Test Methods Standing Technical Committee

2011 Strategic Plan V1.1 - Draft

2/24/2012

Committee Chair:

2011-2012	Dane Christensen	National Renewable Energy Laboratory

Prioritization of Gaps, Barriers and Needs

The following table prioritizes the Gaps, Barriers and Needs described in this document.

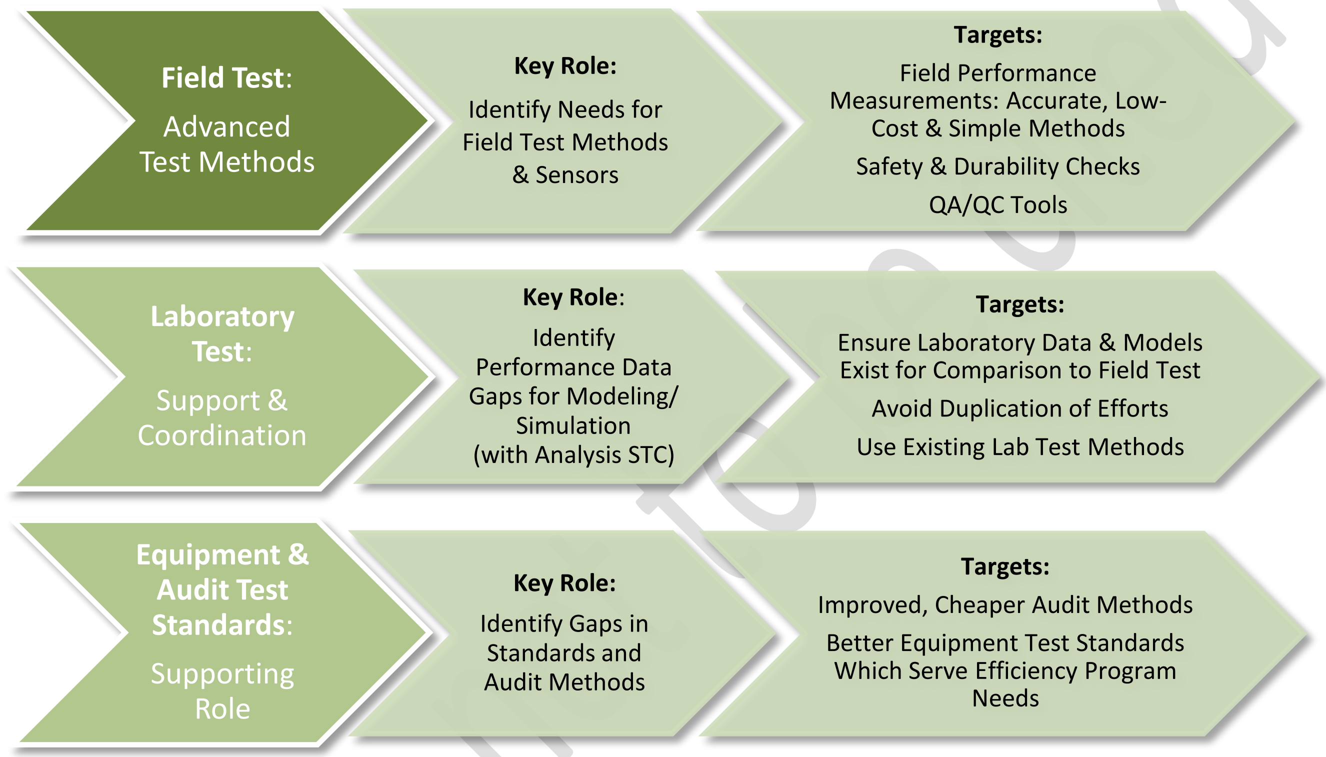
Rank	Description	Estimated	
		Priority	Effort
1	Heat Pump Water Heater Field Test Protocol	H	M
2a	Method for infinitely variable fan airflow measurement	H	H
2b	Non-Intrusive Natural Gas Flow Measurement	H	H
3	Data Logger with Increased Data Capabilities	M	M
4	Room Air Mixing Analysis	M	H

