Dehumidification Systems Research Results

by
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USDOE Building America Program

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Building America program partner:

Production homebuilder
Pulte Homes
Houston, TX

Once structural and fire requirements are met, moisture is the #1 enemy of the durability of a house.

Durability can be insured with respect to moisture by:

- Draining rain and snow melt out of the structure and to the ground
- Providing a building envelope design that can dry should it get wet
- Preventing excessive pressurization and depressurization of occupied spaces and cavities
- Installing controlled mechanical supply ventilation systems, and dehumidification separate from cooling for humid climates

Purposes of mechanical ventilation

1. Point-source ventilation - Remove Pollutants
   - exhaust fans: kitchen, bath, laundry

2. Whole-building ventilation - Dilute Pollutants
   - supply, exhaust, or balanced fans distributing to all rooms

Climate Specific Design Solutions

Windstone community, Houston, TX
Pre-BA reference house

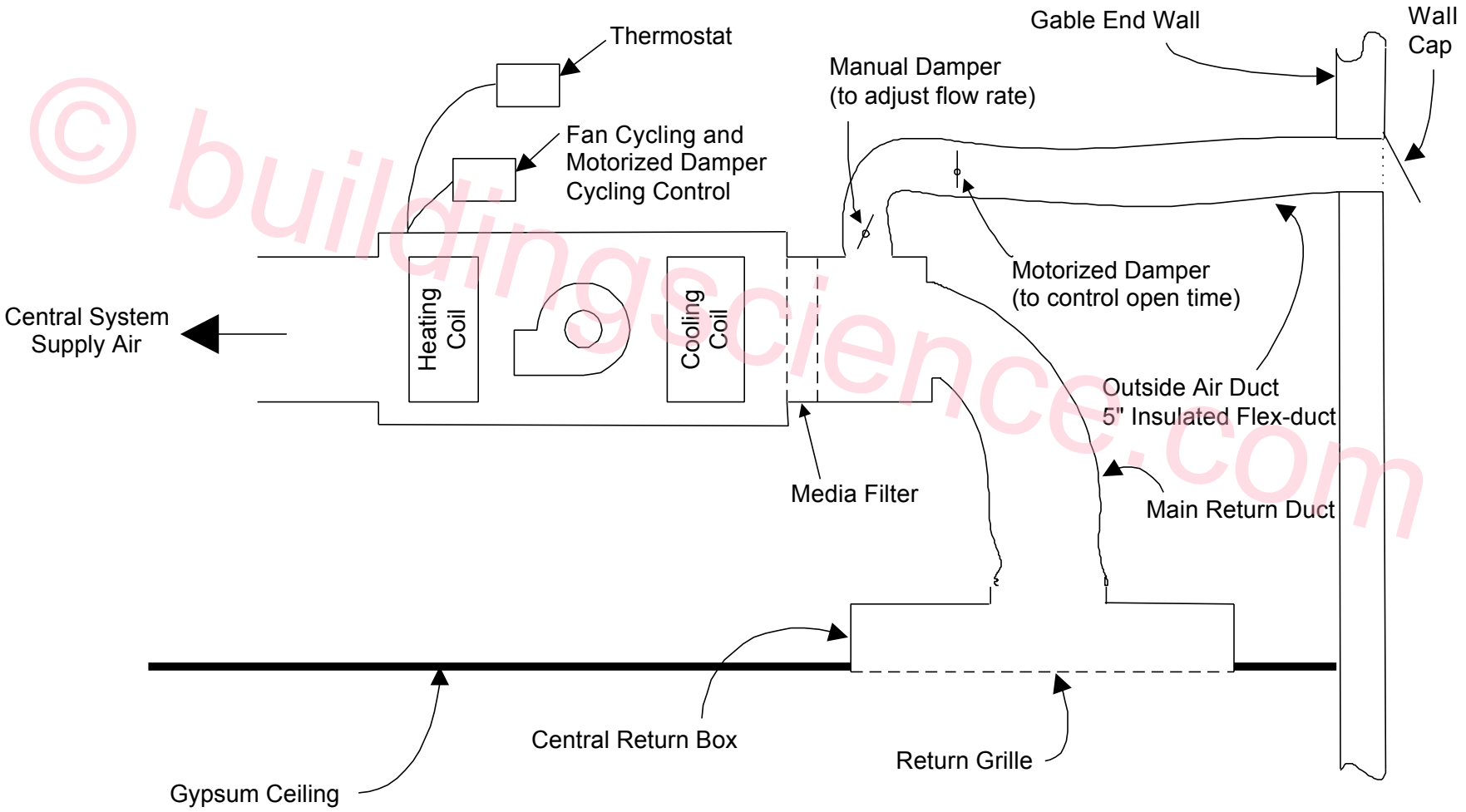
Creek Bend community, Houston, TX
Standard BA reference house

Creek Bend community, Houston, TX
Dehumidification separate from cooling house

Central-fan-integrated supply ventilation

Unvented-cathedralized attic configuration

Media filter and motorized damper

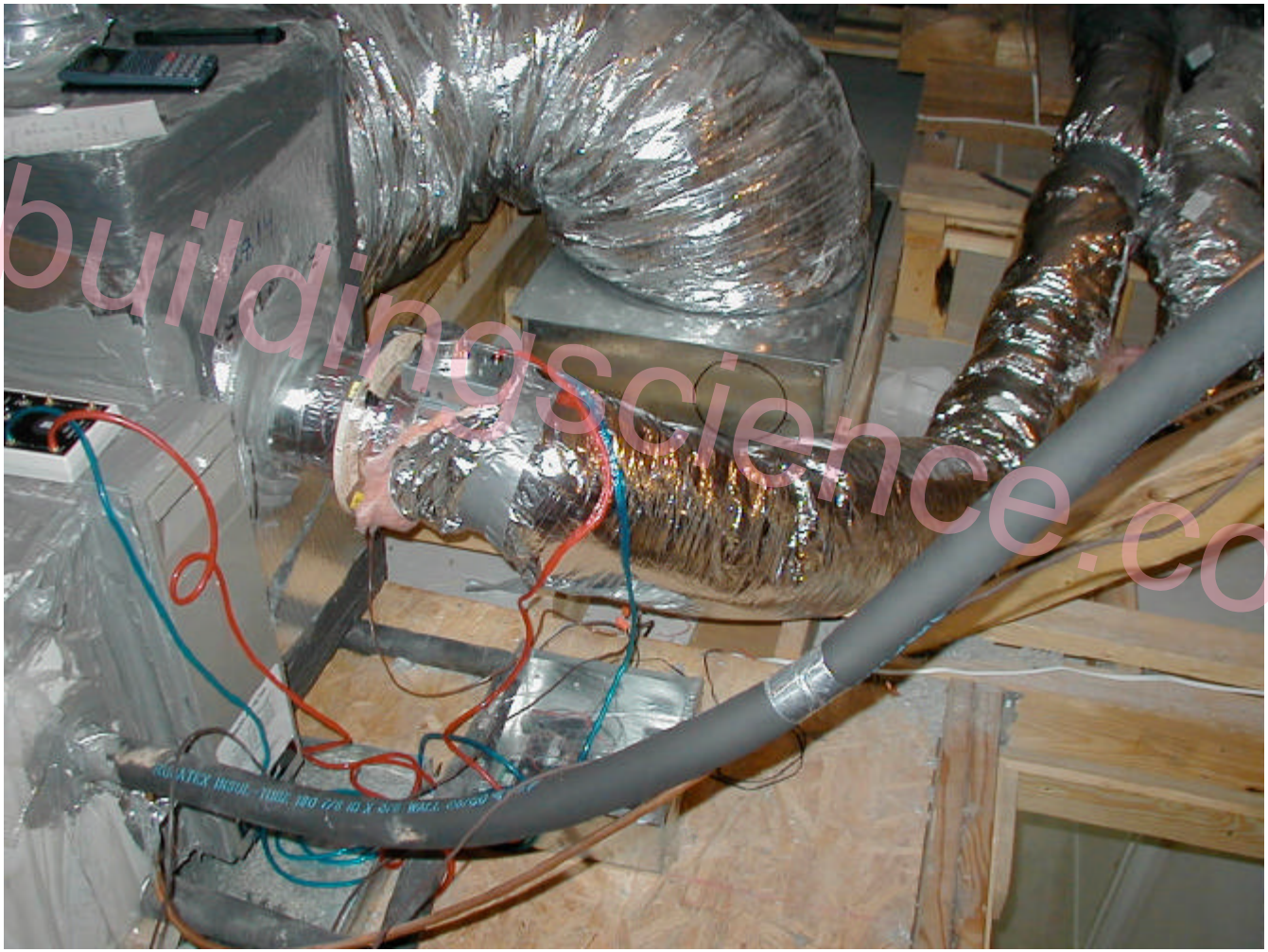


Central-fan-integrated supply ventilation

Air handler with media filter and outside air duct

Central-fan-integrated supply ventilation

Outside air duct with iris damper and motorized damper



Outside air flow rate control damper

Iris damper

Ventilation by Constant Operation of a Separate Fan

- Constant supply ventilation for
  - Ultra-Aire
  - Filter-Vent with ducted dehumidifier
  - ERV
- Determination of constant ventilation rate
  - Constant ventilation air flow was determined by 15 cfm for the master bedroom plus 7.5 cfm for each other bedroom
  - Systems set for about 30 cfm for 3 bedroom houses and 40 cfm for 4 bedroom houses

Ventilation by Intermittent Operation of the Central System Fan

- Intermittent supply ventilation for
  - Stand-alone dehumidifier in interior closet
  - Stand-alone dehumidifier in unvented-cathedralized attic
  - 2-stage compressor and ECM air handler with Thermidisat
  - Standard Building America

