Space Conditioning Standing Technical Committee

Strategic Plan, v2011a

Revised: January 2012

Committee Chair:

2011	Eric Martin Janet McIlvaine	BA-PIRC

Standing Technical Committee Strategic Plan Overview

Standing Technical Committees (STCs) focus on resolving key technical action items required to meet Building America performance goals. STC chairs lead each committees' activities in addressing specific research challenges, gaps in understanding, and new research opportunities. Committees include experts from the Building America research teams, DOE, national laboratories, and outside organizations that possess specialized knowledge or heightened interest in the topics being addressed. Committee chairs can create sub-committees on an as-needed basis to address targeted research needs.

The Strategic Plan is a living document maintained by the committee chair, who coordinates input and review by the committee. Planned revisions follow the three annual Building America meetings (technical, stakeholder and planning). The document should be referenced by other Building America teams when planning research and prioritizing opportunities. It will be used by DOE and other stakeholders when identifying market and research needs and setting priorities. In addition to clearly communicating and prioritizing current gaps (or market needs) and barriers it serves as an archive of accomplishments and failures that inform all ongoing Building America efforts. The Strategic Plan is a living summary document and is NOT intended to be a compendium of all available knowledge.

The Strategic Plan should accomplish the following using the "Gaps and Barriers" template in **no more** than 2 pages per Gap/Barrier:

- Summarize and prioritize gaps and barriers including those identified during the Building America meetings;
- Identify key customers and stakeholders, identify their priorities and desired deliverable timelines;
- Summarize background knowledge related to each gap or barrier;
- Summarize system interactions and relationships specific to each gap or barrier;
- Identify ongoing and planned Building America, DOE, industry and/or academic research activities related to each gap or barrier and to which customers or stakeholders the research is targeted;
- Summarize how success is defined relative to the goals of research activities; and
- Define the research path, including approaches to collect data from market leaders, the timeline and milestones to resolve the gap, barrier or need.

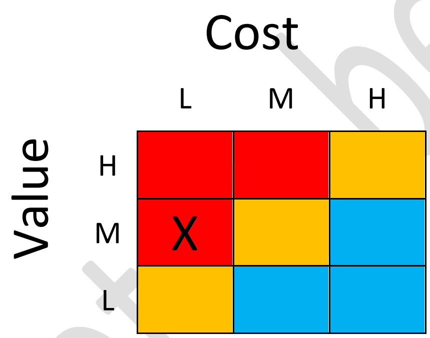
Prioritization of Gaps, Barriers and Needs

Set priorities using the cost-value matrix (Table 1) and the professional judgment of the committee[1]. As a Committee, establish the relative costs[2] and values (low, medium, high) associated with all gaps, barriers and needs within the Committee's domain where:

- Cost is the estimated Building America funding required to research and develop solutions; and
- Value is defined by the key stakeholders and customers including the likelihood of widespread adoption and potential benefits (e.g., energy saving potential) in the marketplace. Other factors that may be taken into consideration assigning value include:
    - Code cycles and needs to meet code goal targets;
    - Revisions to voluntary and mandatory standards (e.g., ENERGY STAR, minimum efficiency)

For example, in Table 1, the gap is assigned as a medium-value, low-cost is therefore given a high priority rating.

Table 1: Example Cost-Value Matrix



[1] The 3x3 cost-value matrix is a coarse approximation may not appropriately set priorities in all situations.
[2] Cost in this context refers to the research and development costs that the Building America program would bear. Committees are encouraged to estimate costs to the best of their abilities.

Table 2: Summary of Gaps

Rank	Description	% of Total Priority Votes	Priority (L,M,H)
	Heating and Cooling Equipment		
1	*Lack of consistency between rated performance and field performance.*	24	H
1a	Modifications to existing standards for rating equipment efficiency, or new standards that communicate installed performance.		
1b	Cooling Performance of Ground Source Heat Pumps		
1c	Performance ratings that compare air vs. water systems.		
1d	Need developments leading towards accurate, reliable commissioning of equipment.		
2	Optimization of hybrid heating system transition point.	19	H
3a	*Proven equipment and strategies to satisfy low loads in high performing homes*	*15*	H
3ai	Lack of availability of centralized small capacity heating and cooling equipment for low-load situations.		
3aii	Research on distributed space conditioning equipment		
3aiii	Developments towards cost-effective, building-integrated thermal storage, coupled with time-of-day operation.		
3aiv	Integration of HPWH into whole home comfort systems.		
3av	Evaporatively Cooled Condensers		
3b	Inability to assess performance of existing heating and cooling equipment	15	H
3c	Need methods, techniques, and tools to improve performance of existing equipment.	15	H
4	Improve performance of fan and pump systems	7	M
5	Lack of use and (in some cases) applicability of design and installation standards.	5	M
	Distribution Systems		
1	*How and when to address duct improvements in existing homes*	*43*	H
1a	Need for cost effective assessment methods to determine when to repair ducts.		
1b	Need for cost-effective methods to conduct repair / replacement of leaky, poorly insulated, and improperly sized ducts.		
1c	Need more data on air handler cabinet leakage		
2	*Distribution issues in high performing homes*	*22*	H
2a	Need low cost space conditioning distribution strategies for low-load homes.		
2b	How should zoning be handled in high performance homes?		
2c	Lack of knowledge on (distribution) performance of ductless systems as an alternative to ducted systems		
2d	Lack of understanding about hydronic system distribution efficiency		
3	Need to improve thermal efficiency of distribution systems.	17	H
4	Multi-family steam/hydronic distribution and distribution control issues.	10	M
5	Distribution Design Standards Gaps	8	M
	Ventilation and IAQ		
1	*Pressure imbalances that may cause health and safety issues*	34	H
1a	How tight is too tight?		
1b	Combustion safety in tight houses		
2	*Optimization of ventilation equipment and strategies*	*32*	H

Rank	Description	% of Total Priority Votes	Priority (L,M,H)
2a	Need better fan motor efficiency and fan blade efficiency for ventilation equipment.		
2b	Hybrid, Energy Efficient Ventilation/Recirculation Systems for Acceptable IAQ		
2c	Should ventilation air be evenly distributed / What is the source of ventilation air?		
2d	Ventilation control technologies to optimize intermittent ventilation.		
3	*Continued quantification of scientific/health basis for impact of ventilation on IAQ*	*26*	H
3a	Lack of understanding of health drivers and contaminant issues which should govern building enclosure tightness and ventilation standards / guidelines.		
3b	Low cost sensors to measure/monitor IAQ		
3c	Climate specific ventilation guidelines / requirements		
4	Strategies for Energy Efficient Make-Up Air and capture efficiency for larger range hoods.	8	M
	RH Control		
1	Determination of total internal moisture gains in homes	55	H
2	*Optimizing when to use supplemental dehumidification equipment to control RH*	*32*	H
2a	Protocol to assess and correct deficiencies in RH control in homes.		
2b	Need a metric for acceptable RH in homes.		
2c	Accurate simulation/prediction of RH in homes.		
2d	Improvements in RH sensors / controllers.		
2e	Adjustments/enhancements to primary HVAC systems for improved RH control.		
3	Need to understand operating performance of existing and emerging supplemental dehumidification equipment.	13	H

Summary of Space Conditioning STC Strategic Plan

The overall goal of the Space Conditioning STC Strategic plan is to ensure that industry has effective equipment, tools, skills, and knowledge to implement energy efficient space conditioning in homes that cost effectively achieve Building America whole-house energy savings targets:

BA Multi-Year Energy Savings Goals for Existing Homes

Energy Savings	Mixed/Hot-Dry and Marine	Mixed-Humid and Hot-Humid	Cold (Includes Cold, Very Cold, and Subarctic)
Current "best in class" (15% or above)	2011	2011	2011
30%	2012	2013	2014
50%	2015	2016	2017

BA Multi-Year Energy Savings Goals for New Homes

Energy Savings	Mixed/Hot-Dry and Marine	Mixed-Humid and Hot-Humid	Cold (Includes Cold, Very Cold, and Subarctic)
Current "best in class" (20% or above)	2010	2011	2011
30%	2011	2012	2013
50%	2014	2015	2016

Specifically, homes achieving whole-house energy savings targets must be kept comfortable, durable, and healthy. Therefore, the committee has focused on identifying gaps, barriers, and associated opportunities for research and implementation needs surrounding heating and cooling equipment, distribution systems, control of relative humidity, and ventilation for acceptable indoor air quality. The list that follows is organized in these four topical areas, which provide a basis for subcommittee organization and activity.

There are general focus areas common among the topical areas including:

- Continuing to assess and define needs, opportunities, and benchmarks to foster progress and achieve results
- Working with stakeholders to increase market demand for available technology whose superior performance is well understood but under-utilized
- Understanding performance of currently available technology that is not currently well understood
- Optimizing performance of currently available technology in a systems context based on that understanding
- Working with industry to justify need for and develop new technology in areas beyond the reach of optimized current technology
- Working with industry to ensure new and existing technology is correctly implemented

The process the committee undertook to identify and define gaps found in this document involved first identifying overarching, general needs in each of the topical areas. These general needs in each topical area were prioritized separately, not as a whole. Gaps in this document then emerged as specific opportunities to fulfill the general needs. These specific gaps have not yet been prioritized.

Table 2 (above) summarizes specific gaps. It can be read as follows:

1	*Lack of consistency between rated performance and field performance.*	24	H

This is an example of a general need that was prioritized and served as the basis for specific gaps. There is no further description of this general need in the document (note italics).

1a	Modifications to existing standards for rating equipment efficiency, or new standards that communicate installed performance.		

This is an example of a case where the general need was broken into >1 specific gaps, each of which are described in the document.

2	Optimization of hybrid heating system transition point.	19	H

This is an example of a case where the general need was specific enough to define as a gap, and did not need to be broken up

Descriptions of Sections

Problem Statement: Describe the gap or barrier itself. What could the industry achieve if this wasn't a problem? What are the risks associated with ignoring this gap or barrier? What are the climatic considerations (e.g., is it isolated to a specific region)? Is the problem primarily cost effectiveness? (One problem can apply to gap/barriers across different categories.)

Key Customers and Stakeholders: List the key customers and stakeholders and the roles they play delivering or implementing solutions. Describe the value to customers and stakeholders if the gap/barrier was resolved.

Background Knowledge: Describe the relevant background knowledge and reference key papers.

System Considerations: Reference how this gap, barrier or need relates to other known gaps, barriers or needs.

Planned or Ongoing Research: Summarize the "who" (Building America and other organizations) and "what" of existing or planned research activities that may resolve the gap, barrier or need. Can and should BA research supplement private industry's efforts by addressing the gap or barrier? Why is there no planned or ongoing research (if applicable)?

"Closing the Gap": What is the goal and how do we know if it has been achieved? Define desired outcome in terms of relevant metrics that can be applied/measured.

Timeline: What are the key milestones and critical path? When do milestones need to be accomplished for them to be useful to stakeholders? What is the realistic timeframe to substantially address the gap or barrier?

Rank	Description	% of Total Priority Votes	Priority (L,M,H)
	Heating and Cooling Equipment		
1	*Lack of consistency between rated performance and field performance.*	24	H
1a	Modifications to existing standards for rating equipment efficiency, or new standards that communicate installed performance.		
1b	Cooling Performance of Ground Source Heat Pumps		
1c	Performance ratings that compare air vs. water systems.		
1d	Need developments leading towards accurate, reliable commissioning of equipment.		
2	Optimization of hybrid heating system transition point.	19	H
3a	*Proven equipment and strategies to satisfy low loads in high performing homes*	*15*	H
3ai	Lack of availability of centralized small capacity heating and cooling equipment for low load situations.		
3aii	Research on distributed space conditioning equipment		
3aiii	Developments towards cost-effective, building-integrated thermal storage, coupled with time of day operation.		
3aiv	Integration of HPWH into whole home comfort systems.		
3av	Evaporatively Cooled Condensers		
3b	Inability to assess performance of existing heating and cooling equipment	15	H
3c	Need methods, techniques, and tools to improve performance of existing equipment.	15	H
4	Improve performance of fan and pump systems	7	M
5	Lack of use and (in some cases) applicability of design and installation standards.	5	M

1a) Modifications to existing standards for rating equipment efficiency, or new standards that communicate installed performance.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	✓
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	✓
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need equipment rating standards that better communicate expected field performance of space conditioning and related (HRV, ERV, etc) equipment through inclusion of representative field conditions in testing protocols. This should apply to both minimum efficiency, baseline systems, as well as high performance systems, as we need to continue to make comparisons. Need to look at the rulemaking and standards modification process to ensure that BA knowledge is properly incorporated.