Contents

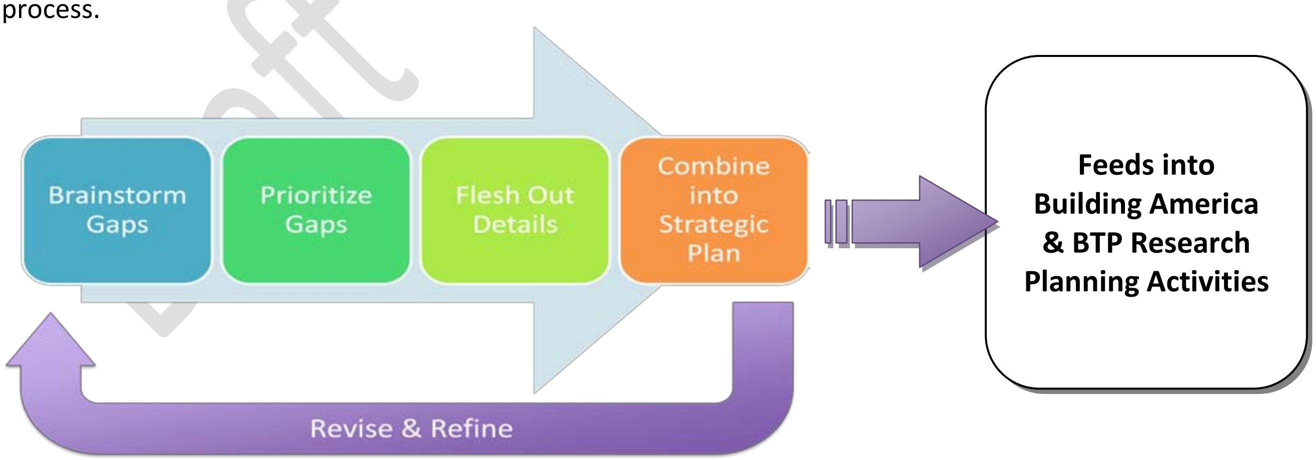
Summary of Test Methods STC Strategic Plan

The primary function of the Building America Standing Technical Committee on Test Methods is to identify and characterize "Gaps and Needs" in the area of test methods and sensors, which prevent or are anticipated to delay successful completion of DOE Program milestones. These Gaps and Needs are identified with respect to three key task areas within the Building America work plan:

1. Field verification of installed component & system performance,
2. Laboratory performance evaluation of buildings components & systems, and
3. Support of DOE and industry standards activities.



Gaps & Needs were identified through a multi-step brainstorming, prioritization, consolidation and development process.



Participants in development of these technical gaps and needs included members of the DOE Buildings Technology Program, DOE National Laboratories, Building America Teams and stakeholders, and interested industry parties. Key contributors of content are listed in the appendix.

Summary of Gaps and Needs

Nineteen Sensor and Test Method Gaps and Needs were identified in the brainstorming process. After consideration and discussion by the committee, the prioritization process filtered out the less critical near-term topics. Five Gaps and Needs are identified in this initial release of the Strategic Plan as having the highest priority for program success.

Heat Pump Water Heater Field Test Protocol

Heat Pump Water Heaters (HPWHs) are receiving renewed market attention due to new product offerings from major manufacturers. These residential tank-integrated HPWHs are expected to provide substantial energy savings opportunity for homeowners, particularly in hot-humid and hot-dry climate regions where the resultant cooling supplements HVAC systems and delivers additional dehumidification. **Builders, plumbers, and homeowners have not readily adopted the new energy-efficient HPWH products due to anxiety about reliability, cost, installation requirements and user expectations.**

Building America is the best organization to address these gaps. Demonstration of energy savings and payback period can motivate these stakeholders, but identification and resolution of integration issues is also necessary. Testing HPWHs in occupied homes will be required. The appliances present unique challenges for field monitoring which are not addressed by a standardized method for consistent evaluation. The gap identified below is development of a HPWH Field Test Protocol providing sensor requirements, installation and measurement methods, and direction on analysis tasks.

Method for infinitely variable fan airflow measurement

Variable-speed fans, particularly those with many or infinite speeds, are becoming common among advanced-efficiency HVAC systems such as mini-split heat pumps. Variable fans have a higher first cost, but are expected to reduce energy consumption and thus have lower operating cost. **HVAC product rating conditions are seldom representative of real-world operating conditions, so the installed energy benefits of variable speed fans are unclear (and thus so is their cost-effectiveness).**

Because of the complexity of fan speed controls, it is not possible to assume an airflow when measuring/estimating load delivery in the field. Continuous measurement of airflow is highly challenging due to system effects, and no sensor exists to effectively meet Building America's field testing needs.