Ventilation by Intermittent Operation of the Central System Fan

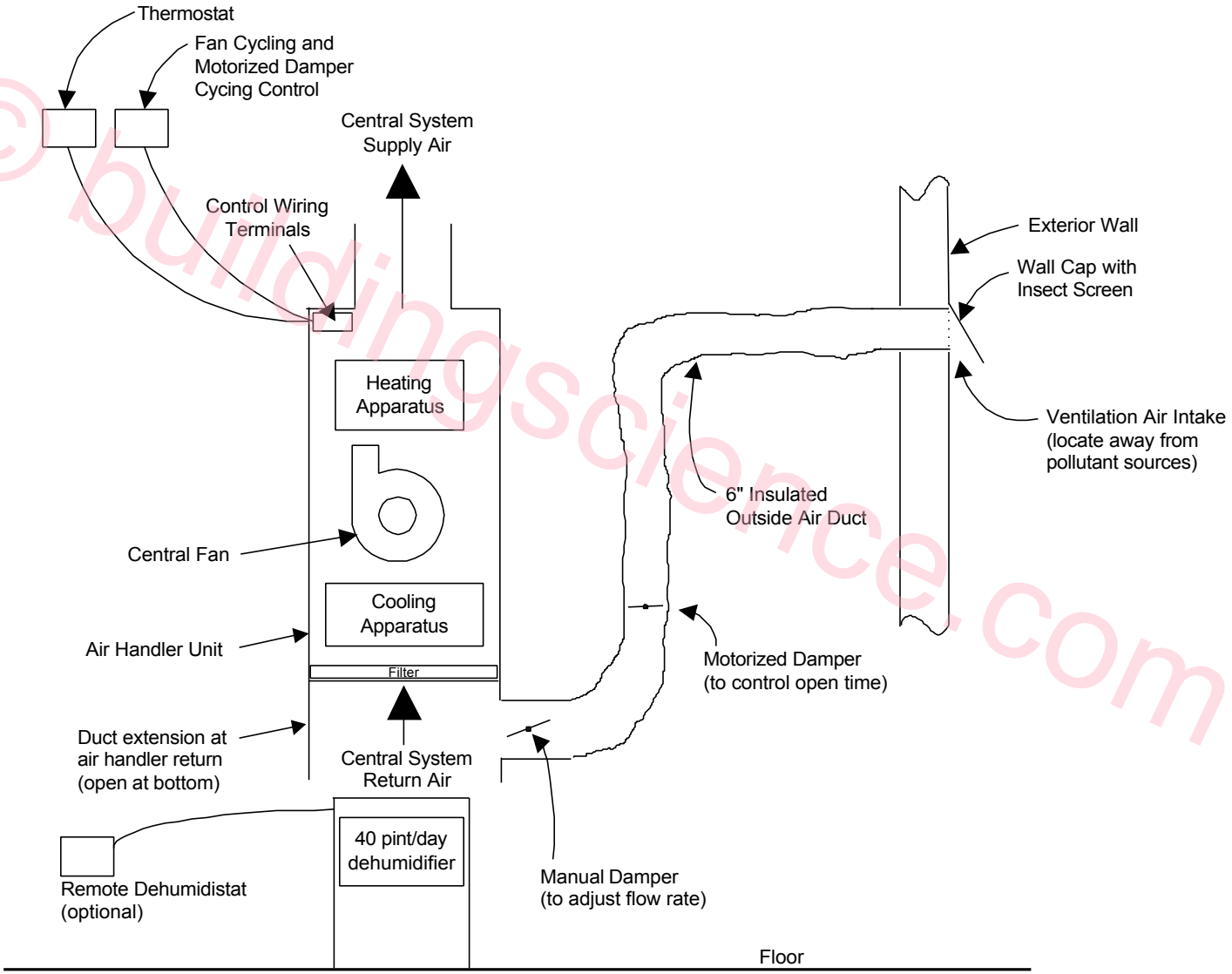
- Determination of intermittent supply ventilation rate
  - Intermittent ventilation rate was determined by the constant flow requirement, the fan duty cycle fraction, and a low-level of background infiltration when the blower is not on
  - Note: Regardless of the size of the house, the intermittent flow is never sized less than the constant flow requirement.

$$\dot{Q}_{in} = \frac{(\dot{Q}_{co}) - (\frac{I}{60} V (1 - f))}{f}$$

Central-fan-integrated supply ventilation

With dehumidification separate from cooling

Hot-humid climate, interior mechanical closet configuration



Stand-alone Dehumidifier In Interior Closet

Indirectly coupled with central air distribution system
Directly coupled to the living space

Stand-alone Dehumidifier In Conditioned Attic

Indirectly coupled with central air distribution system
Indirectly coupled with the living space

