

Implementation of realistic boundary conditions – analysis of their effect on the net annual heating demand in passive schools

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Context

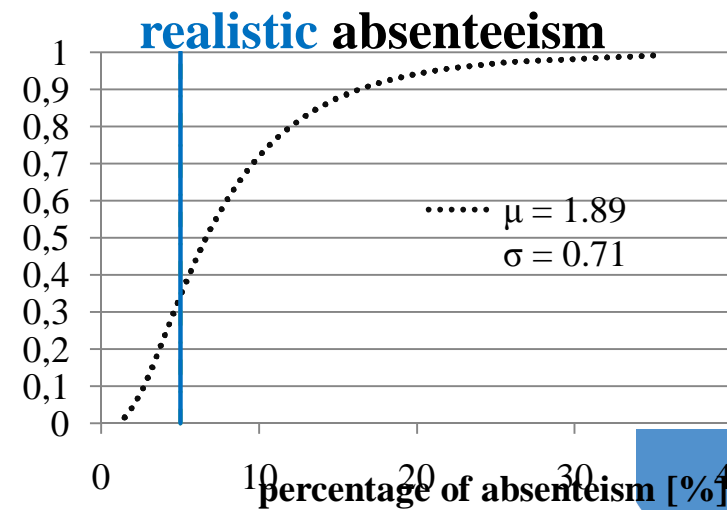
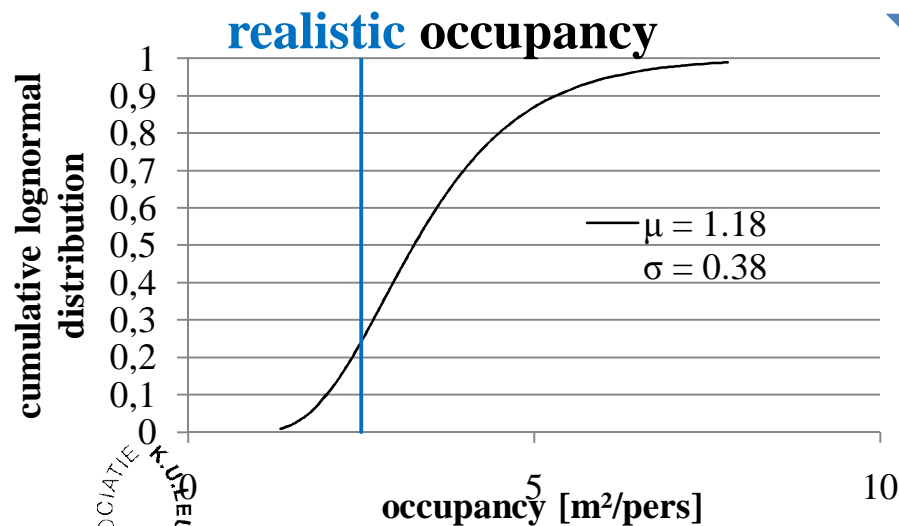
passive schools in Flanders (*7 december 2007*)

1. annual net heating demand $Q_{\text{heat,net,annual}} \leq 15 \text{ kWh}/(\text{m}^2.\text{a})$
 2. annual net cooling demand $Q_{\text{cool,net,annual}} \leq 15 \text{ kWh}/(\text{m}^2.\text{a})$
 3. airtightness level $n_{50} \leq 0.6 \text{ vol/h}$
 4. max.E55
- - simplified calculation methods (EN ISO 13790)
- deterministic boundary conditions specific for schools