Non-Intrusive Natural Gas Flow Measurement

Natural gas flow rate is measured in order to disaggregate energy and cost consumption among various end uses such as water heating, oven, fireplace and furnace. To calculate the installed efficiency of a single gas appliance, it is appropriate to measure its gas consumption directly (instead of inferring based on rated efficiency and runtime). Many appliances could make good use of a low-cost reliable flow meter for on-board fault detection as well. **No practical, low-cost and accurate flow meter is available to meet the needs of researchers, appliance manufacturers, and AHEM system designers.**

Measurement of natural gas consumption in a field test is challenging for two reasons: flow meter cost vs. resolution, and cost/risk of meter installation. Prior field tests have typically employed full-size gas meters for safety; these large, clunky and moderate-resolution meters are not appropriate for some measurements such as instantaneous water heaters which have 20:1 turndown ratios. Other flow meters, such as turbine meters, are not well recognized by plumbers as safe for natural gas installation. Installing meters in existing homes presents additional logistical and safety issues. A low-cost, non-intrusive (i.e. clamp-on or similar) sensor for natural gas flow rate will provide high value to efficiency researchers and would substantially reduce risks to homeowners. It can also provide additional data input for future household automation systems (AHEM).

Data Logger with Increased Data Capabilities

Freestanding data loggers are often used where measurements are needed but a building's infrastructure does not permit interconnection with a central data collection system. Common measurements would include temperature and RH, but these data loggers are capable of recording other analog signals. Existing products have very limited on-board data storage, so for many common measurements the researcher must retrieve data at a too-frequent interval or suffer the risk of infrequent data capture missing a significant event. With recent cost reductions for solid-state data storage and mesh networking capabilities in other sectors, this research tool has not kept up and therefore has limited resolution of (and/or increased the cost of resolving) certain important research questions. **An increase in small and low-cost data logger product versatility is needed to enable cost reductions and increased efficiency so the Building America program can perform field validation at the necessary speed and scale.**

Room Air Mixing Analysis

Increased thermal resistance, decreased air infiltration, and increased radiant uniformity are key features of an efficient building enclosure. These improvements provide three benefits to homeowners. First and foremost, the rooms will be more comfortable to live in. Second, less space conditioning is lost through the building's exterior, so energy consumption is reduced. And thirdly, the HVAC requirements go down leading to an overall lower first cost in addition to the lower operating cost. Not all builders and envelope retrofit contractors have adopted approaches to maximize the improved envelope-HVAC combination. Why is this? They may not understand the benefits, or may not be able to effectively explain the benefits to a prospective homeowner. Customers can see granite and stainless steel upgrades when viewing marketing materials, but not improved HVAC or reduced heat flux.

The benefits of improved envelope technologies and best-practice space conditioning systems are not easy to visualize to home buyers so are often left out of a sales pitch or even excluded from the construction package. A simple tool is needed to drive demand for these proven construction features by showing the comfort and energy differences between systems and between homes in a fair and comprehensible way.

Increasing customer demand for these proven efficiency technologies is facilitated by visualizations. CFD-driven videos can show off the effects of better HVAC design and better envelopes to prospective homeowners. Validation of existing CFD thermal comfort methods should be conducted in real rooms, to demonstrate the analytical methods and increase adoption of high-performance distribution and envelope measure packages. Collaboration with builders and retrofit contractors can then be done to develop the needed visualizations.

Heat Pump Water Heater Field Test Protocol

Related Research Areas:

BA Enclosures		**BA Test Methods & Protocols**		**House Type**	
Walls		Sensors		New	X
Roof/Ceiling		Test Methods	X	Existing	X
Foundations		Standards		Single Family	X
Moisture		Other:		Multi Family	X
Windows		**BA Analysis Methods/Tools**		**DOE Emerging Technologies**	
Other:		House Simulation Protocol		Walls and Windows	
BA Space Conditioning		Analysis Tools	X	Efficient Appliances	X
Heating		Strategic Analysis	X	Advanced Heating & Cooling Fluids	
Cooling	X	Other:		Solar Heating & Cooling	
Dehumidification	X	**BA Miscellaneous Loads**		Geothermal Heat Pumps	
Distribution		Home Energy Management		Solid State Lighting	
Ventilation		Lighting		Bulk Purchase	
Other:		Large MELs (pools, etc.)		Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
BA Hot Water		Small MELs (TVs, VCRs, etc.)			
Test Standards		Other:			
Distribution		**BA Implementation**		**DOE Deployment**	
Condensing/Tankless		Quality Control/Quality Assurance		Labeling/Rating	
Heat Pump Water Heater	X	Training		Codes	
Combined Space & DHW Heating	X	Documentation/Resources	X	Standards	
		Needs Evaluation/Identification		Large Scale Retrofit (Better Buildings)	X
Other:		Other:			

Problem Statement: *Builders, plumbers, and homeowners have not readily adopted the new energy-efficient integrated Heat Pump Water Heater (HPWH) products due to anxiety about reliability, cost, installation requirements and user expectations.* HPWHs have the potential to save significant hot water heating energy and are gaining popularity. However, they are more complex and have a greater impact on their surroundings than traditional water heaters, making them a more challenging system to monitor in the field. The benefits need to be measured and quantified in real homes in order to robustly demonstrate the technology benefits and thus motivate these market participants. This is a core role for Building America. A new field test protocol is needed to define a straightforward set of field tests that quantify performance of the water heater and its cooling/ dehumidification effect on the surrounding area. Internal tank temperatures can also be an important measurement so the test protocol should also include measurement of upper and lower tank temperatures. HPWHs installed inside the living space will reject noise into the home. This performance metric is one factor of user acceptance and should be considered along with hot water delivery, thermal comfort effects, cycling and operating mode usage.