Filter-Vent and Ducted Dehumidifier

Directly coupled with central air distribution system

Filter-Vent and Ducted Dehumidifier

Directly coupled with central air distribution system

Ultra-Aire Ventilating Dehumidifier

Integrated with central air distribution system

Energy Recovery Ventilator

Directly coupled with central air distribution system

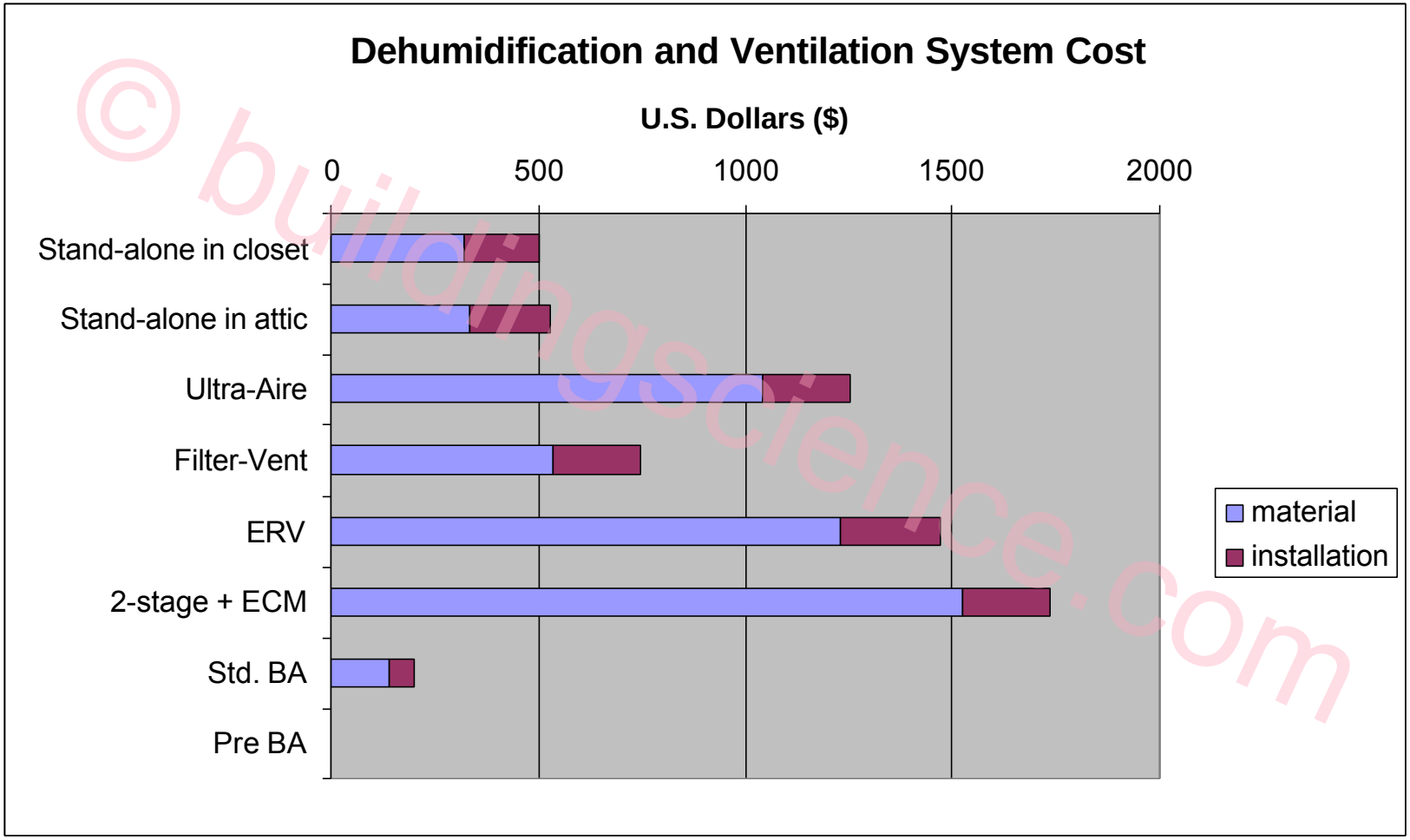
ERV Inside

Good reason for filtering outside air

2-stage compressor with ECM air handler and special thermostat

Electronically Commutated Motor (ECM) closeup

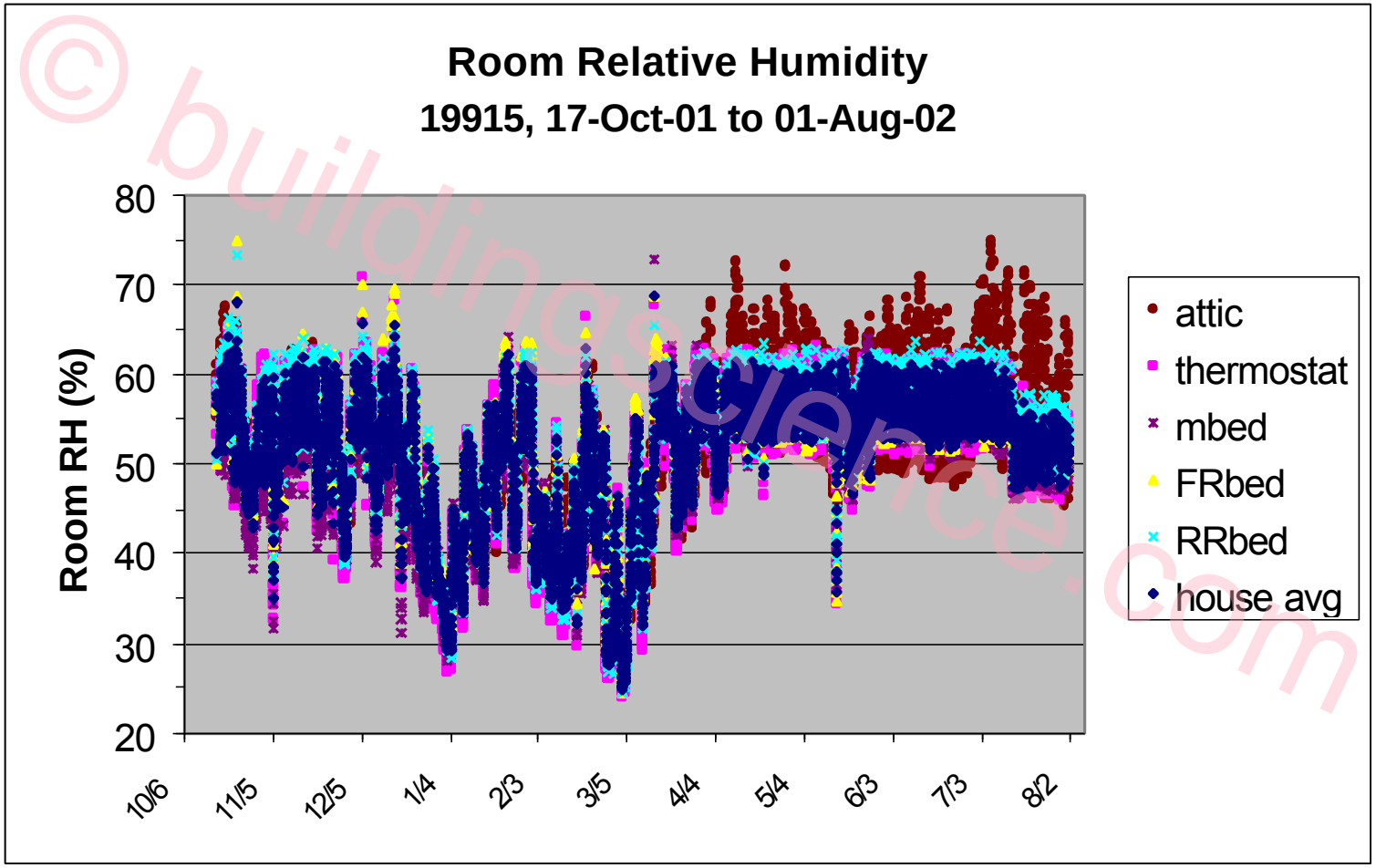
System's Material and Installation Cost



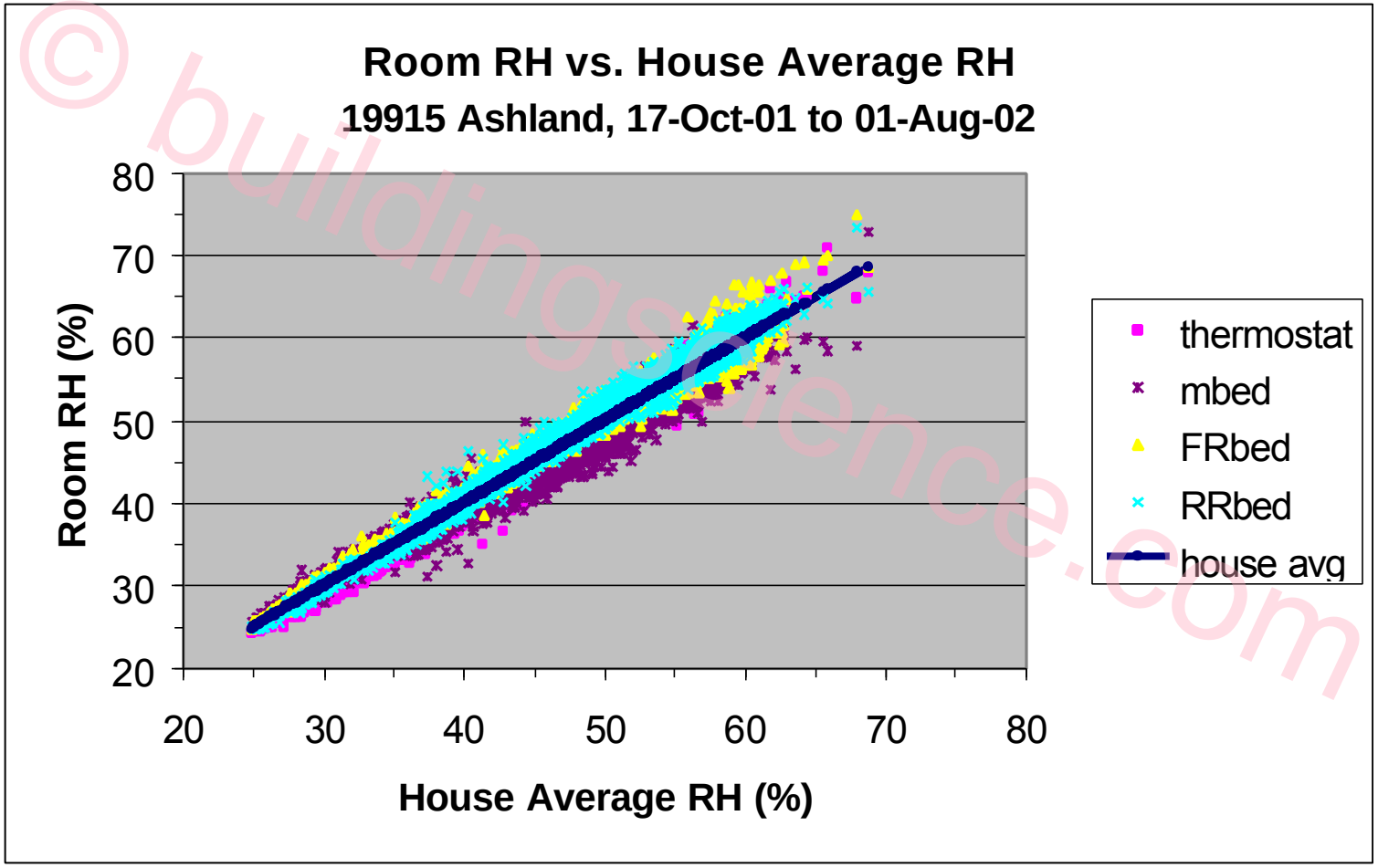
Systems and Monitoring Periods

	Environmental Monitoring Period	Total Days	Equipment Monitoring Period	Total Days
STAND-ALONE IN CLOSET				
19803 Ashland	Oct-01 to Jul-02	286	Oct-01 to Jul-02	301
19902 Ashland	Oct-01 to Jul-02	300	Oct-01 to Jul-02	300
STAND-ALONE IN ATTIC				
19950 Ashland	Jul-01 to Aug-02	366	Jun-01 to Aug-02	398
2731 Sunbird	Jan-02 to Aug-02	189	Oct-01 to Aug-02	303
ULTRA-AIR				
19915 Ashland	Oct-01 to Aug-02	288	Oct-01 to Aug-02	288
19938 Ashland	Jul-01 to Jul-02	365	Jul-01 to Jul-02	365
19923 Ashland	Oct-01 to Aug-02	288	Oct-01 to Aug-02	288
FILTER-VENT + STAND-ALONE				
19934 Ashland	Oct-01 to Jul-02	300	Oct-01 to Jul-02	300
19922 Ashland	Oct-01 to Aug-02	288	Oct-01 to Aug-02	288
19954 Ashland	Oct-01 to Jul-02	300	Oct-01 to Jul-02	300
ERV				
19926 Ashland	Jul-01 to Jul-02	365	Aug-01 to Jul-02	364
19942 Ashland	Oct-01 to Jul-02	287	Oct-01 to Jul-02	301
19930 Ashland	Nov-01 to Jul-02	272	Oct-01 to Jul-02	301
2-STAGE + ECM AHU				
19422 Colony Trail	Oct-01 to Aug-02	274	Oct-01 to Jul-02	274
STD BUILDING AMERICA				
2802 Sunbird	01-Jun-01 to 02-Aug-02	427	23-Mar-01 to 02-Aug-02	497
2814 Sunbird	01-Nov-01 to 01-Aug-02	273	23-Mar-01 to 01-Aug-02	496
19906 Ashland	31-Jul-01 to 01-Aug-02	366	31-May-01 to 01-Aug-02	427
PRE BUILDING AMERICA				
19622 Heritage Elm	02-Jun-01 to 01-Aug-02	425	Jun-01 to Aug-02 (parts)	320
4818 Cottage Stone	30-Jun-01 to 01-Aug-02	397	30-Jul-01 to 01-Aug-02	367
6263 Clear Canyon UP	02-Jun-01 to 01-Aug-02	357	21-Jul-01 to 01-Aug-02	386
DN			11-Jul-01 to 01-Aug-02	376

Ultra-Aire System
Environmental Monitoring



Ultra-Aire System
Environmental Monitoring



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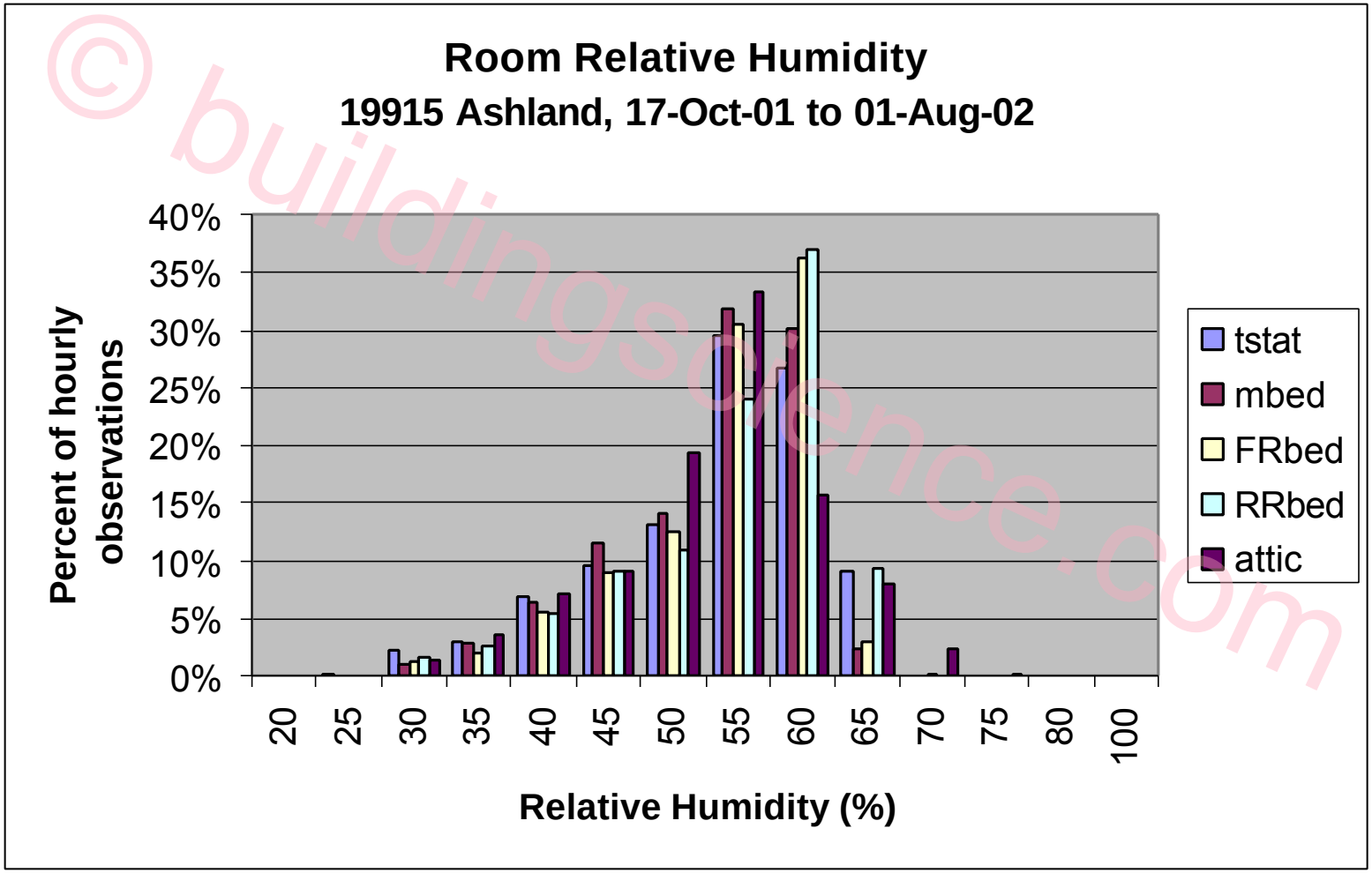