Context

deterministic boundary conditions based on standards

- EN 12464, EN 13779, EN 15251, EN ISO 7730, EN ISO 13790
- DIN V 18599
- NEN 1089, NEN 2916
- NBN B 06-002



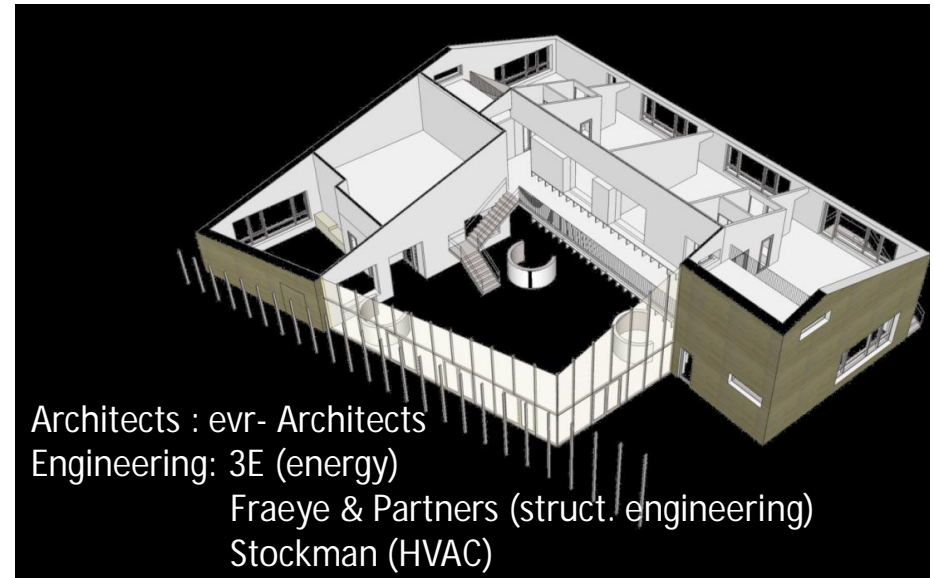
= > Impact on net annual heating demand

- Context
- **Methods**
 - Case study
 - Boundary conditions: occupancy - absenteeism
 - Dynamic simulations
- Results
- Conclusion

Case study

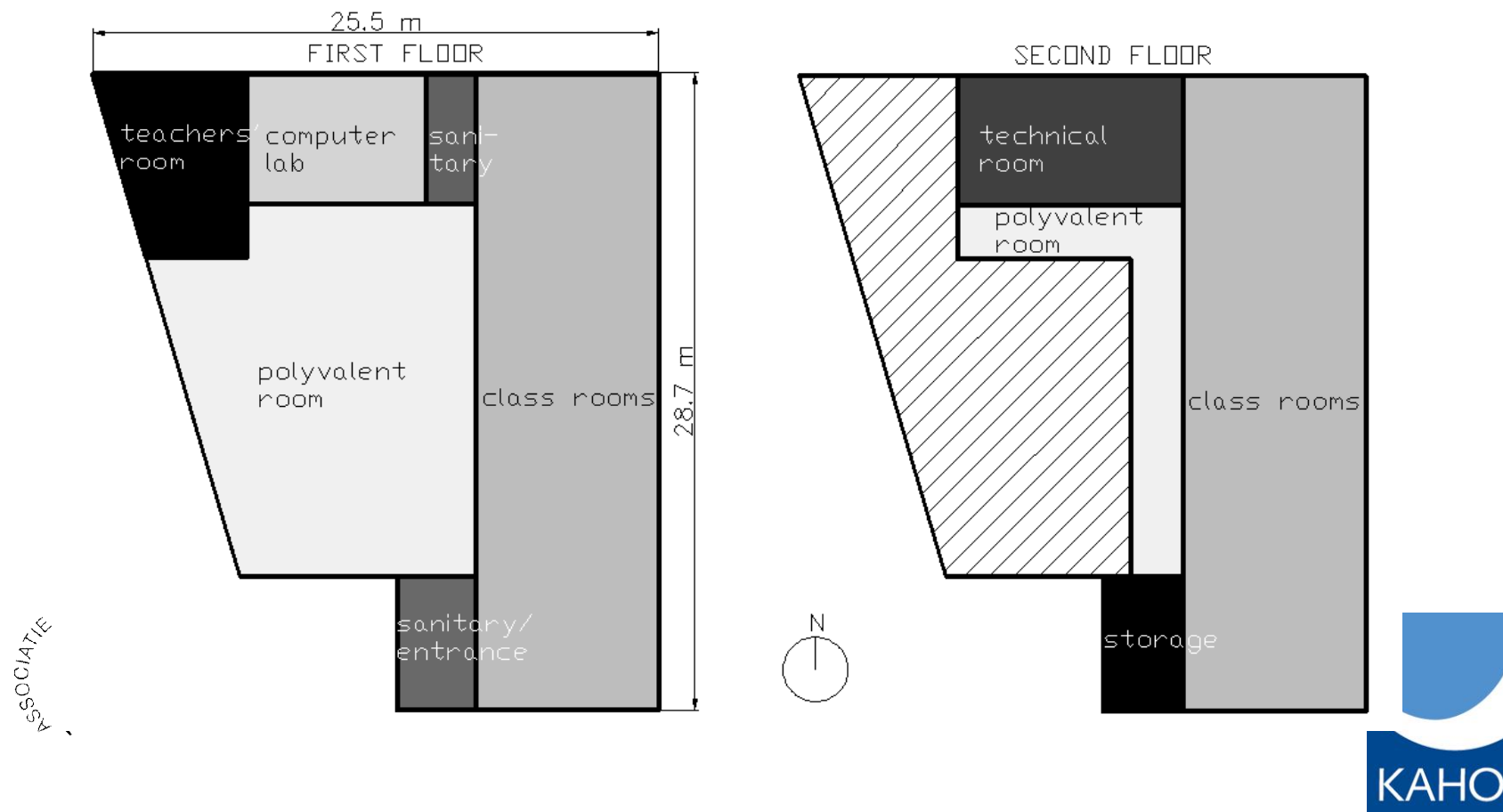
Free standing nursery school Brussels (Etterbeek)

