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Berkeley Lab comments on EPIC 2018-2020 Triennial Investment Plan

Additional submitted attachment is included below.

March 20, 2017

Chair Robert Weisenmiller, Ph.D.
California Energy Commission (CEC)
1516 9th Street
Sacramento, CA 95814

RE: Docket Number 17-EPIC-01 : "EPIC Third Triennial Investment Plan 2018 - 2020"

Thank you for the opportunity to provide comments on the EPIC 3rd Triennial Investment Plan 2018 – 2020 and for the CEC's substantial work developing and executing the previous plans. Lawrence Berkeley National Laboratory (Berkeley Lab) applauds the State of California for your leadership in:

- Setting some of the most ambitious policy goals in the country
- Designing a roadmap to accomplish those goals in a timeframe that addresses both pressing needs and also allows for progress toward a larger and longer term set of research, and market outcomes that build toward impact
- Funding one of the most impactful research & development, demonstration & deployment, and market facilitation portfolios in the world
- Driving technology adoption that acknowledges the diversity of a large and complex state and requires equity for the disadvantaged
- Conducting extensive public workshops to allow for public review and comment of the plan and the portfolio

The purpose of this letter is to identify areas of the 2018 – 2020 Triennial that may benefit from some additional elements that we have not yet seen in the draft powerpoint or heard in the workshop comments to date.

In addition, attached to this letter is a compiled set of Berkeley Lab's comments, project and program recommendations, and a few ideas about potential state-wide Initiatives that may complement the current draft of the plan. We offer them for your consideration.

TRIENNIAL THEMES

THEME 1 – ADVANCE TECHNOLOGY SOLUTIONS FOR DEEP ENERGY SAVINGS IN BUILDINGS AND FACILITIES

The drive toward deep whole-building energy savings and community scale adoption is one of Berkeley Lab's priority research Initiatives that dovetails with the goals of AB32, AB758, the work of Title 24, and the EPIC Investment Plan. As buildings represent 70% of energy consumption and 40% of primary energy use, dramatically reducing the energy footprint of the existing stock of buildings in California will make the difference in whether the state reaches its 2050 goals.

The current focus of THEME 1, Strategies 1.1 through 1.6, will benefit from additional incorporation of physical safety and cyber-security-enhanced solutions. These solutions will contribute to the realization of the Internet of Things (IOT) as an enabling mechanism for building energy management, outdoor lighting, and aggregated sets of components (like exterior lighting or shared HVAC and waste heat recovery) as a managed demand grid resource. Solutions will need to be networked and adaptive. Research and demonstration is needed to integrate those solutions and optimize performance.

We are particularly interested to see Strategy S1.4 included in the 3rd Plan. We are hopeful that as the plan is finalized, the CEC will identify the additional enabling functionality that will require both research and demonstration of:

- Development, testing and demonstration of deep sensor technologies and the platform technologies necessary for their seamless integration
- Design, prototypes, testing and demonstration of standardized protocols that seamlessly run over wired and wireless infrastructure in the built environment – within and outside of buildings
- Easy and seamless data capture and analysis at component, building, system, and community levels
- Testing of and technology integration at reasonable cost
- Development, testing and scaled adoption of advanced diagnostics and control strategies to fully realize the benefits of improved usability, security, and interoperability

Moving from research and demonstration to scale up will require common data standards and protocols that do not currently exist. Examples include the process for standardizing both the technologies and the communications protocols needed to allow the functionality that consumers demanded in the cell phone, smartphone, and tablet markets. In addition, involving original equipment manufacturers and data storage and cloud service providers in the conversation and identified as beneficiaries will be crucial to market success.

We are heartened to see the CEC investing in platforms, technologies, and open source standards and language that will allow buildings, neighborhoods, and communities to be grid resources. Coordination between S1.4 and THEME 2 is critical.

As it relates to decarbonizing California Industries, we see value in also encouraging the CEC to support Carbon Capture and Sequestration. According to the Air Resources Board, almost all credible scenarios for the 2050 climate goals in California involve CCS. In addition, ARB's scoping plan for 2030 is targeting the refinery sector for GHG emissions reductions, which could make carbon sequestration necessary. The goal would be to conduct activities leading to a path that establishes CCS as a viable demonstrated solution to contribute to achieving California's climate goals. Important elements would be: (1) to develop a CCS pilot or demonstration project in California, and (2) develop geological storage hubs in strategic locations within the state (Delta region, Southern San Joaquin, Los Angeles), conducting R&D to develop geological storage solutions.

THEME 2 – ACCELERATE WIDESPREAD CUSTOMER ADOPTION OF DER

As California braces itself for massive storage procurement targets and increased distributed energy resources (DERS), blueprints on the topics below will maximize market efficiencies:

- Business case analysis – storage valuation
- Grid modeling / technical analysis
    - Providing recommendations for optimal storage placement and sizing
    - Optimizing storage dispatch logic based on circuit needs
    - Assessing stacked storage benefits
    - Requirements, specifications, and dependency analysis for various ancillary services participation
    - Requirements and specifications for fast interconnection
- Testing & Interoperability
    - Performance testing
    - Application level testing
    - Accelerated lifecycle testing
    - Safety testing
    - Integration testing
    - Emerging standards testing
- Research and innovation on
    - energy storage management
    - Protocols for behind the meter and in front of the meter deployments
    - Protocols for managed energy storage deployment
- Multi-vendor platforms and integration
    - Control and optimization methods to integrate storage with customer loads

In both THEME 1 and THEME 2 we note the omission of innovative financing models for whole building deep retrofits and DER financing for small and large commercial, multi-family and

residential sectors. We believe this is an area of needed research and engagement with the controls community and the financing community.

As noted above, specifications for energy storage for the grid are essential. For example the target for vehicle storage is set by USABC and is very simple so as to compete with gasoline. Similar specifications do not exist for the electricity grid. Significant research is needed in this area since the specification for frequency control will be different than the specification for load shifting. Finally, as it relates to THEME 2 DER, inclusion of storage physics based models are necessary to understand storage performance and cost.

THEME 3 – INCREASE SYSTEM FLEXIBILITY FROM LOW CARBON RESOURCES

Research is needed to address the changing shape of the net load as California increases the penetration of renewable energy. Our past paradigms of time of use and demand response periods is changing quickly and we need to improve our understanding of how to create more flexible customer loads.

Statewide locational heatmaps of DERS availability co-located with distribution system needs can also enable use cases that may more appropriately direct system investments. Aligning these system and market needs may spur complementary large scale market investments in renewable/clean technologies. It could even lead to region by region auctions - similar to spectrum auctions - which has proven to be very profitable for all parties. This could be done feeder by feeder or locality by locality (perhaps targeting disadvantaged communities) which takes into account load data and the incentive structure with most returns. Combining this with demand charges will make it attractive to bring on new energy storage in a targeted fashion. Without cross-referencing innovative technologies with new market solutions and aligning the incentives for various market actors the State may still be having these roam mapping conversations around different kinds of energy storage years from now.

Research funding is need to support work that seeks to understand mobility patterns of major urban environments such that charging stations can be deployed in locations that both satisfy the increased demand for PEVs and maximize opportunities to provide grid services. Charging infrastructure planning and deployment will also have a substantial impact on PEV adoption and VGI opportunities.

LBNL also encourages the CEC to consider adding research on effective and affordable grid-scale energy storage in the deep subsurface, such as porous media compressed air energy storage, thermal energy storage, or hydrogen storage. It is important to carry out research on capacity assessment, design of systems, performance analysis, assessment of risks, and specialized analysis of site-specific issues.

THEME 4 – INCREASE THE COST OF COMPETITIVE RENEWABLE GENERATION

LBNL proposes to include broader strategies for making geothermal more efficient, e.g., combining geothermal energy and desalination, geothermal and waste heat use, etc.

THEME 5 – CREATE A STATEWIDE ECOSYSTEM FOR INCUBATING NEW ENERGY INNOVATIONS

Affordable storage is the missing link between intermittent renewable power, such as solar and wind, and 24/7 reliability. In addition, utilities are intrigued by the potential for storage to meet other needs such as relieving congestion and smoothing out the variations in power that occur independent of renewable-energy generation. Energy storage cost reductions will enable mass-market affordable electric vehicles and a clean, modern, distributed, and resilient electricity grid with deep impacts in transportation, power and petroleum sectors.

Materials are a key bottleneck in efficient and clean energy generation, consumption, distribution and storage. Limitations in the performance of materials touch all aspects of the energy industry. In the oil business, down-hole materials must withstand aggressive chemical, thermal and mechanical conditions, and their failure comes with tremendous cost and disruption. More efficient solar materials are driving down the cost of solar energy. Higher energy density battery electrodes can lower the cost of grid-scale storage and further advance electrified drivetrains in vehicles. More efficient materials for catalysis and separation can improve efficiency and reduce energy footprints in a range of industries.

But while the benefits of new materials in these applications are real, novel materials exploration is slow and expensive, taking an average 18 years from concept to commercialization. This makes developing new materials a difficult choice for many energy companies.

This slow translation is rooted in impurities, defects, grain boundaries, and the difficulties that arise when materials are scaled from small quantities to larger amounts. As these materials are integrated into components, additional challenges involving the interaction of materials arise, and components assembled together into devices lead to still more challenges.

While we clearly understand the CEC's focus on higher TRL technologies and applaud the CalSEED effort to drive an entrepreneurial pipeline of innovation in the TRL 0-5 range, we are also mindful of the need to support some lower TRL research activities in the more basic innovation pipeline than the commercialization outputs likely to materialize in CalSEED. These basic innovations are needed to bridge the gap between 2030 and 2050 goals in California.

THEME 6 – MAXIMIZE SYNERGIES IN THE WATER ENERGY FOOD NEXUS

The United States per capita water footprint is higher than that of other industrialized countries. California's agricultural sector, which includes more than 400 commodities and 76,400 farms and ranches, received approximately $54 billion/year for its output in 2014. The sector has suffered tremendously from the ongoing drought, and it is in dire need of advanced irrigation tools and the relevant technologies and technology-assessment tools.

These tools include soil- and plant-moisture sensing devices, commercial irrigation-scheduling services, and computer simulation models to assist with water–energy management decisions.

Also, energy costs can be reduced through smart demand-response schemes, deployment of renewable energy sources, and knowledge of how water policy affects water-use efficiency.

The persistent stress on water resources requires continued investment in new technologies to enable enormous water reserves from nontraditional sources. One possible solution for water/energy/food nexus is desalination. At present, the cost and energy intensities of desalinated water are prohibitive for most communities. Developing new desalination technologies operating at cost, electricity, and emission parity with the average price of municipal water today ($100–500 per acre-foot) could increase our overall supply of fresh water, even through extended periods of severe drought.
The inherent complexity of these new methodologies demands a coordinated and integrated science and technology approach to the water-energy nexus – one that leverages basic science, applied research and outreach.

Research needs in this space include:

- New paradigms for separation processes and desalination technologies
- New approaches for integrating renewable energy and/or low-grade heat with desalination
- Research into more robust and cost-effective membranes
- Hybrid desalination processes to increase energy efficiency and recovery
- Assessment and mitigation into environmental issues associated with desalination

THEME 7 – DEVELOP TOOLS AND ANALYSIS TO INFORM ENERGY POLICY AND PLANNING DECISIONS

Developing scalable solutions to meet California's climate goals requires engaged market actors with clear market signals and valuation models. While we have included reference to development of these market models, tools, and asset classes above in THEMES 1 & 2, it bears repeating in THEME 7 which is cumulative in its desire to aggregate all the efforts on the previous themes to accomplish California's goals.

In addition to development of tools and science based research for holistic energy decision making toward long-term planning and modeling for 2030 to 2050, we note several missing critical path needs:

- Development and testing of resiliency and climate risk assessment and financial models
- Development of efficiency as an asset class and new capital revenue scenarios and flows for efficiency investments
- Engagement of insurance providers and financial institutions, banks and accounting firms in the stakeholder group

THEME 8 – CATALYZE CLEAN ENERGY INVESTMENT IN CALIFORNIA'S DISADVANTAGED COMMUNITIES

To ensure that the benefits that accrue from California's policies and its research investments do so equitably, including to disadvantaged communities, we believe it is important to incorporate blueprints and testing plans prior to full scale deployment.

