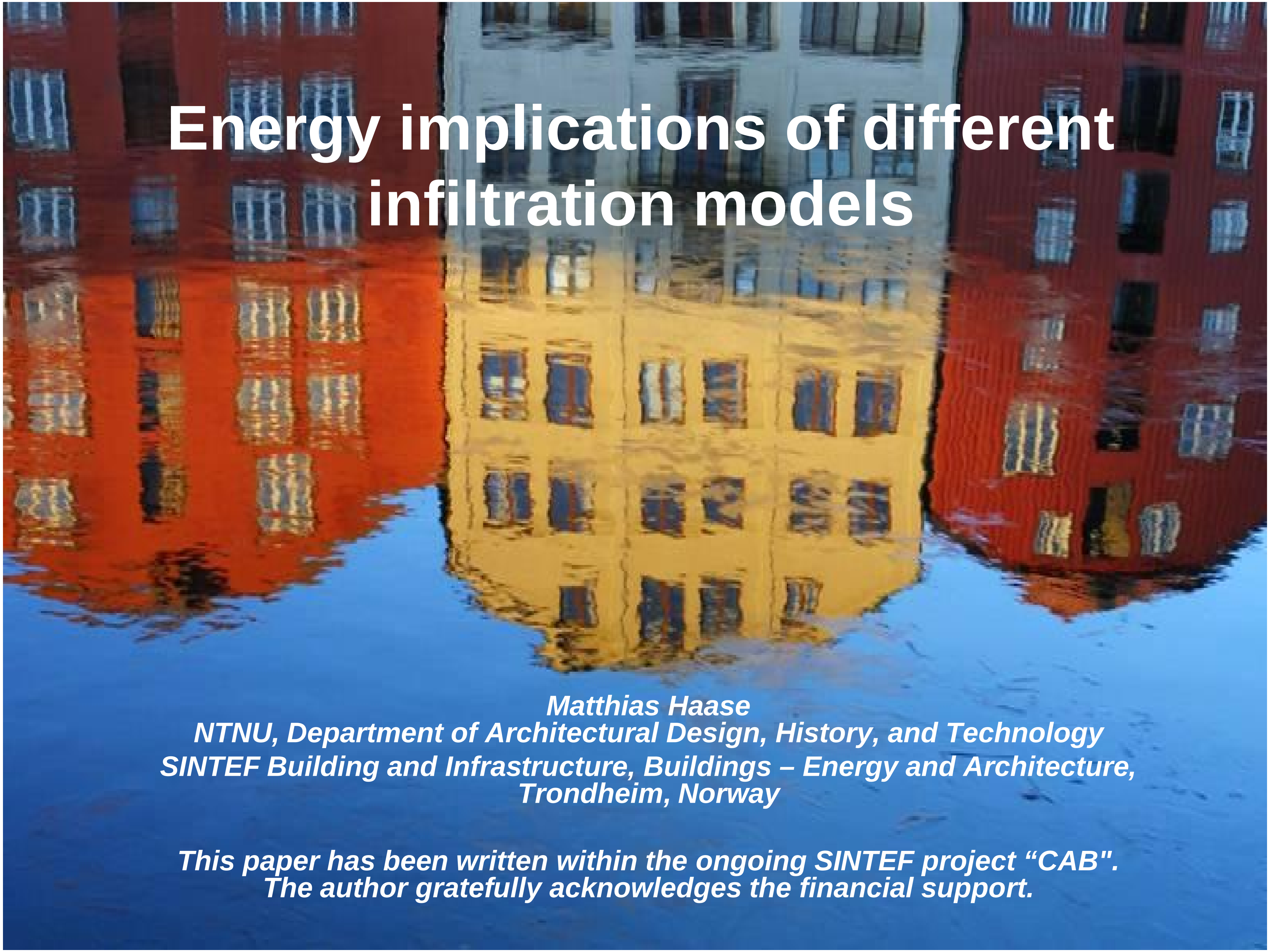

Energy implications of different infiltration models

Matthias Haase
NTNU, Department of Architectural Design, History, and Technology
SINTEF Building and Infrastructure, Buildings – Energy and Architecture, Trondheim, Norway

