FINE CONTROL AND NATURAL VENTILATION
VKR Group Structure
Why are we here?

- WindowMaster, through research and development over the last 20 years has established itself as an authority on Natural Ventilation control, and market leader in energy efficient intelligent solutions delivered in over 500 projects.

- WindowMaster window actuators, and facade integration
  - Fine control with 2 way positional feedback. Unique MotorLink technology
  - mm x mm opening to provide fine control
  - 3 speed actuators including ‘silent’ operation
  - Programmable anti entrapment control

- Window controls specialists and indoor climate consultants with in house expertise

- WindowMaster complete services for complete proven solutions
What is Natural Ventilation?

Where the indoor climate of the building is controlled by fresh air intake through openings within the facade that open automatically to provide single sided or cross ventilation for a stable indoor climate and good air quality with minimum heat loss through use of

- Opening windows and roof lights
- Louvres
- Windcatchers or chimneys
- Hybrid solutions using mechanical ventilation
Natural Ventilation
A History of Control
The Problem with Natural Ventilation…

Natural Ventilation?

- too hot!
- too cold!
- too stuffy!
- Draughty!
- high energy bills!
- unpredictable results!

• Naturally ventilated BSF projects using 300% more energy than expected
• Manual Windows – do they really do the job?
• Good design, but poorly specified or value engineered
• Installed automated systems that can introduce more problems than they solve?
• Acoustics?
• Health?
• Security?
• Perceived performance improvement in SBEM systems…though at what cost?

The answer?
Well designed buildings and controls
Fine control….solution based, not product based
The Need For A Stable Climate

- User comfort
- Optimal window/opening position
- Insufficient air change
- Draught and cold problems
- Air change
A stable climate?

- A stable indoor climate is essential for productivity.
- Incremental movements significantly reduce noise and disturbance.
- Precise control of the ventilation prevents draughts.

- Precise control provides consistent and even spread of ventilation.
- Precise control of natural ventilation provides a comfortable and invigorating environment for all the occupants of the office.
How to Achieve Natural Ventilation

- Natural Ventilation is achieved through controlled openings in the external facade of the building, which on the basis of different indoor and outdoor conditions regulate the indoor climate by means of:

- Wind pressure
- Temp. differences
- Shape of the building
Poor Control of Natural Ventilation

- The human temperature and air quality sensor
  - Reactive
  - Heat loss and additional energy costs
- Heat and purge (fully open/closed)
- Modulating control based on
  - Zone temperature no external drivers for wind pressure
  - Closing windows during rain....no ventilation
- Product only based solutions
  - Windows
  - Louvres
  - Windcathers/Chimneys
  - Hybrid Solutions
- Complex difficult to understand control systems.....the result
- Manual or mechanical solutions
Controlling Natural Ventilation

Manual Control

- Lowest cost option – depends on the user operating the windows at the correct times and by opening the correct amount.

- Research has shown:

  CO2 levels can reach up to 4,000ppm in winter because the natural response to cold outdoor temperatures is to leave windows closed.


- Teachers are there to teach – do they want to open and close each of 4 windows in a class 40 times a day?
- If opened too much or left open it can have a significant impact on heat losses and therefore energy consumption
- Security
- No Night Cooling

The potential consequences – poor air quality, disruption to occupants, high energy useage
Manual Control of Windows?

Temperature

Source: 2009 KONTROLLIERTE FENSTERLÜFTUNG – PILOTPROJEKT SCHULHAUS UNTERMOOS
Werner Hässig and André Galli
Manual Control of Windows?

CO2 in Winter

Source: 2009 KONTROLLIERTE FENSTERLÜFTUNG – PILOTPROJEKT SCHULHAUS UNTERMOOS
Werner Hässig and André Galli
Calculations with Jannick Roth MSC
Wind

Positive Cp values (between 0 and 1)
Negative Cp values (between -1 and 0)

\[ P_{\text{ref}} = \frac{1}{2} \cdot \rho_u \cdot V_{\text{ref}}^2 \]

\[ P_1 = C_{p1} \cdot P_{\text{ref}} \]

\[ P_2 = C_{p2} \cdot P_{\text{ref}} \]
Thermal Buoyancy and wind – several openings

Pressure differential over opening $j$:

\[
\Delta P_j = P_j - P_i = \left( C_{pj} \cdot \frac{1}{2} \cdot \rho_w \cdot v_{ref}^2 + \rho_w \cdot g \cdot \left( H_{0 \text{ ref}} - H_j \right) \frac{\Delta T}{T_i} \right) - P_i
\]

Reference Height $H_{0 \text{ ref}}$:

Typical neutral plane determined by mass balance
Air Exchange Rates by Thermal Buoyancy and Wind

~5 l/s per person
Why: Weather is dynamic

A comfortable indoor climate depends on a precise control of windows opening. The controls specialist should calculate a Cp value for each window from wind pressure from different wind directions.

Based on the Cp-values the required opening area / opening degree is calculated for each wind direction and speed in order to get the necessary air change in the building.
CFD calculation - why?

Complex building design
CFD calculations - why?

Complex building design + surroundings
Pressure/Cp reading

Wind: NE

Wind: SE

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This provides the required degree of opening to achieve a certain air change
CFD simulations - surroundings

Without surroundings

With surroundings
CFD simulations

Without surroundings

With surroundings
Ejbyskole in DK (school)
Importance of Fine Control – Opening distance vs Air flow

Results from Wind Tunnel tests on the specific windows, carried out by WindowMaster.
The Importance of Fine Control

- The importance of the first 5 cm of window opening for Natural Ventilation
- Control within this area is essential for:
  - Control of temperature and CO$_2$
  - Control noise
  - Reduction of Draughts
  - Improved Security
  - Night Cooling
Fine Control and Acoustics BB93

- Sound insulation at different opening distances

![Graph showing sound reduction in dB against degree of opening in mm]
Fine Control and Night Cooling

- Optimised Night Cooling with restricted openings
- Windows located high within façade
- Windcatchers/roof windows for cross ventilation and mixed night cooling strategies
- Potential use of louvres in high risk areas
- Use of internal courtyards
- Use of PIR sensors/CCTV with direct link to automatic controls
Oerestad High School

• Danish architect: 3XNielsen
• Size: 12,500 m²
• Has been occupied since August 2007
• Coordinated control of light and air
• Opening windows and vertical louvres
Oerestad High School – Innovative Design
Oerestad High School – Ventilation Principle
Oerestad High School – Opening Distances

- Window opening distances in October 2007 and March 2008
• Recommendation in British Standard (BB101): Maximum 120 hours above 28°C
• Recommendation in Danish Standard: Maximum 100 hours above 26°C and 25 hours above 27°C
Oerestad High School – Measured Temperatures

Temperatures during a hot summer day (22.08.2007)

Temperature [°C]

Time [hour]

Zone 1
Zone 4
Zone 6
Zone 12
Zone 17
Zone 20
Outdoor temperature
Conclusion

- Good building design
- Analysis required for both design compliance and fine control strategies
- Solution design based not led by one specific product with considerations for
  - Location
  - Acoustics
  - Security
- One controls solution for Natural Ventilation with single point of responsibility
- Strong specifications
- Proof of ability to comply with specification through
  - Live data logging
  - Post occupancy evaluation
  - Client testimonials
- Performance specifications to be ‘specific’ not vague
- Value engineering not cost cutting that devalues the design intent
Any questions?