

Ventilative Cooling – Design & Examples
AIVC & Venticool Webinar 26th March 2020

Design and Performance of Ventilative Cooling: Lessons Learned From a Review of Well Documented International Case Studies

venticool
the international platform for ventilative cooling



Paul D O'Sullivan
MeSSO Research (<https://messocit.ie>)
Cork Institute of Technology, Ireland



agenda

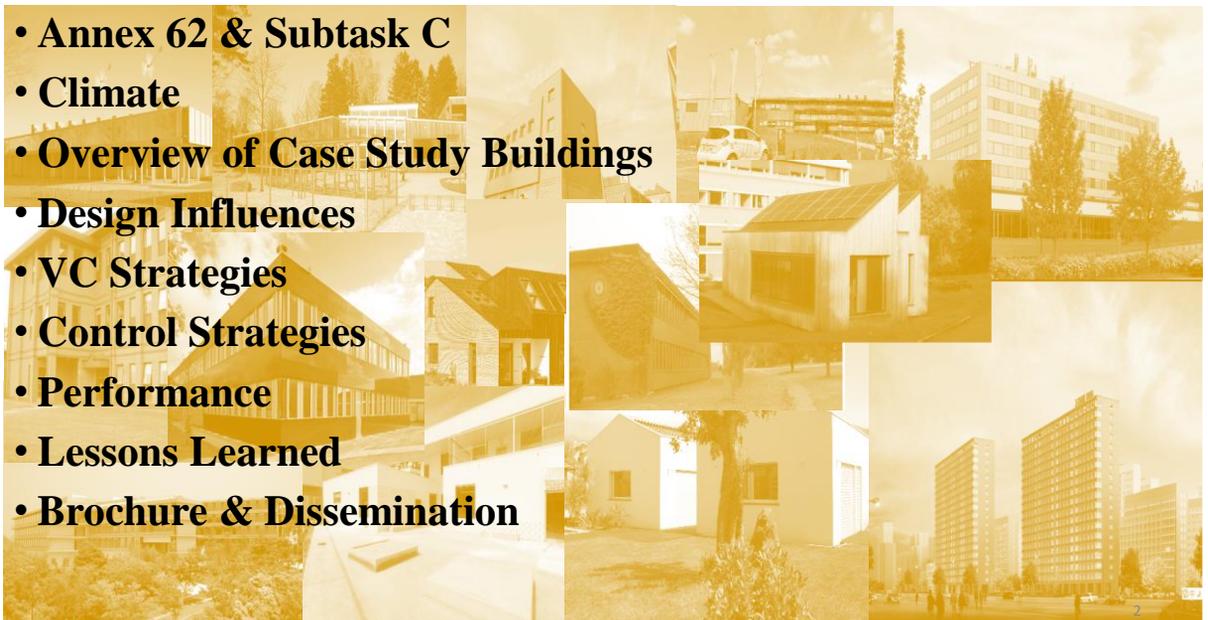
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EBC



- Annex 62 & Subtask C
- Climate
- Overview of Case Study Buildings
- Design Influences
- VC Strategies
- Control Strategies
- Performance
- Lessons Learned
- Brochure & Dissemination



Well Documented Case Studies of VC Annex 62 – Sub Task C

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To fulfil the scope of the Annex and to make energy-efficient use of ventilative cooling (air-based systems) the preferred solution the Annex focuses on the following specific objectives:

- To analyse, develop and evaluate suitable methods and tools for prediction of cooling need, ventilative cooling performance and risk of overheating in buildings that are suitable for design purposes (Subtask A).
- To give guidelines for integration of ventilative cooling in energy performance calculation methods and regulations including specification and verification of key performance indicators (Subtask A).
- To extend the boundaries of existing ventilation solutions and their control strategies and to develop recommendations for flexible and reliable ventilative cooling solutions that can create comfortable conditions under a wide range of climatic conditions (Subtask B).
- **To demonstrate the performance of ventilative cooling solutions through analysis and evaluation of well-documented case studies. (Subtask C).**

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- Activity C.1.

Analysis and evaluation of performance of ventilative cooling solutions and of used design methods and tools using similar criteria and methods

- Activity C.2.

Lessons learned and development of recommendations for design and operation of ventilative cooling as well as identification of barriers for application and functioning.

What Climates Are Covered In The Case Studies?

