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Berkeley Lab Comments to EPIC 4 Staff Draft

Attached.

Thank you!

Additional submitted attachment is included below.

BERKELEY LAB
Bringing Science Solutions to the World

August 18, 2021

Chair David Hochschild
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Re: Lawrence Berkeley National Laboratory Comments to Staff Draft

Dear Chair Hochschild,

On August 4, Commission staff presented draft initiatives for the EPIC 4 Investment Plan, in support of seven objectives. Berkeley Lab is pleased to present our comments in response to the staff draft.

Berkeley Lab believes the staff draft identifies many compelling opportunities to advance decarbonization and deliver tangible benefits to the state's electricity ratepayers. The achievement of California's ambitious climate goals will require the development of new technologies and strategies for mitigation, adaptation, and removal. The draft plan enables the state to leverage the significant work being performed at the national level by agencies such as the U.S. Department of Energy. It identifies promising approaches to overcome obstacles that have hampered consumer adoption of new technologies, including those that may be particularly challenging for those living in disadvantaged communities (DACs).

Berkeley Lab appreciates the continuing inclusion of the federal cost share program in the cross-cutting initiatives, as this will position the state to better compete to bring significant federal funding to California that can help address the state's most urgent priorities. The *SB 100 Joint Agency Report* identified a number of technology areas where further research could lead to technologies that enable the state to achieve its climate protection goals at a lower cost to ratepayers. The U.S. Department of Energy and other federal agencies are undertaking or contemplating significant work to develop technologies that the cost share program will enable the state to leverage. For example, the U.S. Senate's infrastructure package includes $8 billion in funding for the development of hydrogen-based solutions, including at least four regional hydrogen hubs that could receive up to $2 billion each over five years.

At a high level, Berkeley Lab urges the Commission to build in significant flexibility to the EPIC program. Large investments in new technologies are being made worldwide, and breakthroughs may change the landscape. One of these areas, for example, is in the development of new materials, which is critical to the development of more efficient solar materials, high energy density battery electrodes, more efficient materials for catalysis and separation, and other advances. The time required for novel clean energy materials discovery to scale-up has averaged 18 years in recent decades. Cognizant of the urgency of the climate crisis and the need to greatly accelerate the development of timely solutions, Berkeley Lab is working to reduce the new material lab-to-market time frame to 2-4 years, utilizing our assets in high

performance computation, visualization to enable accurate model verification, and development of new modular processing techniques.

Flexibility in the proposed research initiatives will allow the Commission maximum latitude to act nimbly, to quickly fill in key research gaps and position the state for leadership in priority areas. A technology neutral approach (to the extent possible given EPIC's programmatic constraints), whereby the Commission establishes performance objectives and avoids specifying technologies, remains the path most likely to foster innovation. Such flexibility would allow the CAMs to opportunistically seize new opportunities.

The Commission may wish to consider adoption of an open solicitation — similar to those pioneered by the U.S. Department of Energy's Advanced Research Projects Agency (ARPA-E) — allowing consideration of any proposals to advance energy innovation. An open solicitation would help ensure that the Commission does not miss opportunities to support innovative, impactful energy research outside the specific topics in the Investment Plan or that emerge after a prior relevant solicitation has closed. Open solicitations would give the Commission the opportunity to track new and emerging opportunities across the complete spectrum of energy applications with a crowd-sourced approach that can deliver impactful breakthroughs. ARPA-E reports that one-third of the 60 examples of its most successful projects have resulted from open solicitations.[1]

Berkeley Lab offers specific comments to five of the six overarching themes enumerated in the staff draft.

1. ***Accelerate Cost Reductions for Renewable Generation Technologies***

No comments.