- mixed construction
- $U_{\text{roof}}, U_{\text{façade}} = 0.12 \text{ W/m}^2\text{K}$
- $U_{\text{floor}} = 0.14 \text{ W/m}^2\text{K}$
- $U_{\text{glazing}} = 0.7 \text{ W/m}^2\text{K}$
- $g_{\text{glazing}} = 0.5$
- overhang SW/W facade
- $n_{50} = 0.6 \text{ vol/h}$
- balanced mechanical ventilation
heat recovery ($\eta = 85\%$)
- $Q_{\text{vent,tot}} = 10\,625 \text{ m}^3/\text{h}$
from 8h15 till 15h35, except for Wednesday afternoon
Pre-ventilation = 2 h^{-1} (EN 15251)



Case study

- global meteorological data Meteonorm ('61-'90, Uccle)
- 8 zones



boundary conditions

1. Deterministic boundary conditions

	occupancy [m ² /pers]	Q _{vent} [m ³ /h.pers]	IHG _{pers} [W/pers]	IHG _{app} [W/m ²]	IHG _{light} [W/m ²]	absenteeism [%]
class room	2.5	22	60	1	6	5
computer lab	2.5	22	60	30	6	5
canteen	1.5	22	60	1	6	5
teachers'room	15	29	80	10	10	5
gymnasium	10	37	160	-	6	5

2. Realistic boundary conditions

- Large spread, variations in time
- affected by building use, typology, occupant behaviour

Occupancy rate

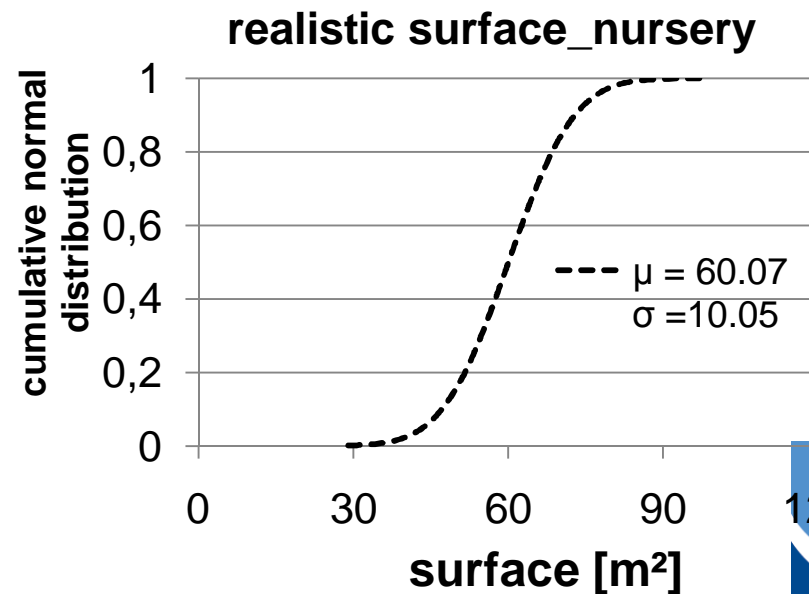
$$\text{occ} = \frac{\text{surf}}{\text{numb}}$$

occ = occupancy rate (m²/pers)

surf = surface area class room (m²)

numb = number pupils per class room (pers)

database Flemish school
characteristics (AGION)