The State of California has unique resources in the national laboratories and federally funded research and development corporations (FFRDCs) as well as its academic institutions. Using these resources to develop blueprints and pre-testing plans will allow us to means test the implications for different communities as the technologies, pilots, and demonstration sites are rolled out statewide.

CONCLUSION

In addition to the research priorities identified in the CEC's current draft of the 2018-2010 Triennial Investment Plan, Berkeley Lab hopes that you will consider the input above by THEME and the attached project write ups attached to this document as you finalize the draft plan for approval.

In addition to these comments, we leave you with a few thoughts regarding opportunities for statewide partnerships and pilots that may also advance California's goals:

- A Framework for Public-Private Partnerships and engagement with Philanthropy across sector
- Evolution of Appliance Standards to serve as both a grid-resource and also a code compliance path
- Virtual coordination of research facilities, demonstration sites and deployment strategies across sector
- Coordinated pilots of innovative regulatory strategies and pricing signals to align consumer and market interests with policy goals

Public Private Partnerships & Engagement with Philanthropy

Given uncertainty of federal funding and research priorities, it is clear that states, industry, and platforms, and solution sets that will deliver the needed infrastructure improvements, energy philanthropy will serve to design, develop and deploy the cadre of technologies, systems, savings and emissions reductions committed to in Paris. Without those pipeline solutions that are still in development, we will be unable to use the decade of the 2020s to deploy said solutions at scale. Coordination with private sector partners and philanthropy will be key.

Virtual Coordination of Research Facilities

Emerging and early-stage energy technologies by small businesses, technology entrepreneurs as well as private sector are an important part of California's energy ecosystem. Early stage technology developers and entrepreneurs of emerging technologies typically have limited

funding and access to tools and resources to develop, test and validate their technology innovations and concepts in a technically sound environment. Developing the proof-of-concept early on provides technology developers and entrepreneurs with strategic wins that are crucial for them to attract funding to advance their technologies further. However, the sophisticated technical tools, resources and equipment typically needed by entrepreneurs/small businesses to develop the early proof-of-concept can be very cost-prohibitive and conversely, do not warrant investment in the technical infrastructure till the proof is developed. As such entrepreneurs and small business find themselves in a bind.
This can be addressed by providing technology developers, entrepreneurs and small businesses access to resources and research facilities represented by the national laboratories, universities, technical facilities and test-beds, incubators and accelerators throughout California. However, it can be often tedious and overwhelming for technology developers, entrepreneurs and small businesses to access the capabilities of various technical resources and decide which facilities might be best fit for their needs. Navigating transactional and contractual needs to access and use these resources might be further deter and delay a technology's development and testing.

Cataloging, coordinating and connecting technology resources and services available throughout California from Universities and Research Facilities such as National Laboratories, User facilities as well as Incubators is a valuable service to the technology developers, entrepreneurs and small businesses while leveraging the technical assets and knowhow of these resources. While CalSEED supports the development of such a database of resources, offering the virtual coordination and match-making assistance to the entrepreneurs and small businesses to find the best research resources to meet their technology development needs and goals will accelerate and de-risk the advancement of innovative and emerging technologies.

Innovative Regulatory Strategies and Statewide Research Programs
One example of an innovative regulatory strategy is to develop a new statewide pricing program similar to the one we had more than a decade ago, but with additional customer segments, newer automation, and price forms that reflect the new shape and value of electricity. The original statewide pricing pilot explored how residential customers could respond to dynamic prices with manual or automated responses. It explored dynamic prices forms, customer preferences, technology platforms, and the ability of customers to respond to these prices. The new pilot would explore a broader set of automation and control technology, customer segments and demonstrate the value of flexible electric loads.

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The Energy Commission is currently soliciting ideas and stakeholder input for the 2018 – 2020 EPIC Triennial Investment Plan. For those that would like to submit an idea for consideration in the 2018-2020 EPIC Triennial Plan, we ask that you complete the form below. Submittals are due by **5:00 p.m. on February 10, 2017.**

Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Develop, Demonstrate and Automate Behind the Meter Distributed Energy Resources To Provide Shift Resources - The goal of this initiative is to develop, component technologies and integrated systems that allow buildings to shift their load for several hours within a day, to balance variable renewable generation. Solutions will involve packages of advanced lighting controls (1.1), solar control/thermal envelope/mass (1.2), HVAC systems (1.3), water heating, miscellaneous loads, controls and automation (1.4), on-site renewables, thermal and electrical storage (2.1), and automated demand response (3.1) technologies. Solutions must be able to deliver several hours of load shifting for various seasons, and at different times of day. There is a need to automate this response so that the shift systems can be dispatchable and change during seasons. Work is also needed to develop the content of the demand response automation signals for a shift response. To enable cost effectiveness and wide scale implementation, integrated/ interoperable controls/ communications are needed for conventional end use devices (lighting, envelope, etc.). A robust, hierarchical controls infrastructure is needed for end uses that directly impact comfort and productivity in occupied zones.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

this initiative overcomes the technical barrier of the lack of flexible electric loads to help California's electric grid manage greater levels of renewables. The demand response resources over the last decade and more have been developed to reduce peak loads on hot summer days. There is a growing need to develop techniques to shift electric loads from later afternoon and early evening to the middle of the day.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The benefits of this initiative are that it will help provide a cleaner, affordable, and renewable grid. Electricity customers will benefit from using more electricity when the price are lowest and less when prices are high. Electric utilities and grid operators will reduce over-generation, and electric demand will be better integrated with electric supply. Technology providers and control companies will have new market opportunities for grid integration and demand responsive shift systems

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The metrics for the technology include the power level and energy shift capabilities of various end-use and DER systems, or power level and duration. The metrics also include costs for automation, predictability of the shift response, and seasonal performance variation.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Alstone et al, CPUC Study, Phase 2 Results: 2025 California Demand Response Potential Study, March 2017.
CAISO DR and Energy Efficiency Roadmap, Maximizing Preferred Resources, Dec 2013.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

The competitive advantage of these control platforms and infrastructure will be designed to use low price electricity and reduce the use of high price electricity, as well as being dispatchable for real-time grid management. This capability does not currently exist in the market.

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Accelerate Widespread Customer Adoption of Distributed Energy Resources

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Accelerate the adoption and capabilities of advanced control and diagnostic technologies: Complementing proposed Initiatives 1.4.1, 1.4.2, and 1.4.3 this initiative will focus on filling the technical, market, and informational gaps necessary to scale the adoption of advanced analytics, and control techniques in California's commercial building stock. The current set of initiatives lays the foundation for improved interoperability, end-user focused design, and security - the benefits of these initiatives can only be fully realized by coupling them with a set of applied R&D, demonstration, and deployment activities to advance the capabilities of commercial diagnostic and control solutions and their market uptake. To date, diagnostics and controls optimization technologies have seen early uptake in large campuses and portfolios, however, they remain under adopted throughout the commercial sector as a whole.
The scope of the initiative would encompass segment-specific: delivery and usage models for technology & services; "all-in" cost-benefit assessments; software performance testing and validation; and barrier-focused technology development to advance commercially available model-predictive, diagnostic and control technologies.
A holistic initiative of this nature will allow California buildings to realize deep energy and demand savings, and persistent operational efficiency as DER, time-of use, and EE and DR continue to converge in our buildings.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Today's analytics and control optimization technologies can enable operational energy savings of up to 20%, yet they remain underutilized. Key barriers and knowledge gaps to more pervasive use include:
The role of service providers in supporting new market delivery models for pervasive ongoing commissioning, M&V, and advanced predictive control and diagnostic technologies.
Credible 3rd party information on the costs to procure, implement, use, and maintain these systems.
Access to software vetting and testing methods (analogous to hardware) for market understanding of what works and what merits investment
Transparency in capabilities and as-used benefits across a diverse product market.
New diagnostic and control solutions that will address the shortcomings in today's commercial tools.
How to increase deployment through a combination of required, voluntary, and incentive-based activities

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The primary impacts will be:
Achievement of operational efficiency savings
Flexible, optimized building control, and goal oriented policies (e.g., minimize demand, cost, consumption, maintenance, etc.)
Demand savings
Persistence in savings over time

The primary users and beneficiaries include a broad cross section of stakeholders:
Building owners and energy managers
Utility efficiency program administrators
Regional energy efficiency organizations
Market transformation entities
Technology and service providers

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Over-time energy, demand, and utility cost savings in participating facilities
Increase in the number of CA buildings using continuous meter analytics, fault detection and diagnostics, automated dynamic control optimization
Increase in sales of technology and service-base analysis in CA
Adoption and delivery of software performance testing methods
Effectiveness of any newly developed technology solutions

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Granderson, J, Lin, G. 2016. Building energy information systems: Synthesis of costs, savings, and best-practice uses. Energy Efficiency 9(6): 1369-1384.
Mills, E, Mathew, P. Monitoring-based commissioning: Benchmarking analysis of 24 UC/CSU/IOU projects. Report prepared for CEC PIER, June 2009, LBNL #1972E.
Granderson, J, Price, P, Jump, D, Sohn, M. 2014. Development and application of a statistical methodology to evaluate the predictive accuracy of building energy baseline models. Energy 66(1): 981-990.
Piette, MA, Granderson, J, Kiiccote, S, Wetter, M. 2012. Intelligent building energy information and control systems for low-energy operations and optimal demand response. IEEE Design and Test of Computers 29(4): 8-16.
Roth, K, Llana, P, Westphalen, D, Broderick, J. 2005. Automated whole building diagnostics. ASHRAE Journal 47(5): 82-84.
Deparment of Energy's Smart Energy Analytics Campaign, smart-energy-analytics.org

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

This initiative is primarily focused on overcoming adoption barriers and advancing the state of technology solutions to maximize the value of Initiatives 1.4.1.-1.4.3.

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
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    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
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    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Urban Building Energy Systems. The goal of the initiative is to develop new data and tools to support and inform stakeholders for the planning, design and operation of viable, sustainable, resilient cities with healthy economies and optimized systems to reduce building energy consumption by 50% by 2030 for cities in California. Expanding research from individual buildings to buildings in a district as part of urban systems is a critical need for California and other states. A city-scale perspective is necessary if energy consumption and emissions are to be cut in half by 2030. A fundamental opportunity of urban building energy systems is to integrate thermal loads so that the diversity of heating and cooling loads can be served by integrated thermal networks, where waste heat from one building supplies needed heat to another – optimizing efficiency at the campus, neighborhood or community level. These systems are district-scale energy networks. A key element of this effort is to develop models and methods to evaluate the risk and uncertainties associated with efficiency investments, and guarantee the performance of urban building energy systems.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Urban Building Energy Systems. Urban-scale computational tools are data analytics, modeling, simulation, optimization and visualization tools used by city stakeholders and consultants to evaluate technologies and strategies that support energy efficiency in a cluster of buildings. The initiative will address knowledge gaps: (1) lack of data ontology and standards to collect and represent city scale building stock and performance data, (2) lack of easy to use, open access, web-based modeling and simulations tools with transparent assumptions and readily available input data, and (3) lack of systematic approaches integrating building energy efficiency, renewable energy, demand response measures, and district energy systems, and considering coupling effects between buildings and between buildings and urban climate. Such modeling and analysis platforms will enable data-driven, informed decisions on planning, design and operation of new urban districts, as well as retrofitting existing districts to reach zero-net-energy and resilience.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Urban Building Energy Systems. Expected impacts include: reducing total urban building energy use by 50% by 2030; lower building operating costs; lower GHG emissions in the building stocks in cities; lower building peak demand; greater flexibility in use and generation of energy, and greater resilience in the face of extreme weather and other disruptive events. Primary users and/or beneficiaries include: California statewide city-related planners and policy makers; city government and officials running energy efficiency programs; utility energy efficiency program managers; urban planners; ESCOs, energy professionals and consultants, and citizen in cities.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Urban Building Energy Systems. Metrics to evaluate the impacts include: urban building energy use (kBtu/ft2-yr); building operating costs ($/ft2); GHG emissions in city building stock; peak demand of the building sector (W/ft2); flexibility in use and generation of energy, and resilience in the face of extreme weather and other disruptive events.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

