Humidity control in houses - ERV technology

Ouazia, B.

NRC·CNRC

Institute for Research in Construction

Humidity Control in Houses ERV Technology

Boualem Ouazia

Indoor Environment Research Program

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Presentation Outline

- Introduction
- Recommended Limits to Relative Humidity
- Moisture in Buildings
- Residential Moisture Removal Approaches
- LBNL Simulation Study
- NRC-IRC Project on Energy Recovery Ventilation
- ERV in Cold Climates
- NRC-IRC Intervention Field Studies
- Conclusions

Introduction

- Efficient RH management in houses through ERV
- Energy savings when using an ERV with independent humidity control (A/C, stand alone dehumidifier)

CONCERNS

- Hours when it is dryer outside than inside, ERVs make the moisture problem worse
- ERV exhausting stale air from bathroom could turn into humidifier
- ERV does not change the humidity distribution compared to a continuous exhaust system

Humidity Control Goals

- Control of indoor humidity levels is important for
  - occupant comfort,
  - building durability
  - IAQ.
- The key is not to be low and not to be high
- High enough to be
  - comfortable
  - avoid non-thermal discomfort.
- Low enough to avoid moisture problems associated with
  - mold, and proliferation of other living micro-organisms
  - condensation
  - deterioration of building materials.

Recommended Limits to Relative Humidity

- ASHRAE Standard 62.1-2010, RH shall be limited to 65% or less, no lower limit set
- ASHRAE Standard 62.2–2010 does not recommend an RH range
- ASHRAE Standard 55–2010, RH shall meet the criteria of acceptable thermal environment for general comfort , does not specify an RH range
- OSHA[1] recommend an RH of 30% - 60% for optimum comfort
- A range of 40% to 50% is suggested to minimize upper respiratory infections[2]
- Health Canada[3] recommend an RH of 30% - 70% (summer) and 30% - 55% (winter)

[1]Occupational Safety and Health Administration (2011)
[2]Federal-Provincial Advisory Committee on Environmental and occupational Health (1989)
[3] Canadian Exposure Guidelines for Residential Environments (1989)

Effect of RH on symptoms and perception of IAQ in office workers

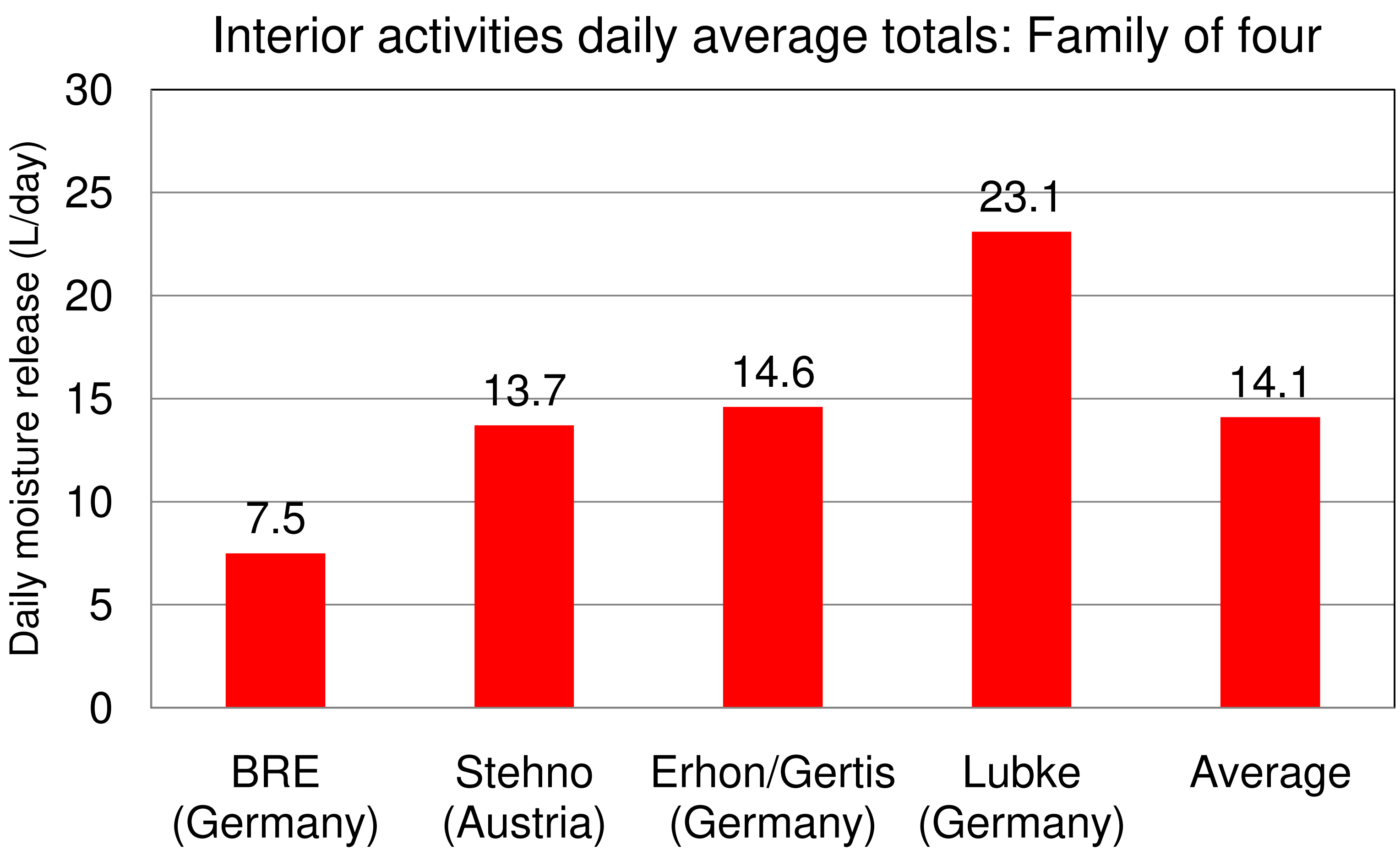
- Increased relative humidity (air humidification) from 12% to 28% & 28% to 39%, led to fewer complaints about thermal discomfort at temperature below 22°C[1].
- RH was negatively associated with a sensation of dryness with RH in the range of 15% to 35%[2,3].
- Subjective reports of dry discomfort increased as humidity levels were reduced below 35% RH[4]
- 5-hour exposures to low humidity conditions (15% and 5% RH) had negative effects on the eye and skin that did not occur at or above 25% RH[4]

[1]Palonen et al. (1993) *"The effects of air temperature and relative humidity on thermal comfort in the office environment" Indoor Air*
[2]Bakke et al. (2007) *"Gender and physical and psychosocial work environment are related to indoor air symptoms" Journal of Occupational and Environmental Medicine*
[3]Reinikainen et al. (2001) *"Effects of temperature and humidification in the office environment" Arch Environ Health*
4Wyon et al. (2002) "Limiting criteria for human exposure to low humidity indoors" Indoor Air

