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

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Definition of the Problem: The thermal efficiency of homes has improved in recent decades. Some of those improvements have reduced the amount of sensible heat entering the house (sensible heat is associated with temperature rise while latent heat is associated with water vapor in the air). Wall and attic insulation, improved duct insulation, improved windows, and better shading of windows and houses have reduced sensible heat entry into the home, which have brought about smaller A/C systems and cause the A/C system to operate less. Smaller A/C units and reduced operation can lead to a reduction in water vapor removal, and the potential for an increase in indoor humidity.

On the other hand, two other factors tend to counter this. The first is that more electronic devices (computers, TVs, video games, etc.) are operating in homes producing considerable internal sensible heat and extended A/C system operation. The second is that natural air infiltration has declined dramatically in recent decades. Typical new homes have declined in air leakage from about 22 ACH50 (air changes per hour at 50 pascals of pressure; a blower door test result) in the 1950s to about 5 ACH50 in recent years. Since about 85% of the cooling load associated with air entering from outdoors during hot and humid weather is latent heat (water vapor) and only about 15% is sensible heat, the tightening of homes has greatly reduced the amount of water vapor that must be removed by the air conditioning system. Tightening of duct systems has also substantially reduced the amount of water vapor entering the house.

Recent versions of the Florida Building Code have addressed most of the 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 such tightly constructed buildings. Thus the need arose to provide designed ventilation to homes by means of mechanical ventilation, primarily applying the ASHRAE 62.2 Standard for residential 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, which basically means that all houses will be required to have mechanical ventilation.

Mechanical ventilation reintroduces a considerable portion of the outdoors-to-indoors air exchange that was eliminated by house tightening. In addition, the new ASHRAE Standard 62.2 (2013 version) goes even further by increasing the required amount of fresh air for homes. The net result of the reduction in envelope sensible loads, increased internal sensible loads, and increase in ventilation-induced latent loads is that some A/C systems may not adequately control indoor humidity.

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.

Scope of Work:

Task 1: Our research team proposes to perform a review of literature, examine existing experimental data, and implement an assessment of the energy efficiency and cost-effectiveness of various approaches to managing the latent load in homes. The primary task is to identify approaches and technologies which can achieve energy-efficient latent cooling in light of requirements that increased ventilation rates be implemented in Florida homes. A report will be prepared that summarizes the findings of this analysis and presents recommendations for energy-efficient and cost-effective approaches and technologies to achieve indoor RH control.

Task 2: A second task is also proposed. Experiments will be implemented in a lab building to assess the resulting indoor RH and energy consumption (with measurement of temperature and humidity, and system energy consumption) when various latent load management approaches and equipment types (including a dehumidifier) are implemented and various levels of ventilation air are introduced to the space. It should be pointed out that this research can be performed in a cost-effective manner because lab, equipment, and data collection instrumentation is largely in place and ready to go[1]. Experimental test configurations are proposed below. , Final test configurations may, however, be adjusted after completing Task 1. The following experiments are proposed to examine energy and RH outcomes using a variety of experimental variations, which is likely to include the following:

- Central ducted fixed capacity system vs high efficiency mini-split heat pump
- Ventilation air delivered directly to the return or mixed in the space
- Outcomes when exhaust air is the method of providing ventilation
- A dehumidifier will be used as backup to various test configurations to manage indoor RH when the approach/technology being examined cannot achieve acceptable indoor RH
  - o Dehumidifier energy will be included in the overall energy accounting for each RH control approach
- Other RH control approaches may also be examined
  - o It may be possible to examine the humidity control performance of a new-generation variable capacity central ducted system.

Goals, Expected Outcome, and Impact on the Code: This research is proposed in two parts.

1. A Task1 report will be prepared that summarizes the pros and cons of various approaches to indoor humidity control, with a focus on the solutions that are most energy and cost-efficient. The report will also address the issue of ventilation and optimized humidity control. It will summarize the findings of literature and field/lab review. Recommendations will be presented on ways of avoiding elevated indoor humidity, approaches to system design, and selection of systems/technologies that can achieve energy efficient humidity control. 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.
2. The data collected from the proposed experiments will be examined to characterize approaches, technologies, and solutions which yield the most energy efficient and cost-effective humidity control, in light of increasing requirements for mechanical ventilation. The advantages of the proposed experimental work are that 1) it is now clear that the Codes and various national programs are pushing buildings toward specific levels of ventilation and 2) there are new approaches to energy-efficient humidity control that have not been closely examined and are now available to address energy, RH control, and indoor air quality. A Task 2 final report will be prepared that explains the purpose, methods, and results of the research. A summary will include recommendations for the most energy- and cost-effective approaches of controlling indoor humidity.

Budget: Budget total is $55,591; Task 1 $24,500 and Task 2 $31,091.

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[1] Currently, the FSEC Building Science Lab is configured with HVAC systems and data collection equipment that is largely ready, with modest modifications, to carry out these proposed experiments. It is likely, however, that the lab may be committed to other research within the near future and the opportunity to perform these experiments in a timely and cost-effective manner may be lost.