U.S. Department of Energy
Advanced Research Projects Agency – Energy

Request for Information (RFI)
DE-FOA-0001580
on
Occupancy Sensors and Controls

Objective:

ARPA-E seeks input from the sensor systems and Heating, Ventilation, and Air Conditioning (HVAC) communities regarding the development of next-generation occupancy sensors for use in building control systems that facilitate reduced HVAC energy use nationwide. ARPA-E's interest also extends to the integration practices of these sensors into current building control systems, and the employment of real-world validation techniques to prove the functionality and cost of such new technologies. Consistent with the agency's mission, ARPA-E is seeking clearly disruptive, novel technologies, early in the R&D cycle, and not integration strategies for existing technologies.

With enhanced occupancy sensors, building control systems can more effectivity optimize heating and cooling strategies to satisfy individual occupant comfort and reduce energy use and emissions. In order to have a significant impact, these sensors need to be extremely low cost, easily retrofitted into current buildings, and compatible with existing equipment. ARPA-E desires input from a broad range of disciplines and fields, including, but not limited to: sensor development; distributed sensing systems; automated buildings; HVAC control systems; control algorithm development; human factors; and others. This includes input from the end-users of such technologies in the HVAC space, such as HVAC system fabricators, building managers, energy utilities, and the like. ARPA-E is particularly interested in how next-generation occupancy sensing technologies will help to realize the promise of minimizing the energy used to heat and cool buildings – especially existing buildings - through more effective automation technologies informed by occupancy detection.

Please carefully review the REQUEST FOR INFORMATION GUIDELINES below, and note in particular: the information you provide will be used by ARPA-E solely for program planning, without attribution. **THIS IS A REQUEST FOR INFORMATION ONLY. THIS NOTICE DOES NOT CONSTITUTE A FUNDING OPPORTUNITY ANNOUNCEMENT (FOA). NO FOA EXISTS AT THIS TIME. Respondents shall not include any information in their response to this RFI that might be considered proprietary or confidential.**

Background:

Heating, cooling, and ventilation of buildings represents about 17%[1] of all energy used domestically, equivalent to about 16.7 QBtu ("quads") of energy annually (primary). This extremely large segment has struggled to benefit from advanced sensing technologies. While there are very detailed breakdowns of energy usage by building type available[2], in this request for information we will consider the simplified case of: a) residential buildings (no ventilation, relatively "binary" occupancy); and b) commercial buildings (requires ventilation along with heating and cooling, with more complex occupancy scenarios.)

[1] DOE Buildings Energy Data Book: http://buildingsdatabook.eren.doe.gov/DataBooks.aspx from March 2012. Data for 2010 Buildings Energy End-Use.
[2] Ibid.

Two factors drive the large energy consumption associated with space heating and cooling: (1) comfort and (2) health. In practice, building occupancy and HVAC requirements have both temporal and spatial components. HVAC controls that are adaptive to fluctuations in occupancy density and distribution should allow optimization of air distribution and provide substantial energy savings (> 1 QBtu).[3]

Occupancy has been a very difficult factor to utilize practically to reduce building energy consumption at a large scale. In most buildings today, unoccupied spaces require as much energy annually as occupied portions of the building. Indoor air quality regulations drive HVAC ventilation set points according to the largest number of people expected to occupy the area during typical usage, and are therefore over-ventilated at any other time[4]. Variable air volume and zonal control strategies work to minimize energy input by maintaining comfort for occupied floor space all while meeting air quality standards in the unoccupied areas of the building. It has been demonstrated theoretically, by identifying the location and number of occupants within buildings, a net energy savings can be achieved of approximately 8.2 $kBtu \cdot sqft^{-1} \cdot yr^{-1}$ [5].This savings strategy requires a minimum of zonal control but a high degree of occupancy detection. Today's state of the art occupancy detection devices are too expensive to be widely adopted and can have latency issues, while lower cost solutions such as IR photodiodes do not have the functionality needed to distinguish between movement and occupancy leading to user over-rides that defeat potential energy savings. With enhanced occupancy detection, ARPA-E estimates that in today's office buildings a savings of approximately 0.6 $QBtu \cdot yr^{-1}$ can be achieved domestically, and employing similar technologies in the residential sector increases the total to approximately 1.6 $QBtu \cdot yr^{-1}$. However, the cost of implementing such automation at a wide scale remains extremely cost prohibitive.

ARPA-E is thus seeking input from the broad research and development community with regard to developing low-cost occupancy sensors; in particular, sensors that can detect the number of occupants per useful zone without direct occupant intervention that can easily interface with existing control systems. For both residential (enabling "invisible thermostats" with no need for human programming) and commercial applications, it is of paramount importance that these systems be as transparent to the users as possible. In addition, we would like to understand all barriers to adoption, whether technical or market- based. Such insights that leverage the application and adoption of these automation systems to well-defined commercial and residential building environments are strongly encouraged.