Key Customers and Stakeholders: Building America teams and National Lab researchers will all benefit from simple, consistent test method for heat pump water heaters. This technology is becoming more common but there are still many questions surrounding their impact on the home's HVAC use; lessons learned from actual installations will help guide practitioners.

Background Knowledge: A thorough understanding of heat pump water heater technology, as well as the expected impact on the home will be critical in designing this test protocol. Since the best test protocol will call for minimal sensors but still allow thorough characterization, past experience with cleverly designed field tests will also be important. The heat pump water heaters on the market now have significant differences between them. In some cases, these differences could impact the test protocol and so familiarity with the available heat pump water heaters will be helpful[1].

System Considerations: Other gaps and barriers identified needing a method for measuring flow rate from a mini split heat pump and a need for a field test method for measuring total, sensible and latent cooling. These measurements will likely be used in heat pump water heater test protocol since capturing flow rate and cooling effect will be critical to defining impact on the HVAC system.

Planned or Ongoing Research: Numerous Building America teams are involved in field tests that include heat pump water heaters. CARB is currently monitoring 14 HPWHs that are installed in homes in the Northeast. Also, a team of researchers from Pacific Northwest National Lab and Oak Ridge National Lab are working on deep energy retrofits, several of which include the installation of a heat pump water heater including a TVA/ORNL collaboration on 3 deep retrofit houses in Knoxville, TN. FSEC is studying the sound levels and related occupant impacts. ARBI and BA-PIRC are monitoring HPWHs too. The experiences from these field tests could provide a starting place. There are likely no private industry efforts on this topic. Most testing done by water heater manufacturers is laboratory-based.

"Closing the Gap": The final goal to address the gap is a straightforward field test protocol for heat pump water heaters that can be used to assess the performance of the water heater and its effect on the space conditioning in the home. Once a protocol is written, researchers with little heat pump water heater experience should be able to follow the instructions and gather useful data. After applying the test protocol in real homes, BA researchers can report on the actual HPAH efficiency and usability, as well as validation of energy simulation expectations. Resolving this gap will result in improved consistency of our program's conclusions.

Timeline: Develop a preliminary test protocol based on laboratory testing and ongoing field tests involving heat pump water heaters – Q2 FY12. Ask for one or more BA team to follow test protocol to ensure that it meets expectations. Suggestions for sensor choice, position, data collection and analysis should be delivered by the end of FY12. Modify test protocol as necessary. Deliver final version by early FY13.

[1] **Recent References:** Sparn, B.; Sparn, B.; Hudon, K.; Christensen, D. (2011). Laboratory Performance Evaluation of Residential Integrated Heat Pump Water Heaters. 77 pp.; NREL Report No. TP-5500-52635. http://www.nrel.gov/docs/fy11osti/52635.pdf

Hudon, K.; Sparn, B.; Christensen, D.; Maguire, J. (2011) Heat Pump Water Heater Technology Assessment Based on Laboratory Research and Energy Simulation Models. ; NREL Report No. CP-5500-51433. (published at 2012 ASHRAE Winter Conference)

Van Baxter and Rick Murphy, ORNL, developed a "lab in a box" that was used on 18 HPWH one year study in a national demonstration project. (No references are available)

Method for infinitely variable fan airflow measurement

Related Research Areas:

BA Enclosures		BA Test Methods & Protocols		House Type	
Walls		Sensors	X	New	X
Roof/Ceiling		Test Methods	X	Existing	X
Foundations		Standards	X	Single Family	X
Moisture		Other:		Multi Family	X
Windows		**BA Analysis Methods/Tools**		**DOE Emerging Technologies**	
Other:		House Simulation Protocol		Walls and Windows	
BA Space Conditioning		Analysis Tools	X	Efficient Appliances	X
Heating	X	Strategic Analysis		Advanced Heating & Cooling Fluids	
Cooling	X	Other:		Solar Heating & Cooling	
Dehumidification	X	**BA Miscellaneous Loads**		Geothermal Heat Pumps	
Distribution	X	Home Energy Management		Solid State Lighting	
Ventilation	X	Lighting		Bulk Purchase	
Other:		Large MELs (pools, etc.)		Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
BA Hot Water		Small MELs (TVs, VCRs, etc.)			
Test Standards		Other:			
Distribution		**BA Implementation**		**DOE Deployment**	
Condensing/Tankless		Quality Control/Quality Assurance	X	Labeling/Rating	X
Heat Pump Water Heater	X	Training		Codes	X
Combined Space & DHW Heating	X	Documentation/Resources		Standards	X
		Needs Evaluation/Identification		Large Scale Retrofit (Better Buildings)	
Other:		Other:			