T Hong, Y Chen, SH Lee, MA Piette. CityBES: A web-based platform to support city-scale building energy efficiency, 5th International Urban Computing Workshop, San Francisco, 2016.
T. Hong, M.A. Piette, Y. Chen, et al. Commercial Building Energy Saver: An energy retrofit analysis toolkit, Applied Energy, 159: 298-309, 2015.
Y. Chen, T. Hong, M.A. Piette. City-Scale Building Retrofit Analysis: A Case Study using CityBES, IBPSA International Conference, San Francisco, 2017 (accepted).
M. Wetter, M. Bonvini and T.S. Nouidui. Equation-based languages - A new paradigm for building energy modeling, simulation and optimization. Energy and Buildings, 117:290–300, 2016.
R.Z. Pass, M. Wetter, M.A. Piette. A Tale of Three District Energy Systems: Metrics and Future Opportunities. Proc. of ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, Aug. 2016.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

NA

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    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify

CALIFORNIA ENERGY COMMISSION
1516 NINTH STREET
SACRAMENTO, CA 95814-5512
www.energy.ca.gov

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Research is needed to help disadvantaged communities participate in citizen science to measure air quality in their communities (indoor and outdoor) that relate to energy choices (e.g., heating, ventilation, air conditioning), including the development of new low-cost air sensors, such as for pollutants like black carbon that contribute both to climate change and severe health impacts. Citizen science will increase community engagement and understanding of linkages between climate and energy policies on air pollution and health.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Development of new low-cost air pollution sensing technologies and air pollution sensing networks, and training workshops within communities to teach citizens how to use air sensors and interpret and share their data

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Ratepayers in disadvantaged communities will be the primary beneficiaries as they will be able to measure air quality impacts of energy use within their community and in their homes at an unprecedented granular level. Empowered with information on air quality, disadvantaged communities may accelerate adoption of cleaner energy technologies, e.g, replacing residential wood burning with electricity or natural gas. Air quality agencies will also benefit as they will have new, actionable information formulate policy and program incentives (e.g., air filtration in new homes near freeways; redirection of commercial traffic) that push towards cleaner, healthy air.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Number of participating citizens in disadvantaged communities; Number of new air pollution sensors/sensor packages developed/distributed within disadvantaged communities

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

CW Noonan, TJ Ward, EO Semmens, Estimating the Number of Vulnerable People in the United States Exposed to Residential Wood Smoke, Environ Health Perspect; DOI:10.1289/ehp.1409136

EG Snyder, TH Watkins, PA Solomon, ED Thoma, RW Williams, GSW Hagler, D Shelow, DA Hindin, VJ Kilaru, PW Preuss, The Changing Paradigm of Air Pollution Monitoring, Environ. Sci. Technol., 2013, 47 (20), pp 11369–11377; DOI: 10.1021/es4022602

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
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    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Envelope systems shape the heating, cooling, ventilation, and lighting requirements of buildings, which together account for about half to total energy use in buildings. Tightening the envelope allows for sizing smaller HVAC units while also providing opportunities for non-compressor type cooling and ventilation systems. Envelope systems also impact key aspects of how occupants experience a building, such as health and wellness, access to daylight and view, and aesthetics, providing benefits that aren't necessarily reflected in energy performance metrics but that can be key factors in deployment decisions. Applied research & development is needed to advance energy-saving window and envelope technologies for existing or new buildings, including the development of non-energy functionality or benefits likely to increase deployment. Examples of potential technologies include (1) Building envelope materials; (2) Air-and liquid sealing technologies; (3) Dynamic windows, and window films; and (4) Highly insulating roofs.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

The initiative would help create low-cost, high-performance building envelope technologies solutions, especially (but not limited to) those that can be retrofit economically to California's aging and inefficient building stock.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Ratepayers, building owners, building occupants, building renovators, regulatory agencies, construction industry, architects

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Annual and service-life primary energy and energy cost savings per building and across California; peak power demand reduction per building and across California; simple payback time.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

R.S. Ulrich, View through a window may influence recovery from surgery, Science 224 (1984) 420–421.
Envelope systems and energy savings
Thanachareonkit, Anothai, Eleanor S. Lee, and Andrew McNeil. "Empirical Assessment of a Prismatic Daylight-Redirecting Window Film in a Full-Scale Office Testbed." LEUKOS: The Journal of the Illuminating Engineering Society of North America 10, no. 1 (2014): 19-45.
Luís L. Fernandes, Eleanor S. Lee, Andrew McNeil, Jacob C. Jonsson, Thierry Nouidui, Xiufeng Pang, Sabine Hoffmann, Angular selective window systems: Assessment of technical potential for energy savings, Energy and Buildings, 90:188-206.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

This proposal is open to a wide range of building envelope solutions. Depending on the technology(ies), possible competitive advantages include improved energy savings, improved occupant comfort and/or satisfaction, reduced operation and maintenance costs.

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

The proposed initiative is an assessment of water use and associated energy consumption within California's industrial sector. The assessment would be based on primary data collection gathered through field visits using a representative statistical sample of California industry. Results would quantify how much water California industry uses and for what purposes. It would quantify the associated energy consumption for conveying, pressurizing, treating, heating/cooling, or for any other end use. It would quantify consumptive use, as well as overall water use. The results would also identify opportunities for water-related energy consumption, water, and by-product recovery (including energy) from effluent streams.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

There is little data available on industrial water use. Based on national water use characteristics, the majority of industrial water use is self-supplied indicating that industrial water use cannot be determined solely through review of municipal water authority customer databases. On site sampling will allow for an accurate estimate of California industrial water use. Further, the energy for water use within industry has not been well studied at any scale (i.e., within California, regionally, or nationally). A quantification of the water-energy nexus within an industrial facility's boundaries would be a first-of-its-kind study. Finally, the opportunities for water, energy, and by-product recovery within an industrial facility will enable California's industries to be more resilient against short term (i.e., price shocks) and long term (i.e., climate change) impacts.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Currently, industry is either neglected when considering water policy and/or decisions are informed without solid supporting data. The results from this initiative would inform policy decisions regarding: maintaining and strengthening competitiveness of California's industrial sector, identifying how California industry can contribute to responses to state water plans and emergency water conservation actions, and increase the incentives for adopting water efficiency measures by providing a better understanding of the associated energy saving benefits. The initiative would also represent a first-of-its-kind nationally and could be leveraged by other states and/or the Federal government to inform their own water-energy policies related to the industrial sector.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

There are several stakeholders for the results of this potential initiative. Impact would be determined based on the number of times the results are downloaded and/or cited. The initiative would work closely with stakeholder groups (e.g. California trade associations representing the industrial sector, water authorities, and government representatives) to ensure that the results are aligned with their knowledge gaps and needs and can inform the decisions of their customers and policies.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Gleick, P.H., D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolff, K.K. Cushing, and A. Mann. 2003. Waste Not, Want Not: The Potential for Urban Water Conservation in California. Oakland, CA. Pacific Institute.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

N/A

Part 3. Connection to Energy Commission's EPIC Framework

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Maximize Synergies in the Water-Energy-Food Nexus

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Packaged Integrated Systems. Component level technologies provide energy savings potential through the development of further emerging technologies. However, opportunities for energy savings are currently available through existing technologies, packaged as integrated systems which have been shown to achieve 20%+ whole building energy savings potential for existing buildings through focused retrofits. Both passive and active technology approaches, or combinations thereof, may be taken, but the challenge is that the design, assessment and procurement of these packaged systems is currently not addressed accessibly or cost effectively by the market. RD&D is proposed to initiate market approaches to address these deficiencies in the deployment chain (which operates mainly in siloes currently), creating product offerings to enable greatly improved accessibility of these otherwise technically cost effective solutions. Work may also be proposed to improve the cost effectiveness of current packages of technologies.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Market barriers to integrated retrofit packages include a lack of available tools, such as the capability to develop:
Packages of integrated system technologies, including system specifications and validated performance metrics.
Simplified assessment methodologies to determine energy savings potentials.
Market alliances and deployment channels developed to enable streamlined deployment of packaged systems, especially where they cross multiple trades.
Measurement and verification methods designed for integrated systems strategies that are cost effective to implement, or approaches that provide quantified levels of uncertainty in savings that enable system applications without excessive M&V related costs.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Impact would be 20%+ existing and new construction energy savings cost effectively. Strategies would impact commercial offices, education, lodging, retail, multi-family residential and single family homes. Beneficiaries are ratepayers, contractors (general and specific trades), M&V implementers, utility rebate program administrators, building owners, operators, design community.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Potential in commercial sector (and possibly residential) for annual energy savings. Peak energy use reduction. Energy cost savings. GHG emission reductions.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Regnier, C., Mathew, P., Robinson, A., Schwartz, P., & Walter, T. (2016). Beyond Widgets – Systems Incentive Programs for Utilities. ACEEE. ACEEE. - Report Number: LBNL-1006195

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Many existing technologies can already apply to packaged systems approaches, making technology development costs low.

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Overall strategies and approaches to achieve widescale building electrification will be developed by end use (water heating, space heating, other heating uses) and by building type (e.g. retrofitting multi-family vs. retrofitting medium commercial vs large commercial buildings). Building electrification, in concert with a lower carbon electricity supply system, is a key decarbonization pathway for building heating end uses. Previous studies have projected that the building heating sector alone will approach 70% of the overall GHG budget for 2050 and current analysis suggests that the 2030 target of 40% GHG reductions applied to the building heating sector cannot be achieved without aggressive electrification. To date, the approaches to achieve building electrification both existing and new buildings have not been clearly defined for the range of residential and commercial building types and heating end uses.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Technical and market barriers include the higher cost of electrified heating and lack of familiarity of electrified technologies in the design and building community. Past work has been fairly high-level, describing the potential GHG savings and the potential additional electricity demands. This proposed initiative would provide a more comprehensive and detailed study to better understand a wide-scale transition to building electrification and delineate implementation options and strategies for building electrification across the span of building types with detailed building modeling, techno-economic analysis and scenario analysis. The work will highlight key technology demonstration and deployment needs, interactions with other sectors (e.g. distributed energy resources, demand response, the need for low GWP refrigerants, etc), and develop policy frameworks for this transition.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

If this initiative is successful, a more detailed strategy and mapping of the approaches to building decarbonization will be achieved. This will help to facilitate the state's statuatory goals for GHG reduction in the building sector for 2030 and the policy goal for 2050. Electricity customers would see less on-site combustion and on-site combustion related air pollutant emissions and electric utilities would see more building electricity demand. More widescale retrofits to electrified end uses will benefit the construction industry and suppliers of electric end use equipment e.g. heat pump equipment suppliers.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

1. GHG reduction with aggressive building electrification vs less aggressive or no building electrification
2. Criteria emission reduction from the reduction of on-site combustion
3. Increase in retrofit activity with aggressive building electrification vs less aggressive or no building electrification

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Jeffery B. Greenblatt, Modeling California policy impacts on greenhouse gas emissions, Energy Policy, Volume 78, March 2015, Pages 158-172, ISSN 0301-4215, http://dx.doi.org/10.1016/j.enpol.2014.12.024.

Mark Z. Jacobson, Mark A. Delucchi, Anthony R. Ingraffea, et al., A roadmap for repowering California for all purposes with wind, water, and sunlight, Energy, Volume 73, 14 August 2014, Pages 875-889, ISSN 0360-5442

M. Wei, J.H. Nelson, J.B. Greenblatt, A. Mileva, J. Johnston, M. Ting, C. Yang, C. Jones, J.E. McMahon, D.M. Kammen, "Deep Carbon Reductions in California Require Electrification and Integration Across Economic Sectors," Environmental Research Letters, 2013; 8:014038.

James H. Williams, et al. The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of ElectricityJScience 335, 53 (2012).

