Expert Meeting

Simplified Space Conditioning Systems for Energy Efficient Homes

Monday September 24, 2012

Arizona Public Service Learning Center, Phoenix, AZ

Overview

The purpose of a heating, ventilation, and air-conditioning (HVAC) system is to provide temperature and humidity levels within a thermal enclosure that meet occupants' comfort expectations along with sufficient fresh air for good indoor air quality. When the performance of the thermal enclosure is improved, such as in a "low-load" house, the requirements for the HVAC system change such that a traditional ducted forced-air system may no longer be capable of meeting those requirements.

The purpose of this research is to determine alternative solutions that have reduced implementation costs with improved energy efficiency, while providing occupant requirements for comfort and fresh air. Strategies being explored include increased equipment modularity, decreased equipment size, reduced on-site component customization, and reduced on-site time of trades with specialized licenses (e.g., for refrigerant handling).

IBACOS anticipates that houses achieving 50% whole-house source energy savings (WRT B10) will be low load. There is currently no industry-accepted definition of a low-load house; however, at the Building America technical update meeting in July 2012, the following three definitions of a low-load house were articulated:

- Total system capacity of less than 2 tons because currently there is a lack of traditional form factor (e.g., a traditional ducted forced-air heat pump or furnace with air conditioner) high-efficiency equipment available in capacities smaller than 2 tons.

  OR

- A reasonable, but somewhat arbitrary, number that looks good on paper such as 10 Btu/(h*ft^2) or 1 ton/1200 ft^2.

  OR

- A load density per unit floor area (w/m^2 or Btu/(h*sq.ft.)), below which the infiltration and conduction through the thermal enclosure are no longer the dominant factors influencing the occupant comfort in the house.

For the third definition, research by various Building America teams (Bergey 2011) has indicated that, in some instances, we can achieve sufficient temperature uniformity throughout the house with a radically simplified space conditioning system and interior partition doors open; however, when those doors are closed, temperatures are non-uniform.

As one potential solution for this non-uniformity issue with doors closed, IBACOS has studied passive air transfer from the main space of the house to bedrooms with doors closed in two unoccupied test houses (Pittsburgh, Pennsylvania and Fresno, California). Although the passive strategies have not proven successful, measured data indicate the potential of limited fan-forced supply from the main space to the bedrooms with doors closed can maintain comfort conditions from one or two primary sources of heating or cooling in the main living space.

This project links to the "Low-Load HVAC" research priority in the DOE SON, specifically "effective air distribution HVAC systems for ultra low load homes." It also falls within the "Achieving Retrofit Efficiency: Equipment vs. System" because the eventual goal of the research is to provide prescriptive language in appropriate codes and standards regarding when to use the strategies.

More research is needed to evaluate the conditions where simplified space conditioning systems will work in new and retrofitted houses. Guidance is needed on the design and installation of these systems to support a wider adoption throughout the new construction and retrofit markets. Research is being performed by IBACOS to address these issues.

Furthermore, even for houses not meeting the low-load definitions, one proven and general strategy for significant energy savings is to bring all of the ducts of a forced-air system inside the conditioned space. During new construction or a retrofit of a conventional system, it is generally impractical to bring the ducts inside the conditioned space unless the attic roof deck is insulated, which can be costly. The use of some of the same technology from low-load houses (e.g., distributed fan coils with minimized ducts, terminal fan coil units, or point source units with buoyant force or ventilation-driven distribution) may provide distributed space conditioning solutions located entirely within conditioned space that would provide a cost-competitive alternative to standard systems in cathedralized attics.

In 2011, IBACOS held an expert meeting on the topic of simplified space conditioning systems (Stecher 2012). Since then, IBACOS has constructed and instrumented one additional house beyond the existing Pittsburgh, Pennsylvania, new construction unoccupied test house. In these two test houses, IBACOS installed a central space conditioning unit with various amounts of active distribution (ductwork) and room-to-room air transfer systems (passive high- and low-through-wall transfer grilles or active through-wall fans) to simulate various terminal conditions that are characteristic of simplified systems such as those incorporating mini-split heat pumps, distributed fan coil units, or central ventilation systems. IBACOS has assessed the ability of each system to meet existing standards for temperature uniformity in the Air Conditioning Contractors of America (ACCA) Manual RS (Rutkowski 1997) and stability in American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 55-2010 sections: 5.2.5 Temperature Variations with Time, 7.3.2 Temperature Cycles and Drifts, and 7.4 Measuring Conditions (ASHRAE 2010). This field work and corresponding mathematical modeling will be used to draw larger conclusions for a variety of climatic regions and house configurations.

The purpose of this meeting is to discuss the results of the research performed by IBACOS to verify if any of the general key research questions can be confidently answered based on current information and to determine what research should be performed to address any remaining gaps. Additionally, the meeting will guide what actions (e.g., literature searches, modeling, laboratory

tests, field tests, or collaboration with other teams or industry partners) should be taken by IBACOS in 2013 to address its specific research questions for the year.