Moisture Sources

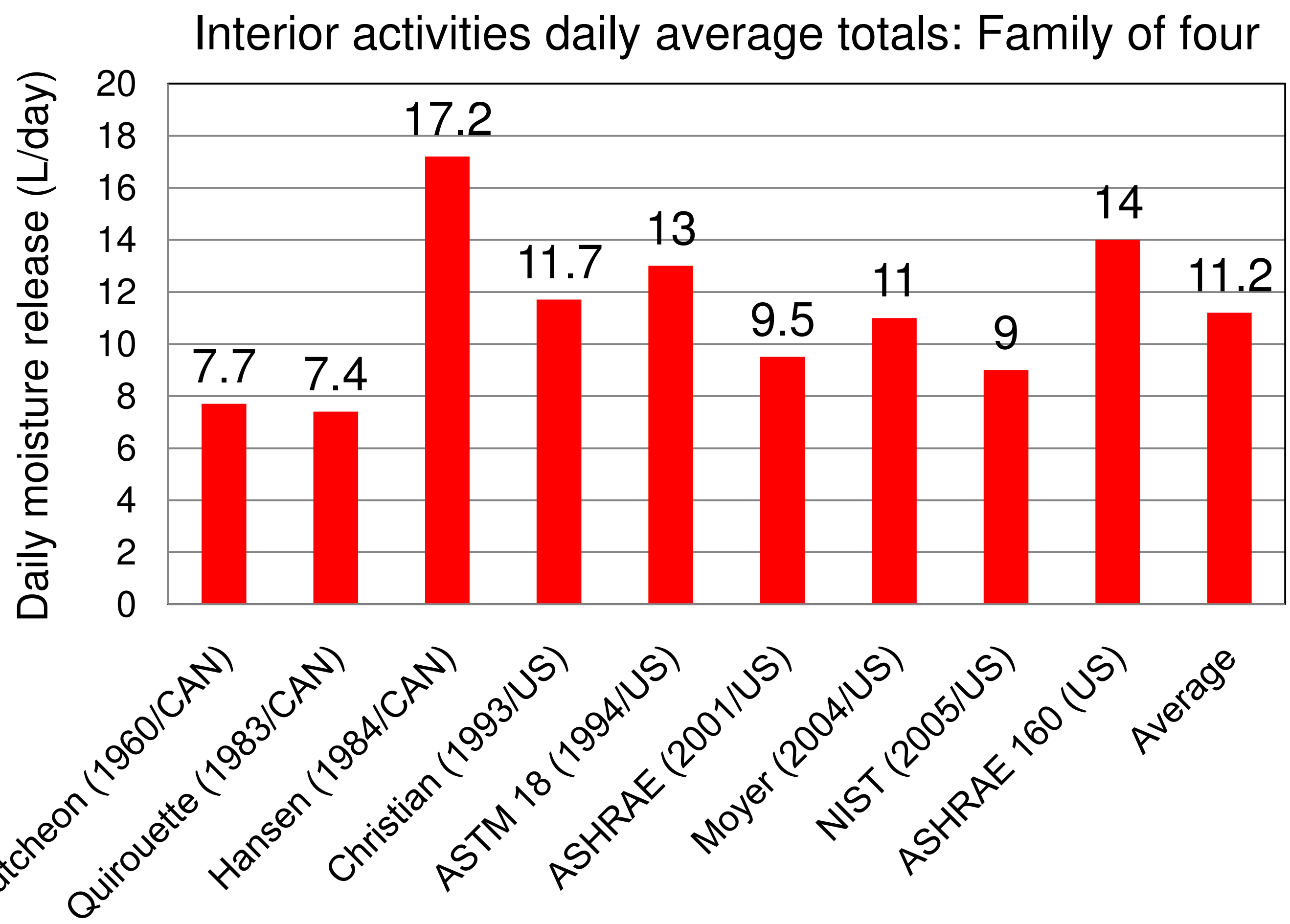
- Indoor
  - Occupants
  - Bathrooms - shower and bath
  - Kitchens - cooking and dishwashing
  - Clothes washing and drying
  - Evaporation from wet surfaces
  - Plants
- Outdoor
  - Ground moisture migration
  - Rain penetration
  - Seasonal high outdoor absolute humidity

Daily Moisture Loads in European Dwellings



Jeffrey E. Christian "A Search for Moisture Sources" Workshop on Bugs, mold & Rot II Proceedings, 1993

Daily Moisture Loads in North American Dwellings



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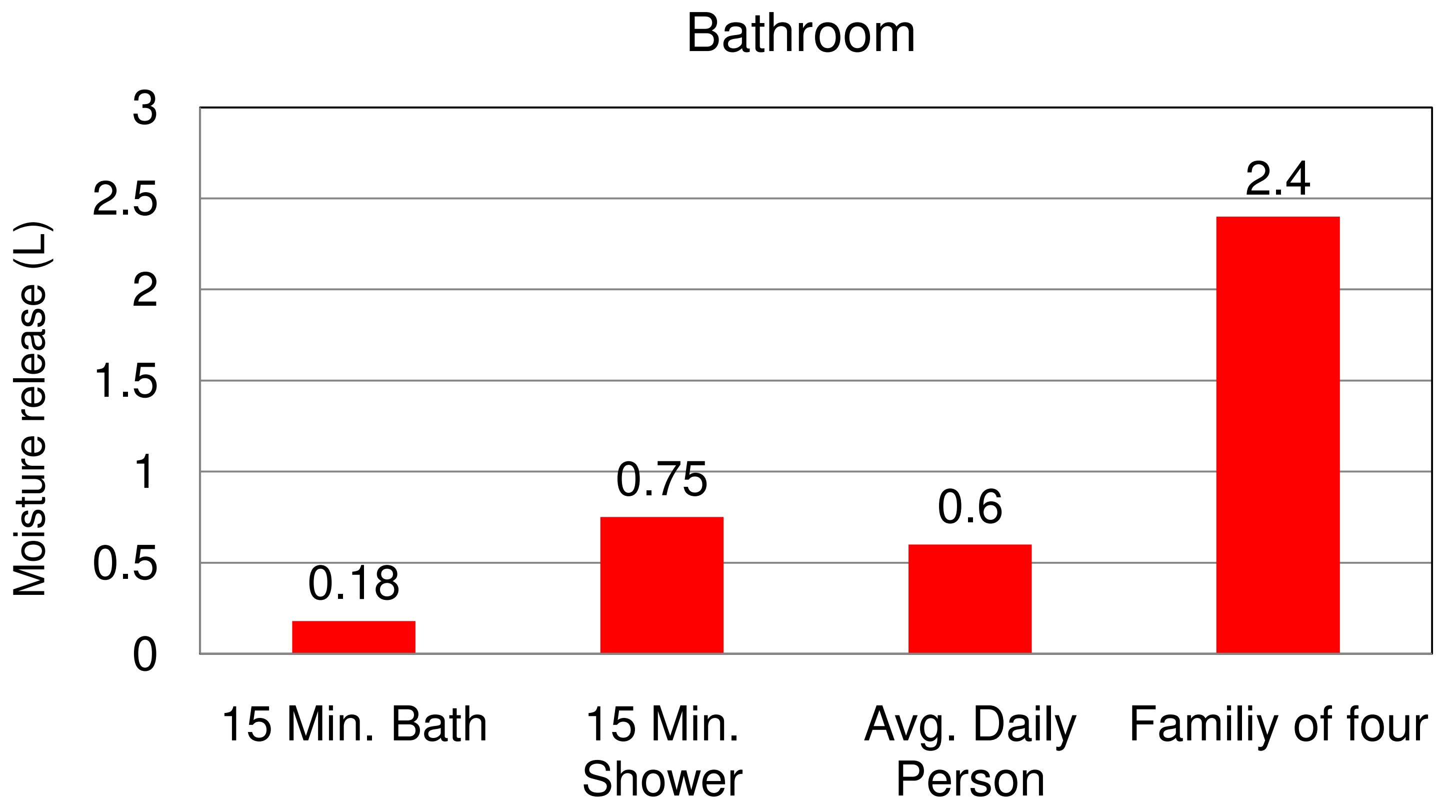
Moisture Generated in Bathroom



