Is ventilative cooling effective in light weight wooden constructions?

DO IT houtbouw

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DO-IT

- Sustainable innovation wood based applications
  - Air tightness, water & wind tightness
  - hygrothermal performance
  - Construction and fire safety
  - Acoustics
  - Indoor air quality
  - Summer Comfort
  - Case studies
  - Sustainable management
- Financial support of IWT, BBRI, TCHN

DO-IT

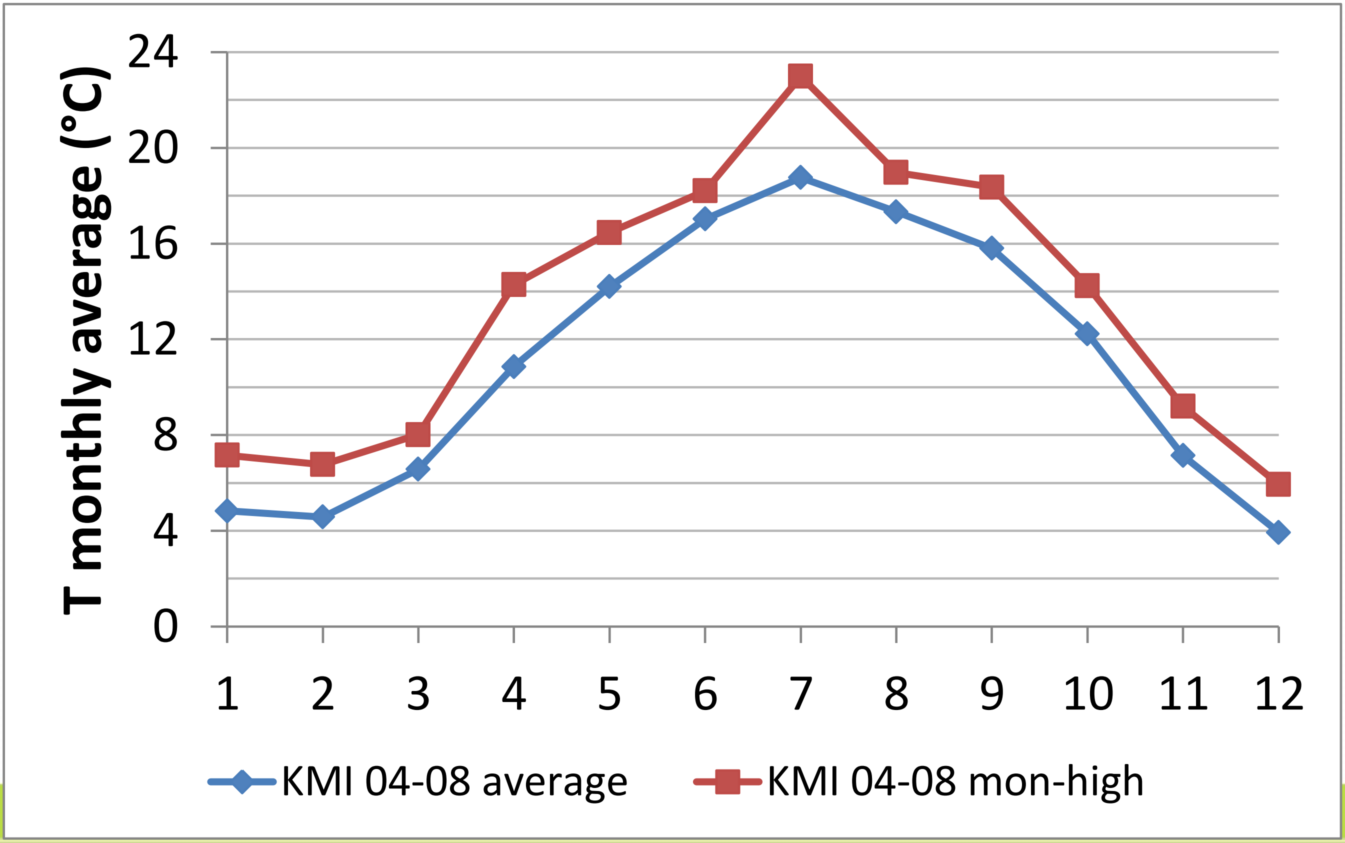
- Summer Comfort
  - Development design guidelines in light weight wooden construction (KAHO, Thomas More)
    - Sensitivity analysis
    - Guidelines residential <> office buildings
  - Optimalisation existing EPBD legislation (UGent)
    - Development of overheating indicator for light weight wooden construction
    - Optimalisation overheating indicator

Summary

- Context
- Design challenges
- Reference buildings
- Method
- Results
- Conclusions

Design challenges

- Ventilative cooling in light weight constructions?
- Impact of weather data on prediction cooling need/overheating risk



Summary

- Context
- Design challenges
- Reference buildings
  - Quality levels
  - Residential <> office buildings
  - Characteristics: building – HVAC - user
- Method
- Results
- Conclusions

