STATE OF CALIFORNIA
EPIC TRIENNIAL INVESTMENT PLAN 2015-17
Proposed Energy Research Initiative
Questionnaire

CALIFORNIA ENERGY COMMISSION

Title of Proposed Initiative: Estimation, Controls and Faults Detection for Better Building Operation

Investment Areas (Check one or more) – *For definitions, see First Triennial Investment Plan, page 12*:

☒ Applied Research and Development
☐ Technology Demonstration and Deployment
☐ Market Facilitation

Electricity System Value Chain (**Check only one**): *See CPUC Decision 12-05-037, Ordering Paragraph 12.a. http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF.*

☐ Grid operations/market design
☐ Generation
☐ Transmission
☐ Distribution
☒ Demand-side management

Issues and Barriers:

Building operators and system service personnel rarely have adequate time, expertise or resources to address any but the most egregious performance problems, despite the many research studies that have shown that 20-30% energy savings could be routinely achieved through better building operations. In 2009, just 13 of the most common faults in U.S. commercial buildings are thought to have caused over $3.3 billion in energy waste, while a survey of over 55,000 air conditioning units showed that more than 90% were operating with one or more kinds of faults.
Better estimation, controls and fault detection strategies based on energy models could help reducing such a waste. However, the resources required for set up these strategies are still too, and there are very few people in the world who can make the models and even fewer that can then write the scripts necessary to use these models for control or fault detection purposes. Better tools can ease the design, development and deployment of said techniques.

Initiative Description and Purpose:

We propose the development of a toolbox that will ease the design and deployment of advanced estimation, controls and fault detection techniques, making them available to a broad audience thus increasing the use of these techniques in both residential and commercial buildings. Its purpose is two-fold. (1) Providing a software wherein building modeling users and/or controls experts can develop model-based estimators, controls and fault detection strategies, which can then be automatically deployed through code generation; and (2) to allow that relatively small group of expert users producing apps for non-experts that can sit on top of existing control systems, or within third-party energy monitoring software, or on the iPad of HVAC service technicians, or on the laptop of mechanical system designers. Both the experts and the non-experts can thus test and improve their strategies under a wide range of conditions through simulations, and can ensure that their intent is carried through to practice through automated code generation.

Stakeholders:

Possible stakeholders are control manufacturers, component manufacturers/assemblers, HVAC & control design firms, energy system companies (ESCOs), and companies that develop energy information systems (EIS).

Background and the State-of-the-Art:

Nowadays there is a gap between the use of energy models during the design of buildings or HVAC systems and their operation. These two phases are completely disconnected. LBNL and others have long advertised the potential benefits of using building simulation models to improve performance during the operations phase. Model-based benchmarking, model-based Fault Detection and Diagnostic, model-based controls testing, Model Predictive Control (MPC), model-based operator training, model-based retrofit analysis, and model-based estimators can all share the same modeling effort.

LBNL is an authority in the development of simulation tools and models for evaluating the energy performance of buildings and HVAC systems. Some of the tools developed by LBNL represent the state of the art in the context of energy simulation; EnergyPlus[1], DOE-2[2], and the Modelica Buildings Library[3] are examples.

LBNL developed also the Building Control Virtual Test Bed[4] (BCVTB), a tool that eases the interaction between energy monitoring systems and different simulation tools. The BCVTD has already been tested in real cases where the energy information system of a building has been coupled with EnergyPlus models to compare the performances of the real building against its expected behavior.

LBNL is currently leading the International Energy Agency Annex 60[5], an international project in which 37 institutions from 16 countries are cooperating for advancing the research in the field of energy efficiency in buildings and energy grids. The objectives of Annex 60 are to develop and demonstrate next-generation computational tools that allow building and community energy grids to be designed and operated as integrated, robust, performance based systems.

LBNL is currently working on a project for the Department of Defense (DOD) in which is evaluating and testing the impact of model-based strategies for the estimation of the efficiency, the identification of faults, and the optimization of district cooling plants.

Given the premises, LBNL is the ideal candidate for closing the gap between energy simulation tools and the real world where estimators, control systems and fault detection strategies can support the operation of building and HVAC systems.

[1] http://apps1.eere.energy.gov/buildings/energyplus/energyplus_about.cfm
[2] http://www.doe2.com/
[3] http://simulationresearch.lbl.gov/modelica
[4] http://simulationresearch.lbl.gov/bcvtb
[5] http://www.iea-annex60.org/

Justification:

This research will have different positive impacts on the taxpayers. This research will make available control and monitoring technologies to a larger audience, with the proposed approach these technologies will be more affordable both for residential and commercial applications. Making these technologies available to a larger number of operators and technicians will create new job opportunities.
The introduction of said techniques will reduce the energy impact of existing buildings and HVAC systems, limiting their Green House Gases (GHG) and CO_2 emissions. Also, this research will ease the introduction of control strategies able to reduce the peak of electric load, increasing the reliability of the electrical grid.

Ratepayer Benefits (Check one or more)**:**

☐ Promote greater reliability
☒ Potential energy and cost savings
☐ Increased safety
☐ Societal benefits
☐ Environmental benefits - specify
☐ GHG emissions mitigation/adaptation in the electricity sector at the lowest possible cost
☐ Low emission vehicles/transportation
☐ Waste reduction
☐ Economic development

Describe specific benefits (qualitative and quantitative) of the proposed initiative

Public Utilities Code Sections 740.1 and 8360:

The proposed research will enrich the portfolio of tools and instruments the LBNL is actually providing. The related works done in other projects show that the proposed research is promising and it will have a direct impact on the market.
This research will have a direct impact on the energy consumption because it supports the development and deployment of systems that aim at optimizing the use of HVAC systems and improving the actual operation of existing as well as future commercial and residential building.