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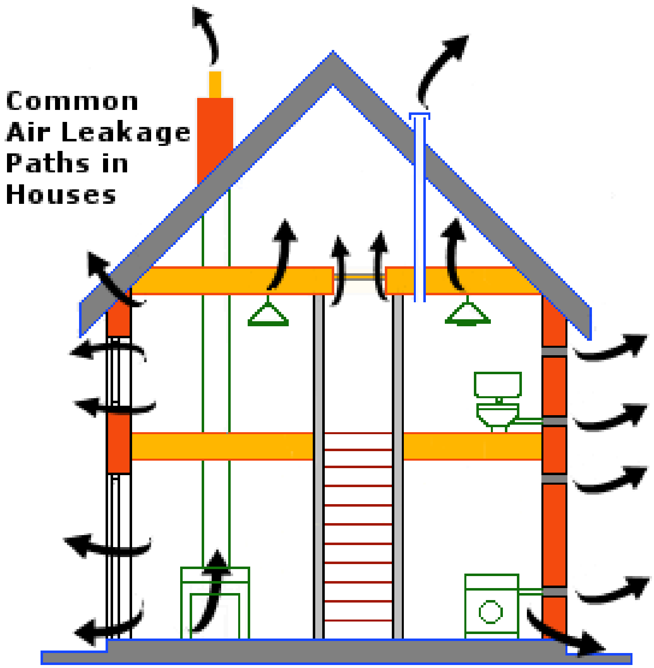
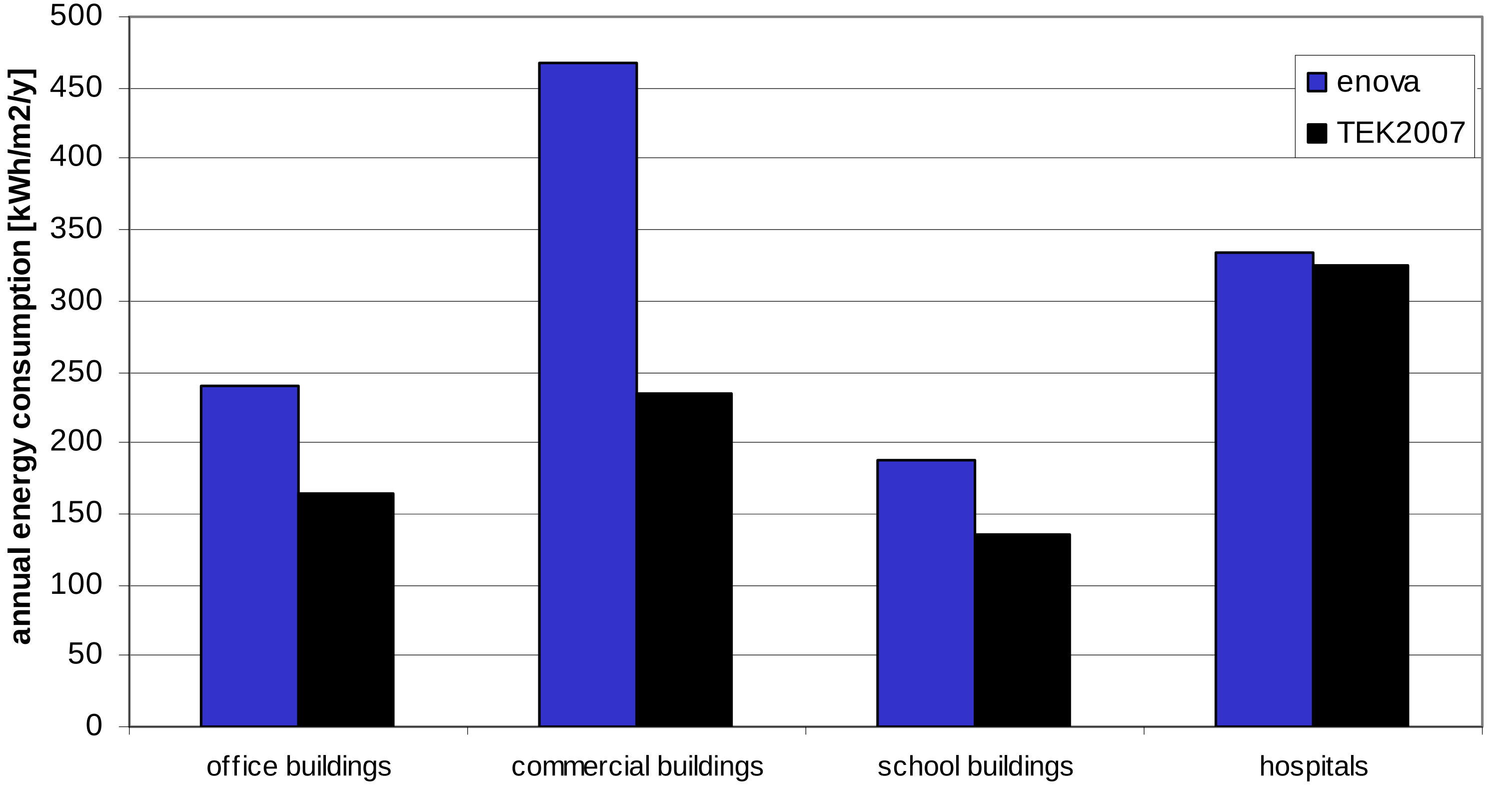