2. ***Achieve Reliability and Create a Nimble Grid Responsive to Intermittent Renewable Generation***

As currently written, Topic 5, "Long-Duration Energy Storage Technology Demonstrations to Support Grid Reliability," does not include consideration of long-duration grid-scale energy storage solutions as provided by the subsurface formations in California. Solutions that involve subsurface formations may be required to achieve large-scale energy storage for very long duration storage periods of weeks, months, or even seasonal storage. Research is needed to demonstrate and optimize this so-called "earth battery" concept, across different storage media (chemical, thermal, or mechanical) and for different geologies and storage depths (shallow aquifers to deep sedimentary reservoirs). While California has long relied on natural gas storage in underground formations, more forward-looking technologies like hydrogen storage in depleted reservoirs or thermal energy storage in aquifers (aquifer thermal energy storage, or ATES) are less mature and need further testing and demonstration. Similar opportunities and research needs remain for mechanical energy storage underground, such as via injection and later recovery of compressed air or pressurized water or CO_2 into subsurface formations. Important questions about the feasibility, safety, efficiency, and economics of such technologies have not been fully answered, and integration with complex renewable energy systems needs to be improved. Opportunities for the repurposing of oil and gas industry assets (such as active and shut-in oil and gas wells, depleted oil and gas reservoirs, and workforce) for subsurface

[1] ARPA-E Funding Opportunity Announcements. https://arpa-e-foa.energy.gov/

underground storage need to be explored. Questions about environmental sustainability and equity also need to be answered.

3. *Increase the Value Proposition of Distributed Energy Resources to Customers and the Grid*

Prior demand management efforts often have focused on industry and large buildings. An important new goal is to ensure that new load management technologies can expand those tangible financial and comfort benefits to residential consumers and under-resourced communities. One of the most challenging areas for retrofits is multifamily homes. There is growing interest in heat pump water heater (HPWH) retrofit concepts. Research and development is needed to evaluate the performance of these systems as a function of various factors, such as the number of apartments connected and the climate zone. The results will provide recommendations for system designs that ensure adequate hot water delivery, minimize use of the backup resistance elements, and provide full load shifting from the evening peak period to the midday solar peak period.

There also is growing interest in creating appliances that can respond to dynamic electricity prices and other grid signals. Research is needed on residential and commercial appliances to evaluate how to embed the control of the appliance in the device when it is sold. This R&D should include evaluating the load response strategies and modes of operation that the appliance can provide, as well as describing what information in the communication signal is needed to enable the load response.

4. *Improve the Customer Value Proposition of End-Use Efficiency and Electrification Technologies*

Regarding Topic 26, “Energy Efficiency and Decarbonization in the Cement Industry,” we recommend that advances in carbon capture utilization and geological sequestration technologies (CCS) also be considered in this initiative for decarbonization of the cement industry, as the volumes of CO_2 potentially captured may be larger than can be utilized, at least in the near term.

Regarding Topic 29, “Innovative Solutions for Improving the Value Proposition for Building Envelope Upgrades,” Berkeley Lab agrees that as more homes decarbonize with electric HVAC heat pumps, it becomes critical that building envelopes in existing buildings become more tightly sealed. Berkeley Lab recommends that this initiative also support the scale-up of existing — and develop new — high-performance envelope technologies and manufacturing processes to reduce cost.

Portable Decarbonization Technology. Berkeley Lab reiterates our suggestions that research is needed to evaluate the costs and benefits to develop and demonstrate technologies that are not built-in to a home but can be transported from home to home. These can be called *transportable decarbonization technologies* (TDTs). TDTs could be considered for many devices and systems, such as HVAC, cooking, water heating, storm windows, and more. This concept could change investments away from property owners alone to all citizens, and massively improve the equity of both government and state home decarbonization programs. Renters suffer most disproportionately from the adverse health impacts associated with gas combustion and related health/safety issues in residences. The focus would be on TDTs that can be owned, used, and taken to the next rental property by individuals. TDTs enable everyone to participate in the

decarbonization and energy savings efforts that are needed to meet our climate goals. They eliminate the need for costly panel/service/circuit upgrades, the removal of existing systems, and the bottleneck of having too few contractors getting to scale with decarbonization. TDTs also allow for increased resilience — for example, by allowing many more people to have amenities like air-conditioning to help survive heat waves by zonally cooling bedrooms or other occupied areas only when needed.

