DE-FOA-0002117: Request for Information (RFI): "Research and Development Opportunities for Innovations in Sensors and Controls for Building Energy Management"

DATE: April 17, 2019
SUBJECT: Request for Information (RFI)

Description

Sensors, actuators, and controllers, which collectively serve as the backbone of cyber-physical systems for building energy management, are one of the core areas of technological investment for achieving the U.S. Department of Energy's (DOE) Building Technologies Office (BTO)'s goals for energy affordability in the national building stock – both commercial and residential. In fact, an aggregated annual energy savings of 29% is estimated in the commercial sector alone through the implementation of energy efficiency measures using current state-of-the-art sensors and controls to optimize programmable settings based on occupant comfort requirements, as well as to detect and diagnose equipment operation and installation problems.[1] Savings of 1.7 quads are targeted by BTO by 2030 and 3.6 quads by 2050 across applicable end uses in both the residential and commercial sectors through advancements in the sophistication and scalability of emerging control strategies that can incorporate learning and adaptive capabilities based on changes in building operating conditions.[2,3] Peak reduction is also anticipated with studies showing that 10-20% of commercial building peak load can be temporarily managed or curtailed to provide grid services.[4,5] Accordingly, these strategies are also available and necessary for implementing flexible, grid-interactive strategies to further reduce and shift electricity consumption of buildings. Furthermore, adaptive control architectures are important to resiliency by offering a flexible framework with which to mitigate impact from cybersecurity threats and maintain reliable operations. In total, adoption of next

[1] Fernandez, N., Katipamala, S. et al., (2017). "Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction." Pacific Northwest National Laboratory, PNNL-25985.

[2] Sofos, M., Langevin, J.T. (2018). "Laying Down the Foundation: An R&D Roadmap for Energy Savings through Advancements in Smart Building Technologies," 2018 ACEEE Summer Study on Energy Efficiency in Buildings.

[3] Based on Energy Information Administration (EIA) 2017 Annual Energy Outlook numbers.

[4] Kiliccote, S., Olsen, D., Sohn, M. D. and Piette, M. A. (2016). "Characterization of demand response in the commercial, industrial, and residential sectors in the United States." WIREs Energy Environ., 5: 288–304. doi: 10.1002/wene.176

[5] Piette, M.A., Watson, D.S., Motegi, N., Kiliccote, S. (2007). "Automated critical peak pricing field tests: 2006 pilot program description and results." Lawrence Berkeley National Laboratory, LBNL-59351.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

generation sensor and control technologies can generate $18 billion in annual energy savings by 2030.[6]

Through this RFI, BTO seeks input on its recently developed R&D opportunities document 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. This document will inform BTO's strategic planning moving forward in identifying early-stage and innovative technology solutions to meet these goals. Successful solutions will strengthen the affordability, reliability, and resiliency of the energy consumed by the buildings sector, contributing to DOE's priorities for the energy sector as a whole.

Background

Monitoring and control of building operations has advanced significantly from the invention of the modern thermostat at the start of the previous century, to the mid-century incorporation of direct digital control into devices, to the introduction of open protocols and network communications at the end of the last century, and finally to the invention of cloud-based computing and additional advancements that have enabled remote operation along with a proliferation of connected and intelligent devices in building automation. Despite this potential, however, two main challenges hinder widespread adoption of sensors and controls in building operations that can ensure savings for high-efficiency components and equipment (e.g., heat pumps, windows, and lights), as well as enable additional savings from more sophisticated control architectures and algorithms.

First, centralized monitoring and control of operations through building automation systems (BAS) are prevalent in 8% of floor space for small commercial buildings (<50,000 square feet) and 46% of floor space for large commercial (>50,000 square feet) in the U.S. This translates to 43% of the total floor space for the commercial building stock.[7] Similar to small commercial, residential buildings typically do not have a centralized management system, although smart home assistants are beginning to take on this role. In the residential sector, 41% of buildings had some type of a programmable thermostat installed, but only 12% used the programmable functionality, and only 3% had a smart or learning thermostat that learns occupant behavior

[6] Based on Energy Information Administration (EIA) 2017 Annual Energy Outlook numbers.

