Date: February 15, 2018

Interim Report for the Period thru February 15, 2018
Submitted to
Department of Business and Professional Regulations
Office of Codes and Standards

Grantee Name:	University of Central Florida/Florida Solar Energy Center		
Grantee Address:	1679 Clearlake Road, Cocoa, FL 32922		
Grantee's Grant Technical Manager:	Charles Withers	*Telephone No:*	321-638-1419
Reporting Period:	Through February 15, 2018 (Interim Report)		
Project Number and Title:	**#B21551; Investigate Energy Impact of Whole-House Dehumidifier Location**		

Provide a summary of Project accomplishments to date. (Include comparison of actual accomplishments to the objectives established for the period. If goals were not met provide reasons why

Project Overview

The primary goal of the Energy Impact of Whole-House Dehumidifier Location research project is to determine if there are energy impacts upon home space conditioning energy in Florida homes depending upon how a dehumidifier is ducted and where it is installed. Space conditioning energy is air conditioning energy as well as dehumidifier energy use.

Task Updates

Scope of Work Item (a). Alternate the method of dehumidifier air distribution for the three cases identified in Scope of Work item (b). Testing to be completed in FSEC Building Science Lab.

Work completed on this task from start of contract through February 15, 2018 includes:

- Acquisition of all necessary equipment and materials to complete work. This included an Ultra-Aire 70H whole-house dehumidifier rated at 70 pints/day removal, 3 Vaisala temperature and relative humidity sensors, as well as materials needed for air distribution ducting and internally generated sensible and latent loads. The dehumidifier was donated by Therma-Stor with the helpful assistance of company engineering consultant, Mr. Andy Ask.
- Completed installation of whole-house dehumidifier, condensate collection, and associated air

distribution systems for all three test configurations.

- All required data collection sensor and data acquisition system installation was completed as well as necessary associated datalogger programming.
- Full data collection began December 16, 2017. Some normal occasional interruptions to testing have occurred such as calibration and testing work. All three test configurations have been implemented so far, however the weather has been very mild with notable dry and cold periods. Such periods severely limit opportunities to measure impacts on dehumidifiers. This has been planned for by expecting to rotate through each test during different weather conditions. We expect ample time to test through warmer weather conditions in the coming months.
- Building and duct tightness tests were completed. The normalized building tightness was found to be 2.4 ACH50. There was no measurable duct leakage to outdoors (CFM25out=0).
- Internal sensible and latent loads have been established within the lab. More details on this are provided in the next three paragraphs.

Internal sensible loads were set at about an average of 4,200 btu/h through the use of interior lights and space heating. Based upon a Manual J8 sizing calculation, this is an amount appropriate for the installed central air conditioner (35,400 btu/h rated cooling capacity) during the testing configurations on a design day.

Based upon the measured building tightness for a 3 bedroom 2,000 ft^2 home, ASHRAE 62.2-2013 would call for a total ventilation rate of 90 cfm, of which 70 cfm would come from mechanical ventilation and 20 cfm from infiltration. Due to the highly variable moisture content in outdoor air in east central Florida during winter and spring, mechanical ventilation will not be added. Instead, moisture will be generated internally at a rate of 60 pounds per day representing about 70°F dewpoint. This rate will be delivered as long as outdoor temperatures average around 68°F or greater. This moisture rate represents 48 pounds per day that would have come in from mechanical ventilation (at 70°F dp) and another 12 pounds per day internally generated by occupant activities.

Because 60 pounds of latent is abnormally high during cool weather, internal latent generation was reduced during December 16-February 10. Internal moisture was generated at a rate of 15 pounds per day generally when daily average outdoor temperatures were about 65°F or colder. Internal moisture was generated at a target of 30 pounds per day when daily average outdoor temperatures were between about 60°F-72°F.

Next steps include continuing monitoring data collection to ensure that equipment and sensors continue to operate as expected. Monitoring of weather patterns will also occur to help inform when to change from one test configuration to the next in an effort to obtain similar sets of test conditions among the different tests over time.

<u>Scope of Work (b). Dehumidifier distribution shall be configured to do the following 3 tests:</u>

1) Air to and from return side of central cooling system with gravity damper to avoid short-circuiting of dehumidifier air.

2) Air to and from supply side of central cooling system with gravity damper to avoid short-circuiting of dehumidifier air.
3) Stand-alone dehumidifier with air to and from the central main body of building.