Bundled Retrofits: Currently, DAC/low income residents need to apply separately for energy efficiency upgrades, solar photovoltaic (PV) incentives, and clean vehicle rebates or incentives. These pose very high transaction costs for these community residents that are neither equitable nor efficient. A more streamlined and potentially scalable approach would be to bundle these measures into one program, together with fuel switching measures in HVAC and water heating, for maximal benefits in comfort, air quality, decarbonization, and equity. A starting point would be to pilot this type of program in disadvantaged areas to quantify the benefits (e.g., indoor and outdoor air quality monitoring), collect user surveys on the comfort and impacts of the new equipment and/or upgrades, and monitor overall energy costs in utility bills and vehicle costs.

5. Enable Successful Clean Energy Entrepreneurship Across California

Berkeley Lab suggests adding lithium discovery and extraction R&D in Topic 39, "Advanced Battery Manufacturing." Unconventional resources in California (such as geothermal brines or sedimentary formations) have sufficient lithium to satisfy demand for many decades. Berkeley Lab agrees with the Commission that the availability of lithium offers a promising opportunity to develop leadership in battery manufacturing. We recommend broadening this initiative to encompass further research on lithium discovery and sustainable extraction, with specific attention to unconventional resources in California.

6. Inform California's Transition to an Equitable, Zero-Carbon Energy System that Is Climate Resilient and Meets Environmental Goals

Berkeley Lab is supportive of Topic 42, "Advancing Environmental Sustainability of Energy Deployments," but recommends that this category be broadened to encompass investment in environmentally compatible solar technologies and approaches. The scale of solar deployment necessary to achieve positive climate outcomes will necessitate the dedication of significant areas of land to solar production. Large solar projects often meet strong community resistance based on perceived negative impacts to the land. However, new solar hardware technologies and new deployment approaches can significantly improve the ecological impacts of solar development. In fact, if done properly, solar installations can provide significant co-benefits in terms of pollinator habitat, shade, water use, and soil health. However, these technologies and approaches are not as well developed as those for traditional solar installations. Research and development in this area could significantly improve the rate of solar installation and adoption in California while providing important land stewardship co-benefits.

Low carbon cooling. Demand for cooling electricity is typically greatest in the late afternoon or early evening — hours during which (a) grid demand is already high because homes and nonresidential buildings are occupied, and (b) generation from solar PV panels, especially those facing south, is limited by low late-day solar availability. A variety of passive or low-energy building-cooling strategies (such as, but not limited to reflective roof and walls, solar-control glazing, shading, ceiling fans, and natural ventilation) are known to effectively reduce peak cooling load, while also offering greater resiliency during periods of power loss, but may be unattractive in underserved communities because (a) they are more expensive than traditional

building materials or practices, raising the first costs of new construction; and/or (b) are not subsidized for retrofits by existing weatherization programs. Research is needed to evaluate opportunities for (a) reducing the incremental first cost of choosing passive/low-energy cooling strategies, and (b) developing and implementing effective financial mechanisms to subsidize the incremental first cost, such as upstream rebates (those issued to manufacturers) that are easier to administer and avoid subsequent wholesale and retail markups.

7. Cross-Cutting Initiatives

Berkeley Lab supports the continued investment in providing cost share, Topic 43, for promising EPIC related projects attracting federal, private, or nonprofit foundation funding opportunities to California. The previous cost share initiatives played a critical role in enabling California to compete successfully for large federal clean energy research investments, which attracted multiple federal dollars for each state match dollar invested.

EPIC events such as the EPIC symposium, technology forums, innovation tours, and outreach platforms such as Energize Innovation and Empower Innovation, Topic 44, have helped California achieve greater networking and partnership opportunities. Berkeley Lab supports this continued investment, which will help advance decarbonization and deliver tangible benefits to the state's electricity ratepayers.

Climate Emergency

To meet California's net zero greenhouse gas (GHG) goal in 2045, the current trend of GHG emissions reduction of 4.6 million metric tons of CO_2 equivalent (MMt CO_2e) per year (2006–2018) will be insufficient; 15.8 MMt CO_2e reductions will be needed each year to reach the 2045 goal. California will still exceed carbon neutrality by 56–106 MMt CO_2e, depending on the success and pace of decarbonization across all sectors; in particular transportation, industry, and agriculture. Moreover, note that these exceedance projections do not include wildfire emissions.

