UNIVERSITY OF THESSALY
SCHOOL OF ENGINEERING

DEPARTMENT OF ARCHITECTURE

Investigation of the occupants' behaviour and satisfaction with the indoor environmental conditions in typical historic buildings in Veria.
Primary results of airtightness test in Chatzikou House

Katerina Drakou

Aris Tsangrassoulis

Aim of the study

suggestions for construction techniques

improve the energy performance of traditional houses

Building occupants

building shell and its systems

Need for comfort (expectations ?)

Maximum benefit from the sustainable design and construction techniques

higher energy consumption due to lifestyle choice

User behaviour significantly affects energy consumption simulation estimates

regional behavioural pattern

Methodology

Occupant Behaviour

- subjective survey (questionnaires)

Building shell

- Airtightness
- Blower Door Test
- Case study

Dynamic Thermal Simulation

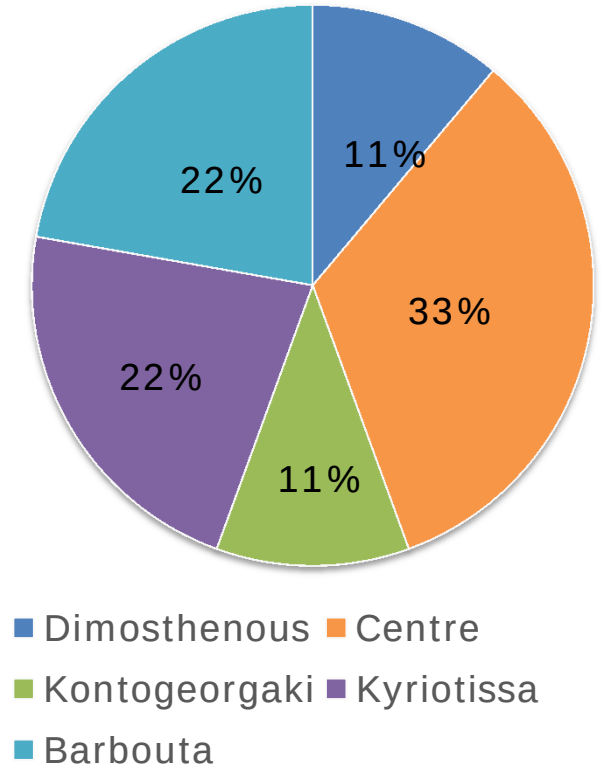
- Case study
  Tool: Energyplus
- Traditional Construction techniques – Estimation of current thermal behaviour
- Parametric and sensitivity analysis

Results

- Suggestions for improvement of construction techniques

Questionnaires' descriptive analysis

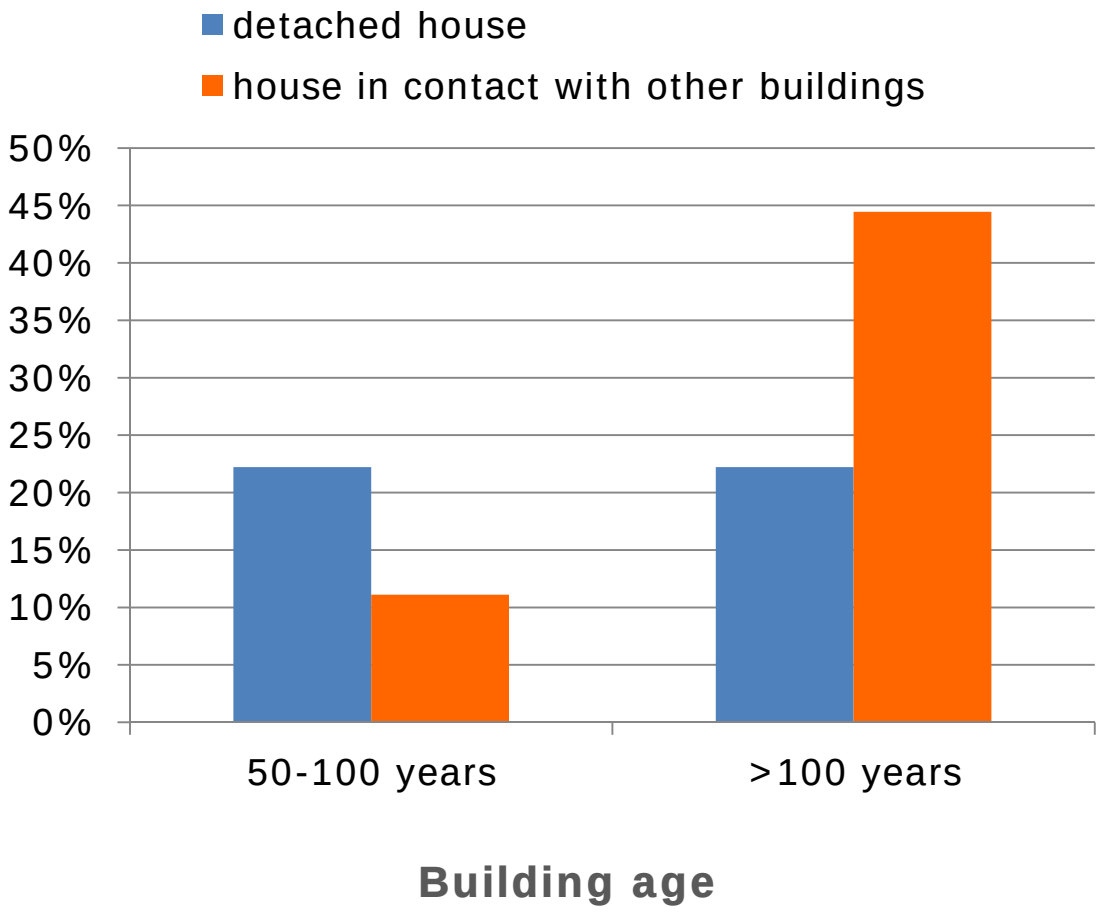
- 9 questionnaires – an ongoing process (aiming for a sample of 30)
- initial findings of the questionnaire about user behaviour



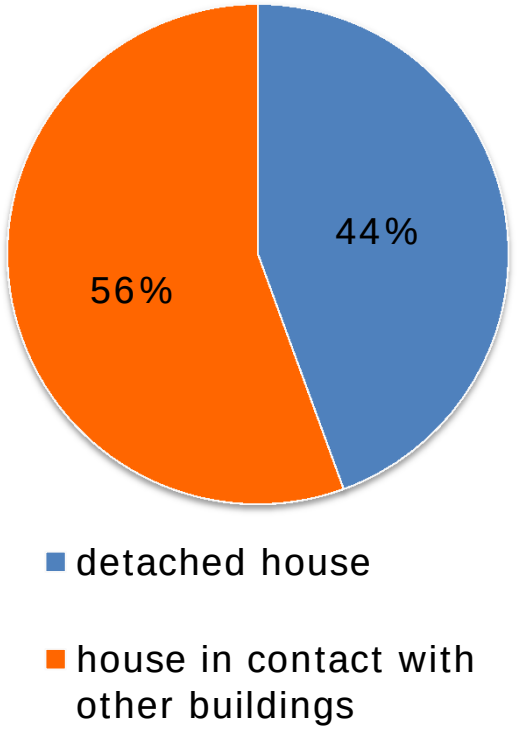
Distribution of questionnaires

Questionnaires' descriptive analysis

Dwelling typology



Building age



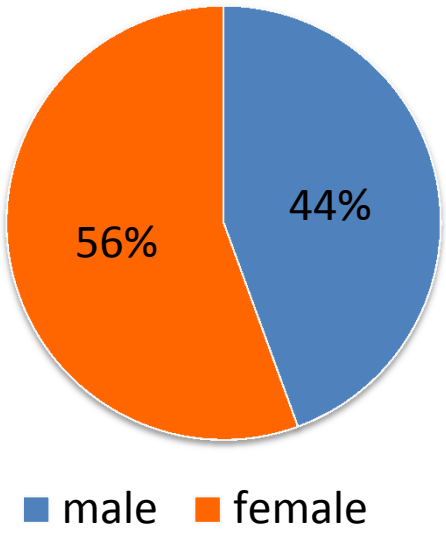
Building type

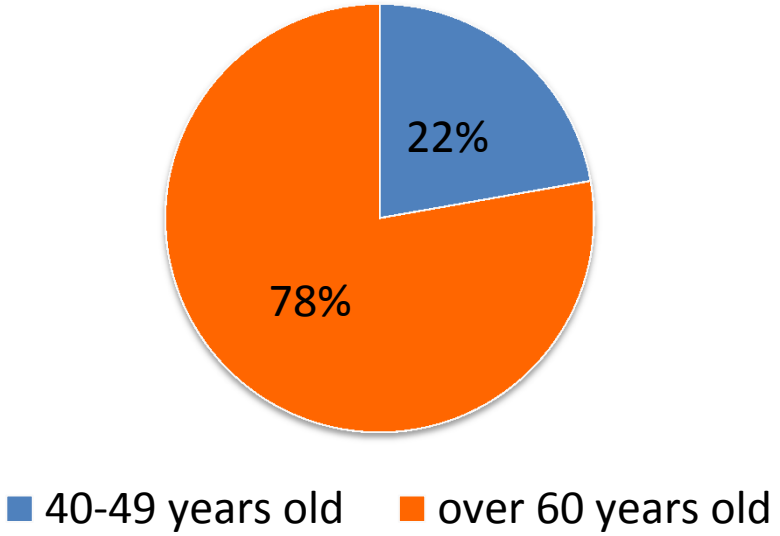
Dwelling typology

Building age and construction technique (as noted by the users)

