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Berkeley Lab - EPIC 4 - Building Decarbonization Workshop Comments

Attached.

Thank you!

Berkeley Lab

Additional submitted attachment is included below.

BERKELEY LAB
Bringing Science Solutions to the World

July 6, 2021

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

RE: Lawrence Berkeley National Laboratory Recommendations for the Development of the EPIC 4 Investment Plan - **Building Decarbonization** workshop

Thank you for the opportunity to provide comments on the EPIC 4 Investment Plan and for the CEC's substantial work developing and executing the previous plans. As noted in the draft 2021 California Building Decarbonization Assessment, residential and commercial buildings together account for 25 percent of the state's GHG emissions and Lawrence Berkeley National Laboratory (Berkeley Lab) agrees with the Commission that reducing these emissions in a timely and cost effective manner is essential to meeting California's ambitious GHG reduction and climate goals.

Mary Ann Piette, Sumanjeet Kaur, and Robert Hart - researchers in the Energy Technologies Area at Berkeley Lab - participated in the workshop that took place on June 28th and provided a variety of recommendations to improve building decarbonization. This letter provides additional examples of R&D needs to enable more building decarbonization in California.

Decarbonization of Large Commercial Buildings

- **Develop optimal design and control concepts** to integrate heat pump retrofits for different building types with systems such as active and passive thermal energy storage (TES), heat recovery heat pumps, and integration of solar thermal.
    - Integrate with DERs: EV, electric storage and PV
    - Develop decision support tools
    - Consider needs in different facilities: office buildings, hospitals, retail, grocery, universities, etc.
- **Develop and evaluate district and campus scale systems heating and cooling systems** that integrate decarbonization retrofits for multiple large buildings.
- **Determine** optimal times for decarbonization retrofits in the context of the real-estate life cycle.
- **Develop Direct Current (DC)** technologies to integrate loads with electric storage and PV. Full electrification will ultimately require major upgrades to existing grid infrastructure, particularly with the conversion to electric vehicles. While on-site solar and storage have been proposed to offset this upgrade, they do not solve the problem. The utility sizes its feeders for the worst-case scenario. The best solution going forward is a DC microgrid because its gateway inverter capacity imposes a hard limit on the necessary feeder size. Also, construct a stand-alone, DC platform that simultaneously provides life-safety services during power outages and reduces standby power use in those products.
- **Saving Electricity in Unoccupied Buildings:** Develop a means of reducing the electricity use of miscellaneous electrical loads (MELs) in buildings during times when nobody is in them. Reducing energy use in "vacant" buildings is an attractive target for

policy initiatives because nobody is present to complain about reduced services. At one university campus, the buildings were fully vacant about 29% of the time. These times mostly corresponded to nights, weekends, and holidays (and, more recently, pandemics). About 24% of the buildings' electricity use occurred during these times, even though no people were in the buildings.

- **Modular water reuse technologies:** Water use in buildings represents a significant fraction of the total energy use and contributes to the overall carbon footprint of our built environment. Premise-scale water reuse has the potential to reduce primary water demand and also reduce municipal energy cost due to lower pumping costs of fresh water to a building and lower wastewater treatment costs.

Energy Storage for Building Retrofit

- **Codes and Standards:** Develop codes and standards for TES in building applications with consistent performance measurement criteria. Dynamic performance standards needed to capture true benefits of storage integrated systems.
- **TES Material Optimization for higher Efficiency, Utilization and Lifetime:** Buildings generally cannot use one TES system for all thermal end-uses in a building since they are at different temperatures. Tunable and smart materials may change this paradigm.
- **Modeling:** Improve modeling capabilities for assessing the potential of thermal energy storage. Tools must be suitable for use by sales personnel and non-researchers.
- **Controls:** Develop controls to integrate the TES with the thermal system which might be HVAC, refrigeration, or hot water.
- **Packaged Solutions:** Design systems with installation in mind. Turn-key products with minimal on-site customization.
- **Life Cycle Analysis:** We need to take LCA tools from research to application. Modeling of these systems is difficult and can help support sales pitches beyond demand reduction. Incorporate embodied carbon and end of life characteristics to compare to other technologies.
- **Certification Process:** Standardized methods are needed for certifying the performance and reliability of storage components and systems. Commissioning processes may be helpful in validating the nominal amount of energy and carbon savings of TES systems.