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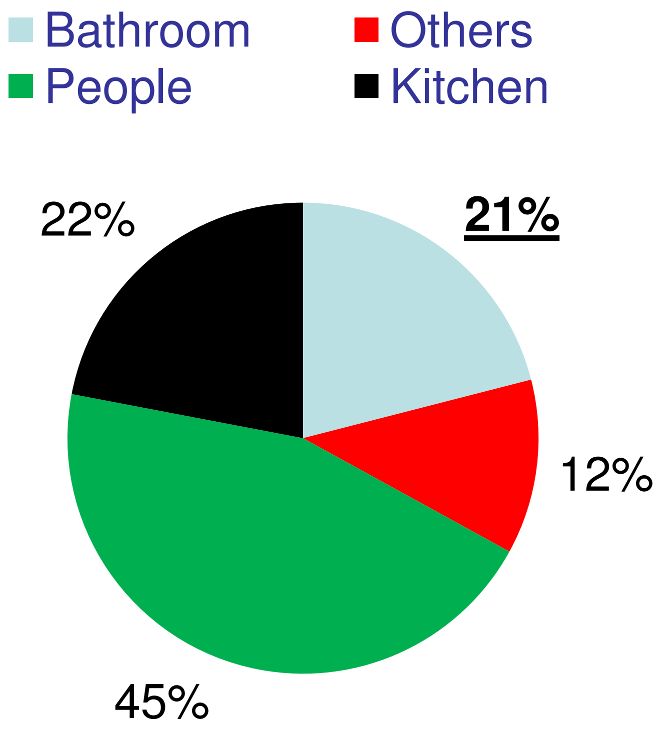
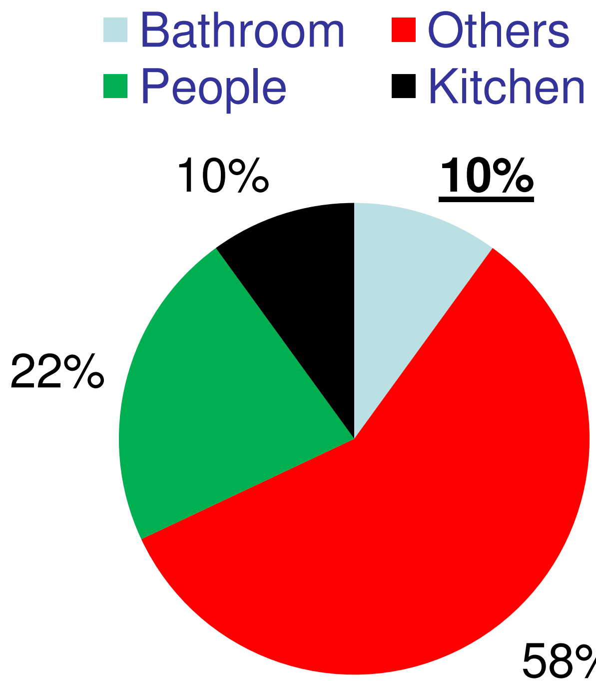
Moisture Release Ratio: Bathroom/House



Average value of 11.2 L/day



Worst case conditions of 23 L/day

Only a small portion of the total moisture generated in a home comes from bathroom activities

Residential Moisture Removal Approaches

1. Local exhaust for humidity removal
   - Kitchen
   - Bathroom
   - Laundry
2. Stand-alone dehumidifier
   - Problem areas such as basement
   - Does not dehumidify the whole house
3. Dehumidifiers integrated with HVAC system (cooling to remove moisture from air)
4. Central ventilation systems of any type : exhaust, supply, integrated exhaust-supply, HRV, **ERV**, etc.

Energy Recovery Ventilator (ERV): Theory

- Consists of an energy recovery module, two fans, and two filters
- One fan brings outdoor air (supply air) through the ER module and into the house
- Second fan causes an equal amount of house air (exhaust air) to pass through the ER module
- Heat is transferred from the warmer to the cooler airstream (without mixing)
- Moisture is transferred from humid to the dryer airstream

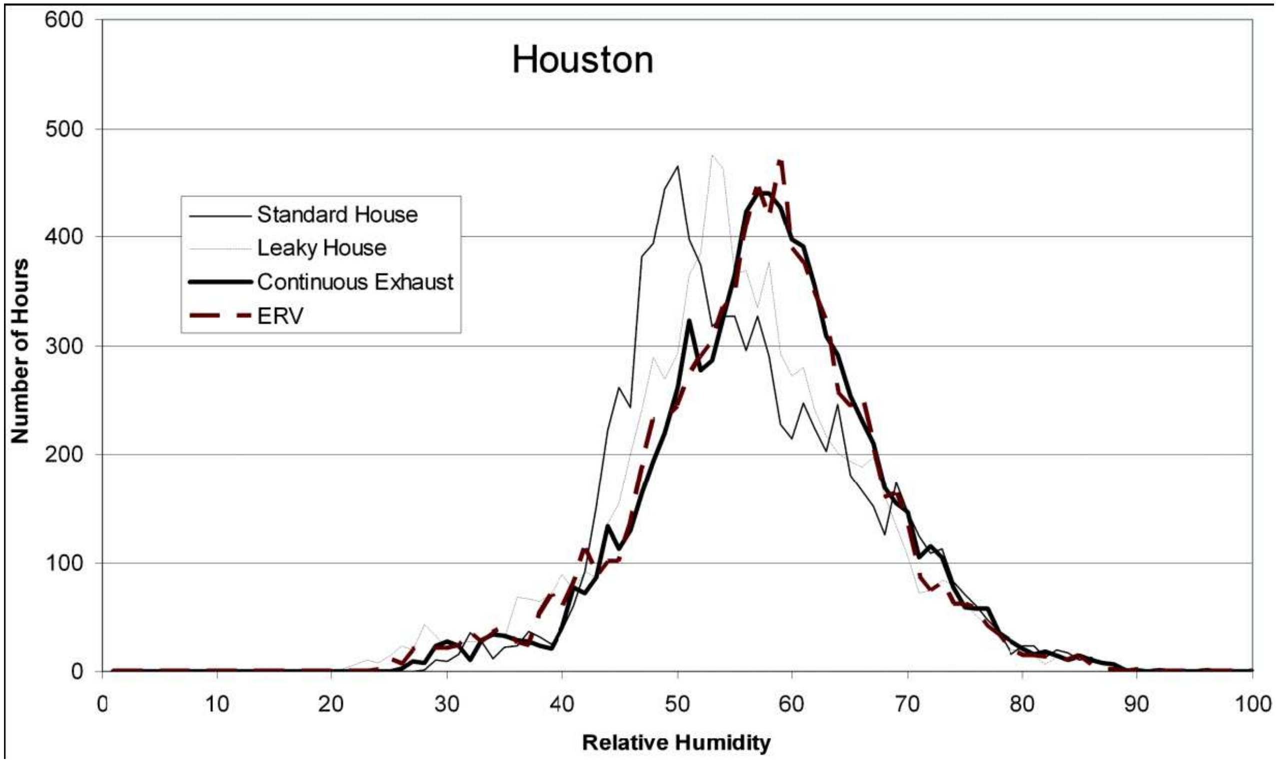
LBNL study by Walker and Sherman (2007)

