

Major IEQ Research Projects Since 2001

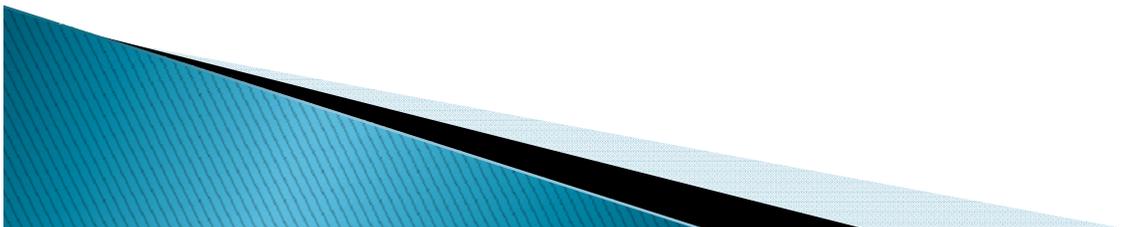
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Davis, California

PIER Workshop on IEQ Research Roadmap Update

July 28, 2011, Sacramento, CA

Major Studies of IEQ and/or Its Determinants: *Selection Criteria*

- ▶ Field studies or surveys with large sample sizes
- ▶ Field studies conducted in California, unless noted otherwise
- ▶ Chamber or test home studies with several products or test conditions
- ▶ Appropriate study design, methods, and quality control



Major Studies of IEQ and/or Its Determinants: *Types of Research Areas*

- ▶ Indoor Pollutant Sources
 - Residential and Commercial
- ▶ Building Field Studies
 - Commercial
 - Schools and Daycare
 - Residential
 - Low Energy (Low E)
 - Single Family, new and existing
 - Multi-family
- ▶ Air Cleaners and Filters

Indoor Pollutant Sources: Residential and Commercial

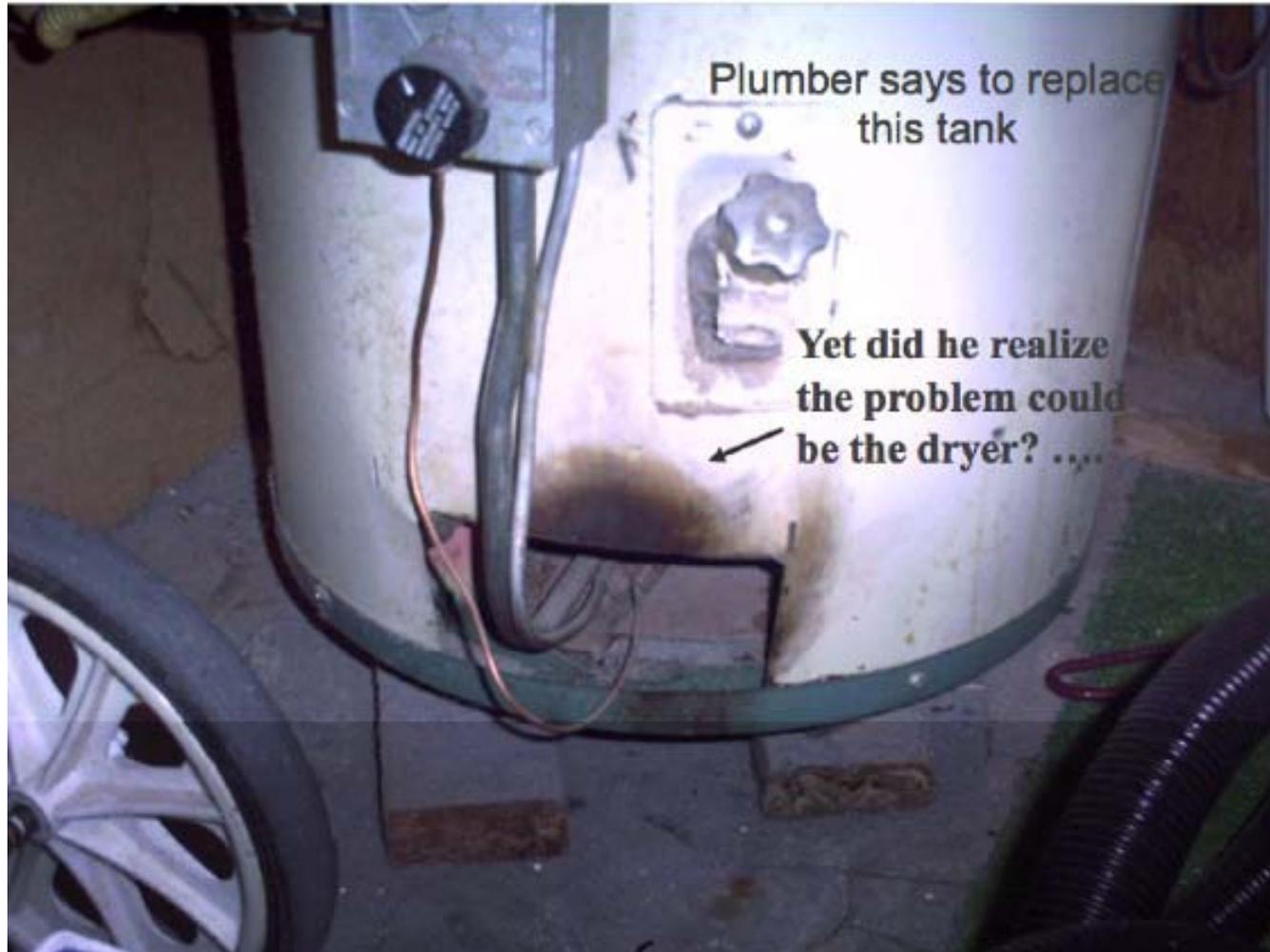
- ▶ Residential Cooking Study
 - CARB / Arcadis, 2001
 - Test house: Particulate matter (PM), ultrafine PM, NO₂, CO, PAHs, ventilation
- ▶ Garage Depressurization Field Studies
 - CMHC / Sheltair, 2004
 - Health Canada / Scanada / Others, 2001
 - Ventilation, CO modeling (Canada)
- ▶ Office Equipment Emissions Study
 - PIER / CARB / LBNL (Ongoing)
 - VOCs*, SVOCs*, ozone, PM, ultrafine PM