Problem Statement: *HVAC product rating conditions are seldom representative of real-world operating conditions, so the installed energy benefits of variable speed fans are unclear (and thus so is their cost-effectiveness).* Simulations and ratings motivate increased use of variable-speed components, but we need to validate those expectations in real-world demonstrations. Researchers are currently unable to directly, accurately, and continuously monitor airflow through variable speed HVAC fans to calculate the delivered load. At this point, the primary focus of this method advancement would be in field performance evaluation of mini-split heat pumps (MSHPs) but will enable monitoring of many other systems as variable speed fan use increases. The lack of an appropriate measurement method prevents measurement of the in-field performance of MSHPs across the operational range of variable-speed compressors and variable-speed fans.

Key Customers and Stakeholders:
Primary benefit is to Building America teams initially, but using this capability to better understand the true performance of MSHPs will benefit homeowners, builders, and utilities. This information will also assist in being able to more accurately model MSHPs. Finally, the results of this work will help manufacturers to most effectively integrate variable speed components into systems.

Background Knowledge:
Mini-split heat pumps (MSHP) are gaining market share in the industry because their lack of a ducted distribution system reduces retrofit system installation cost and thus is an excellent option for existing homes, particularly those with open floor concepts. Inverter-driven and variable-refrigerant-volume

mini-split heat pumps are entering the market and showing promise as a highly-efficient heating/cooling option. The ability of these units to modulate down to better match building loads is highly desirable for minimizing energy usage. Though single-stage MSHPs can have very high energy-efficiency ratings (SEER, EER, HSPF), these variable capacity units typically don't perform as well in the AHRI rating certification. Part-load efficiencies of these units are reportedly significantly better than full-load efficiency, but are not captured in the current rating metric.

To have a better understanding of the true in-field performance of these MSHPs, researchers need to be able to assess the delivered load. To do this, several measurements are needed: temperatures, relative humidity (RH), and air flows. With a non-ducted system, typical methods for obtaining flow measures (multi-point pitot traverse) are not readily available. Supply air flows for MSHPs are not ideal to measure as many unit have adjustable blades to direct airflow and having sensors on the front side of the indoor unit is not desirable for long-term monitoring. Therefore, the only option is on the return side (typical on the top, rear of the indoor wall unit) or through the unit.

NREL has developed a testing protocol[2] that correlates the fan revolutions per minute (measured using a tachometer) frequency to an equivalent air flow measurement based on initial short-term testing to generate airflow curves with a powered flow hood. Ecotope[3] utilized a single-point return side flow measure in their MSHP evaluation in the Northwest for NEEA, but NREL's evaluation is that the measurement was neither sufficiently accurate nor robust enough for Building America purposes.

System Considerations:
Capturing the true performance of MSHPs to validate simulation of the technology enables better packages available for existing home retrofits: replacement of fuel oil space heating (primarily in the Northeast), efficient solutions for locations that don't have natural gas available, lower cost solutions for homes where ductwork doesn't exist or can't be effectively relocated into conditioned space, multi-family units, and homes seeking to be net-zero electric homes.

Planned or Ongoing Research:
NREL is seeking to do additional field testing of their MSHP testing protocol. There are several utilities across the country seeking evaluations of MSHPs to better coordinate incentive programs. EPRI is conducting field work on MSHPs; coordination with that effort should be sought. BA Teams including CARB, CEER, BIRA, and IBACOS, as well as ORNL, are measuring MSHP performance in the field.

"Closing the Gap":
The goal is to have a flow-sensing device or method that can be directly applied to multiple MSHP types and other variable speed systems to accurately measure air flow either at the return or through the system without significantly affecting the system's operating pressures. Ideally, a sensor manufacturer will produce this device or MSHP manufacturers will incorporate it into their units (with a data output port). Potential exists for manufacturers to have a "surrogate" or onboard diagnostics, which could eventually be standardized across all manufacturers' models and capabilities.

