Mechanical vs. Natural Ventilation in Schools: Less Can Be More

Brad Stanley
Purafil, Inc.
Outline

- Natural Ventilation (N.V.)
- Climate Factors
- Contaminant Factors
- ASHRAE 62.1 Options
Natural Ventilation (1)

  - N.V. using operable windows
    - N.V. can be an effective and energy-efficient way to supplement HVAC systems – temp & humidity permitting
    - Sealed buildings with appropriately designed and operated HVAC systems can often provide better indoor air quality
Natural Ventilation (2)

- IAQ Design Tools for Schools & CHPS Best Practice Manual (cont.)

- Most parts of the country require conditioning of outdoor air to provide acceptable thermal comfort for building occupants
Natural Ventilation (3)

Potential Benefits
- Eliminate need for cooling
- Other savings (higher ceilings = daylighting)
- Occupant adaptation

Potential Problems
- Noise
- Uncontrolled moisture
- Outdoor sources of pollutants
- Outdoor air quality
Climate Factors (1)

Recommendations from Literature


- Mild Climate = Yes for N.V.
- Hot, Dry Climate = some potential for N.V.
- Hot, Humid Climate = No for N.V.
- Cold Climate = No for N.V.
Climate Factors (2)

Map of the United States showing climate zones:
- **Marine (C)**
- **Dry (B)**
- **Moist (A)**

Key:
- **Zone 1** includes Hawaii, Guam, Puerto Rico, and the Virgin Islands
- **Zone 2**
- **Zone 3**
- **Zone 4**
- **Zone 5**
- **Zone 6**
- **Zone 7**

Legend:
- All of Alaska in Zone 7 except for the following Boroughs in Zone 8:
  - Bethel
  - Dillingham
  - Fairbanks N. Star
  - Nome
  - North Slope
  - Northwest Arctic
  - Southeast Fairbanks
  - Wade Hampton
  - Yukon-Koyukuk

Warm-Humid Below White Line
Climate Factors (3)

- Where are buildings which have incorporated N.V.?
- New Building Institute’s Getting to Fifty Database
  - Location of buildings which incorporated some level of N.V. in design
Climate Factors (4)

GT 50 - US Buildings with N.V.

= Building Location
Climate Factors (5)

Getting to Fifty – US Buildings with some level of N.V.
- Total Buildings = 32
- Temperatures
  - 34% in zone 4 (Mixed)
  - 31% in zone 3 (Warm)
  - 19% in zone 5 (Cool)
  - remaining 12% in zones 1, 6, & 7 (Very Hot, Cold, Very Cold)
- Humidity
  - 66% in Dry & Marine (38% in Marine, 28% in Dry)
  - 34% in Humid
- Majority of buildings = warm, mixed, cool temperatures; dry & marine humidities - Western United States
Climate Factors (6)

GT 50 - US K-12 Schools with N.V.

= Building Location

All of Alaska in Zone 7 except for the following
Boroughs in Zone 8:
Bethel
Dillingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon-Koyukuk

Zone 1 includes
Hawaii, Guam, Puerto Rico, and the Virgin Islands.
Climate Factors (7)

Getting to Fifty – US Schools with some level of N.V.
- Total Schools = 11
- Total Schools with N.V. = 5
- Temperature Zones of all N.V. Schools: 3 - 5 (Warm, Mixed, Cool)
- Humidity Zones of all N.V. Schools: Dry, Marine
- Western United States
Contaminant Factors (1)

- US EPA National Ambient Air Quality Standards (NAAQS)
- Related to Criteria Contaminants in Air:
  - carbon monoxide (CO), ozone (O$_3$), nitrogen dioxide (NO$_2$), sulfur dioxide (SO$_2$); particulate matter, lead
  - particulate matter: PM$_{10}$, PM$_{2.5}$
### Contaminant Factors (2)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Primary Std</th>
<th>Averaging Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon monoxide</td>
<td>9 ppm</td>
<td>8-hour</td>
</tr>
<tr>
<td></td>
<td>35 ppm</td>
<td>1-hour</td>
</tr>
<tr>
<td>nitrogen dioxide</td>
<td>0.053 ppm</td>
<td>annual</td>
</tr>
<tr>
<td>Ozone</td>
<td>0.08 ppm</td>
<td>8-hour</td>
</tr>
<tr>
<td></td>
<td>0.12 ppm</td>
<td>1-hour (limited areas)</td>
</tr>
<tr>
<td>sulfur oxides</td>
<td>0.03 ppm</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>0.14 ppm</td>
<td>24-hour</td>
</tr>
<tr>
<td>lead</td>
<td>1.5 µg/m³</td>
<td>quarterly average</td>
</tr>
<tr>
<td>PM&lt;sub&gt;2.5&lt;/sub&gt;</td>
<td>15.0 µg/m³</td>
<td>annual</td>
</tr>
<tr>
<td></td>
<td>35 µg/m³</td>
<td>24-hour</td>
</tr>
<tr>
<td>PM&lt;sub&gt;10&lt;/sub&gt;</td>
<td>150 µg/m³</td>
<td>24-hour</td>
</tr>
</tbody>
</table>
Contaminant Factors (3)
Contaminant Factors (4)

- Getting to Fifty – US Schools with some level of N.V
  - 5 Total Schools; 2 Schools in nonattainment areas
  - CA Orange County
    - Carbon Monoxide - Serious
    - 8-Hr Ozone - Severe
    - PM-10 - Serious
    - PM-2.5 - Nonattainment
  - CA Santa Clara County
    - 8-Hr Ozone - Marginal
ASHRAE 62.1 Options (1)

- Is less natural ventilation more in your location (more occupant comfort, more air quality)?
- There are options for saving energy in ASHRAE 62.1 with the two ventilation methods
  - Ventilation Rate Procedure
  - Indoor Air Quality Procedure
ASHRAE 62.1 Options (2)

- Ventilation Rate Procedure
  - Air filtration (gas-phase and particulate)
  - VAV, Dynamic Reset

- IAQ Procedure
  - Air filtration (gas-phase and particulate)
  - Alternate amount of outside air (lower)
Summary

- Less N.V. can be more (comfort & air quality)
  - Climate: hot, humid, cold zones
  - Air Contaminants: nonattainment areas (site specific sources, urban areas)

- Other Options to Reduce Energy Consumption and Provide Comfort & IAQ
  - 62.1 VRP – VAV, Dynamic Reset
  - 62.1 IAQP – Possibility of less outdoor air
References & Further Info