* VOCs: Volatile Organic Compounds, generally including formaldehyde and other carbonyls. SVOCs: semi VOCs.

Indoor Pollutant Sources (contd.)

- ▶ **Residential Range Hoods as Mitigation Strategy**
 - PIER / LBNL / GTI, Ongoing
 - Lab tests of pollutant removal, flow, noise, energy.
- ▶ **Unvented Combustion Gases**
 - PIER / LBNL, Ongoing
 - Evaluate mitigation measures for gas appliances; surveys and/or field studies; test advanced technology water heaters
- ▶ **Natural Gas Variability**
 - NG and LNG Combustion Emissions from Appliances.
PIER / LBNL / GTI, 2009.
 - Indoor Air Quality Impacts of NG & LNG Combustion.
PIER / LBNL / GTI, Ongoing.

IEQ Problem Solved by Weatherization



Source: C. von Schrader, ACI Conference, March 30th, 2011, San Francisco, CA.

Indoor Pollutant Sources (contd.)

- ▶ **Building Materials Emissions Study**
 - CalRecycle / CDPH, 2003
 - VOCs

- ▶ **East End Office Building Pre- and Post-Occupancy VOC Study**
 - CDPH / BAA / Levin, 2006
 - VOCs

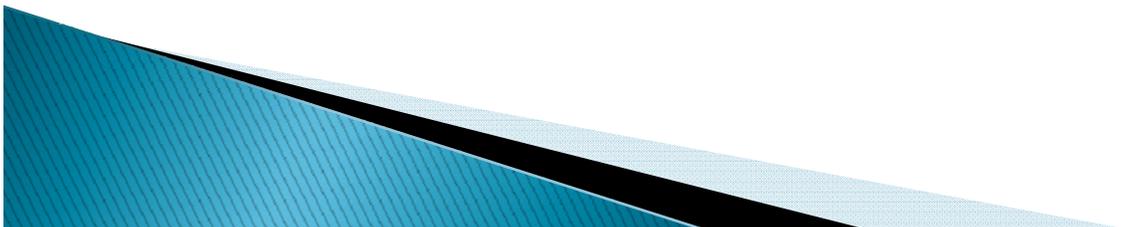
- ▶ **Indoor Chemistry Studies**
 - Cleaning Product VOC Emissions.
CARB / UCB, 2006.
 - Aircraft Cabin Studies of VOCs.
DTU / UCB / EOHSI / Others, 2005 on.

