Title of Proposed Initiative: *Sensors and Controls for Buildings*

Investment Areas:

- o Applied Research and Development

Electricity System Value Chain (**Check only one**)**:**

- o Demand-side management (Note: also important for grid operation)

Issues and Barriers:

The organization of the buildings strategies in the Investment Plan along end-use lines (lighting, HVAC, plug loads, indoor air quality), may have the result that sensors and controls, which are applicable to each of these end uses, do not receive adequate attention. Especially when dealing with demand response, integration of controls and sensing across end-uses increases the value and reduces the cost of the response. Also, control strategies and sensor packages that address only single end uses may not create enough value to be cost effective. This problem may be especially acute in small- and medium-size commercial buildings.

Initiative Description and Purpose:

A significant portion of the energy consumed in buildings is wasted because of the lack of building controls or the inability to use existing Building Automation Systems (BAS) properly. Over 90% of the buildings in the U.S. are either small-sized (<5,000 ft^2) or medium-sized (between 5,000 ft^2 and 50,000 ft^2); these buildings typically do not use BAS to monitor and control their building systems from a central location. While there are a number of reasons why small- and medium-sized buildings do not deploy BAS, a central problem is the high cost of currently available closed-architecture single-end-use control systems.

In most small- and medium-size buildings HVAC is controlled by thermostats. More sophisticated systems are needed to provide a range of functionality to minimize energy costs, provide energy cost feedback, and provide remote monitoring for control and security. Internet-protocol-based controls could provide the ability to integrate the building with the grid to make the building more Demand Responsive (DR). Although BASs are the preferred way to implement many energy efficiency and DR strategies in buildings because they allow for automatic programming, the penetration rate of these systems into small- to medium-size commercial buildings is low because these systems are expensive and because the building owners are not fully aware of the benefits.

Automated lighting control systems range from simple scheduling, to sensor-based systems that actuate electric lights according to occupancy or ambient light levels; they may also incorporate a variety of occupant personal control options. Dimmable ballasts, lumen maintenance, daylighting, and set point tuning are also possible. However, networked control solutions are needed to provide grid-integrated demand response, interface with and “optimize” HVAC controls, and enable remote monitoring and control.

Commercial Miscellaneous and Electronic Loads (CMELs) are a large and growing end use, but few data exist to identify which specific devices consume most of the energy and which control/savings strategies would be most effective to implement. CMELs are diverse and vary by building type, but research shows that some CMELs are very amenable to controls both for energy efficiency and/or demand response. Strategies for controls solutions for small- and medium-sized commercial buildings could include scheduling, occupancy-based controls, and, when properly integrated with other building systems, grid responsiveness, including control of personal computers (PCs) in office

environments and occupancy-based control of non-essential loads in office and non-office environments.

According to the DOE, the major requirements for a BAS for small- and medium-sized commercial buildings are: 1) interoperability; 2) scalability; 3) ease of deployment; 4) open architecture; 5) plug and play capabilities; and 6) the ability to provide local or remote monitoring.

Effective sensing is an essential element of good control. Improvements in sensors offer significant potential for energy savings in buildings. For example, a recent study on the use of advanced occupancy sensors compared with conventional occupancy sensors revealed that advanced sensors yielded average energy savings of 17.8%, compared with only 5.9%, relative to a base‐case commercial building.[1] Siemens Corporation estimates that energy savings of 30% are possible in buildings with improved climate, air quality, and occupancy sensors.[2] Additionally, low-cost, wireless, and other advanced sensors are considered an "enabling technology" for a variety of building energy-efficiency strategies, including building commissioning (0.5 -1.8 Quads technical potential), damper fault detection and diagnosis (0.02 to 0.1 Quads technical potential), demand‐controlled ventilation (0.2 to 0.3 Quads technical potential), duct leakage diagnostics (0.15 to 0.4 Quads technical potential), and optimal whole-building control (≥ 0.4 Quads technical potential).[3]

Open-architecture sensors and sensor systems that easily share data to enable building operators and owners to cost effectively capture energy and cost savings through the use of new and existing control system applications are needed to realize this potential. Among the strategies that should be considered are innovative approaches that reduce the cost and power consumption for data collection of common building operation variables (temperature, pressure, relative humidity, etc.), open-source sensor packages that allow for data acquisition and transmission with increased lifespan between manual calibrations, "virtual sensors" enabled by innovative combinations of hardware and software, and easily installed "plug and play" sensor packages in which sensors would be automatically recognized by building energy management systems, in a manner similar to how conventional printers are easily recognized by an existing computer network.

Stakeholders:

Improvements in sensing and control will create value for utility companies and for building owners and operators.

Background and the State-of-the-Art:

The Energy Commission has supported research on sensors and controls through PIER's Enabling Technology Development program.

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[1] Zhang et al., 2013, "Energy Savings for Occupancy‐Based Control (OBC) of Variable-Air-Volume (VAV) Systems, PNNL‐22072

[2] OECD, 2009," Smart Sensor Networks: Technologies and Applications for Green Growth," OECD Digital Economy, Papers, No. 167

[3] Roth et al. 2005. "Energy Impact of Commercial Building Controls and Performance Diagnostics: Market Characterization, Energy Impact of Building Faults and Energy Savings Potential." Prepared for U.S. D.O.E. Building Technologies Program, November 2005.

The Department of Energy is supporting research in this area. The description above of the research needs is derived in part from DOE funding opportunity announcements.

Justification:

See description above for a discussion of benefits. Research on sensors and controls is appropriate for public funding because, as enabling technology, the benefits to energy users that are enabled by good sensors and controls far exceed the revenues that can be obtained from the sale of sensors and controls. Thus, the majority of the benefits from successful research are spillovers to building owners and operators that cannot be captured by actors in the sensors and controls business.

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

- o Promote greater reliability
- o Potential energy and cost savings
- o Societal benefits
- o Environmental benefits – improved indoor air quality
- o GHG emissions mitigation/adaptation in the electricity sector at the lowest possible cost
- o Waste reduction
- o Economic development

Public Utilities Code Sections 740.1 and 8360:

Improved sensors and controls are an essential element in the implementation Public Utilities Code Section 8360. Improved sensors and controls are especially relevant to the implementation of 8360 a – d & j:

> (a) Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid.
>
> (b) Dynamic optimization of grid operations and resources, including appropriate consideration for asset management and utilization of related grid operations and resources, with cost-effective full cyber security.
>
> (c) Deployment and integration of cost-effective distributed resources and generation, including renewable resources.
>
> (d) Development and incorporation of cost-effective demand response, demand-side resources, and energy-efficient resources.
>
> (j) Identification and lowering of unreasonable or unnecessary barriers to adoption of smart grid technologies, practices, and services.

Research on Sensors and Controls fully satisfies the requirements of Public Utilities Code Sections 740.1. In particular, research needs for sensors and controls are diverse and there are many promising avenues to pursue. Problems with redundant research (see 740.1(d)) are unlikely to occur.