Phase II Assessment of Energy Efficient Methods of Indoor Humidity Control for Florida Building Commission Research

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Research Purpose: The purpose of this research is to evaluate the effectiveness of specific residential RH control strategies to effectively control indoor RH and minimize energy use in mechanically ventilated buildings.

Definition of the Problem: Recent versions of the Florida Building Code have addressed the most significant building envelope and HVAC issues that contributed to higher energy use and indoor humidity (such as building air leakage, duct leakage and proper AC equipment sizing). The unintended consequences of these energy conservation measures have brought about a need to address IAQ in more tightly constructed buildings. In Florida, natural air infiltration has declined dramatically in recent decades. House tightness is measured using a blower door test assembly and is quantified as air changes per hour at 50 pascals of pressure or ACH50. Typical new homes have declined in air leakage from approximately 20 ACH50 in the 1950s to about 6 ACH50 in recent years. Thus the need arose to provide designed mechanical ventilation.

The new Florida 5th Edition (2014) Code will require that newly constructed houses be tested for envelope air leakage, not permitting leakage in excess of 5 ACH. At the same time, the new Mechanical Code requires that Mechanical Ventilation be provided for any house that has less than 5 ACH. This practically means that all houses will be required to have mechanical ventilation. The 2012 International Mechanical Code requires 0.35 ach, but not less than 15 cfm/person. Currently it is estimated that homes built within the last decade have an average ach of about 0.21 ach.

Sensible heat is associated with temperature rise while latent heat is associated with water vapor in the air. During humid weather, about 85% of the cooling load associated with mechanical ventilation air from outdoors (OA) is latent heat (water vapor) and only about 15% is sensible heat. Given that the air exchange rate is expected to increase from about 0.21 ach to about 0.35 ach, there is particular concern about how to maintain acceptable indoor RH when latent load from OA becomes a greater fraction of the overall load at times such as overnight or long periods of low heat gain such as swing seasons. Even without OA, there are several hours of the year when a “properly sized” cooling system will be oversized and have limited runtime. The net result of increased ventilation-induced latent loads is that most central ducted air conditioning systems may not adequately control indoor humidity.

There is particular concern in cases where homes have high capacity kitchen exhaust rates on the order of 600-1200 cfm, and where clothes dryers are located inside the home resulting substantial increases in mechanical ventilation beyond code required OA ventilation. High capacity kitchen exhaust systems and substantial runtime of indoor located clothes dryer will result in depressurization of the home which increases infiltration rates, increased potential for higher indoor RH, greater potential for moisture damage, increased space conditioning energy use, and increased potential of transported pollutants into the conditioned space from outside (such as radon, various particulates, and volatile airborne compounds from attached garages). With an increased emphasis on tighter homes, exhaust ventilation rates will also result in greater negative pressure differentials that may potentially be large enough to limit gas or wood fuel combustion gases from drafting effectively to outdoors.

There is a need, therefore, to identify methods of improved humidity control in homes to prevent moisture-related occupant health problems as well as preservation of building materials. It is of course also essential that humidity control be achieved in ways that are energy-efficient and cost-effective.

Background Work: Previous research (referred to as Phase 1 here) regarding this proposed research topic has been completed by FSEC and focused on discovery and preliminary lab research. Phase 1 has just been completed with a final report accepted by the Florida Energy Technical Advisory Committee June 26, 2014. The first task of Phase 1 conducted a literature review of RH control methods for homes in Florida's climate. The second task of Phase 1 tested four experiments in a mechanically ventilated building to evaluate the RH control effectiveness and energy use. The Phase I contract ended June 30, 2014 and was not long enough to evaluate RH control methods during the most challenging Florida conditions that occur during various periods throughout the fall, winter and some spring seasons. Phase 1 was also too short to evaluate base-efficiency methods to which higher-efficiency methods may be compared to. Phase 2 of this research is important to evaluate more latent load approaches and collect additional data for experiments occurring during more variable weather conditions.

Phase 2 Scope of Work: Phase 2 research will be a continuation of Phase 1 lab experimental tests. It will complete additional experimental test configurations to assess the resulting indoor RH, temperature and energy consumption for each test under different seasonal conditions in the same mechanically vented lab building used in Phase 1.