Indoor Pollutant Sources: *Microbes*

- ▶ No major monitoring studies or adequate assessment tools
- ▶ Major reviews of health effects
 - Institute of Medicine, 2004. Damp Indoor Spaces and Health.
 - Fisk et al., Indoor Air 2007. Meta-analyses.
 - World Health Organization, 2009. Dampness and Mould (Guideline).
 - Mendell et al., Env. Health Perspec. 2011.
- ▶ Microbial Ecology of Indoor Environment
 - Sloan Foundation / UCD / UCB / Others (ongoing)
 - Fungi, bacteria, viruses, moisture (CA and US)

Indoor Pollutant Sources: *Air Cleaners*

- ▶ Ozone Emissions of Portable Electronic Air Cleaners, CARB 2005
- ▶ Electronic Air Cleaner Survey, CARB / UCB 2006
- ▶ In Duct Air Cleaner Ozone Emission Study, CARB / UMR / Others (ongoing)



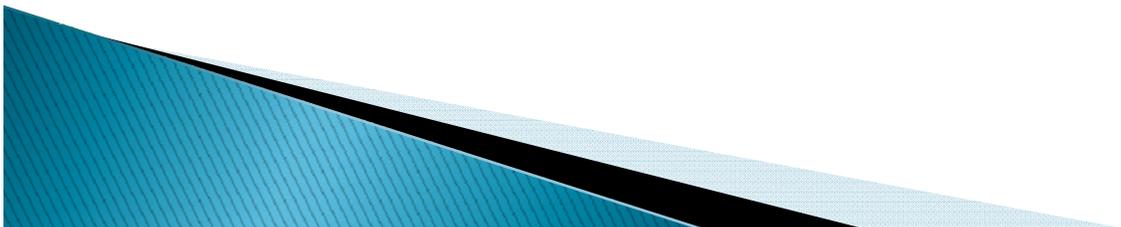
Indoor Pollutant Sources (contd.)

▶ SVOCs

- Endocrine disruptors in indoor air and house dust.
Silent Spring Inst., 2003 on.
California and US.
- SVOC Needs Assessment.
Indoor Air Inst., 2009 and 2011 (US)

▶ Formaldehyde

- No major studies; measured primarily for product certification



Commercial Buildings

- ▶ Low Energy buildings: none
- ▶ Building Assessment Survey & Evaluation (BASE)
 - EPA / Others, 1999 – 2007
 - Mostly large office buildings
 - Field study; VOCs, mold, bacteria, allergens, PM, CO₂, HVAC, filtration, symptoms (US).
- ▶ IAQ and HVAC Survey of Small & Medium Commercial Buildings:
 - PIER / CARB / UCD / LBNL / UCB, Ongoing.
 - Survey and field study
 - VOC, PM, black carbon, sources, comfort, ventilation, filtration, operation, and maintenance.
- ▶ Healthy Zero Energy Building Program
 - PIER / LBNL, Ongoing.
 - Research methods; lab, field, modeling, & cost studies; IAQ, sources, comfort, perception, performance.

Schools

- ▶ **California Portable (and Traditional) K-12 Classrooms Study**
 - CARB / CDPH / RTI, 2003
 - VOCs, PM, CO, allergens, mold, metals, pesticides, ventilation
- ▶ **CO2 and Attendance in Elementary Schools**
 - PIER / WSU / LBNL / NWAPA, 2004
 - Ventilation, attendance, SES (Washington & Idaho)
- ▶ **Several smaller studies, e.g.:**
 - Texas IAQ in Schools, UT Austin, 2002 (Texas).
 - IAQ Problems in Schools and Classrooms and Retrofit Benefits, ASERTTI / Florida Solar Energy, 2006 (US)