Credit: lowenergyhouse.com

Introduction

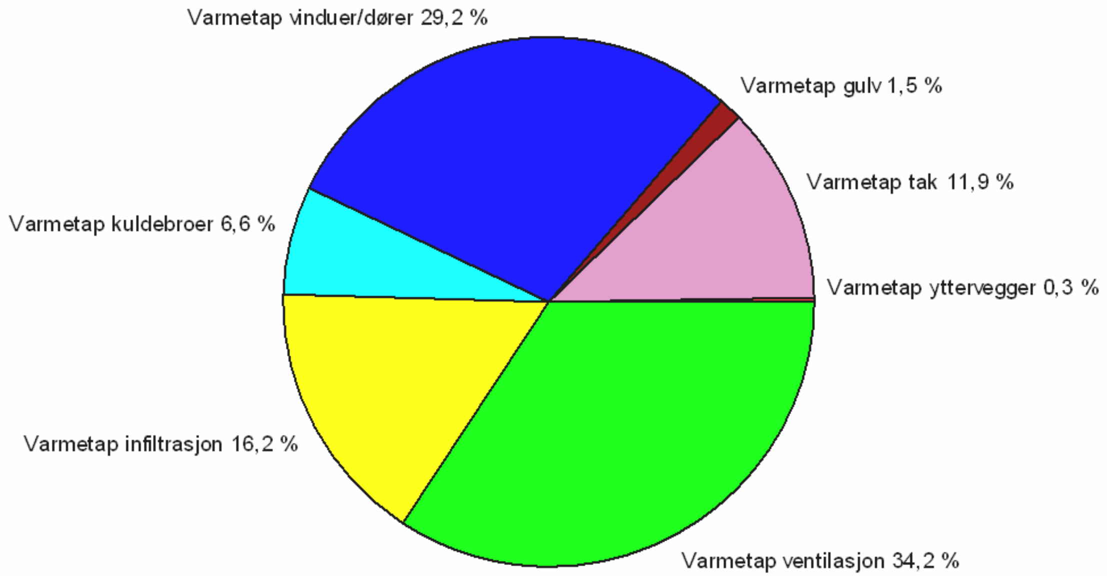
- Energy in buildings in Norway



Credits: enova

Introduction

Varmetapsbudsjett (varmetapstall)



Varmetapstall yttervegger	0,00 W/m²K
Varmetapstall tak	0,11 W/m²K
Varmetapstall gulv på grunn/mot det fri	0,01 W/m²K
Varmetapstall glass/vinduer/dører	0,27 W/m²K
Varmetapstall kuldebroer	0,06 W/m²K
Varmetapstall infiltrasjon	0,15 W/m²K
Varmetapstall ventilasjon	0,31 W/m²K
Totalt varmetapstall	0,91 W/m²K

Objectives

- Air infiltration in buildings has been the focus of many research projects (Sherman and Chan 2004, Orme, Liddament and Wilson 1998).
- However, today's building simulation tools incorporate infiltration calculations in different degrees (Crawley et al. 2005).
- In this study it was interesting to investigate the influence of air tightness requirements on resulting energy use due to infiltration.
- Three different infiltration models were chosen and their calculation processes were analyzed in order to evaluate the energy implications of the different methods in the form of heat losses.
- This will help designers and planners to become more sensitive to infiltration issues in the building process.

