

## SOLUTIONS AND TECHNOLOGIES

DR. THEOFANIS PSOMAS  
VENTILATIVE COOLING IN BUILDINGS: NOW & IN THE FUTURE  
INTERNATIONAL WORKSHOP  
23<sup>RD</sup> OCTOBER 2017



### Ventilative Cooling Sourcebook: Annex 62

The sourcebook is oriented to architects, engineers and building service designers, aiming to support them in selecting the right component, in appropriate quality, for implementation in their specific ventilative cooling projects.

- Supplementary material of the Ventilative Cooling State-Of-The-Art-Review
- ✓ Airflow guiding ventilation components
- ✓ Airflow enhancing ventilation components
- ✓ Passive cooling ventilation components
- ✓ Automation components
- Performance indicators of components
- New developed components (13 national projects) and product examples
- Glossary (AIVC, Standards and other sources)



## Ventilative Cooling Sourcebook: Annex 62

The screenshot shows the venticool website. The URL `venticool.eu/annex-62-publications/deliverables/` is circled in red. The page features the venticool logo and a navigation menu. A red circle highlights the navigation menu items: Home, About, Partners, Publications, Events, Contact, WELCOME, FAQs, Home, About, Participants, and Publications. Another red circle highlights the list of Annex 62 deliverables:

- Ventilative Cooling, State-of-The-Art Review
- Recommendations for legislation and standards (To be published December 2017)
- Ventilative cooling source book (To be published December 2017)
- Ventilative cooling case studies (To be published December 2017)
- Guidelines for ventilative cooling design and operation (To be published December 2017)
- Ventilative Cooling potential tool – User guide (version 1.0)

The Aalborg University Denmark logo is visible at the bottom of the page.

## Overheating risk

- Even during transition months
- Central and northern Europe
- Simplified monthly methods of calculation (average in time and space)
- New challenge for designers and occupants (unknown problem)

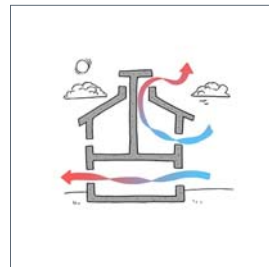
Degrade the indoor environmental quality, affect productivity, satisfaction, well-being, morale, increase morbidity and mortality-vulnerability of the occupants



## Ventilative cooling

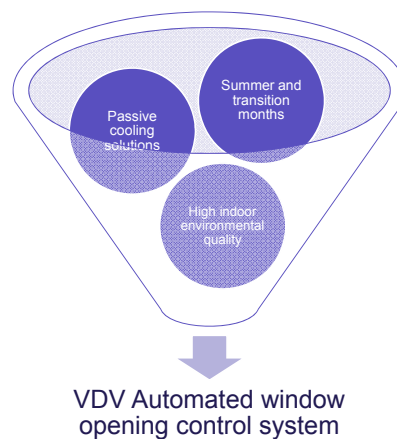
### *Cooling from the outdoor air*

- Energy-efficient, attractive, sustainable, simple and cost-effective solution
- High potential in central and northern Europe
- High efficient at night
- Present in every buildings through natural and/or mechanical systems
- Remove excess heat gains as well as increase air velocities and thereby widen the thermal comfort acceptability