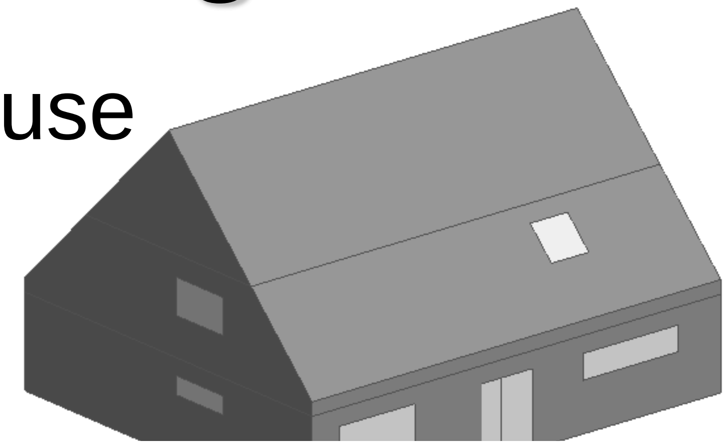
Reference Buildings

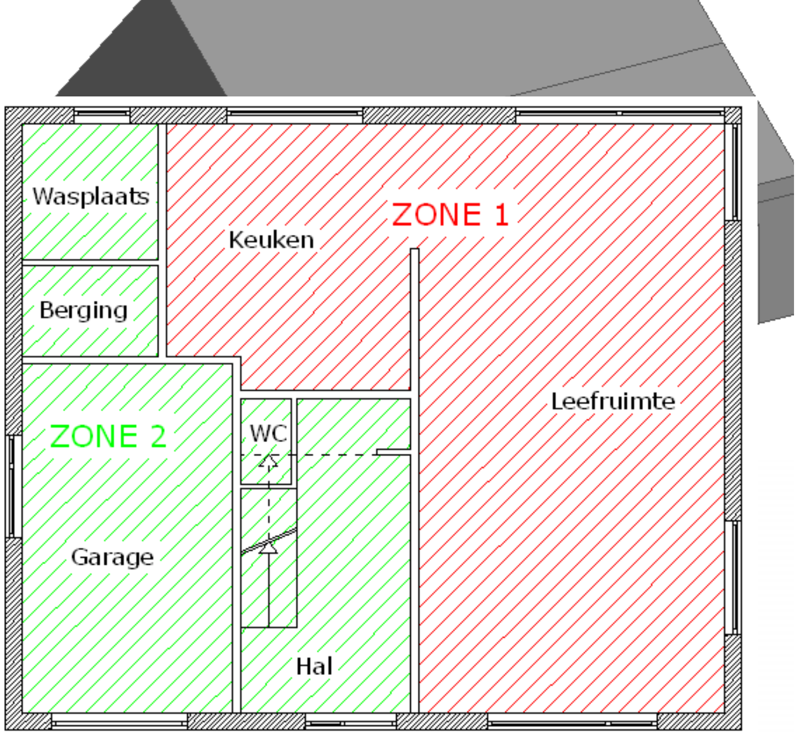
- 2 Quality levels: building envelop
  - Insulation level
  - Air tightness
- Flemish EPBD (2014) <> PH standard

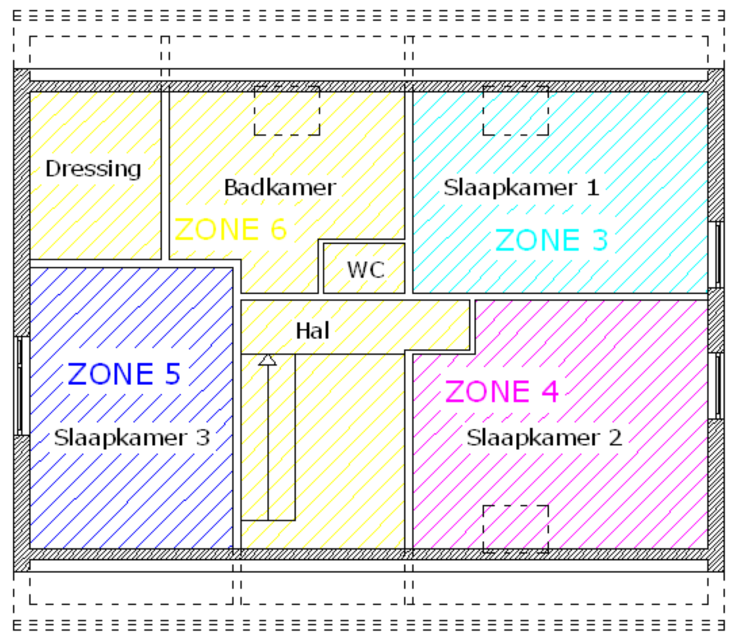
	EPBD 2014	PH standard
	U [W/m²K]	U [W/m²K]
Façade/Roof/Floor	0,24	0,15
Window –glazing	1,1	0,8
Window – frame	1,8	0,8
External door	2,0	0,8
	n_{50} (h^{-1})	n_{50} (h^{-1})
	3	0.6

