IEA-Annex 68 IAQ Design and Operation Strategies for Low Energy Residential Building

A Proposed Framework for Modeling and Benchmarking (draft for discussion)

By

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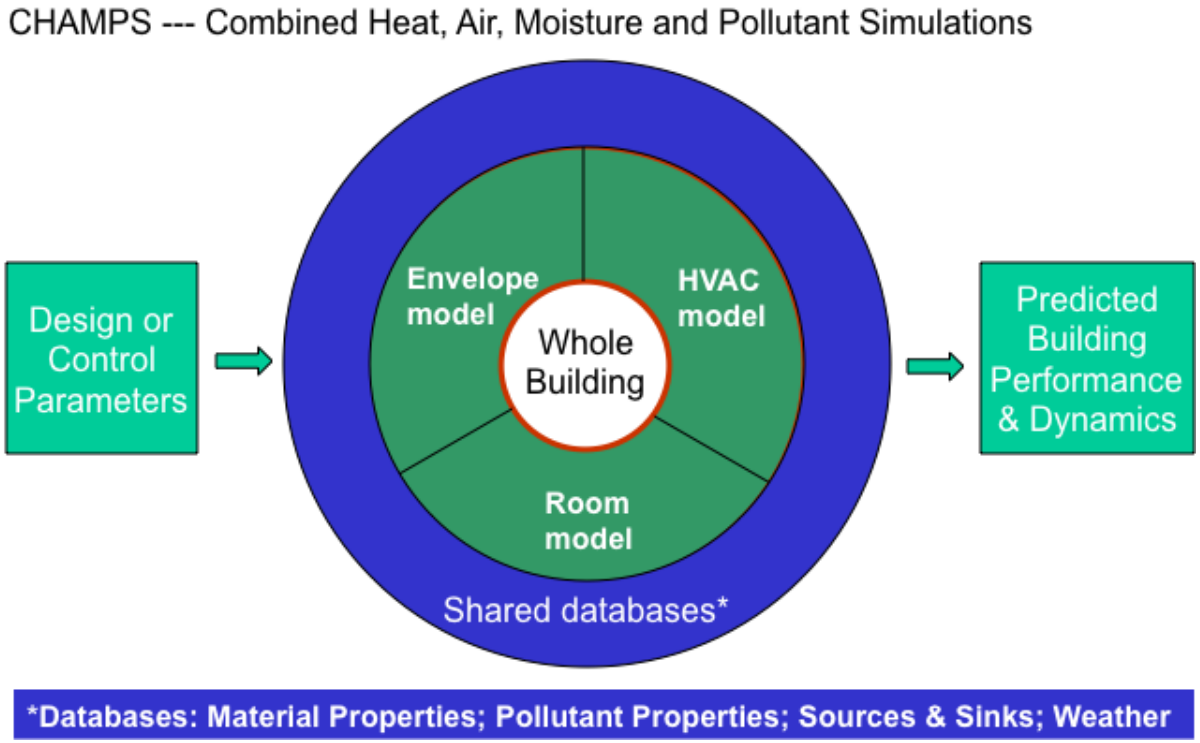
Outline

- Introduction
  - *Objectives of IEA-Annex 68 Task 3 Modeling*
  - *Potential IAQ problems in low-energy buildings*
  - *IAQ control concepts and principles*
  - *Role of modeling and benchmarking*
- A proposed framework for modeling and benchmarking
  - *A single zone model for load analysis*
  - *Multizone whole building models*
  - *Definition of reference buildings*
- Next steps and challenges

Objectives of Annex-68 Task 3: Modeling

- Review, analyze knowledge gaps, and categorize existing models and simulation methods
- Collect and develop validated reference cases for modeling and simulations
- Use contemporary whole building analysis tools and methods to predict the hygrothermal conditions, sorption and transport of humidity and chemical substances, and energy consumption within buildings