Occupancy rate

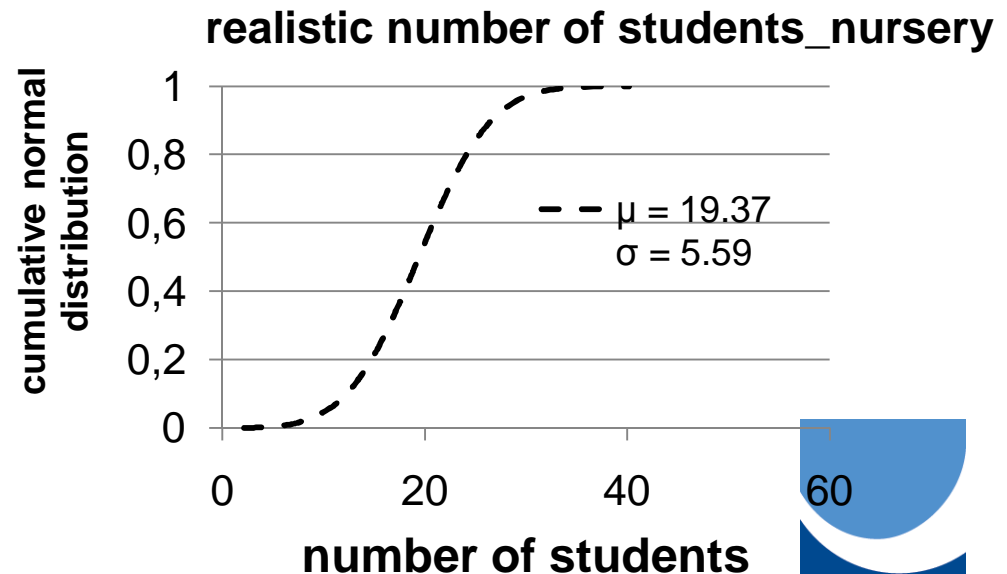
$$\text{occ} = \frac{\text{surf}}{\text{numb}}$$

occ = occupancy rate (m²/pers)

surf = mean surface area class room (m²)

numb = mean number pupils per class room (pers)

large scale questioning
Flemish nursery schools



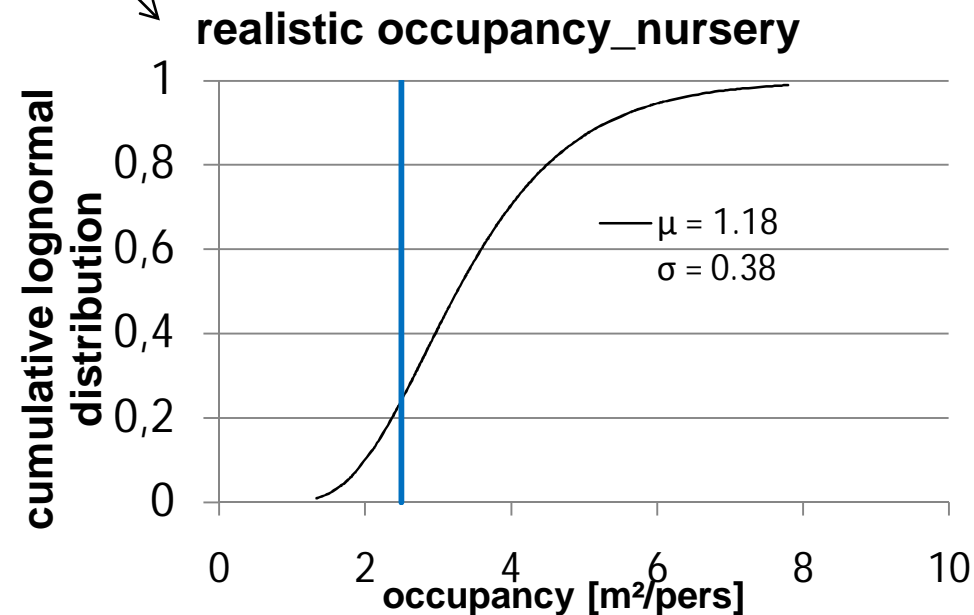
Occupancy rate

$$\text{occ} = \frac{\text{surf}}{\text{numb}}$$

occ = occupancy rate (m²/pers)

surf = surface area class room (m²)