Questionnaires' descriptive analysis

Sample profile



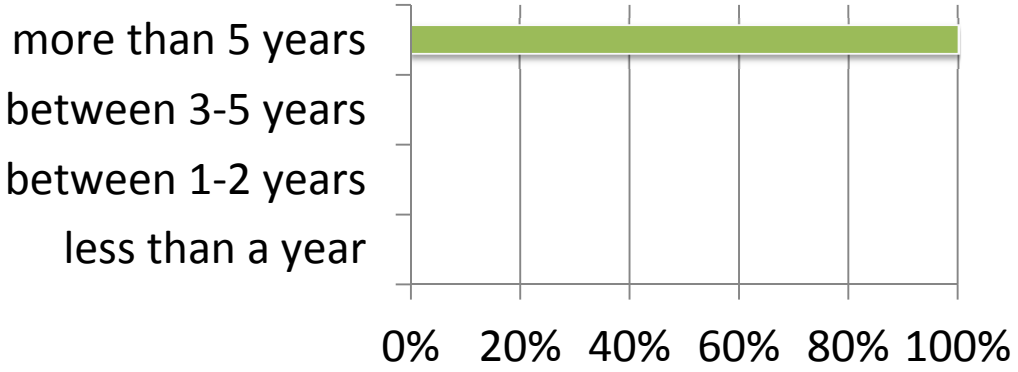


The sample consists mainly of female over 60 years old

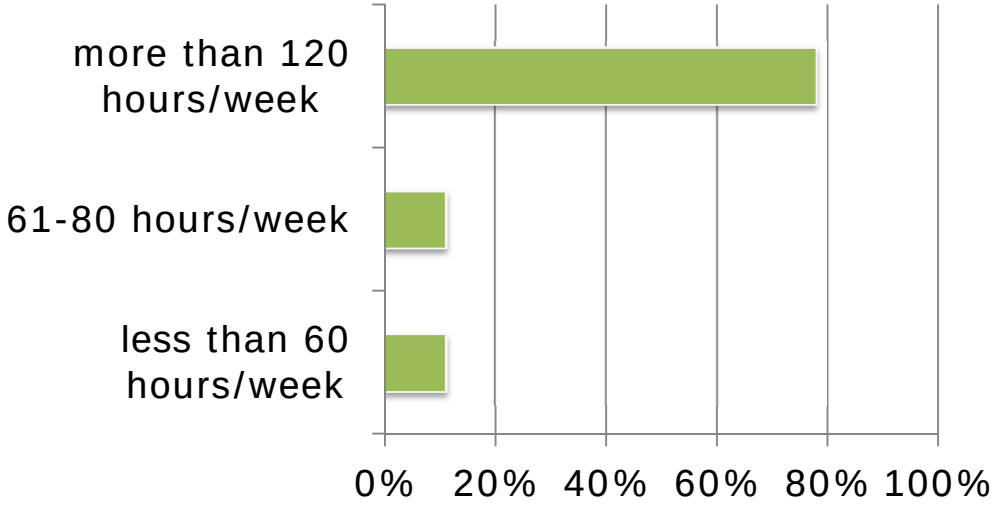
Questionnaires' descriptive analysis

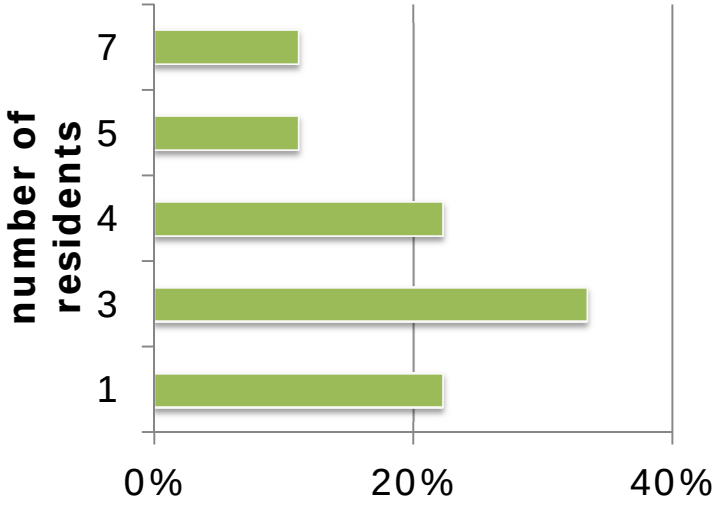
Sample profile

Period of living in the current house



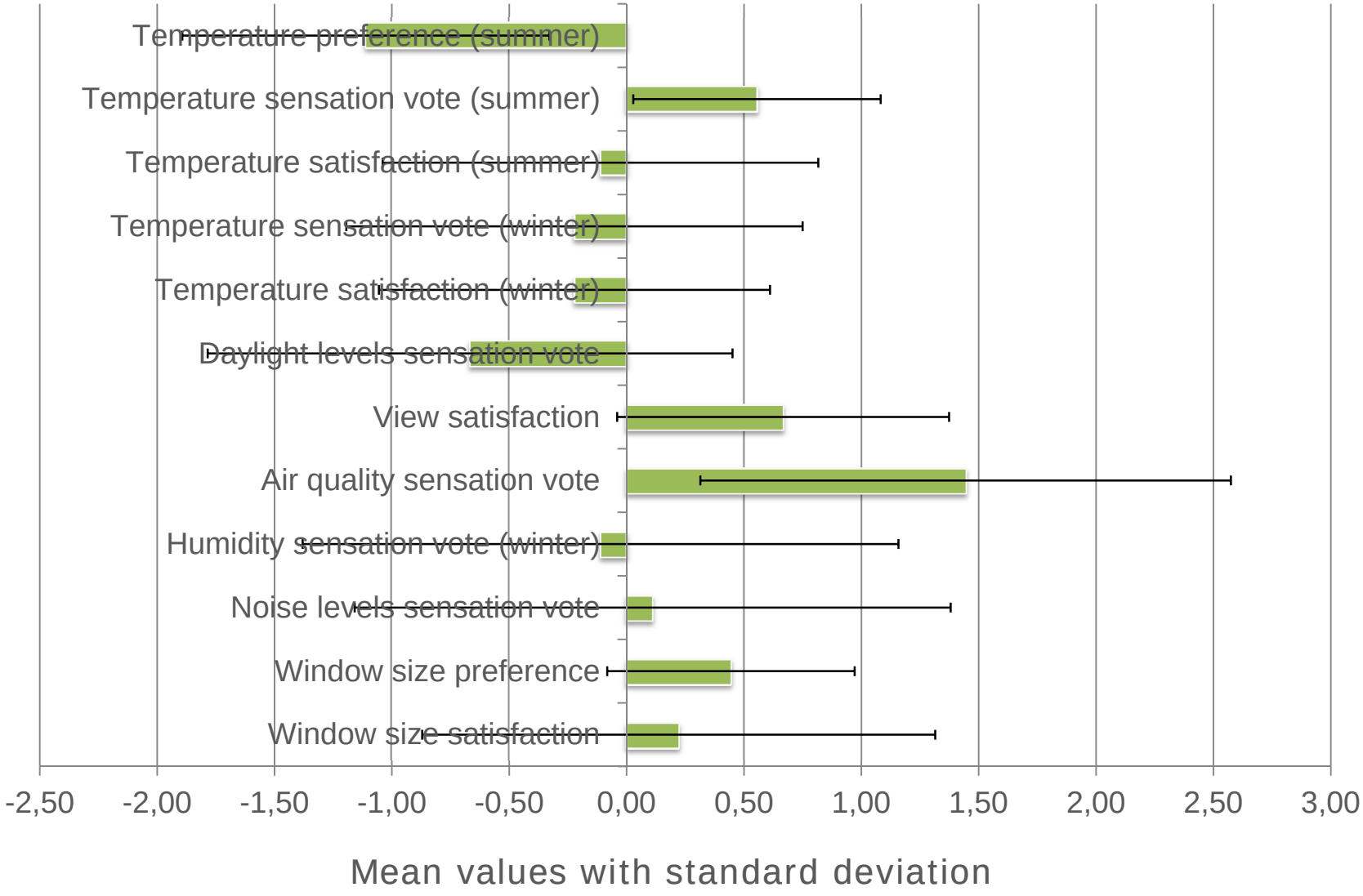
The participants have already formed a behavioural pattern