Schools: *Childcare and Others*

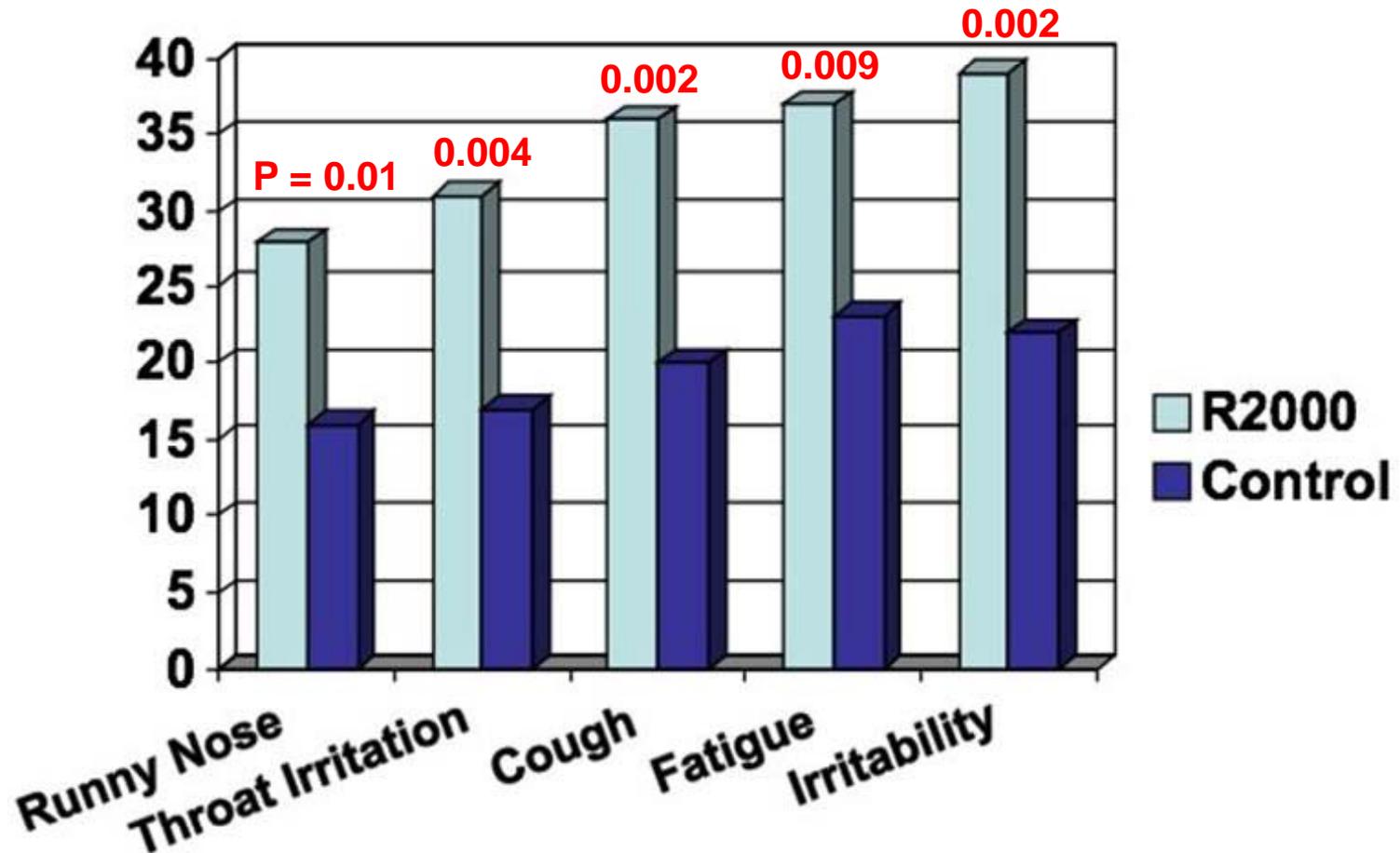
- ▶ Early Childhood Education Environments Study
 - CARB / UCB (ongoing)
 - VOC, SVOC, pesticides, PM
- ▶ Ventilation Strategies of Child Care Centers
 - Zuraimi et al., 2007
 - PM, CO, microbes, ventilation, allergy and respiratory symptoms (Singapore).
- ▶ Post-secondary schools: none

Residential: *Low Energy Homes*

- ▶ No major IEQ, ventilation, or health studies
- ▶ Review of international programs:
 - Zero Carbon Trust / NHBC Foundation/ Crump et al., 2009
 - “dearth of information” regarding IAQ
 - “urgent need for research” on ventilation system performance and the impact on the health and well-being of occupants.
- ▶ R-2000 Pilot Health Study
 - Health Canada, 2004
 - HRVs, low-VOC materials, symptoms (Canada)
- ▶ Ventilation and leakage studies
 - Several case studies in CA, US, and Canada