Method

- The infiltration is calculated for three different methods and the results are compared.
- The following methods were applied for estimating infiltration rates:
  - LBL infiltration model (ASHRAE 2005)
  - EN ISO 13789 (NS-EN-ISO13789 2007)
  - Marsh (Marsh 2009), Szokolay (2007)

Method

- As a basis for comparison a building with a volume of 300m^3 and 21°C room temperature was chosen and located in Oslo, Norway with a moderate shielding.
- The air tightness was assumed to be
  - case 1: n_{50}= 2.5h^{-1}
  - case 2: n_{50}= 0.6h^{-1}

- Infiltration
- Heat losses

LBL infiltration model

$$L_{inf} = \sqrt{q_{stack}{}^2 + q_{wind}{}^2 + (L_{extr} - L_{sup})^2}$$

- With infiltration
- temperature induced, wind induced, from the ventilation system

LBL infiltration model

temperature induced infiltration

$$q_{stack} = A_{leak} \times f_{stack} \times \frac{3600s}{h} \times \sqrt{\frac{g \times h_{stack} \times (T_r - T_{ex})}{293K}}$$

With

A_{leak} = area of leakage [m^2]

f_{stack} = stack factor [-]

g = 9.81 [$kg/(ms^2)$]

h_{stack} = height of stack [m]

T_r = room temperature [K]

T_{ex} = external temperature [K]

$$f_{stack} = \frac{(1+\frac{R}{2})}{3} \times \sqrt[\frac{2}{3}]{\left(1 - \frac{\sqrt[3]{X}}{\sqrt[2]{(2-X)}}\right.}$$

LBL infiltration model

wind induced infiltration

$$q_{wind} = A_{leak} \times v_{wind} \times \frac{3600s}{h} \times C \times \sqrt[3]{(1-R)}$$

With

$$A_{leak} = \frac{n_{50} \times V}{50000}$$

A_{leak} = area of leakage [m^2]

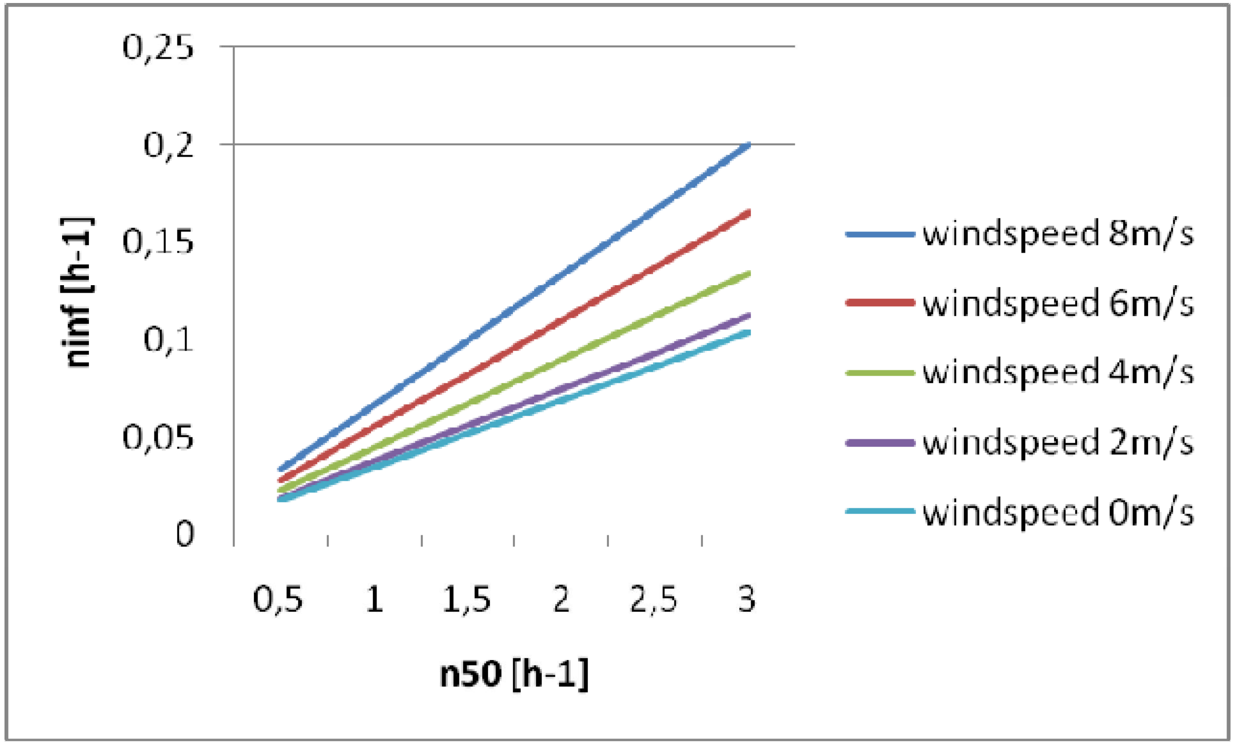
v_{wind} = wind speed [m/s]

C = shielding factor (0.11 for high, 0.225 for moderate, and 0.34 for no shielding)

n_{50} = infiltration rate at 50 Pa pressure difference [h^{-1}]