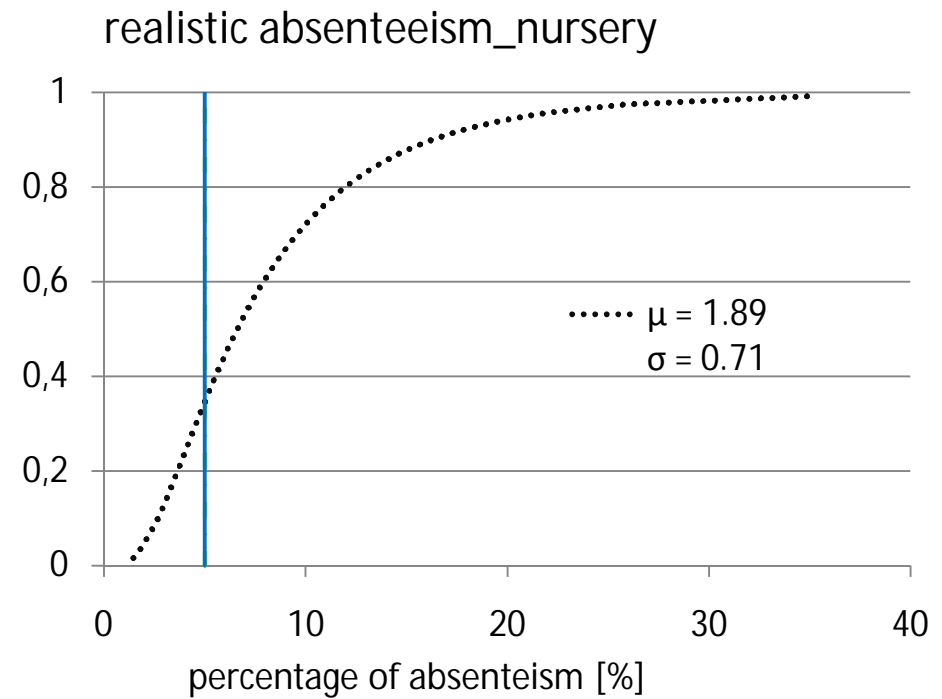
numb = number pupils per class room (pers)



Absenteeism

large scale questioning
Flemish nursery schools

cumulative lognormal distribution



Dynamic simulations

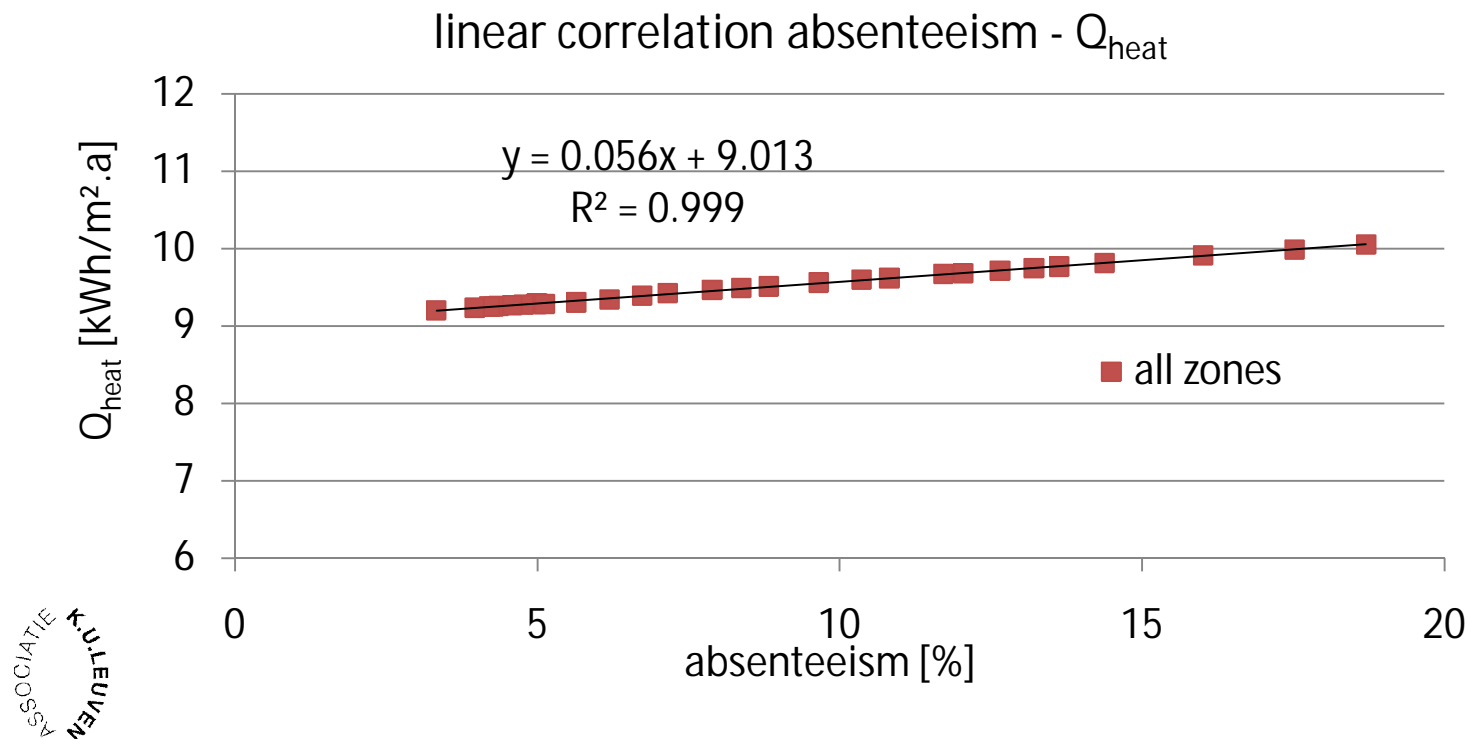
- Variation: 1 variable at a time
- 30 simulations per variable
- Randomly - lognormal distribution functions
- $Q_{\text{vent}} = 22/29/36 \text{ m}^3/(\text{h.pers})$ (IDA3)