Key Customers and Stakeholders: HVAC equipment industry, HVAC design industry, DOE Codes/Standards, AHRI, Energy Star, builders, remodelers, utilities

Background Knowledge: There are many situations where equipment installed in the field does not achieve the same performance as when tested in the lab. There are a variety of reasons why, including lab testing done in the absence of balance of system components necessary in the field, and lab testing conducted at limited number of rating points. Northwest Energy Efficiency Alliance is doing work on ductless heat pumps and finding ratings under-predict performance. Other issues identified include those with ground source heat pumps, crankcase heaters, and air conditioners continuing to provide cooling during the heating season.

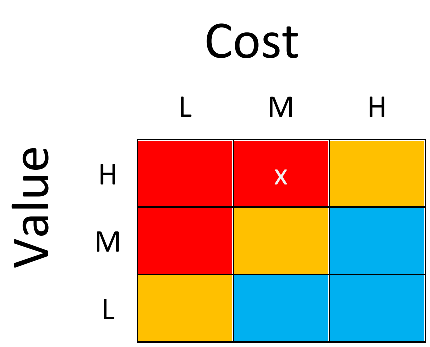
System Considerations: Overall system performance is desired, inclusive of distribution system, ventilation, and RH control.

Planned or Ongoing Research: PARR testing lab performance of equipment over a range of installation practices, BAPIRC testing SEER 21 variable capacity heat pump and has some GSHP data, and is proposing to collect more, ORNL is field testing a variety of variable capacity systems. CARB is testing condensing boilers in the field. BSC developing method to test equipment at multiple rating points.

"Closing the Gap": BA can be engaged in process of creating ratings or some mechanism to communicate expected field performance. BA knowledge and experience should be incorporated into the rulemaking and standards modification process. BA and BA partners can help communicate need for this information to manufacturers. Provide available data.

Timeline: Communicate with people in federal rulemaking to see their plans and timeline. Brian Dougherty at NIST. Greg Rosenquist at LBL.

Table 2: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1b) Cooling Performance of Ground Source Heat Pumps

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	✓
Other: ________________		Other:________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ________________	
Other: _peak demand impacts______	✓		
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	✓
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ________________	
Strategic Analysis			
Other: ________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	✓
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: How do the best performing ground source heat pump (GSHP) systems compare to best performing air source systems in terms of realized cooling efficiency and peak demand impacts?

Key Customers and Stakeholders: GSHP industry, HVAC installers, HVAC designers, builders, remodelers

Background Knowledge: There is a lack of data documenting good performance of GSHP for cooling. In addition to overall rated efficiency degradation do to pumping energy, some data shows deep ground loop installations not achieving adequate heat transfer with the ground.

System Considerations: Problem of ground source thermal resource saturation and parasitic power. How to optimize heat exchange between fluid and ground source. How to design fluid distribution and pump selection in order to minimize pump parasitic power?

Planned or Ongoing Research: ORNL collecting data, BA-PIRC has some data, CARB has data for heating applications. niversity of Minnesota is conducting a field monitoring project of residential GSHP systems (not a BA funded project).

"Closing the Gap": Need partnerships with manufacturing, installation, and construction industry that allow careful monitoring of system designs, installations, and associated performance data to judge merits of technology for high performance cooling when compared to available high efficiency air source systems.

Timeline: 2011 - 2012

Table 3: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		X	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1c) Performance ratings that compare air vs. water systems.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	✓
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	✓
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Current standards do not allow adequate comparison between air and water systems, making an optimized choice difficult for situations that could benefit from either type.

Key Customers and Stakeholders: HVAC designers, installers

Background Knowledge: As heating and cooling loads continue to decrease, water systems including combo systems are becoming increasingly cost effective at delivering low capacity, especially in multi-family.

System Considerations:

- Energy use of pumping systems for water to air systems is known to be a critical factor. This can be large for ground source systems, but also much larger for open loop systems where pump power use can dominate achieved efficiencies. There are other practical considerations for the later systems such as filter silting, pressure reservoir valve reliability etc.
- How to integrate with solar thermal and still maintain optimum system efficiency, especially in space heat/DHW combo systems.

Planned or Ongoing Research: - LBL - flowchart to help evaluate trade-offs among air and water based systems; ARBI – air/water heat pumps with mixed mode distribution. ARBI's hydronic distribution study will use TRNSYS modeling to identify performance differences between typical forced air and hydronic systems, and will evaluate cost differences and potential economic benefits. BA-PIRC has some data on GSHP.

"Closing the Gap": System enabling relational comparison. Data on realistic system performance when compared in a realistic fashion. BA can be engaged in process of creating ratings , and help communicate need. Provide available data.

Timeline: 2012

Table 4: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1d) Need developments leading towards accurate, reliable commissioning of equipment.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	✓
Lab Test Methods		Training	✓
Field Test Methods	✓	Documentation / Resources	✓
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Installed equipment often does not achieve rated efficiency. There are gaps related to equipment performance standards. But there are also gaps related to proper vs. improper installation and commissioning of equipment.

Key Customers and Stakeholders: HVAC equipment industry, HVAC contractor/service industry

Background Knowledge: Even with modified equipment rating standards that better predict expected performance of equipment in the field, there are still gaps preventing universal achievement of this expected field performance.

System Considerations: Commissioning for the thermal distribution system would also be important to achieving system performance consistent with equipment ratings. Matching of high performance equipment with distribution systems with poor thermal insulation, a hot thermal environment, distribution system air leakage, or unbalanced return air will lead to disappointing system performance.

Planned or Ongoing Research: LBL is working on tools to measure air flow.

"Closing the Gap":

- Need accurate, reliable, cost effective means for measuring air flow in the field.
- Need improvements in equipment controls and on-board diagnostics. Not only for field techs, but also for homeowners to let them know their system is in need of service, or refrigerant charge is not ideal.
- Need contractor education on procedures, tools, and equipment – Measure Guideline.

Timeline: 2013 - 2014

Table 5: Cost-Value Matrix for XXXXXX

Value / Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2) Optimization of Hybrid Heating System Transition Point

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Hybrid, or "dual fuel" heating systems, offer the potential for optimizing site energy, source energy, energy costs, or even CO_2-production associated with space heating. Research is needed to document the potential energy savings from optimal system set-up, along with User tools to make optimal transition point selection easier for contractors. There is a good deal of misinformation among contractors regarding heat pump efficiency in cold weather, often claiming that heat pumps do not work below 40^{o}F, whereas some manufacturers claim operation down to 13^{o}F below zero. There is also a need for the ability to model hybrid systems in BEopt.

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers.

Background Knowledge: Under the most common control configuration for a dual fuel (DF) system, an air source heat pump (ASHP) provides space heating while the outdoor temperature is above the transition temperature; below the transition temperature, the heat pump switches off, and a natural gas-or propane-fired furnace provides space heating. Selection of the transition temperature has an enormous impact on the total potential energy and emissions savings of DF systems.

This system offers great potential for energy, cost, and CO_2 emissions savings, by utilizing the relatively high efficiency of the ASHP at milder outdoor temperatures, while relying on a high efficiency furnace at lower outdoor temperatures. Modern heat pumps claim operation to temperatures well below 0^{o}F, but where is the optimized transition temperature?

Standard heat pumps with electric resistance heat backup can also be thought of as a dual fuel system. In many systems, the electric backup comes on at inappropriate times (often as a result of raising the thermostat by 2°F, or more). More commonly implemented and foolproof methods of avoiding unnecessary electric resistance heat operation would greatly improve the real-world operational efficiency of heat pumps.

System Considerations:

Planned or Ongoing Research: DOW/Ferris - dual fuel vs. single fuel heating retrofits, BA-PIRC proposing investigation

"Closing the Gap":

- Measure and demonstrate how much energy savings and energy cost savings are "lost" due to non-optimal transition (switch-over) temperatures for these systems;
- Characterize occupant comfort issues associated with various transition temperatures to determine if transition temperatures should be influenced by comfort concerns;
- Develop algorithm to optimize transition point under applicable scenarios;
- Disseminate energy savings findings which result from optimal transition temperatures to HVAC groups, utilities, and energy efficiency programs to influence market practices;
- Information from this research should be provided to ACCA to inform the Manual S update.

Timeline: 2011 - 2012

Table 6: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H	x		
	M			
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3ai) Lack of availability of centralized small capacity heating and cooling equipment for low-load situations.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: As the BA Program goals continue to strive for higher efficiency targets in new and existing homes, the targets will continue to be achieved through a combination of advanced enclosure, reduced internal loads, and space conditioning equipment measures. Research is required to document that expected whole house, systems based performance is achieved when matched to low loads produced by advanced enclosure measures. **Much of the industry is accustomed to centralized systems, and switching to distributed systems presents additional challenges.**

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers, multi-family stakeholders/customers

Background Knowledge:
1) There is a lack of conventional (centralized), readily available space conditioning equipment with sufficiently low capacity, below 1.5-2 tons. Some new equipment that does have target capacity, such as mini-splits, presents distribution challenges. Other new equipment, such as continuously variable ducted heat pumps has potential, but lacks field data.
2) How much energy efficiency penalty is produced by oversizing of fixed capacity heating and cooling equipment? How much RH control penalty is produced by oversizing of fixed-capacity cooling equipment (note that increases in RH control can lead to additional capital expenditure and energy

waste if dehumidifiers or other equipment must be installed to provide RH control)? Can variable capacity systems kill two birds with one stone? A two-ton system that varies in capacity from 34% to 100% can therefore operate at 0.8 ton capacity. In multi-family, dwelling units can be surrounded on four or five sides, and space conditioning loads can be small. Sensible cooling loads, for example, can vary by a factor of 10 or more (under identical weather) depending upon the space temperature setpoints of adjacent dwelling units. Systems that can respond to such extreme variability would be ideal.
3) If ducts are designed for the full capacity, what is impact of oversized ducts at low capacity? May benefit sound and fan power.

System Considerations: As Enclosures gaps are closed, loads will get smaller. Some smaller capacity systems present distribution challenges, related to other indentified gaps dealing with applicability of system sizing procedures to high performance homes. Need equipment that can accommodate future changes in enclosure loads due to envelope upgrades. Mini-split heat pumps can achieve potentially lower interior moisture loading as infiltration is not induced due to the pressure differences seen in single or dual return ducted central system.

Planned or Ongoing Research: BAPIRC - variable capacity SEER 21 heat pump (test plan), ductless heat pumps (test plan); CARB – researching multi-family issues; ORNL - field testing variable capacity systems; LBNL. As mini-split heat pumps readily address this need (and eliminate duct losses) more effective comparisons with central systems is desirable. FSEC is collecting data on a single 0.75 ton mini-split that is being compared to a central system to evaluate relative comfort and energy use. Fraunhofer researching ductless mini-splits.

"Closing the Gap":

- Need more data on performance of oversized, variable capacity units including peak demand reduction benefits and interactions with leaky duct systems.
- Need to develop sizing guidance for variable capacity systems.
- Work with industry to communicate needs and develop solutions (smaller equipment and/or adjustment of system air flows in real time to achieve improved SHR)
- Research on effective distribution when dealing with low flows
- SHR implications
- A/B performance of efficient central systems with mini-split heat pumps
- Can innovative systems achieve appropriate interior dewpoints in humid climates?

Timeline: BA 30% milestones are likely to be achieved with currently available technology. Select 30% evaluations are utilizing new technologies providing key data and feedback (2011-2013). The path to 50% savings (2013 - 2016) will require more complete understanding, availability, and integration of systems that efficiently manage lower loads.

Table 7: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3aii) Research on distributed space conditioning equipment

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	✓
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: As the BA Program goals continue to strive for higher efficiency targets in new and existing homes, the targets will continue to be achieved through a combination of advanced enclosure and space conditioning equipment measures. Research is required to document that expected whole house, systems-based performance is achieved when matched to low loads produced by advanced enclosure measures. **Another approach to achieving efficient space conditioning in low load situations is to utilize a distributed approach.** Currently, simulation tools lack ability to model these approaches, such as multi-split systems

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers, multi-family stakeholders/customers

Background Knowledge: Standard central AC systems do not allow for zoning of less occupied spaces, leading to needless energy use. On the other hand, zoned central AC systems often use a configuration with powered dampers that have large standby energy – up to 20 watts per damper. On the other hand, ductless mini-split heat pumps automatically allow zoning, eliminate the need for dampers and induced less unintended air infiltration during operation.

