

2016 Winter Conference



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Conference Paper Session 12 Heat Pumps and Unitary Equipment: Optimizing Efficiencies

Annual Performance of a Two-Speed, Dedicated
Dehumidification Heat Pump in the NIST Net-Zero
Energy Residential Test Facility

Orlando, Florida

Learning Objectives

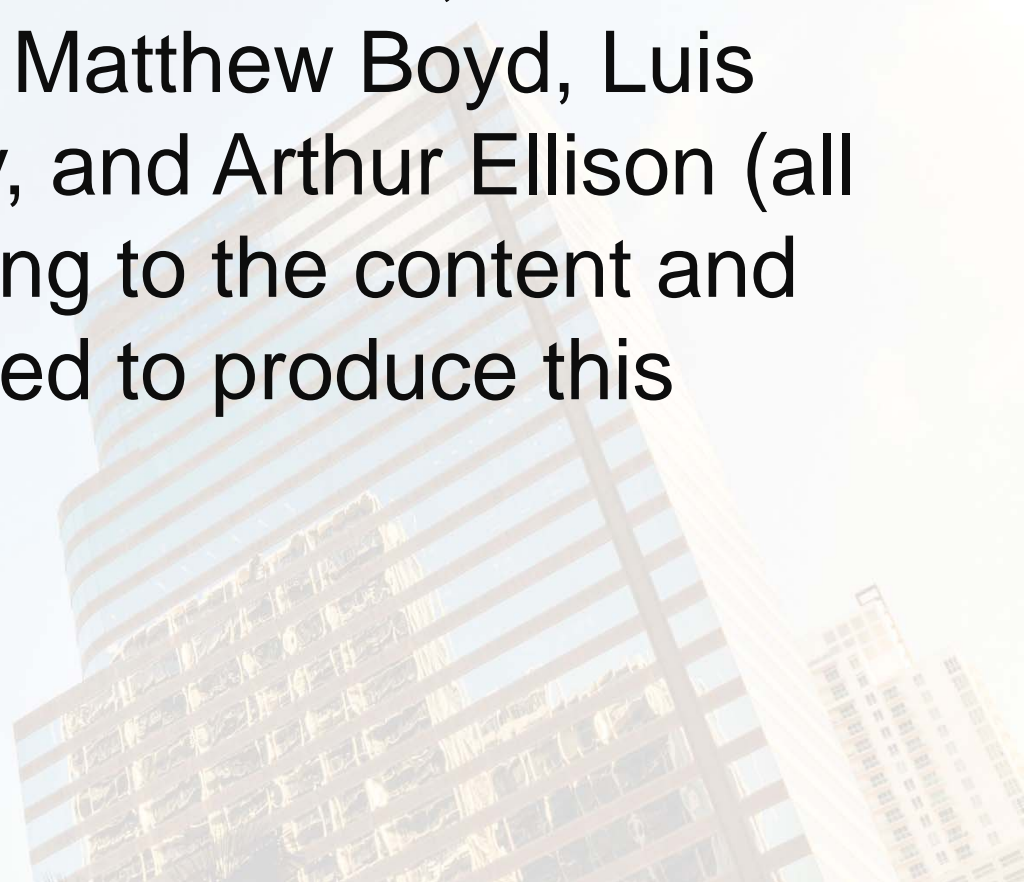
- Become familiar with the characteristics of a net-zero home and its mechanical systems
- Learn about the cooling and heating performance of a dedicated dehumidification heat pump

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Outline/Agenda

- NIST Test House
 - Dedicated Dehumidification Heat Pump
 - Heating and Cooling Performance
 - Dehumidification Performance
 - Effect of Standby Energy Demand
 - Heat Recovery Ventilator Impact
 - Overall Performance Summary
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NIST Net-Zero Energy Residential Test Facility

- Two stories having 2715 ft² (252 m²) of living area
- 1453 ft² (135 m²) fully conditioned basement
- 1162 ft² (108 m²) conditioned but unoccupied attic
- R-72 roof insulation
- R-45 walls
- R-5.3 windows (U=0.19)
- R-23 basement walls
- R-35 rim joist (spray foam)
- R-10 basement slab
- Manual J Cooling Load=16.5 kBtu/h (4.8 kW), Heating Load=21.2 kBtu/h (6.2 kW)



- 10.2 kW solar photovoltaic system
- Solar thermal hot water system with heat pump water heater