R-2000 Pilot Health Study

% Homes with Significant Improvement of Symptoms

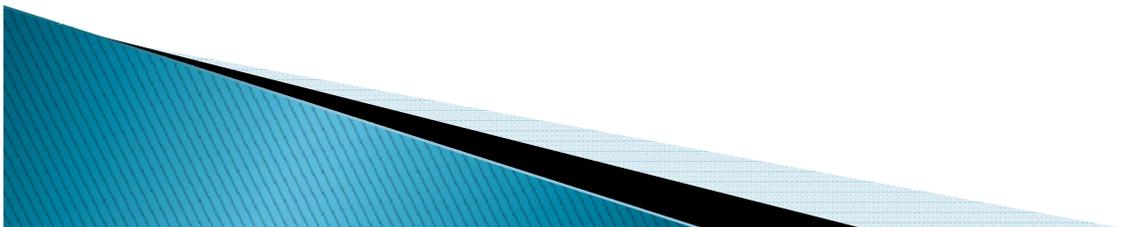


Single Family Homes: *New*

- ▶ **Ventilation & IAQ in New Homes**
 - PIER / CARB / Offermann, 2009. VOCs, PM, NO₂, CO, ventilation.
 - PIER/ CARB/ UCB / LBNL, 2007. Ventilation survey.
- ▶ **California New Home Energy Survey.**
 - PIER / Wilcox et al., 2011.
 - Ventilation, leakage paths, flows, HVAC zoning, IAQ problems.
- ▶ **Residential Energy Savings from Air-tightness and Ventilation Excellence**
 - PIER / LBNL, Ongoing.
 - Improved building systems, ventilation, source emissions; commissioning methods; retrofit guidelines; codes and standards.

Single Family Homes: *Existing*

- ▶ Characterization of Indoor, Outdoor, and Personal PM (COPD Patients)
 - CARB / EPA/ Harvard, 2002 (Los Angeles)
 - PM, elemental carbon, elements, nitrate, ventilation
- ▶ Detailed Characterization of Indoor and Personal PM.
 - CARB / EPA/ Harvard, 2004 (Los Angeles)
 - PM, ultrafine PM, Black carbon, nitrate, house dust phthalate, ventilation
- ▶ Indoor, Outdoor, and Personal Air (RIOPA).
 - Leland Center / Rutgers / Others, 2005 on. Los Angeles, Houston TX, Elizabeth NJ.
 - PM, VOCs, ventilation.



Existing Single Family Homes (contd.)

- ▶ IAQ of Sound Treated Homes
 - MNCEE, 2002 (Minnesota)
 - Depressurization, leakage, combustion safety, CO

- ▶ Weatherization and IAQ
 - ORNL / Energy Center of Wisconsin, Ongoing (US)
 - Radon, formaldehyde, CO, symptoms

- ▶ Residential Ventilation Intervention
 - NRC Canada, Ongoing (Canada)
 - VOCs, PM, ventilation, symptoms

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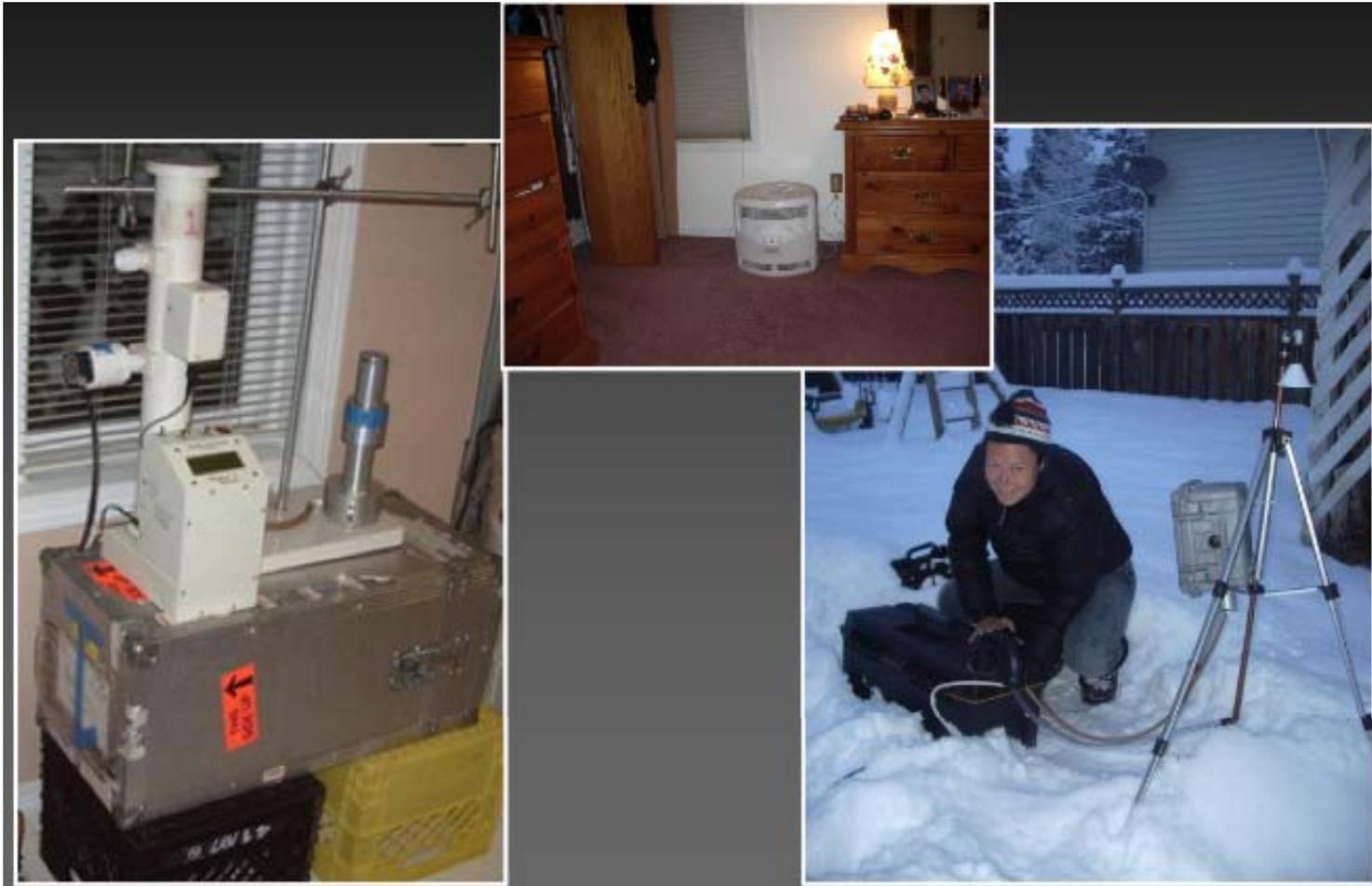
Multi-family Homes