Given the documented existential risks from global climate change, the accelerated and growing impacts happening now, and the current emissions trajectories, California should consider declaring a statewide climate emergency, accompanied by an immediate shift in investment priorities and policy goals, to focus policymaker and public attention, and to develop commensurate measures to mobilize resources, consolidate efforts, and lead the way for other states and the world.

California must make policy decisions and investments today about technologies and assets to plan for the end of fossil fuel use, since long-lived assets and technology built in the next few years will operate for decades. On the technology supply side, California needs greater investment levels to speed research and deployment time with government sponsored deployment programs (e.g., incentives, tax credits, feed-in tariffs) that help bend technology cost curves and facilitate greater commercialization. On the demand side, the state needs more purchase related programs that provide market certainty and encourage greater competition and supply chain diversity. At the same time, consumer education through widespread outreach across multiple sectors at points of sale or interaction is needed to spur more rapid adoption of transformative technologies and approaches.

We have the following recommendations for addressing the climate emergency:

- To avoid a risk of misallocated resources, model and evaluate various investment pathways across sectors that integrate and address multiple policy objectives.
- Conduct early stage basic science and early stage development activities and funding of new materials, improved designs, and technology families.
- Accelerate system integration and system demonstrations. For several sectors, system component technologies are at a high maturity level, but integration and demonstrations of all system components is urgently needed to scale up.

However, even with radical and transformative demand reductions, electrification of all end uses and dramatic improvements in other technologies, the state will not meet its net neutrality goal. There is a need for CO_2 capture from pathways that go beyond traditional concepts of CO_2 CCS at power plants and refineries. As such, biological pathways for CO_2 capture and direct air capture for negative emissions may be required.

Negative emission technologies (NETs), while promising, have not yet been demonstrated at scale. Even if they were readily available today, they would still be subject to delays in construction from permitting and environmental reviews. Several promising NETs, such as direct air capture and terrestrial and geological carbon removal, lack scalable implementations and scientifically defensible upper bounds on their potential.

Meeting the grand challenge of successfully and economically removing CO_2 from the climate system via NETs will require the development of novel systems engineering approaches for capturing, handling, and converting atmospheric and biologically sourced CO_2 into biofuels, bioproducts, and biomaterials. It will also require new technologies to securely transport and store captured CO_2 in shallow soils and the deeper subsurface. Examples of relevant technologies needed to advance negative emissions science and technologies include metal-organic frameworks (MOFs) to capture diffuse carbon from the atmosphere, bioenergy with carbon capture and storage (BECCS), thermal reactors for adsorbents and hydrogen fuels, approaches to store carbon in soils and deeper geological systems, biomanufacturing to transform carbon into products, and energy systems life-cycle analysis and engineering.

The California Energy Commission's *2021 SB 100 Joint Agency Report* provides an assessment of and recommendation for various pathways for 100% clean electricity in California. One study scenario (referred to as *generic zero-carbon firm resources*) suggests the potential importance of cost-competitive firm dispatchable decarbonized generation achieved by CCS technologies such as natural gas with carbon capture or hydrogen combustion with CCS. The ability to safely sequester CO_2 underground also will play a major role as an enabler for two of the most promising negative emissions technologies — bioenergy with CCS and direct air capture — and provides options for decarbonizing hard to abate industries. We therefore recommend adding an initiative to advance technologies for efficient carbon capture and safe permanent geologic sequestration in California. Areas of emphasis include: (1) develop and demonstrate new or improved CO_2 capture/separation technologies for zero-carbon firm resources that have less energy penalty and are more cost-effective; (2) develop improved technologies for ensuring the long-term integrity of CO_2 storage underground in California's subsurface, such as methods for site characterization, risk assessment, monitoring of CO_2 migration and leakage, and management of pressure and geomechanics response to large-scale injection; (3) conduct system-level optimization and life-cycle studies that allow for statewide CCS deployment at competitive costs and meaningful scales while minimizing

potential impacts on local communities and environments; and (4) support at least one CCS pilot project across the state.

Berkeley Lab appreciates the opportunity to provide these comments in support of development of the EPIC 4 Investment Plan.

Sincerely,

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