<https://www.youtube.com/watch?v=JXBmYb9hNdg>

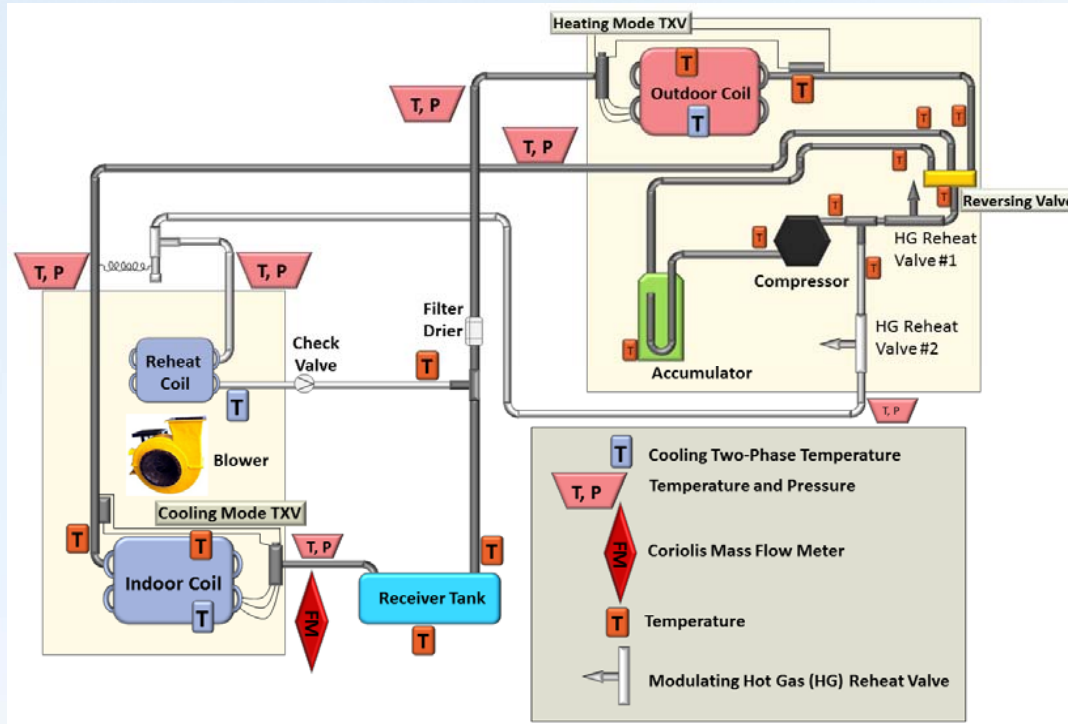
NZERTF (continued)

Occupant simulation

- Computer control of facility from the detached garage
- Family of four sensible and latent loads are simulated: two adults and two children
- Water usage, appliance and plug loads are simulated based on DOE Building America Reference Home