Questionnaires' descriptive analysis

Respondents' evaluation of their indoor environmental conditions



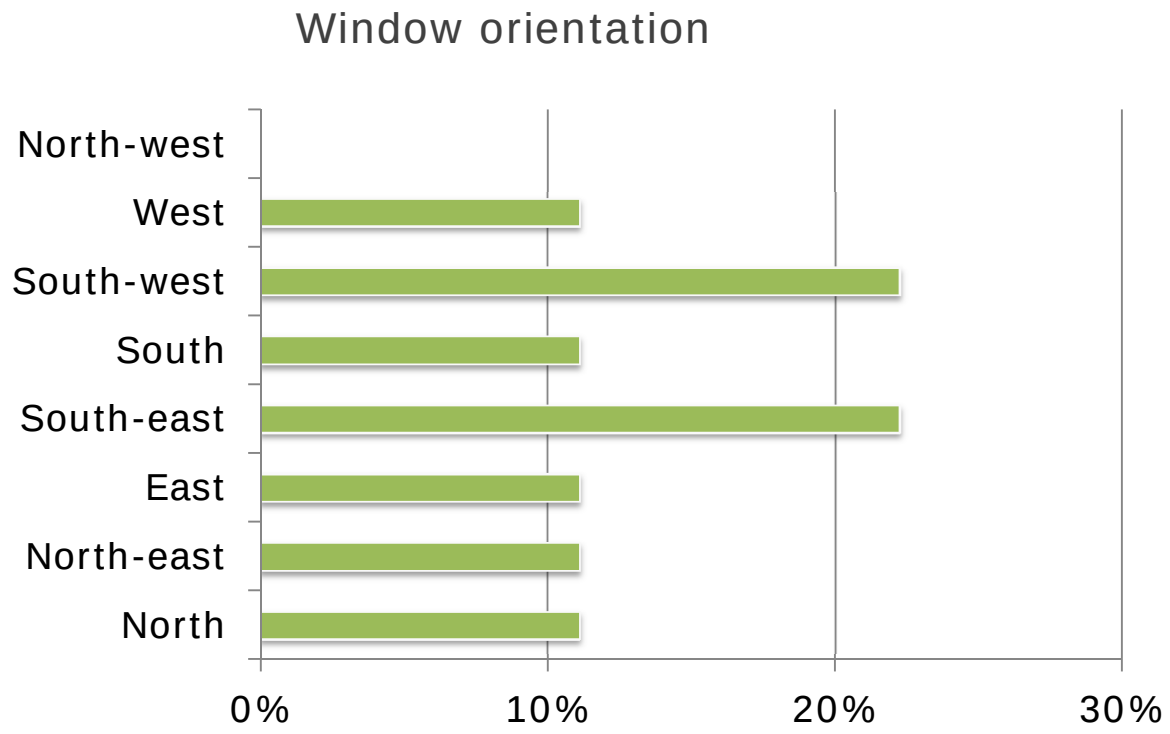
Questionnaires' descriptive analysis

Window typology and orientation

56% sliding windows

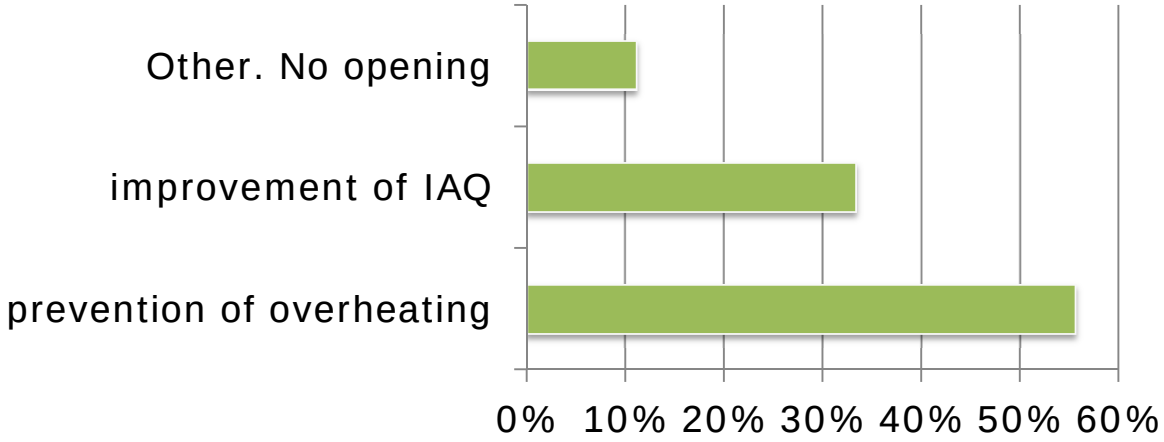
34% openable windows

10% sliding top hung

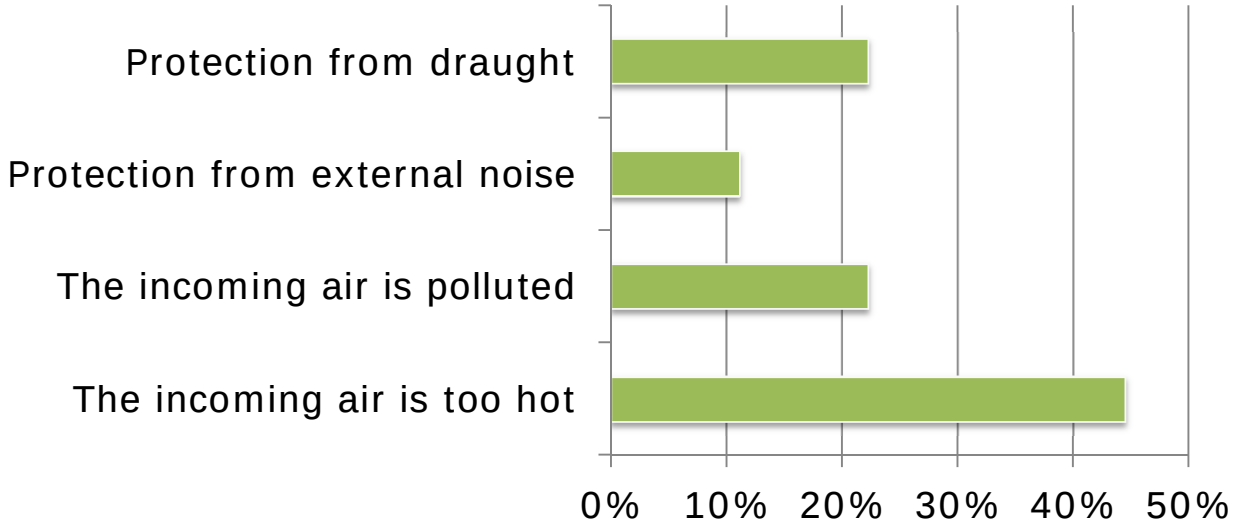


Questionnaires' descriptive analysis

Occupant interaction with the building shell



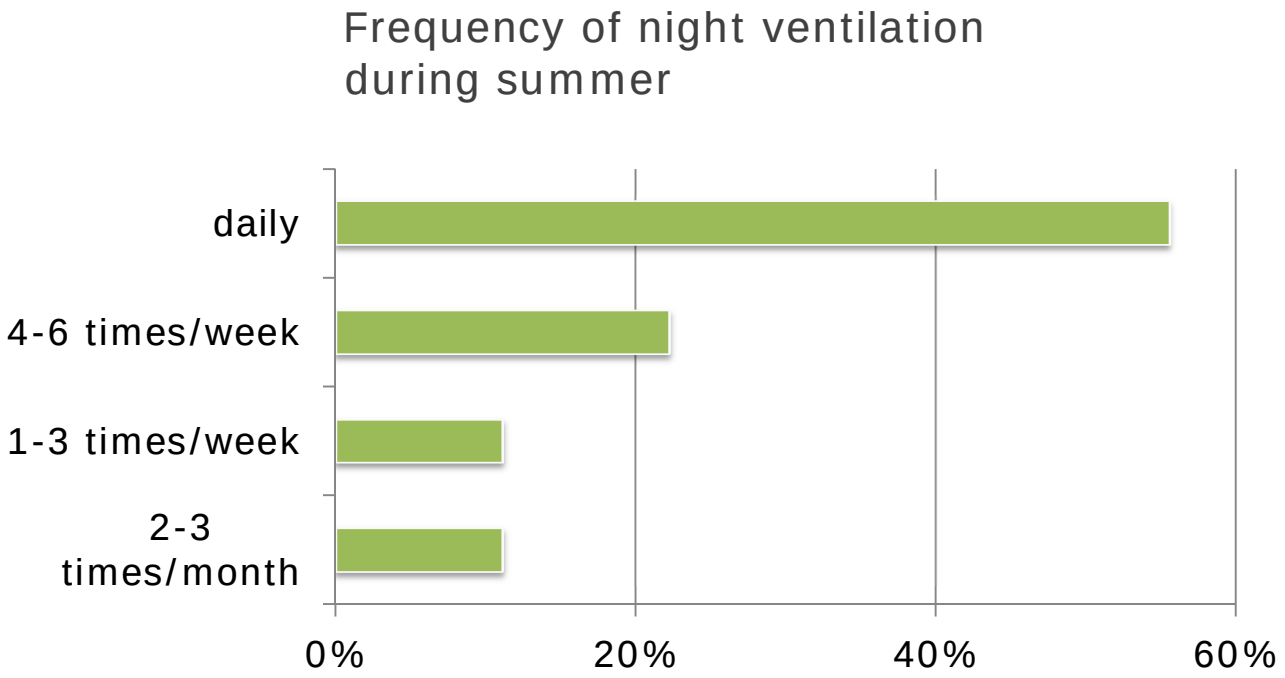
Distribution of reasons for window opening during summer.