[2] http://www.nrel.gov/docs/fy11osti/49881.pdf

[3] Ecotope. 2009. "Mini-Split Ductless Heat Pump Bench Test Results." Available at www.bpa.gov/energy/n/emerging_technology/BPA-Report_Ductless-Heat-Pump- June2009_FINAL.pdf

NEEA. 2009. *Report: Northwest Ductless Heat Pump Pilot Project, Market Progress Evaluation Report #1.* Portland, OR: Northwest Energy Efficiency Alliance. Report #E10-215. Available at: http://neea.org/research/reportdetail.aspx?ID=773

Non-Intrusive Natural Gas Flow Measurement

Related Research Areas:

BA Enclosures		BA Test Methods & Protocols		House Type	
Walls		Sensors	X	New	X
Roof/Ceiling		Test Methods	X	Existing	X
Foundations		Standards		Single Family	X
Moisture		Other:		Multi Family	X
Windows		**BA Analysis Methods/Tools**		**DOE Emerging Technologies**	
Other:		House Simulation Protocol		Walls and Windows	
BA Space Conditioning		Analysis Tools		Efficient Appliances	X
Heating	X	Strategic Analysis		Advanced Heating & Cooling Fluids	
Cooling		Other:		Solar Heating & Cooling	
Dehumidification		**BA Miscellaneous Loads**		Geothermal Heat Pumps	
Distribution		Home Energy Management	X	Solid State Lighting	
Ventilation		Lighting		Bulk Purchase	
Other:		Large MELs (pools, etc.)		Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
BA Hot Water		Small MELs (TVs, VCRs, etc.)			
Test Standards		Other:			
Distribution		**BA Implementation**		**DOE Deployment**	
Condensing/Tankless	X	Quality Control/Quality Assurance		Labeling/Rating	X
Heat Pump Water Heater		Training		Codes	X
Combined Space & DHW Heating	X	Documentation/Resources		Standards	X
		Needs Evaluation/Identification		Large Scale Retrofit (Better Buildings)	
Other:		Other:			

Problem Statement: Currently there are many ways to measure electricity use in buildings – both total and end-use breakdowns – at high resolution (easily <1% of total). There are no analogous solutions for natural gas; all existing gas measurement methods bring higher risk, unacceptable cost, unacceptable accuracy, and/or intrusively large hardware. **No practical, low-cost and accurate natural gas flow measurement method is available to meet the needs of researchers, appliance manufacturers, and AHEM system designers.** While range and dryer energy consumptions can be inferred from simultaneous electricity use, furnace and gas water heater consumption has usually required separate full-size gas meters. These meters require installation directly in the gas line with the necessary risks of leaks, damage, and etcetera. Low-cost gas meters require additional hardware if a signal is to be received by a field data logger. Finally, in-line metering equipment causes reduced pressure at the end use, which is highly undesirable. A low-cost (or moderate cost, i.e. won't consume the whole field test budget), non-intrusive (i.e. temporary, clamp-on) measuring device is needed that provides moderate-to high-resolution volumetric consumption.

Key Customers and Stakeholders: Key customers are the research community and the existing energy monitoring industry. If we could give researchers better tools for gas monitoring we will have a much better understanding of energy used for heating, hot water, cooking and clothes drying (the major categories of gas end-use in homes). This information is currently lacking and significantly restricts our ability to correctly assign energy use to end-uses or even estimate energy savings by various measures (due to low resolution equipment). The energy monitoring industry is eager to monitor gas use and provide feedback in the same way as they do for electricity – particularly because gas use dominates energy use in most homes. Developing new measurement techniques and sensors is essential for both of these constituencies. In the long-run, use in household energy monitoring systems will allow home occupants to get a much better picture of their energy use because current system do not provide feedback on what is usually their biggest energy use. In turn, this will allow better decision making and lead to energy reductions in gas use as well as electricity.

Background Knowledge: Current gas meters are physically too large to install in many situations, such as behind gas stoves or next to water heaters or furnaces in closets. In addition, their resolution is often insufficient to clearly see the real-time differential effects of reduced consumption. Non-invasive gas monitoring technologies which can meet program research requirements exist, and are used extensively in industrial and utility applications. The cost of these technologies, though, is prohibitive for most research budgets. With outreach to industry partners, and the development of resource sharing programs, it may be possible to bring the cost of using these devices within the scope of more project budgets.

System Considerations: None known.

Planned or Ongoing Research: FSEC, BA-PIRC and ARBI have significant projects in this area. PNNL previously considered using flue temperature measurements to indirectly correlate with gas flows. Several BA teams and National Labs have estimated gas consumption indirectly using known BTU/hr burn rates from appliance ratings. ARIES is considering a similar challenge – indirectly measuring fuel oil flows.

"Closing the Gap": The goal is a simple, low-cost, non-intrusive, high resolution gas flow monitoring device or method to measure gas flow in residences, focused on end uses including: furnaces, water heaters, ranges and clothes dryers. As a first step, a standard specification for the program's metering requirements would be developed and transmitted to industrial partners to identify fits with existing technologies. A bulk purchase may be needed to achieve pricing commensurate with budgetary constraints. A procedure to lease/borrow metering equipment and offer training and technical assistance could also be developed to allow teams to have access to this equipment for defined scopes of work.