Variation in climate regions for all case study buildings.

(Please refer to the Koppen-Geiger climate classification system for details on KG abbreviations in column 1)

K-G	General Description	Qty	Locations
Cfb	Temperate with warm summers and no dry season	5	Cork, IE; Ernstbrunn, AT; Waregemand Ghent, BE; Verrieres-le-Buisson, FR; Bristol, UK
Cfa	Temperate, hot summers and no dry season	3	Changsha, CN; Hayama, JP
Dfb	Cold with warm summers and no dry season	3	Stavern, NO; Trondheim, NO; Innsbruck, AT
Dfc	Cold with no dry season and cold summer	1	Larvik, NO
Csa	Temperate with dry, hot summers	2	Sicily, IT; Lisbon PT

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Who, Where, What, When?

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Contributions

Country	Building Name	Building Type	Year	Floor Area m ²	Strategy
IE	zero2020	Office	2012 ^(R)	223	Natural
NO	Brunla Primary school	Education	2011 ^(R)	2500	Hybrid
NO	Solstad barnehage	Kindergarten	2011 ^(N)	788	Hybrid
AT	UNI Innsbruck	Education	2014 ^(R)	12,530	Hybrid
AT	wk Simonsfeld	Office	2014 ^(N)	967	Hybrid
BE	Renson	Office	2003 ^(N)	2107	Natural
BE	KU Leuven Ghent	Education	2012 ^(N)	278	Hybrid
JP	Nexus Hayama	Mixed Use	2011 ^(N)	12,836	Natural
JP	GFO Building Osaka	Office	2013 ^(N)	394,000	Hybrid
PT	CML Kindergarden	Education	2013 ^(N)	680	Natural
UK	Bristol University	Education	2013 ^(R)	117	Mechanical

Country	Building Name	Building Type	Year	Floor Area m ²	Strategy
CN	Wanguo MOMA	Residential	2007 ^(N)	1109	Mechanical
FR	Maison Air et Lumiere	House	2011 ^(N)	173	Natural
IT	Mascalucia ZEB	House	2013 ^(N)	144	Hybrid
NO	Living Lab	Residential	2014 ^(N)	100	Hybrid ⁹

What were the design influences for Ventilative Cooling ?

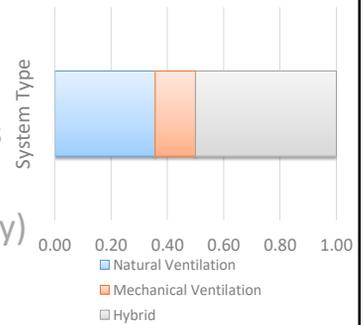
Country		Building	Lower Initial costs	Lower Maintenance Costs	Lower Energy Costs	Reducing Solar Loads	Reducing Internal Loads	Reducing External Noise	High internal noise propagation	Elevated Air Pollution	Avoiding Rain Ingress	Insect Prevention	Burglary Prevention	Reduced Privacy	Air Leakage
IE	R	zero2020	H	M	H	H	L	L	L	L	M	L	H	M	M
NO	R	Brunla Primary school	H	H	H	L	M	L	L	H	M	L	L	L	H
NO	R	Solstad barnehage	L	L	H	L	L	L	M	H	L	L	L	L	H
AT	U	UNI Innsbruck	H	H	H	M	L	M	L	L	M	L	L	L	H
AT	R	wk Simonsfeld	H	H	H	M	L	L	L	L	L	L	L	L	M
BE	R	Renon	L	M	L	H	H	H	L	L	L	L	L	L	L
BE	U	KU Leuven Ghent	H	L	H	H	H	L	L	L	M	L	L	L	H
JP	R	Nexus Hayama	M	M	H	H	L	L	L	L	M	H	H	M	M
JP	U	GFO Building	H	M	L	L	L	L	L	L	L	L	L	L	L
PT	U	CML Kindergarden	H	L	L	M	M	L	L	L	M	M	M	M	L
UK	R	Bristol University	H	H	H	L	H	L	M	L	M	M	H	L	L
CN	U	Wanguo MOMA	H	M	H	H	L	L	L	L	M	L	M	L	H
FR	U	Maison Air et Lumiere	M	M	L	H	M	L	L	H	L	L	M	L	M
IT	R	Mascalucia ZEB	H	M	H	H	L	L	L	L	L	L	M	L	M
NO	U	Living Lab	L	L	H	H	M	L	M	L	H	L	L	L	H

How did We Do VC?