[7] U.S. Energy Information Administration (EIA). 2016. *Commercial Buildings Energy Consumption Survey 2012*. Washington, DC: EIA. https://www.eia.gov/consumption/commercial/data/2012/bc/cfm/b6.php

over time, eliminating the need for continual user activity as of 2015.[8] This number is steadily growing with 40% of the 40 million thermostats sold in 2015 classified smart.[9]

Second, most centralized systems currently installed exclusively manage heating, ventilation, and air-conditioning (HVAC). These systems are typically separated from control of other building end uses such as common area lighting and plug loads. For example, home energy management systems, usually consist of programmable thermostats for central and single-zone space conditioning, rather than more holistic management across multiple loads and appliances. Even modern systems incorporate a limited range of inputs, and prescriptively map these inputs to control strategies to meet occupant needs and sometimes save energy. Much of installed equipment in buildings today is also not capable of digital communication and control. These conditions result in approaches that are customized in nature with new devices managing their own operation through built-in capabilities and intelligence.

While efforts to embed intelligence in buildings that enable "smart" operations for energy management have proliferated in the past decade, they have generally lagged behind other sectors and applications (e.g., large-scale industrial process plants, automotive, aerospace) due to several factors. This includes utilization in less operationally critical applications (e.g., occupant comfort instead of safety and security), the fragmented nature of the buildings market (e.g., owner owned and tenant occupied), the customized nature of incorporating intelligence into building equipment rather than integrating into the design process, and the diversity of system configurations and limited modeling and integration capabilities of stochastic variables (e.g., occupants, weather forecasts). As such, building controls are still predominately designed to meet short-term thermal and ventilation loads and are rule-based and reactive, rather than adaptive and autonomous, in nature.

As such, this document is an R&D plan organized around four interrelated focus areas that build from each other and are aimed at two central goals: (1) reducing the cost and improving the accuracy of sensing and sub-metering along with the development of new sensing modalities (e.g., occupancy and building equipment health); and (2) optimizing replacements to rule-based controls over longer temporal periods (e.g., hours and days rather than minutes) and multiple spatial scales (e.g., occupant, zone, whole-building), as well as incorporating predictions (e.g., occupancy patterns, weather forecasts, equipment health) and current state information from which to learn from and adapt.

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[8] U.S. Energy Information Administration (EIA). 2017. *Residential Building Energy Consumption Survey 2015.* Washington, DC: EIA. https://www.eia.gov/todayinenergy/detail.php?id=32112

[9] Parks Associates. July 15, 2015. "Over 40% of thermostats sold in 2015 will be smart thermostats." http://www.parksassociates.com/blog/article/pr0715-smart-thermostats.

The R&D focus areas examined in the attached document are 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. The technical barriers that need to be addressed through 2030 for each of the areas (i.e. multi-functional plug-and-play wireless sensor networks, advanced monitoring and analytics, adaptive and autonomous controls, occupant-centric controls) are summarized in Table 1 along with energy savings performance goals and the overall technical potential based on quantitative estimates using BTO's impact analysis tool, Scout.[10] These estimates are calculated using energy conservation measures developed from energy savings results in the literature.[11]

The evaluation of enabling technologies, such as sensors and controls, whose impacts are at the systems-level are more challenging to properly attribute compared to component-based technologies. While energy savings goals are only presented for end-uses where sufficient measure performance and baseline energy data are available for estimation and analysis, addressing the technical barriers listed will enable savings across several building loads (e.g., HVAC, lighting, plug loads). At a portfolio-level, sensor and control technologies are anticipated to save 1.7 quads in 2030 and 3.6 quads in 2050 with further technological advancements and sophistication of the approaches identified in the priority research areas.[12] This 2050 estimate is equivalent to roughly 10% of total energy consumption from the buildings sector in 2018.