"Occurrence of high humidity levels for Standard 62.2 residential ventilation requirements"

- Four residential ventilation systems;
  - Standard house (no whole house mechanical ventilation, only bathroom and kitchen exhausts)
  - Leaky envelope
  - Continuous exhaust, using bathroom exhaust fan
  - HRV and ERV, connected to the forced-air duct system
- Simulation for six climates – Houston, Phoenix, Charlotte, Kansas City, Seattle and Minneapolis

Simulation Results for Houston

Continuous exhaust versus ERV



Above 60% RH

	Continuous Exhaust	ERV
Houston	3266	3076

Above 70% RH

	Continuous Exhaust	ERV
Houston	758	614

- ERV did not change the humidity distribution compared to a continuous exhaust system (using bathroom exhaust fan)
- No disadvantage using ERV
- Occurrence of high humidity is slightly lower with ERV

Impact of Energy Recovery Technology on Housing Performance

Assess the performance of an Energy Recovery Ventilator

- *Indoor relative humidity control*
- *Overall house energy performance*

<u>Reference House</u>

- A/C
- **HRV**
- Furnace

<u>Test House</u>

- A/C
- **ERV**
- Furnace

www.ccht-cctr.gc.ca

Ouazia et al. "Assessment of the enthalpy performance of houses using the energy recovery technology" ASHRAE Transaction 2006, Vol. 112

HRV (Reference house)/ERV (Test House) Installation

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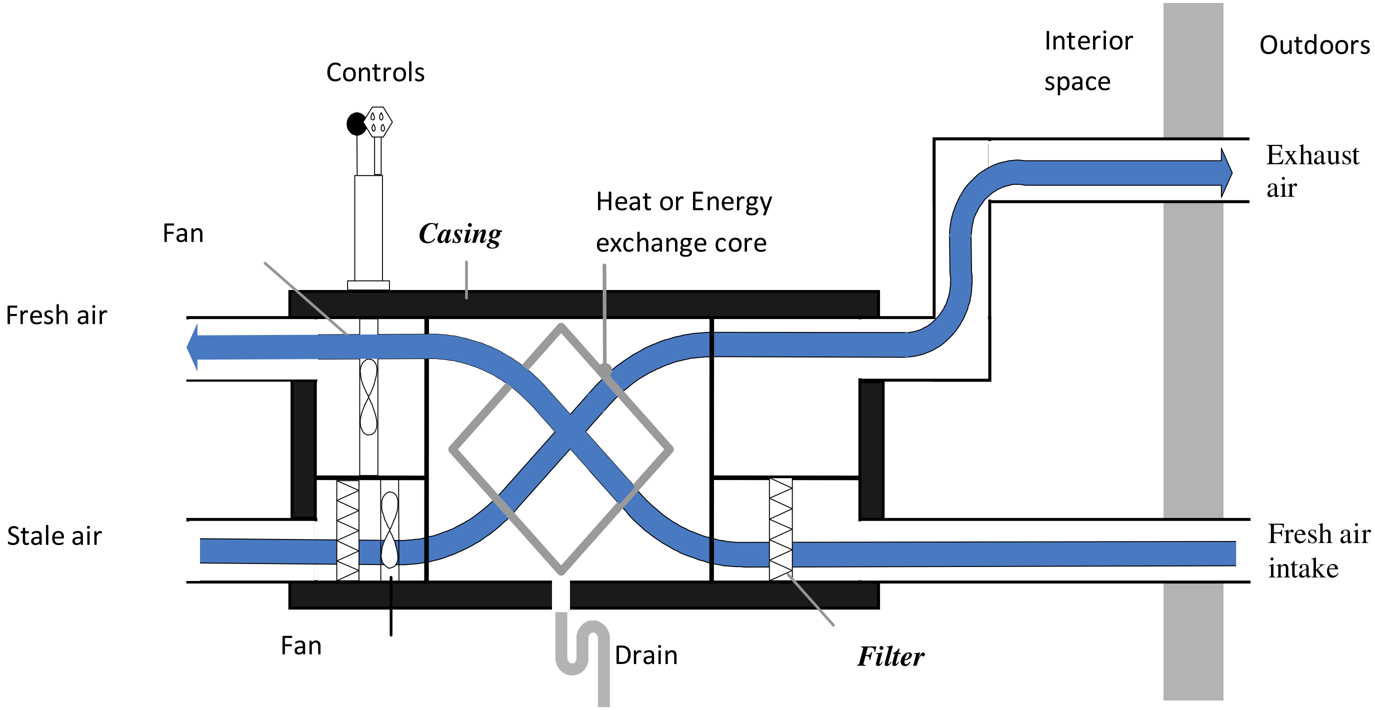
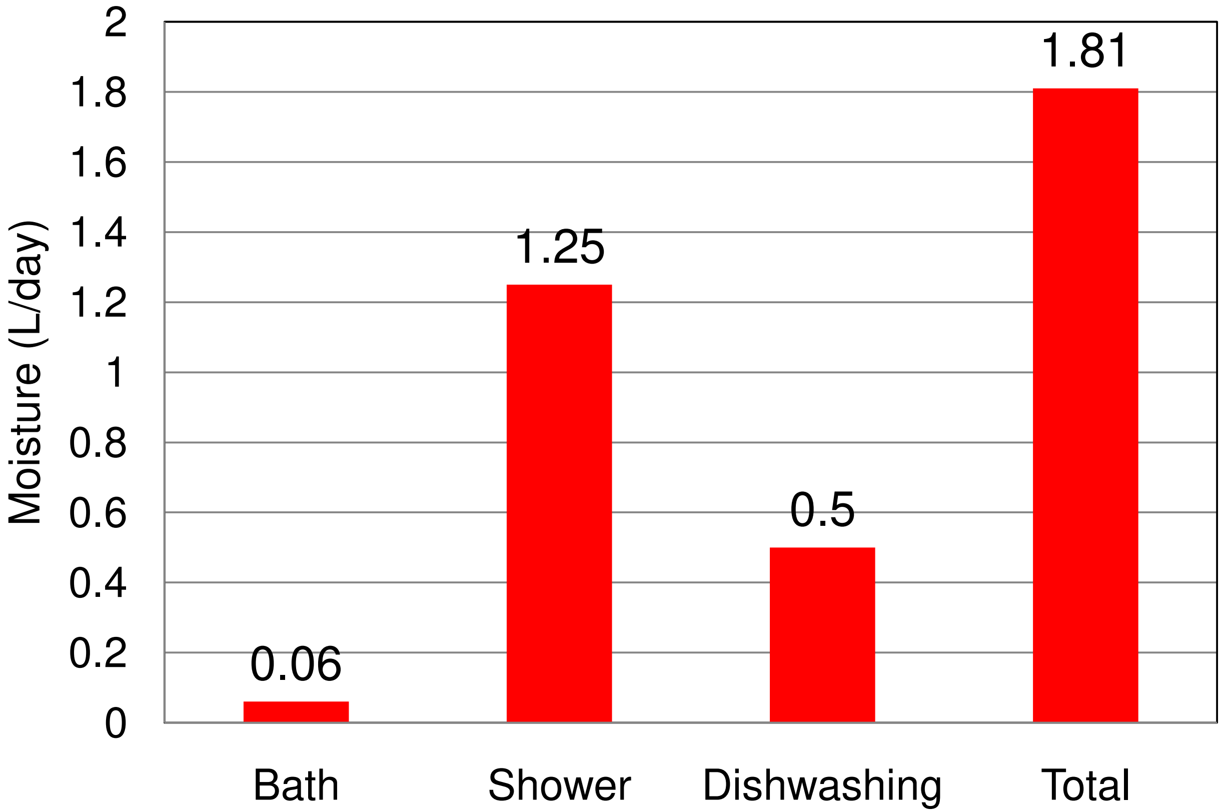