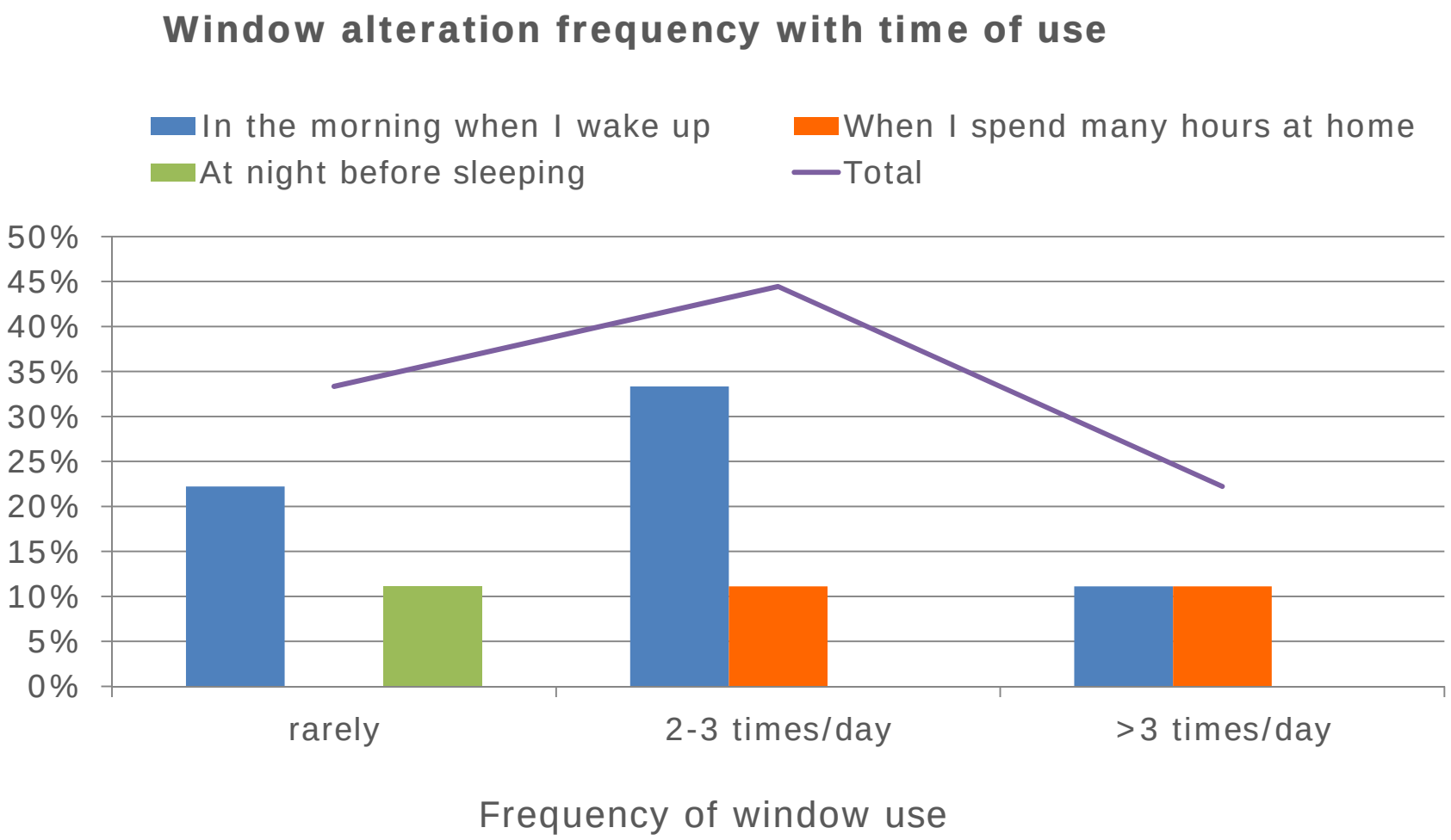
Distribution of reasons for window closing during summer.