Robert Lowe, Technical options and strategies for decarbonizing UK housing, Building Research & Information Vol. 35 , Iss. 4,2007

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Part 3. Connection to Energy Commission's EPIC Framework
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7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Heating and Cooling 2.0. This initiative will develop and assess the system-level performance of all-electric heating and cooling systems with novel architectures that utilize solar thermal, geothermal, and thermal energy storage technologies and can be integrated with district-scale thermal energy networks. The goal of this initiative is to develop system-level solutions for heating and cooling of residential and commercial buildings that are Net Zero Energy, grid-friendly, cost-effective and have minimum environmental footprint. The drivers are the trend towards all-electric buildings that utilize relatively low-temperature energy sources for heating and cooling, such as solar thermal and geothermal. This raises the need to develop next-generation solutions that provide adequate building services while also including demand shifting capabilities for potential integration with district-scale renewable energy harvesting, storage and markets as appropriate for a given urban density.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Wetter and Blum - Heating and Cooling 2.0. When to prioritize system-level solutions (such as solar thermal heating and cooling systems or low-lift vapor compression systems with near-room temperature phase change materials) versus component-level efficiency improvements (such as better windows and high-efficiency compressors) is not well understood. Efficiency improvements have traditionally been achieved through higher component efficiencies, through 2nd law inefficiencies due to large temperature lifts that ultimately result in higher electricity use are not given sufficient attention. Studies show that in conventional cooling systems, 60% of electricity is wasted due to design for too-high temperature lifts. This poses a great opportunity for better system integration with low-temperature solutions rather than increasing component level efficiencies by the typical 10 to 20%. In addition, system-level research on energy efficient buildings with low-temperature district heating and cooling networks that allow for buildings to share waste heat and excess cooling target a reduction of the environmental footprint by a factor of three by 2035 (https://www.sccer-feebd.ch/).

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The benefits of this initiative are that it will identify and promote the energy efficiency and life-cycle cost advantages “low-exergy” heating and cooling solutions have over conventional heating and cooling systems. Primary users and/or beneficiaries include building owners, building mechanical system designers and consultants, and building mechanical system manufacturers.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Heating and Cooling 2.0. The metrics are annual energy use and greenhouse gas emissions versus life-cycle cost for different Net Zero Energy systems, in different California climate zones, under the constraint of providing adequate thermal comfort, visual comfort and indoor air-quality.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Mei Gong, Sven Werner, Exergy analysis of network temperature levels in Swedish and Danish district heating systems, Renewable Energy, Volume 84, December 2015, Pages 106-113, ISSN 0960-1481, http://dx.doi.org/10.1016/j.renene.2015.06.001.
IEA EBC Annex 64 – LowEx Communities, http://www.annex64.org/
Future Energy Efficient Buildings & Districts, https://www.sccer-feebd.ch/
Alessandro Maccarini, Michael Wetter, Alireza Afshari, Göran Hultmark, Niels C. Bergsøe, Anders Vorre, Energy saving potential of a two-pipe system for simultaneous heating and cooling of office buildings, Energy and Buildings, Volume 134, 1 January 2017, Pages 234-247, ISSN 0378-7788, http://dx.doi.org/10.1016/j.enbuild.2016.10.051 .
Forrest Meggers, Volker Ritter, Philippe Goffin, Marc Baetschmann, Hansjürg Leibundgut, Low exergy building systems implementation, Energy, Volume 41, Issue 1, May 2012, Pages 48-55, ISSN 0360-5442, http://dx.doi.org/10.1016/j.energy.2011.07.031 .
Tea Zakula, Peter Armstrong, and Leslie Norford, Advanced cooling technology with thermally activated building surfaces and model predictive control, Energy and Buildings, Volume 86, January 2015, Pages 640-650. http://dx.doi.org/10.1016/j.enbuild.2014.10.054

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Heating and Cooling 2.0. These technologies are beyond the prototype stage. Isolated demonstrations of such "low-exergy" systems exist for various climates. To bring to scale, we recommend developing guides for energy consultants to query what system-level solutions are most favorable for given climate zones and load profiles. This is expected to lower the barriers of designing such systems and proposing them to clients for new constructions and deep energy retrofits. Similarly, such guides will be used by policy makers to prioritize energy code and by utilities as inputs to strategize incentive programs.

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Connected to 3.2. Assessing the effects of VGI services on battery life. The battery on a PEV is one of the more expensive components. Plausible VGI services could lead to a myriad of uses of the vehicle's battery. As part of the cost/opportunity analysis and the warranty process one must factor in the effect on battery life as a result of different use scenarios. Mechanisms of battery fade as a function of state of charge and depth of discharge will be investigated. Preferred use cases will be identified.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Automakers are reluctant to add VGI capabilities to their vehicles not only because the potential economic benefits are not clearly identified but potential harm to the battery is poorly understood. Car manufacturers critically need to understand the added degradation that VGI services bring to vehicle batteries.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Warranties are based on predicted use cases of the battery in the vehicle. If the battery is to also provide VGI services, appropriate warranties will need to be established. The beneficiaries are the car companies, the consumers, and the utilities.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

If properly assessed and understood, car companies will start adding VGI features to vehicles. The more vehicles that come with these features, the more benefit the public can gain from this capability. VGI features will eventually become standard equipment on all PEVs.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Off-line discussions at USABC meetings.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

A vehicle with known response to VGI will have a much greater advantage on selling on the market than those where the effects are unknown.

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    - Maximize Synergies in the Water-Energy-Food Nexus
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    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Accelerate Widespread Customer Adoption of Distributed Energy Resources

If Other, Please Specify

CALIFORNIA ENERGY COMMISSION
1516 NINTH STREET
SACRAMENTO, CA 95814-5512
www.energy.ca.gov

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Connected to 3.4. Low-cost, long-life energy storage for the grid. Much fundamental research is conducted around the world developing batteries. However, the materials selection starts from a perspective of maximum energy density which typically requires operation outside the thermodynamic stability window of the materials with the research focused on slight modifications of the material properties for improved limited impacts on costs. Since energy density is not as critical as cost and life for energy storage on the grid, an enormous opportunity presents itself to develop batteries that start from a minimal cost perspective that have a much greater ability to provide extremely large lifetimes by not being stressed beyond their thermodynamic limits. Today's vehicle batteries also require water organic electrolytes that contain only parts per million quantities of water that today are flammable and require expensive manufacturing capabilities. Materials selected from the start for their safety and life would be bring a critically new approach to battery research.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

In order for batteries to make economic sense, they need to be able to accept and provide back energy that is several orders of magnitude of the size of the battery to accept a full charge and to be inexpensive. Energy density is a secondary requirement but is where nearly all battery research today is focused. Finding low-cost, long lived batteries that are inherently safer than today's Li-ion is critical to enabling renewable, intermittent power. This effort will help identify potential candidates.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The development of an inexpensive, extremely long-lived battery with much less safety risk than today's Li-ion battery would greatly accelerate adoption by the utilities.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Utilities putting these new batteries online, especially for mega- and giga-watt applications where cost and safety are a premium would be a clear indicator of the success of this initiative.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Off-line discussion with members of ESIC (Energy Storage Integration Council).

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Today's lithium ion battery is built for energy at the expense of safety and cost (the cost projections are low based on volumes, but large grid storage installations could require comparable volumes.) The proposed technologies could surpass both benchmarks and have longer life.

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Accelerate Widespread Customer Adoption of Distributed Energy Resources

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Connected to 7.3. Environmentally Benign and Renewable/Regenerative Batteries. Today's Li-ion battery, mass produced for their energy density have become the default solution for the grid. Because of acute safety concerns related to thermal management, these cells are usually produced in small configurations of 50 Ah and less, requiring excessive quantities of packaging. Because the transport inside relies on diffusion in media of less conductivity than aqueous systems, the electrodes, current collectors and separators are all produced at 100 micron thicknesses and less. Separation and regeneration of materials in such a configuration is not cost effective which leads many manufacturers losing money in the recovery process. This is not a sustainable business model. What is needed are aqueous based systems that are inherently safer and have greater transport properties which result in components closer to millimeters in thickness (as in the electrodes designed for lead acid batteries where recycling occurs fat a rate of over 95%.) that are either easily recovered and recycled or rejuvenated and put back into operation with minimal treatment.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Non-flammable, non-toxic, low-cost, refurbishable batteries would greatly reduce initial costs and could lead to batteries that would last multiple times longer than today's Li-ion battery, proportionately reducing cost. It would also result in less impact on the environment and pose less of a health risk in the case of an untimely disassembly or leak that today's Li-ion. Research in this area would reveal several new alternatives that would push grid technology to and beyond the current state of Li-ion in terms of performance and manufacturability.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

If this initiative is successful one would see the production of large, safe battery systems for the distribution network or smaller and safer systems for the home. The beneficiaries would be the utilities and the general public that is interested in capturing and using the energy produced at their own homes.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The development of new, safe, low cost alternatives would be an obvious indicator of success. Interim success could be measured in the development of new small-businesses, patents, and publications.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

The proposed technology would be safer, lower cost, and longer life than today's alternative

Part 3. Connection to Energy Commission's EPIC Framework
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7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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Accelerate Widespread Customer Adoption of Distributed Energy Resources

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

The proposed initiative calls for the need to develop and test new water heating systems that would serve the needs of California regions. The study would determine components and operational strategies of heat pump water heaters that contribute to higher efficiency, smarter control, lower cost and greater system reliability. In particular, more attention would be given to implementation of new compressor system, alternative refrigerant, passive heat storage materials, and environment-specific control design. The study would include full scale field implementation in various climate-specific regions in California to understand the impacts of seasonal patterns, extreme conditions, and other household characteristics on performance and efficiency of the system. Energy use and economic analysis would be conducted and compared to conventional systems.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Heat pump water heating systems (hpwhs) have been considered one of the key products that would significantly reduce energy. However, issues associated with inconsistent performance, poor reliability, and reduced efficiency due to climate have been associated with current generation of hpwhs available in the market. Improvements are required to these systems to achieve the full potential of hpwhs. The proposed initiative aims to achieve this goal.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The study is expected to introduce new products in the market of hpwhs. The new system is expected to perform at twice the efficiency level of current hpwhs, which would directly benefit the consumer and electricity providers. The impact on policy would be an increase in efficiency level for water heaters. The study supports goals outlined in policies for California's Energy Future - Electricity Pricing and Electrification for Efficient Greenhouse Gas Reduction.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The metric would be energy use saving, peak demand, payback period, and on larger scale, carbon reduction.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Various components required for the prototype are beyond prototyping stage. The study would approach the new design and technology as integrated product that still needs to be tested in the laboratory, then assembled and manufactured for field testing in a selected climate zones.

Part 3. Connection to Energy Commission's EPIC Framework
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7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Near-term adoption of residential and commercial air conditioners that are suited for California's unique and varied climatic conditions.

As is well known, air-conditioning for both the residential and commercial sectors is a driver of peak demand in California. As a result, there have been efforts at both the national level and in California to create a market for air-conditioning that encourages the adoption of equipment that matches California's specific climatic needs. At the national level, minimum energy efficiency standards for residential central air conditioners are now specified for three regions, one of which is a hot-dry region that includes California. Although the hot-dry efficiency standards now require a metric to address air conditioner performance at near peak conditions, the metric alone is not specific enough to address air conditioner performance in all of the unique climates that are relevant to California. At the state level, action was taken back in the mid-2000s to develop a residential hot-dry air conditioner (HDAC). Although the project was successful in developing an air conditioner prototype that was demonstrated to save energy in a handful of field applications, the designs were not optimized to achieve maximum reductions in energy and demand for all climates. In addition, the project did not result in the creation of HDAC market, i.e., it did not result in the wide-spread adoption of HDACs.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

The initiative would overcome the market barriers of adopting residential and light commercial air conditioners that are designed perform efficiently and effectively in all of California's climates. There are few technical barriers to overcome, as the technologies for optimizing air conditioners to different climatic conditions are relatively well known. But additional scientific analysis is required to optimize and minimize the number of air conditioner designs that are needed for California-specific conditions. Climate analysis would be needed to disaggregate the state into as few climate zones as possible to minimize the number of air conditioner designs that would optimally address California's needs. The air conditioner designs developed would then be fabricated and/or assembled into prototypes that would be tested in psychrometric air conditioner test chambers for laboratory evaluation. Field evaluation would follow to verify the performance observed in laboratory tests. Finally, a market strategy would be developed to both incentivize manufacturers to produce the products and for consumers to adopt them over conventional air conditioners.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The expected impact is a significant reduction in both residential and commercial sector peak demand and energy use. There would also be a reduction in CO2 emissions from fossil-fuel fired power plans.

