and contradictions that others have identified as barriers to organizational change within colleges and universities—for example, competition/territoriality vs. collaboration; individual vs. collective systems of support and reward; expertise/leadership action vs. grassroots involvement; and "rational/pragmatic" systems governance vs. environmental and holistic worldviews—emerged as important factors in our case study as well (Hoover and Harder, 2015).

The data we gathered reveal a tension between, on the one hand, the public commitments made by UC and campus leadership and the goals and desires of many members of the UC campus communities, and on the other hand, the existing commitments and competing priorities those leaders and community members face. As is true for broader society, these tensions and complex decarbonization challenges involve values, social structures and roles, cultural meanings and norms, and ways of doing things—all phenomena that do not lend themselves to purely technical energy solutions. Our results thus serve to strengthen calls by other researchers (e.g., Ceschin, 2014; Miller et al., 2015; Ceschin and Gaziulusoy, 2016) for reconceptualization of energy transition as a socio-technical challenge. While numerous studies have identified and highlighted the importance of the social aspects of energy systems, there remain many questions about how such systems function, and in particular, what conditions and factors are most effective at catalyzing system changes (Ávila et al., 2017; Adams et al., 2018). Opportunities for universities to take a leading role in society's much-needed energy transitions emerge from these complex socio-technical challenges and unknowns.

Universities are uniquely positioned to conduct the types of socio-technical experiments called for by social-innovation researchers. University communities possess deep expertise in designing experiments and evaluating their outcomes; their communities (including staff, faculty, and students) are comprised of individuals with diverse cultures, backgrounds, knowledge, and values; and their energy operations and governance systems are of relatively large scale and high complexity (Purcell et al., 2019). Perhaps, however, the factor that most uniquely distinguishes universities as ideal sites for socio-technical energy experiments is their considerable freedom from the commercialization and market constraints faced by businesses and other organizations aiming to generate social innovations for energy transitions. Because the primary missions of universities are research and education, any activities (including socio-technical energy experiments) that produce high-quality education and research outcomes can be considered wise use of university resources, even if they do not immediately produce high-impact social innovations. Universities that plan strategically can, in fact, offer their students and faculty cutting-edge learning and professional opportunities while engaging in socio-technical experiments that would be considered too risky even for social-innovation-focused businesses (Nicholls and Murdock, 2012; Tjörnbo and McGowan, 2022). If pursued under this framework, social innovations for energy transitions could be a valuable tertiary outcome of universities' research and educational activities while contributing to, rather than detracting from, those important missions.

So why haven't these types of experiments emerged already within UC? Some experiments, in limited forms, have. Each campus has been engaged in work to reduce their carbon emissions, and many of these efforts have involved students or members of the research community. For example, since 2015 a Climate Action Fellowship Program has funded student-generated projects at each campus in support of UC's greenhouse-gas emission-reduction goals; and in 2022, UC invested $11.5 million in new multicampus–national laboratory collaborative projects tackling climate and decarbonization, and providing training support for early career scientists (University of California Office of the President, 2022). Such efforts have, however, been limited in various ways—they have been relatively small in scale, short in duration, lacking strong integration between operational implementation and evaluative research, or without the broadly inclusive and deliberative governance and decision-making processes that characterize the conditions leading to social innovation (Maclean and Harvey, 2012; Mulgan, 2012). UC campuses, and the individuals and teams on those campuses who have been working persistently to decarbonize have made incremental progress, but their efforts have not yet produced transformative change, or "permanently alter[ed] the perceptions, behaviors, and structures that previously gave rise to these challenges" (Pol and Ville, 2009; Surman, 2018).

Our research, together with previous work on social innovation, provides insights into factors that may be impeding transformative energy-systems innovation at UC and other universities. Our data reveal a degree of mismatch between UC governance structures and organizational culture and the

conditions that researchers have identified as conducive to the emergence of social innovation.