Questionnaires' descriptive analysis

Occupant interaction with the building shell

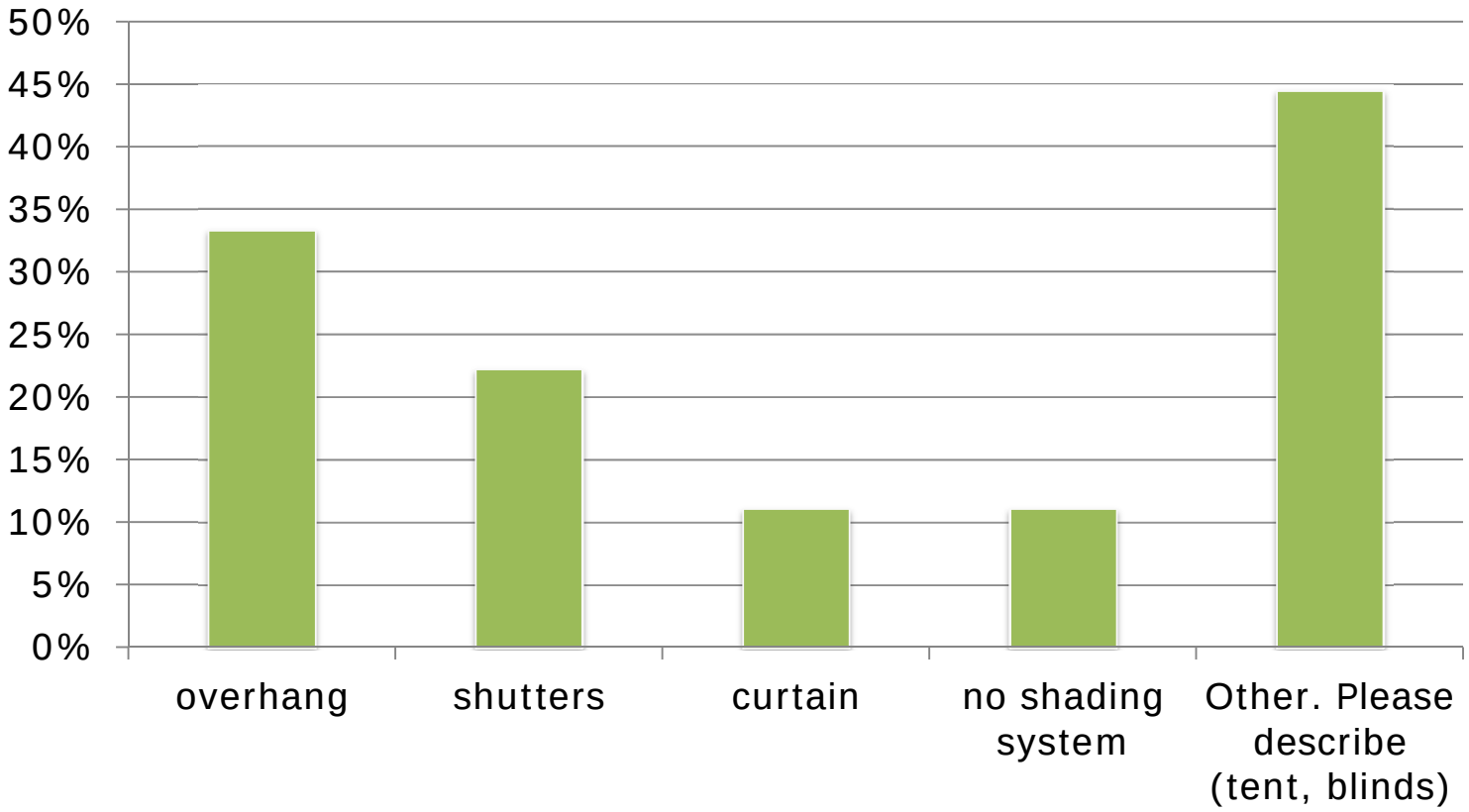


Occupant interaction with the building shell

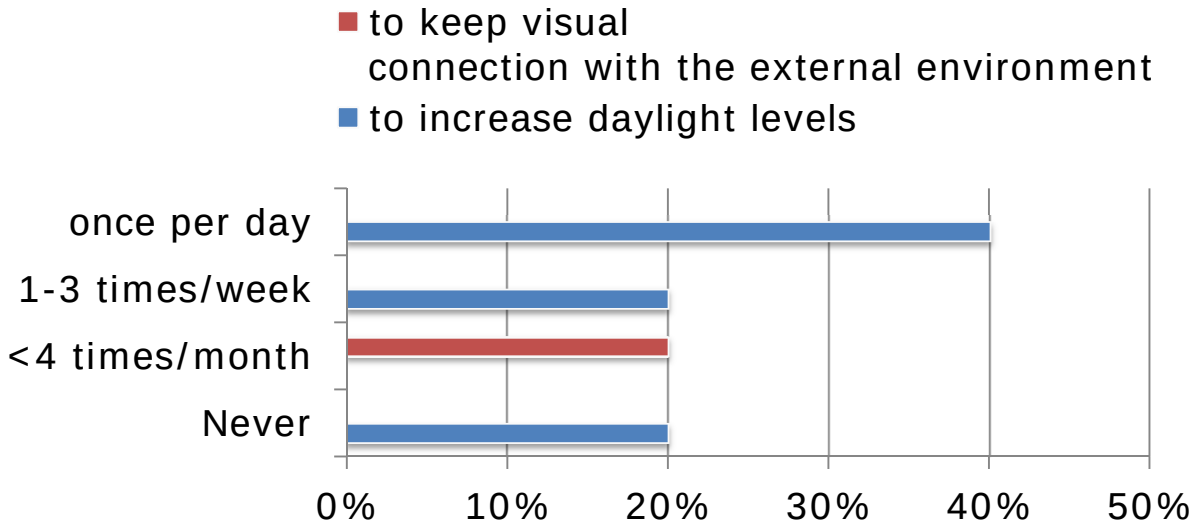


Questionnaires' descriptive analysis

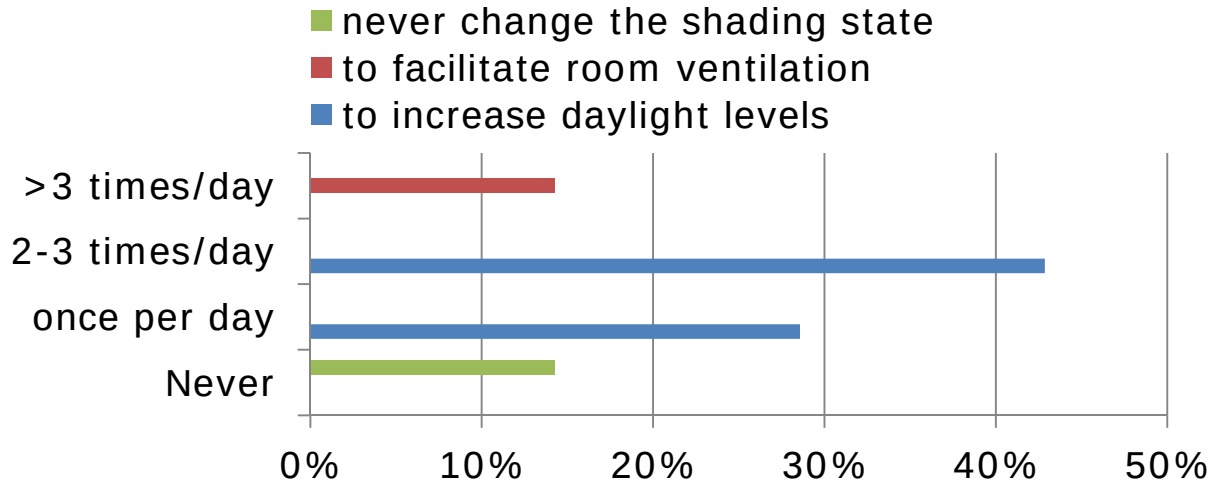
Shading systems



Use of shading



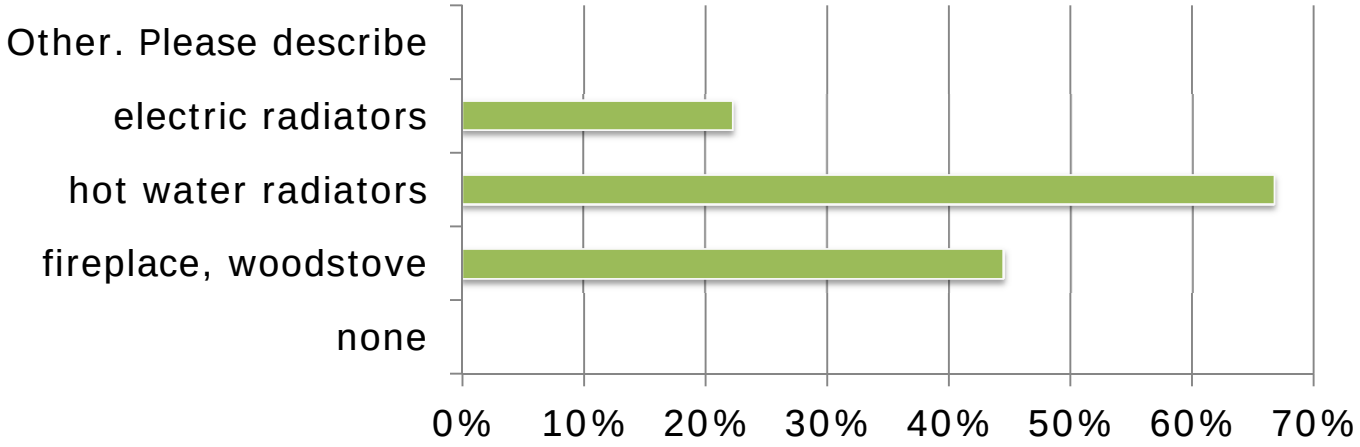
Use of shading during winter

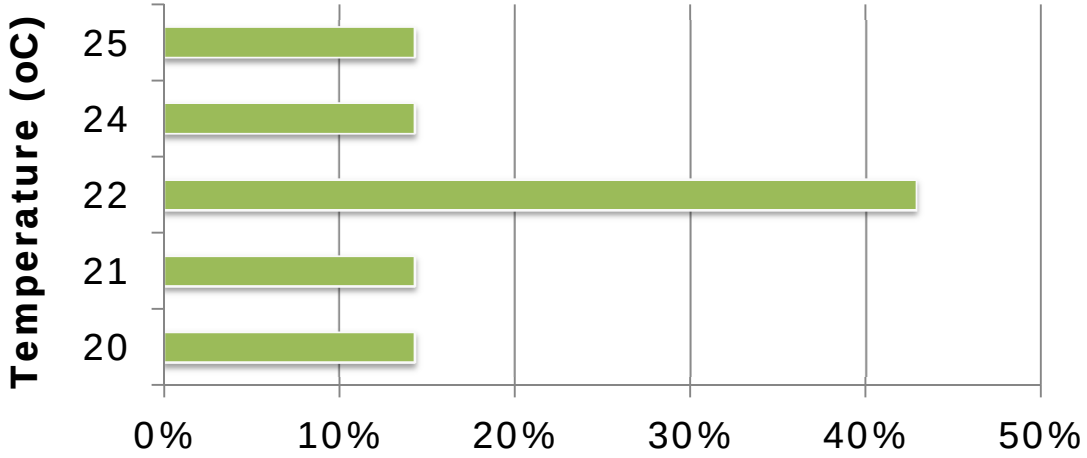


Use of shading during summer

Questionnaires' descriptive analysis

Heating systems

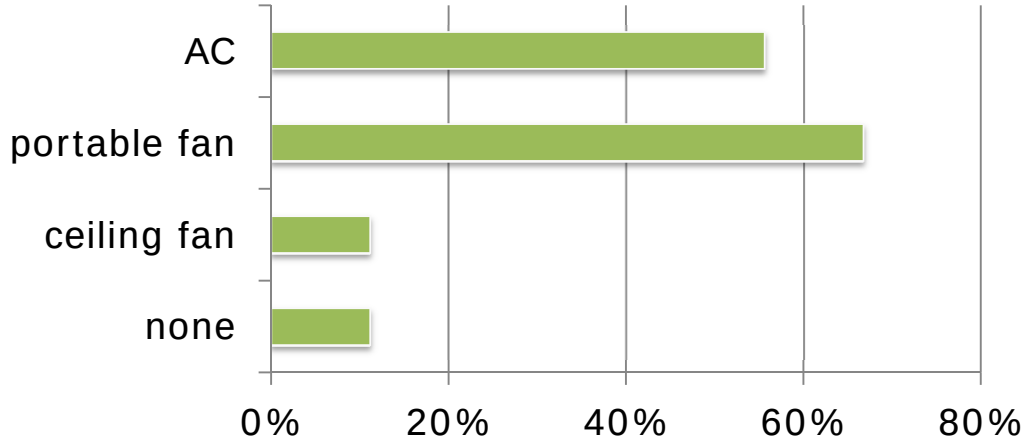




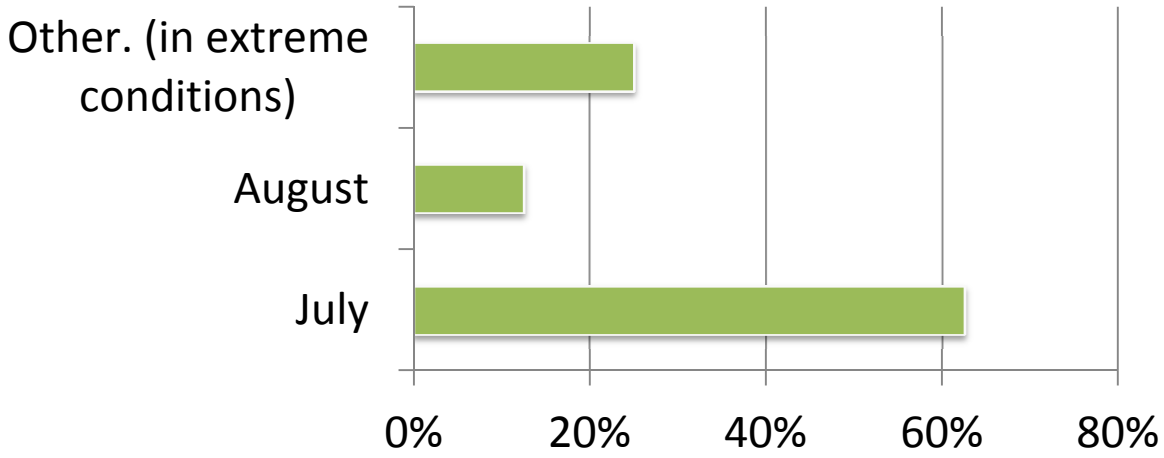