Purpose and Need for Information:

The purpose of this RFI is solely to solicit input for ARPA-E consideration to inform the possible formulation of future programs intended to help create transformative occupancy sensing for improved building HVAC control systems. ARPA-E will not provide funding or compensation for any information submitted in response to this RFI, and ARPA-E may use information submitted to this RFI on a non-attribution basis. This RFI provides the broad research community with an opportunity to contribute views and opinions regarding the occupancy sensor systems development path, building energy use, and building technology adoption patterns. Based on the input provided in response to this RFI and other considerations, ARPA-E may decide to issue a FOA. If a FOA is published, it will be issued under a new FOA number. No FOA exists at this time. ARPA-E reserves the right to not issue a FOA in this area.

REQUEST FOR INFORMATION GUIDELINES:

[3] Zhang et al. Energy Savings for Occupancy-Based Control (OBC) of Variable-Air-Volume (VAV) systems. PNNL-22072.
[4] Ibid.
[5] Ibid.

ARPA-E is not accepting applications for financial assistance or financial incentives under this RFI. Responses to this RFI will not be viewed as any commitment by the respondent to develop or pursue the project or ideas discussed. ARPA-E may decide at a later date to issue a FOA based on consideration of the input received from this RFI. No material submitted for review will be returned and there will be no formal or informal debriefing concerning the review of any submitted material. ARPA-E reserves the right to contact a respondent to request clarification or other information relevant to this RFI. All responses provided will be taken into consideration, but ARPA-E will not respond to individual submissions or publish publicly a compendium of responses. **Respondents shall not include any information in the response to this RFI that might be considered proprietary or confidential.**

Responses to this RFI should be submitted in PDF format to the email address ARPA-E-RFI@hq.doe.gov by **5:00 PM Eastern Time on ~~May 6th~~ May 20th** 2016. ARPA-E will not review or consider comments submitted by other means. Emails should conform to the following guidelines:

- Please insert "Responses for RFI for FOA DE-FOA-0001580" in the subject line of your email, and include your name, title, organization, type of organization (e.g. .. university, non-governmental organization, small business, large business, federally funded research and development center (FFRDC), government-owned/government-operated (GOGO), etc.), email address, telephone number, and area of expertise in the body of your email.
- Responses to this RFI are limited to no more than 10 pages in length (12 point font size).
- Responders are strongly encouraged to include preliminary results, data, and figures that describe their potential methodologies.

- **Questions:** ARPA-E encourages responses that address any subset of the following questions of relevance to the respondent and encourages the inclusion of references to important supplementary information.

    1) Sensors and related hardware/software

        a) What technical opportunities exist for disruptively low-cost occupancy sensing? Technical opportunities may include concepts that have not yet been explored, recent scientific advances, ideas drawn from existing technologies, technologies far from commercialization, practices in unrelated industries, or others. What technical challenges must be overcome for these technologies to make an impact?
        b) What functionality would be desired for such technologies (such as lower power draw, increased accuracy and reliability relative to the state of the art, improved instrument response time, precision/accuracy in space and time, etc.) which could make a transformative difference in HVAC systems usage? What are desirable functionalities for such technologies in terms of installation and commissioning?
        c) What other crucial technical needs are there in conjunction with the active sensing element? Examples: low-power electronics, wireless communication including issues of interference in retrofit installations, processors, and the like; energy scavenging, analytics/algorithms for integrating sensor data into control systems, non-GPS based intra-network positioning, etc.
        d) What other gaps exist for current occupancy sensor technologies, both in functionality and cost (including system/installation/commissioning)?
        e) What sensor communication protocols are particularly suited for interfacing with current building control systems and communication hardware? Please also address this in the context of operational constraints and energy use.

f) What scientific and engineering analyses have been done, or need to be performed, to provide a quantitative value assessment of occupancy sensing systems?
g) What technical disciplines outside the norm do you believe could contribute to the effort? What industries working in related areas should contribute to occupancy sensing systems?
h) What security risks (or perceived risks) exist, and what role can technology choice and implementation play in mitigating these risks?
i) Are there technologies that can infer actionable occupancy specific demands without having to install occupancy sensors or build and manage complex buildings models?

2) Markets
   a) In what types of buildings could improved occupancy sensing systems be most easily introduced? In what types of buildings could improved occupancy sensing systems make the largest difference in energy use? What would the key requirements be for occupancy sensors in these buildings?
   b) What markets are most ripe for commercial adoption of advanced occupancy sensor systems?
   c) How important is it to couple demand/response capabilities with occupancy-based HVAC control systems? If so, which market segments/areas of the country would lead adoption?
   d) Are there human factors approaches that can be used to drive adoption or mitigate adoption risks, such as addressing perceived privacy risks?
   e) What markets are likely to provide the highest energy savings with implementation of advanced occupancy sensing systems?
   f) What market barriers exist to the adoption of occupancy sensors for HVAC control?
   g) What additional markets (especially any regarding energy saving) exist for low-cost, lower-fidelity (i.e. non-personally-identifying) occupancy sensing?