	occupancy [m ² /pers]	absenteeism [%]	$Q_{\text{vent_IDA3}}$ [m ³ /h.pers]	Infiltration n_{50} [vol/h]
occupancy	2.06-8.41	5	22/29/36	0.6
absenteeism	2.5	3.33-18.70	22/29/36	0.6

- Context
- Methodology
- **Results**
 - Impact on heating demand
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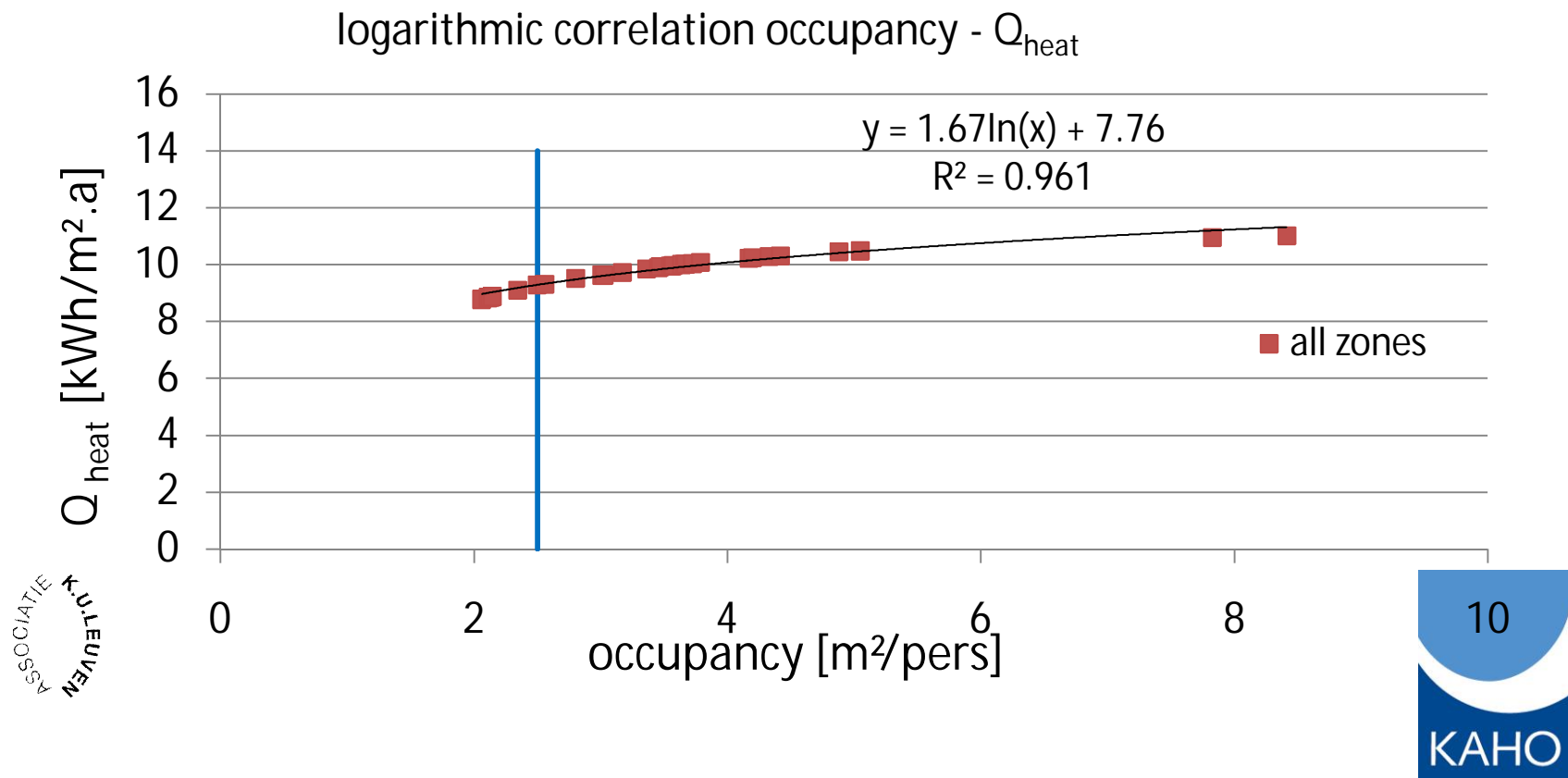
Impact absenteeism