Work completed on this task from start of contract through February 15, 2018 includes:

- These test configurations have been chosen with input from Andy Ask and based upon various manufacturer recommended options for dehumidifier installations.
- All required equipment has been installed. A remote dehumidistat (not on board dehumidifier) was installed next to the central cooling system thermostat where local temperature and RH are monitored. This location is not within close proximity of supply distribution or internally generated loads.
- Interior central cooling temperature is set to be controlled at 77°F. This results in an interior average temperature of about 76°F during typical cooling season. Relative humidity is set to control the dehumidifier at 50% RH.
- Air flow and static pressure testing has been completed to ensure that dehumidifier operates within manufacturer specifications for each of the three test configurations.
- Each test configuration has been tested during at least one set of weather conditions and has demonstrated adequate functionality of the experiments to evaluate energy impacts as intended. To date, 62 days of data collection have occurred. Some of these days will be screened out due to interruptions resulting from change-over between test configurations. The number of full days testing so far for each configuration is shown below:
    - Stand-alone, 24 days; much of this period was during very cold and dry weather.
    - Dehumidifier to/from central return, 18 days; periods of cold dry weather
    - Dehumidifier to/from central supply, 13 days; periods of mild dry weather

Next steps include continuing scheduling of each test configuration as far into May 2018 as possible prior to delivery of the final report.

<u>Scope of Work (c). For each configuration tested, the following measurements shall be made:</u>

1) Temperature and humidity of the entering and leaving air of the dehumidifier and AC system.
2) Energy use of the dehumidifier and AC system.
3) Condensation removal of dehumidifier and AC system.
4) Outdoor air temperature and humidity

All necessary sensors have been installed. Work completed on this task from start of contract through February 15, 2018 includes:

- Vaisala Temperature and relative humidity HMP60 sensors have been installed. These sensors have a manufacturer stated accuracy of +/- 3% of reading. Thermocouples are also used to measure temperatures. These have accuracy of 0.2°F.
- Continental Control Systems Wattnode power meters with manufacturer stated accuracy of +/- 1% have been installed to measure dehumidifier energy, central AC system, internal generated sensible loads.
- Condensate removal of dehumidifier and AC system is being measured by calibrated tipping buckets at each appliance. Tipping buckets were calibrated by mass of water measurement collected along with the pulse output signal. Stated accuracy is 3% or better.

- Outdoor air temperature and humidity are measured by Vaisala HMP60 sensors.
- Airflow stations measure central system airflow and dehumidifier airflow. These are measured using digital manometers with stated pressure accuracy of +/- 1%. Dehumidifier airflow calibration was performed using a TSI Model 8390 Bench Top WindTunnel accuracy +/- 2%.

Samples of data collection are shown in Figures 1 and 2 below. Figure1 shows the daily average indoor and outdoor conditions beginning December 15, 2017 up to February 9, 2018. Indoor RH is being maintained between 45%-50% except when very cool dry weather decreases indoor RH to around 40%.

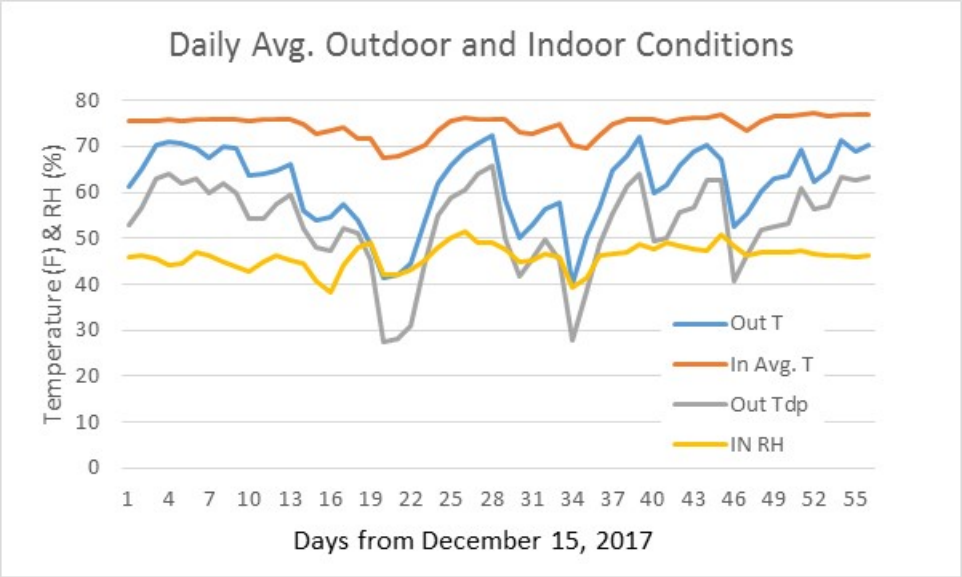

Figure 1. Measured outdoor and indoor conditions December 15-February 9, 2018.