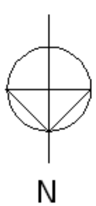
Reference Buildings

- Residential: detached house
  - $A_{floor,tot}$ = 252 m²
  - Zone 1



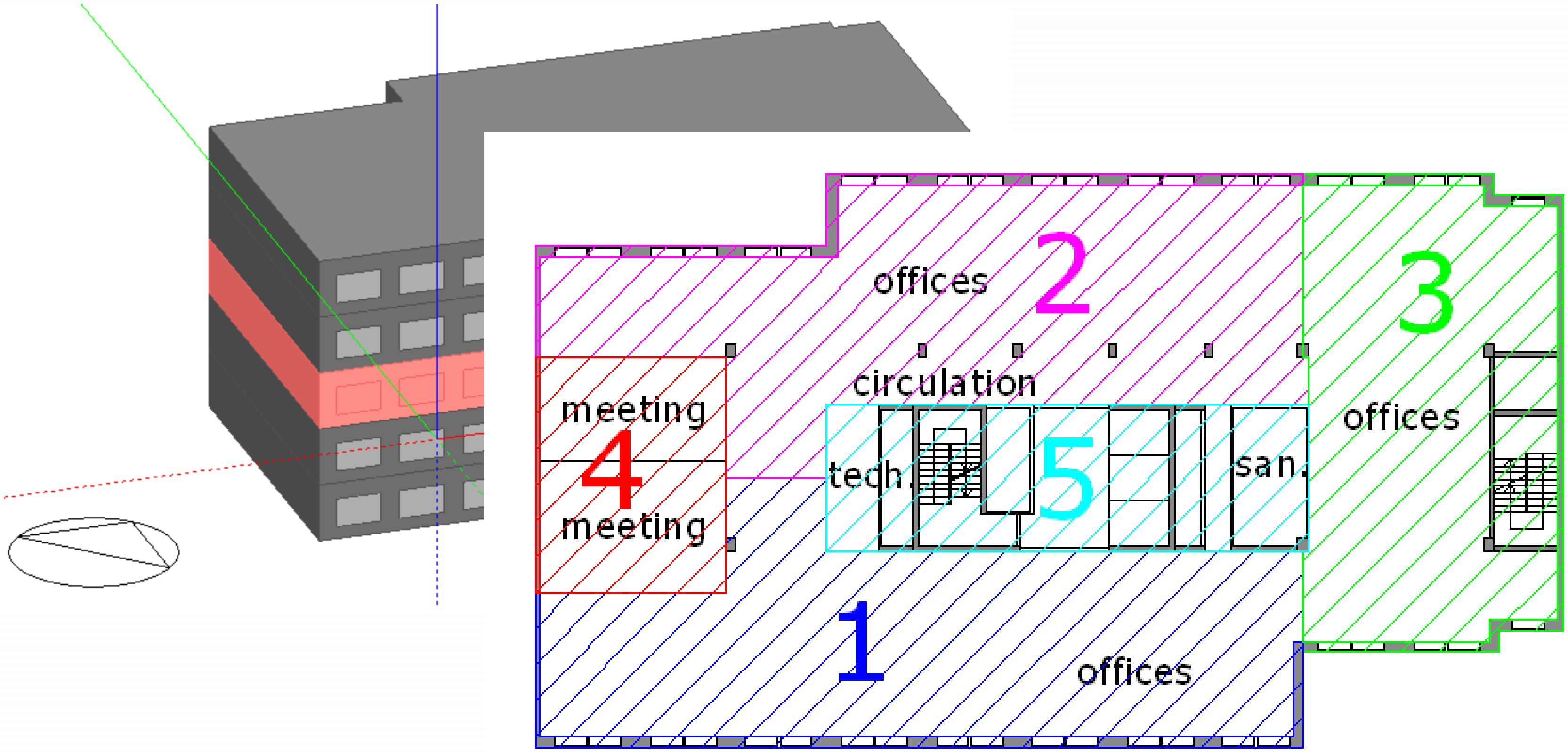






Reference Buildings

- Office building
  - Zone 1: A_{floor} = 200 m²



Reference Buildings

- Characteristics: walls

material	c [J/kg.K]	ρ [kg/m³]	λ [W/m.K]	d [m]
façade				
structure -wood fraction (15%)	1600	500	0.130	0.300
structure - MW (85%)	1030	50	0.040	0.300
OSB	1700	650	0.130	0.015
cavity - wood fraction (15%)	1600	500	0.130	0.050
cavity - MW (85%)	1030	50	0.040	0.050
gypsum board	1000	900	0.260	0.013
internal wall				
gypsum board	1000	900	0.260	0.013
structure -wood fraction (15%)	1600	500	0.130	0.100
structure - MW (85%)	1030	50	0.040	0.100
gypsum board	1000	900	0.260	0.013
internal floor				
floor covering	1400	1200	0.190	0.010
OSB	1700	650	0.130	0.015
structure -wood fraction (11%)	1600	500	0.130	0.200
structure - MW (89%)	1030	50	0.040	0.200
gypsum board	1000	900	0.260	0.015