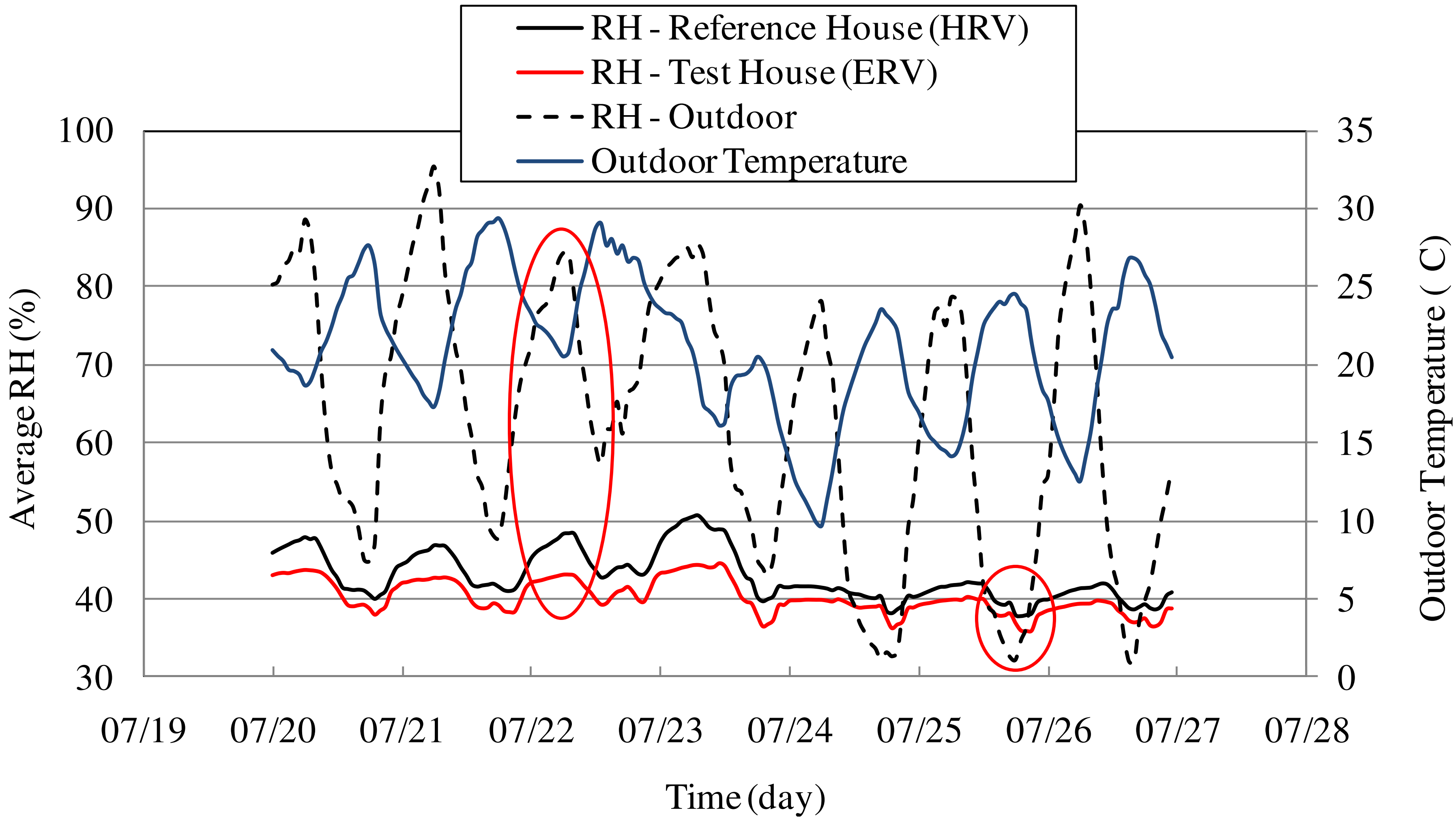
- Partially dedicated system
  - Exhaust air drawn in from bathroom
  - Supply air to the return air duct of the furnace

Simulated Moisture Generation in the CCHT Houses

- Houses were unoccupied
- Internal moisture was provided via simulated occupancy