Peak reduction is also anticipated with studies showing that 10-20% of commercial building peak load can be temporarily managed or curtailed to provide grid services.[13,14] As such, innovations in sensor and control technologies will enable the conversion of demand flexibility into the provision of grid services, for which BTO is in the process of developing research goals via a recently closed RFI.[15] Initial results show that the HVAC, lighting, and plug loads targeted by the efficiency measures in this document account for 982 TWh of source electricity use

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[10] www.scout.energy.gov. Scout translates simulation-based measure end-use savings estimates to a national scale using a consistent national building energy use baseline, allowing for a rigorous consideration of improvements to individual component-based technologies (e.g., more efficient heat pump or higher insulating window) alongside systems-level efficiency improvements (e.g., a controls measure for more energy efficient building operation). Quantitative estimates are coupled with qualitative insights that account for technology characteristics not currently represented in the Scout analysis framework (e.g., ease of installation and maintenance through automation of the mapping, configuration, and commissioning of supported technologies).

[11] Further details on the full analysis are included in the attached document.

[12] Sofos, M., Langevin, J.T. (2018). "Laying Down the Foundation: An R&D Roadmap for Energy Savings through Advancements in Smart Building Technologies," 2018 ACEEE Summer Study on Energy Efficiency in Buildings.

[13] Kiliccote, S., Olsen, D., Sohn, M. D. and Piette, M. A. (2016). "Characterization of demand response in the commercial, industrial, and residential sectors in the United States." WIREs Energy Environ., 5: 288–304. doi: 10.1002/wene.176

[14] Piette, M.A., Watson, D.S., Motegi, N., Kiliccote, S. (2007). "Automated critical peak pricing field tests: 2006 pilot program description and results." Lawrence Berkeley National Laboratory, LBNL-59351.

[15] U.S. Department of Energy Request for Information DE-FOA-0002070.

annually between the peak hours of 2-8 PM, which is well over half (57%) of annual peak period electricity use and worth $49 billion in electricity costs; these loads also account for 234 GW of average peak summer demand.[16] Accordingly, a controls measure that enables a 20% shed of peak period HVAC, lighting, and plug loads would avoid 196 TWh of annual electricity use, reduce average peak summer demand by 46 GW, and save $10 billion in consumer energy costs nationally, while a measure that shifted these loads earlier by 6 hours without reducing electricity use would still save $2.4 billion in electricity costs under time-varying electricity rates.

Installed cost targets are estimated for each technology category based on the technology's anticipated energy performance assuming a one-year payback period. The overall timeline provided for technology development within the individual action plans for each priority area is notional and based on the performance improvements that need to be achieved within the designated time frame in order to meet the estimated energy savings goals. Actual timelines will also depend on advancements outside of building energy management, which are not included (e.g., microelectronics, data analytics, and machine learning) due to the interdisciplinary nature of this field. Finally, market and deployment barriers are included in the attached document, even though they are outside of scope and not addressed explicitly in the action plan sections themselves, because these challenges need to be considered when conducting R&D in a quickly evolving sector to ensure advancements made are relevant to current building operating conditions.

Table 1. Energy savings and cost goals for focus areas of research[17]

Focus Area	Energy Conservation Measure	Sector	Installed Cost Target[18]		Energy Savings Goal (end use)		Technical Potential[19]
			Market Entry	2030 Target	Market Entry	2030 Goal	2030

[16] Estimated using time-sensitive analysis capabilities in Scout (https://scout-bto.readthedocs.io/en/latest/analysis_approach.html#time-sensitive-adjustment-of-total-co2-and-cost), which incorporate load shape data from the EPRI End Use Load Shape library (http://loadshape.epri.com/enduse) and Utility Rate Database (URDB, http://openei.org/wiki/Utility_Rate_Database). Peak demand estimates are based on average daily summer load shapes from the EPRI library. Costs are based on the 50th percentile time-of-use rate structure in the URDB, in terms of peak/off-peak price ratio.

[17] Calculated based on EIA AEO 2017 data using Scout tool

[18] Cost premium based on 1 year payback period

[19] Full technical potential assuming no competition with measures from other technologies