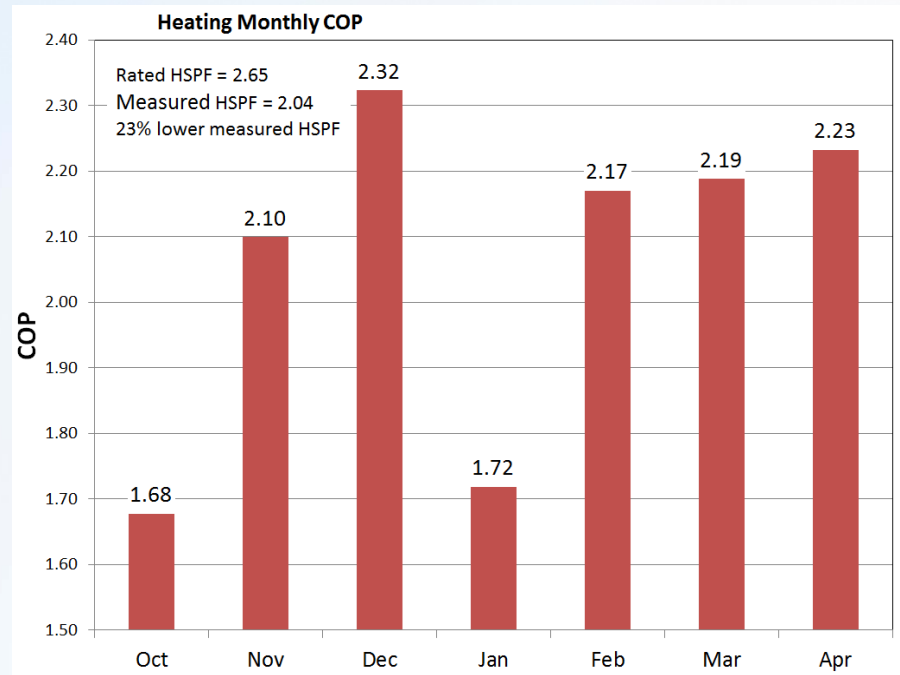
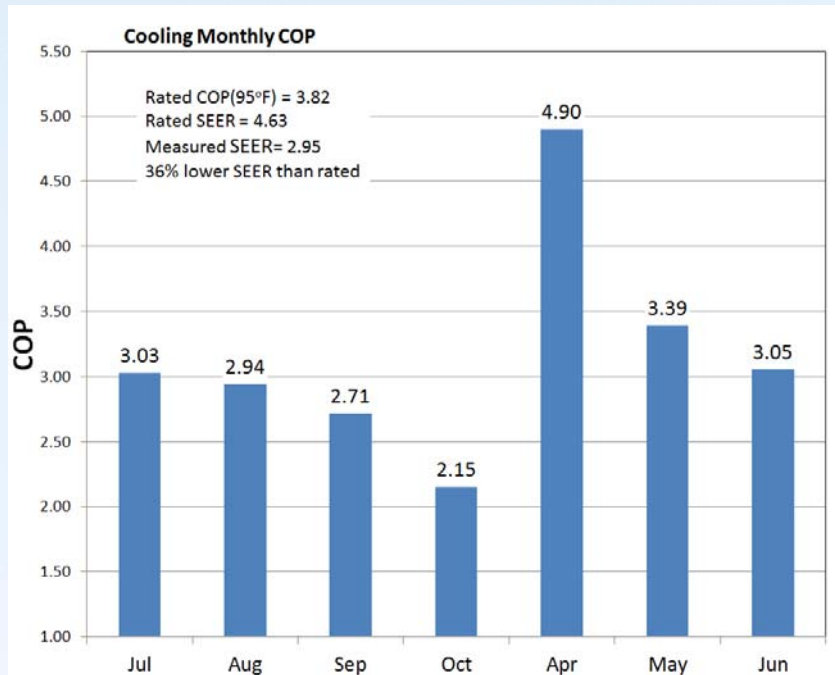
Dedicated Dehumidification Heat Pump



- Two-speed compressor with ECM on indoor blower
 - Rated cooling capacity of 26 kBtu/h (7.6 kW), EER=13.05, SEER=15.8
 - Rated heating capacity of 26.6 kBtu/h (7.8 kW), HSPF=9.05
- 3rd Pipe for hot gas reheat of indoor supply air using two modulating valves