System Considerations: Related to zoning issues: How can the impact of zoned cooling/heating be effectively measured? What are the achieved room-by-room temperature and RH profiles? Can home automation help to improve homeowner comfort while maximizing energy savings with occupancy sensing?

Planned or Ongoing Research: CARB – stand-alone room heaters; ARBI – ductless hydronic distribution, air/water heat pumps with mixed mode distribution; ORNL – field testing ductless variable capacity systems; NREL – performance mapping five mini-splits with Purdue; FSEC is monitoring a single mini-split system which is being compared to central system operation to evaluate relative energy use and comfort implications. Franhofer CSE looking at ductless heat pumps in Austin.

"Closing the Gap": Need more data on performance of central vs. mini-split heat pumps and how room temperature and dewpoint temperature distribution is affected. A series of case study measurements are warranted. Development of small electric heaters as supplemental heat source.

Timeline: 2012 - 2013

Table 8: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3aiii) Developments towards cost effective, building-integrated thermal storage, coupled with time of day operation.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls	✓	Test Standards	
Roof/Ceiling	✓	Distribution	
Foundations	✓	Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	✓
Solar Heating and Cooling	✓
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Building-integrated thermal storage has the potential to improve the overall performance (in terms of both seasonal energy use and peak demand to the electrical grid) of HVAC systems, especially those that employ space cooling and heat pump-related space heating. This requires time-of-day variation in space temperature setpoints, and collaboration or at least tolerance by home occupants. In cooling, for example, a high mass house could be operated at 74^{o}F overnight and then raised to 76^{o}F during the day. In heating, the thermostat could be raised to 74^{o}F during the warmer hours of 3:00 PM to 8:00 PM (to pre-warm the house) and then lowered to 72^{o}F during colder nighttime hours. It would be useful to understand the seasonal energy and peak demand implications of such an approach. Time-of-day electrical rates could help motivate customer participation. Design of building mass could assist in making building thermal storage effective.

In the larger scope, as attempts are made to move our electric grid to renewable energy sources (especially wind and solar), energy storage is required to match available time-of-day resource to time-of-day energy demand. Thermal storage (and latent storage) within the mass of the building could represent a major mechanism by which the larger, national energy storage needs could be met.

Key Customers and Stakeholders: building contractors, electric utilities, space conditioning equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers

Background Knowledge: Time-of-day operation of AC and heat pump (heating) systems can yield improved system performance because AC system and heat pumps operate more efficiently during milder outdoor weather. A typical heat pump, for example, will provide space heating at 42% higher capacity and 32% higher efficiency at outdoor conditions of 40°F compared to 15°F. Additionally, it is much more likely that operation of defrost cycles and strip heat backup will be avoided while operating at 40°F compared to 15°F. Furthermore, air distribution system losses (both conductive and air leakage losses) are much less during cool summer night periods and mild winter afternoons. Massive homes that are well-insulated can allow increased cooling at night (using a slightly lower thermostat set point) and increased heating during late afternoon and early evening (using a slightly higher thermostat set point), in effect improving total system efficiency and considerably reduced peak demand from a utility perspective.

System Considerations: How much does a house weigh? How much of the mass of the building participates in daily cycles of heat storage and heat discharge? What mechanisms can be used to enhance thermal storage that can effectively charge and discharge within 12-hour periods? What materials can be used to increase thermal capacitance? How important is it to store moisture for periods of reduced space cooling operation? How do we deal with ventilation needs in circumstances where the space heating or cooling system is reduced? Given large mass, will it make sense to down-size cooling and heating equipment?

Planned or Ongoing Research: FSEC has plans to add thermal mass to the MH Lab and perform time-of-day load shifting by means of variations in setpoints, for both heating and cooling.

"Closing the Gap":

- Characterize seasonal and peak demand savings that can result when heat pumps are operated with scheduled setpoint variations and high mass.
- Identify the need for RH control during periods when the heat pump (AC unit) cycles off due to thermostat changes.
- Cooling and heating equipment sizing guidance for high mass homes.

Timeline: 2013

Table 9: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3aiv) Integration of HPWH into whole home comfort systems.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	✓
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: How do retrofit and new construction designs effectively take advantage of sensible and latent cooling capacity provided by heat pump water heaters? How to avoid the disadvantages of cooling delivered to house or basement in a heating climate?

Key Customers and Stakeholders: Water heater manufacturers, heat pump water heater manufacturers. HVAC components manufacturers.

Background Knowledge: The idea of harvesting cooling from HPWH for space conditioning is very attractive—particularly in hot and humid climates. Some units allow for distribution, others do not. Unfortunately, only a single unit currently allows for cooled air to the harvested for use to offset space conditioning.

System Considerations: Measurements at Florida Solar Energy Center show that HPWH remove about half a gallon of water from its environment in a humid climate. Moreover, data from Florida shows available cooling is shown to be about 20,000 Btu/day (1.7 ton hours) about 5%-10% of the cooling needs a typical home in summer.

Planned or Ongoing Research: ORNL has worked on this in their ZEH's, including linking to crawlspace. BSC thinking of researching integration into unvented attics.

"Closing the Gap": Determine best integration approach for various climates. Need dampered system that will provide cooled air to the space depending on thermostat setting (cooling = provide available cooling; otherwise reject cooled air to ambient.

Timeline: 2012-2013

Table 10: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H	x		
	M			
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3av) Evaporatively Cooled Condensers

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Conventional AC systems often exhibit poor performance in very hot climates or on very hot afternoons when utilities experience their peak loads. Need to characterize the seasonal energy and peak demand benefits of evaporative cooling of the condenser coil. Need to characterize the quantities of water that would be needed to implement this approach on a wide-scale basis and in specific areas of the country where water resources are limited. What coil degradation may occur when exposed to extended periods of evaporative cooling? There is also a need for methods, techniques, and tools to improve efficiency of existing equipment in-situ.

Key Customers and Stakeholders: AC manufacturers, utility AC DSM programs, low energy building designers in hot climates.

Background Knowledge: Evaporative cooled condensers have long been used in larger commercial air conditioning systems to reduce effective condensing temperatures and hence to improve air conditioning efficiency. This is why most commercial air conditioners larger than about 150 tons typically rely on cooling towers to cool water and remove heat generated from the compression cycle of the chiller. Efficiency gains of 15% are typical with improvements under peak conditions of 25% or better.

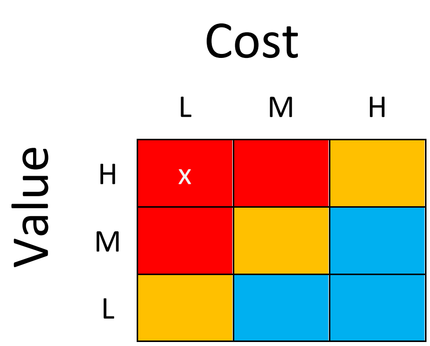
System Considerations: While it has long been known that an indirect, evaporative cooled condenser system can improve condenser performance, there are a host of issues associated with long-term reliability that has precluded their use with residential scale systems. These include media pad fouling and associated pressure rise, water system and pump/valve reliability, potential for water biological growth, freeze protection and water energy use in dry climates.

Planned or Ongoing Research: FSEC – development/testing of advanced evaporative condenser. The approach uses both an indirect evaporative cooling system as well an innovative fan system to achieve better condenser air moving efficiency even with the greater pressure rise of the constructed system. Currently the revised fan unit is being tested after which the evaporative cooling pads will be assembled. Prototype testing will be conducted through the first quarter of 2012. Field deployment of an early prototype system is slated for next summer.; ARBI - Advanced evaporative condenser performance and reliability testing. ARBI has been working with NREL to model evaporatively cooled condensers into BEopt.

"Closing the Gap": Realistic performance data needs to be developed for conceptual design. Baseline data on a SEER 22 system has been conducted in a lab. Current efforts are to evaluate the innovative fan system and then mate that to the evaporative cooling system. Both exact lab data and field performance are needed to verify concept potential. BEOPT needs data on various models and options. Performance curves, fan power, water consumption, etc.

Timeline: 2012-2013

Table 11: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3b) Inability to assess performance of existing heating and cooling equipment *(much of write-up taken from Analysis Methods and Tools: "Old Air Conditioners" gap)*

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ________________		Other:________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ________________	
Other: ________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: ________________	
Strategic Analysis			
Other: ________________			

House Type	
New	
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: The installed performance of old air conditioning equipment is not well characterized and, as a result, it is difficult to confidently assess the benefits of retrofitting a house with newer air conditioning equipment. Without proper characterization, contractors and energy analysts may be overstating or understating the value of air conditioning retrofits, which could ultimately result in unnecessarily high costs to the homeowner or unrealized energy saving potential.

The Building America House Simulation Protocols (HSP) currently describes a method (based on engineering judgment) to de-rate the Seasonal Energy Efficiency Ratio (SEER) of old equipment based on age and level of maintenance. However, the HSP does not describe the full range of inputs required to fully describe air conditioner performance, including all of the off-rated performance maps necessary to describe the full range of operation.

If the performance was better-described in the HSP based on lab or field testing results, analysts could more accurately predict energy savings and comfort improvements due to air conditioning retrofits.

Key Customers and Stakeholders: DOE Speed and Scale Programs (e.g. Better Buildings) – Accurate predictions of air conditioner performance will influence DOE programmatic decisions and are necessary to find the most cost-effective way to meet national energy-saving targets.

Utilities – Accurate predictions of air conditioner performance will lead to suggesting more efficient replacement units which may reduce peak power demand.

Others (Air conditioner manufacturers, Energy retrofit contractors, Homeowners) - Accurate predictions of air conditioner performance will lead to suggesting appropriate, energy-saving, cost-effective solutions.

Background Knowledge:
In general, air conditioning performance is difficult to describe. New air conditioners are rated based on the AHRI standard 210/240 definition of SEER, but this information was not standardized for much of the older equipment still found in homes. Air conditioner performance also varies significantly depending on the operating conditions of the equipment. Some manufacturers provide performance maps for new equipment (for the purpose of system sizing and selection), but this information is also not commonly available for older units.

There are many factors that contribute to degradation of air conditioning system performance:

- Improper installation
- Over/undercharged refrigerant
- Incondensibles in refrigerant
- Wear and tear on the compressor
- Fouling of the heat exchangers.

These factors are difficult to quantify for a specific system. There is a disconnect between the complexity of these problems encountered in the field and the simplicity of the models used to quantify the performance of the units they represent.

Davis Energy Group recently prepared a report for the Southern California Edison which evaluates the effectiveness of programmatic HVAC maintenance on the performance of systems[3].

System Considerations:
Old AC performance is also influenced by the performance of the old air handler. Inefficiencies in the air handler can result in lower airflow over the evaporator and affect performance significantly. - Also influenced by distribution system efficiency.

There are several considerations that revolve around replacing an old AC, such as: downsizing the new equipment, replacing the air handler and furnace, and the effect replacement will have on meeting loads (improving capacity means the unit will be able to meet more of the load, and possibly use more energy).

Planned or Ongoing Research:
Ferris State University (BA) – FSU is under contract (through the CEER BA Team) to perform some tests on old air conditioners in the West Michigan area.

Field Diagnostic Services, Inc. (non-BA) – FDS has been monitoring systems and diagnosing problems in old residential air conditioners. They have a sizable database of system characteristics from around the U.S.

[3] Hunt, M., Heinemeier, K., Hoeschele, M., & Weitzel, E. (2010). HVAC Energy Efficiency Maintenance Study.

It remains to be seen if data from these two efforts will be enough to provide a meaningful representation of the range of air conditioners encountered in the field.

"Closing the Gap":
Energy Analysis tools need to provide an accurate estimate of the performance of old air conditioning systems. From the modeling perspective, this means defining the as-used efficiency and performance maps of systems ranging in quality of installation, age, and level of maintenance.

