Introduction to Dynamic Buffer Zones (DBZ)

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Presentation Outline

• Introduction to Dynamic Buffer Zones
  *What is it?  Why use it?*
• Advantages and Limitations
• Modes of Operation
• Case Studies
What is a Dynamic Buffer Zone?

“...an area that actively separates the interior and exterior air using pressure differences, in order to prevent them from mixing.”
Why Use a Dynamic Buffer Zone?

1) Prevent bulk moisture migration through air leakage control (traditional use)

2) Heat recovery to reduce space heating requirements (less common)
Advantages & Limitations of a Dynamic Buffer Zone

**Advantages:**

- Good for new or retrofit
- Heritage
- Relatively inexpensive
- Simple concept
- Easy to commission
- Minimal disruption to interior finishes or exterior cladding

**Limitations:**

- Requires energy input
- Additional capital
- Difficult to install if no cavity exists (retrofit)
- Contaminants problematic (depending on application)
Two Modes of Operation

“Balloon” System

- Air is pumped into the cavity with no intentional exhaust air
- When pressure drops below set point - fan turns on again

“Exhaust” System

- Supply continuous airflow into the cavity and intentionally exhaust air to maintain pressure at pre-determined level
- How and where the air is exhausted from and to is unique to the building
Ottawa’s Canadian Museum of Nature
Ottawa, Ontario

• Retrofit for Heritage Building
• High interior humidity requirement for exhibits
• Moisture migration into exterior wall deteriorating the mortar between the stones
• DBZ introduced to prevent moisture migration
Butterfly Conservatory
Niagara Falls, Ontario

- Condensation Control
- High temperature and humidity requirement in cold climate
- Butterflies stick to glass and then…
- Nets are traditional solution
- “building within a building”
- DBZ pressurizes between envelopes
Library
Toronto, Ontario

• Mitigation of existing condensation problem
• Lower cost solution
Library

LIBRARY ATRIUM
Library

- Stacks
- Painted GWB
- Open Web Stud
- Cell Glass Insulation
- CIP Concrete Wall
Library

In (+) 24° 40%
Cavity (- -) 24° 40%
Out (-) -18°
Library
Library

24°
40%
30%?
Using Solar Dynamic Buffer Zone Walls to Increase Performance of Air Source Heat Pumps in Cold Climates

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The Goal

• Develop a near passive strategy to reduce heating energy in buildings
• Strategy should be at little to no extra cost
• Strategy should not sacrifice architectural features
The Goal

• Propose Solution – Façade Solar Heat Recovery
• Build an Analytical Model
• Validate the Model (Software, Experiments)
• Assess potential of proposed solution to save energy
• Applications
The Residential Wall

89mm brick

25mm unvented cavity

38mm extruded polystyrene

38mm x 89mm batt filled stud space

12.5mm gypsum board
The DBZ Wall

- 89mm brick
- Shelf Angle
- Variable size vented cavity
- 38mm extruded polystyrene
- 38mm x 89mm batt filled stud space
- 12.5mm gypsum board
- Ambient air intake
- Typical floor construction
- Fan
- Duct to air handler
Heat Transfer Mechanisms

- SW radiation from sun
- LW radiation to sky
- LW radiation to air
- LW radiation to ground
- Ambient-Brick convection
- Radiation exchange between surfaces
- Conduction
- Brick-Airflow Convection
- Sheathing-Airflow Convection
- Interior-Gypsum convection
- Airflow absorbing heat from brick and sheathing
Analytical Model

• 5 Unknown Temperatures
  • Interior/Exterior Brick Surfaces
  • Interior/Exterior Wall Assembly
  • Exit Air
• System of 5 Equations to Solve
Model vs Experimental

- 3 of 4 surface temperatures agreed to within 1°C
- Exit air temperatures agreed to within 1°C
- Accurate Model
Performance Results

Delta T vs Flow Rate

Temperature Rise (°C)

Flow Rate

21 m³/h/m²
36 m³/h/m²
72 m³/h/m²
Thermal Storage

Solar Energy

Heat Recovered
Potential Applications

- Preheating Ventilation Air
- Air Source Heat Pumps
  - Improve heating efficiencies
  - Cold temperature operation
Preheating Ventilation Air

• Analysis using the “analytical model”
• 25-75 kWh/m²/year compared to 150-200 kWh/m²/year for commercial systems (i.e. Solarwall)
• Efficiencies of up to 33% (heat rec. / solar radiation)
Air Source Heat Pumps

Efficiency of ASHP

\[ \Delta \text{COP} \]
Air Source Heat Pumps

Heating Capacity of 3-Ton ASHP

Δ Heating Capacity

Heating Capacity (kW)

OAT (°C)
Air Source Heat Pumps

- Reduction in heating energy by 8% due to
  - Higher COP’s with increase in OA temperatures
  - Longer compressor run time (instead of electric heating)
Low Temperature Heat Pumps

- Variable Refrigerant Flow Systems
- Operate down to -15°C
- Capital cost premium
- Still decrease in performance with lower OAT
Conclusions and Recap

• It works! Can preheat air up to 12°C
• Minor modifications to standard construction
• Efficiencies of up to 33% for preheating ventilation
• Can recover up to 70 kWh/m2/year of solar energy for preheating ventilation air
• ASHP improved efficiencies and reduced heating energy by 8%
• Longer compressor run times