<table>
<tr><td rowspan="2">Multi-functional Wireless Sensor Networks</td><td rowspan="2">Plug-and-play sensors self-powered with wireless communication</td><td>Residential[20]</td><td>$35/ node</td><td>$29/ node</td><td colspan="2" rowspan="2">17% (HVAC), 35% (Lighting)</td><td>1.14 quads</td></tr>
<tr><td>Commercial</td><td>$115/ node[21]</td><td>$57/ node</td><td>0.99 quads</td></tr>
<tr><td>Advanced monitoring and analytics</td><td>Automated fault detection and diagnostics (AFDD) incorporating sub-metered energy data</td><td rowspan="2">Commercial[22]</td><td colspan="2">$0.14/ ft² floor</td><td>25% (HVAC)</td><td rowspan="2">30% (HVAC)</td><td rowspan="2">1.18 quads</td></tr>
<tr><td>Adaptive and autonomous controls</td><td>AFDD</td><td>$0.12/ ft² floor</td><td>$0.14/ ft² floor</td><td>20% (HVAC)</td></tr>
<tr><td rowspan="4">Occupant-centric Sensors and Controls</td><td rowspan="2">Occupancy counting inputs</td><td>Residential[23]</td><td colspan="2">$70/ occupant</td><td rowspan="2">15% (HVAC), 15% (Lighting)</td><td rowspan="2">30% (HVAC), 40% (Lighting)</td><td>2.31 quads</td></tr>
<tr><td>Commercial[24]</td><td colspan="2">$36/ occupant</td><td>1.10 quads</td></tr>
<tr><td rowspan="2">Occupancy comfort inputs</td><td>Residential</td><td colspan="2">$92/ occupant</td><td rowspan="2">20% (HVAC), 30% (Lighting)</td><td rowspan="2">40% (HVAC), 60% (Lighting)</td><td>3.14 quads</td></tr>
<tr><td>Commercial</td><td colspan="2">$49/ occupant</td><td>1.49 quads</td></tr>
</table>

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to sensor and control technologies for optimizing building energy management. This information will be used by BTO to update its Sensors and Controls R&D strategy and supporting energy savings and cost reduction goals, as well as to inform future strategic planning and adjustments to its R&D portfolio. This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications.

[20] Based on all residential buildings; single/mobile homes use 0.0021 nodes/ft² floor and make up ~87% of all residential square footage (from residential EIA AEO 2017 microtables); multi family homes use 0.0041 nodes/ft² floor and make up ~13% of all residential square footage (EIA AEO 2017 microtables)
[21] Based on 0.002 nodes/ft² for large office commercial building
[22] Based on all commercial building types
[23] Based on single family home
[24] Based on large office commercial building

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Proprietary Information

Because information received in response to this RFI may be used to structure future programs and FOAs and/or otherwise be made available to the public, **respondents are strongly advised to NOT include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.** If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:
Pages [List Applicable Pages] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI DE-FOA-0002117. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

In addition, (1) the header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure" and (2) every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Categories and Questions

Category 1: Multi-Functional Wireless Sensor Networks
Advancing wireless sensor networks that are automated, plug-and-play, and capable of monitoring multiple parameters through effective power management will enable a low-cost approach to accurately detect and diagnose failures and resulting inefficiencies in building equipment and subsystems, while also allowing for optimal and localized whole-building control opportunities to improve building operations along with reducing energy use. Extending the operational power lifetime, reducing network infrastructure, and automating the configuration and calibration processes are all targeted in order to reduce the cost by minimizing the complexity of the sensor node architecture. These solutions will also have applicability to use cases where a singular variable is being monitored.

Category 1 Questions – Multi-Functional Wireless Sensor Networks

1. In reference to the Technical Barriers and Challenges section in Table III.2 of the attached document:
    a. Are there any R&D barriers that are missing for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any R&D barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    c. Are there any Installation & Maintenance barriers that are missing for achieving the energy savings goals and cost targets laid out? If so, please describe.
    d. Are there any Installation and Maintenance barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
2. In reference to the Market and Deployment Barriers section in Table III.3 of the attached document:
    a. Are there any barriers that are missing that could limit the achievement of the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any barriers listed that will not limit the achievement of the energy savings goals and cost targets laid out for 2030 in a measurable way if they are not addressed? If so, please describe.
3. In reference to the Technology Action Plan section in Table III.4 of the attached document:
    a. Are there any activities missing? If so, please identify and include a supporting timeline and applicable milestones.
    b. Are there any activities and milestones listed that are not necessary or have been sufficiently addressed by current state-of-the-art? If so, please identify and explain.
    c. Is the timeline of the listed activities and milestones consistent with achieving the energy savings goals and cost targets laid out for 2030? If not, please explain any necessary modifications.
4. In reference to the Benefits and Impact section in Table III.4 of the attached document, are any modifications necessary? If so, please identify the building type and explain why.
5. Are there any advancements from other sectors that are not considered that need to be included and leveraged in the assumptions made in terms of technology development, cost targets, energy savings goals, and supporting timelines?