V = building volume [m^3]

LBL infiltration model



EN ISO 13789

$$n_{inf} = \frac{n_{50} \times e}{1 + \frac{f}{e}\left(\frac{\dot{V}_1 - \dot{V}_2}{V \times n_{50}}\right)^2}$$

n_{50} = infiltration rate at 50 Pa pressure difference [h^{-1}]

f, e = shielding factors [-]

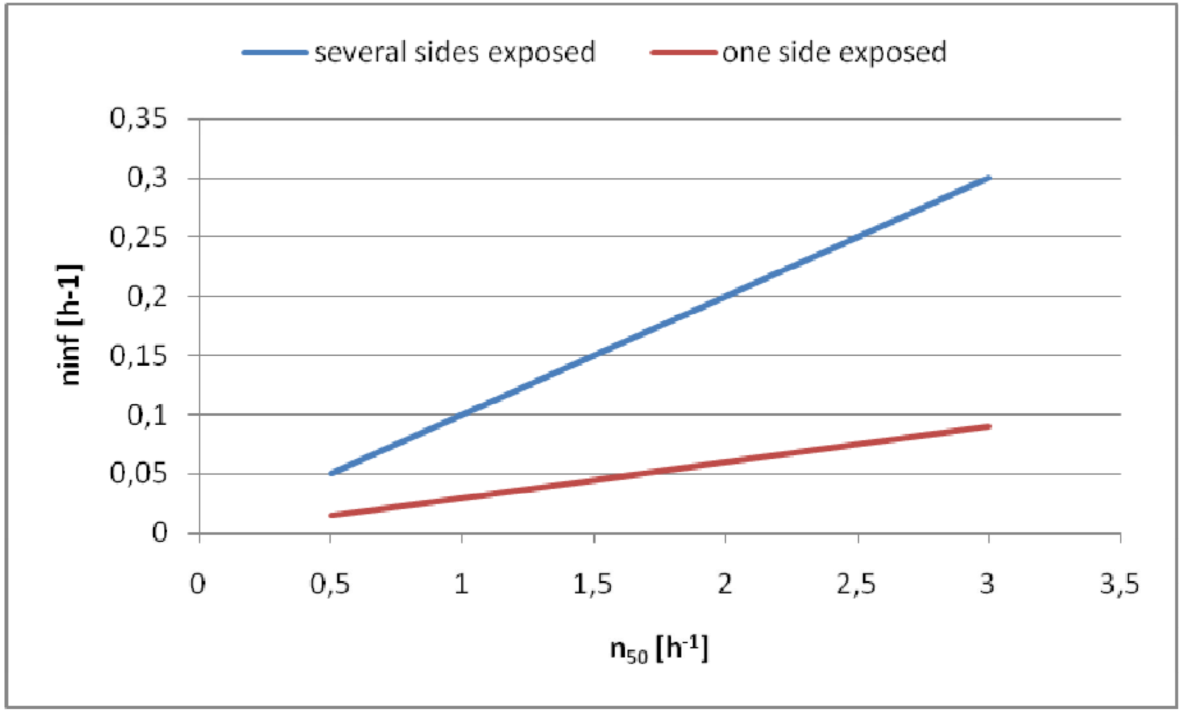
V_1, V_2 = supply and exhaust airflow [m^3/h]

EN ISO 13789

Wind Protection Coefficients According to EN 13789

Coefficient e for Screening Class	Several Sides Exposed	One Side Exposed
No Screening	0.10	0.03
Moderate Screening	0.07	0.02
High Screening	0.04	0.01
Coefficient **f**	15	20

EN ISO 13789



several sides exposed
one side exposed
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
ninf [h-1]
0
0,5
1
1,5
2
2,5
3
3,5
n50 [h-1]

Marsh, Szokolay

$$n_{inf} = (A \times n_a) + (B \times s_{wind} \times f_t \times \sqrt[2]{v_{wind}})$$

A, B = window position factors (Table 1)

n_a = infiltration rate (ach) [h^{-1}], fixed value taking also ventilation into account (here n_{inf} from EN ISO 13789 was assumed)

s_{wind} = wind sensitivity (between 0.1 and 1.5) [-]

f_t = terrain factor (between 0.58 and 1.02) [-]