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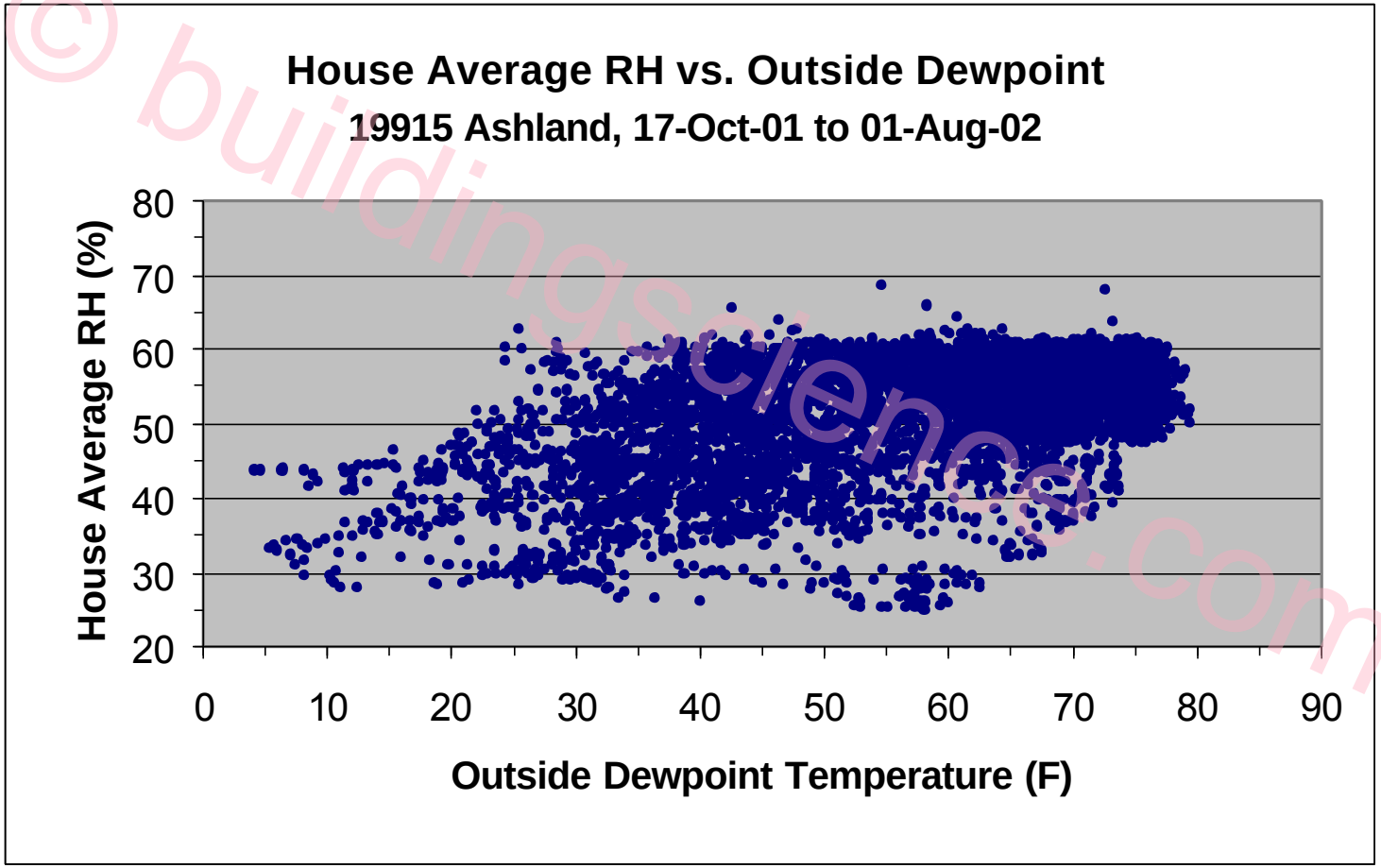
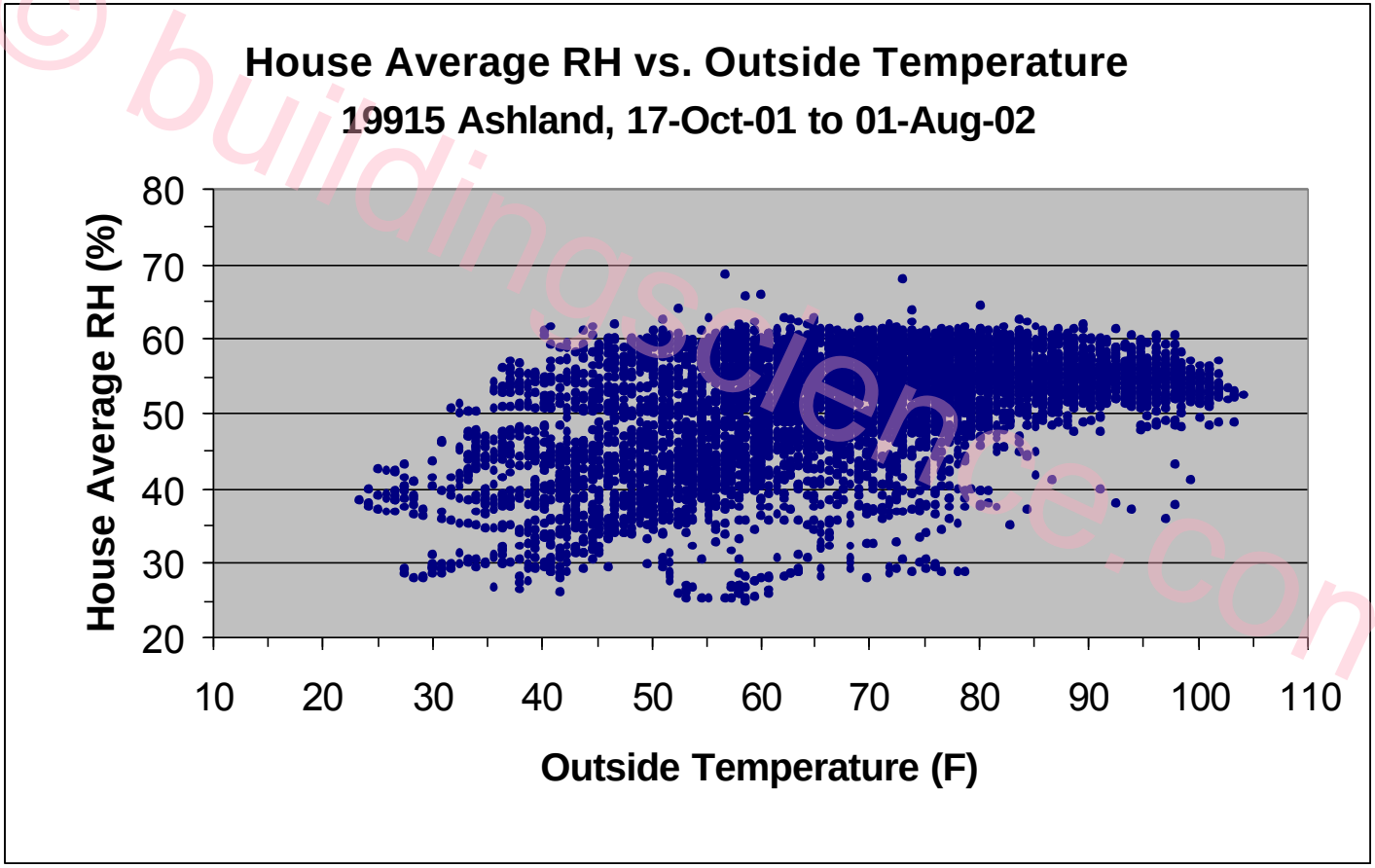
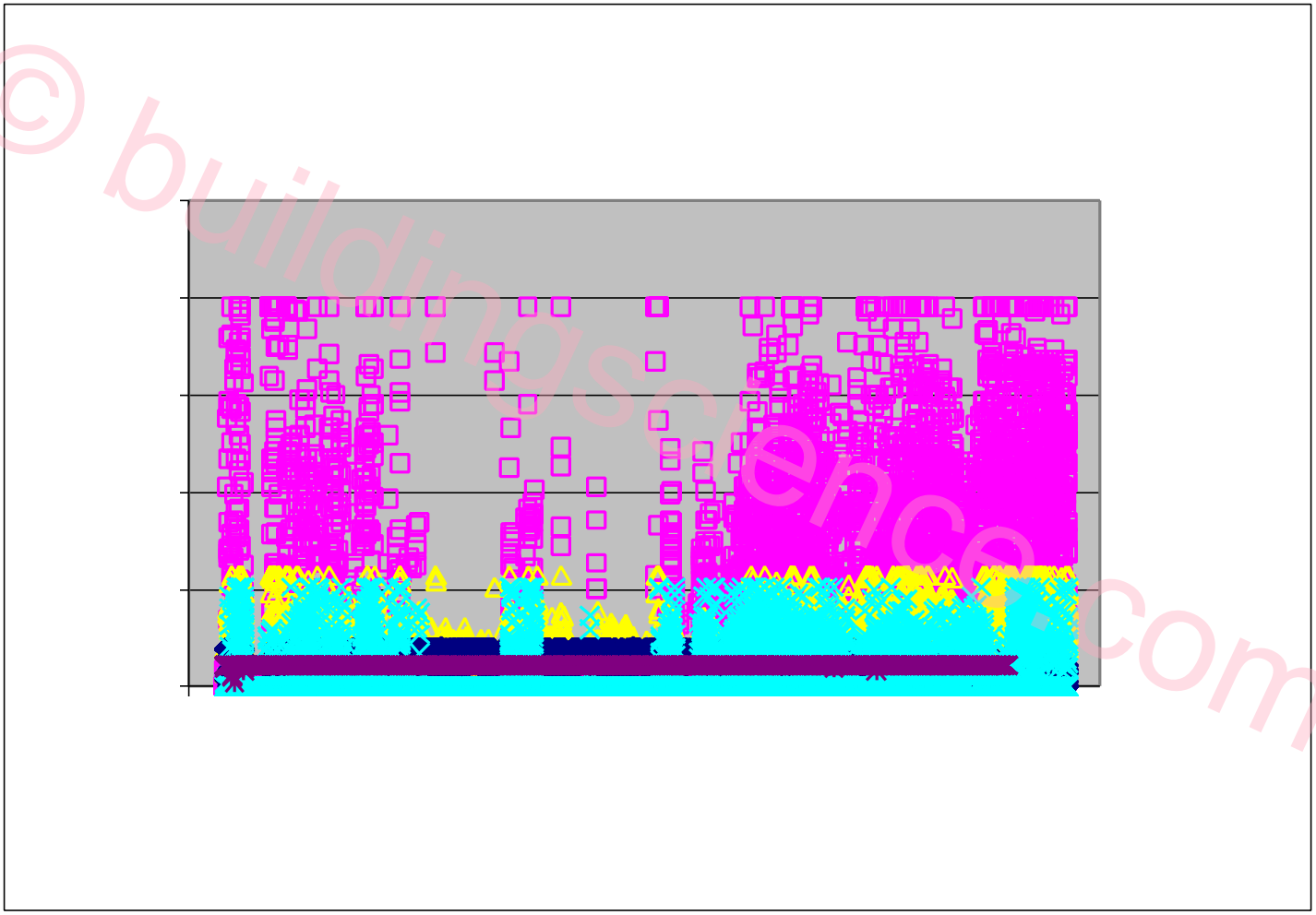
Environmental Monitoring