6. Are there any modifications to the assumptions for market penetration and the methodology used to calculate cost reduction and energy savings goals shown in Table III.1 in this document that should be considered? If so, please describe.

Category 2: Advanced Monitoring and Data Analytics

Advancing pervasive monitoring (e.g., sub-metering) and supporting analytics such that all relevant equipment and operations are being monitored at low cost and with sufficient accuracy and identification will provide essential data to help maximize and verify energy savings, as well as provide critical information on the state and usage patterns of specific equipment to enable monitoring-based commissioning and aid in model calibration and training data collection for more sophisticated control strategies. Enhancing the hardware accuracy, improving load disaggregation algorithms and other analytic techniques (e.g., automated fault detection and diagnostics), and reducing the overall systems cost of sub-metering at the individual load level through materials development are all required to address the remaining challenges and facilitate the correction of anomalous behavior to reduce whole-building energy use.

Category 2 Questions – Advanced Monitoring and Data Analytics

1. In reference to the Technical Barriers and Challenges section in Table III.5 of the attached document:
    a. Are there any R&D barriers that are missing for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any R&D barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    c. Are there any Installation & Maintenance barriers that are missing for achieving the energy savings goals and cost targets laid out? If so, please describe.
    d. Are there any Installation and Maintenance barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
2. In reference to the Market and Deployment Barriers section in Table III.6 of the attached document:
    a. Are there any barriers that are missing that could limit the achievement of the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any barriers listed that will not limit the achievement of the energy savings goals and cost targets laid out for 2030 in a measurable way if they are not addressed? If so, please describe.
3. In reference to the Technology Action Plan section in Table III.7 of the attached document:

   a. Are there any activities missing? If so, please identify and include a supporting timeline and applicable milestones.
   b. Are there any activities and milestones listed that are not necessary or have been sufficiently addressed by current state-of-the-art? If so, please identify and explain.
   c. Is the timeline of the listed activities and milestones consistent with achieving the energy savings goals and cost targets laid out for 2030? If not, please explain any necessary modifications.
4. In reference to the Benefits and Impact section in Table III.7 of the attached document, are any modifications necessary? If so, please identify the building type and explain why.
5. Are there any advancements from other sectors that are not considered that need to be included and leveraged in the assumptions made in terms of technology development, cost targets, energy savings goals, and supporting timelines?
6. Are there any modifications to the assumptions for market penetration and the methodology used to calculate cost reduction and energy savings goals in Table III.1 of this document that should be considered? If so, please describe.

Category 3: **Adaptive and Autonomous Controls**
Developing and optimizing integrated building control schemes at the whole-building level with predictive and adaptive capabilities to correct for faults and respond to external (e.g., weather forecasts, grid events) and building equipment conditions over longer temporal and spatial periods will reduce energy consumption from building equipment and their associated controls not operating as designed. Dynamic models that simulate stochastic variables along with machine learning approaches to train building controls to recognize complex patterns in real-time digital representations of building environments and adapt accordingly, are necessary.

Category 3 Questions – Adaptive and Autonomous Controls

1. In reference to the Technical Barriers and Challenges section in Table III.8 of the attached document:
   a. Are there any R&D barriers that are missing for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
   b. Are there any R&D barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
   c. Are there any Installation & Maintenance barriers that are missing for achieving the energy savings goals and cost targets laid out? If so, please describe.