Marsh, Szokolay

Window position factor

factor	Single sided window	Cross-window
A	0.5	1
B	1	2

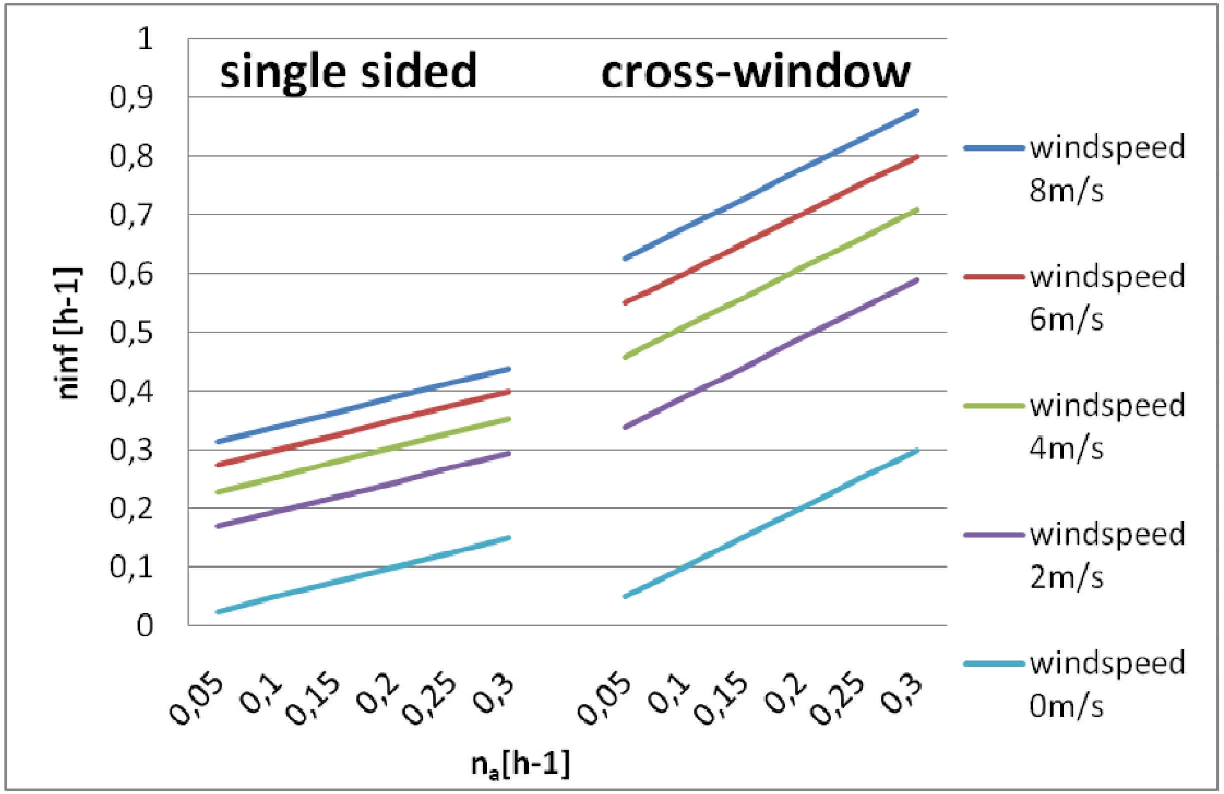
Terrain factor

	Terrain factor
exposed	1,02
rural	0,8
suburban	0,63
urban	0,58

Wind sensitivity

	wind sensitivity	
well protected	0,1	ach
reasonable protected	0,25	ach
somewhat sensitive	0,5	ach
very sensitive	1	ach
sensitive and exposed	1,5	ach