Heating setpoint

Questionnaires' descriptive analysis

Cooling systems



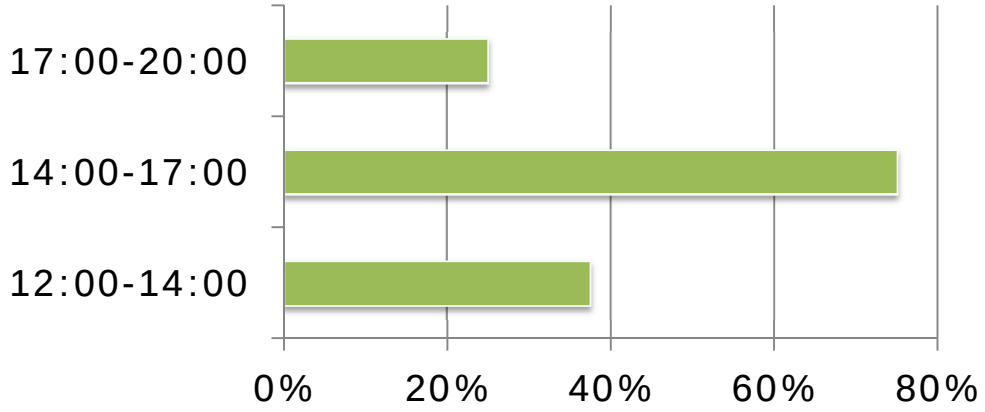
Wide use of AC



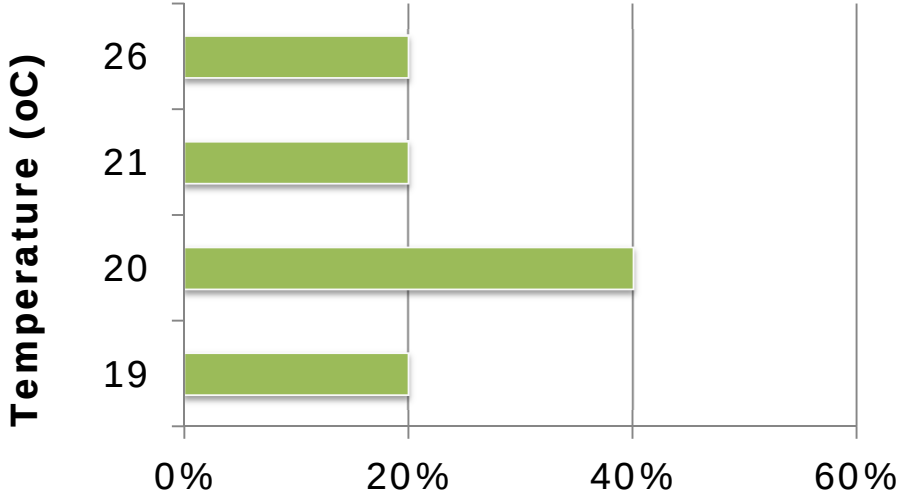
Use of cooling systems per month

Questionnaires' descriptive analysis

Cooling systems



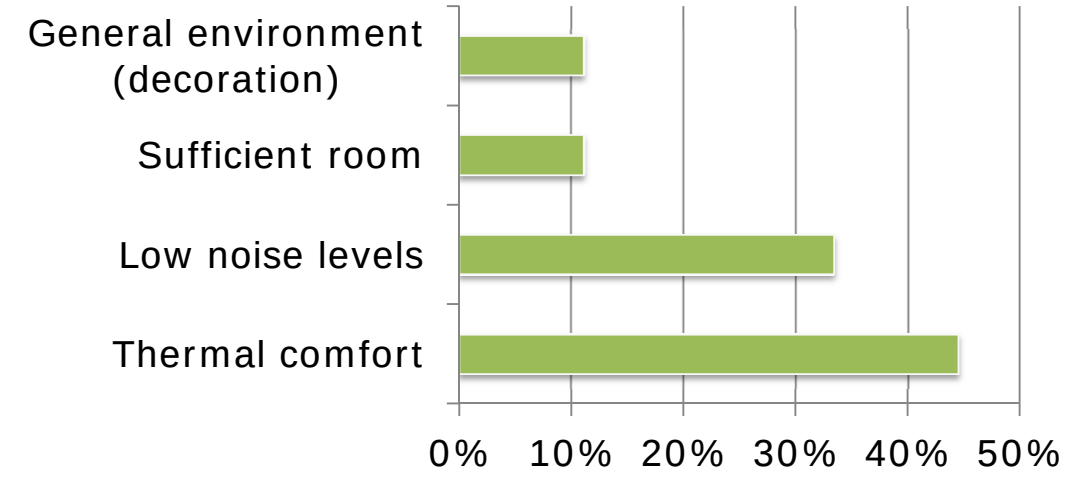
Use of cooling systems by time of day



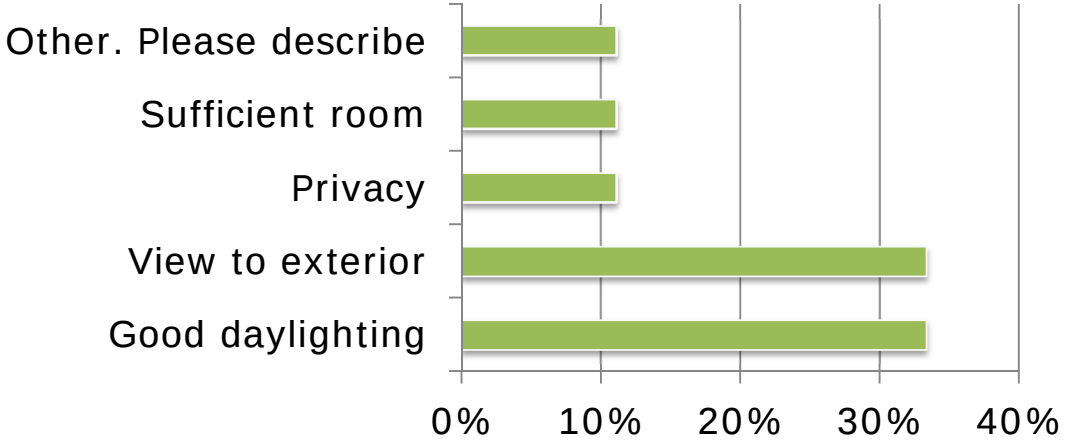
Preferred cooling setpoint

Questionnaires' descriptive analysis

Features of pleasant dwelling



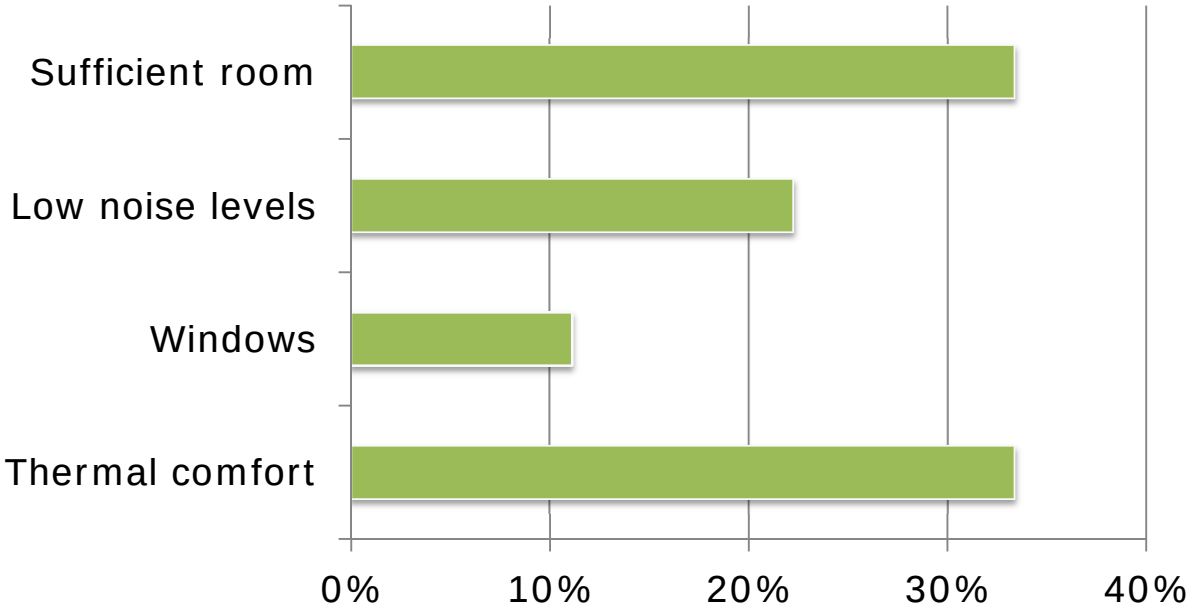
The most important (1) feature of a pleasant dwelling