First, there is a *misalignment of reward systems and priorities*. We observed a high level of interest across the campus community in actively contributing to decarbonization of the operations of our campuses. Our analyses reveal multiple opportunities to engage the campus community intellectually and physically in climate solutions, and the need for programs that offer co-benefits to those who participate. Our identification of high interest in alignment between reward mechanisms (e.g., tenure, promotion, publication) and faculty engagement in campus decarbonization aligns with findings from previous work (e.g., Ferrer-Balas et al., 2008; Bayuo et al., 2020; Cinar and Benneworth, 2021). Students who participated in our research expressed the most interest in engaging with campus decarbonization activities that also provide hands-on opportunities for career development, such as authentic research opportunities, group work with a diversity of participants, paid internships, and class credit. Without opportunities to engage in the types of activities that are deemed valuable within the organizational culture (i.e., research and learning), university-community members will feel compelled to deprioritize their contributions to campus decarbonization efforts and projects.

Our findings also underscore the *importance of the location of power and ability to effect change*, and the *need to link power with accountability*. Across the various campus groups we studied, a recurring theme was a lack of knowledge about decarbonization strategies, and about how much (or how little) impact particular projects or actions can have on overall campus emissions. This lack of awareness of the full range of potential strategies poses an important limitation on the types of actions individual members of the campus community are willing to support. Students who participated in our research expressed more support for initiatives that allow them to actively participate, and identified access to credible, salient data and information as key to enabling this type of active participation. Students expressed a need for the freedom to create and direct their own activities and saw systems for supporting long-term communication and collaboration as key to student engagement and effectiveness. The low levels of awareness and knowledge about campus decarbonization that our studies revealed indicate that many members of the campus community have not been invited into discussion of decarbonization pathways for UC. At the same time, many of those who have been engaged with the issue feel that their power to effect change is very limited, or that primary responsibility for change does not rest with them. A few within the system have been tasked with leading the change, but in many cases, they have lacked access to the resources necessary to make change happen. And those in leadership positions who have taken the lead in making high-profile climate commitments have reaped the benefits of these commitments (e.g., image building as a sustainable university) without being held accountable for delivering on those commitments (Bekessy et al., 2007) or for transparent and open sharing of the data and information necessary to evaluate their progress toward the goals.

Insufficient structures and processes for inclusive deliberation and decision making delay action due to unresolved disagreements about strategy. Without arenas and incentives to debate, discuss and co-create plans for action, universities can encounter difficulties in directing resources toward different types of decarbonization projects. For example, individual knowledge and worldviews play an important role in which potential decarbonization strategies are seen as useful or desirable. On one hand, those who see markets as a powerful and efficient driver of change are inclined to endorse strategies like carbon offsets and renewable-energy credits as avenues for quick and relatively inexpensive progress. On the other hand, many in the campus communities endorse the notion that transformative change involves "walking the walk" and reducing one's own carbon emissions rather than paying someone else, somewhere else, to reduce emissions in their place. Those who endorse this worldview are inclined to see market-based mechanisms as "greenwash" and as detracting effort and resources from the "real" work of campus decarbonization. Without opportunities to collaboratively make decisions about decarbonization paths for UC campuses, fundamental differences such as these will serve as a barrier to transformative change (Antadze and McGowan, 2017).

Differences in ideas about *organizational culture* and how to approach challenges like campus decarbonization have complicated progress for UC. Efforts like the CNI have often been seen as top-down mandates imposed on a community with a preference for consultative, deliberative, and collaborative decision making. While some see financial and technical commitments made exclusively by those in leadership positions as an efficient pathway to change, many in the university community are looking for shared governance and inclusion of academic and resource-management perspectives in the context of such decisions. As others have noted, "command and control" approaches neglect the systemic processes that produce transformative change, and are likely to result in controversies and resistance (Voulvoulis et al., 2022). Rather, governance systems for social innovation should eschew top-down prescriptions in favor of generative rules that encourage evolution and adaptation (Mulgan, 2012).