Low-Energy Buildings and IAQ

- Energy efficiency measures
  - *Air-tight construction*
  - *Super insulation*
  - *Heat recovery ventilation*
  - *Natural or hybrid ventilation*
  - *Wind energy harvesting*
  - *Solar heat and solar PV*
  - *Thermal storage*
  - *Efficient lighting*

- Potential IAQ problems
  - *Low tolerance for error in construction and operation*
  - *Inadequate control of indoor pollution sources*
  - *Introduction of pollutants from outdoors and building enclosure*
  - *Insufficient outdoor air for pollutant dilution*
  - *Inadequate moisture control*

Air Pollution Processes and Control

Transport

Inhibitors & Sinks

Pollutant Sources

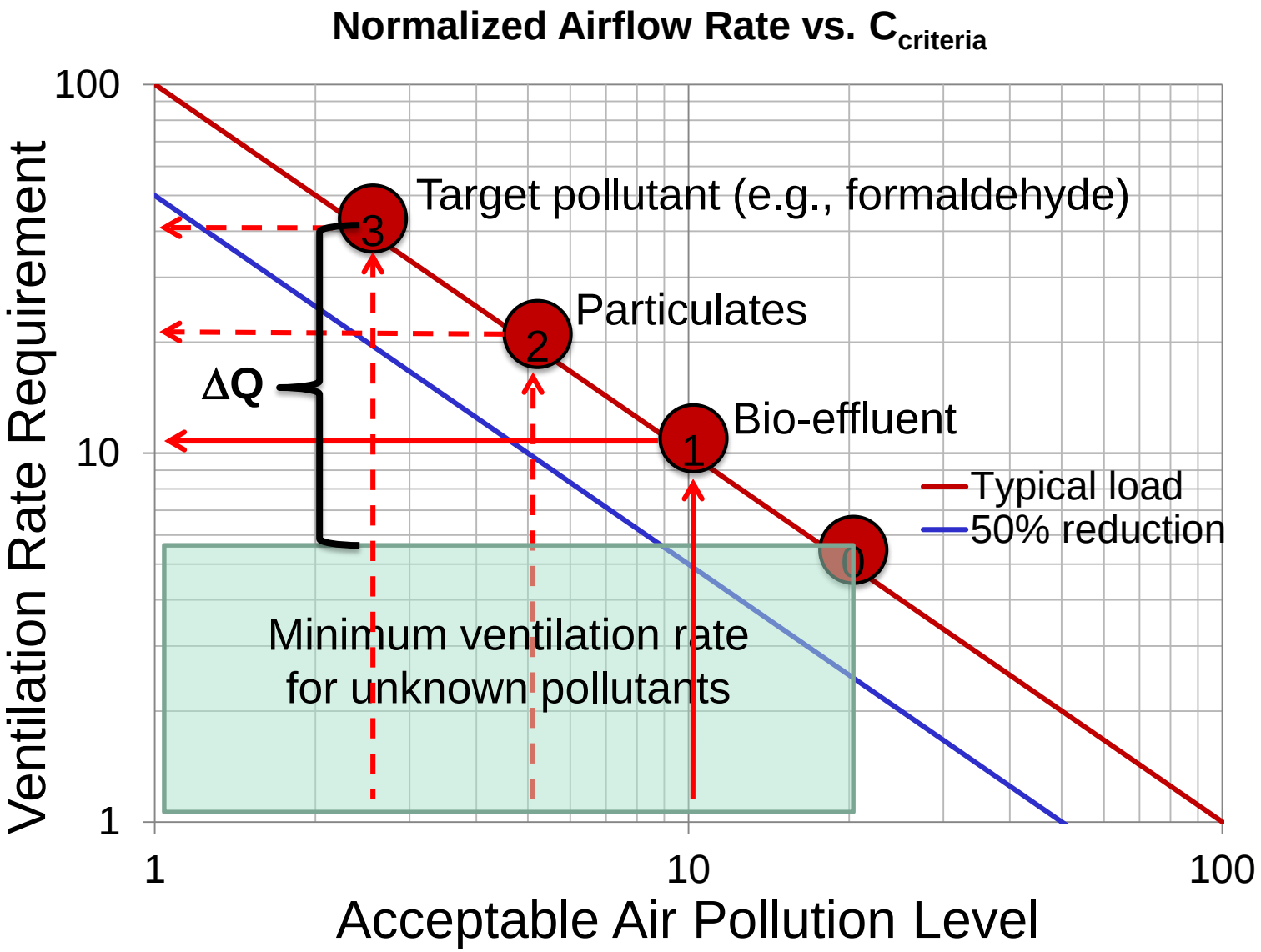
- Outdoor
- Indoor
  - People
  - Materials & equipments
  - Reactive compounds