The impacts from DOE's recently adopted standards for residential central air conditioners and commercial rooftop air conditioners serve as the basis for estimating the energy, CO2, and consumer utility bill savings resulting from a California air-conditioner initiative. Through 2030, DOE's recent air conditioner standards are estimated to save 1.4 quads of primary energy, which is equivalent to 1% of total U.S. energy consumption. The savings in operating costs for households and businesses are estimated to total $6.5 billion. The estimated reduction in CO2 emissions are estimated to be 75 million metric tons. Assuming that California roughly represents 10% of the U.S. economy, California ratepayers will realize over $600 million in operating costs savings from the air conditioner standards. Adoption of California-specific air conditioners would significantly add to this total. The beneficiaries of such a program are obvious: consumers who benefit from lower utility bill savings; electric utilities that need to provide less power during times of peak demand; and the state in helping achieve its goals of lowering carbon emissions.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The first set of quantitative metrics are specific to the air-conditioning equipment, namely, metrics that capture air conditioner efficiency and performance under California-specific climatic conditions.

The second set of quantitative metrics measure the success of market adoption of California-specific air conditioners. Metrics include: (1) energy and demand savings from more-efficient air conditioners, which are initially estimated from laboratory test data and then validated though field tests and (2) actual shipments of California-specific air conditioners.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

The most relevant reference in support of the proposed initiative is the CEC's past initiative to develop hot-dry air conditioners:

"Energy Performance of Hot, Dry Optimized Air Conditioning Systems." Prepared for: California Energy Commission, Public Interest Energy Research Program. Final Report, July 2008. (http://www.proctoreng.com/dnld/EnergyPerformaceofHotDryOptimizedAirConditioningSystem.pdf)

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Because most climates in California are dry relative to the eastern and southeastern regions of the U.S., California-specific air conditioners can incorporate technologies that focus more on the removal of sensible load rather than latent load. Therefore, over-sized evaporative coils and blowers with high air volume rates would be utilized. Such technologies are not employed in conventional or benchmark air conditioners.

Part 3. Connection to Energy Commission's EPIC Framework
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7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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    - Increase System Flexibility from Low-Carbon Resources
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    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
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Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Combined heat and power systems that use high quality thermal energy (high exergy content) that is traditionally reduced to low quality (low exergy content) in space heating and water heating, thereby raising the total efficiency of the fuel source. The increase in efficiency can lead to reduced fuel use, pollution, and greenhouse gas (GHG) emissions when compared to systems that obtain their power and thermal energy separately. Therefore, we propose research and development of reliable, low maintenance combined heat and power (CHP) systems that will integrate into (retrofit) or replace building air and/or water heating furnaces. This will make the building air and/or the water heating furnaces to also generate electricity. For example a typical residential space heater can generate 4 - 8 kW of electricity while providing space heating.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Develop cutting edge technologies that harness high temperature (> 700 deg C) heat and convert it to electricity for a combined heat and power system while improving overall efficiency of the system.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Primary users and beneficiaries include the State of CA, ARB, AQMDs, Industry, and California residents. If successful, this project could harness the 2,765 MW potential for CHP systems sized 50-500kW (Hedman, Bruce, Ken Darrow, Eric Wong, Anne Hampson. ICF International, Inc. 2012. Combined Heat and Power: 2011-2030 Market Assessment. California Energy Commission. CEC-200-2012-002) and address Assembly Bill 32 and the Global Warming Solutions Act of 2006.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The advanced CHP system must displace fuel or electricity purchases and provide electricity output at cost less than current electricity and natural gas equivalent prices.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

1. Hedman, Bruce, Ken Darrow, Eric Wong, Anne Hampson. ICF International, Inc. 2012. Combined Heat and Power: 2011-2030 Market Assessment. California Energy Commission. CEC-200-2012-002 (http://www.energy.ca.gov/2012publications/CEC-200-2012-002/CEC-200-2012-002.pdf).

2. Chittum, A., and Kaufman, N., (2011) Challenges Facing combined Heat and Power Today: A Statey-byState Assessment. IEEE report, Report Number IE111. (http://aceee.org/sites/default/files/publications/researchreports/ie111.pdf)

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Advanced technology combined heat and power systems would offer the option of new or retrofit solutions to maximize efficiency and electricity generation from water and air heating systems. Efficient, reliable, low cost, and low maintenance technologies for converting high waste heat to electricity could also be used for upgrading water and air heating systems to CHP systems.

Part 3. Connection to Energy Commission's EPIC Framework

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7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
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    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

If Other, Please Specify

BTUS Collective EPIC Comment Form

Please clearly identify your response for each initiative for each prompt by including your name with each.

<u>Part 1. Initiative Description and Purpose:</u>

1. Please provide a brief description of the proposed initiative:

Tianzhen Hong, Mary Ann Piette –

We propose a Urban Building Energy Systems Initiative, which aims to develop new technologies and tools for the planning, design and operation of viable, sustainable, resilient cities with healthy economies and optimized systems to **reduce building energy consumption by 50% by 2030 for cities in California.** Expanding research from individual buildings to buildings as part of urban systems is a critical need for the U.S. and other nations around the world. A city-scale perspective is necessary if energy consumption and emissions are to be cut in half by 2030.

Cities are growing faster than at any point in history, with a projected global doubling of urban space over the next three decades. Cities represent the majority of energy use and emissions, and therefore offer the largest opportunities for gains in efficiency and cuts in greenhouse gas emissions. New technologies, policies, and business models are increasing engagement in energy and greenhouse gas (GHG) reduction strategies. Many Californian governments have set ambitious climate and energy goals. Their authority over buildings, property taxes, land use, and public infrastructure, along with their close relationships with constituencies, provide an opportunity to create cities that are low carbon, affordable, livable, economically viable, and resilient to extreme events.

Developing and implementing energy plans that will achieve these goals, however, remains a challenge for cities due to the lack of data, analytic tools, and computational models that can capture complex energy interrelationships among buildings, infrastructure, markets, and human behavior. The proposed Urban Building Energy Systems Initiative aims to create new, integrated capabilities to support the planning and policy decisions necessary to radically transform the energy and emissions profiles of California cities. The main objective of the Initiative is to develop new scientific knowledge, technology, methods and tools to enable California cities to make informed decisions to cut building energy use and GHG emissions in half.

A fundamental opportunity of urban building energy systems is to integrate thermal loads so that the diversity of heating and cooling loads can be served by integrated thermal networks. In an integrated thermal network, waste heat from one building supplies needed heat to another –

optimizing efficiency at the campus, neighborhood or community level. These systems are ***district-scale energy networks***. A key element of this effort is to develop models and methods to evaluate the risk and uncertainties associated with efficiency investments, and guarantee ***the performance*** of urban building energy systems.

This Initiative will transition buildings from individual structures to ***integrated urban energy systems***. Our goal is to demonstrate scalable strategies and technologies to reduce building energy use by 50% by 2030 in California.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Tianzhen Hong, Mary Ann Piette –

Urban-scale computational tools are data analytics, modeling, simulation, optimization and visualization tools used by city stakeholders and consultants to evaluate technologies and strategies that support energy efficiency in a cluster of buildings. We propose to develop a data and computing platform integrating various urban computational tools, including:

- City Building Energy Saver (CityBES) – a web-based, city-scale, building energy retrofit analysis tool
- Modelica tools to model transactive thermal networks, and
- Urban data models based on CityGML, an international standard for representation of 3D city models.

The platform will enable co-simulation, using the open standard functional mockup interface (FMI) between different urban domain tools (e.g., buildings, renewables, DHC systems, urban climate). CityBES provides a 3D GIS-based visualization of key performance indicators, including energy use, peak demand, and GHG emissions of urban buildings. CityBES integrates 3D city models, identify buildings for retrofit, and estimate energy savings with recommended technology and behavior measures. This provides cities a tool for targeting key buildings for retrofits. The platform will enable data-driven, informed decisions on planning, design and operation of new urban districts. It will also enable retrofitting existing building stock to reduce energy use and mitigate environmental impacts.

Cities have large and growing volumes of data from city projects, public records, and various departments. However the data vary in quality, feature different levels of resolution, and are not organized in a central repository. Most cities use simple tools, spreadsheets, and text files to manage their data, while pilot cities have adopted the Department of Energy's suite of tools, including the Standard Energy Efficient Data Platform and the Building Energy Data Exchange Specification (BEDES).

We propose to develop CityGML models for cities using these various city data sources. CityGML is an international Open Geospatial Consortium standard for representation and

exchange of 3D city models. CityGML defines 3D geometry, topology, semantics and appearance of urban objects, including buildings and their components, bodies of water, city furniture (street lighting, traffic lights), transportation infrastructure (streets, roads, bridges, tunnels) and vegetation. CityGML also provides various levels of detail to represent urban objects for various types of applications requiring different levels of detail.

CityGML-based 3D models will enable information exchange and interoperability for use in city projects that need different data analytics and modeling and simulation tools, thus significantly increasing the use of such tools and reducing the time and effort needed to use them effectively.

We propose to develop Modelica tools that enable design and operation of bi-directional district energy systems, and research how to adapt them to California climates. The anticipated outcome is a five-fold reduction in energy demand of buildings, and a transformation of building heating and cooling systems to bi-directional systems that can transact thermal energy in a dynamic market.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Tianzhen Hong, Mary Ann Piette –
Expected impacts include:

- Reducing total urban building energy use by 50% by 2030
- Lower building operating costs
- Lower GHG emissions in the building stocks in cities
- Lower building peak demand
- Greater flexibility in use and generation of energy, and
- Greater resilience in the face of extreme weather and other disruptive events.

Primary users and/or beneficiaries:

- California statewide city-related planners and policy makers
- City government and officials running energy efficiency programs.
- Utility energy efficiency program managers
- Urban planners
- ESCOs
- Energy professionals and consultants
- Citizen in cities

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Tianzhen Hong, Mary Ann Piette –
Metrics to evaluate the impacts:

- Urban building energy use (kBtu/ft^2-yr or MJ/m^2-yr)
- Building operating costs ($/m^2)
- GHG emissions in city building stock
- Peak demand of the building sector (W/m^2)
- Flexibility in use and generation of energy, and
- Resilience in the face of extreme weather and other disruptive events.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Tianzhen Hong, Mary Ann Piette –

T Hong, Y Chen, SH Lee, MA Piette. CityBES: A web-based platform to support city-scale building energy efficiency, 5th International Urban Computing Workshop, San Francisco, 2016.

T. Hong, M.A. Piette, Y. Chen, et al. Commercial Building Energy Saver: An energy retrofit analysis toolkit, Applied Energy, 159: 298-309, 2015.

Y. Chen, T. Hong, M.A. Piette. City-Scale Building Retrofit Analysis: A Case Study using CityBES, IBPSA International Conference, San Francisco, 2017 (accepted).

M. Wetter, M. Bonvini and T.S. Nouidui. Equation-based languages - A new paradigm for building energy modeling, simulation and optimization. Energy and Buildings, 117:290–300, 2016.

R.Z. Pass, M. Wetter, M.A. Piette. A Tale of Three District Energy Systems: Metrics and Future Opportunities. Proc. of ACEEE Summer Study on Energy Efficiency in Buildings, Asilomar, CA, Aug. 2016.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Tianzhen Hong, Mary Ann Piette –

A bi-directional thermal network for district heating and cooling is analogous to a smart grid, in that the direction of the water flow reverses depending on heating or cooling needs of its

consumers. Buildings can feed waste heat and excess renewable energy into the grid, and offer storage capabilities as well. Such networks exhibit very high efficiency if used with heat pumps, and can play a key role in the transition to zero-carbon and zero-energy communities. As these systems can be built out modularly, they can gradually be expanded by adding new buildings and new generation and storage, allowing for incremental investments. They have been shown to be cost competitive with conventional heating systems in Switzerland, where they are a key part of the strategy to reduce building end energy demand by a factor of five. We propose to pilot test the bi-directional thermal network for district heating and cooling in some campus or new/re-development of urban districts.

Part 3. Connection to Energy Commission's EPIC Framework

Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:

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• Accelerate Widespread Customer Adoption of Distributed Energy Resources
• Increase System Flexibility from Low-Carbon Resources
• Increase the Cost-Competiveness of Renewable Generation
• Create a Statewide Ecosystem for Incubating New Energy Innovations
• Maximize Synergies in the Water-Energy-Food Nexus
• Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
• Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

[Choose One - If Other, Please Specify]

Tianzhen Hong, Mary Ann Piette –
Our propose urban systems initiative fits two strategic framework themes –
• Advance Technology Solutions for Deep Energy Savings in Building and Facilities
• Develop Tools and Analysis to Inform Energy Policy and Planning Decisions

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

This initiative would perform market monitoring and data analysis to provide a more robust empirical understanding of the impacts of CEC appliance efficiency standards.