The second most important (2) feature of a pleasant dwelling

Questionnaires' descriptive analysis

Features of pleasant dwelling



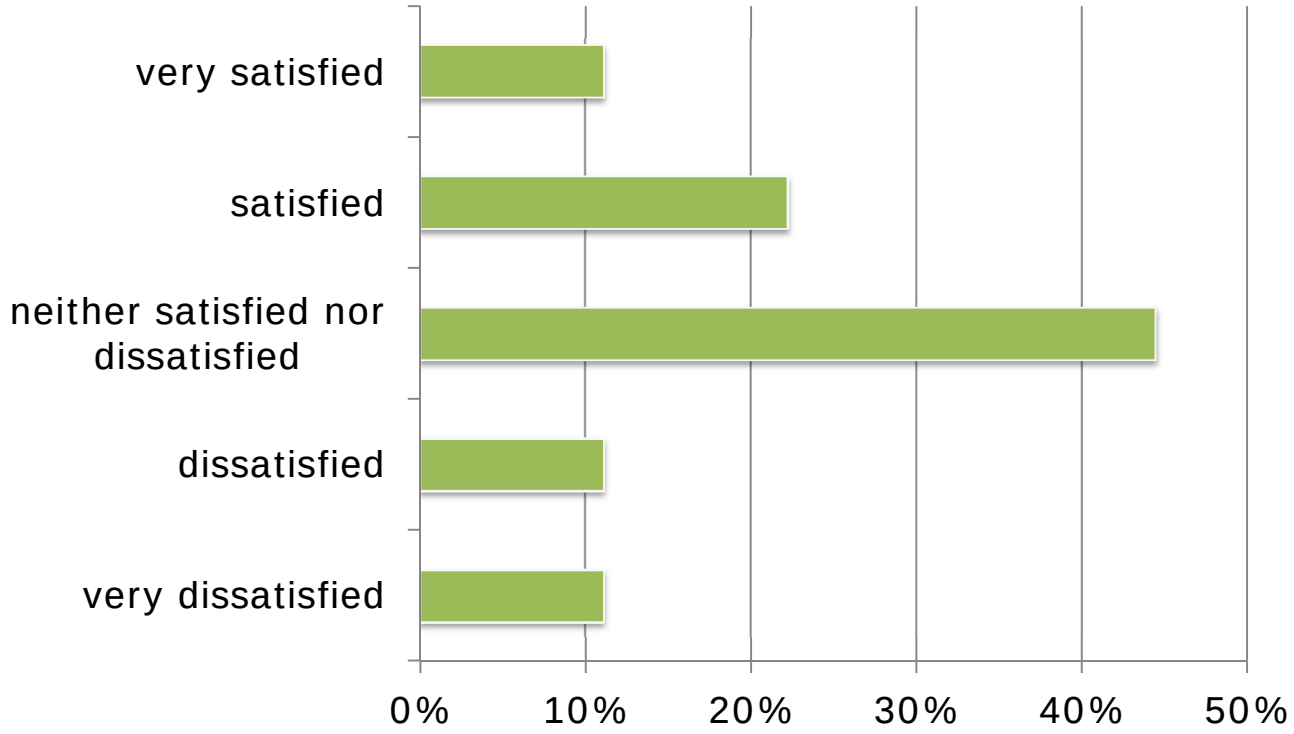
The third most important (3) feature of a pleasant dwelling