- ▶ Energy and IEQ Retrofits In Low-Income Apartments
 - PIER / LBNL / EPA / HUD, Ongoing
 - PM, VOCs, CO, NO_x, ozone, ventilation, spillage, noise, comfort, tenant satisfaction
- ▶ Mother and Children's Study
 - Columbia University, Ongoing (New York City)
 - PM, PAHs, allergens, developmental effects
- ▶ Env. Tobacco Smoke Control Study
 - MNCEE, 2004 (Minnesota)
 - Air sealing and ventilation controls.
- ▶ PM in Assisted Living and Rest Homes
 - EPA, 1998–1999. Fresno and Baltimore
 - PM, criteria gases, ventilation

Air Cleaners and Filters

- ▶ Only small studies to date; no long-term testing
- ▶ Residential HEPA, Woodsmoke, and Cardiovascular Effects
 - Simon Fraser U. / UBC / Others, 2011
 - Northern British Columbia (3 towns)
 - 25 homes and 45 persons
 - PM_{2.5}, smoke tracer, biomarkers
- ▶ HEPA in Classrooms (Pilot)
 - SCAQMD / IQ Air, 2009
 - Los Angeles (9 classrooms, 3 schools)
 - PM, ultrafine PM, VOCs, black carbon

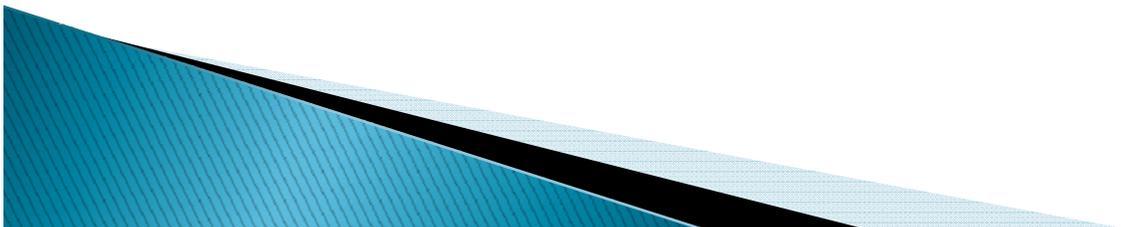
Collecting AQ Data in Northern BC



Source: R. Allen. Presentation at ISEE Conference, August 26, 2009, Dublin, Ireland.

Summary

- ▶ IEQ benchmark data are lacking for many categories of buildings, e.g., low-E buildings and buildings for sensitive populations.
- ▶ Good data and guidance are lacking on many determinants of IEQ
- ▶ Health impact data are rare.



Any Other Studies?

Please send citations and websites to:

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