Key Research Questions

As part of IBACOS' five-year research plan, these are the key research questions that must be answered to determine the viability of alternatives to typical forced-air heating and cooling systems:

- In low-load homes (freestanding houses, townhomes, or multifamily buildings), what are the alternative strategies to conventional central ducted space conditioning systems that will provide thermal comfort for the occupants according to ASHRAE 55-2010, ACCA, and others (air temperature, relative humidity, air speed, and mean radiant temperature)?
- What are the terminal conditions and parameters needed for simplified space conditioning systems (e.g., face velocity, Btu/cfm, duration of run cycle) to provide thermal comfort in new and existing homes in different U.S. climate regions?
- What are the economic trade-offs involved with changing from a central ducted space conditioning system?
- What implementation issues—including technology gaps, code restriction, or installation issues—need to be resolved to enable simplified space conditioning strategies to succeed in providing good thermal comfort, humidity control, and ventilation air distribution?
- How do low-load homes (new or retrofit) respond to externally induced peak load situations or internally induced peak loads (e.g., large gatherings of people in one space, significant home electronics waste heat, solar load)? What is the impact on simplified space conditioning strategies and operation?

As part of this meeting, the group will address specifically the questions IBACOS is asking as part of its 2013 research objectives:

1. In the main living spaces and bedrooms of new houses with load densities of 1,000 to 1,800 s.f./12,000 Btu/h of heating or cooling in various climates:
   A. What are the space conditioning loads, given a realistic range of external and internal gain conditions?
   B. What is the equipment runtime of a properly sized high-efficiency central heating and cooling system, and what ability does it have to maintain room-to-room air temperatures within relevant ACCA and ASHRAE guidelines? How much annual energy would this system use?
   C. What is the equipment runtime of a properly sized simplified heating and cooling system, and what ability does it have to maintain room-to-room air temperatures within relevant ACCA and ASHRAE guidelines? How much annual energy would this system use?
2. What is the incremental cost between a typical builder standard system/minimum efficiency replacement system and the systems described in 1.B and 1.C above?

Expert Meeting Objectives

1. Review the results of existing field data and participant experiences with respect to energy savings, occupant comfort, and implementation issues in houses with minimized space conditioning systems.
2. Find gaps and help to prioritize IBACOS' research plans in the area.
3. Determine relevant and useful outputs for stakeholders using the results of this research.
4. Identify the current gaps between the existing market-based space conditioning products and future needs.
5. Build partnerships with outside groups that can help support IBACOS' research needs and objectives.

Location and Schedule

Location

IBACOS proposes to hold this session in conjunction with The Energy & Environmental Building Alliance (EEBA) Excellence in Building Conference on Monday, September 24, 2012, at Arizona Public Service Learning Center, 400 East Van Buren Street, Phoenix, Arizona. This location is desirable because a number of the expert meeting participants will most likely already be attending the EEBA conference.

The expert meeting will be broken down into four main topic areas related to simplified space conditioning systems:

1. Prior Work
2. Comfort Conditions
3. Economics
4. Implementation Issues

IBACOS will start each of the four sessions with a brief presentation, including proposed research for 2013, and then will facilitate a discussion with the group around our key research questions. IBACOS intends to use the session to identify other Building America teams with resources such as monitored data or past modeling projects that can contribute to our 2013 research.

Preliminary Schedule

12:00 p.m. – 12:30 p.m.	Lunch
12:30 p.m. – 1:15 p.m.	Introductions and IBACOS' Prior Work
1:15 p.m. – 1:30 p.m.	Break
1:30 p.m. – 2:15 p.m.	Comfort Conditions – Field Tests and Modeling
2:15 p.m. – 2:30 p.m.	Break
2:30 p.m. – 3:30 p.m.	Comfort Conditions – Field Tests and Modeling (continued)
3:30 p.m. – 3:45 p.m.	Break
3:45 p.m. – 4:45 p.m.	Economics and Implementation Issues
4:45 p.m. – 5:00 p.m.	Summary and Next Steps
5:00 p.m.	Meeting Conclusion

References

ASHRAE (2010). ANSI/ASHRAE Standard 55-2010, Thermal Environmental Conditions for Human Occupancy. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Bergey, D. and Ueno, K. (2011). New England Net Zero Production Houses. Research Report 1103. Building Science Press. http://www.buildingscience.com/documents/reports/rr-1103-new-england-net-zero-production-houses.

Rutkowski, Hank (1997). Manual RS—Comfort, Air Quality, and Efficiency by Design, 1st ed. Washington, D.C.: Air Conditioning Contractors of America Educational Institute, pp. 1–9.

Stecher, D. et.al. (2012). KNDJ-0-40341-02.3.7.2. Technical Report: Long-Term Results from Evaluation of Advanced New Construction Packages in Test Homes: Martha's Vineyard. Pittsburgh, PA: IBACOS.