This work will collect diverse appliance data from retailers, manufacturers, and government databases to paint a detailed and comprehensive picture of the mix of products on the market in California. (For certain appliances, it may also be of interest to collect similar data outside of California, to provide a control or to examine the extent to which California standards have impacts outside of the State.) By collecting this data in the period before and after a new efficiency standard is developed and comes into effect, it will be possible to estimate changes in the market in response to the standard and analyze the impacts on consumers, including costs, benefits, and economic welfare effects.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

The development of appliance efficiency standards is typically based on using engineering estimates to perform prospective cost-benefit analyses, in which an increased appliance price is offset by savings from efficiency improvements. However, past retrospective studies have shown that the typical cost-benefit analyses often overestimate the costs associated with standards [1], and that in some cases appliance prices may stay constant or even fall after the implementation of standards [2, 3], suggesting that the benefit-cost ratio of standards may be significantly higher than estimated by the standard analysis. Moreover, typical policy analyses for standards do not account for the broader impact of a modified product mix on consumer welfare. Using a recent new approach to the collection and management of market data for appliances [4], this initiative will provide an empirical, ex post assessment of the market shifts accompanying new appliance standards in California, to allow direct assessment of actual consumer impacts.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The success of this initiative would enable a more complete and accurate assessment of the consumer impacts of appliance efficiency standards. It will result in an improved analytical framework within which to perform policy impact assessment for developing new appliance efficiency standards that have a more nearly socially optimal impact. The primary users of this framework are efficiency-policy decisionmakers in California and beyond; the beneficiaries are the consumers in the affected markets.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

This initiative will provide empirical estimates of the true consumer costs and benefits, as well as the broader consumer-welfare impacts, of new California appliance standards. Because of the rich data on product features that will be available, it will be possible to perform this assessment for a variety of market segments to gain a more detailed understanding of the impacts on different consumer subgroups. These results can be compared against the outputs of the traditional engineering-based analysis and inform a more accurate and comprehensive analytical approach to future policy development.

If data collection is undertaken outside of California, this initiative could also estimate the spillover impact of California appliance standards on other States and nationally.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

[1] Dale, Larry L., Camille Antinori, Michael A. McNeil, James E. McMahon, and Sydny K. Fujita. "Retrospective Evaluation of Appliance Price Trends." Energy Policy 37, no. 2 (2009): 597-605.
[2] Houde, Sebastien, and Anna C. Spurlock. "Minimum Energy Efficiency Standards and Appliances: Old and New Economic Rationales." Economics of Energy & Environmental Policy 5, no. 2 (2016).
[3] Van Buskirk, Robert D., Colleen Kantner, Brian F. Gerke, and S. Chu. "A retrospective investigation of energy efficiency standards: policies may have accelerated long term declines in appliance costs." Environmental Research Letters 9, no. 11 (2014): 114010.
[4] Gerke, Brian F., Michael A. McNeil, Thomas Tu, and Feiyang Xu. "The International Database of Efficient Appliances (IDEA): A New Resource for Global Efficiency Policy." In 2016 ACEEE Summer Study on Energy Efficiency in Buildings. Pacific Grove, Ca, 2016.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Develop Tools and Analysis to Inform Energy Policy and Planning Decisions

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

We propose to develop a mobile phone platform and application ("app") that can be used to collect survey data on household usage behavior of consumer appliances. The app will feature a collection of surveys on a variety of consumer products and allow users to answer questions about their usage. When combined with demographic information, which may be voluntarily provided through the app, aggregated data can be used to build statistically significant sample of state usage to inform policy decisions. Users would also be able to compare their responses relative to aggregate collection of responses to inform how their behavior compares to the distribution. Analyzed data can be used to provide recommendations to the user on how to lower energy bills through the app. The app can also have a component that will allow users to take a picture of the appliance model number to get energy usage information for that device pulled from a state or federal database. Partnerships with utilities could allow collected usage data to be combined with smart-meter data allowing for accurate modeling of end-use loads.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Accurate usage profiles of consumer appliances remains notoriously elusive. Although field-metering studies are the most accurate option, it remains challenging to deploy, maintain, and analyze enough data to build a statistically-significant sample. Traditional surveys require a significant amount of time to run and often suffer from transcription errors. An app provides a low-barrier solution to quickly gathering demographic and usage behavior. Data provided voluntarily through the app could be used to identify strategies to encourage energy efficiency and decrease overall state energy consumption. Additionally, the flexibility of asking questions through an app allows for continual optimization of the app to increase user engagement.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The impact of the app could be many-fold. California residents will be able to provide their data and interactively compare themselves to the aggregated distribution as a whole. This could allow for increased consumer awareness of appliance energy use. If combined with smart-meter data, utilities would be able to reliably target consumer rebates to encourage users to move to more efficient products. Aggregate data collected from the app could be used for estimates of energy demand by end use.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

User engagement with the app would be monitored through number of app downloads, time spent within the app, and the number of questions answered within a survey. 'A/B testing' can be used to optimize engagement within the app.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Dennison, Laura et al. “Opportunities and Challenges for Smartphone Applications in Supporting Health Behavior Change: Qualitative Study.” Ed. Gunther Eysenbach. Journal of Medical Internet Research 15.4. 2013.

Fernee, Henk et al. "Data Collection with smartphones: experiences in a time of use survey". New Techniques and Technologies for Statisics. Conference Proceedings. 2013.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

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1. Please provide a brief description of the proposed initiative:

Initiative: Data Center Energy Efficiency

Data Centers consume 1.8% of the US power and likely more in "high tech" states like California. The demand for computations doubles every 18-24 months and efficiency is critical to keep the energy consumption in check. Significant strides have been made especially in large data centers but over half the servers are in small data centers where significant opportunities remain. Small and medium sized data centers are found in all types of California businesses and technology (e.g. the Internet of Things) is driving us towards greater data center demands.

Historically approximately half a data center's energy use goes to the IT equipment while the other half goes to the building infrastructure supporting the equipment (e.g. the electrical supply and cooling systems). That ratio has generally improved in large data centers, but remains high in the smaller ones. Energy efficiency in data centers requires a holistic systems approach addressing the IT equipment and software, cooling, and the electrical supply chain. System reliability and security are additional drivers.

The energy intensity or density in data centers continues to rise leading to new electrical and cooling system demands that should be met with more efficient and reliable systems.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Technical Barriers:
* Warm water compressor-less cooling and use of waste heat.
* Integration of data centers into micro-grids including demand response and direct current integration.

Market Barriers:
* Need for standardization of new technologies (e.g. liquid cooling and "high voltage" DC power distribution).
* Need for standard retrofit packages for small data centers that can't afford custom engineering.
* Fear/risk aversion requiring more fail safe systems and demonstrations

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

A recent (national) study of the potential impact of further efficiency in data centers indicates a possible savings of 45%, hence in California that could be approximately 1% of our electrical consumption. Opportunities to use the network for redundancy could also yield opportunities for shifting load between data centers to control peaks and address power shortages.

California businesses of all sorts would benefit by lower IT operations cost. While there is still room for improvement in the large data centers, the primary target and beneficiary of this initiative would be the small and medium sized data centers where the opportunities are greatest.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Technology development would be judged based on the successful implementation of lab studies and field demonstrations. Both demonstrations as well as market barrier reduction aspects can be quantitatively measured using the PUE performance metric - the ratio of the total energy consumption of a data center to the IT equipment. Typically for small and medium sized data centers that is about two. For every Watt going to the IT equipment, another Watt goes to the infrastructure. An important metric on the IT side is utilization. Typical servers running only one application are often less than 5-10% utilized. Utilizing virtualization and the network for redundancy can lead to increases in utilization (reduced number of servers and associated infrastructure energy use).

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

For a comprehensive list of references relative to opportunities for efficiency in data centers, see: https://datacenters.lbl.gov/resources

For a copy of the U.S. Data Center Energy Usage Report (peer-reviewed) see: https://datacenters.lbl.gov/resources/united-states-data-center-energy-usage

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

A comprehensive data center initiative is proposed that would address new technology, emerging technology, best practices, and market transformation opportunities. A portfolio approach would initiate new technology research and development while at the same time help to transform the market for emerging technologies and best practices.

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1. Please provide a brief description of the proposed initiative:

This initiative will focus on filling the technical, market, and informational gaps necessary to scale the adoption of advanced analytics, diagnostic, and control technologies in California's commercial building stock. To date, these technologies have seen early uptake in large campuses and porfolios, however, they remain under adopted throughout the commercial sector as a whole.
The scope of the initiative would encompass segment-specific: market assessment; delivery and usage models for technology&services; "all-in" cost-benefit assessments; software performance testing and validation; identification and pursuit of viable deployment mechanisms; and barrier-focused technology development to advance commercially available technolgies.
A holisitc initaitve of this nature will allow California buildings to realize deep energy and demand savings, and persistent operational efficiency.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Today's analytics and control technologies (Energy Management and Information Systems, EMIS) can enable operational energy savings of up to 20%, yet they remain underutilized. Key barriers and knowldege gaps to more pervasive use include:
Credible 3rd party information on the costs to procure, implement, use, and mantain
Access to software vetting and testing methods (analogous to hardware)
The role of analysis-as-a-service in increasing access to unerserved sectors
Transparency in capabilities and as-used benefits across a diverse product market
Technical and organizational best practices to maximize savings - solutions to integrate into everyday operational/business processes
How to increase deployment through a combination of required, voluntary, and incentive-based activities
Reducing the cost and complexity of data access and integration

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The primary impacts will be:
Achievement of operational efficiency savings
Demand savings
Persistence in savings over time

The primary users and beneficiaries include a broad cross section of stakeholders:
Building owners and energy managers
Utility efficiency program administrators
Regional energy efficiency organizations
Market transformation entities
Technology and service providers

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Over-time energy, demand, and utility cost savings in participating facilities
Increase in the number of CA buildings using continuous meter analytics, fault detection and diagnostics, automated dynamic control optimization
Expansion of voluntary, requires, and incentive-based deployment activities
Increase in sales of technology and service-base analysis in CA
Adption and delivery of software performance testing methods
Effectiveness of any newly developed technology solutions

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Granderson, J, Lin, G. 2016. Building energy information systems: Synthesis of costs, savings, and best-practice uses. Energy Efficiency 9(6): 1369-1384.
Mills, E, Mathew, P. Monitoring-based commissioning: Benchmarking analysis of 24 UC/CSU/IOU projects. Report prepared for CEC PIER, June 2009, LBNL #1972E.
Granderson, J, Price, P, Jump, D, Sohn, M. 2014. Development and application of a statistical methodology to evaluate the predictive accuracy of building energy baseline models. Energy 66(1): 981-990.
Piette, MA, Granderson, J, Kiiccote, S, Wetter, M. 2012. Intelligent building energy information and control systems for low-energy operations and optimal demand response. IEEE Design and Test of Computers 29(4): 8-16.
Roth, K, Llana, P, Westphalen, D, Broderick, J. 2005. Automated whole building diagnostics. ASHRAE Journal 47(5): 82-84.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

This initiative is primarily focused on overcoming adoption barriers. Where new technology development is determined to be necessary, the benchmark will be commercially available software technolgoies and their associated control, data acquisition, integration and communication hardware elements.

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Advance Technology Solutions for Deep Energy Savings in Building and Facilities

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Streamlined grid signaling technology pathways to communicate with responsive loads, storage and other DER systems.

This initiative will improve the technology to manage a clean, affordable and reliable grid. California supply and demand side stakeholders need to improve and standardize methods to communicate with distributed energy resources. There needs to be a more common set of methods for end-use loads, storage (e.g., thermal and electrical), PV and related DERs. At this time there are a number of activities, standards, and demonstrations in this area, but there is great misunderstanding of the capabilities of these various systems, how to use them, and how to lower costs for interoperability.