Reference Buildings

- Characteristics: walls

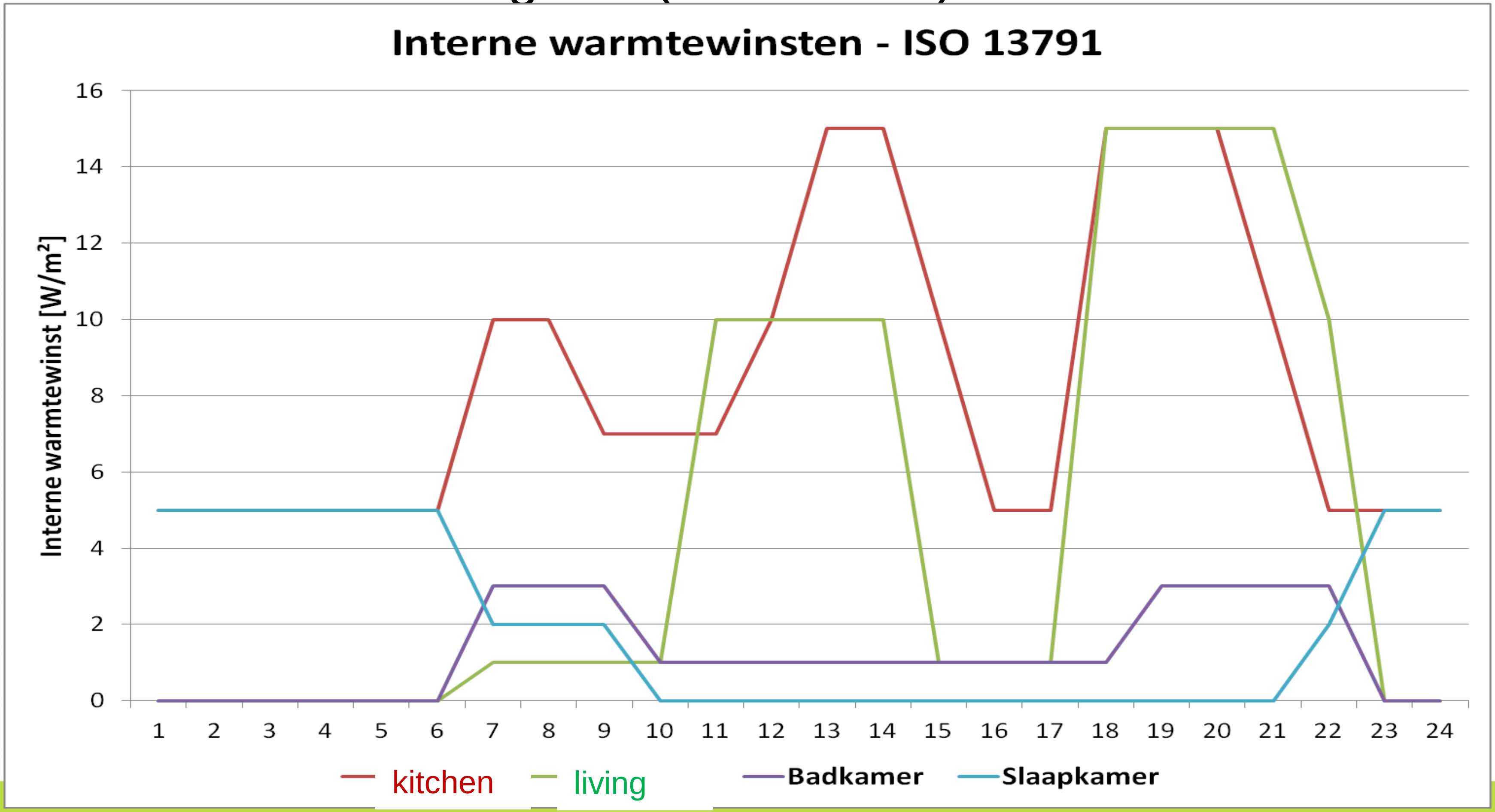
material	c [J/kg.K]	ρ [kg/m³]	λ [W/m.K]	d [m]
floor				
tiles	1000	1700	0.810	0.010
light concrete	1000	1050	0.320	0.070
insulation	1400	30	0.035	0.170
light concrete	1000	1050	0.320	0.050
reinforced heavy concrete	1000	2400	2.200	0.150

Reference Buildings

- Characteristics: residential building
  - Solar shading
    - g_{window} = 0.50
    - Fixed overhang (d = 1m)
  - Hygienic ventilation rates
    - Zone 1: n = 1 h^{-1}
  - Extra natural ventilation
    - Daytime (T_i > 24°C, 7h-22h)
    - Nighttime ($T_i > T_e$+1°C, T_i > 18°C, 22h-7u)
    - n = 0 <> 3 h^{-1}
  - Thermal mass
    - Light weight wooden construction
    - Heavy weight brick internal walls

Reference Buildings

- Characteristics: residential
  - Internal heat gains (ISO 13791)



Reference Buildings

- Characteristics: Office building
  - Solar shading
    - $g_{window} = 0.55$
    - Fixed overhang (d = 1m)
  - Hygienic ventilation rates & occupancy
    - IDA 3 (29 m^3/h)
    - 15 m^2/pers
    - zone 1: $n = 0.67\ h^{-1}$
  - Night ventilation
    - n = 0 <> 3 <> 6 h^{-1}