Ventilative cooling Concepts	Natural driven	Mech. Supply Driven	Mech. exhaust driven	Natural night ventilation	Mech. night ventilation	Air conditioning	Indirect Evap. Cooling	Earth to Air Heat Exch.	Phase Change Materials
zero2020 (IE)	X			X					
Brunla Primary school (NO)	X			X					
Solstad barnehage (NO)	X		X	X	X				
UNI Innsbruck (AT)	X		X	X					
wk Simonsfeld (AT)	X		X						
Renson (BE)	X			X					
KU Leuven Ghent (BE)	X		X				X		
Nexus Hayama (JP)	X					X			
GFO Building (JP)	X	X	X			X			
CML Kindergarden (PT)	X			X					
Bristol University (UK)					X	X			X
Wanguo MOMA (CN)		X	X		X	X			
Maison Air et Lumiere (FR)	X								
Mascalucia ZEB (IT)	X			X				X	
Living Lab (NO)	X								13

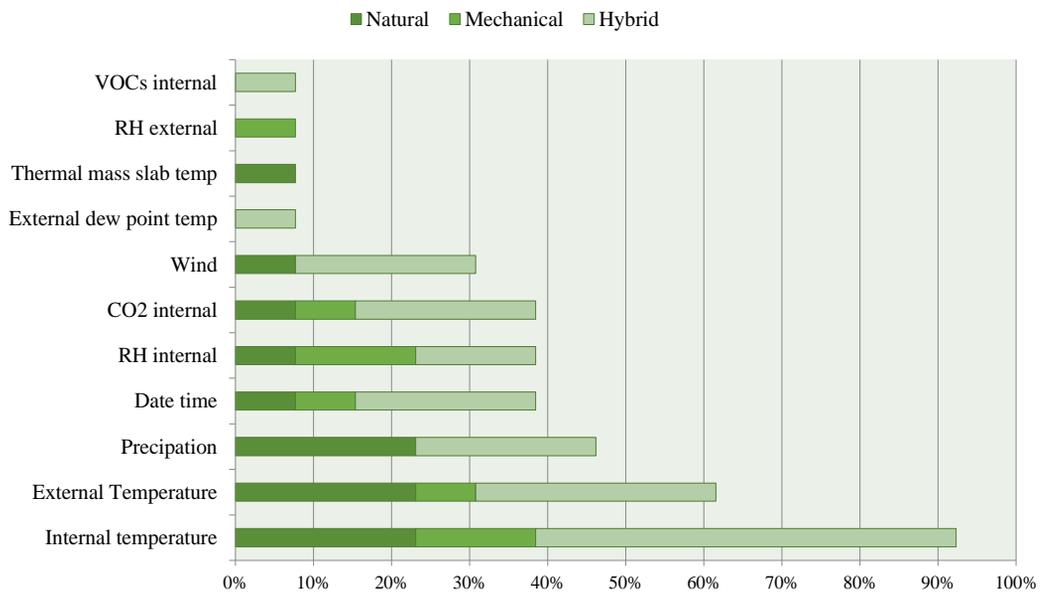
Summary points

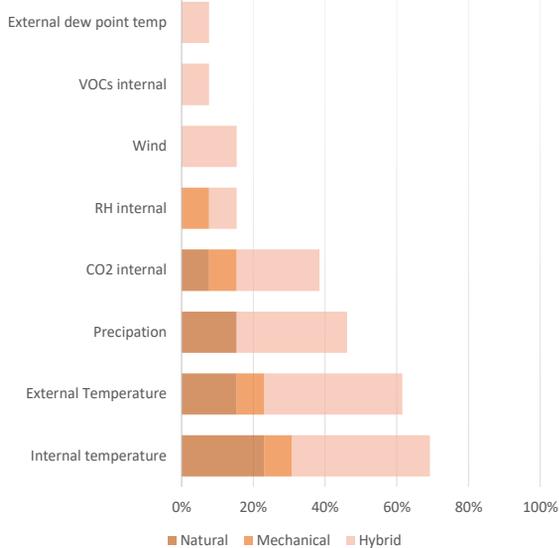
- 86%, of the VC case studies use natural ventilation
 - Generally, sensible internal loads for NV $\leq 30 \text{ Wm}^{-2}$. (Average is 25 Wm^{-2} .)
- 50% of buildings using Hybrid VC (most prevalent strategy)
 - Internal loads in Hybrid spaces were:
 - $\geq 40 \text{ Wm}^{-2}$ in Norway and Belgium
 - $\leq 10 \text{ Wm}^{-2}$ in Austria & Italy
- No. of Days with a maximum daily external temperature $\geq 25^\circ\text{C}$ ranged from 10 to 120 days across all cases