Marsh, Szokolay



Energy implication

$$H_D = \sum_t (c_p \times n_{inf} \times (T_r - T_{ex}))$$

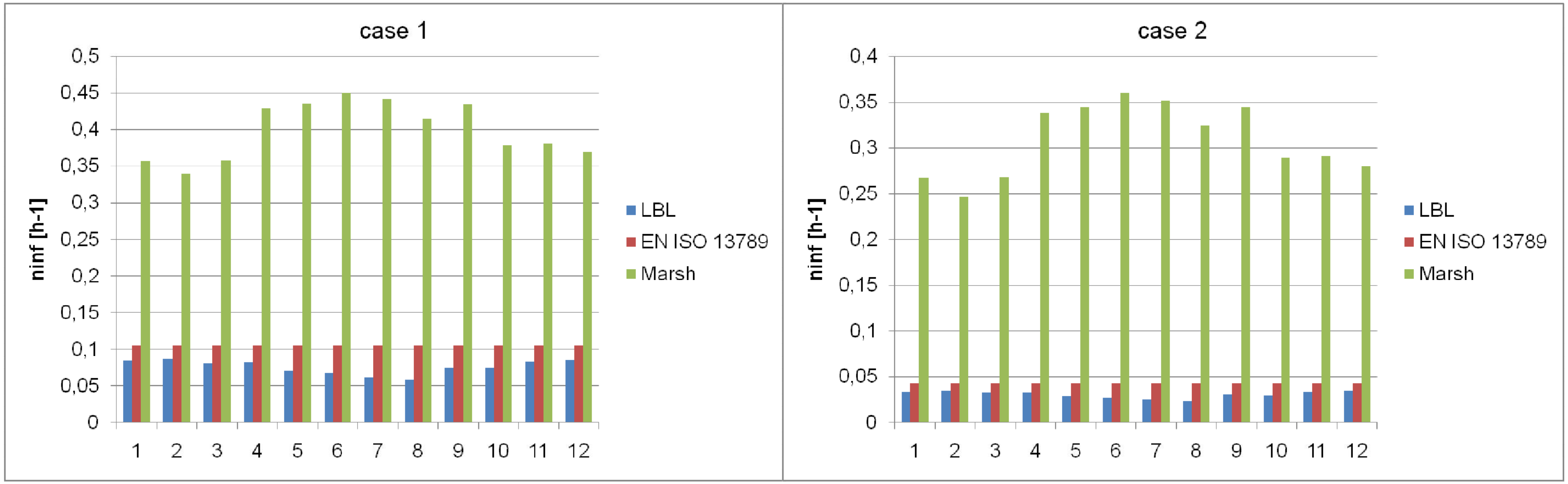
c_p = heat capacity of air [Wh/K]

n_{inf} = infiltration rate [h^{-1}]

T_r, T_{ex} = temperatures in room and external [K]

Results

- Infiltration



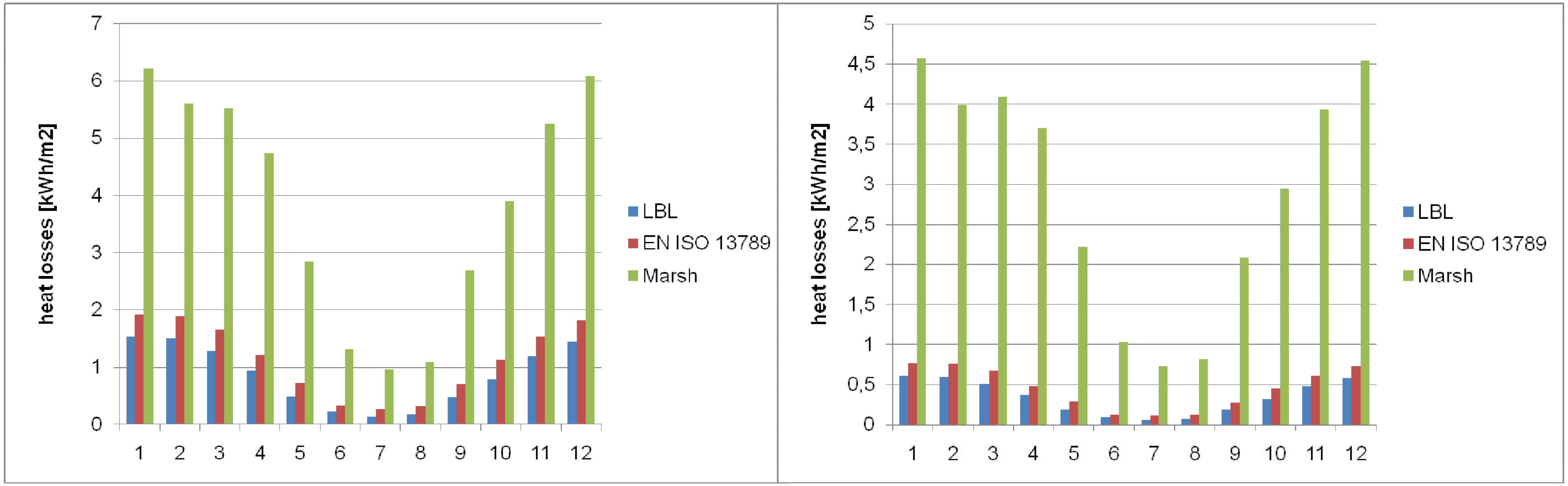
Results

- Infiltration

n_{inf} [h^{-1}]	LBL	EN ISO 13789	Marsh
Case 1	0.076	0.105	0.399
Case 2	0.030	0.042	0.309