The HSP should be updated to reflect a better understanding of old air conditioner performance. For a given installation, vintage, and maintenance level, the HSP should define typical:

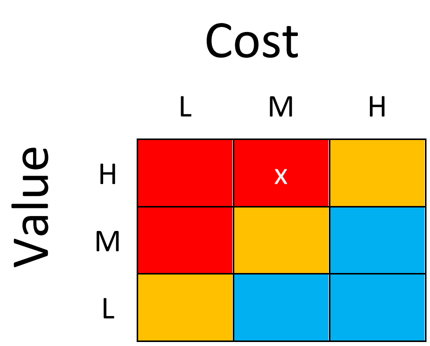
- System efficiency (SEER, EER, COP, etc.)
- Cycling degradation
- Capacity degradation
- Performance maps
- Fan efficiency.

As part of this process, sensitivity/uncertainty analysis should identify parameters (such as percent refrigerant charge, refrigerant line length, etc.) that have large impacts on simulation results and are not typically accounted for in simulation inputs. These identified parameters will inform what information is important to collect on the pre-retrofit HVAC system and what information should be defaulted based on best practice procedures (stated in the HSP).

The accuracy of energy analyses after the HSP and analysis tools have been updated should be validated against field test data.

Timeline:

Table 12: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3c) Need methods, techniques, and tools to improve performance of existing equipment.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need effective means to improve performance of existing equipment in situations where equipment replacement is not cost effective. This is going beyond a traditional "tune-up" to look at potential for cost effective system modifications.

Key Customers and Stakeholders: Auditors, Space Conditioning Equipment industry, HVAC contractors, remodelers.

Background Knowledge: Utility program investments towards improving existing HVAC are not yielding expected savings. Poor control over refrigerant charging, including incorrect charge and introduction of non-condensables.

System Considerations: Synergy with research on effective fans, pumps, and motors. Efficacy of equipment replacement depends on the adequacy/performance of what you are attaching it to (distribution system). Improving performance of existing equipment in-situ may require synergistic upgrades to other systems. Solutions affect Implementation area and Testing Method/Protocol area.

Planned or Ongoing Research: PARR - HVAC audit/repair program (test plan); DOW/Ferris - Development of field test methods to determine degradation of efficiency; ARBI - strategies for effective tune up (reduce measurement error and guidelines for refrigerant charge). CARB - Starting a field study of ECM drop-in replacement motors this year.

"Closing the Gap":

Timeline: 2011-2012

Table 13: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

4) Improve performance of fan and pump systems

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need greater use of available, more efficient, fan and pump systems. Need to continue to improve performance of fans/impellers and motors to increase overall heating/cooling equipment efficiency.

Key Customers and Stakeholders: HVAC manufacturers, Equipment ratings, designers, installers, code officials, auditors, Space Conditioning Equipment industry, HVAC contractors, remodelers.

Background Knowledge: Inefficient motors, fans, and impellers coupled with poor distribution designs and undersized/highly restrictive filters result in high energy use and low air and water flows.
Need to extend the efficiency of fan/pump systems over a greater percentage of their operating range as performance had direct efficiency implications.

System Considerations: Relates to distribution and ventilation system design. There are also practical considerations relative to the size of optimized fan assemblies as best designs will use, and top-mounting diffuser stage.

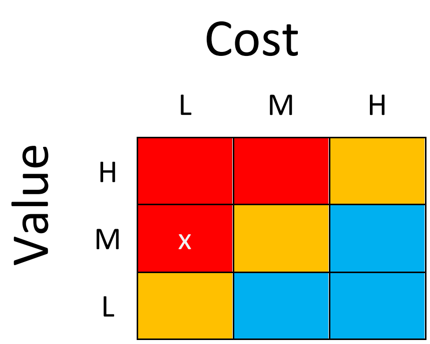
Planned or Ongoing Research: FSEC - high efficiency condenser fan research. A high efficiency fan system is being developed for the evaporatively cooled air conditioner being evaluated at FSEC. The stand-alone fan system will be evaluated to see how it can impact the efficiency of the SEER 22 AC system with which it is being mated. Data on this system will be available in 2012.

"Closing the Gap":

- Identify target
- Quantification of savings potential through use of state of the art currently available fan/motor technologies
- Work closer with equipment manufacturer stakeholders to communicate needs and expectations
- Work with codes and standards organizations to require performance benchmark
- Develop standards to rate fan/pump performance
- BA can do best practices guide on reducing fan energy through proper duct design.
- Testing and field evaluation will allow determination of the specific EER/SEER advantage of the higher efficiency fan systems for very high efficiency AC equipment.

Timeline: 2012-2013

Table 14: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

5) Lack of use and (in some cases) applicability of design and installation standards.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: ACCA Manual J/S/QI (and others) - are they in use and working for all situations (new and retrofit)? ACCA Manual Zr (zoning) coming out later this year.

Key Customers and Stakeholders: HVAC designers and contractors, educators, auditors, utilities and others likely to provide incentives for advanced equipment.

Background Knowledge:

1) Need for contractor and code inspector education. Problems with inconsistent code inspection. Some retrofits performed without permit, and therefore without standards, code enforcement, or accountability.
2) Emerging research is pointing towards benefit of oversizing variable capacity systems to allow for operation at low capacity for extended periods of time.

System Considerations: Poor or inappropriate HVAC design and installation can create a ripple effect breaking down the whole house systems approach to high performance homes.

Planned or Ongoing Research: LBL - examining issues; BAPIRC - investigating oversizing benefit of variable capacity heat pump (test plan).

"Closing the Gap": Ensuring applicable design standards are in use for high performance homes.

Timeline: 2011 - 2012

Table 15: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H			
M	x		
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

Rank	Description	% of total Priority Votes	Priority (L,M,H)
	Distribution Systems		
1	*How and when to address duct improvements in existing homes*	*43*	H
1a	Need for cost effective assessment methods to determine when to repair ducts.		
1b	Need for cost effective methods to conduct repair / replacement of leaky, poorly insulated, and improperly sized ducts.		
1c	Need more data on air handler cabinet leakage		
2	*Distribution issues in high performing homes*	*22*	H
2a	Need low cost space conditioning distribution strategies for low load homes.		
2b	How should zoning be handled in high performance homes?		
2c	Lack of knowledge on (distribution) performance of ductless systems as an alternative to ducted systems		
2d	Lack of understanding about hydronic system distribution efficiency		
3	Need to improve thermal efficiency of distribution systems.	17	H
4	Multi-family steam/hydronic distribution and distribution control issues.	10	M
5	Distribution Design Standards Gaps	8	M

1a) Need for cost effective assessment methods to determine when to repair ducts.

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: _infiltration______________	✓	Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	✓
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Depending upon duct location, duct leakage can create significant impacts upon HVAC system energy use and transport various types and quantities of contaminants (including water vapor) into the occupied zone. Improper duct insulation, duct sizing (static pressure, airflow, and noise), air balancing, and return air pathways can also increase energy use and decrease comfort. Need methods, techniques, equipment, etc. to quickly and accurately determine extent of problems with a duct system and the degree of energy, comfort and IAQ improvements that will result from repair.

Key Customers and Stakeholders: Contractors, diagnostic equipment manufacturers, auditors, remodelers

Background Knowledge: Correcting duct leakage issues in existing homes can lead to significant energy savings, but efficacy is sometimes difficult to determine and prioritize. Current methods to quantify duct leakage (delta Q, cfm 25, etc) are typically part of a detailed audit, and add cost. Even if it is quantified, what can we expect to reduce the leakage to? What is the potential? Estimating difficulty/effectiveness of repair is difficult, especially when ducts are difficult to access. Pressure pan can help prioritize where to begin repairs. Answers are important to duct repair becoming part of a retrofit package.

System Considerations: Duct leakage often acts as a driver for both positive and negative interactions with other systems. Potential for change with these interactions must be considered on case-by-case basis.

Planned or Ongoing Research: LBL - develop standard for evaluating air flow measurement techniques; ARIES – multi-family HVAC air distribution retrofits (test plan); PARR - HVAC audit/repair program (test plan); NELC has a relevant 2011/2012 study.

"Closing the Gap": Duct evaluation methods that are able to be performed as part of a simple, low-cost audit.

Timeline: 2011 - 2013

Table 16: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1b) Need for cost effective methods to conduct repair/replacement of leaky, poorly insulated, and improperly sized ducts.

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: _infiltration______________	✓	Other:_________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: _________________	
Other: _________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	✓
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: _________________	
Strategic Analysis			
Other: _________________			

House Type	
New	
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need methods, techniques, equipment, etc. to quickly and cost effectively improve performance of air distribution systems.

Key Customers and Stakeholders: Contractors, HVAC equipment industry, auditors, remodelers

Background Knowledge: Ducts are often inaccessible and difficult to repair. AeroSeal can work in some situations. There is a resistance to and lack of options enabling abandonment/replacement/relocation of ductwork inside the enclosure.

System Considerations: Duct leakage often acts as a driver for both positive and negative interactions with other systems. Potential for change with these interactions must be considered on case-by-case basis.

Planned or Ongoing Research: NAHBRC - evaluating sealing/insulating existing ductwork; LBL - develop standard for evaluating air flow measurement techniques; ARBI - "inflatable ducts" for retrofit applications, methods to correct airflow problems; CARB - encapsulated/buried ducts (test plan), ARIES – multi-family HVAC air distribution retrofits (test plan); PARR - HVAC audit/repair program (test plan); BA-PIRC - ductless heat pump retrofits

"Closing the Gap":

- Work to develop improved methods for installing ducts inside the conditioned space.
- Work to assess the energy savings from modifying attic and crawl spaces to put those spaces within the air and thermal boundary of the building.
- Assessment of methods, such as encapsulation, which can both airseal and insulate existing ductwork, while avoiding moisture condensation problems.

Timeline: 2011 - 2012

Table 17: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1c) Need more data on air handler cabinet leakage

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	✓
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Air leakage in air handler cabinets may result in increased HVAC energy use and IAQ degradation. In some circumstances, transport of carbon monoxide from garages can lead to life threatening circumstances. ASHRAE Standard 193-2010 provides a method of test (MOT) for AHU cabinets from the factory, but there is relatively little data for available equipment. Additional air leakage may occur during the installation process. Over time, other factors may result in additional air leakage of the AHU cabinet. Because of the high operational pressures in the AHU cabinet, even small leak openings can result in substantial air distribution system leakage and potential depressurization of building zones, including those containing atmospherically-vented combustion appliances.

Key Customers and Stakeholders: HVAC equipment manufacturers, HVAC contractors, building auditors, energy model developers

Background Knowledge: Standard 193-2010 is a MOT to determine the air-leakage rate of HVAC equipment rated at less than 3000 CFM. Building codes such as IECC-2011 and CEC reference Std.193 is the MOT used for determining air tightness compliance for residential air handling equipment. Air-handlers located in attics, garages, crawlspaces and other unconditioned spaces can affect the energy performance and indoor air quality of residential buildings. These air leaks may contribute to loss in distribution fan and overall system efficiency, especially if the equipment is located in a non-conditioned space. Factors contributing to box leakage include poorly sealed access panels and filter slots, penetrations of wiring, condensate lines, and refrigerant lines, etc.

Information is needed on the relative performance of a variety of HVAC equipment applicable to Std. 193. Currently, the little testing that has been conducted during the development of Std 193-2010 has focused on residential furnaces and duct fittings. At this time, designers, installers and contactors are unable to make good equipment choices because we do not know the extent of air leakage in HVAC system components, typical air leakage values, the range of typical values and the impact on building performance.

FSEC (Cummings, Withers) measured air handler air tightness in 69 Florida homes age four to twelve months.

System Considerations: While testing according to Standard 193 can result in tighter AHUs from the factory, installation and user-interaction leakage over time can produce additional leakage that can waste energy and endanger building occupants.

Planned or Ongoing Research:

"Closing the Gap":

- Research to characterize AHU leakage in various climate and house stock zones.
- Research to identify AHU leakage repair methods and materials.
- Measure guideline to provide guidance on AHU leakage repair.

Timeline: 2012

Table 18: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2a) Need low cost space conditioning distribution strategies for low-load homes.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	✓
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: There is a lack of proven low cost air distribution solutions for providing space conditioning in homes (or individual multi-family units) with peak loads of less than approximately 1.5-2 tons. This creates a disincentive to reducing building energy consumption or results in oversized equipment. What are the viable strategies that take advantage of reduced loads in energy efficient houses? As the envelope load diminishes, passive heat transfer within the structure becomes a larger factor, perhaps allowing little or no distribution.