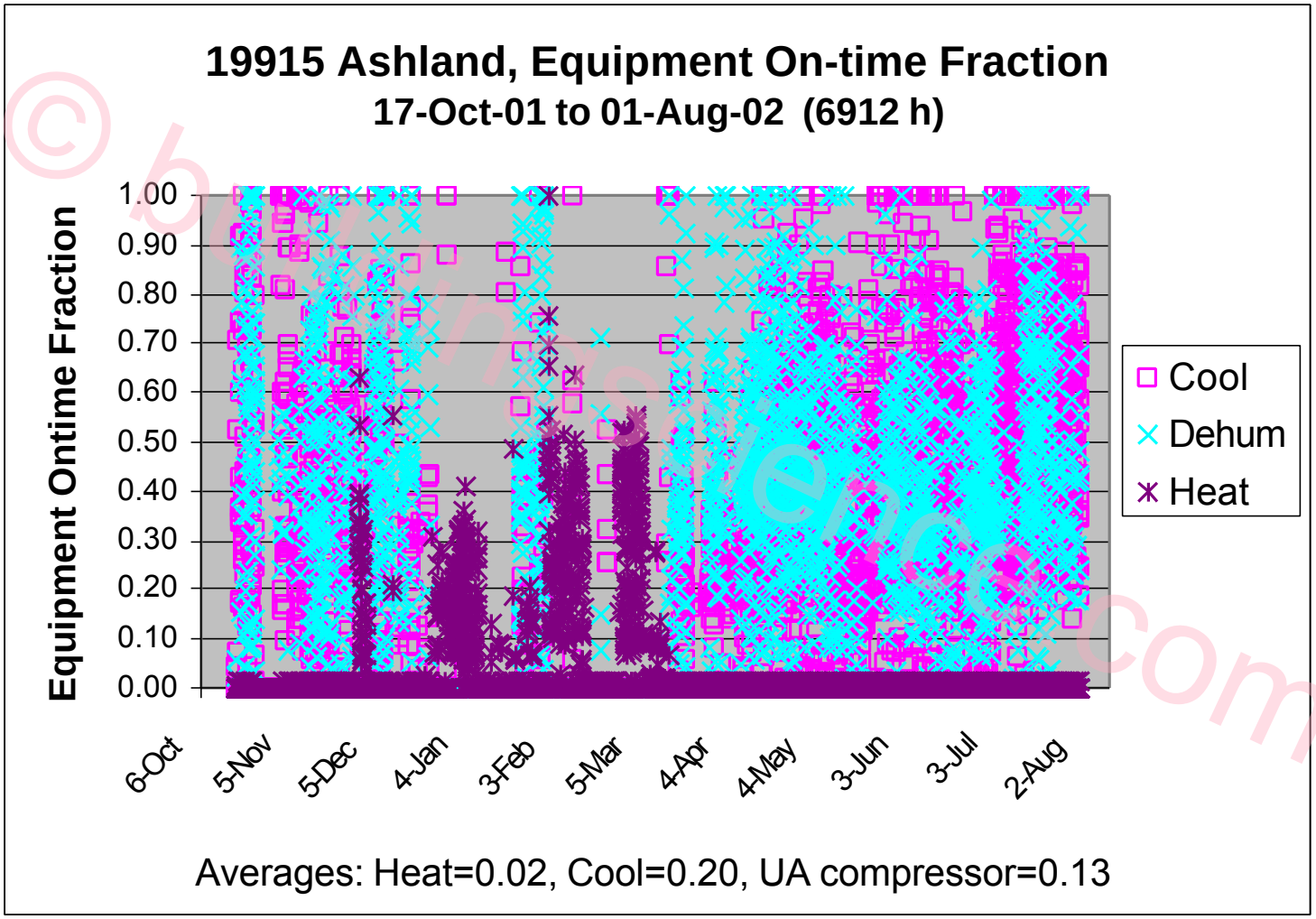
Ultra-Aire System
Environmental Monitoring