   d. Are there any Installation and Maintenance barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
2. In reference to the Market and Deployment Barriers section in Table III.9 of the attached document:
   a. Are there any barriers that are missing that could limit the achievement of the energy savings goals and cost targets laid out for 2030? If so, please describe.
   b. Are there any barriers listed that will not limit the achievement of the energy savings goals and cost targets laid out for 2030 in a measurable way if they are not addressed? If so, please describe.
3. In reference to the Technology Action Plan section in Table III.10 of the attached document:
   a. Are there any activities missing? If so, please identify and include a supporting timeline and applicable milestones.
   b. Are there any activities and milestones listed that are not necessary or have been sufficiently addressed by current state-of-the-art? If so, please identify and explain.
   c. Is the timeline of the listed activities and milestones consistent with achieving the energy savings goals and cost targets laid out for 2030? If not, please explain any necessary modifications.
4. In reference to the Benefits and Impact section in Table III.10 of the attached document, are any modifications necessary? If so, please identify the building type and explain why.
5. Are there any advancements from other sectors that are not considered that need to be included and leveraged in the assumptions made in terms of technology development, cost targets, energy savings goals, and supporting timelines?
6. Are there any modifications to the assumptions for market penetration and the methodology used to calculate cost reduction and energy savings goals in Table III.1 of this document that should be considered? If so, please describe.

Category 4: Occupant-Centric Controls

Occupant-centric control schemes are essential in moving to a more localized paradigm of building conditioning where base level conditioning is provided by central systems, personal preferences are made up via local devices, and the control system manages the integration and optimization of both central and local conditioning states. Cost-effective and accurate estimation and forecasting of individual and group-level occupant presence and comfort in building control schemes along with timely response and adjustments of equipment controllers will enable these strategies to match building operating conditions to occupancy patterns and preferences.

Category 4 Questions – Occupant-Centric Controls

1. In reference to the Technical Barriers and Challenges section in Table III.11 of the attached document:
    a. Are there any R&D barriers that are missing for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any R&D barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
    c. Are there any Installation & Maintenance barriers that are missing for achieving the energy savings goals and cost targets laid out? If so, please describe.
    d. Are there any Installation and Maintenance barriers that have already been sufficiently addressed through current state-of-the-art for achieving the energy savings goals and cost targets laid out for 2030? If so, please describe.
2. In reference to the Market and Deployment Barriers section in Table III.12 of the attached document:
    a. Are there any barriers that are missing that could limit the achievement of the energy savings goals and cost targets laid out for 2030? If so, please describe.
    b. Are there any barriers listed that will not limit the achievement of the energy savings goals and cost targets laid out for 2030 in a measurable way if they are not addressed? If so, please describe.
3. In reference to the Technology Action Plan section in Table III.13 of the attached document:
    a. Are there any activities missing? If so, please identify and include a supporting timeline and applicable milestones.
    b. Are there any activities and milestones listed that are not necessary or have been sufficiently addressed by current state-of-the-art? If so, please identify and explain.
    c. Is the timeline of the listed activities and milestones consistent with achieving the energy savings goals and cost targets laid out for 2030? If not, please explain any necessary modifications.
4. In reference to the Benefits and Impact section in Table III.13 of the attached document, are any modifications necessary? If so, please identify the building type and explain why.

5. Are there any advancements from other sectors that are not considered that need to be included and leveraged in the assumptions made in terms of technology development, cost targets, energy savings goals, and supporting timelines?
6. Are there any modifications to the assumptions for market penetration and the methodology used to calculate cost reduction and energy savings goals in Table III.1 of this document that should be considered? If so, please describe.

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

Category 5 Questions – Overarching Areas of Interest and Cross-cut Strategies

1. Are there any areas of R&D that are not addressed in the four priority topic areas above? If so, please identify and explain their necessity in achieving BTO cost reduction and energy savings goals? What are the strategies required for these areas?
2. Are there any additional cross-cutting strategies that need to be included in Chapter III of the attached document? If so, please identify and explain.
3. Are there any additional cross-cutting challenges and opportunities that need to be included in Chapter IV of the attached document? If so please identify and explain.
4. Are the cost reduction targets laid out in Table 1 of this document sufficiently aggressive to achieve the calculated energy savings goals?
5. With respect to demand flexibility, which advancements at the building-level described in this document can be leveraged when considering integration and coordination across multiple buildings and/or opportunities for microgrids?
6. Are there any areas of foundational development in sensor and control technologies at the building-level that are not included in this document that need to be considered to contribute to demand flexibility across multiple buildings and/or opportunities for microgrids?

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to BTO_SensorsControls_RDO@ee.doe.gov no later than 5:00pm (ET) on June 3, 2019. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 10 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.