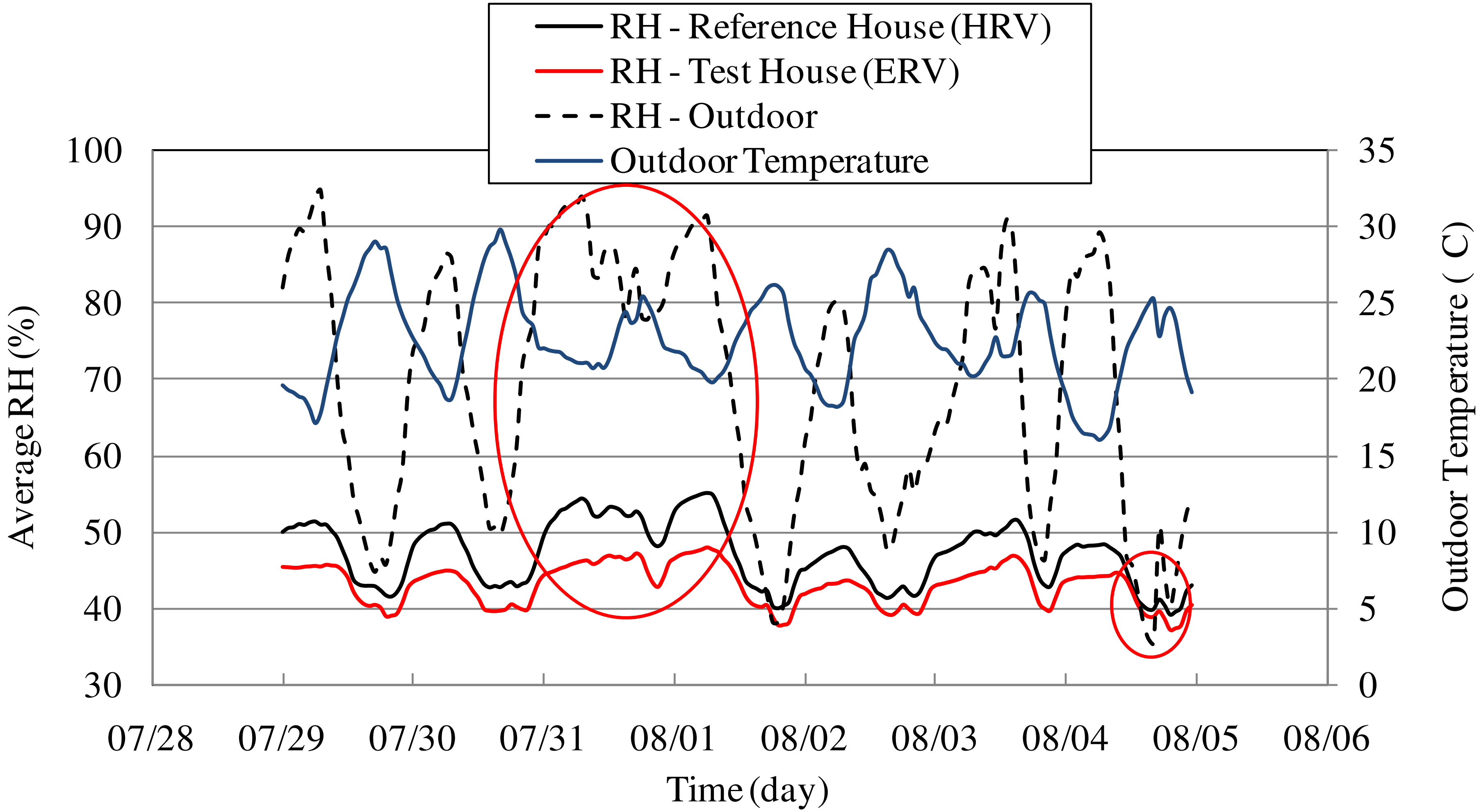


Outdoor and Indoor RH – Week 1 (65 cfm)



RH in the test house (ERV) is always lower than in the reference house (HRV) for 7 consecutive days

Outdoor and Indoor Relative Humidity – Week 2 (115 cfm)



Again, RH in the test house (ERV) is always lower than in the reference house (HRV) for 7 consecutive days

Indoor RH Control & Cooling Energy Saving

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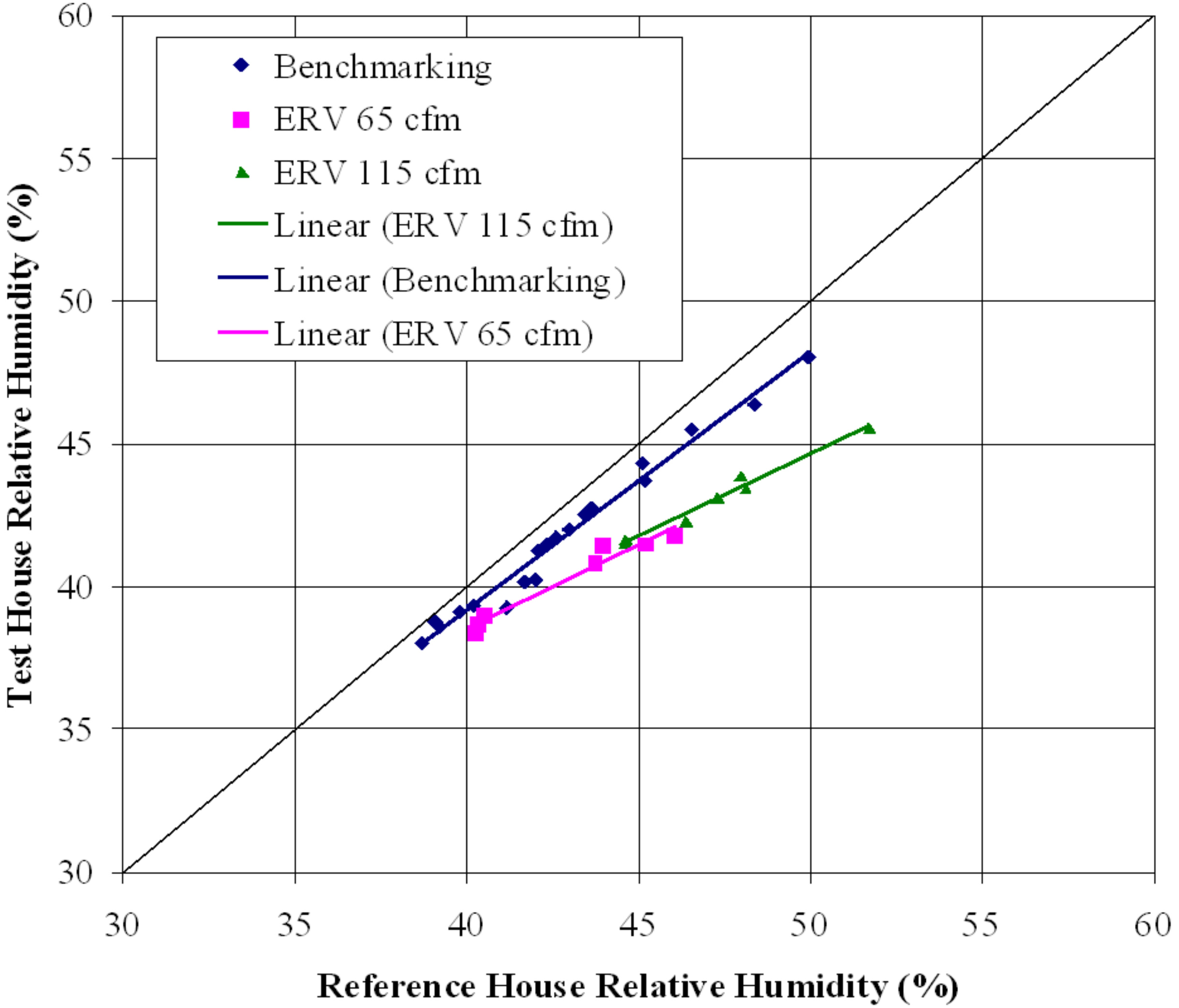


A/C Electricity Consumption

CFM	Saving
65	9%
115	12%

Potential for higher humidity control and cooling energy saving

Project Results

Use of ERV with air conditioning under summer conditions in Canada can deliver:

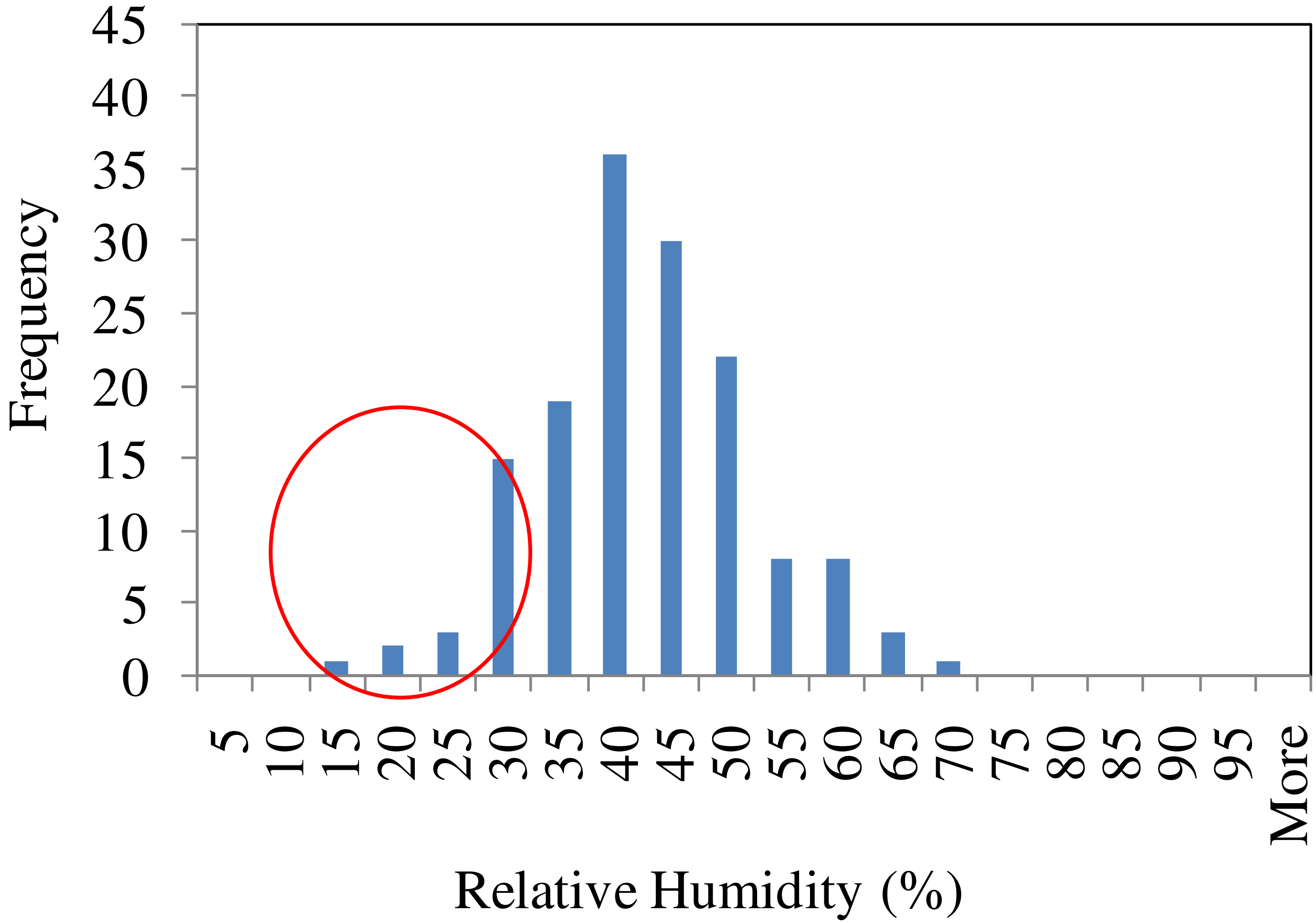
- Improved indoor humidity control
- Reduction in air conditioning electricity consumption
- Performance depends strongly on the outside conditions
- Potential for humid climates, where A/C systems are used
- Potential for higher cooling energy saving
- Exhaust from the bathroom did not negatively impact the humidity control performance

ERVs in Cold Climate

- Inhabitants of cold climates may experience low levels of indoor humidity (<30% RH)
- Periods of up to several weeks,
- Symptoms of dryness of the eyes, nasal cavity and skin
- Energy-efficient house with no major moisture sources in a very cold climate - code-required level of ventilation will dry out the house excessively
- The house could benefit from an ERV – remove a portion of moisture from exhaust air and return it into the house

Quebec Field Study: Pre-Intervention Phase

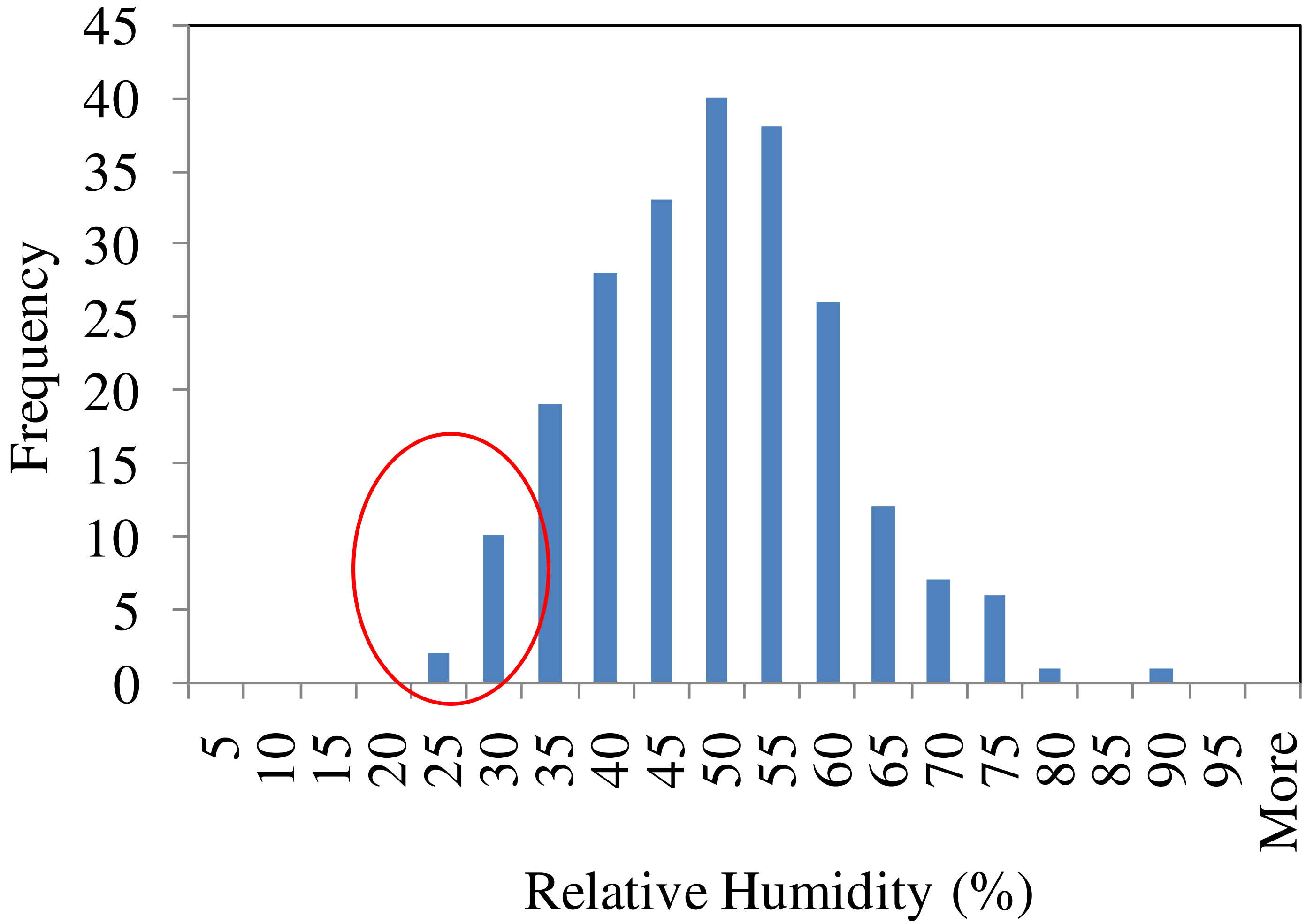
RH in Living Room (Winter 2008-2009 and 2009-10)