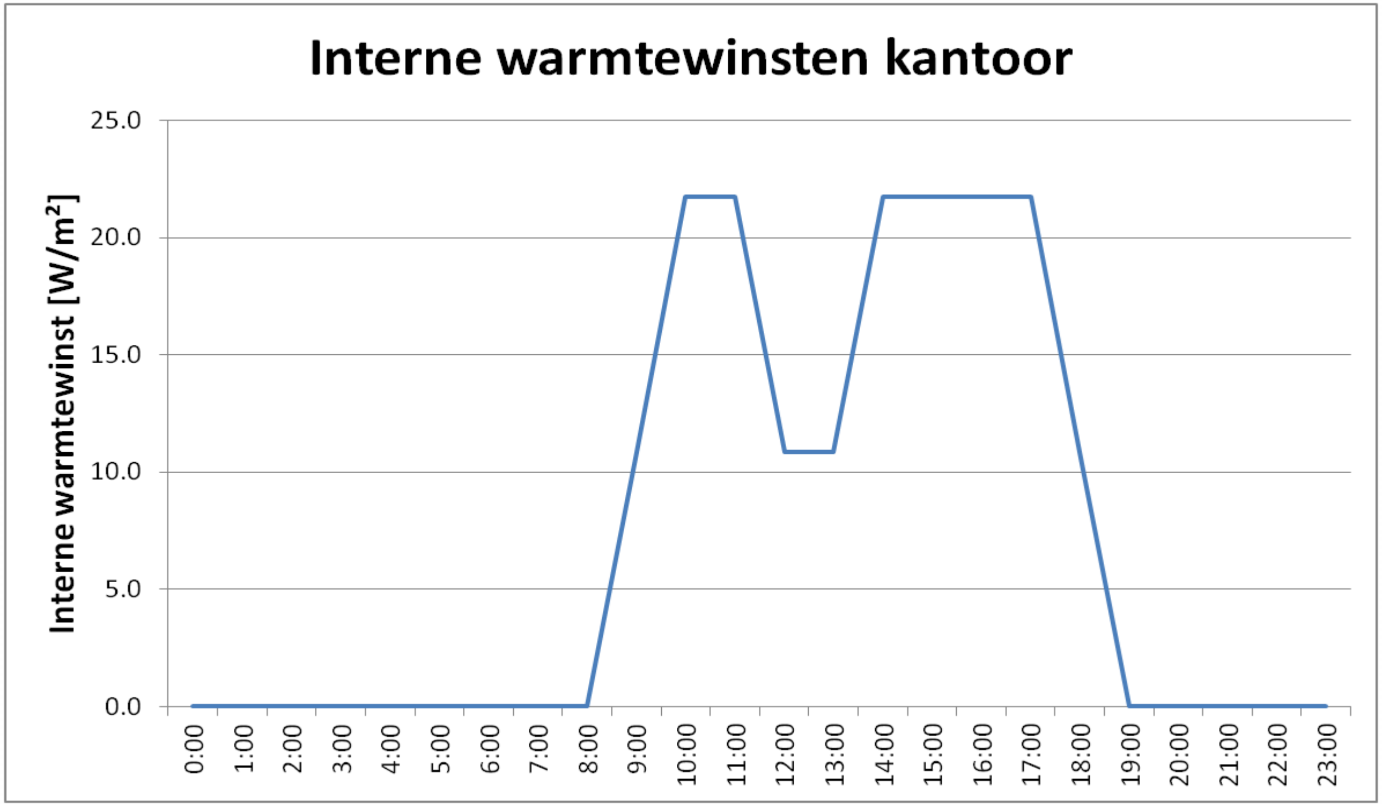
Reference Buildings

- Characteristics: Office building
  - Thermal mass

Classification (EN 13790)	Heat capacity C_m (J/K)	construction
Very light	1.13×10^7	All light weight wooden walls
Light	2.19×10^7	Functional core heavy concrete
Very heavy	7.91×10^7	Functional core heavy concrete Internal floor + ceiling concrete slab

Reference Buildings

- Characteristics: Office building
  - Internal heat gains



Summary

- Context
- Design challenge
- Reference buildings
- Method
  - Dynamic simulations
  - Evaluation overheating
- Results
- Conclusions

Method

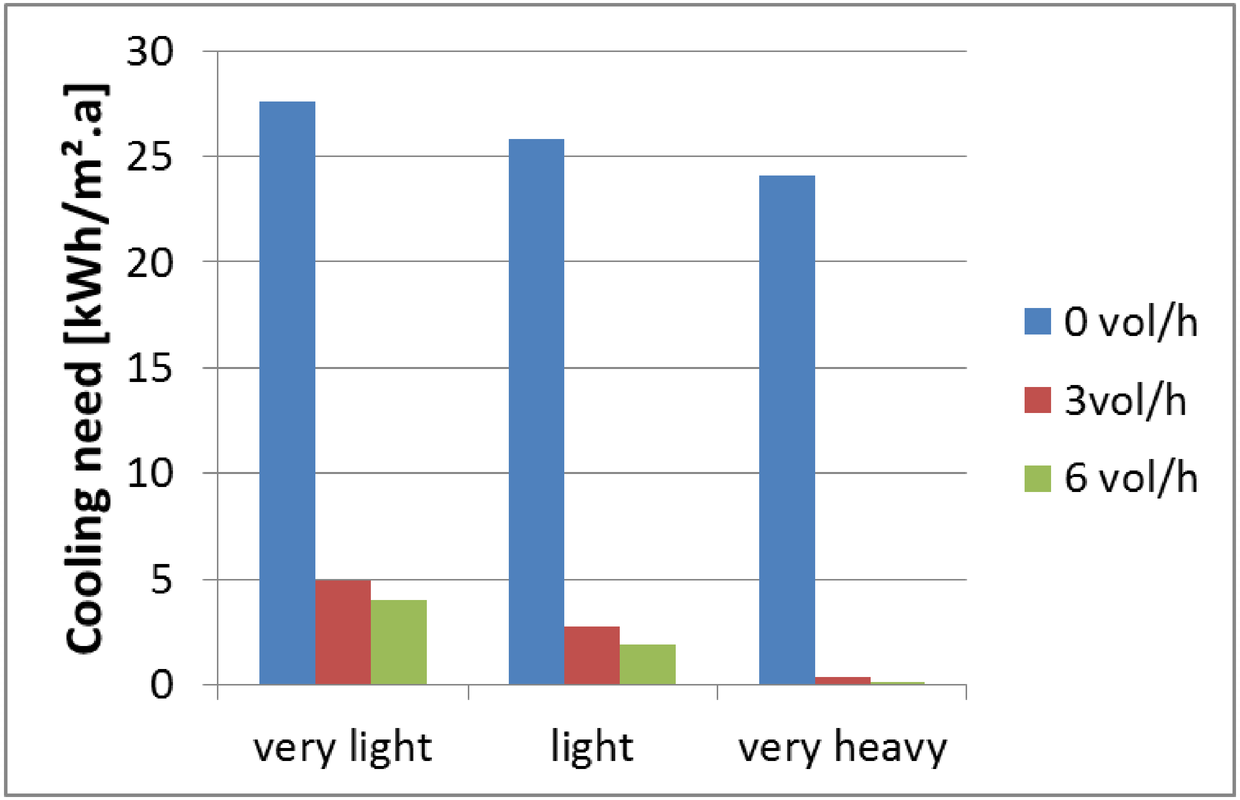
- Multizone dynamic simulations
  - Design Builder (E+)
  - Time step = 1h
  - Cooling: $T_i > 26°C$
- Evaluation overheating (EN 15251)
  - Comfort limit: PMV = 0.5 – PPD = 10%
  - Weight factor $$wf = \frac{PPD_{actualPMV}}{PPD_{PMVlimit}}$$
  - Max weighted temperature exceedings
    5% on yearly basis = 438h residential

Summary

- Context
- Design challenges
- Reference buildings
- Method
- Results
  - Impact ventilative cooling on cooling need & peak cooling load in office buildings
  - Impact ventilative cooling on overheating risk in residential buildings
  - Effect ventilative cooling in warm weather data
- Conclusions