- Influences IHG_{pers}
- Linear relation absenteeism – heating demand



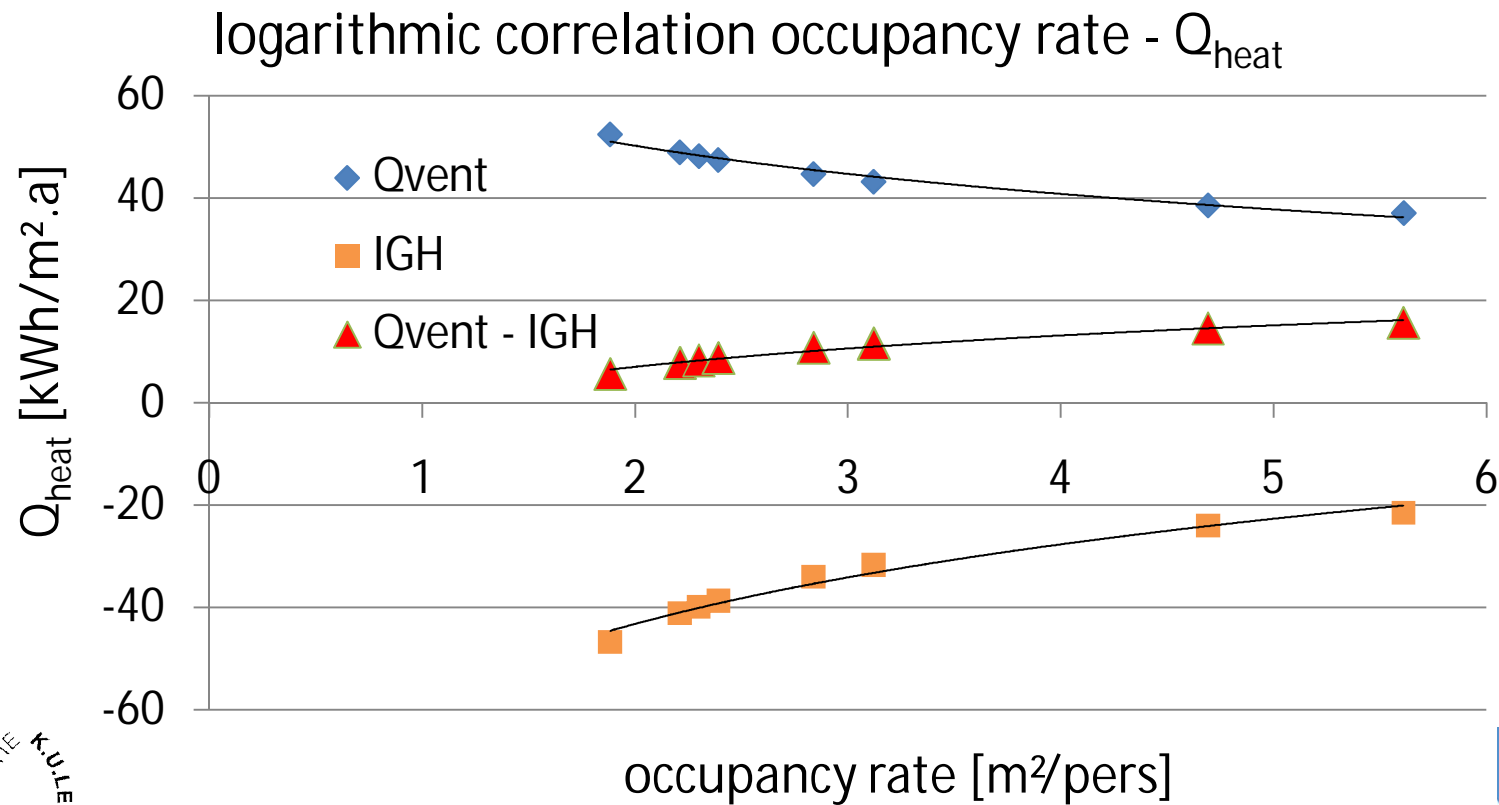
Impact occupancy rate

- Influences Q_{vent} and IHG_{pers}
- Logarithmic relation occupancy – heating demand

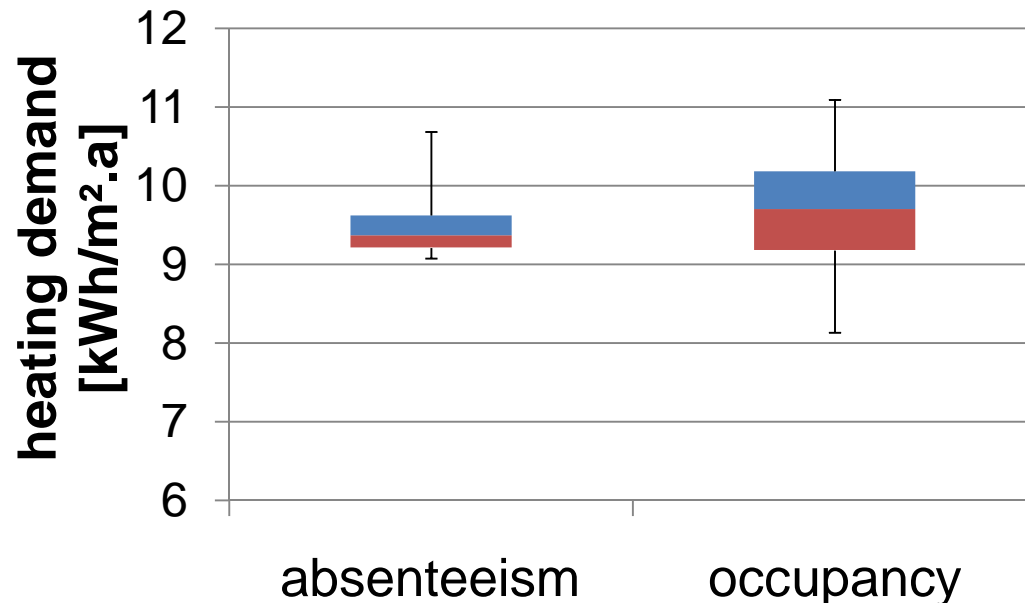


Impact occupancy rate

- $Q_{\text{vent}} < > \text{IGH}_{\text{pers}}$



Impact on heating demand



Absolute [kWh/m ² .a] /relative [%] impact on heating demand of variations BC	Nursery school	
	22 m ³ /(h.pers)	36 m ³ /(h.pers)
absenteeism percentage [%]	1.6/17.3	1.8/16.6
occupancy [m ² /pers]	3.0/31.8	1.7/15.2

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Conclusions

- Realistic < > deterministic boundary conditions
- Impact variations boundary conditions on heating demand in passive schools
 - Abstenteeism: limited impact
 - occupancy rate: important impact
- Accurate assumption based on realistic data is important

	nursery
absenteeism	5%
occupancy	2.5 -> 3.1 m ² /pers