Results

- Heat losses



Results

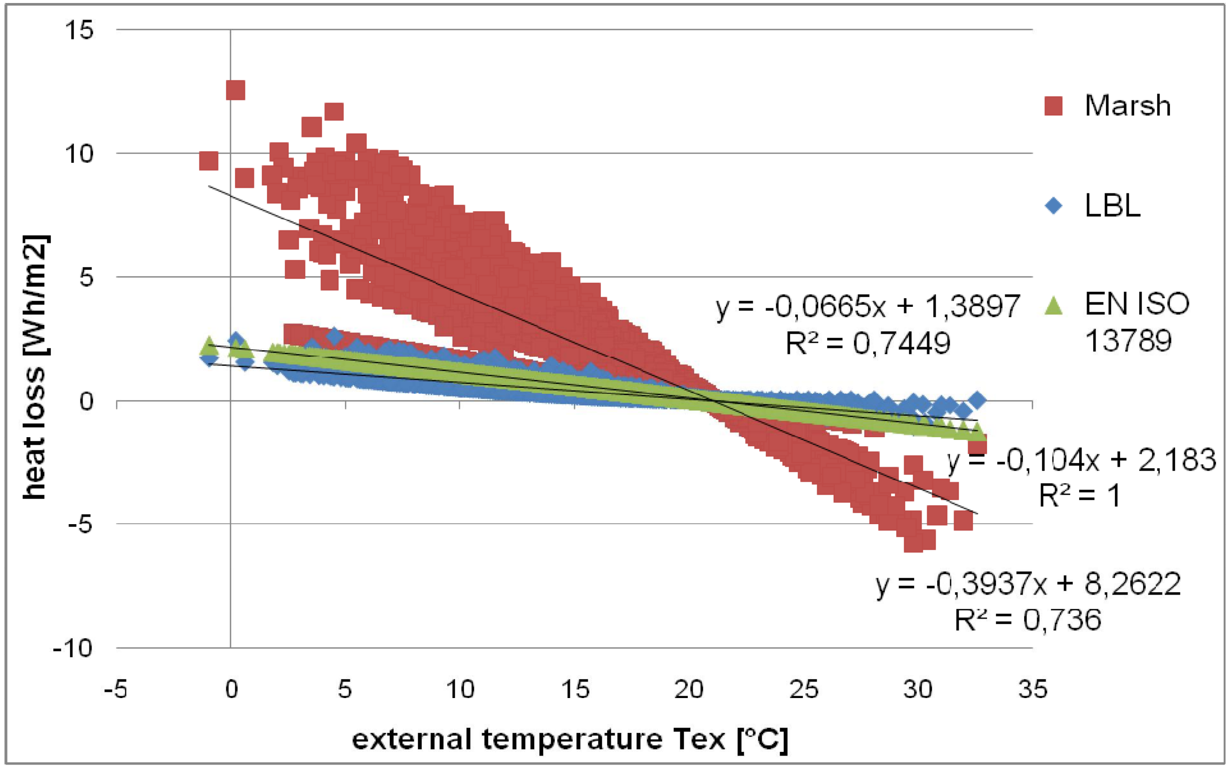
- Heat losses

H_D [kWh/m2]	T_r [21°C]	LBL	EN ISO 13789	Marsh
Case 1	21	10.20	13.51	46.24
	20	9.55	12.60	42.77
	19	8.89	11.68	39.31
Case 2	21	4.08	5.40	34.66
	20	3.82	5.04	32.00
	19	3.56	4.67	29.30

Results

heat losses over external temperature for different approaches

(case 1 with n_{50} =1.5h[-1])



Conclusions

- This study focused on examining the influence of air tightness on calculated energy use due to infiltration.
- Three different infiltration models were chosen and their calculation processes were analyzed and the energy implications of the different methods in the form of heat losses were evaluated.
- The comparison of the infiltration rates as well as the heat losses for the three different approaches show that the LBL model and EN ISO 13789 are close while Marsh is much higher.
- Depending on the air tightness of the building heat losses vary between 10 and 46 kWh/m^2 for a building with n_{50} = 1.5 h^{-1} and between 4 and 35 kWh/m^2 for a building with n_{50} = 0.6 h^{-1}.

Conclusions

- The results show a large variation and demonstrate that infiltration calculation is a very important topic.
- Different models deliver different results which might lead to the wrong design decision.
- The implications for cooling loads should be further explored.
- The results hopefully help designers and planners to become more sensitive to infiltration issues in the building process.

Summary

- Introduction
- Objectives
- Method
- Results
- Conclusions