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## Goals of the system

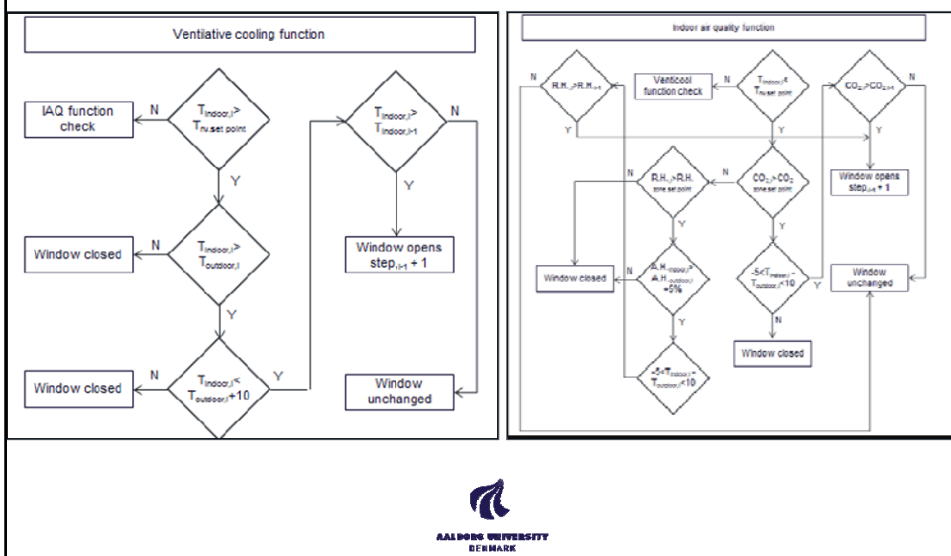


## VDV Automated window opening control system

- 3 Functions (cooling, shading and indoor air quality)
  - ✓ Indoor natural ventilation cooling temperature, set point range: 18-30°C
  - ✓ Indoor temperature for shading, set point range:  $\pm 3^\circ\text{C}$  relative to indoor natural ventilation cooling temperature
  - ✓ Carbon dioxide, set point range: 400-2000ppm
  - ✓ Relative humidity, set point range: 50-90%
  - ✓ Time interval for control action, range: never, 10 minutes, 30 minutes, 1 hour, 4 hours
- 3 Occupancy states (non-occupied, occupied, night (zone level), also based on time)
  - Possibility to set parameters, override or deactivate the system
  - Environmental parameters of current day
  - Special signals show up for critical values
  - Rain sensors pre-fitted



## Heuristic algorithms of the system



## Case study

- Built in 1937 in Birkerød, Denmark
- Area: 172.4 m<sup>2</sup> (363.3 m<sup>3</sup>)
- East-West orientation
- 2-storey detached with inclined roof and basement (4 members family)
- Renovation in steps 2006-2014
- Façade side-hung wooden windows from 90s (internal shading systems)
- Pivot roof windows (9 with motors and actuators); all internal blackout shading and southern with external shading systems (awnings)
- Mechanical ventilation with heat recovery (both floors)



## Case study



## Monitoring campaign

- May 2015: Silver-box encapsulated accurate commercial sensors (ISO 7726:1998) of upper floor and outdoors
  - ✓ Temperature (indoor, outdoor;  $\pm 0.3$  °C )
  - ✓ Carbon dioxide concentration ( $\pm 50$  ppm or 5%)
  - ✓ Relative humidity (indoor, outdoor;  $\pm 3$  %)
- May 2016: additional 2 sensors, at the living room and kitchen, ground floor
- Time step: 5 mins