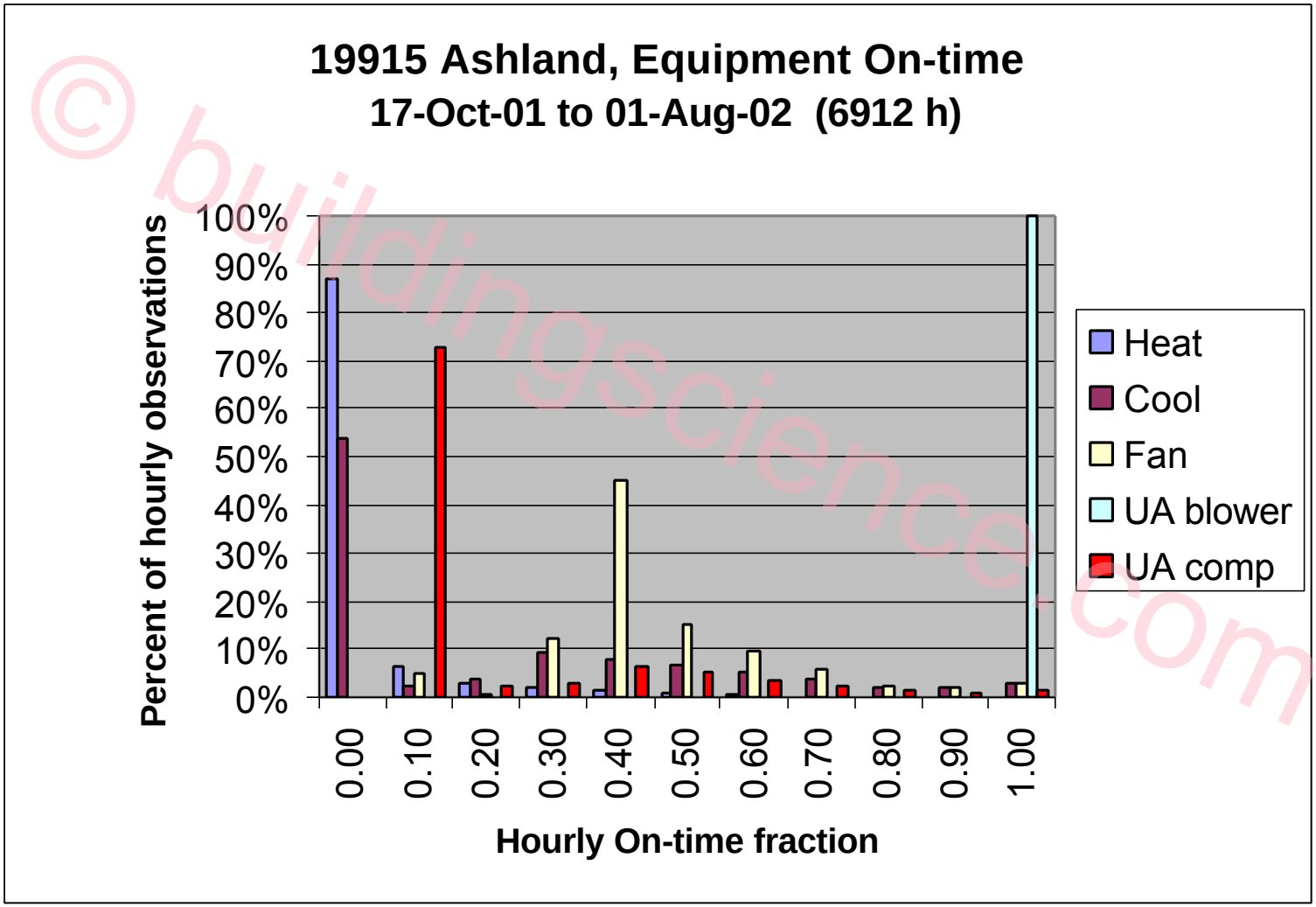
Ultra-Aire System Equipment Monitoring



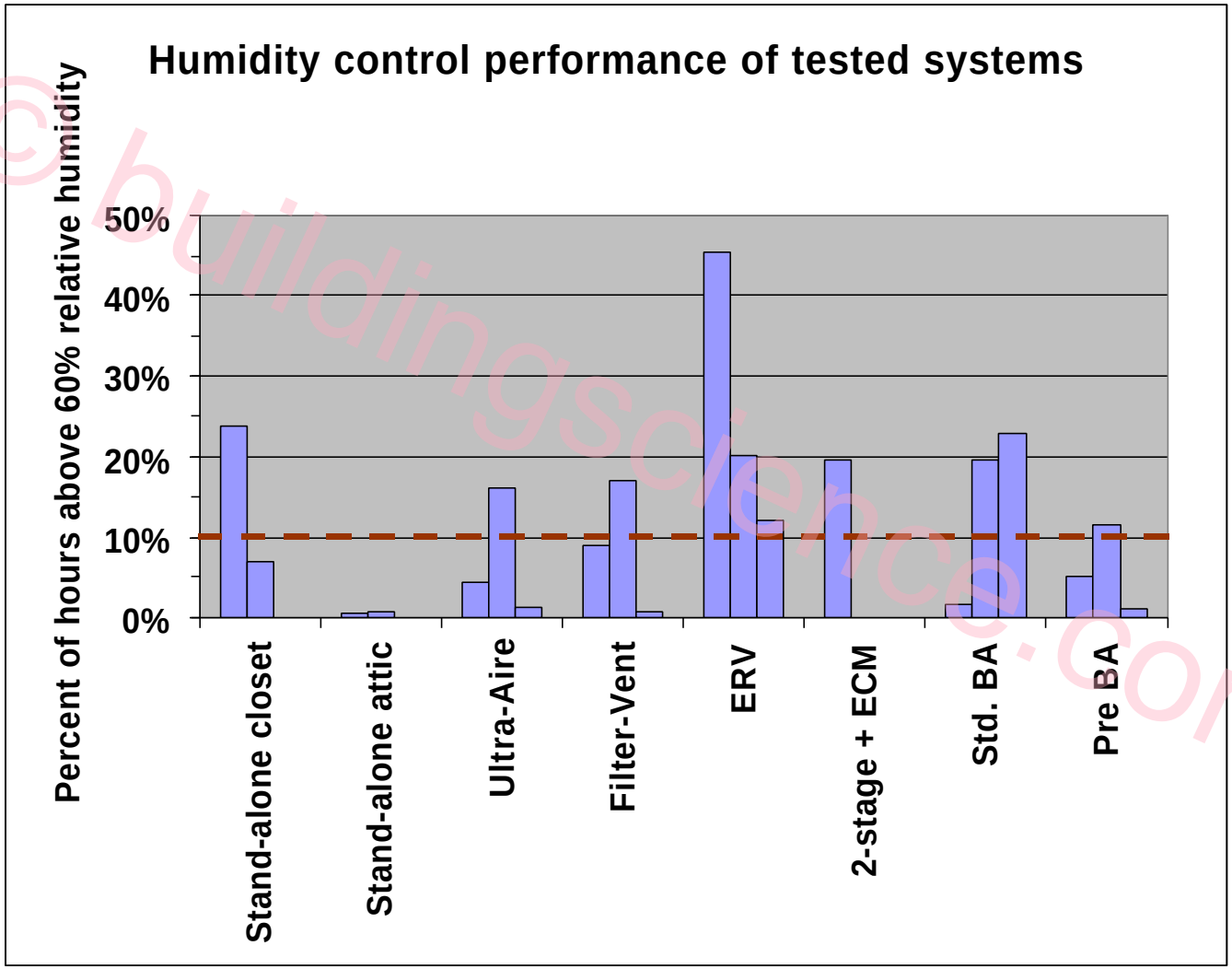
Ultra-Aire System Equipment Monitoring



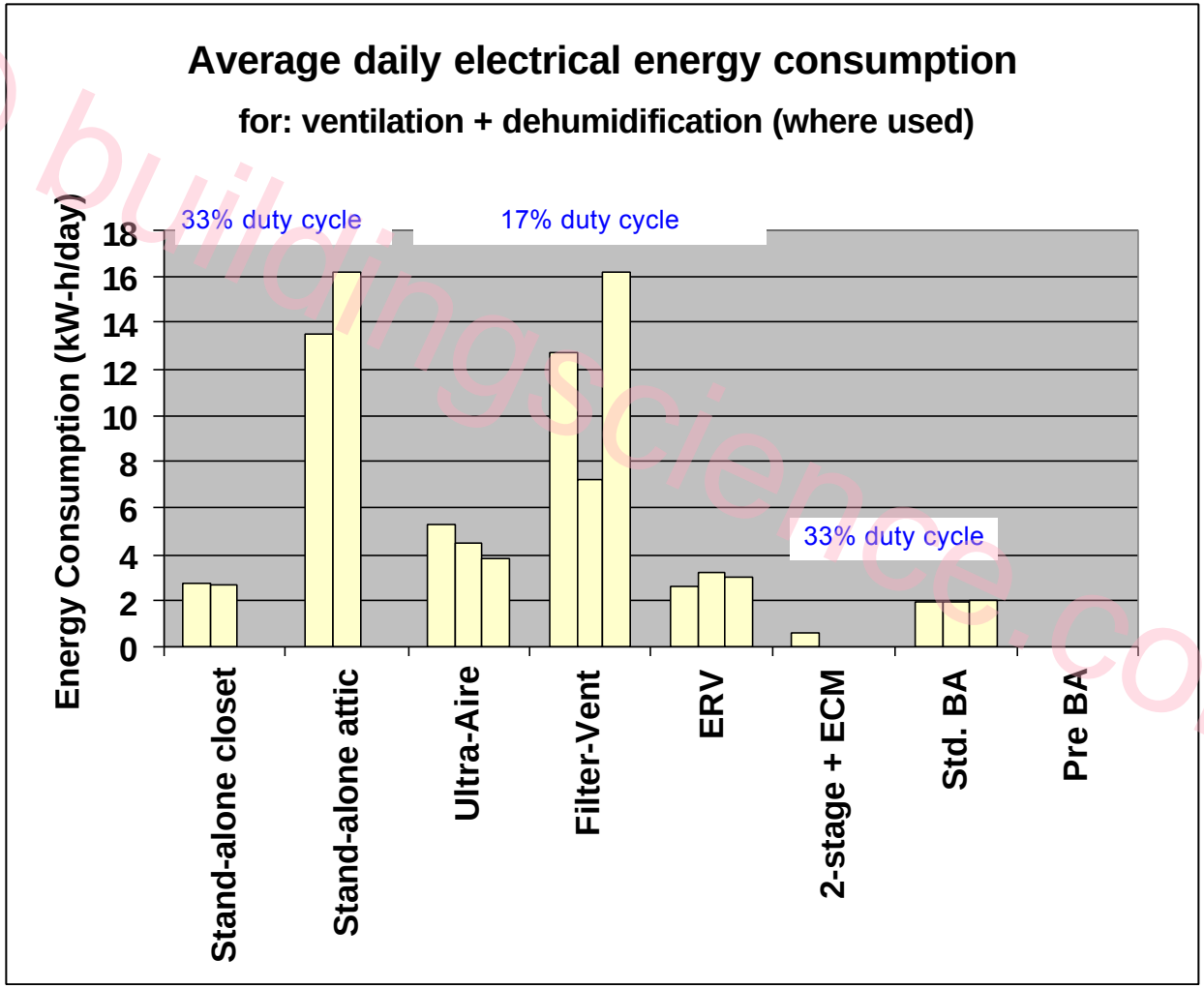
Ultra-Aire System Equipment Monitoring



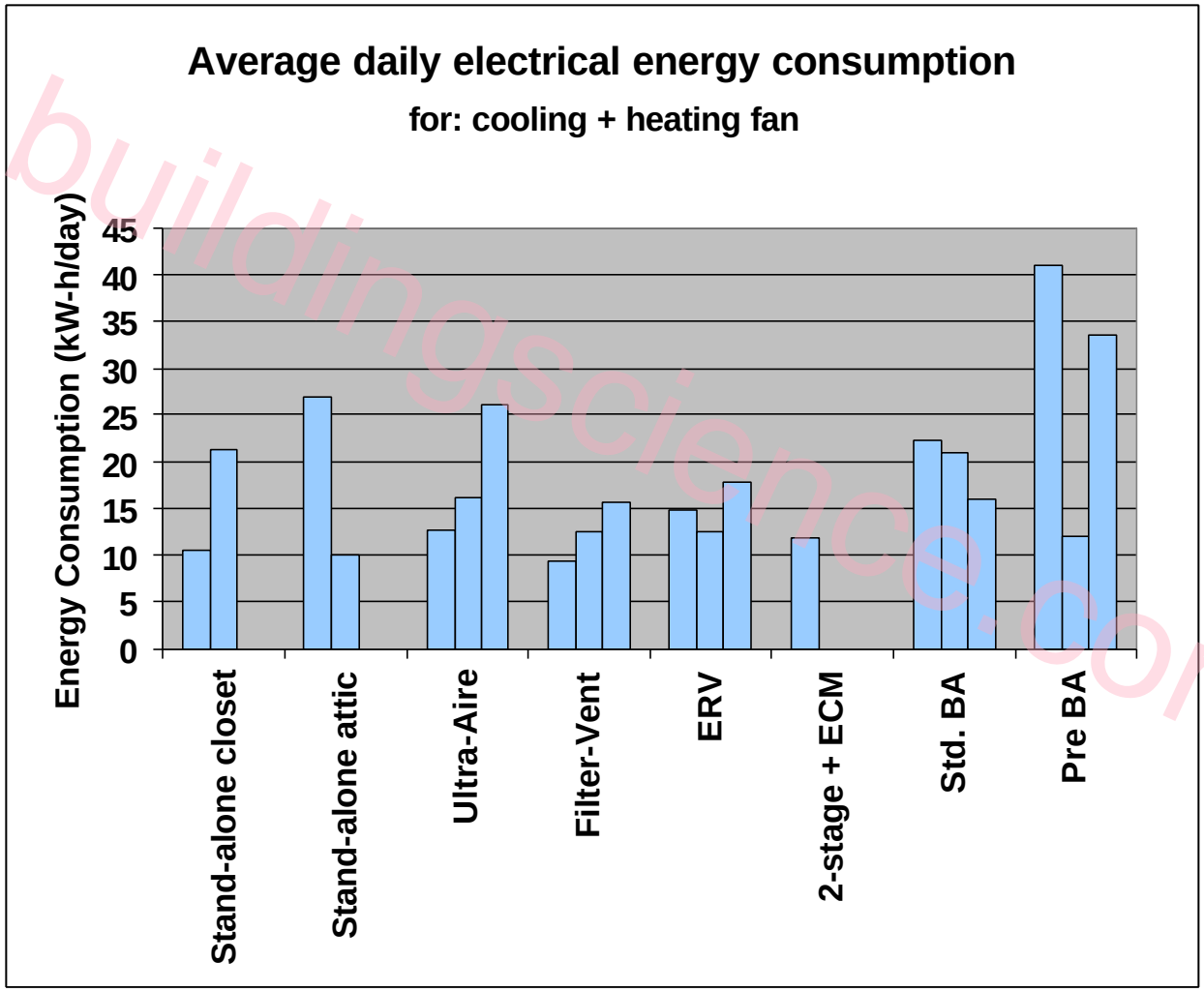
System Humidity Control Performance