Timeline: Key milestones on the critical path would be: 1) Develop and verify the appropriate specification, 2) Put this spec out to bid, 3) Identify close fit available technologies and collaborate to meet any specification mismatches, 4) Negotiate a volume purchase or lease agreement, and 5) Develop a structure for making the technology available to teams.

Data Logger with Increased Data Capabilities

Related Research Areas:

BA Enclosures		**BA Test Methods & Protocols**		**House Type**	
Walls		Sensors	X	New	X
Roof/Ceiling		Test Methods		Existing	X
Foundations		Standards		Single Family	X
Moisture		Other:		Multi Family	X
Windows		**BA Analysis Methods/Tools**		**DOE Emerging Technologies**	
Other:		House Simulation Protocol		Walls and Windows	
BA Space Conditioning		Analysis Tools		Efficient Appliances	
Heating	X	Strategic Analysis		Advanced Heating & Cooling Fluids	
Cooling	X	Other:		Solar Heating & Cooling	
Dehumidification	X	**BA Miscellaneous Loads**		Geothermal Heat Pumps	
Distribution	X	Home Energy Management		Solid State Lighting	
Ventilation		Lighting		Bulk Purchase	
Other:		Large MELs (pools, etc.)		Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
BA Hot Water		Small MELs (TVs, VCRs, etc.)			
Test Standards		Other: Controls	X		
Distribution		**BA Implementation**		**DOE Deployment**	
Condensing/Tankless		Quality Control/Quality Assurance	X	Labeling/Rating	X
Heat Pump Water Heater		Training		Codes	
Combined Space & DHW Heating	X	Documentation/Resources		Standards	
		Needs Evaluation/Identification		Large Scale Retrofit (Better Buildings)	X
Other:		Other:			

Problem Statement: Remote standalone monitoring devices are used to assess actual conditions in buildings as well as tracking energy use and building performance. These devices are critical for confirming a building's performance and to track specific parameters over time. However, the limited onboard data capacity and capabilities can be an impediment to long term monitoring or monitoring with very small tracking intervals or mismatched acquisition and storage intervals. As Building America begins to monitor larger and larger house counts, larger, costly data systems are prohibitive so options such as standalone loggers become a necessity. *An increase in small and low-cost data logger product versatility is needed to enable speed and scale of Building America field testing.*

As an example, a Temperature/%RH monitoring device can be installed in a forced air duct system to track the performance and reaction of an HVAC system, but the measuring intervals would need to be very small in order for the data to be useful. However, with the memory currently available on these small devices, the units would need to be downloaded often (once a month or so). This leads to excessive and intrusive site visits to homes that may be occupied. An alternate example is monitoring hot water draws, where rapid sampling (say of water flow and temperature) is needed, but can be stored in aggregate. i.e. "Water draw started at XX:XX:XX for 41 seconds with total volume of 1.2 gallons at average temperature of 126*F" requires scanning the channels every few seconds, but only needs a small amount of storage.

The companies that make these devices have not chosen to increase the onboard memory and summarizing capabilities, but rather have invested in developing web based data loggers with remote access to allow for internet downloading of the data. While this is convenient, it is expensive and requires integrating the devices with the occupant's phone or internet connection which in some cases are not even available (unoccupied homes included).

Key Customers and Stakeholders: DOE Research partners, teams, builders, contractors, developers, automated home energy management device developers, utilities seeking demand response solutions that minimize the impact on occupant comfort, and raters would all benefit from the increased capacity of remote monitoring devices. It will increase the effectiveness of quality control in buildings and will allow for more detailed data collection that could influence the modifications of existing models.

Background Knowledge: Online research on the manufacturer's websites[4] confirmed that this type of device does not exist and a discussion with a technical representative also confirmed that this specific manufacturer does not have immediate plans to develop such a device.

System Considerations: N/A

Planned or Ongoing Research: There is no evidence that any other teams or organizations are researching this gap. BA may be useful in driving the industry to address this gap, and may be able to provide technical support. Manufacturers are most likely not addressing this gap because they have invested in wireless/internet connected technologies instead of increasing the onboard memory capacity of data loggers. BA-PIRC has performed some related research.

"Closing the Gap": There are two goals for the project which are not mutually exclusive:

1. a remote data logger with the onboard capacity for around 2 million measurements that can be downloaded with a USB cable, or similarly simple interface (SD card, Bluetooth, etc)
2. a remote data logger capable of being programmed to effectively summarize data to reduce long-term data storage requirements

Timeline: The goal would be to drive the industry or specific manufacturers to develop this technology. There is no accurate time table available at this time. Storage, capability, and battery life needs should be identified after a full survey of the potential applications.