Aubin, D. et al. (2010) "Preliminary results from a field study investigating the impact of ventilation rates on indoor air quality and the respiratory health of asthmatic children in Québec City " Presented at the Air and waste Management 103rd Annual Conference.

Quebec Field Study: Pre-Intervention Phase

RH in Child's Bedroom (Winter 2008—09 and 2009-10)



Aubin, D. et al. (2010) "Preliminary results from a field study investigating the impact of ventilation rates on indoor air quality and the respiratory health of asthmatic children in Québec City " Presented at the Air and waste Management 103rd Annual Conference.

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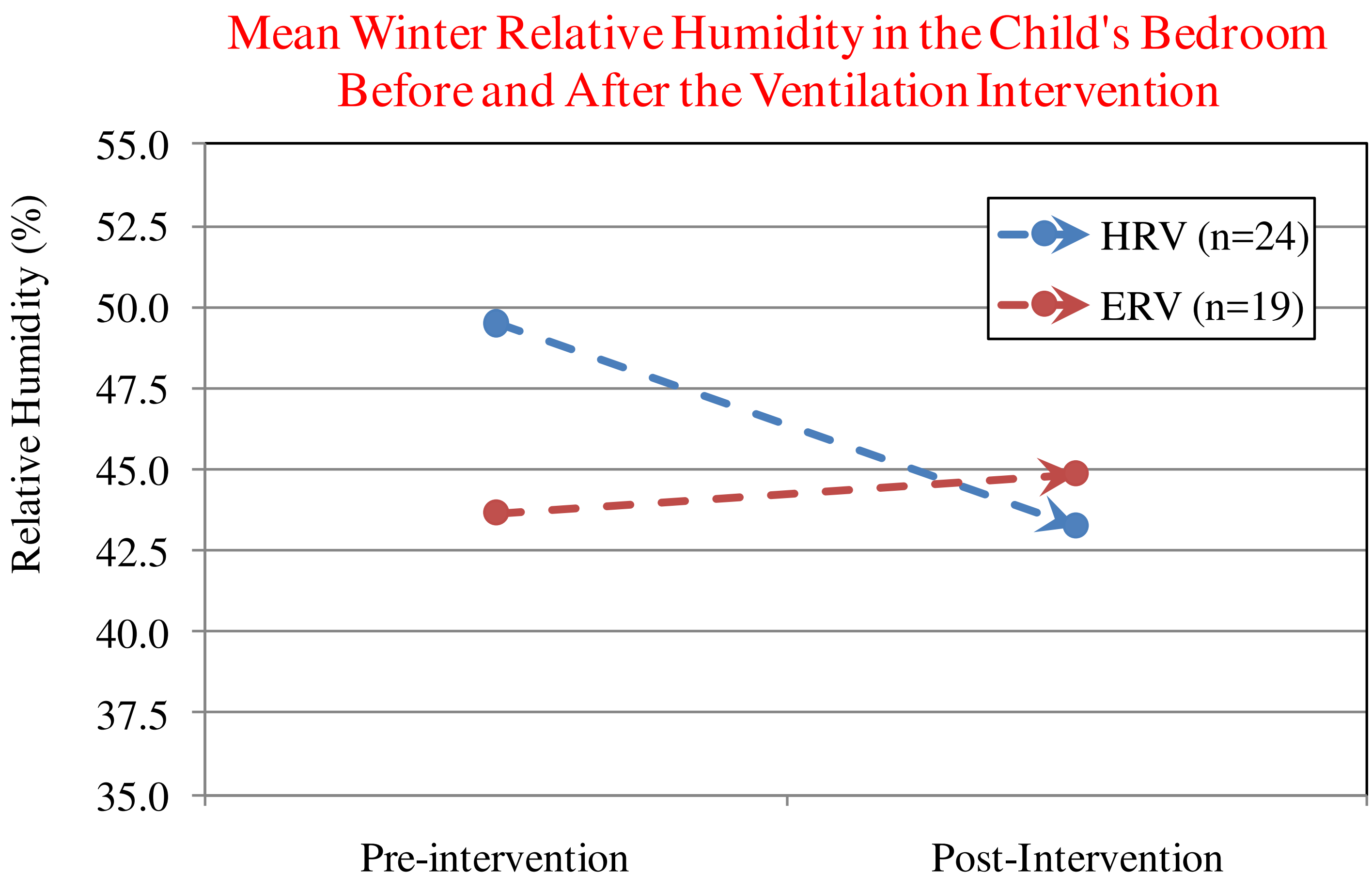
Quebec Field Study: Ventilation Intervention

- 83 “under-ventilated” (ACH < 0.30 h^{-1}) homes were eligible for a ventilation intervention
- Control Group (n=40)
  - Served as a baseline. These homes had a low ACH and did not receive any intervention.
- Intervention Group (n=43)
  - Homes with a low ACH but with acceptable RH received an HRV (n=24)
  - Homes with a low ACH and low RH (<30%) received an ERV (n=19). Prior to intervention, 9 had an HRV, 7 had a mixing box and 3 had no mechanical ventilation system
- Overall, the median air change rate was increased from 0.19 to 0.36 h^{-1} in all homes receiving an ERV/HRV

Quebec Field Study: Intervention ERV vs. HRV

- Homes receiving HRV showed a decrease in mean RH (dried out in winter)
- Homes receiving ERV showed no change in the mean RH



ERV's effective at preventing excessive dryness

Conclusions

1. Field studies have shown that the use of an ERV has a favorable impact on the RH control
2. In warm and humid season, the use of an ERV to exhaust air from bathrooms leads to lower indoor RH when used with an A/C system
3. In wintertime, the use of ERV to ventilate helps prevent drying the indoor air any further
4. Premature to conclude that an ERV with bathroom pick-up will have a favorable or unfavorable impact on indoor RH control in every climate conditions
5. Premature to penalize the ERV technology which looks promising on an indoor RH control standpoint at this time

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boualem.ouazia@nrc-cnrc.gc.ca