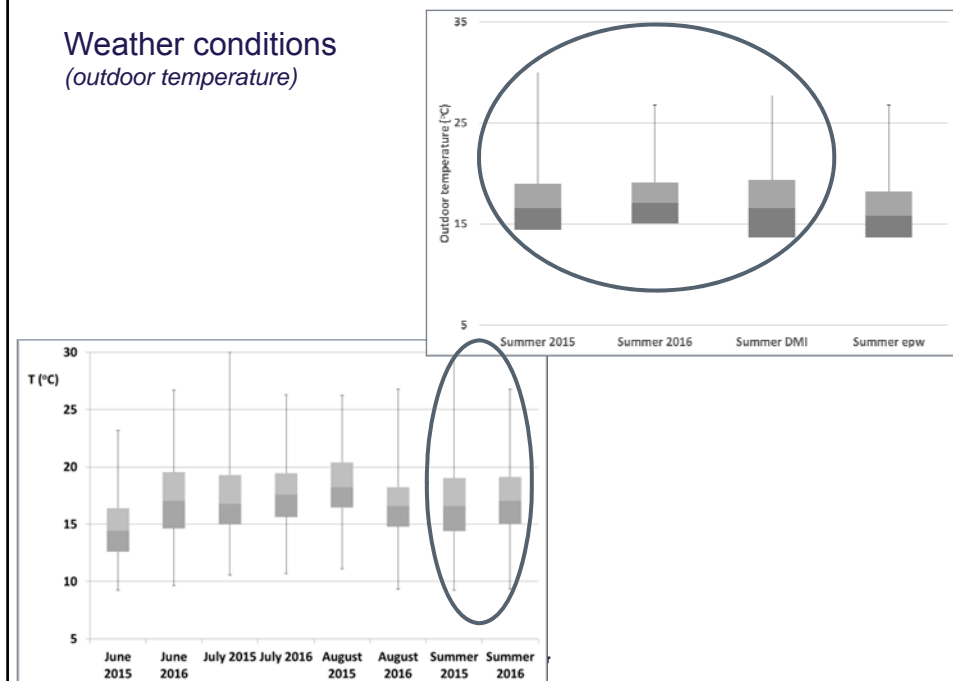


## Ventilation and cooling of the space

- 2015 summer (June, July, August)
  - ✓ Manual use of façade-shading systems
  - ✓ Balanced mechanical ventilation system constantly (based on temperature setpoints)
  - ✓ Semi-automated system (4 times per day 15', 50% for 15' (manual), leaving home and holiday system, sun screening hotter hours, goodnight/morning function etc.) at the roof windows
- 2016 summer (June, July, August)
  - ✓ VDV system at the roof windows
  - ✓ No use of façade windows and shading systems (also 2 roof windows without actuators)



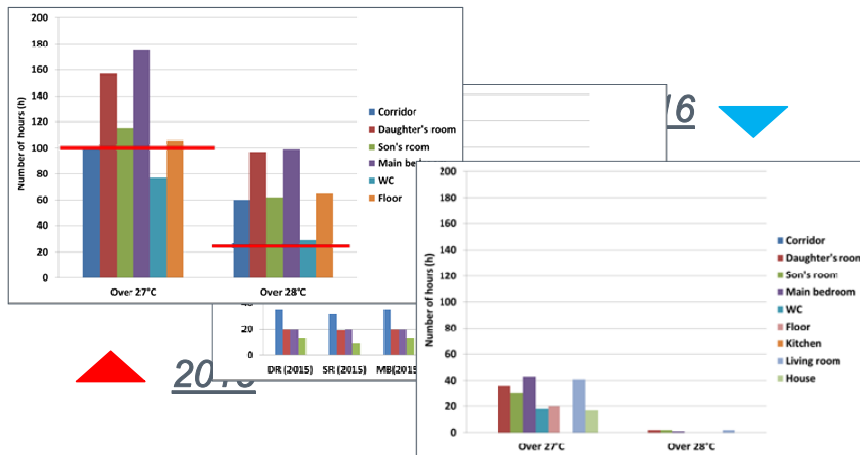
## Weather conditions (outdoor temperature)



## Weather conditions

- 2015 and 2016 are “typical” Danish summers
- Peak temperature in July for 2015 and in August for 2016
- Similar wind intensity, temperature and global solar radiation
- 181 hours of rain (2015) and 185 (2016)

## Thermal comfort assessment (Static index)



## Energy use

- Mechanical ventilation system: **Summer 2015**  
220.8 kWh
- VDV system (opening, shading and both gateways): **Summer 2016**  
10.1 kWh

**95.4% savings!**



## Conclusion

The developed window system (95% energy savings) may significantly diminish the indoor discomfort without any compromise of the air quality.



### Automated Windows Market is Predicted to Grow Approximately At 5.12% CAGR By 2023

Press release from: [Market Research Future](#)



Global Automated Windows Market By Product (Electric, Mechanical, Hybrid), By Component (Sensors & Detectors, Control Panels, Motors & Actuators, Switches and Others), By Application (Residential, Commercial, Industrial) & by Region - Global Forecast to 2023

Factors such as rising population and favorable conditions for international trade & tourism have impelled various governments across the globe to invest heavily in the construction of urban infrastructure and public infrastructure projects, which is anticipated to drive the automated windows market during the forecast period. The automated windows market is expected to reach USD 7.1 Billion by 2023.

Get a sample report at [www.marketresearchfuture.com/sample\\_request/4023](http://www.marketresearchfuture.com/sample_request/4023).