High Performance Windows

- Highly insulating windows can help reduce and stabilize the load. Going to electric heating can shift peak to am
- Dynamic glass and shades can help with flexible loads and grid integration. Shifting elec load shapes that use the cleanest energy and reduce load during other times of the day
- Revised codes & standards promoting high-performance building envelope – tie HVAC and envelope upgrade

Decarbonization with Efficient Lighting

- Commercial office spaces are increasingly being illuminated not just for visual comfort and performance but also for circadian wellness of occupants, as substantial research has proved the role of the lighting environment in circadian health. There is a risk however with adoption of circadian performance criteria that lighting energy intensity will increase substantially. To ensure lowest-energy lowest-carbon solutions, LED lighting systems need to be tested and evaluated to determine the performance metrics and specifications that lead to best visual and circadian performance for least energy and carbon cost. This research initiative will also demonstrate emerging and new-to-market technologies, and findings and recommendations should spur further product innovations in this field. Research is needed to evaluate advanced commercial LED lighting systems for visual and circadian performance and energy efficiency through lab testing of high photopic efficacy, high melanopic equivalent daylight efficacy fixtures (tunable white LED as well as fixed CCT) with optimized luminous distributions, spectral power distributions, and connected lighting controls.

- Research is also needed to prototype and test closed-loop lighting control system for efficient visual and circadian performance, using newly-developed and emerging networked wireless spectral illuminance sensors that measure photopic and circadian (melonpic equivalent daylight) performance and dimmable, tunable white LED commercial lighting and low-power desktop circadian lighting appliances responsive to photopic and circadian sensor inputs.

Decarbonization for Residential/multifamily Buildings

- **Demand management** efforts in the past have often focused on industry and large buildings: an important goal is to ensure that new load management technologies can provide tangible financial and comfort benefits for residential consumers and in under-resourced communities.
- **Home electrification without a panel or service upgrade:** Research is needed to understand the costs to upgrade electrical service to homes for electrification. There is a need to collect data in the field on current costs. This topic would also explore affordable ways homeowners in California, particularly in disadvantaged communities, can electrify their appliances and vehicles without having to pay for an electrical panel or utility service upgrade. These solutions may include controls, smart breakers, and storage. This topic would ultimately study a portfolio of low-cost solutions and determine the best solutions for various types of homeowners.
- **Research on water heating:** Heat pump water heaters (HPWHs) typically use low-efficiency electric resistance elements as backup heating when the heat pump cannot provide adequate supply. The resistance elements provide heat until the water stored in the tank reaches the set temperature. An alternative approach is to use an instantaneous electric water heater on the outlet of the tank to ensure the outlet water is at the set temperature. Doing this would improve hot water delivery performance while also reducing resistance element use, increasing the efficiency of the device. The increase in efficiency will make HPWHs more cost-effective for occupants. The improvement in hot water delivery performance would also make 120 V / 15 A retrofit-ready HPWHs more attractive.
- **Health impacts of combustion:** Removing combustion from a home as part of home electrification/decarbonization offers great opportunities to reduce health risks from exposure to combustion contaminants from furnaces, boilers, water heaters and cooking equipment. A key argument in support of decarbonization has been reduced exposure to contaminants from cooking related to gas cooktops and ovens compared to electric alternatives. There are also potential additional health benefits from using induction cooktops (that also use less energy) due to the lower temperatures used in many cooking processes. Laboratory and field testing is needed to better quantify the reduction in contaminants and to investigate the effects on range hood performance of different cooktops. A key equity issue with cooking is that exposures are much higher in small apartments than in large single-family homes such that any health improvements

in electrification of cooking accrue mostly to retners/lower income ratepayers. Another topic is related to the use of ovens for heat in homes suffering from fuel poverty. Field & laboratory studies are needed to determine contaminant concentrations and occupant exposure when gas ovens are used for heat and the potential reductions when using electric ovens, or , preferably, affordable electric alternatives.