This improvement needs to include two-way control, local distribution system identification, automation, ease of installation and testing, plug-and-play interoperability, and integration into grid management. These features are not present and in operation in today's technology.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Technical Barriers - As we transition from historical hot summer day peak load shedding and demand response, and to a more dynamic grid with more dynamic tariffs, the need to both give and take load, and to store and shift load and PV energy, we need to revisit communication and control technology that has been in development of the last 10-15 years. For example, OpenADR 2.0 is now a national standard with a broad set of technical capabilities and a language of signals. There is a need to test, demonstrate, package and streamline these communication systems. California utilities, aggregators, end-use customers, technology providers and others are aware of that these standards exist, but are unaware of how they function and what their capabilities are.

Market Barriers - As the programs, tariffs, and markets evolve and California's grid changes with more PV and wind systems, there is a need to better understand how to communicate with DERs. While there are several technologies, programs and markets that use OpenADR, SEP 1.x, SEP 2 and other standards, there is an urgent need to develop and deliver clear pathways for communication technology and interoperability.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

This initiative will increase the ability of California to have a smart, cost-effective, and modern grid by improving the use automation to communicate with end-use loads, storage and other DERS. This will increase the effectiveness of DERS and lower costs to own and operate them.

The impact is to allow better control of the grid, less over-generation that happens as we have more renewables, and move cost effective linkages between supply and demand.

The primary users and benefactors are utilities, electricity customers, aggregators, the CAISO, and technology and control companies.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

There are a variety of metrics we can use to evaluate this initiative

1 - Cost/kW for DER automation (This has many components of cost, first costs to install, costs to own and operate the automation, maintenance, etc.)

2 - Number of customers with DER automation

3 - Number of MW with DER automation

4 - Locational MW with DER automation

5 - Use of and compliance with Title 24 and Title 20 in supporting these communication systems

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Alston, P, et al., 2015 California Demand Response Potential Study, CPUC Study, Final report will be available March 1, 2017.
http://www.cpuc.ca.gov/General.aspx?id=10622

Ghatikar, Girish, David Riess, and Mary Ann Piette. Analysis of Open Automated Demand Response Deployments in California and Guidelines to Transition to Industry Standards., 2014. LBNLReport 6560E.

Ghatikar, Girish, Mary Ann Piette, and Ella Hae Yeon Sung. Diffusion of Automated Grid Transactions Through Energy Efficiency Codes. Proceedings of the ECEEE Summer Study on Energy Efficiency, 2015. France, 2015.

DOE Grid Modernization Invitation to Join Interoperability Project
https://energy.gov/under-secretary-science-and-energy/downloads/gmlc-invitation-join-project-3-interoperability

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

The advantage that the proposed technology has over the current benchmark is the following. First, the current technology is not being used in wide spread scaled practice and that is the biggest obstacle we need to overcome in streamlining these systems. Second, there are new features that need to be evaluated as the grid changes with new levels of distributed energy resources. Third, the locational signaling is needed. As we have more DERs we need to control them on a more local scale.

The strategies to bring this to scale include more clear direct and upstream incentives, better use of codes and standards, requirements for DER infrastructure, and improved links to existing customer systems.

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Accelerate Widespread Customer Adoption of Distributed Energy Resources

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This initiative will develop and demonstrate validated investment grade risk-management tools and processes to identify, quantify, and mitigate performance risk for the purpose of financing and guaranteeing energy performance, particularly in under-served sectors such as small- and medium-sized commercial buildings. This will allow energy efficiency and other aspects of the building performance value stream to be properly valuated and reflected in asset values at low transaction costs, and that in turn can significantly expand the scope and scale of energy efficiency finance.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

All energy efficiency investments have performance risk i.e. actual performance does not meet design intent because construction was not as designed, systems are not operated as intended, or occupancy and use assumptions prove incorrect. From a financing perspective, this performance risk is a major barrier to greater investment in high-performance, energy-efficient buildings because it is not properly and routinely quantified or managed, compared to other risks such as income, vacancy, and costs of capital.

The absence of robust investment-grade performance risk management products and services in commercial real estate creates significant impediments to sourcing investment capital at scale. A key problem is that commercial real estate stakeholders simply do not have the means to routinely conduct investment-grade valuation of building performance. Conventional underwriting and appraisal processes do not traditionally account for high-performance property attributes.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The primary impact would be significant increase in the scope and scale of energy efficiency finance, particularly in under-served sectors such as small and medium sized buildings, by virtue of lowering transaction costs and increasing the transparency of energy performance risk analysis and management.

The primary users of the risk management tools and strategies developed under this initiative are building developers, owners and financiers.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Energy savings ($, kBtu) attributable to investments that were enabled by these risk management products and services.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Mathew, P., Wallace, N., Alschuler, E., Kolstand, L. Commercial mortgages: An underutilized channel for scaling energy efficiency investments? ACEEE Summer Study on Energy Efficiency in Buildings. August 2016. American Council for an Energy Efficient Economy.

(Note: The above reference is limited to commercial mortgages. But the initiative is intended to cover a range of financing channels)

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

N/A - This initiative is not about technology development, but rather about tools and processes for performance risk management.

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(Select One)

If Other, Please Specify

Accelerate Widespread Customer Adoption of Energy Efficiency by Addressing Financing Barriers

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

This initiative will focus on IEQ as a critical enabling technology for the state to achieve its objectives of zero net energy new buildings and deep reductions in energy use of existing buildings. Energy efficiency standards for new and existing buildings must comply with the California Environmental Quality Act by considering potential impacts on human health and safety, and by mitigating any significant adverse impacts. This requirement is recognized to apply to indoor environmental quality (IEQ) including air quality, thermal comfort, noise, and lighting. In addition to the regulatory requirement that building standards may not adversely impact IEQ, there is quantifiable economic value in improving the health, safety, and productivity of building occupants through IEQ. There is also a growing recognition that IEQ improvements are an important motivating factor for building owners to undertake retrofits that include energy efficiency upgrades. Providing guidance on how to achieve synergistic IEQ and energy improvements and documenting the health and productivity benefits will be a powerful tool in state efforts to dramatically

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

There are substantial challenges to assessing IEQ because of the large number of relevant variables concerning indoor air quality, thermal comfort, noise, and lighting. Many of the relevant IEQ variables may have complex interacting relationships affecting the overall evaluation. While many zero net energy building and energy retrofit projects have considered some aspects of IEQ (e.g., comparison of changes in indoor air pollutant concentrations with respect to health guidelines, occupant satisfaction with thermal comfort using ASHRAE standards), evaluation of potential impacts and benefit valuations are limited to an incomplete set of IEQ parameters, and evaluation methodologies varied from project to project, complicating any attempts to determine aggregate value. This initiative would fill the knowledge gap that energy efficiency standards in California are required to consider - how changes in standards would affect IEQ and consequently human health. The definition of IEQ metrics and a set of practical assessment methods that would enable gathering of information from a wide range of residential and

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

This initiative would benefits all California living and working in new and existing residential and commercial buildings. For California, the economic impacts of indoor air quality on health and productivity alone have been estimated to be at least $45 billion per year. About $11 billion of the total impact was attributed to health impacts from indoor air pollutant other than environmental tobacco smoke, and about $9 billion was attributed to lost productivity in office workers and teachers. This initiative would enable energy efficiency standards and programs to better select technologies with IEQ co-benefits, and therefore reduce the economic impacts from poor IEQ on Californians. A study that surveyed building commissioning projects found that the desire to ensure or improve thermal comfort and indoor air quality are also main drivers for commissioning, aside from energy savings. Data from homeowner valuation of weatherization and EnergySTAR new homes program, and also from studies of green and high performance commercial properties, suggest that the valuation of good IEQ often outweigh the energy savings.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The proposed set of IEQ evaluation tools from this initiative can be applied to assess impacts from changes in Title 24 in the next update cycle and in designing programs to incentivize and improve the value of retrofits. Findings from this assessment will inform the Commission on changes with substantial co-benefits in comparison with others that do not. This information can be used by the Commission to set Title 24 standards and implement building retrofit programs to benefit Californians by improving IEQ while achieving the overall energy saving objectives. The gathering of IEQ data for benchmarking and the assimilation of information linking energy efficiency measures to IEQ impacts would generate scientific knowledge that energy efficiency programs can rely on to identify key opportunities to improve IEQ while performing energy retrofits.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

California Air Resources Board (ARB), July 2005. The Report to the California Legislature: Indoor Air Pollution in California, Chapter 3. Estimates in Year 2000 dollars and population. http://www.arb.ca.gov/research/indoor/ab1173/rpt0705.pdf.

Conant D, 2009. Evaluation of the Massachusetts New Homes with ENERGY STARÆ Program, 2008 Findings and Analysis, Final Report. Nexus Market Research. http://www.env.state.ma.us/dpu/docs/electric/09-64/12409nstrd2aa.pdf.

Finch P, 2014. Energy Efficiency & Financial Performance: A Review of Studies in the Market. US Department of Energy and Waypoint. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/Energy%20Efficiency%20and%20Financial%20Performance_12_2015.pdf

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Currently there is no comprehensive and systematic evaluation of IEQ for projects that aim to improve energy efficiency in new and existing buildings. Existing green building rating or labeling systems are limited in scope in terms of the IEQ variables and/or building types or applications that they considered. There is lack of data on IEQ in a wide range of building types and sizes to support benchmarking of IEQ. This initiative will generate the data and knowledge needed to evaluate impacts on IEQ from energy efficiency standards and programs. It will enable valuation of IEQ that is currently not possible to do in a consistent way for the many energy efficiency measures that may have potential impacts on IEQ. This initiative aims to develop a set of evaluation tools that will be made publicly available for all energy efficiency programs to utilize in their selection of measures/approaches that would save energy and improve IEQ.

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

The proposed initiative is an assessment of water use and associated energy consumption within California's industrial sector. The assessment would be based on primary data collection gathered through field visits using a representative statistical sample of California industry. Results would quantify how much water California industry uses and for what purposes. It would quantify the associated energy consumption for conveying, pressurizing, treating, heating/cooling, or for any other end use. It would quantify consumptive use, as well as overall water use. The results would also identify opportunities for water-related energy consumption, water, and by-product recovery (including energy) from effluent streams.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

There is little data available on industrial water use. Based on national water use characteristics, the majority of industrial water use is self-supplied indicating that industrial water use cannot be determined solely through review of municipal water authority customer databases. On site sampling will allow for an accurate estimate of California industrial water use. Further, the energy for water use within industry has not been well studied at any scale (i.e., within California, regionally, or nationally). A quantification of the water-energy nexus within an industrial facility's boundaries would be a first-of-its-kind study. Finally, the opportunities for water, energy, and by-product recovery within an industrial facility will enable California's industries to be more resilient against short term (i.e., price shocks) and long term (i.e., climate change) impacts.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Currently, industry is either neglected when considering water policy and/or decisions are informed without solid supporting data. The results from this initiative would inform policy decisions regarding: maintaining and strengthening competitiveness of California's industrial sector, identifying how California industry can contribute to responses to state water plans and emergency water conservation actions, and increase the incentives for adopting water efficiency measures by providing a better understanding of the associated energy saving benefits. The initiative would also represent a first-of-its-kind nationally and could be leveraged by other states and/or the Federal government to inform their own water-energy policies related to the industrial sector.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

There are several stakeholders for the results of this potential initiative. Impact would be determined based on the number of times the results are downloaded and/or cited. The initiative would work closely with stakeholder groups (e.g. California trade associations representing the industrial sector, water authorities, and government representatives) to ensure that the results are aligned with their knowledge gaps and needs and can inform the decisions of their customers and policies.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

The Pacific Institute noted in its 2003 study "Waste not, Want not" that cost-effective water conservation could result in saving over 2,000,000 acre-feet/yr of water in California (of a total use of 6,960,000 acre feet/yr). The commercial, institutional, and industrial share of this conservation potential was 660,000 acre-feet/yr (industrial was not segregated from commercial and institutional in the report).

However, the report also states: "As highlighted in different sections of the report, lack of information (or failure to disseminate that information) hinders effective action. Although we calculate the most accurate water use and conservation potential we can with the information available, increasing the accuracy of future estimates is necessary. This will depend on water users, suppliers, and managers at all levels taking specific steps to increase the reliability, quality, and quantity of available data on water use and water conservation options. Some specific data needs should be a top priority.