Source controls
- Remove or prevent sources
- Lower source emissions
- Exhaust pollutants locally

Ventilation
- Delivery clean air
- Dilute pollutants

Air purification

Source Control, Ventilation or Air Purification?



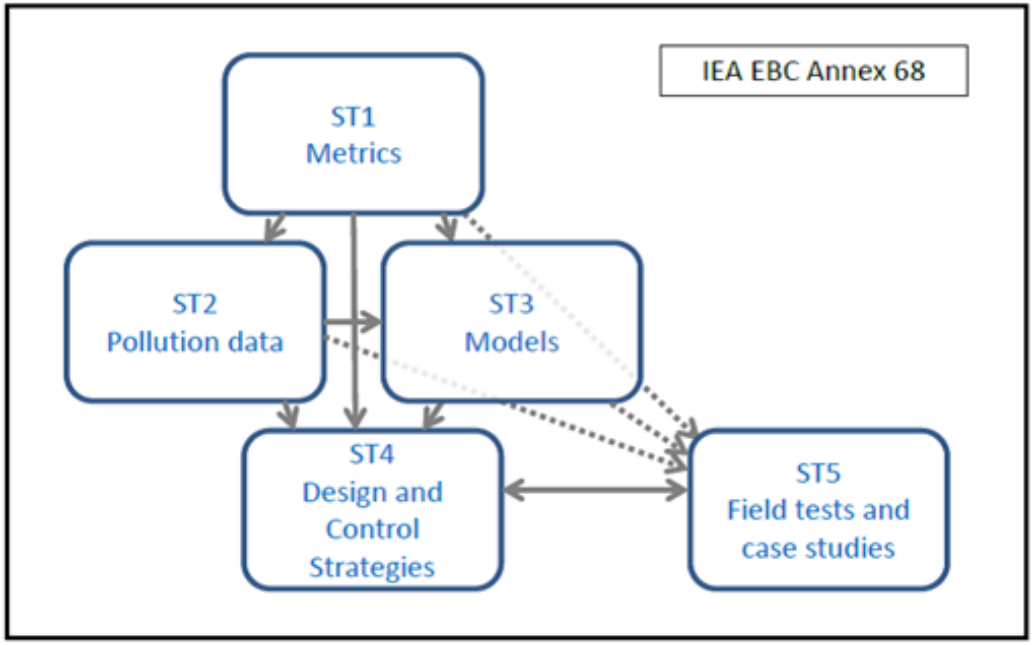
Integrated IAQ Strategies

1) Source control to the extent possible
   - *Removal and prevention of pollutant sources*
   - *Emission reduction*
   - *Local exhaust/suction*
2) Ventilation
   - *Dilution for all pollutants (known or unknown)*
   - *Personal air delivery*
3) Air cleaning/purification
   - *Active or passive*
   - *For target pollutants*
   - *No harmful byproducts allowed*

The goal of integration is to improve IAQ in a most energy-efficient and cost-effective manner.