Key Customers and Stakeholders:

- Builders (want to pay less for HVAC system to offset cost of upgrading envelope)
- Homeowners (want comfortable house without changing their behavior)
- HVAC contractors (need to be ensured that callbacks will not occur with new systems).

Background Knowledge:

1) Better thermal enclosures result in reduced need for actively conditioning individual rooms (Passivhaus Institute, Illinois Small Homes Research Council air based heating research, various other independent studies in conduction through partitions, and convective fluid flow through openings)

2) Developing low cost space conditioning solutions will increase market acceptance of energy efficiency strategies by enabling builders to make energy efficient houses that are First Cost neutral, and eliminating the need to "sell" energy efficiency through savings paybacks.
3) A minimized duct system, such as a high interior wall register design, as a promising, low-cost approach to install ducts in conditioned space and accomplish objectives. Research should address low airflow requirements and designs that potentially create unacceptable stratification, drafts, noise, air balancing, and drywall cooling.

Ridouane, El Hassan. "Evaluation of Air Mixing and Thermal Comfort From High Sidewall Supply Air Jets". Technical Report NREL/TP-5500-48664, September 2011.

System Considerations: Thermal enclosure must have sufficient performance to minimize drafts, radiant losses/gains and other typical sources of occupant discomfort. Heat transfer through internal partition assemblies dividing actively conditioned spaces from passively conditioned space must be balanced with heat transfer through thermal enclosure of the passively conditioned space

Planned or Ongoing Research: IBACOS: Determine viability and develop design guidelines via comparison of distribution systems in unoccupied new and retrofit test houses in most climates; NAHBRC - single zone balancing for inaccessible, interior ducts; ARBI - mixed mode ducted and ductless distribution; ductless hydronic distribution. PARR has relevant research in progress.

"Closing the Gap": Determine viable strategies, determine sizing guidelines, work with appropriate agencies to implement guidelines.

Timeline: Now through the end of 2013.

Table 19: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2b) How should zoning be handled in high performance homes?

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Zoning can help reduce space conditioning energy use, especially when various zones are used only intermittently. Zoning can also optimize comfort by providing the desired temperature in each zone. Zoning can be effective in multi-story homes to achieve summer versus winter temperature balance between floors when the house is served by a single conditioning system. An unbalanced return air problem may exist, however, when only the supply air is zoned while the return air operates continuously. In this circumstance, individual rooms may be depressurized by the return air when the supply air is zoned off and the door to that room is closed. There is also a need for improved modeling of zoned systems.

Key Customers and Stakeholders: HVAC equipment industry, HVAC contractors, builders, remodelers.

Background Knowledge: Energy savings and comfort in zoned systems is not well documented. May have significant energy savings in retrofits of two or three level homes. Is zoning as necessary as enclosure gaps are closed? Is it even more necessary as we may focus on only providing space conditioning to smaller and smaller parts of houses at any given time (maybe based on occupancy)?

System Considerations:

Planned or Ongoing Research: NAHBRC - single zone balancing for inaccessible, interior ducts; ARBI has projects looking at mixed mode distribution; NREL data and field data indicate that zoning issues are significant; and a relevant NIST study (non-Building America funded).

"Closing the Gap": Research collecting temperature /pressure/ comfort distribution data in high performance homes.

Timeline: 2012

Table 20: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2c) Lack of knowledge on (distribution) performance of ductless systems as an alternative to ducted systems

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Mini-split AC and heat pump systems can be installed to serve individual zones. However, because the cost of these systems tends to be high, to provide space conditioning to all zones tends to be relatively expensive compared to standard central/ducted systems. Installation of five ¾ to 1-ton high-efficiency mini-splits could cost $10,000 - $12,000, which could be considerably higher than a central high efficiency system.

Multi-zone mini-splits appear to have significantly lower space conditioning efficiency ratings. How do their costs and performance compare?

As envelope loads become very small (and MELs become smaller, for cooling), the number of mini-split fan coil units needed is reduced and the ease of moving the required amounts of heated and cooled air from one zone to another is improved.

Currently, simulation tools lack ability to model for multi-split systems.

Key Customers and Stakeholders: Builders, HVAC contractors, manufacturers.

Background Knowledge: There is a need for tested and validated options for heating/cooling low-load buildings with non-ducted systems. Energy codes are increasingly making leaky duct systems outside of the conditioned space a liability, while tight and well insulated envelopes are reducing design loads. As a result, cost-effective, non-ducted options (electric and/or gas-fired) can potentially offer improved efficiency and comfort.

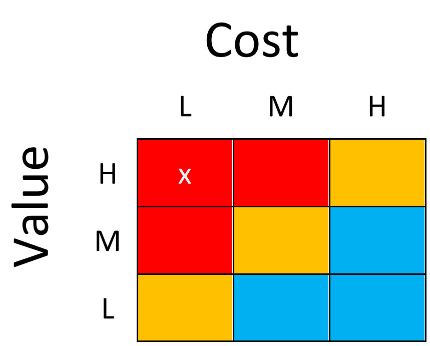
System Considerations: Ductless systems assist with gaps that result from poorly designed/installed ducted systems.

Planned or Ongoing Research: ORNL – field testing ductless variable capacity systems; NREL – performance mapping five mini-splits with Purdue; BA-PIRC is monitoring a single mini-split system which is being compared to central system operation to evaluate relative energy use and comfort implications, and supplementing existing heating systems with ductless heat pumps (test plan); Franhofer researching ductless mini-splits, monitoring comfort in rooms and detailed performance conditions; ARBI is looking at ductless hydronic systems and the distribution of temperature comfort parameters and planning an expert meeting in this area; and BIRA has relevant research in this area.

"Closing the Gap": Research collecting temperature /pressure/ comfort distribution data in high performance homes.

Timeline: 2011 - 2012

Table 21: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2d) Lack of understanding about hydronic system distribution efficiency

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	✓
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Lack of understanding of hydronic system distribution efficiency, affecting issues with ASHRAE Standard 152 and BEOpt. Ignoring potential benefits of chilled water generation such as improved performance due to elevated evaporator temperatures, hydronic distribution may provide a more efficient means of delivery for low-load buildings and buildings with multiple thermal control zones, and mitigates the problem of duct heat gain and loss in forced air systems. What is not understood is the relative seasonal distribution efficiency of hydronic systems. Chapter 7 (Hydronic Distribution Systems) of ASHRAE Standard 152 is under revision and should provide methods that could be incorporated into BEOpt and other tools, but field validation will be needed, particularly for the more difficult to model systems such as radiant floors. Research is needed to identify controls that will regulate chilled water temperature and coil airflow to provide appropriate levels of latent cooling in humid climates.

Key Customers and Stakeholders: Single and multi-family homebuilders, hydronic systems suppliers and manufacturers, building scientists, engineers and system designers, industry associations.

Background Knowledge: The Hydronics Institute has published design and installation guides for residential hydronic heating systems for more than four decades. ASHRAE Journal has published multiple articles on hydronic and radiant heating and cooling distribution (some recent), and the ASHRAE Handbook (2008 Systems, Chapter 12) is dedicated to hydronic system design. Some manufacturers (such as ITT and Wirsbo) have produced design guides, and the Radiant Panel Association publishes design and installation guidelines for radiant systems. There are also recent textbooks on the subject (e.g. Siegenthaller, *Modern Hydronics*).

System Considerations: Hot and chilled fluid can be conveyed over long distances to fan coils and radiant surfaces to provide forced air or radiant distribution. Comfort can be delivered using ceiling cassettes, small fan coils, or radiant surfaces. Pumps typically require a fraction of the energy of fans, and losses from pipes, which can be routed within the thermal enclosure, are lower because of the decreased surface area. Water piping (PEX) is less costly to install than copper refrigerant piping used with mini-split heat pumps. "Buffer" tanks can be used to decouple the boiler, heat pump, or condensing unit from the load, allowing systems to serve infinitely small loads.

Planned or Ongoing Research: ARBI – hydronic distribution feasibility study (technical report); ARBI - field tests of two mixed mode radiant-fan coil systems with air-to-water heat pumps; ARBI conducting a webinar on hydronic distribution; ARIES - MF hydronic distribution projects (test plan); PARR – multi-family steam system balancing (test plan); CARB II – condensing boilers

"Closing the Gap": ARBI's hydronic distribution study will use TRNSYS modeling to identify performance differences between typical forced air and hydronic systems, and will evaluate cost differences and potential economic benefits. ARBI's field test data will be used to estimate the distribution efficiency of radiant floor cooling (projects have not been approved for continuation, so no heating data will be available).

Timeline: 2011 - 2012

Table 22: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		X	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3) Need to improve thermal efficiency of distribution systems.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need to research, develop, and implement design strategies and techniques to further reduce conductive and radiative losses in distribution systems.

Key Customers and Stakeholders: Contractors, equipment manufacturers, auditors, remodelers

Background Knowledge: Conductive and losses of air distribution systems create proportionately larger energy losses for variable capacity systems because of the extended dwell time of air within the ducts. There is resistance to, and barriers to relocating ducts in conditioned space.

System Considerations: Synergy with high efficiency equipment operating at larger percentage of runtime. Synergy among enclosure issues related to where ducts are located. Also potential for moisture condensation issues. Certain measures to reduce conductive losses may also act to reduce leakage losses at the same time.

Planned or Ongoing Research: CARB - encapsulated/burried ducts (test plan), proof of concept research - compact air supply duct using aerogel insulation. BA-PIRC SEER 21 research.

"Closing the Gap": Research on cool roofs, cool ducts, insulation wraps, radiant shields over ducts, interior ducts, spray-on foam insulation, and loose fill insulation to bury ducts, etc

Timeline:

Table 23: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

4) Multi-family steam/hydronic distribution and distribution control issues.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	
Existing	✓
Single Family	
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need for cost-effective retrofit solutions to reduce overheating; including steam to hydronic conversion. Control of hydronic/steam heating distribution in MF buildings - need to optimize retrofit solutions and validate/measure performance of existing strategies, including steps to moderate inter-floor and stack effect air flows within taller buildings.

Key Customers and Stakeholders: Multi-family specific

Background Knowledge:

System Considerations:

Planned or Ongoing Research: ARIES - MF hydronic distribution projects (test plan); PARR – multi-family steam system balancing (test plan), CARB II Condensing Boilers

”Closing the Gap”:

- Identify multi-story building envelope and airtight compartmentalization issues which contribute to substantial stack effect in taller residential buildings and contribute to solutions to air flow control problems, including new construction and retrofit solutions.

Timeline:

Table 24: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H			
	M		x	
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

5) Distribution System Design Standards

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ___________________		Other:___________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: ___________________	
Other: ___________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ___________________	
Strategic Analysis			
Other: ___________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: ACCA Manual D - is it in use effectively and is it working in all situations? Current ACCA Manual D does not provide enough design guidance to the HVAC contractor/designer industry on best practices with triangular splitter boxes or rectangular distribution boxes. New equivalent length with different configurations are needed in the Manual D guide. Manual D specified in some codes and guidelines and yet Manual D does not recognize market realities (cost and availability of materials). Does manual D need update to address current best practices, market realities and low airflow requirements? Manual D is imperative when it comes to high performance homes; how do we get more designers to use the tool? ACCA Manual T could also be included (Air Distribution Basics).

Key Customers and Stakeholders: Contractors and designers.

Background Knowledge:

1) Need ACCA Manual D Design guide on Effective lengths.
2) Return ducts have to be designed and installed as carefully as supply ducts.
3) Very little guidance on how to design water based distribution systems

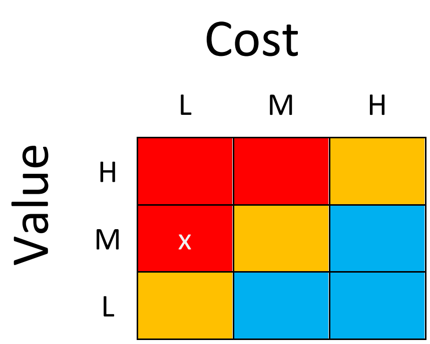
System Considerations:

Planned or Ongoing Research: IBACOS - planned research for 2012 related to the airflow characteristics of certain Splitter Box (i.e. boxes made out of fiberglass ductboard that are used flex duct) geometries that are widely used in production housing, but have no current ACCA design standards.