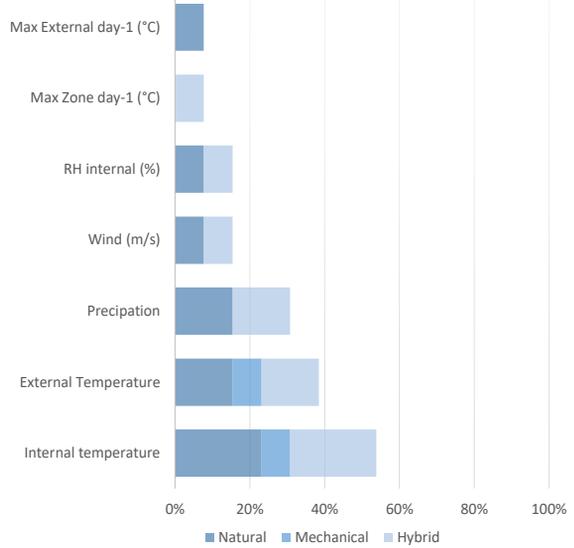
How Do We Control VC?

Control Strategies Overall





Occupied Hours



Night time ventilation

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Summary points

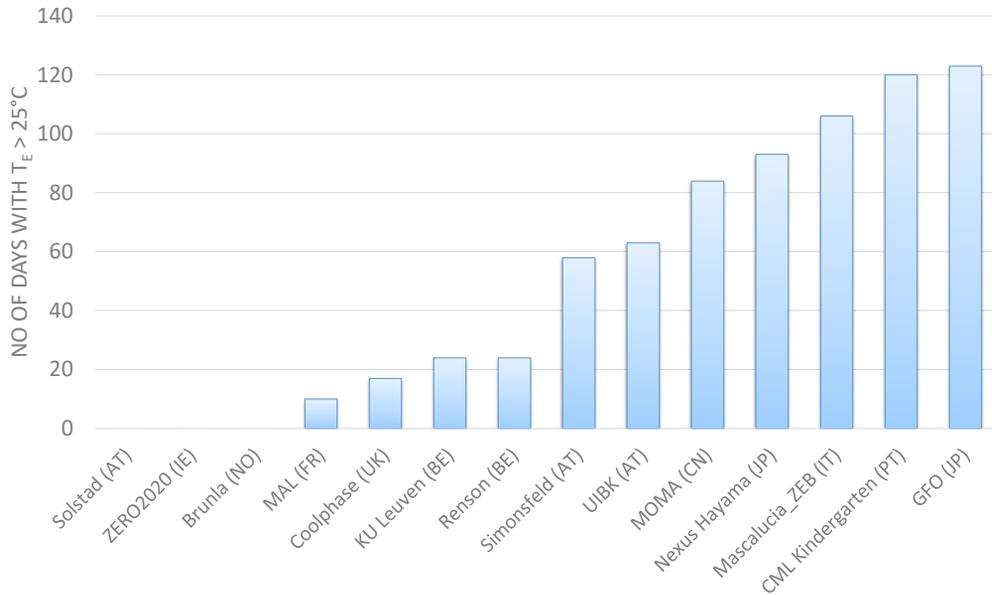
- **Temperature** and **RH** were the **main parameters** used (CO₂ for IAQ).
- Internal temperature used by all cases studies with set-point control
- Mean internal air temperature set-point was around 22°C. (20-24°C)
- Over 60% of case studies use **external temp** as a **low temp limit**
- Mean external low temperature limit set-point 14°C. (10-18°C)

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Summary points

- All NV case studies had occupant interaction with the VC system
- Only 60% of hybrid systems had this interaction.
- 69% of the case studies had a night ventilation strategy
- Wind speed had to be $\leq 10\text{m/s}$ with no rain for night ventilation systems

How Have these Buildings Performed?