Market Research Analysis

The global automated windows market has been analyzed based on the three segments, namely product, component, application and regions. On the basis of product, the global automated windows market is segmented as electric, mechanical and hybrid. Electric segment accounted for largest market share in 2016. The integration of high reliable actuators and sensors for automated control and the ability to maintain the ambient temperature will augment the growth of the segment.

Based on component, the global automated windows market is bifurcated as sensors & detectors, control panels, motors & actuators, switches and others. Through the installation of these components, noise reduction and automated control can be achieved. Based on application, the global automated windows market is bifurcated as residential, commercial, and industrial. Among these, the residential segment accounted for the largest share in 2016.

Scope of the Report

This study provides an overview of the global automated windows market, tracking two market segments across four geographic regions. The report studies key players, providing a five-year annual trend analysis that highlights market size, volume and share for Asia-Pacific, North America, Europe and Rest of the World (ROW). The report also provides a forecast, focusing on the market opportunities for the next five years for each region. The scope of the study segments the global automated windows market by its product, by component, by application and regions.

DENMARK

Ventilative cooling in buildings: now & in the future  
International Workshop  
23 October 2017

## Solstad Kindergarden

Solutions and technologies

Professor Hans Martin  
Mathisen

Department of Energy and Process  
Engineering

Faculty of Engineering

Norwegian University of Science and  
Technology



Norwegian University of Science and Technology



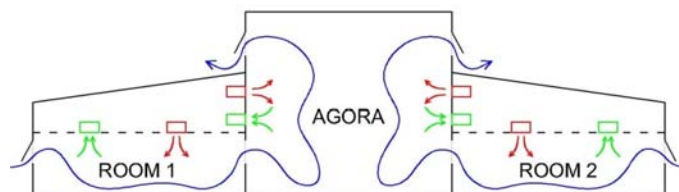
## Solstad Kindergarden in Larvik

- Floor area 788 m<sup>2</sup>
- Completed in 2011
- South of Norway, close to the coast
- Heating Degree Days, 3870
- Annual average temperature, 7 °C
- Design temperature heating, -18 °C
- Well insulated building:
  - Window U-value 0,92 W/m<sup>2</sup>K
  - Wall U-value 0,18 W/m<sup>2</sup>K





## Ventilation principle



- Balanced mechanical ventilation
- Natural ventilation through motor operated windows and hatches
- Mixed mode type of hybrid ventilation
- Advanced control system for mechanical and natural ventilation
  - Demand controlled ventilation (DCV) due to CO<sub>2</sub> and temperature
- The janitor stops the mechanical ventilation during the warmer time of the year



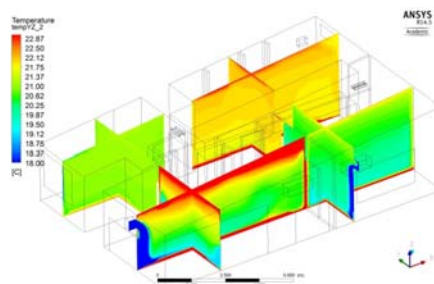
## Control system

- Winter:
  - DCV for mechanical: Set point 900 – 1200 ppm CO<sub>2</sub>
  - DCV for window: Set point 950 – 1500 ppm CO<sub>2</sub>
  - Window operation limited by indoor temperature, 19 °C
  - Windows will only operate if mechanical system can not handle air quality (as measured by CO<sub>2</sub>)
- Summer
  - DCV for mechanical: Set point 900 – 1300 ppm CO<sub>2</sub>
  - Zone set point for window operation is indoor temperature exceeding 21 °C
  - Night time ventilation allowed (If  $t_i > 23$  °C after 17:00, open until  $t_i < 18$  °C)
- Limitations related to wind and rain

7

NTNU

## Simulations, window ventilation



- Outdoor temperature 9 °C
- Simulated indoor temperatures 1,5 K lower than measured
- However, indicates a risk of overcooling

NTNU

## Other findings and comments

- Users and building owner are very satisfied with the solutions for ventilation, cooling and heating
- The indoor temperature is very well controlled with very few to warm hours. 2 % of working hours > 25 °C, less than 1 % above 28 °C
- The system requires qualified personnel for operation
- The janitor overrules the control system i.e. he stops the mechanical ventilation during summer
- There is a risk of overcooling