Figure 2 shows the combined daily energy use of the dehumidifier and the central cooling system plotted against the daily average outdoor temperature. There are three primary test configurations, however results are shown for each of these at two different internal moisture generation rates of 15 pounds per day (squares) and 30 pounds per day (circles) provided by measured water evaporated into the air. Most of the remaining data is expected to be at 60 pounds per day provided by an ultra-sonic humidifier which was purchased by FSEC and received January 12. The 60 pound per day rate testing was just begun February 10 (results not yet available).

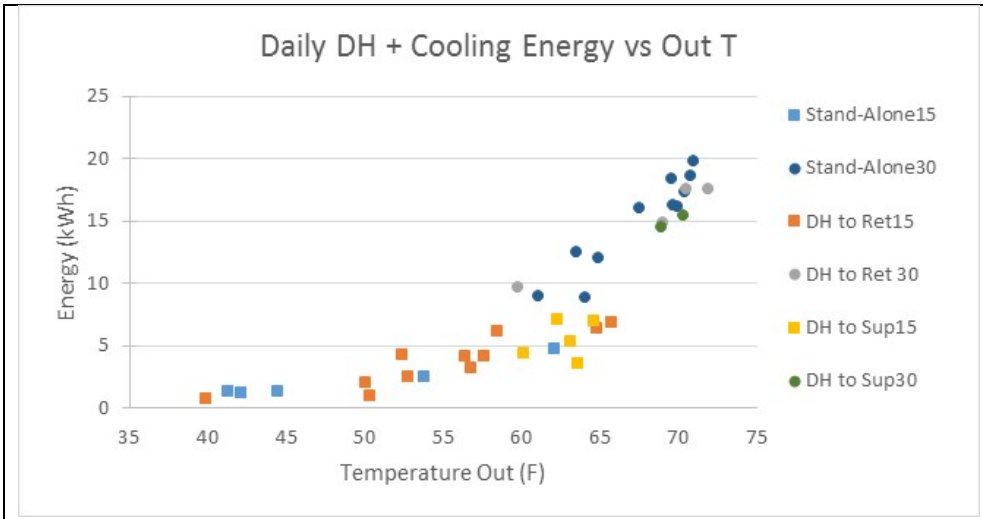

Figure 2. Measured daily total space conditioning energy plotted against daily average outdoor temperature.

Data in Figure 2 show the expected trend for increase in space conditioning energy as outdoor temperature increases. Most of this is space cooling energy particularly for days with daily average temperatures greater then 65°F.

The dehumidifier power is rated at 580 Watts and the air conditioning system is rated at 3,000 Watts. While the DH rated power is 19% of the central cooling, the actual proportion of energy it uses depends upon weather conditions. So far, the dehumidifier daily energy use has ranged from 80% of total space conditioning energy to as low as 4% of daily total energy. The trend of higher proportion of dehumidifier energy use during lower outdoor temperatures and lower proportion during warmer weather is as expected.

Next steps will require in-depth analysis of energy impacts across a wider range of outdoor weather conditions particularly at the internal moisture generation rate of 60 pounds per day. It is too soon to begin drawing any further conclusions at this time. As warmer conditions increase cooling loads and permit longer dehumidifier and central space cooling system runtimes at comparable sets of conditions, we will evaluate if there are any measureable space cooling and dehumidifier performance differences among the three test configurations.

<u>Scope of Work (d). Utilizing lab results, FSEC shall simulate energy use based upon the physical location of the dehumidifier located in a garage, conditioned indoor space, and attic location accounting for any duct gain/loss effects. FSEC will modify EnergyGauge to use it for simulations.</u>

No work has been completed on this task at this time.

Next steps will include setting up simulation home to evaluate the required locations after an adequate amount of experimental data has been collected. It is estimated that this work will begin around early May 2017.

Deliverable Update:

Deliverable #1 Interim Report

Completed with the submission of this February 15, 2018 Interim Report.

Deliverable #2 Final Report

Due no later than June 1, 2018

A. ***Provide an update on the estimated time for completion of the project and an explanation for any anticipated delays.***

No delays in meeting deliverable due dates are anticipated at this time.

B. ***Provide any additional pertinent information including, when appropriate, analysis and explanation of cost overruns or high unit cost***

No cost overruns are anticipated.

C. ***Identify below, and attach copies of, any relevant work products being submitted for the project for this reporting period (e.g. report data sets, links to on-line photographs, etc.)***

No products have been produced as of the completion of this report.

D. ***Hours and budget update***

Not available at this time

This report is submitted in accordance with the reporting requirements of Work Authorization not to exceed $32,400 dated November 15, 2017.

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Signature of the Grantee's Grant Manager Charles Withers	Date