HP Cooling and Heating Performance

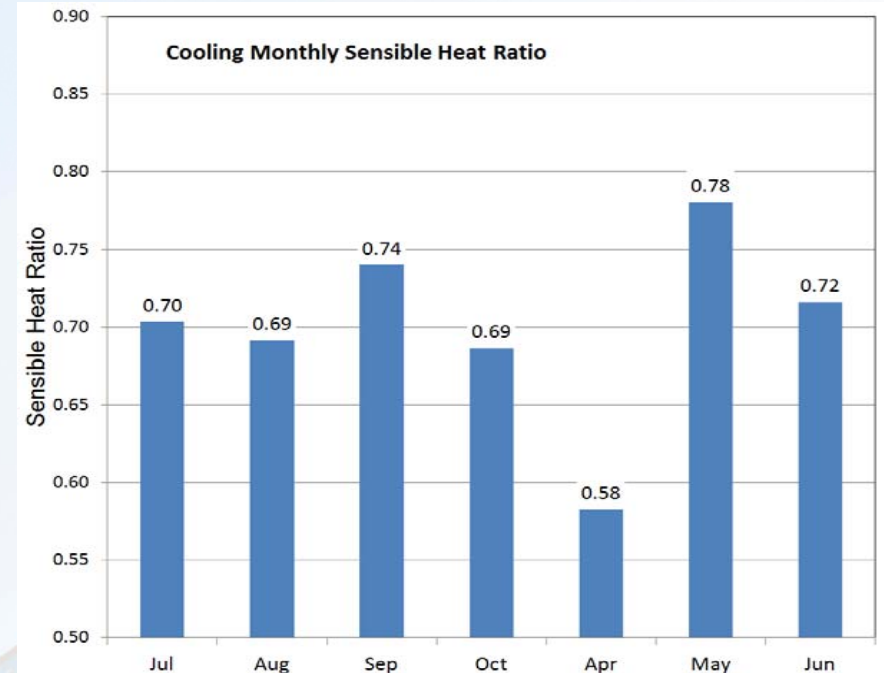
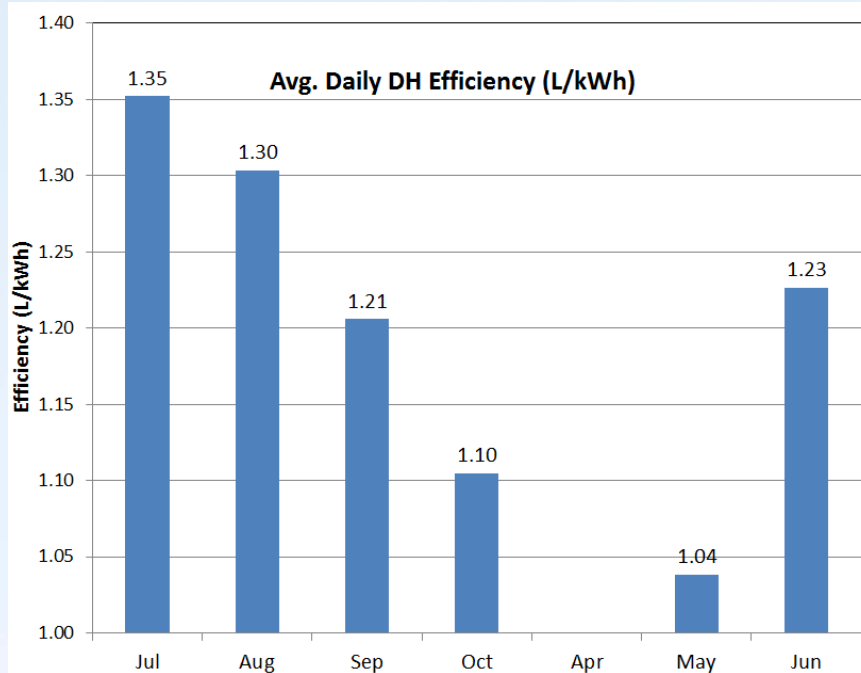
1st Year of Operation from July 2013 to June 2014



Thermal Loads

Cooling, kWh						
Jul-2013	Aug-2013	Sep-2013	Oct-2013	Apr-2014	May-2014	Jun-2014
2123	1621	937	306	67	603	1560
Heating, kWh						
Oct-2013	Nov-2013	Dec-2013	Jan-2014	Feb-2014	Mar-2014	Apr-2014
56	832	1351	2157	1635	1423	253

Dehumidification Performance



Active Dehumidification with Reheat Runtime (min)						
Jul-2013	Aug-2013	Sep-2013	Oct-2013	Apr-2014	May-2014	Jun-2014
9891	9510	4198	2280	0	829	7989
Active Dehumidification Electrical Energy (kWh)						
246	246	114	60	0	22	204

Standby Power Demand

Cooling Standby Energy (kWh) and Percentage of Time in Standby Mode

Jul-2013	Aug-2013	Sep-2013	Oct-2013	Apr-2014	May-2014	Jun-2014
12.6, 34%	17.2, 46%	23.4, 64%	25.6, 87%	3.1, 99%	30.5, 82%	16.2, 45%