Role of Modeling and Benchmarking

- Physical, chemical and biological processes affecting IAQ
  - *Sources and sinks, ventilation, and air purification*
- Interactions between energy efficiency and IAQ strategies
  - *e.g., Energy recovery and ventilation, Solar heating and material emissions, Natural ventilation and air cleaning*
- Performance evaluation of energy efficiency and IAQ strategies
  - *How do the proposed strategies compare to reference buildings?*
- Recommendations of optimal IAQ strategies in low-energy buildings



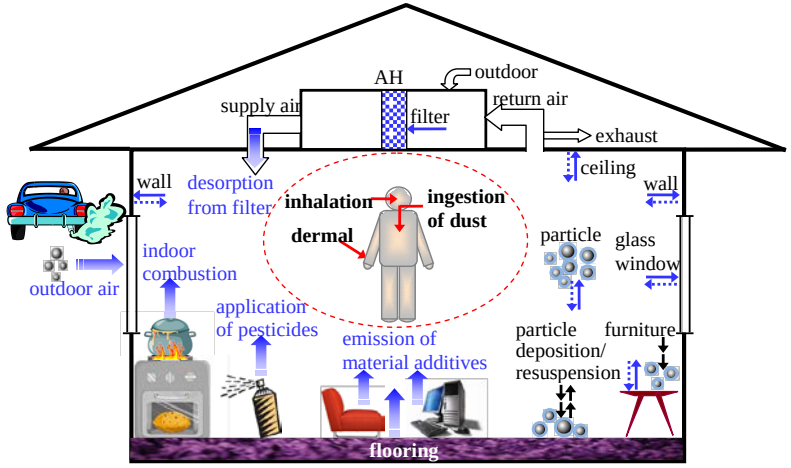
A Framework for Modeling and Benchmarking

- A single zone model
  - *Pollution load and "budget" analysis comparing to the established IAQ targets*
    - ☞ Sources and sinks, and their interactions
    - ☞ Indoor and surface chemistry
    - ☞ Effects of temperature and humidity
  - *Validation by full-scale chamber test data*
  - *Evaluation of IAQ strategies for the reference house and extrapolation to other houses*
- Multizone whole building models
  - *CHAMPS-MZ, CONTAM, DesignBuilder/E+, VDS/E+/CHAMPS-MZ*
  - *Energy and IAQ performance evaluation against the reference house*
- Definition of reference buildings for benchmarking
  - *Different references for dissimilar type of residences - Single family house, semi-detached, townhouse, low-rise apartment, high-rise apartment*
  - *Different references for dissimilar climate zones*

A Single Family House Example

- Definition of a reference house for single family houses
  - *Climate zone: 6A*
  - *Size and occupancy: 1500 SQFT, two stories with a basement, 3 bedrooms, two bathrooms, a kitchen/dinning room, a living/family room*
  - *Design specifications: Building America practice, ASHRAE 62.2, and 90.2*
  - *Design Builder/E+ simulation to determine baseline energy consumptions*
- Single zone model representation
  - *Indoor sources and sinks*
  - *Infiltration*
  - *Ventilation*
  - *Air purification*
- Whole building model representation
  - *DesignBuilder/E+ and CONTAM*
  - *VDS (CHAMPS-MZ and E+)*
  - *Modelica + GUI*

Source: Tim Stenson, Syracuse University



Source: Xu, Ying and Zhang, J.S. 2011. Indoor SVOCs Exposure and the Role of HVAC Systems. ASHRAE Journal

Next Steps and Challenges

- Develop an approach for scaling and extrapolation
  - *Dimensional analyses and reference scales*
  - *Design and operating conditions*
  - *Performance indices*
- Develop a method to quantify the uncertainties in the simulation results
- Develop a protocol for reliable modeling and simulations – quality assurance
  - *Comparison between different tools for reference buildings*
  - *Parametric studies for trend analysis*
  - *Comparison with field measurements (e.g., NIST Net-zero energy house)*


Thank you.