Beyond organizational culture, there are also issues related to *territories, conflicts, and competition*. In our study, there were some campus-based personnel who perceived the CNI as an effort by systemwide leadership to take credit for emissions-reduction progress that individual campuses had been working to achieve prior to the launch of the CNI. Within campuses, there were reports of competition between sustainability staff, facilities staff, and administrators over who "owns" particular projects, and therefore who controls funding and direction for them. Also at the campus level, there was concern about the zero-sum nature of funding for sustainability projects and competing priorities both within and outside of sustainability programs that could decrease access to funding. Finally, there were also reports of competition between campuses as a barrier to collaboration on certain types of projects. While many identified collaboration (e.g., between sustainability offices, facilities departments, and leadership) as critical to progress on campus decarbonization, questions arose about who was given opportunities to collaborate (and who was not), and about what structures and rewards were needed to make collaboration more desirable.

Can universities generate the social innovation necessary for their own decarbonization?

The integration of our observations with previous work on social innovation leads us to propose two stages of decarbonization-focused social innovation possible for UC and other universities: the first stage being a prerequisite for the emergence of the second. The first stage is reasonably well-prescribed by current understanding of the interplay between organizational culture and governance, the catalyzing conditions for social innovation.

Challenge 1: organizational change to create enabling conditions for inclusive socio-technical experiments

Can universities redesign their organizational cultures and governance processes, including communication and information sharing, inclusive decision-making, resource allocations, and reward structures to create context and opportunities for energy-focused social innovation to emerge? We are optimistic that the answer is yes, but such change will require courage on the part of university decision makers, and building of trust across all sectors of university communities.

Opportunities for institutional change

Multiple leaders in higher education have called on the twenty-first century university to encourage academically relevant work that simultaneously meets campus goals and societal needs such as decarbonization (Duderstadt, 2000; Douglas, 2016). With the appropriate organizational structures and incentives for faculty, staff, and students, the university's contributions to society can serve additional missions—such as sustainability or climate action, while enhancing the primary missions. Campus energy use or decarbonization projects can be viewed as "experiments" or "case studies" aimed at reducing carbon emissions. Because members of the campus communities are engaged in designing, implementing, observing, and documenting these projects, they have potential for achieving campus decarbonization goals, furthering the primary university missions of education and research, and providing scalable solutions for the benefit of society.

To enable societally relevant socio-technical experiments that reflect the values, goals and perspectives of the campus communities, university administrators would need to initiate dramatic changes in the ways in which their campuses make energy-relevant decisions, integrating research and education aspects into energy system selection, implementation, maintenance, and improvement, and doing so in a way that involves broadly inclusive co-design, co-creation, and co-evaluation. In addition to inclusive and deliberative decision making and development, administrators would need to allocate resources to these projects, or foster collaborations focused on procurement of funding (e.g., extramural grants) to support these socio-technical experiments and associated educational activities.

A decarbonization "collaboratory"

We described above the opportunities and challenges we observed in our study of UCs community engagement and governance readiness for transformative innovation for decarbonization; we now turn to describing a potential "Collaboratory" initiative for UC (and other universities) that has potential to mitigate many of the barriers we identified. At the same time, we recognize that there is much still to be learned about the intricate relationships between organizational cultures and dynamics and social innovation.

Across the campus community, our findings point to opportunities to better align decarbonization activities with the core missions of teaching and research by using our campuses as classrooms and laboratories for sustainability. This transition could go much further in taking up the moral and ethical case for transformative change within the university (Green, 2021), addressing societal challenges related to energy transitions in a way that more naturally risk-averse and constrained governmental and philanthropic organizations may not (Nicholls and Murdock, 2012; Chalmers, 2013).