[4] For examples: http://www.onsetcomp.com/
http://www.mccdaq.com/index.aspx
http://www.logtagrecorders.com/
http://www.lascarelectronics.com/

Room Air Mixing Analysis

Related Research Areas:

BA Enclosures		BA Test Methods & Protocols		House Type	
Walls		Sensors	X	New	X
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		Needs Evaluation/Identification		Large Scale Retrofit (Better Buildings)	
Other:		Other:			

Problem Statement: *The benefits of improved envelope technologies and best-practice space conditioning systems are not easy to visualize to home buyers so are often left out of a sales pitch or even excluded from the construction package. A simple tool is needed to drive demand for these proven construction features by showing the comfort and energy differences between systems and between homes in a fair and comprehensible way.* The average homebuyer understands neither the comfort implications of changing from a U-0.35 window to a U-0.17 window nor where drafts come from. Visualizations from CFD models are useful tools to enable builder sales staffs to show potential homebuyers the improved comfort resulting from better insulated airtight thermal enclosures, impacts of blocking registers with furniture, better supply registers that cost more but actually have velocities that completely mix and can be used on interior walls in lower cost distribution systems rather than washing the exterior walls at great distribution efficiency expense, etc. Although CFD tools are very accurate in describing air movement in rooms, current CFD models (and associated boundary condition assumptions) have not been validated with field data.

Key Customers and Stakeholders: Potential Homebuyers, Builders, Retrofit Contractors including HVAC and Window

Background Knowledge: Some prior analytical work has been done at NREL[5]. Thermal comfort monitoring equipment is available for use on field tests.

Existing method of room airflow measurements are through visualization studies via rapid video recording (luminescent smoke) or laser scanning (laser doppler anemometry). Those methods are very expensive and limited in mobility to real buildings that would make so much bigger an impact to encouraging better design of HVAC supply registers and quantifying the benefits of triple pane windows and improved insulation.

System Considerations: *<u>This gap limits development of Best Practices for advanced HVAC distribution systems</u>*, including high-velocity ducting and high sidewall registers. Present design strategies rely heavily on "rules of thumb" which has led to poor air mixing and insufficient comfort in some conditions, particularly in swing season periods where HVAC systems have short runtimes.

Planned or Ongoing Research: There is currently no planned research involving verifying whole room airflow models. There is existing work in verifying High sidewall register performance. And upcoming work in verifying the natural convective flow through over and under door transfer grills. But neither of these studies is attempting to address the connection between the quality of the thermal enclosure and the resultant improved occupant comfort it provides. IBACOS has projects covering part of this research space. Also, a related ASHRAE project is underway at UT Austin.

"Closing the Gap": Determine if existing single point location comfort measurement device can be used to support CFD model for use as basic description of comfort in the room. (E.G. show that comfort meter results from room with R-13 walls and U-0.4 windows are proportionately worse than room with R-20 walls and U-0.3 windows and so on with R-30 walls and U-0.2 windows)

Timeline:

- Perform transient CFD simulation for basic thermal enclosure values and various supply locations and conditions
- Build same 5 enclosures, use comfort measurement device and expose to similar climatic and supply conditions as modeled
- Verify if models sufficiently describe conditions measured.
  - If yes, develop models for more climates and disperse short animations to builders
  - If no, abandon project
- Identify methods to simplify the models for better guidance and visualization purposes. The goal must be to reduce sensitivity to the boundary condition inputs, which vary widely from real home to real home.

[5] Ridouane, E. H. (2011). Evaluation of Air Mixing and Thermal Comfort From High Sidewall Supply Air Jets. NREL Report No. TP-5500-48664.
Ridouane, E. H.; Gawlik, K. (2011). Prediction of Air Mixing From High Sidewall Diffusers in Cooling Mode: Preprint from ASHRAE Transactions. NREL Report No. CP-5500-49010.
Ridouane, E. H.; Gawlik, K. Numerical Evaluation of Indoor Air Distribution from High Sidewall Diffusers. ; NREL Report No. PR-5500-50311.

Appendix A: Change Log

Record of additions and modifications to the summary sheets.

Date	Version of Plan (updated version #)	Title of Gap/Barrier/Need	Description of Change
10/18/2011	1	All	Initial Release
2/24/2012	1.1	All	Revision of Initial Release

Appendix B: Past Research – Resolved Gaps, Barriers and Needs

When gaps or barriers are resolved, a brief summary will be appended to the strategic planning document as a running record of Building America achievements.

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