June 3, 2019

The Honorable Daniel Simmons
Assistant Secretary of Energy
Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

Re: Request for Information (DE-FOA-002117): Research and Development Opportunities for Innovations in Sensors and Controls for Building Energy Management

Dear Mr. Simmons,

Thank you for the opportunity to submit comments in response to the U.S. Department of Energy's (DOE's) April 24, 2019, request for information (RFI) that seeks input on research and development (R&D) opportunities for the integration and optimization of systems at the whole-building level through connected and controllable loads for increased energy affordability, improved occupant comfort, and enhanced provision of grid services that will strengthen the integration between buildings, other distributed energy resources, and the electric grid.

The Alliance to Save Energy (Alliance) is a nonprofit, bipartisan coalition of business, government, civil society, and academic leaders who work together to drive greater U.S. energy productivity to achieve economic growth, a cleaner environment, and greater energy security, affordability and reliability. Since the Alliance was founded in the aftershocks of the energy crises of the 1970s, the U.S. has made huge strides in driving energy efficiency throughout our economy through the research, development, demonstration, and deployment (RDD&D) of new technologies, significant public- and private-sector investments, and sound policies. Thanks in part to federal energy efficiency policies, including energy conservation standards, building energy codes, and fuel economy standards, the U.S. today extracts twice as much gross domestic product from each unit of energy we consume when compared to 1980.

Category 1: Multifunctional Wireless Sensor Networks

The RFI is "structured to address systems-level challenges prevalent across individual building end-uses with a focus on integrated and coordinated approaches for monitoring and control at the whole-building level." We appreciate the strong focus on systems integration in this RFI because sensors and controls enable significant efficiency gains—beyond the efficiency gains possible at the component level—by facilitating "systems efficiency." The term "systems efficiency" refers to, with respect to the built environment, the co-optimization of multiple energy-consuming or producing technologies and structures to maximize energy efficiency, conservation, and productivity at the building system, building subsystem, multi-building system, whole-building, neighborhood, microgrid, or electricity distribution grid level. The Alliance convened the Systems Efficiency Initiative (SEI) to define and investigate the potential for improving systems

efficiency in U.S. buildings. In the first of two SEI reports, "Greater than the Sum of Its Parts: The Case for a Systems Approach to Energy Efficiency,"[1] a systems-efficient building is defined as a building in which multiple building systems (e.g., heating, ventilation, and air conditioning (HVAC) or lighting systems) are designed, installed, and operated to optimize performance collectively to provide a high level of service or functionality for a given level of energy use or input. Addressing the two main challenges identified in the RFI—increasing the use of centralized monitoring in more buildings and applying centralized monitoring to more systems beyond HVAC—are key strategies for improving the systems efficiency of U.S. buildings, and thus achieving significantly greater energy savings. In addition, the convergence of multifunctional wireless sensor networks, advanced monitoring and data analytics, adaptive and autonomous controls, and occupant-centric controls is making it even easier for building systems to act as distributed energy assets for the utility grid. The resulting energy savings from this convergence will also lead to national energy productivity gains through greater savings in the buildings sector.

We also appreciate the intent to ensure that R&D on sensor and controls technologies is complementary to appliance and equipment energy conservation standards and model building energy codes, which have saved American households and businesses billions of dollars in avoided utility expenditures. DOE has policies and programs at its disposal to encourage systems efficiency enabled by sensors and controls, including the Building Energy Codes Program, Federal Energy Management Program (FEMP), and (in cooperation with the Environmental Protection Agency (EPA)) the ENERGY STAR® program. The Alliance encourages DOE to explore the added value of sensors and controls when paired with highest-efficiency products covered by energy conservation standards, certified by ENERGY STAR, or designated by FEMP, which are all critical building blocks for systems efficiency. There may be opportunity for this pairing to be encouraged in model building energy codes. DOE also can build on lessons-learned through the development of the ENERGY STAR Smart Home Energy Management Systems (SHEMS) specification.

Furthermore, the RFI acknowledges the "slow turnover rate of the domestic building stock," which underscores the need to ensure that building technologies R&D supports the continuous improvement of efficiency requirements of model building energy codes. The building element with the longest lifetime is its shell; therefore it is critical to invest in and scale up the use of high-performance building envelope technologies, including high R-value (i.e., high thermal resistance) insulation to minimize energy wasted on thermal control and maximize long-term energy and cost savings. There may be opportunity to explore any variances between measured performance and building energy modeling (BEM) that may be a result of underperforming aspects of a building's envelope. We encourage DOE to leverage the insights offered by advanced monitoring and data analytics to identify opportunities to improve energy efficiency related to the building envelope.

[1] Systems Efficiency Initiative (2016). Greater Than the Sum of its Parts: The Case for a Systems Approach to Energy Efficiency. Year 1 report, May 2016. https://www.ase.org/systemsefficiency

Category 2: Advanced Monitoring and Data Analytics

Advanced monitoring and data analytics have significant potential to improve fault detection and diagnostics (FDD) and predictive controls. DOE found a "lack of standardized verification checklists and testing" for operators to identify faults. While automated fault detection and diagnostics (AFDD) can reduce the need for manual verification of faults, it would be informative for operators or occupants to have more formalized guidance on fault detection to bolster their capacity to detect faults in addition to the support offered by AFDD, especially considering the high prevalence of common faults.[2] We encourage DOE to consider exploring the lack of guidance for verification checklists and testing as a potential barrier under "Occupant/operator engagement and feedback" in Table III.5.