- **Portable Decarbonization Technology**. 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, etc.. This concept could change investments away from property owners to all citizens and massively improve the equity of government and state home decarbonization programs. Renters suffer most disproportionately from adverse health impacts associated with gas combustion and related health/safety issues in residences. The focus would be in TDTs that can be owned, used and taken to the next rental property by individuals. TDTs allow everyone to participate in the decarbonization and energy savings efforts that are needed to meet our climate goals. TDTs eliminate the need for costly panel/service/circuit upgrades, the removal of existing systems, and the bottleneck of having too few contractors to get to scale with decarbonization. TDTs allow for increased resilience – for example, allowing many more people to have things like air-conditioning to help survive heat waves by zonally cooling bedrooms or other occupied areas only when needed.

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 both 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.

Viability and Vulnerability Stock Assessment and Scaled Retrofit Methods

- **Research is needed to understand decarbonization retrofit opportunities:** There is a need for a tool to evaluate the viability and vulnerability of the building stock in California in order to identify decarbonization potential based on geographical location rather than at the individual building scale. Such a tool could consider the following. 1. Energy upgrade viability assessment – Assess viability for decarbonizing buildings, including factors such as current energy use, vintage, climate, occupancy, design, operation, etc. This indicates the potential for decarbonization at an urban scale. 2. Vulnerability analysis – Assess the occupants' health and mobility, building safety and use/functionality (such as improved space conditioning making more useful areas in a building) and the potential for changing these parameters through decarbonization. These assessments could allow the rating of the viability and vulnerability of the building stock for decarbonization, and the data would be aggregated to an urban scale (e.g., in GIS). The obtained information could be overlapped with existing information about energy poverty, low income communities, extreme climate areas, outdoor air quality, and occupant's health to prioritize decarbonization efforts.

- **Neighborhood Scale Retrofits:** The current model of voluntary EE upgrades and voluntary fuel switching to HP-based HVAC and water heaters is not scalable to the over 12 million residential and 3 million commercial properties in California. A more scalable approach would target homes or buildings with similar characteristics for a set of upgrades that can be done en masse across a neighborhood or city area. Piloting such a program for measures such as attic insulation, electric resistance water heaters to heat pump water heaters, or old room ACs and wall heaters to packaged terminal heat pumps (PTHPs) across many buildings would reduce costs, develop contractor capabilities, and touch more homes and buildings than what is possible today. Pilot programs can utilize existing urban/neighborhood building modeling programs such as CityBES (free and available at CityBES.lbl.gov) for energy modeling, and programs for at-scale energy auditing with community-based partners such as Rising Sun would be needed, or potentially a program with resident or property owner provided data on existing building equipment.
- **Bundled Retrofits:** Currently DAC/LI residents need to apply separately for EE upgrades, solar PV incentives, and clean vehicle rebates or incentives. These pose very high transaction costs for residents in these communities that are neither equitable nor efficient. A more streamlined and potentially scalable approach would bundle these measures in 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 these benefits (e.g., indoor and outdoor air quality monitoring), collect user surveys on comfort and impacts of new equipment and/or upgrades, and monitor overall energy costs in utility bills and vehicle costs.

Prefabricated Buildings

- Low carbon/carbon negative materials including concrete can be used for precast and prefabricated building components. This technology can use low carbon materials such as light weight and bio-concrete or mass timber for precast and prefabricated building components, possibly using 3D printing technology, to build houses and other small structures like schools. The Precast/Prestressed Concrete Institute (PCI), a U.S. industry trade association, has expressed interest in this concept. If tested and demonstrated successfully, such application could be deployed at scale and speed with lower costs, and could be used to construct carbon neutral structures in climate disadvantaged communities, to assist with post-disaster recovery, and to address climate resilience, equity, and just transition, all of which are key aspects of the California and Biden-Harris Administration's climate plan and global climate change mitigation and adaptation efforts.

Collaboration With Disadvantaged Communities
As noted in our comments above, building decarbonization is a critical issue for disadvantaged communities and Berkeley Lab agrees with the Commission that the EPIC program must continue to play its important role of bringing together the research community and disadvantaged communities to advance equitable building decarbonization solutions. This should include support for effective collaboration in demonstration projects. Further, as contracting among large agencies and large research institutions can be complicated, and as contracting requirements can be burdensome on community groups, agencies might consider the adoption of simplified contracting procedures -- and even direct contracting -- with community based-organizations to support their engagement in research and demonstration projects.

On behalf of Berkeley Lab, we appreciate the opportunity to provide these comments on the EPIC 4 Investment Plan.

Sincerely,

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