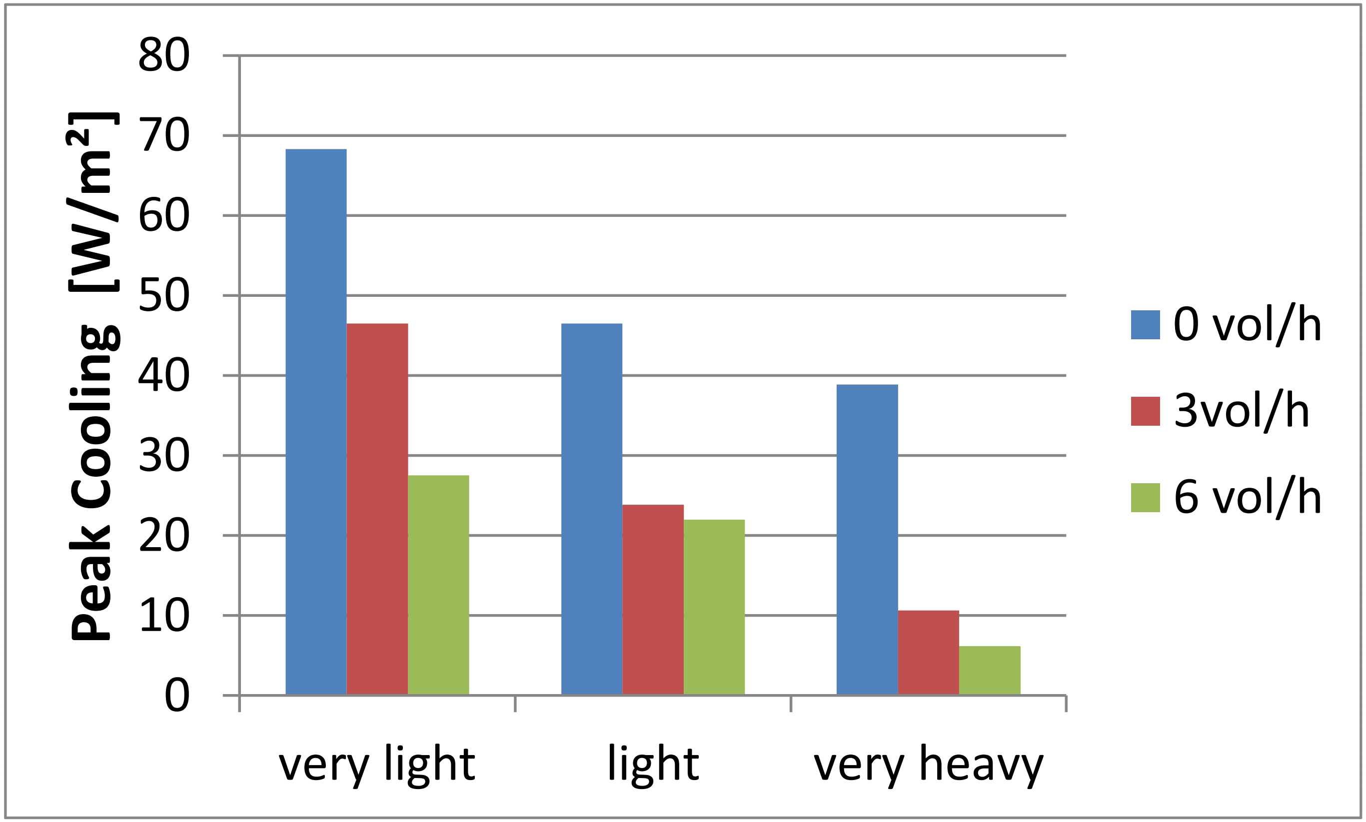
Results

- Impact ventilative cooling on cooling need in office buildings



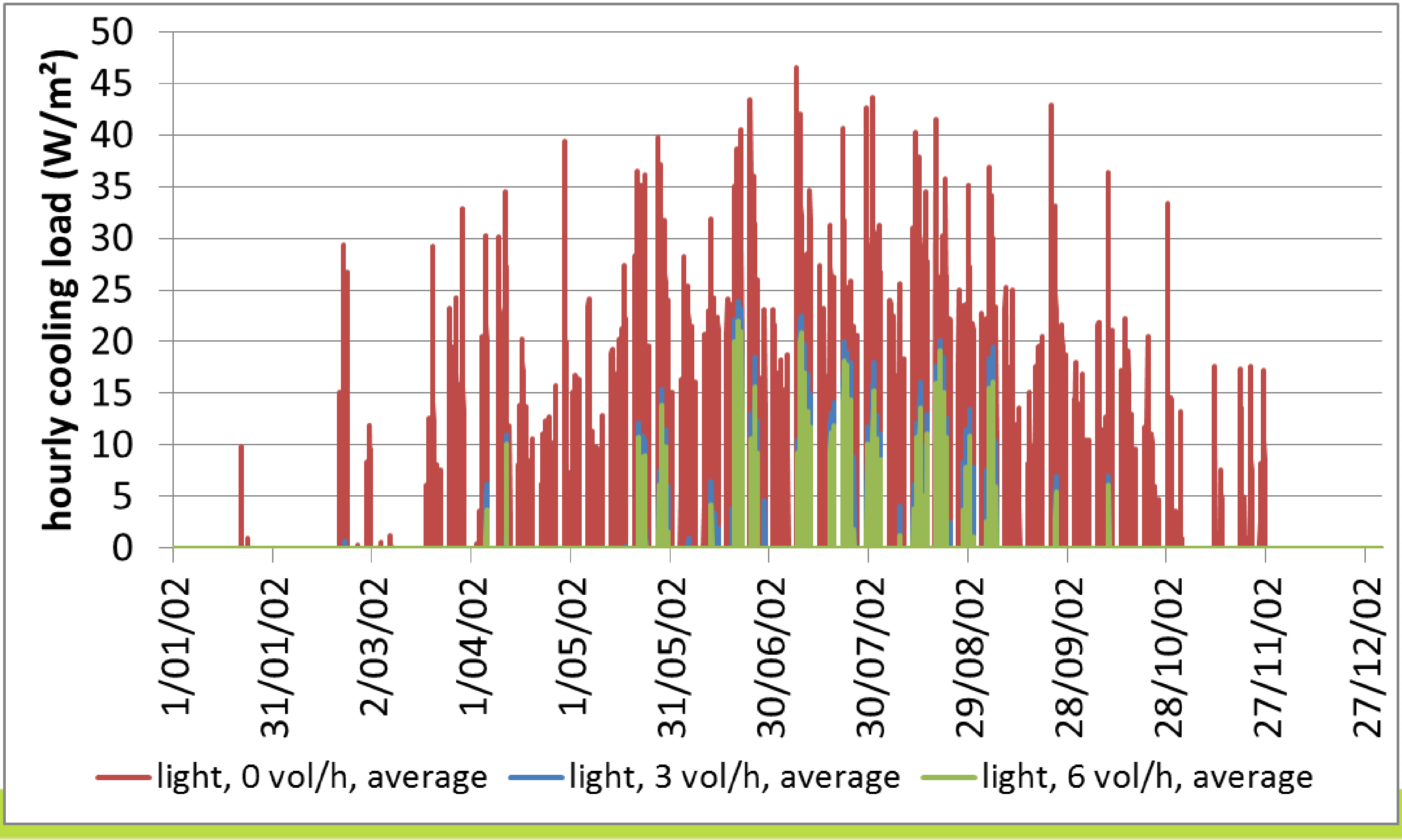
Results

- Impact ventilative cooling on peak cooling load in office buildings



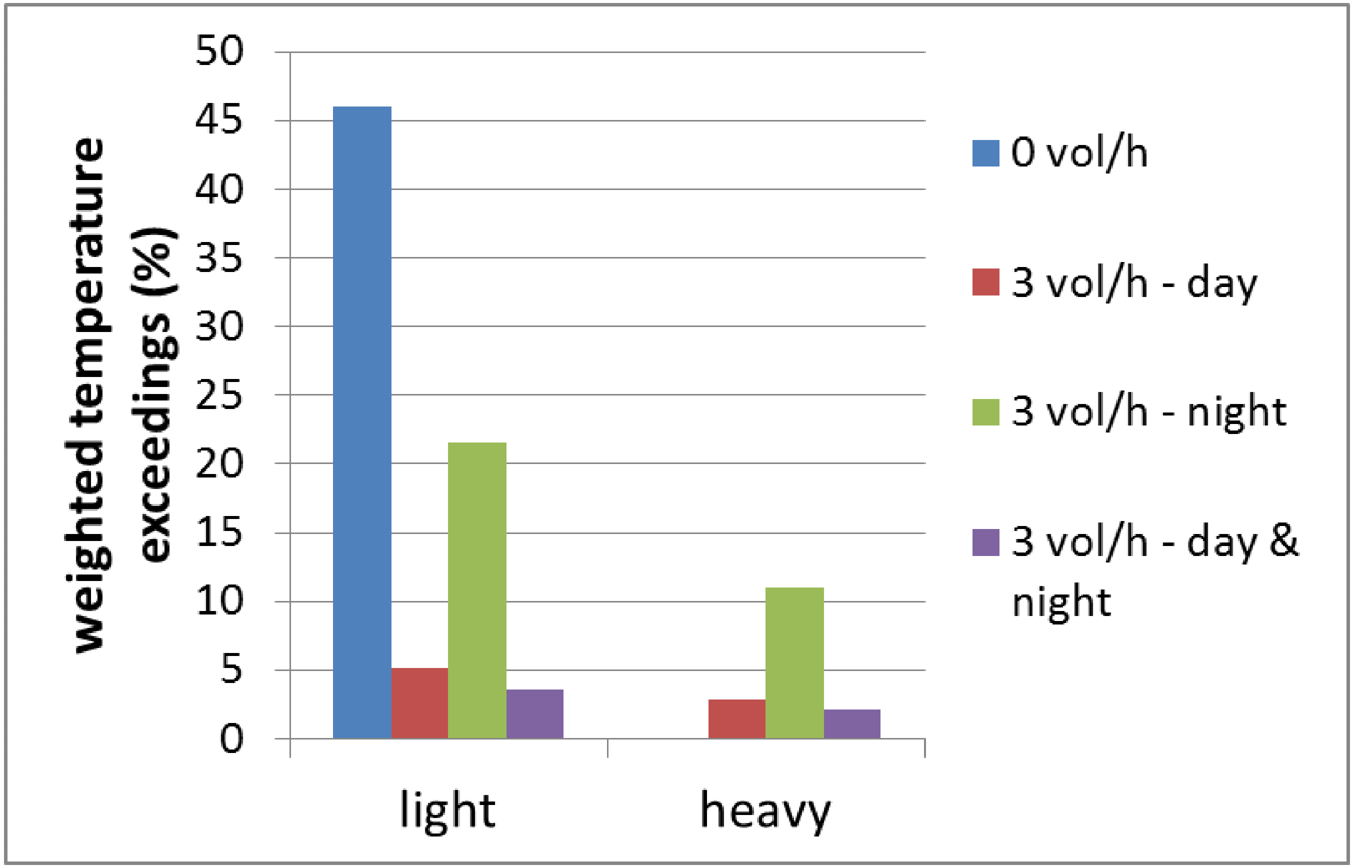
Results

- Impact ventilative cooling on peak cooling in office buildings



Results

- Impact ventilative cooling on overheating in residential buildings



Results

- Impact weather data on performances
  - Temperature
  - Solar radiation
- Meteonorm 7
  - Synthetical based on measurements
    - temperature (2000-2009)
    - Solar radiation (1986-2005)
  - Average <> Warm weather data (1 per 10 year)