Furthermore, broader system-related factors should be considered in FDD. As systems and components become increasingly interlinked and integrated (e.g., Power over Ethernet where network cables carry electrical power), checklists for FDD should include factors that could affect other related or connected systems or components to consider whether the issue affecting one component or system also affects others. This is particularly critical given DOE's intent to expand AFDD development beyond HVAC systems.

Category 3: Adaptive and Autonomous Controls

In addition to improving energy management at the building level, adaptive and autonomous controls can inform efforts to shift loads from peak periods. Insights gained from controls research could further support the development of guidance on various applications for load flexibility. At present, the load management literature reflects consumer experience with relatively lumpy (and rarely used) on/off control of a few larger end-use devices (HVAC, water heaters, sometimes office lighting). We encourage the DOE to consider using insights gained from its controls R&D to explore the development of a detailed map of potentially aggregable and controllable loads by building type, representing a wider range of control scenarios ranging from very short-term trimming to longer interruptions—varying by time of day, season, location, and frequency of occurrence.

In addition, adaptive and autonomous controls support predictive maintenance and present opportunities to proactively manage energy performance. There is a milestone listed in DOE's Advanced Controls R&D Technology Plan for development of a "formal process that connects design to operation and verification of design intent across all relevant building loads successfully implemented and available for developers and engineers." We recommend that DOE expand this formal process to include building operators, owners, contractors, and any other stakeholders involved in designing energy systems or managing energy performance of buildings. One of the principal barriers to energy efficiency in the building design and construction market is fragmentation in the lifecycle of projects. Across the lifetime of the

[2] Department of Energy. Emerging Technologies Research and Development: DRAFT—Opportunities for Innovations in Sensors and Controls for Building Energy Management, April 2019. Citing Katipamula, et al. (2012): "The prevalence of common faults in commercial air conditioning units is estimated as 15-25% for sub-optimal evaporator flow, 35% for rooftop unit (RTU) damper failure, and 50-60% for improper charging or airflow."

building, it is important to have buy-in from operators to ensure that operation matches design intent. Integrated project delivery (IPD) is a model that integrates all the individuals involved in building design and construction into a single team, beginning at the earliest stages of design. This approach facilitates optimized design and construction by providing numerous opportunities for collaboration and can include the engagement of operations personnel. Using the IPD approach also could help building automation systems (BAS) address the "fragmentation of the BAS market" by ensuring that buildings are programmed to operate in ways that are fully optimized for the specific building configuration. There is opportunity for the "formal process" described above to include pre-installation testing and commissioning, which would enable building professionals to determine how various systems and devices will actually perform in relation to one another throughout the life of a building. This is in line with DOE's note that "Incorporating the commissioning of controls themselves as part of installation during the building design phase will also maximize the actual energy performance so that these systems or not misused or abandoned."

Category 5: Overarching Areas of Interest and Cross-cut Strategies

Systems-level Metrics

As DOE works to develop design and decision tools that "help apply efficient operational practices and technologies through an improved understanding of their cost and benefits," systems-level metrics will be key for making the value proposition for investments into sensors and controls. In its Advanced Controls R&D Technology Action Plan, DOE aims to establish key performance indicators (KPIs) to demonstrate performance. The Alliance encourages this strategy: Developing systems-level KPIs will help quantify the energy and cost savings of systems-level energy performance strategies enabled by sensors and controls. While component-level and whole-building-level KPIs exist, there is a lack of systems-level KPIs.[3] We encourage DOE to explore the potential for incorporating systems-level KPIs into BEM development to help optimize the performance of building control systems, into the Scout tool to further characterize systems-level impacts, and into measurement and verification practices and continuous commissioning to validate and ensure systems-level benefits are achieved. Systems-level KPIs may also provide direction in developing multi-objective optimization and prioritization practices for controls.

Miscellaneous Electric Loads

While the emphasis of DOE's R&D Report is on HVAC and lighting, DOE notes that further research into understanding miscellaneous electric loads (MELs) is underway. We encourage DOE to consider elevating the importance of MELs within the context of this sensors and controls RFI. MELs represent one of the fastest-growing end-uses of energy in buildings. Although addressing the efficiency of MELs at the equipment level will result in energy reductions, even greater energy savings (and reduced costs) might be achieved by integrating MEL controls, including occupancy monitoring and energy diagnostic tools, with other building systems. Integrating MEL controls into a holistic building performance analytic system will help ensure that all building systems are operating efficiently and optimally. Further, the growing

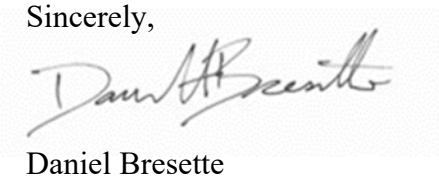
[3] Li, Han, et al. Systems Level Key Performance Indicators (KPIs) for Building Performance Evaluation, submitted for publication, 2019.

share of energy consumption by MELs, which could be further increased by the addition of sensors and controls, is an indicator that systems integration inclusive of MELs is key. We encourage DOE to partner with private-sector efforts to develop improved end-use data and energy models to more reliably predict system-level energy savings potential from MELs. In addition, we encourage DOE's efforts to enhance open-system protocols and interoperability, which could facilitate the integration of MEL local controls with building energy management systems.

Conclusion

Thank you for the opportunity to comment on DOE's Sensors and Controls RFI. Within the confines of current statute, there are several approaches available to the Department of Energy's Building Technologies Office to take advantage of systems-level opportunities across individual building end-uses with a focus on integrated and coordinated approaches for monitoring and control at the whole-building level. The Alliance looks forward to the results of this work and stands ready to support BTO's efforts to continue to advance energy efficiency and improve U.S. energy productivity.

Sincerely,



Daniel Bresette
Vice President of Policy