Based upon Phase 1 results, input from the Florida Energy Technical Advisory Committee, and indications that work authorization is not likely to be granted until September 1, 2014, the four test configurations below are recommended for Phase 2. These are assumed to occur September 1, 2014 through April 30, 2015. A dehumidifier will be operational for all tests when the indoor RH exceeds 60% and its energy and moisture removal will be measured. Except as noted in Test 3, all mechanical ventilation tests will occur at a continuous rate of 60 cfm. This rate of ventilation represents requirement for most homes (those with 3 bedrooms ranging from 1501ft^2-3000 ft^2).
The tests are:

1. 60 cfm OA ducted to MS with a low efficiency SEER 13 central ducted fixed capacity system. Phase 1 experiments found operating the MS with the SEER21 central system used more energy but, given the much lower efficiency of the SEER13, this proposed Phase 2 Test 1 may result in lower operating cost than running the S13 unit alone. Furthermore, based on results so far, the MS operation will result in lower indoor RH which should eliminate the need for an inefficient dehumidifier.
2. MS off and 60 cfm OA to return of SEER 13 central ducted fixed capacity system
3. SEER 13 central ducted fixed capacity with continuous exhaust ventilation including impact from scheduled clothes dryer and high flow capacity kitchen air exhausted from conditioned space to outdoors.
    a. The house code required ventilation will be at continuously exhausted at 60 cfm.

   b. Brief research will be conducted to provide guidance on residential clothes dryer and residential high capacity kitchen exhaust flow rates and operational schedules.
   c. The dryer and kitchen exhaust fans will be operated on a schedule and at a flow rate to be determined after preliminary research on typical run-time and flow rates.
4. Collect additional seasonal data for Phase 1 Test 3, 60 cfm OA ducted to return of variable capacity SEER21 central ducted system. This test uses a vent rate close to average size homes and was the most efficient of Phase 1 testing.

It is expected that rotating through each proposed experiment on approximately six-day cycles will result in about 8-9 cycles for each experiment. Actual times will be adjusted depending upon weather conditions. Past experience has shown this method to be effective at collecting data for several tests across a wide variety of outdoor conditions that results in similar sets for comparison. *The actual number of test configurations that can be effectively evaluated in Phase 2 depend upon being able to begin testing September 1, 2014 and continue through late April 2015. High quality RH control evaluations are also dependent upon adequate swing-season type weather periods for each test configuration. Should limitations outside FSEC control occur, such as shorter contractual time than proposed here or limitations in variable weather conditions for each test, then we recommend that priority be given to three tests. The three tests to be given priority are proposed above as Phase 2 Test 1, Test 2, and Test 3*.

Goals, Expected Outcome, and Impact on the Code: Building codes and various national programs are pushing buildings toward specific levels of building tightness and mechanical ventilation. It is expected that ventilation rates in new Florida homes will increase and that the indoor RH is likely to increase. The data collected from the proposed experiments will be examined to characterize approaches and technologies which yield energy-efficient and cost-effective humidity control in mechanically ventilated homes. The advantages of the proposed experimental work are to build upon earlier work to collect additional data allowing a more comprehensive analysis than possible in Phase 1. A Phase 2 final report will be prepared that explains the purpose, methods, and results of the research. The final report will include recommendations on methods of minimizing elevated indoor humidity potential in mechanically ventilated buildings. It will also report economic analysis of tested systems that focusses on first cost, and payback periods. From the recommendations of this report, it is expected that the Florida codes may be modified or adjusted to take into account the best approaches to energy-efficient and cost-effective control of humidity in the Florida climate.

<u>Budget:</u> The estimated budget is $31,500. The phase 2 budget reflects the increased scope and costs of supplies for exhaust ventilation work requested by the Energy TAC compared to what had been originally proposed in December 2013. The Florida Energy TAC has requested specifically that exhaust ventilation testing be expanded to include impact from clothes dryer and high flow kitchen exhaust fans in addition to future code required exhaust ventilation rates. This requires additional equipment and labor to implement.

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