Preliminary results of VC performance evaluation

Country	Building	Summer Design Values		overheating criteria	% Occ hrs above threshold		Occ hrs
		T_e	$T_{i,o}$		28°C	25°C	
IE	zero2020	26.0	25.0	$T_i < 28^\circ\text{C}$ for 99% occ hrs	0.7	5.5	2600
NO.1	Brunla School	25.0	26.0	$T_i > 26^\circ\text{C}$	0.0	0.0	2600
NO.2	Solstad	25.0	24.0	$T_i > 26^\circ\text{C}$	0.0	0.0	2860
AT.1	UNI Innsbruck	34.0	27.0	$T_i < 26^\circ\text{C}$ for 95% occ hrs	1.1	16.2	2600
AT.2	wkSimonsfeld	34.5	24.0	$T_i > 26^\circ\text{C}$ zone / $T > 29^\circ\text{C}$ gallery	0.0	5.0	3250
JP	Nexus Hayama	26.0	26.0	$T_i < 28^\circ\text{C}$ for 99% occ hrs (check)	1.0	40.0	8736
PT	Kindergarden	30.0	26.0	80% acceptability for 99% hr occ	2.6	16.0	3640

What Lessons did We Learn?

Design and Construction

- **Detailed building simulation is important when simulating ventilative cooling strategies.** Most case studies analysed highlighted the need for reliable building simulations in the design phase of a ventilative cooling system. This was considered most important when designing for hybrid ventilation strategies where multiple mechanical systems need harmonization.
- Some studies also said that **simulating the window opening in detail was important.**
- **Customisation may be an important factor when designing a ventilative cooling system.** In order to ventilate certain buildings it may be necessary to design custom components. Some case studies highlighted the need to have custom design systems that were specific to country regulations and the use of a building or space.



Design and Construction

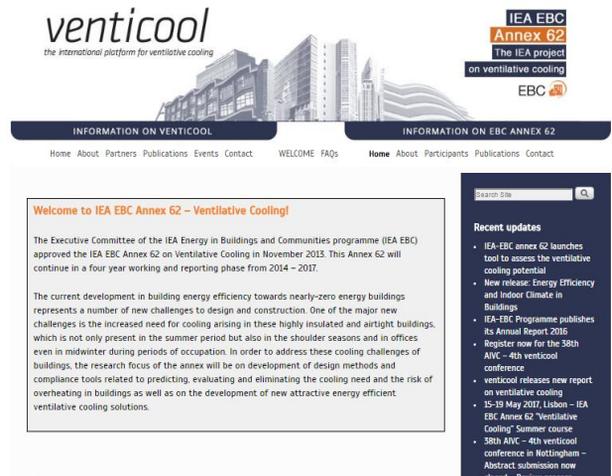
- Some consideration should also be given to the **clients expectations** around specific issues like **rain ingress and insect prevention**.
- **Ventilative cooling systems were considered cost-effective and energy efficient in design** by most case studies, but **particularly with naturally ventilated systems**. It was indicated that designing with the integration of manual operation and control was important, particularly in a domestic setting.



Operation

- **Engaging with the building owners or operators as soon as possible is integral to guaranteeing building performance for IAQ, comfort or energy savings**. For some case studies this specifically meant educating or working with the facilities operator or manager for the building, for others it meant educating the building occupiers themselves.
- It was suggested by some that this **engagement should be as early as the design stage**.

- All brochures are now available at the IEA-EBC Annex 62 website
- A summary document also available
 - Overview with key data distilled into important findings
 - Key lessons learned
 - Recommendations