"Closing the Gap": List concerns with current Manual D, work with ACCA to address concerns. Possible best practices guideline for retrofit duct systems, help HVAC contractors determine when to use and when to abandon the existing duct system for space conditioning retrofits.

Timeline: 2012

Table 25: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

Rank	Description	% of total	Priority

		priority votes	(L,M,H)
	Ventilation and IAQ		
1	*Pressure imbalances that may cause health and safety issues*	34	H
1a	How tight is too tight?		
1b	Combustion safety in tight houses		
2	*Optimization of ventilation equipment and strategies*	*32*	H
2a	Need better fan motor efficiency and fan blade efficiency for ventilation equipment.		
2b	Hybrid, Energy Efficient Ventilation/Recirculation Systems for Acceptable Indoor Air Quality		
2c	Should ventilation air be evenly distributed / What is the source of ventilation air?		
2d	Ventilation control technologies to optimize intermittent ventilation.		
3	*Continued quanitification of scientific/health basis for impact of ventilation on IAQ*	*26*	H
3a	Lack of understanding of health drivers and contaminant issues which should govern building enclosure tightness and ventilation standards / guidelines.		
3b	Low cost sensors to measure/monitor IAQ		
3c	Climate specific ventilation guidelines / requirements		
4	Strategies for Energy Efficient Make-Up Air and capture efficiency for larger range hoods.	8	M

1a) How tight is too tight?

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: _infiltration & excess building pressure	✓	Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: At what level of building airtightness do we need to be concerned about pressure imbalances? What effect do differing levels of airtightness have on ventilation delivery (exhaust vs. balanced system). Once a desired amount of ventilation is determined, how should ventilation be provided in a way that best maintains IAQ and durability over time? What percentage should be natural vs. mechanical considering limitations of mechanical devices, and changes that affect drivers? If mechanical dominated, at what tightness level must a balanced ventilation system be utilized vs. commonly used exhaust only systems to maintain IAQ and prevent over-ventilation resulting from changes in drivers?

Key Customers and Stakeholders: New construction and retrofit industry in general. Continuous exhaust based ventilation is common in multi-family and Passive House sectors.

Background Knowledge: The 2012 International Residential Code and International Energy Conservation Code have air tightness requirements and mechanical ventilation requirements that will likely result in whole house mechanical ventilation (WHMV) systems being installed in all new single family low rise construction where these codes are adopted. Air tightness requirements of 5 ACH 50 or better in warm climates and 3 ACH 50 or better in moderate and cold climates may change the approach that builders have to air sealing, ventilation, and even equipment and appliance specifications in homes. Achieving Building America energy savings goals frequently entails specifying building tightness levels below these levels, due to the cost effectiveness of energy efficiency achieved through tight enclosures. Inadequate research has been performed to inform limits to air tightness without providing fail safe controls.

Super tight buildings depend upon the ventilation system as dilution mechanism for contaminants including VOC, HCHO, CO_2, CO, H_2O. Ventilation systems must operate effectively and continue to operate over long periods of time consuming energy and potentially creating maintenance issues. They also depend upon balanced air flows, because unbalanced air flows in very tight homes can produce large pressure differentials which can interact unfavorably with moisture migration in building cavities and with combustion safety. Airflow drivers creating unbalanced flows can develop over time and can affect building pressures, safety, and IAQ.

System Considerations: RH/comfort control implications, and also linked with enclosures.

Planned or Ongoing Research: LBL has a leakage database, but not many supertight homes. LBL exploring fail safe devices and working with manufacturers to indentify pressure limits of operating environment for combustion equipment.

"Closing the Gap": Modeling of pressure conditions can predict the effect of exhaust systems (e.g., combustion equipment, appliance, kitchen, bath, WHMV, radon, etc.) and other pressure difference drivers (stack effect, duct leakage, interior door closure, imbalanced return air, etc) on building pressurization/depressurization with respect to outdoors. Modeling should be followed by in-situ testing to verify modeling assumptions and outputs. A large, long term study of occupied homes may be necessary to fully gauge impact of extensive air sealing and retention of associated ventilation strategies over time.

Timeline: Expert meeting in 2012 to explore timeline and activities.

Table 26: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

1b) Combustion safety in tight houses

Check all that apply:

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

Problem Statement:

Combustion safety in tight houses is a critical measurement requirement in new construction and retrofit (upgrade) projects when houses are being tightened to reduce air infiltration. Reducing the availability of combustion air through tightening the building envelope can cause draft-hood equipped appliances to have excessive priming times or continuously backdraft creating the potential for excessive CO production. Issues relating to IAQ, ventilation, pressurization/depressurization need to be considered.

Key Customers and Stakeholders:

Gas utilities, ASHRAE committees, contractors, inspectors, homeowners, and Building America Teams

Background Knowledge:

The National Fuel Gas Code, Uniform Mechanical Code, International Residential Code, and IECC all contain requirements for combustion air supply for non-direct vent appliances including ventilated closets and combustion air ducting under certain circumstances depending on the installation. BPI and RESNET use a different set of recommendations as does the Measured Home Performance community. The California Energy Commission has funded a project investigating labeling of draft hood equipped water heaters against measured house depressurization levels which could lead to yet another set of recommendations. BPI and RESNET are rewriting combustion safety guidelines.

System Considerations:

Atmospheric equipment (water heaters and furnaces) in new construction and retrofit when installed in a non-direct-vent configuration are impacted. New ventilation requirements in ASHRAE 62 also impact the performance of buoyancy-driven vent systems.

Planned or Ongoing Research:

Gas Technology Institute has proposed an ASHRAE seminar on this topic for the January 2012 meeting. The Partnership for Advanced Residential Retrofit BA team will conduct an expert meeting and produce a strategy guideline in 2012. BAPIRC – unbalanced (supply dominated) ERV operation for combustion air/combustion safety; LBL - researching new combustion safety diagnostics and working with manufacturers to disclose how much pressure their equipment can overcome safely.

”Closing the Gap”:

Research Questions: 1) What are the current requirements in the codes for combustion safety testing? 2) How do field practices agree or disagree with the code coverage? 3) What additional data needs to be collected to develop a common standard for combustion safety? 4) What low-cost or no cost options are currently available that satisfy the need for combustion safety in homes with low air leakage?

Timeline:

- PARR Expert Meeting – June 2012
- Identification of new products/sensors and measurement techniques will be an outcome.
- PARR Final Strategy Guideline (based on existing products/techniques) – August 2012
- Additional research into low cost/no cost solutions in 2013.

Table 27: Cost-Value Matrix for Combustion Safety in Tight Houses

Value \ Cost	L	M	H
H	x		
M			
L			

2a) Need better fan efficiency achieved through implementation of better motors, electronics, and blade design.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ________________		Other:________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: ________________	
Other: ________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ________________	
Strategic Analysis			
Other: ________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Improvements to energy efficiency of ventilation equipment can be gained by improving efficiency of fan blades and fan motors.

Key Customers and Stakeholders: Builders and buyers/occupants of high efficiency homes, manufacturers of ventilation equipment, equipment standards.

Background Knowledge: Low fan efficacy in HRVs and ERVs could result in these technologies actually using more energy than lower first cost alternatives, even considering energy recovery. What is target? Greater than 2 cfm/watt? Also important for ventilation integrated with primary heating/cooling systems. 2012 IRC requires ECM. Shouldn't recommend technology, should reference a performance benchmark.

System Considerations: Need for similar research has been identified to improve primary heating/cooling equipment. Considerations with regard to improving energy use by proper duct desian.

Planned or Ongoing Research: FSEC – high efficiency condenser fan research

"Closing the Gap":

- Identify target.
- Quantification of savings potential through use of state of the art currently available fan/motor technologies
- Work closer with equipment manufacturer stakeholders to communicate needs and expectations.
- Work with codes and standards organizations to require performance benchmark.
- BA can do best practices guide on reducing fan energy through proper duct design.

Timeline:

Table 28: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2b) Hybrid, Energy Efficient Ventilation/Recirculation Systems for Acceptable Indoor Air Quality

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	✓
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Research is needed toward the optimization and integration of active pollutant removal technology with the currently favored dilution strategies, as a means to reduce energy use through reduction of ventilation air volumes recommended by industry standards.

Key Customers and Stakeholders: Space conditioning equipment industry, occupants, builders/remodelers, health professionals.

Background Knowledge: A number of manufacturers currently market a range of technology designed to remove biological and chemical contaminants from the living space, some of which are integrated with primary heating/cooling equipment. ASHRAE Standard 62.2 acknowledges that air cleaning could be an important factor in achieving acceptable indoor air quality and envisions work on inclusion within a companion guideline or as a potential future addenda. The ability to clean and recycle air within a residence has potential to save considerable energy over the need for introducing and conditioning outside air to maintain IAQ via dilution alone. Some dilution ventilation devices such as ERV's are speculated to transfer contaminants amongst the air streams along with H20. LBL has done some work on evaluation of technologies.

System Considerations: Synergy with determination of enclosure air tightness.

Planned or Ongoing Research: BA-PIRC proposed evaluation / optimization of equipment.

"Closing the Gap":

- Data documenting performance of existing and equipment to maintain IAQ in concert with dilution.
- Evaluation of energy savings resulting from optimized equipment designs.
- Equipment standards documenting energy use and IAQ efficiency (AHRI?).
- If overall results promising, inclusion in ventilation standards (62.2).

Timeline:
2012 – technology inventory/evaluation
2013 – 2014 potential for advanced, optimized designs
2013 – 2014 – standards activities

Table 29: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2c) Should ventilation air be evenly distributed? What is the source of ventilation air?

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: While there may be enhanced energy efficiency and cost effectiveness with undistributed ventilation systems, especially when retrofitting existing homes, it is unknown if there is an effect on comfort and acceptable indoor air quality compared to well distributed systems. Very much dependent on the source of ventilation air, the nature and location/source of the contaminants, and contaminant distribution pathways?

Key Customers and Stakeholders: New construction and retrofit industry.

Background Knowledge: Local ventilation systems can sometimes be used to meet whole-building ventilation requirements. An efficient bath fan, for example, can provide continuous exhaust-only ventilation in some homes. There is also at least one local ERV available (Panasonic WhisperComfort™) which exhausts air and provides fresh air at the same location. These systems can usually be installed at much lower cost than fully-ducted systems, but a potential drawback is that outdoor air is not actively distributed throughout a home.

Several researchers (NREL, BSC, CARB, LBL) have documented that RAoA (reciprocal age of air) values can be quite disparate within the same home when:

- Local or non-distributed ventilation is used, AND
- Doors to rooms (typically bedrooms) are closed.

CONTAM models (BSC, LBNL) have shown that there may be more potential for pollutants building up in homes without distributed ventilation, but the practical impacts are still uncertain.

More field data is needed to fully understand contaminant issues.

System Considerations: Local and whole-building ventilation, ducted and non-ducted heating and cooling distribution, system maintenance.

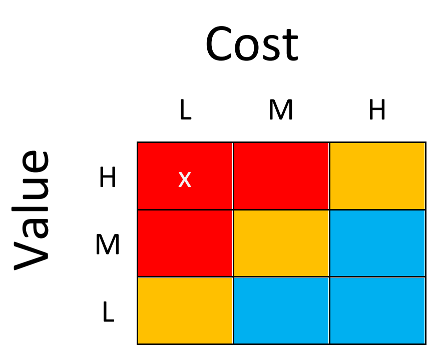
Planned or Ongoing Research: CARB is conducting further studies in the Northeast and West on distribution and BSC is looking at contaminant issues as a function of source of ventilation air.

"Closing the Gap":

A. How does the source of ventilation air affect the nature of contaminants and overall IAQ?
B. What factors affect mixing of fresh air in a home (home plan, HVAC systems, occupancy patterns, etc.)? With what types of systems and homes must distribution and/or fresh air mixing be considered more closely.
C. What is the metric for "acceptable ventilation performance"? RAoA differentials within a home?
D. What role should system operation and maintenance play in assessing "acceptable performance" over time?

Timeline: Fair amount of work already done that show in some cases mixing is bad, and in other cases mixing is good. Different technologies achieve different mixing performance. Since this is tied to knowledge of contaminant issues, maybe should wait for that. Consensus that we won't get consensus until then.