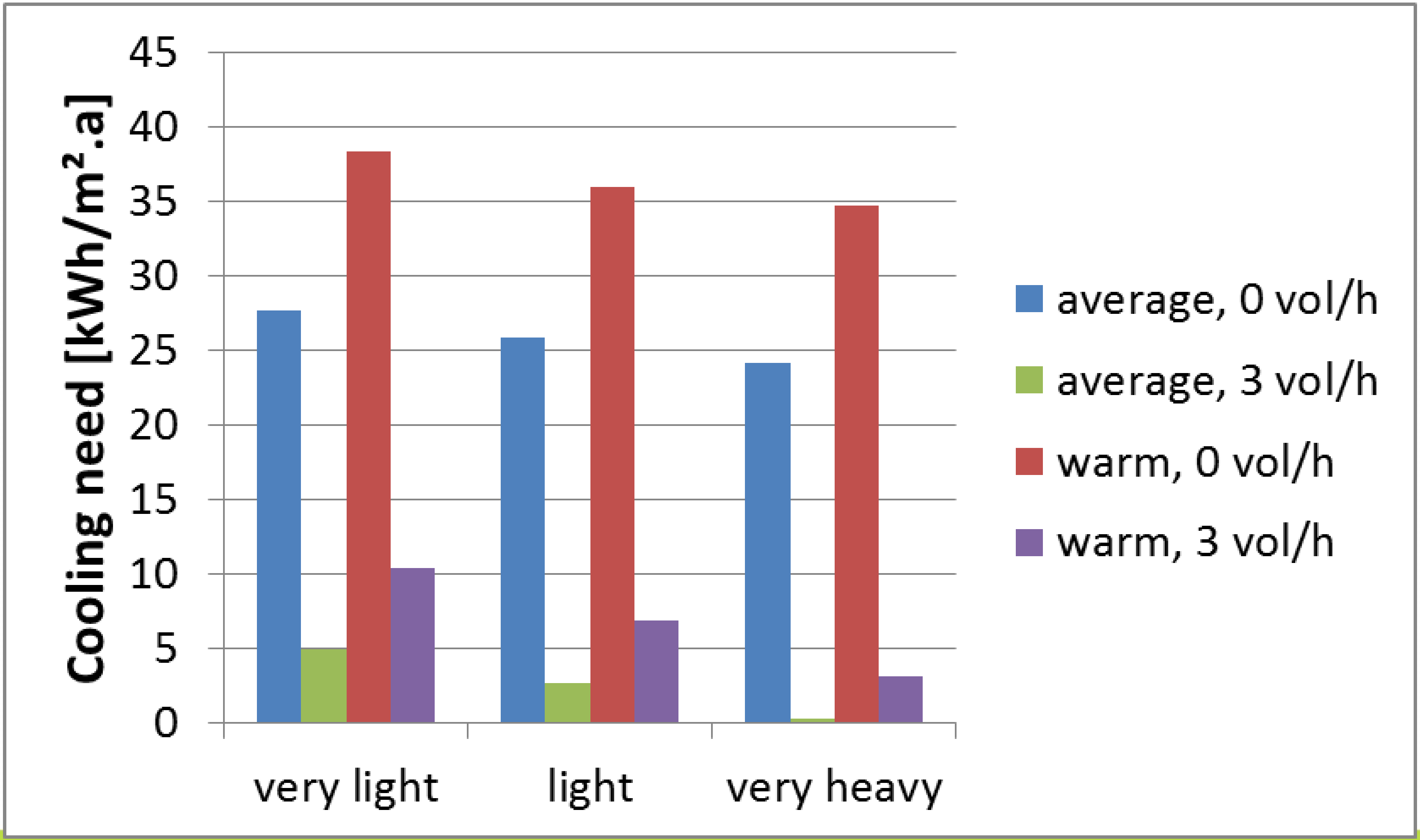
Results

- weather data: temperature

Month	Average Uccle (B)		Warm Uccle (B)	
	KMI 04-08	Meteonorm 7	Max KMI 04-08	Meteonorm 7
1	4.83	4.00	7.16	6.70
2	4.58	4.90	6.77	7.20
3	6.57	7.10	8.02	8.60
4	10.86	10.70	14.28	13.00
5	14.20	14.40	16.46	15.70
6	17.03	17.20	18.20	18.50
7	18.76	18.60	22.99	21.30
8	17.33	18.50	18.97	20.20
9	15.80	15.50	18.36	17.70
10	12.23	11.80	14.23	14.50
11	7.14	7.80	9.20	9.50
12	3.93	4.10	5.94	5.80
Annual average	**11.11**	**11.22**	**13.38**	**13.23**

Results

- Warm weather data: cooling need in office



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Conclusions

- Is ventilative cooling effective in light weight wooden constructions
  - Office buildings: night ventilation
    - Cooling need: very effective
    - Peak cooling load: less effective - larger impact thermal mass
  - Residential buildings: day & night ventilation
    - Overheating: day ventilation effective
- warm weather data: impact ventilative cooling
  - Office buildings: night ventilation effective
  - Residential buildings:
    - Only day ventilation not effective
    - Need automatically controlled shading device -> good thermal comfort