Collect and report more water-use data in standard formats, consistently and regularly. Data on landscape use and self-supplied water are particularly poor. Details on end uses of water are limited. And experience with conservation efforts to date is poorly documented."

Reference: Gleick, P.H., D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolff, K.K. Cushing, and A. Mann.
2003. Waste Not, Want Not: The Potential for Urban Water Conservation in California.
Oakland, CA. Pacific Institute.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Part 3. Connection to Energy Commission's EPIC Framework

Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
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    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Maximize Synergies in the Water-Energy-Food Nexus

If Other, Please Specify

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Integrated building thermal load management to reduce capital expenditure on HVAC equipment and save energy. That is, certain efficiency measures taken together can do more than save energy — they can provide immediate capital savings by avoiding the need to install or replace HVAC equipment.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Many building energy efficiency measures implemented alone or even together are not cost effective because (a) future energy cost savings are depreciated, and (b) some measures reduce the marginal benefits of other measures. This initiative would identify integrated sets of complementary measures that would permit elimination, downsizing, or delaying replacement of HVAC equipment in many California buildings.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Ratepayers could implement building energy efficiency measures at a reduced or even negative cost per unit of energy conserved, made possible by immediate capital savings. Elimination or at least downsizing of HVAC equipment would also help utilities manage peak power demand in the cooling season. This initiative would benefit both existing and new buildings, and would work especially well for homes, which represent the vast majority of California's building stock.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Impact would be measured by energy, energy cost, and capital cost savings per building and across California, as by the cost per unit energy saved.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Figure ES-21 in the 2009 California Residential Appliance Saturation Survey (KEMA 2010) shows that the saturation of residential air conditioning systems in California homes varied strongly with forecast climate zone (FCZ) , ranging from < 20% in FCZ 5 to > 95% in FCZ 2. This confirms that the rate of AC installation is sensitive to expected cooling load, and indicates that measures that reduce this load can be expected to slow this rate.

Reference:

KEMA, Inc. 2010. 2009 California Residential Appliance Saturation Study. California Energy Commission. Publication number: CEC- 200-2010-004-ES. http://www.energy.ca.gov/2010publications/CEC-200-2010-004/CEC-200-2010-004-ES.PDF

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

The individual efficiency measures exist, but have not been integrated in a manner that permits equipment savings. The building energy use, indoor environmental quality, and comfort consequences of integrated measures must be simulated and measured to evaluate and guide their application.

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Bruce Nordman, Ken Christensen, and Alan Meier, “Think Globally, Distribute Power Locally: The Promise of Nanogrids,” (Green IT column) IEEE Computer, Vol. 44, No. 9, pp. 89-91, September 2012.
Bruce Nordman and Ken Christensen, “Local Power Distribution with Nanogrids,” Proceedings of the International Green Computing Conference, June 2013.
Chris Marnay, Bruce Nordman, and Judy Lai, “Future Roles of Milli-, Micro-, and Nano-Grids,” presented at the CIGRE International Symposium The Electric Power System of The Future- Integrating Supergrids and Microgrids, Bologna, Italy, LBNL-4927E, 2011.
Bruce Nordman and Ken Christensen, DC Local Power Distribution with Microgrids and Nanogrids, First International Conference on DC Microgrids, Atlanta, GA, June 2015.
Bruce Nordman and Ken Christensen, The Need for Communications to Enable DC Power to be Successful, First International Conference on DC Microgrids, Atlanta, GA, June 2015

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

The proposed initiative is to study the usage and energy consumption of "smart" (i.e., Internet-connected) appliances (such as light bulbs, coffee makers, or refrigerators). The purpose of the initiative would be two fold: (1) estimate the impact of the propagation of such devices on energy consumption in California, based on changes in usage patterns compared to non-smart devices and any power consumption associated with smart devices, and (2) estimate the potential for improved or more cost-effective field metering techniques using smart devices.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Smart devices represent one of the fastest growing market segments for a number of appliances, but how the use of a smart device affects energy consumption compared to a non-smart device is largely unknown. Smart devices offer the potential to control appliances in additional ways, through wireless networks and smart phones, and using more sophisticated techniques, including advanced scheduling (e.g., incorporating online weather data) or smart phone geofencing. But the impact of this additional functionality on overall usage is unknown. Smart devices also consumer power for their communication systems when they are otherwise off (or in “network standby” mode), but the magnitude of standby power consumption is largely unexplored thus far. This initiative would help fill those knowledge gaps.

Additionally, there has been some interest in using smart devices as meters, though there are some privacy concerns. This initiative could shed light on the potential for this approach.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

California consumers are the ultimate beneficiaries of this initiative. The results of this initiative would provide valuable insight to help optimize future codes and standards work, which is likely to increasingly include, and need to account for, smart appliances. The work would also be useful in assessing the potential value of new devices with connected functionality in order to better optimize state-funded research and development. If using smart devices as meters proves to be promising, future metering studies could potentially provide more useful information and/or become more cost-effective than might otherwise have been possible.

Utilities would also benefit from being able to better forecast generation and capacity needs as smart devices increasingly penetrate the market.

The study could also result in a reduction of standby energy consumption associated with smart devices and/or an increase in the availability of energy saving features as more attention is brought to that aspect of smart devices.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

This initiative would result in estimates of unit energy consumption for smart appliances and aggregated estimates of the impact of smart devices on energy consumption in California for certain categories of appliances. Future impacts could also be estimated if coupled with projections of market penetration of smart appliances.

One metric for evaluating the impact of the initiative would be the number of codes or standards rulemakings that reference the resulting study in supporting analyses.

Another indicator would be a reduction in the average standby power consumption associated with smart devices or an increase in the number of energy savings features available for such devices.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Page, E., et al., 2015, “Not so clever when they are off: standby power use in smart lamps”, European Council for an Energy Efficient Economy (ECEEE) Summer Study, Presqu'île de Giens, France.

Price, K., et al., 2015, "Real Time Monitoring and the Internet of Things: Reshaping How we Collect Data", International Energy Program Evaluation Conference, Long Beach, CA.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
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    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
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Develop Tools and Analysis to Inform Energy Policy and Planning Decisions

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

R&D to support the development and deployment of packages of technologies or systems of technologies, along with the tools and process to support their selection, specification and assessment.

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Single component technologies are well supported by R&D programs and industry deployment channels such as incentive programs. However, in order to achieve aggressive energy reductions in new construction and especially retrofits, combinations of technologies are often required which leverage each other to create greater energy savings reductions than a single technology could produce on its own. This R&D program would aim to identify and develop deployable systems or packages of technologies with controls as required to deliver on the deeper savings levels. Current industry gaps include controls strategies developed for combinations of products, available in an 'off the shelf' condition, analysis and selection methods to enable characterization of performance without the need for extensive whole building modeling (which further enables utility incentive program assessments and evaluations), and the silo-ed nature of building technologies vendors creating barriers to the natural development of packaged solutions.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

Cost effective technology packages and systems, enabling deep low energy retrofits of existing buildings as an example. Utilities would be better able to create incentive programs using simplified approaches (such as the deemed path), lowering program administration and costs to utility customers. Technology and service providers could offer means for consumers to access deeper levels of energy savings.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

kBtu/sf/yr energy savings, or kWh energy savings when applied to DOE reference building models. Peak energy use reduction. Energy cost savings. GHG emission reductions.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Regnier, C., Mathew, P., Robinson, A., Schwartz, P., & Walter, T. (2016). Beyond Widgets – Systems Incentive Programs for Utilities. ACEEE. ACEEE. - Report Number: LBNL-1006195

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

It provides deeper levels of energy savings. Some existing commercial technologies can be packaged together to deliver on the goals of this initiative, or new technologies and/or controls can be developed or optimized.

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Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

The California Energy Efficiency Strategic Plan (CPUC 2011) has the following goals for existing homes: "Energy consumption in existing homes will be reduced by 20% by 2015 and 40% by 2020 through universal demand for highly efficient homes and products". Going beyond this goal, if brought up to current Title 24 standards, California homes have the potential to cut their energy use in half, and this can be done using only technologies currently available off-the-shelf, and with current construction practices (Less et al. 2012). Through rapid deployment of Very Efficient Home Retroits (VERs) California ratepayers can save 60% or more on their individual energy bills and about one-third of household energy use statewide. Similarly, there will be an almost one-third savings in peak electric demand resulting in lower peak electricity prices and a more stable and reliable electricity supply.

What is needed in order to realize these goals is a comprehensive plan, funding, and demonstrated benefits for large scale retrofitting of existing homes with energy efficient products. One integral step in this plan is the identification of residential retrofit packages that are cost-effective for each of the most common California housing types whose energy efficiency falls significantly below that required by current standards. The next is demonstration of these retrofit packages in California homes. Finally, education of both contractors and homeowners on the results of the analyses and demonstrations and methods for implementation will allow for rapid deployment of Very Efficient Home Retrofits (VERs).

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

The barriers to widespread adoption of very efficient retrofits are a combination of the cost to perform the work, the lack of knowledge in the industry on how to carry out the very efficient retrofits and the fact that both homeowners and contractors are risk-averse and uncomfortable making unproven out-of-the-ordinary changes to homes. External funding is needed to overcome these barriers because the current market is highly fragmented into small companies and lacks the financial resources to perform a similar study of its own. Also, in order to mitigate risk, customers need information from trusted third-party sources and EPIC projects are just such a source.

The cost barrier to VERs can be addressed by developing packages of retrofits for common house types that remove some of the up-front design costs. The packages would seek the lowest-cost approaches to achieving the goals of retrofitting existing homes to perform better than Title 24 2008 and realizing significant energy savings.

The uncertainty barrier can be addressed demonstrating these packages and proving that these approaches will deliver the promised savings without compromising health, safety, comfort, durability, or building integrity.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

A combination of demonstrations, packages, tools for contractors and outreach activities can be used to overcome the market barriers discussed above and help the state meet its energy saving and GHG emission goals, while expanding the building performance contracting business, and generating more employment through this critical upgrade for California's infrastructure. Beneficiaries and users include homeowners who will benefit from lower utility bills, utilities who will benefit from reduced peak demand and associated cost to produce electricity, contractors who will benefit from an uptick in specialized work which can't be outsourced, and society as a whole which will benefit from lower GHG emissions and associated effects.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

Monitoring of building energy use and indoor environmental quality should be conducted throughout any project funded under this initiative. At the conclusion of the project, the data should be used to determine annual energy use, peak loads, pre-post savings and CO2e. A parallel analysis of the California housing stock should be done to quantify the number of homes in each geographic area or climate zone that are reasonably represented by the study homes and that could be retrofitted with packages similar to those demonstrated in the project. Five years from the completion of the demonstrations, a randomized survey of California homeowners should be conducted to assess participation.

From this, aggregate energy use, peak load, pre-post savings and CO2e benefits of implementation of retrofit packages across suitable homes across the state can be used as the primary indicators used to evaluate the impacts of the proposed initiative.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

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Fisher, Jeremy. Deep Energy Retrofits - Ten California Case Studies. 2011. http://thousandhomechallenge.com/sites/thousandhomechallenge.com/files/userfiles/Fisher_THESIS_FINAL_DRAFT.pdf. Berkeley, California: UC Berkeley.

Keesee, Mike. (2012). Deep Energy Retrofits: Six Real World Examples and Lessons Learned. Paper presented at the ACEEE Summer Study on Energy Efficiency in Buildings-Fueling Our Future With Efficieincy, Pacific Grove, CA. pp. 1-141- 1-152. [http://www.aceee.org/files/proceedings/2012/data/papers/0193-000006.pdf]

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Less, Brennan. (2014). A Meta-Analysis of Single-Family Deep Energy Retrofit Performance in the U.S. . Lawrence Berkeley National Laboratory: Lawrence Berkeley National Laboratory. LBNL Paper LBNL-6581E.

PNNL: Building America Residential Deep Energy Retrofit Research Project. 2011. http://deepenergyretrofits.pnnl.gov/. Richland, Washington: Pacific Northwest National Laboratory

Primen/The Response Center. 2001. 2001 CA Residential Remodeling/Renovation Market Study

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

N/A

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

Advance Technology Solutions for Deep Energy Savings in Building and Facilities

If Other, Please Specify