Table 30: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2d) Ventilation control technologies to optimize intermittent ventilation.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: ________________		Other:________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: ________________	
Other: ________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: ________________	
Strategic Analysis			
Other: ________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Whole house mechanical ventilation delivery should be optimized to achieve greatest levels of energy efficiency and cost effectiveness, and there is a lack of research on optimization of intermittent scheduling.

Key Customers and Stakeholders: New construction/remodeling, HVAC equipment industry, HVAC designers

Background Knowledge: 62.2 contains effectiveness guidelines, but purely as a function of ventilation system runtime %. Effectiveness is based on an annual average health exposure (not odor or anything else), but truncated for 1 day to avoid 3 months on and 9 months off cycle.

System Considerations:

Planned or Ongoing Research: CARB II – Demand ventilation based on occupancy, LBL researching various controls

"Closing the Gap": Research should be conducted on

- Variable ventilation rates as a function of outdoor conditions (e.g. temperature, windspeed, etc.)
- Occupancy/time of use controls
- Other controls, such as CO2 sensors and humidity sensors
- Other issue is capacitance / equivalence, which 62. 2 is on top of.

Timeline: 2011 - 2012

Table 31: Cost-Value Matrix for XXXXXX

	Cost		
Value	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3a) Lack of understanding of health drivers and contaminant issues which should govern building enclosure tightness and ventilation standards / guidelines.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: _enclosure tightness	✓	Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need to scientifically determine health drivers, contaminants, and threshold/action levels to provide a firm basis for implementation of methods for acceptable IAQ.

Key Customers and Stakeholders: medical community, builders/remodelers, equipment manufacturers, materials manufacturers, controls/sensor industry

Background Knowledge:

1) Lack of data upon which consensus can be built.
2) Where does moisture fall in the mix?

In addition to VOCs, formaldehyde, radon, CO2 etc. combustion safety is a big issue. Elevated indoor RH, especially in the winter, is a big issue. All are intertwined with source control, dilution, and active removal methods.

System Considerations: An identified RH control gap involves similar investigation of internal moisture generation as a driver.

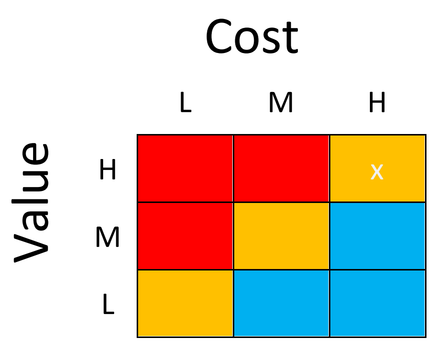
Planned or Ongoing Research: LBL - current state of IAQ in housing, 62.2 already working on performance based standard, identifies particulates as a big issue

"Closing the Gap":

- Identification of health drivers/contaminants (types, concentrations, etc)
- Review/make amendments to threshold/action levels
- Evaluation of methods/equipment for acceptable indoor air quality against these parameters

Timeline: 2011 - 2014

Table 32: Cost-Value Matrix for XXXXXX



Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3b) Low cost sensors to measure/monitor IAQ (including building air change rates)

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	✓
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: Lack of quantitative, low cost, accurate sensors that can measure health drivers in situ, and can measure zonal air change rates

Key Customers and Stakeholders: standards organizations, equipment manufacturers, controls industry, health professionals,

Background Knowledge: Low cost equipment to measure IAQ will benefit both the code/standards process as a whole and the design process for acceptable indoor air quality on an individual residence. Sensors will also enable monitoring of IAQ over time. Currently, sampling is conducted in situ, but quantification is conducted in an analytical laboratory (GCMS, HPLC, etc). Some portable devices exist, but they are bulky, expensive, and not designed for deployment/permanent installation.

System Considerations: Synergy with gaps on ventilation control technologies

Planned or Ongoing Research:

”Closing the Gap”:

- BA needs to invest something to create spark if true gap. Otherwise drop it, because no other significant driving force.
- Once technology is developed, BA can work towards Linking manufacturers of industrial hygiene equipment / devices / sensors with residential space conditioning industry to integrate technology.

Timeline: 2013 - 2014

Table 33: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H			x
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3c) Climate specific ventilation guidelines / requirements

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: If supplemental dehumidification is required in certain climates to achieve acceptable IAQ given standard ventilation guidance, how is that guidance implemented when supplemental dehumidification is not practical for a given project?

Key Customers and Stakeholders: New home builders, ASHRAE researchers, remodelers

Background Knowledge: Is whole house mechanical ventilation being implemented in the field in hot-humid climates with the achieved ventilation rate equal to the 62.2 rates? It appears most builders of BA homes in hot-humid climates are not implementing full 62.2 and the reasons should be examined and field performance documented. If they are what has been the field experience and customer feedback? Are there other climates (humid or otherwise) where there is a similar level of avoidance of recognized ventilation guidance?

System Considerations: Related to other gaps that include determination of what factors drive determination of ventilation guidelines.

Planned or Ongoing Research: PNNL is getting data on 10 BA homes in the Gainesville, FL area with a run time only vent system.

"Closing the Gap": Application of IAQ testing protocols , feedback from builders / remodelers / occupants. Go back to BA homes that have been occupied for 5 years and see how systems are operated and get feedback from occupants about health and comfort. Do we look at homes meeting 62.2 or not meeting 62.2 (or both)?

Timeline: 2011 - 2012

Table 34: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

4) Strategies for Energy Efficient Make-Up Air and capture efficiency for larger range hoods.

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification		Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	✓
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Make-up air strategies for large kitchen range hoods which handle CFM requirements and moisture load while also addressing energy efficiency are needed. Range Hood capture efficiency should be investigated as cooking makes a big impact in overall IAQ.

Key Customers and Stakeholders: HVI, 62.2 committee (Don Stevens – Panasonic) range hood industry, mechanical designers, larger custom homes, residential buildings with larger communal kitchens

Background Knowledge: IRC defines large range hoods as > 400cfm. Requires make-up air and interlock device. Where to put make up air damper? No requirements for tempering. Tighter building envelopes are more common and increasingly code-mandated, while code-driven make-up air requirements for larger range hoods are also in place now. As a result, make-up air strategies which handle CFM requirements and moisture load while also addressing energy efficiency are needed.

Andrew Persily work with NIST? University of Wisconsin/Madison work in the 80's?

System Considerations:

Planned or Ongoing Research:

"Closing the Gap": Work with HVI on capture efficiency standards.

Timeline:

Table 35: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H			
	M		x	
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome: *Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

Rank	Description	% of total priority votes	Priority (L, M, H)
	RH Control		
1	Determination of total internal moisture gains in homes	55	H
2	*Optimizing when to use supplemental dehumidification equipment to control RH*	*32*	H
2a	Protocol to assess and correct deficiencies in RH control in homes.		
2b	Need a metric for acceptable RH in homes.		
2c	Accurate simulation/prediction of RH in homes.		
2d	Improvements in RH sensors / controllers.		
2e	Adjustments/enhancements to primary HVAC systems for improved RH control.		
3	Need to understand operating performance of existing and emerging supplemental dehumidification equipment.	13	H

1) Determination of total internal moisture gains in homes.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	✓
Windows		Combined Space and DHW Heating	
Other: __________________		Other:_________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: _________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: _________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement:

- What are the principle sources of internal moisture gains in homes and what is their relative contribution to the total?
- What are the average rates of internal moisture gains in typical homes and what is the variation that can be expected to be found across homes?

Key Customers and Stakeholders: HVAC equipment manufacturer and design industry, software models

Background Knowledge: There has been very little previous work in this area of investigation. While there has been significant work related to heat and moisture generation due to human metabolic activity, this does not provide sufficient data to make reasonable determinations of total internal moisture gains in homes as many result from activities not directly related to human metabolic activity like cooking, bathing and cleaning. Current "estimates" of internal moisture generation in homes vary by a factor of four – from a low of about 10 pounds per day to a high of almost 40 pounds per day.

There is significant concern regarding the impacts of ASHRAE 62.2 compliant mechanical ventilation with respect to moisture control in homes. Without more accurate estimates of the rates of internally generated moisture in homes, it is virtually impossible to make accurate assessments of the requirements for enhanced dehumidification in these homes. In addition, the requirements of ASHRAE 62.2 require intermittent spot ventilation of kitchens and bathrooms. The efficacy of these intermittent ventilation systems with respect to net moisture removal is largely unknown. This also can make a substantial difference in the requirements for enhanced dehumidification in highly efficient homes.

LBL has a 2007 NIST paper containing some research.

System Considerations: Enhancements to this fundamental knowledge affects many Space Conditioning related gaps.

Planned or Ongoing Research: BA-PIRC and LBL are proposing to develop and oversee implementation of a measurement protocol.

"Closing the Gap": Statistically significant data on sources and generation rates of internal moisture gains in typical and high performance occupied homes. May involve detailed data from a small sample of homes, and less detailed data from a larger sample of homes. Protocol would aim to calculate a moisture balance in homes, including measuring moisture removed from space conditioning systems and spot ventilation systems.

Timeline:

- Develop field/lab test protocol – 2012
- Collect data – 2012 - 2013

Table 36: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H			x
	M			
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2a) Protocol to assess and correct deficiencies in RH control in homes.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: reduced sensible loads yields reduced AC runtime and reduced latent cooling	✓
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: A protocol is needed to guide the industry towards correction of RH control issues in homes. The protocol will assist with determination of when supplemental dehumidification is needed in high performance homes vs. when RH can be properly controlled through identification and correction of deficiencies in enclosures, distribution systems, and primary heating/cooling equipment.

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers, multi-family stakeholders/customers.

Background Knowledge: Supplemental equipment to control RH is costly and energy intensive. RH control can often be achieved through identification and correction of moisture drivers.

System Considerations: Closely linked with ventilation, heating/cooling equipment, and enclosure issues.

Planned or Ongoing Research: BA-PIRC developed a technical report on moisture and air flow drivers and methods to correct. BSC proposes working on a guideline document.

"Closing the Gap": Consensus driven protocol and documentation via Measure guideline or similar. Expert Meeting could inform the process. Could also serve as webinar topic.

Timeline: Complete measure guideline in 2012.

Table 37: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2b) Need a metric for acceptable RH in homes.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	✓
Distribution		Small MELs (TVs, VCRs, etc.)	✓
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol	✓	Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	✓
Large Scale Retrofit (Better Buildings)	

Problem Statement: What should be the RH target for humidity control in homes?

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, standards organizations

Background Knowledge: What range of indoor RH is acceptable, for various climate zones, for various thermal efficiency of house construction, etc? (For what length of time is 65% RH, for example, acceptable from a microbial growth perspective – summer versus winter?) There are several potential metrics that could serve as a basis including ASHRAE 55 (comfort), durability, dust mite control, condensation potential, etc. Maybe an accepted metric should be based on some combination of factors? It cannot be the "lowest common denominator", for that could be unacceptably low in some cases, and in other cases, could be dictated by occupancy characteristics which change over time, therefore creating a moving target.

In addition to an RH target, need to identify a time basis. Dustmite research calls for 50% on a daily average basis, but important measure for biological drivers may be on surfaces rather than in the air. 60% RH for no longer than 4 hours? ASHRAE RP-1449 evaluating 13 different dehumidification technologies and resulting % of time above 60% RH. Expand ASHRAE 55 beyond comfort to include more stringent requirements for health and durability?

Fang and Winkler from NREL published research in June 2011 HVAC&R.

Another good reference: Arlian LG, Platts-Mills TAE. 2001. The biology of dust mites and the remediation of mite allergens in allergic disease. J Allergy Clin Immunol. 107:S406-13

System Considerations: Far reaching impact on general design for high performance.

Planned or Ongoing Research: ASHRAE RP-1449 looking at energy/cost efficient humidity control via 13 different dehumidification technologies, results to be presented at the 2012 Affordable Comfort Conference in Baltimore in March 2012

"Closing the Gap": Definition of target and range. BA should consider holding an expert meeting on the topic.

Timeline: Expert Meeting on Humidity Control - 2012

Table 38: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H	x		
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2c) Accurate simulation/prediction of RH in homes.