128.6 kWh standby cooling, 5.2% of total cooling electrical energy

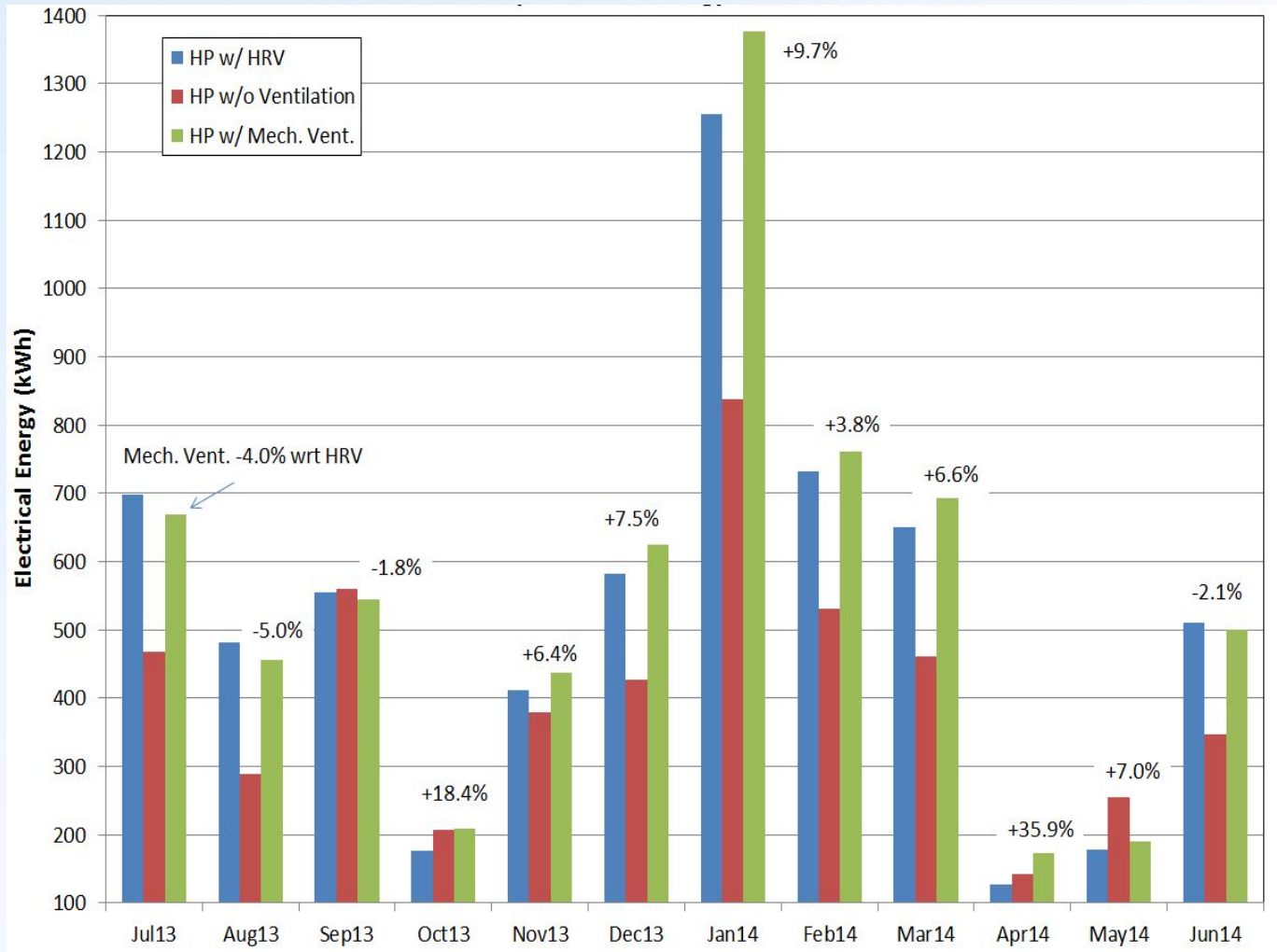
Heating Standby Energy (kWh) and Percentage of Time in Standby Mode

Oct-2013	Nov-2013	Dec-2013	Jan-2014	Feb-2014	Mar-2014	Apr-2014
6.8, 98%	25.2, 72%	21.3, 59%	14.3, 38%	14.9, 45%	21.5, 59%	29.4, 93%

133.2 kWh, 3.5% of total heating electrical energy



Effect of Heat Recovery Ventilator



7 % savings in heat pump energy use on average over the year compared with ventilating without heat recovery

Overall Results

- Heat pump system consumed 6225 kWh of energy, 48 % of total site energy (13039 kWh) for the first year
- HP Standby energy was 262 kWh, 2% of total site electrical energy
- Dedicated dehumidification consumed 892 kWh, 14.3 % of heat pump energy or 6.8 % of total site energy (maintained 50% RH)
- Heating mode electrical resistance heat consumed 1157 kWh (352 kWh defrosting and 805 kWh heating), 12.9 % of heat pump energy, 6.2 % of total site energy
- Thermostat utilized too much electrical resistance heating and was replaced for the 2nd year study
- A sensible heat ratio of 70 % was needed in the cooling mode to maintain indoor conditions at 50 % RH

Bibliography

- Payne, W. V., 2016, *Annual Performance of a Two-Speed, Dedicated Dehumidification Heat Pump in the NIST Net Zero Energy Residential Test Facility*, (OR-16-C040), 2016 ASHRAE Annual Conference, Orlando, FL, January 23- 27.



Questions?

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