Our findings reinforce those from previous studies pointing to a need for engagement of the campus community, evolving the "living laboratory" concept toward a "collaborative laboratory," or "collaboratory." Leveraging the university's strengths as research, teaching, learning, and innovation, a collaboratory could be used in this context to develop energy, sustainability, and climate solutions. The term "collaboratory," in use since the 1980s, has recently been defined as "an open-space, creative method for hosting meaningful conversations where various stakeholders tap into the collective intelligence to generate solutions to complex problems" (Muff, 2014). It is an inclusive implementation, research and learning environment where action-learning and action-research meet, and where formal separation of knowledge production and knowledge transfer dissolves. The related term, *living laboratory*, appears in multiple reports of successful engagement of campus communities, transforming campus cultures to embrace sustainability, and enabling the creativity of students and faculty (St. Clair and Chiang, 2016). It has been reported that a living-laboratory framework can help transform a campus from a passive to an active environment for teaching and learning (Evans et al., 2015) and foster a cyclical process of co-design, co-production, and co-evaluation involving members of academic and practitioner communities (Wanner et al., 2018). We propose the term collaboratory, however, as the *living-laboratory* term lacks the explicit horizontal and vertical integration implied by *collaboratory*, which places emphasis on co-equal sharing of decision making and resources across sectors, disciplines, and roles.

In contrast to other decarbonization approaches that mandate change (and often fail to provide the resources or authority necessary to make those changes), the collaboratory approach positions campus decarbonization as an opportunity to advance the university's teaching, research, and sociotechnical-innovation missions. Such an approach complements and builds upon existing awareness-raising efforts by offering an explicitly inclusive, dialogue-based, engagement-centered effort. Beyond active engagement of campus communities in pursuing solutions, a campus-based, system-wide collaboratory would help involve

a broader segment of the campus communities by linking decarbonization to other synergistic campus initiatives.

Transformative research

Collaboratory projects are qualitatively different from simply doing societally relevant research, with results provided to external groups. To develop societally relevant insights into complex socio-technical energy systems, researchers can no longer work in isolation from "real-world" implementation, and they need to co-design, co-create, and co-evaluate with the communities and individuals that the energy systems serve. The collaboratory approach embeds academic work "in" society rather than just "for" society. It builds on the suggestion that given the existential threats we now face, "universities might now fully embrace the unprecedented challenge of helping eight billion people live on a planet that is wholly unprepared for them (Latour, 2016)."

Challenge 2: inclusive socio-technical experiments that can lead to energy systems transformation

Once universities redesign their organizational structures and governance to encourage and support inclusive socio-technical experimentation, will campus communities be able to catalyze the transformative change needed for their own decarbonization?

Although there is much yet to be understood about the factors and contexts that lead to the emergence of transformative change, we are once again optimistic that the answer is yes. At the very least, creating the conditions for more-resourced and rapid development of potentially transformative social innovations increases the chances that one of them has the power to change our relationship with energy. And if they don't? Then we will have at the very least a new generation of university graduates who have a deep understanding of the decarbonization challenge our society faces and a hard-earned appreciation for the difficulty in making change.

A Collaboratory provides time and space for creative problem solving, and for everyone to have a space "at the table" when developing ideas and planning for energy transitions. Small but important changes in resources, communication and transparency can unleash this creativity and create champions who can lead on energy transitions, and climate solutions more generally. One large university system like UC making these types of innovations in energy systems governance could represent a social innovation that spills over into other institutions of higher education, expanding the number of social innovation-focused experiments, and increasing the chances that a truly transformative innovation will emerge and move beyond the borders of the university into broader society.

> *"the foundation of social innovation is a belief in people's capacity to create, to shape and experiment, in tension with the present, but also with a bias against both over-confident top down control or planning, and the fatalistic view that nothing works."*

—Geoff Mulgan, *The Theoretical Foundations of Social Innovation,* 2012.

Data availability statement

Original data are available in the supplementary material of Bales et al. (2018), and at https://escholarship.org/uc/item/0r05944j.

Ethics statement

The studies involving humans were approved by Human Subjects Committee, University of California, Santa Barbara. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

SR-H and RB planned and coordinated data collection, carried out analysis, and wrote manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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