Check all that apply:

BA Enclosures		**BA Hot Water**	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	✓
Windows		Combined Space and DHW Heating	
Other: ________________		Other:________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution	✓	Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: ________________	
Other: ________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: ________________	
Strategic Analysis			
Other: ________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Models to accurately simulate and predict RH according to a variety of design conditions are needed to assess cost effectiveness of RH control in high performance new construction and retrofit package.

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers,

Background Knowledge: While DOE 2 remains in use for design and BA program analysis, Energy Plus will soon be more frequently used, with greater simulation of latent loads and comfort parameters. Currently (January 2012), there is no complete BEopt model with RH modeling capability. Current Building America House Simulation Protocol calls for simulation of active dehumidification in the reference building if present in research building. ASHRAE RP-1449 looking at 13 different dehumidification technologies using a TRNSYS model. Accurate model prediction of RH should be validated for current and future tools, along with other energy and comfort related parameters. Prediction of balance point temperature (exterior temp at which no heating/cooling needed) and balance point depression (degrees of exterior temperature below interior set point at which cooling is activated) are key parameters to assist validation, as they affect simulated runtime of equipment. Validation work should be conducted in homes of varying performance levels (range of HERS Index).

NREL (Xia Fang, Jon Winkler, and Dane Christensen) produced a simulation study in 2011, Using EnergyPlus to Perform Dehumidification Analysis on Building America Homes, to compare supplemental dehumidification approaches. FSEC (Neil Moyer, et. al.) conducted a study in 2004 assessing six ventilation strategies in a lab home with simulated occupancy.

System Considerations: Related to gaps addressing RH control, use/need for supplemental dehumidification equipment, and latent performance of primary heating/cooling equipment.

Planned or Ongoing Research: ASHRAE RP-1449 using models to predict RH in homes.

”Closing the Gap”: Validation of simulation models with data from lab and test homes.

Timeline: 2013 - 2014

Table 39: Cost-Value Matrix for XXXXXX

		Cost	
Value	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2d) Improvements in RH sensors/controllers.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	✓
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need an accurate, reliable, low cost RH controller with minimal drift that can be incorporated into primary and/or supplemental space conditioning equipment.

Key Customers and Stakeholders: HVAC equipment manufacturing industry, controls industry, equipment standards/rating organizations

Background Knowledge: FSEC did study on RH control for snow bird homes and found 7 different RH controllers inadequate. Variety of issues including 15% deadband.

In efforts to include RH control in Energy Star HVAC specs, EPA receiving pushback from industry over proposed long term reliability requirements for controller accuracy (10 years?).

Need to define specifications for accuracy. +/- 3% of RH? 0.005%RH/F? Drift Rate 0.5% RH/year? Chilled mirror (dew point technique) accurate to 0.1 C? Are we looking at new technology, or improvements to existing? Two common existing low cost sensor technologies include resistance type and capacitive type. The resistance type of sensor uses a conductive grid coated with a hygroscopic substance. The conductivity of the grid varies with water retained thus the resistance varies with humidity. Literature indicates that response time may be an issue. The capacitance type of sensor is based on a membrane. Literature indicates response time may be faster. Both generate non-linear responses, which are linearized electronically via the sensor's output. To be accurate, relative humidity sensors must respond to both moisture and temperature.

Panasonic has recently released a "condensation sensor" measuring both temperature and dew point.

System Considerations: Linked with heating/cooling equipment and RH control equipment gaps.

Planned or Ongoing Research: None identified.

"Closing the Gap": RH control technology/device that meets industry requirements of cost and accuracy. This could be transitioned to Test Methods/Protocols STC, depending on if the focus is on development of controllers to improve space conditioning performance, or if the focus is to understand operating conditions.

Timeline:

- determination of desired parameters – 2011
- coordinate with industry over sensor development 2012 – 2014

Table 40: Cost-Value Matrix for XXXXXX

		Cost		
		L	M	H
Value	H		x	
	M			
	L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

***Outcome**: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

2e) Adjustments /enhancements to primary HVAC systems for improved RH control.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating	✓	Home Energy Management	
Cooling	✓	Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation	✓	Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods	✓	Training	
Field Test Methods	✓	Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools		Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	
Existing	
Single Family	
Multi-Family	
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: Need more research on ability for field and/or manufacturer adjustments to primary HVAC systems that enable better RH control. As sensible loads are minimized in high performance homes, addressing this need becomes more urgent to prevent moisture failure.

Key Customers and Stakeholders: Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, utilities, multi-family stakeholders/customers.

Background Knowledge: Several adjustments/corrections could be made to HVAC systems to improve RH control including

- Reducing AHU air flow slightly (400 cfm/ton to 320 cfm/ton)
- Installing a thermostat that does not short-cycle. Nmax of 3 or fewer (cycles per hour at 50% load factor).
- Getting the refrigerant charge to the correct level
- Correcting excessively long refrigerant piping runs

Equipment manufacturers can also include:

- Heat pipes
- Subcool/reheat
- Enthalpy exchange latent cooling enhancement (e.g., Cromer Cycle)

- Continuously variable compressors

EPA reports that a metric is needed for the HVAC industry to report dehumidification performance and allow comparison across different technologies. Also would like to tie in energy and cost savings. Removing moisture always consumes energy, so only compare among those claiming performance. Industry feedback to EPA indicated that manufacturers are asking how to communicate the value of RH control to consumers.

Would be good to collect data to validate (or invalidate) assumption that with good dehumidification performance, cooling set points will be raised by occupants.

System Considerations: Affects heating/cooling equipment gaps

Planned or Ongoing Research: EPA working on including disclosure of dehumidification performance into Energy Star HVAC standards. BSC has proposed to develop RH control improvements for primary heating and cooling equipment reducing the need for supplemental dehumidification. CARB has a future test house looking at supplemental dehumidification and the issue of energy efficiency.

"Closing the Gap":

- Influence EStar/AHRI certifications to include disclosure of dehumidification performance – provide metric 2011 – 2012
- Work with industry to demonstrate need for and to develop combined equipment with greater RH control – 2012 - 2014

Timeline:

- Influence EStar/AHRI certifications to include disclosure of dehumidification performance – 2011 – 2012
- Work with industry to demonstrate need for and to develop combined equipment with greater RH control – 2012 - 2014

Table 41: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

3) Need to understand operating performance of existing and emerging supplemental dehumidification equipment.

Check all that apply:

BA Enclosures		BA Hot Water	
Walls		Test Standards	
Roof/Ceiling		Distribution	
Foundations		Condensing/Tankless	
Moisture		Heat Pump Water Heater	
Windows		Combined Space and DHW Heating	
Other: __________________		Other:__________________	
BA Space Conditioning		**BA Miscellaneous Loads**	
Heating		Home Energy Management	
Cooling		Lighting	
Dehumidification	✓	Large MELs (pools, etc.)	
Distribution		Small MELs (TVs, VCRs, etc.)	
Ventilation		Other: __________________	
Other: __________________			
Testing Methods/Protocols		**BA Implementation**	
House Simulation Protocol		Quality Control / Quality Assurance	
Lab Test Methods		Training	
Field Test Methods		Documentation / Resources	
Analysis Methods/Tools		Needs Evaluation / Identification	
Analysis Tools	✓	Other: __________________	
Strategic Analysis			
Other: __________________			

House Type	
New	✓
Existing	✓
Single Family	✓
Multi-Family	✓
DOE Emerging Technologies	
Walls and Windows	
Efficient Appliances	
Advanced Heating and Cooling Fluids	
Solar Heating and Cooling	
Geothermal Heat Pumps	
Solid State Lighting	
Bulk Purchase	
Onsite Renewables (Building-Integrated Photovoltaic, onsite cogen)	
DOE Deployment	
Labeling/Rating	
Codes	
Standards	
Large Scale Retrofit (Better Buildings)	

Problem Statement: There is a lack of performance maps for supplemental dehumidification equipment to properly inform simulation models, and their performance capabilities for direct treatment of ventilation air are unknown.

Key Customers and Stakeholders: Equipment manufacturers, designers, software modelers Space Conditioning Equipment industry, HVAC contractors, designers, builders, remodelers, code officials, utilities, software developers, multi-family stakeholders/customers

Background Knowledge: Multiple system approaches using sorption (desiccant), condensation (vapor compression), or combinations of the two technologies are emerging with dramatically higher dehumidification efficiencies than earlier supplemental dehumidifiers. Need to fill additional gaps in the laboratory performance testing and development of the semi-empirical simulation modeling algorithms for emerging supplemental DHs, along with improving the quantification of sensible heat penalties on air conditioning systems. Also need to test the ability of such equipment to handle mixed air streams (recycled indoor + outdoor ventilation air)

System Considerations: Affects gaps related to modification of performance standards.

Planned or Ongoing Research: GTI and NREL - performance mapping supplemental dehumidification equipment, including those which utilize renewable solar energy to enhance efficiency. Also evaluating performance to dehumidify “mixed” air streams (outside air + recycle air).

”Closing the Gap”: Performance maps indicating performance / energy consumption for a variety of conditions.

Timeline: Complete current evaluations in 2012. Continuous effort thereafter as new devices emerge.

Table 42: Cost-Value Matrix for XXXXXX

Value \ Cost	L	M	H
H		x	
M			
L			

Gap/Barrier Resolution (page 3 of Gap/Barrier, to be completed after substantial completion)

Outcome*: Description of how gap, barrier or need was resolved or modified. What role did Building America play? What are the indications that industry has benefited from the resolution of the gap/barrier? Did the resolution uncover other gaps or barrier? Include the date of resolution and the duration of research effort needed to resolve the issue.*

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

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

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

Appendix C: Contributors

The following individuals participated in face-to-face meetings and/or conference calls during 2011.

First Name	Last Name	Organization
Charlie	Adams	A.O. Smith
Robb	Aldrich	CARB / Steven Winter Associates
Ren	Anderson	NREL
Ed	Barbour	Navigant Consulting
Brad	Bartholomew	Total Comfort Pros
Marcus	Bianci	NREL
Dave	Bohac	MN Center for Energy Efficiency
Chuck	Booten	NREL
Larry	Brand	PARR / GTI
Ted	Cater	Panasonic
Subrato	Chandra	PNNL
Jim	Cummings	BA-PIRC / FSEC
Abagail	Daken	EPA
Jordan	Dentz	ARIES
Steve	Easley	BARA
Philip	Fairey	BA-PIRC / FSEC
Xia	Fang	NREL
Curtis	Flores	PECI
Mike	Gestwick	NREL
Anthony	Grisolia	IBACOS
David	Hales	BA-PIRC / WSU
Marye	Hefty	PNNL
Hugh	Henderson	CDH Energy
Walt	Heppard	Veterans Green Jobs
Briann	Holton	CEER (DOW)
Pat	Huelman	Univ. of MN
Ron	Judkoff	NREL
Douglas	Kosar	BA-PIRC / GTI
Neal	Kruis	NREL
David	Lee	DOE
Emanuel	Levy	ARIES
Terry	Logee	Building Energy Diagnostics and Retrofits
Mike	Lubliner	BA-PIRC / WSU
James	Lyons	BA-PIRC / Newport Partners
David	Mallay	NAHBRC
Samuel	Marall	Veterans Green Jobs
Arn	McIntyre	Ferris State Univ
Mike	Moore	BA-PIRC / Newport Partners
Jay	Murdoch	BA-PIRC / WellHome
Pat	O'Maley	Building Knowledge

First Name	Last Name	Organization
Danny	Parker	BA-PIRC / FSEC
Nathan	Perney	Veterans Green Jobs
Duncan	Prahl	IBACOS
Sri	Puttagunta	CARB / Steven Winter Associates
Sam	Rashkin	DOE
Hassan	Ridouane	NREL
Stacey	Rothgeb	NREL
Armin	Rudd	BSC
Max	Sherman	LBL
David	Springer	ARBI / Davis Energy
Dave	Stecher	IBACOS
Robert	Stephenson	Southface
Dennisr	Stroer	BA-PIRC / Calcs-Plus
Paulo	Tabares	NREL
Sam	Taylor	DOE
Kohta	Ueno	BSC
Ian	Walker	LBL
Jared	Wells	MEEA
Eric	Werling	DOE
Linda	Wigington	ACI
Eric	Wilson	NREL
Jon Winkler	Winkler	NREL
Craig	Wray	LBL
Bill	Zoeller	CARB