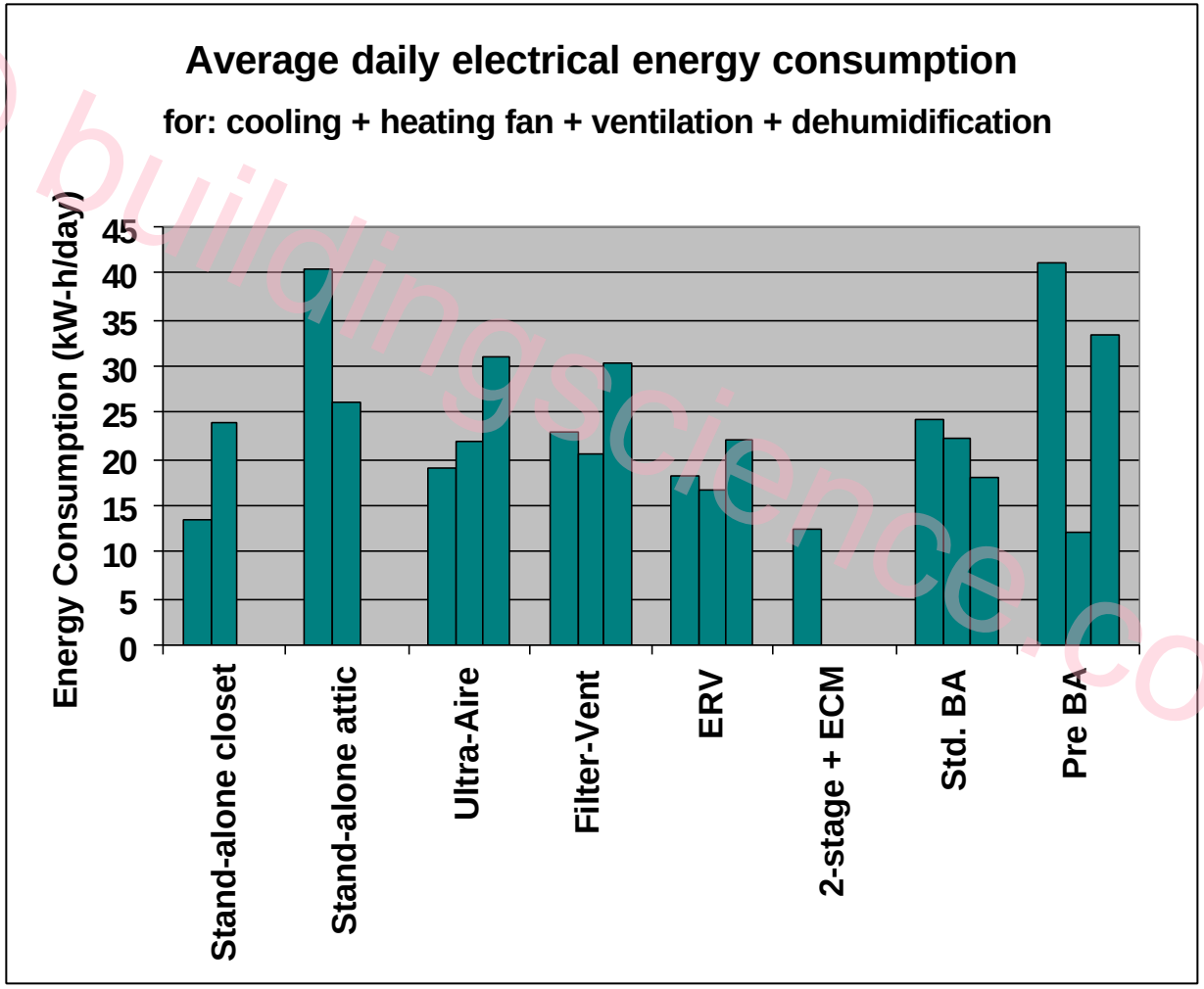
Ventilation and Dehumidification Energy Consumption

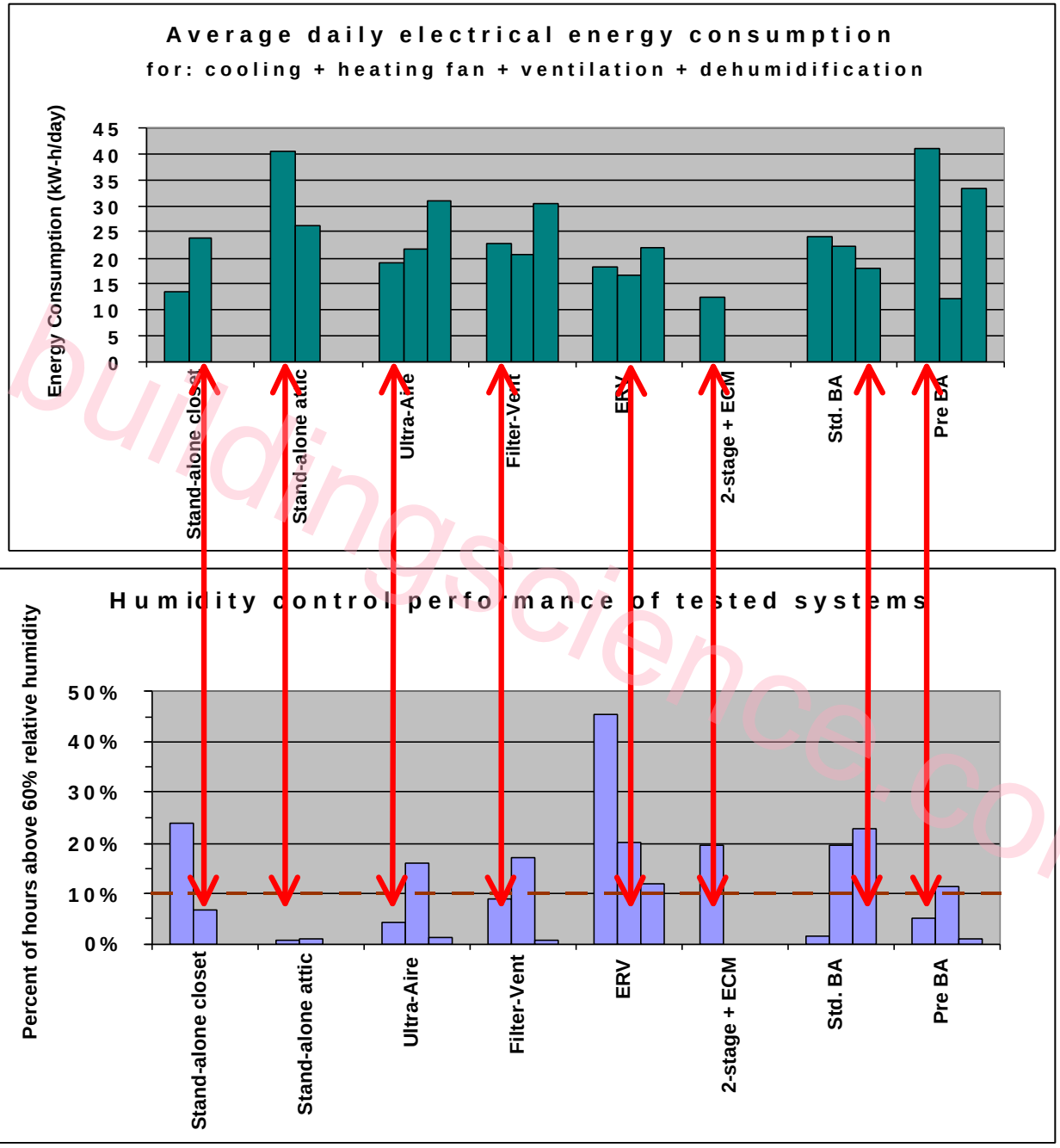


Cooling and AHU
Energy Consumption



Total Cooling, Heating Fan, Ventilation, and Dehumidification Energy Consumption





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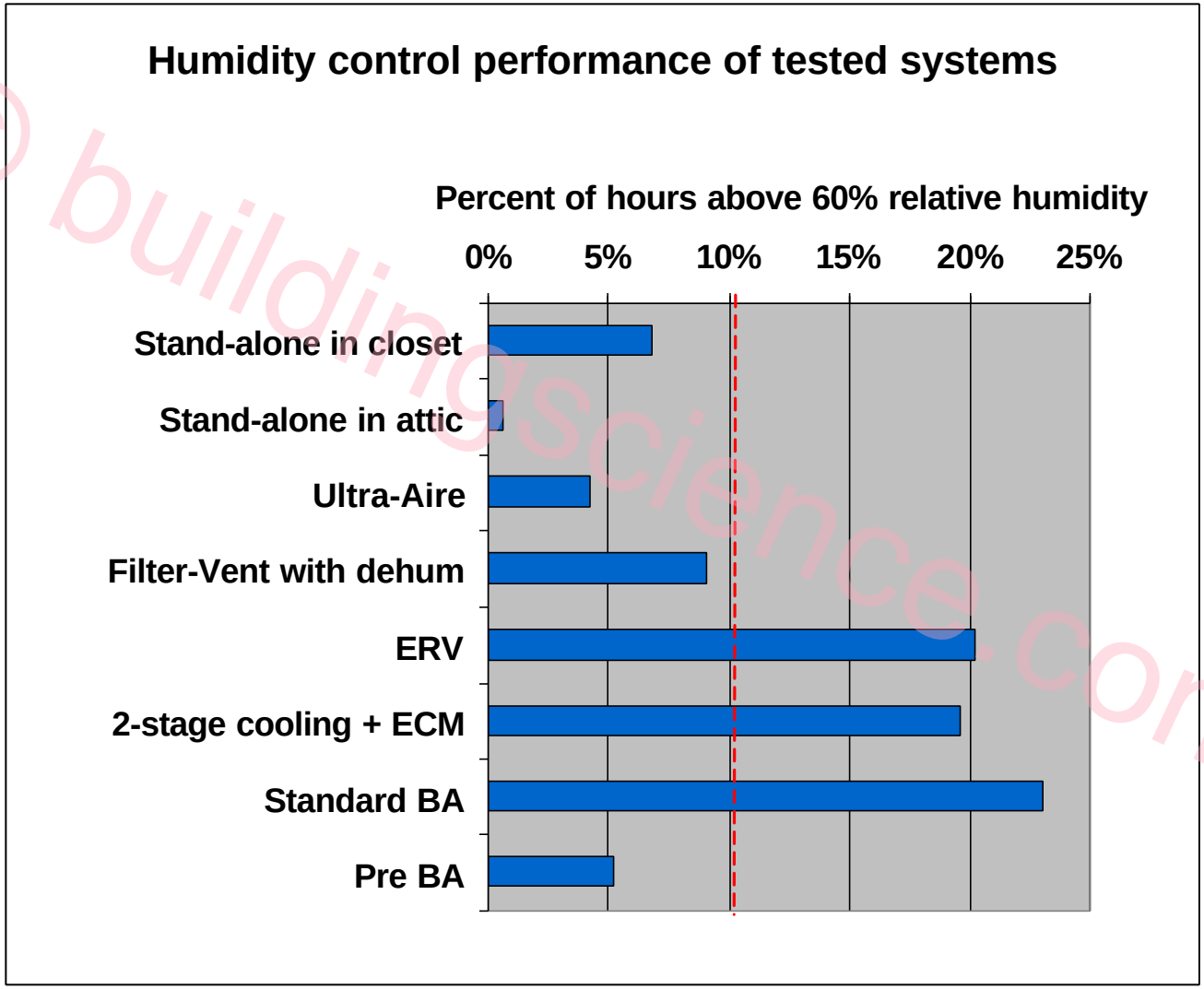