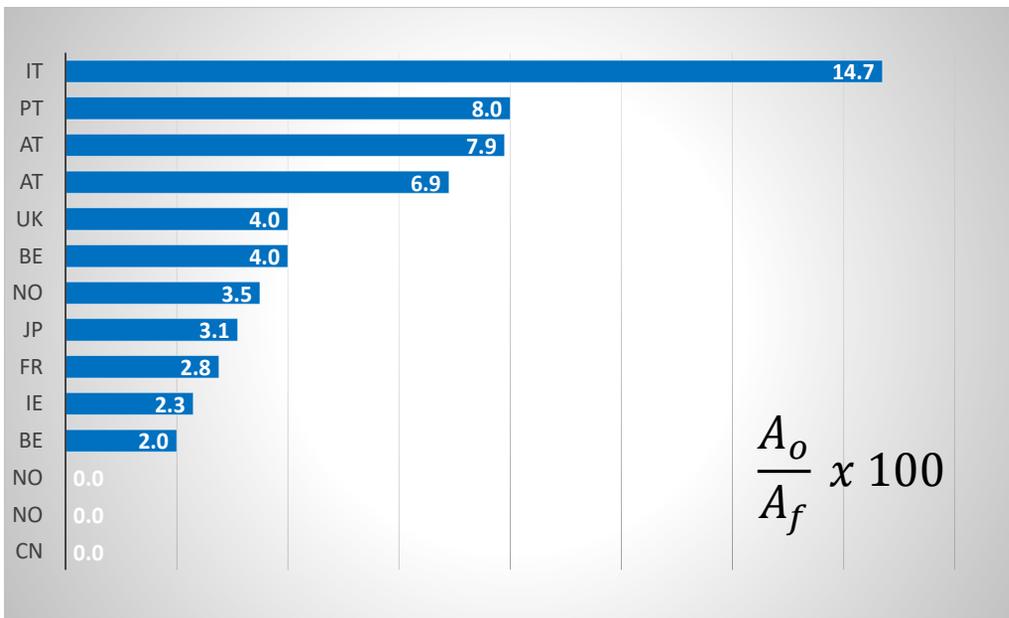
<http://venticool.eu/annex-62-publications/deliverables/>

Thank You!

(I hope you and your family are keeping safe and healthy during this SARS-CoV-2 crisis. Good Ventilation of homes and work spaces is a key recommendation from the WHO.)

What about the Percentage Opening Area to Floor Area Ratio? A Key VC Metric?

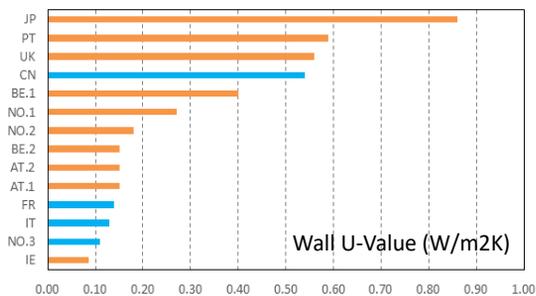
Design Metrics - POF Ratio



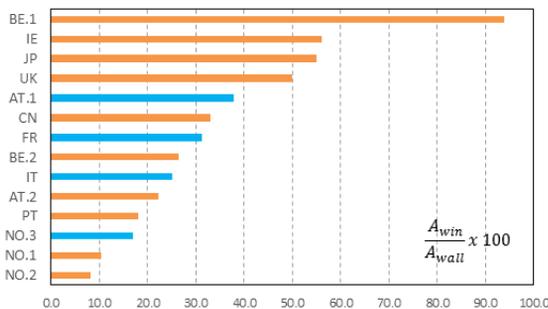
What Were the Building Characteristics?

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Building Characteristics

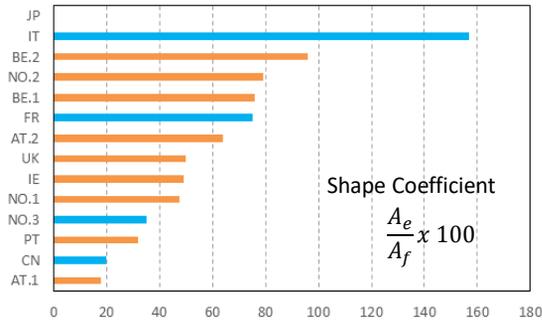


- Mean elemental U-value is 0.41 W/m²K
- standard deviation is 0.34 W/m²K
- Six case studies heavy /very heavy thermal mass (ISO13790)
- Average infiltration at 1.13 h⁻¹, (0.51 to 1.85 h⁻¹)
- Average window/wall area ratio is 34%.
- Four case studies area ratios greater than 50%



- Some very good and very poor thermal performance
- Large variation in building shapes
- Norwegian case studies lowest window/wall ratios
- Belgium Offices from 2003 almost exclusively glass

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- Minimum shape coefficient of 0.18
- Maximum shape coefficient of 0.96
- Italian home has very high shape coefficient



How are We Simulating VC?