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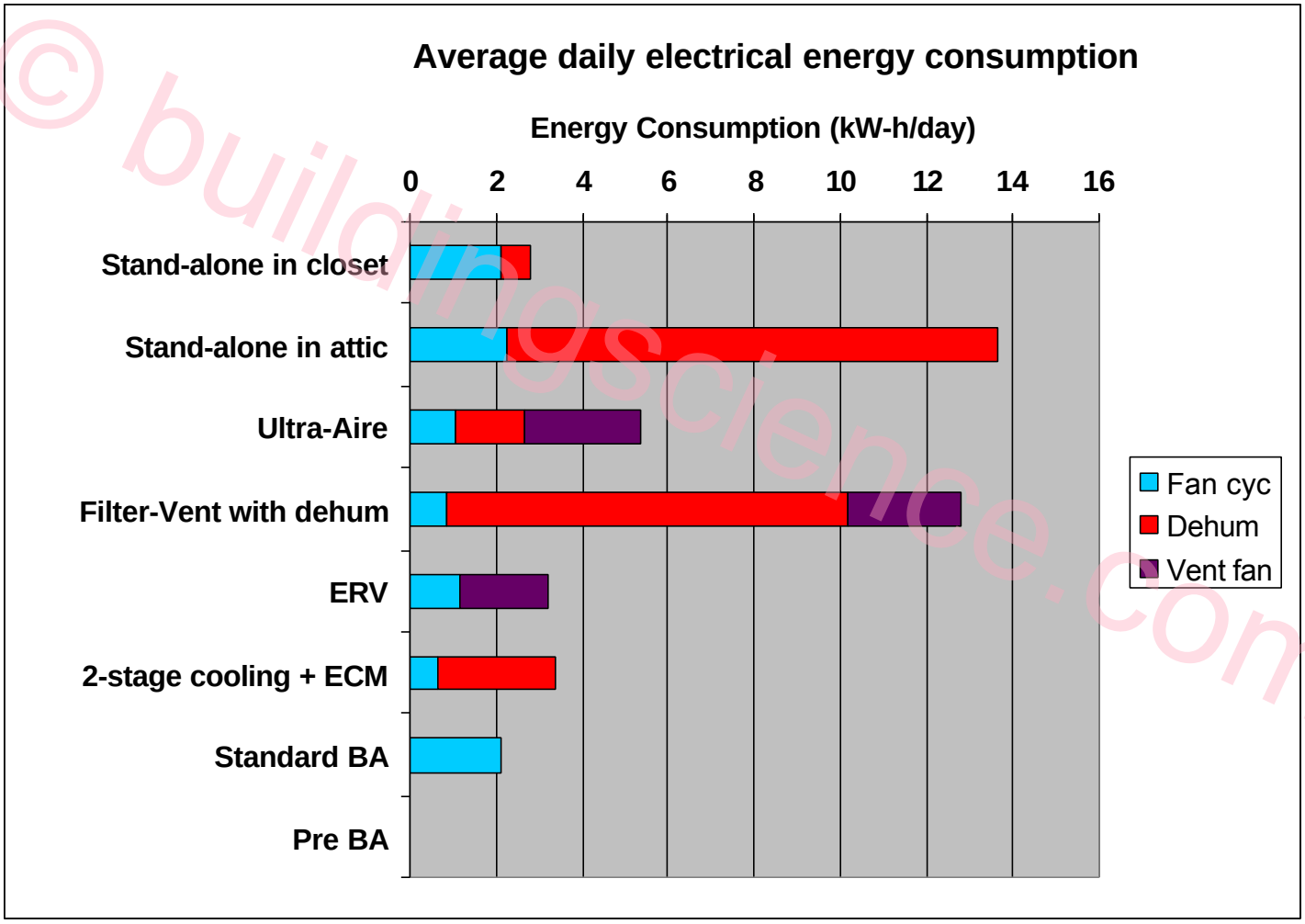

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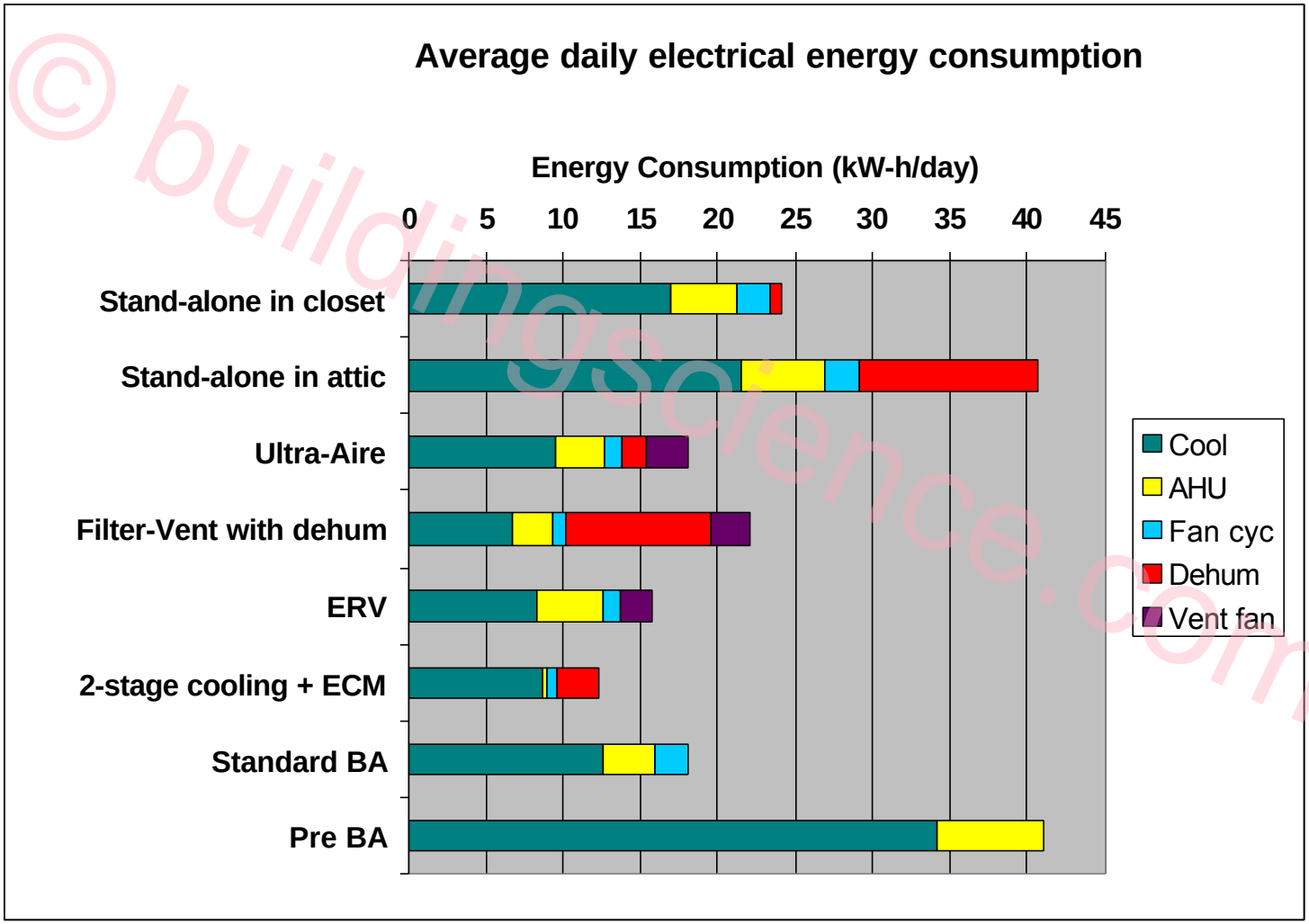

Conclusions and Recommendations

- Houses built prior to the improvements of the Building America program, and without mechanical ventilation, had much fewer hours of high relative humidity than standard Building America houses with mechanical ventilation.
  - High-performance windows and insulation, and locating air distribution ducts inside conditioned space, reduce sensible heat gain to the extent that the percentage of latent load is beyond the capacity range of even the best currently available mass-market cooling equipment.

Conclusions and Recommendations (cont.)

- All of the systems with dehumidification of recirculated air separate from the cooling system exhibited much better humidity control than those with dehumidification of ventilation air only and those with dehumidification only as part of the cooling system.
  - Therefore, the problem does not lie with mechanical ventilation, and the solution does not lie with the cooling system.
  - The problem of elevated humidity in energy-efficient homes in hot-humid climates is a result of interior moisture generation and lowered sensible heat gain.
  - The solution, for now, is to employ dehumidification separate from cooling for hot-humid locations.

Conclusions and Recommendations (cont.)

- The stand-alone dehumidifier in an interior closet with central-fan-integrated supply ventilation had the lowest initial cost and operating cost while providing good humidity control.
  - This system is recommended
  - Requires loss of bottom shelf in hall closet
  - Some occupants are sensitive to the additional noise

- The stand-alone dehumidifier in the attic also had low initial cost and very good humidity control, however, the dehumidifier operating cost was high since the attic was kept so dry even though the dehumidistat setting was the same for all systems with that type of dehumidifier. We suspect that that type of dehumidistat is very sensitive to the wider temperature range experienced in the conditioned attics. More testing with the dehumidistat remoted in the living space is warranted.

Conclusions and Recommendations (cont.)

- The Ultra-Aire system showed good humidity control but had higher first cost and higher operating cost due to the continuously operating ventilation fan.

- The Filter-Vent with ducted dehumidifier system showed generally good humidity control but had higher first cost and much higher operating cost.
  - Dehumidifier dehumidistat always seeing humid ventilation air; would probably be better to remote the dehumidistat in the living space
  - Continuously operating ventilation fan

Conclusions and Recommendations (last)

- The Energy Recovery Ventilator (ERV) system did not show good humidity control performance; its first cost was high but operating cost was low

- The 2-stage compressor with ECM air handler and Thermidistat system did not show good humidity control performance; it's first cost was the highest but operating cost was low
  - we believe that the humidity control performance could be improved if the fan speed was lower during first stage cooling to keep the evaporator coil colder, and if the fan was stopped at the end of cooling calls