Most important features of pleasant dwelling according to occupants

1. Thermal comfort
2. Good daylighting
3. Sufficient space

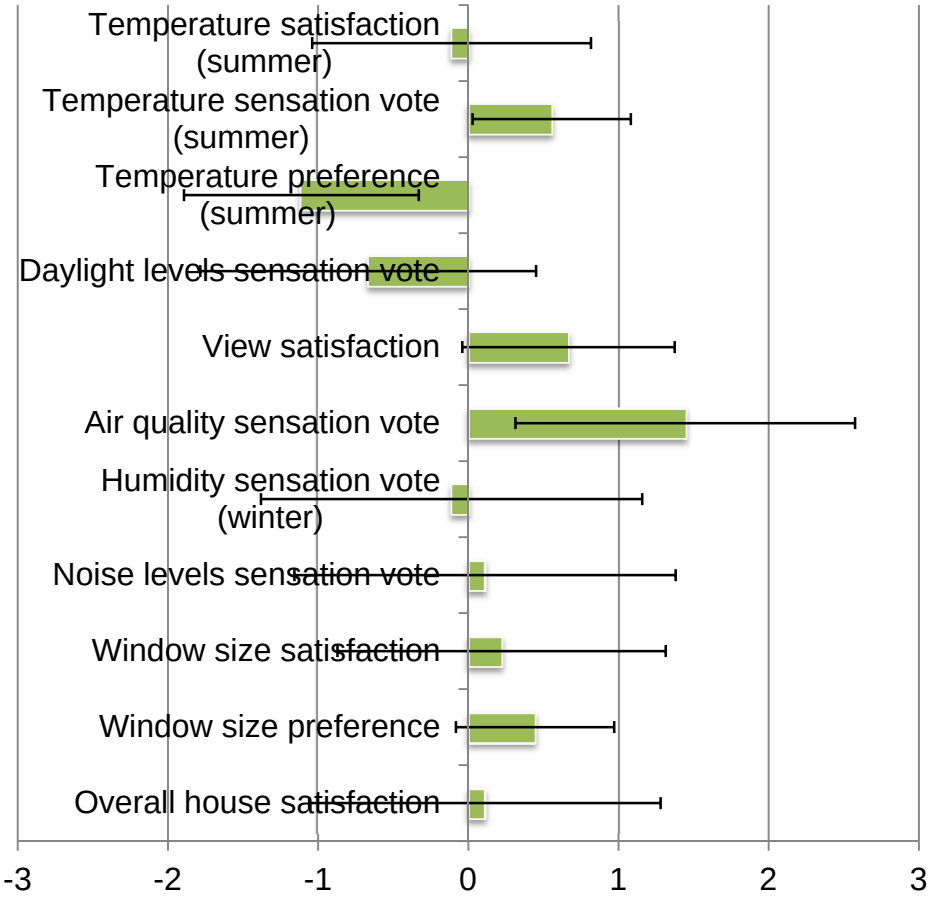
Questionnaires' descriptive analysis

General satisfaction with the dwelling

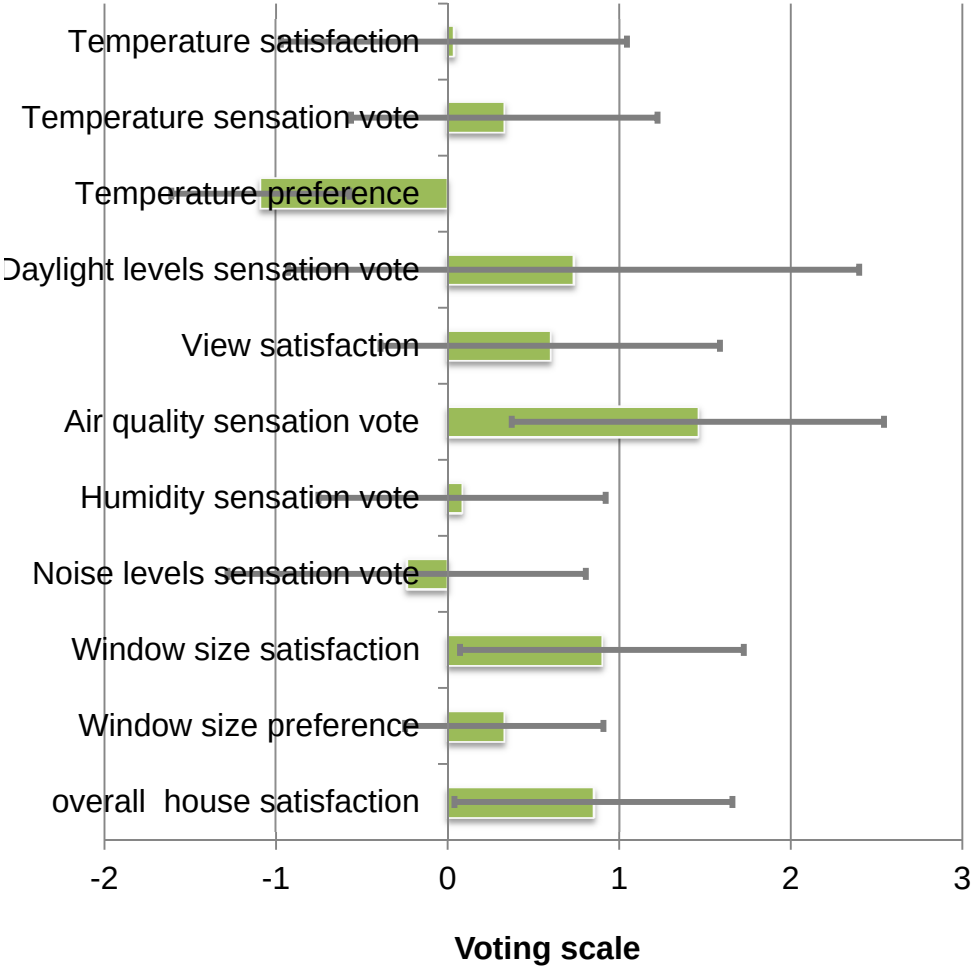


Questionnaires' descriptive analysis

Comparison of questionnaires results



Traditional houses in Veria



Contemporary houses in Greece

Conclusions

On average

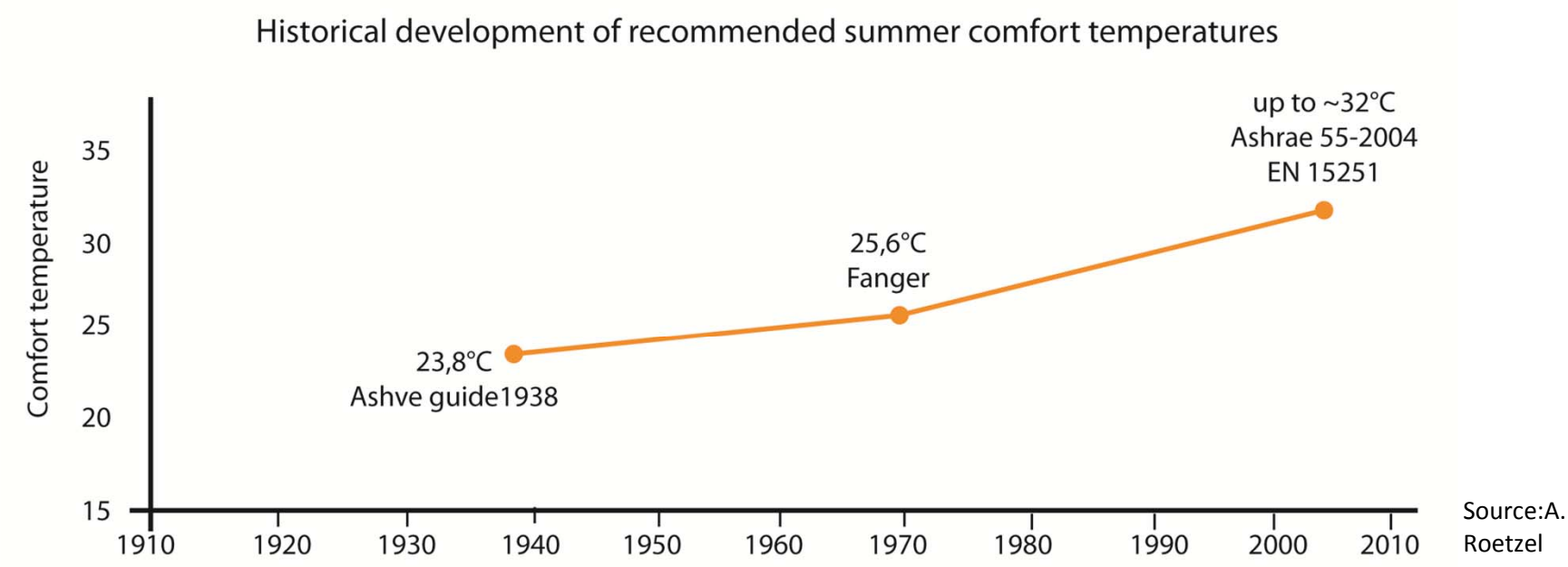
- the majority of the indoor environmental conditions neutral with a slight trend towards bad (large standard deviation - small size of the sample)
- the mean temperature satisfaction vote close to acceptable, but all the survey occupants prefer to feel "cooler" during a typical summer day.
- most occupants control window state and shading 2-3 times/day.
- Prevention of overheating is the main reason for window opening, while improvement of daylighting levels constitutes the main reason for opening the shading.
- Prevention of overheating is the principal reason for closing windows.
- Daily use of summer night ventilation
- Wide use of AC (56% of the participants own AC units)

Conclusions

- Heating setpoint: 22-25ºC
- Cooling setpoint: 19-21ºC

Demanding expectations
According to the current trend

- Significant interaction of the building occupant with the building shell



Source:A. Roetzel

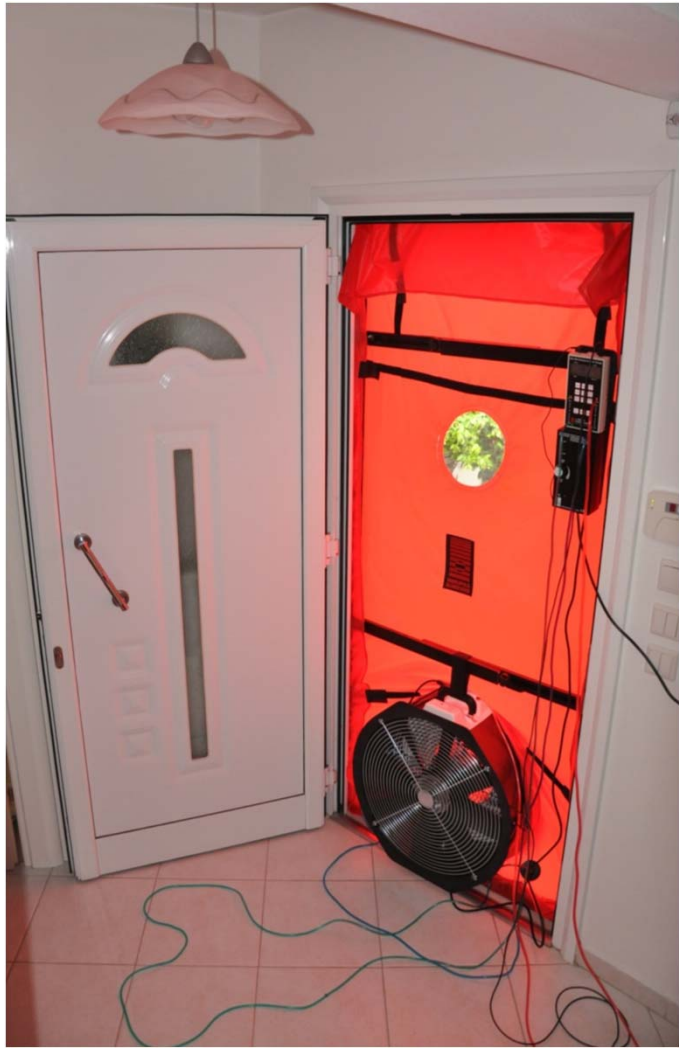
Blower Door Test

A blower-door system includes

- a calibrated fan,
- a door-panel system,
- a device to measure fan flow and building pressure.

The fan blows air into or out of the building, creating a small pressure difference between inside and outside. This pressure difference forces air through all holes and penetrations in the building enclosure.

The tighter the building (e.g. fewer holes), the less air is needed from the blower door fan to create a change in building pressure.



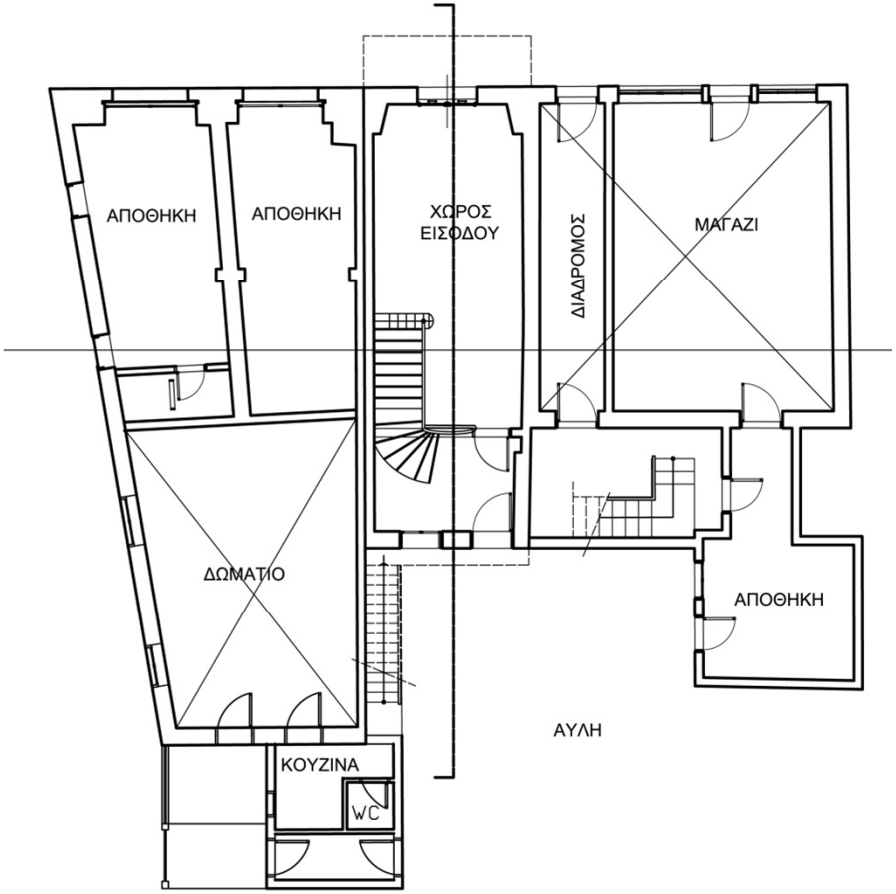
Blower Door Test – case study

- **Veria**
- **Chatzikou house**
- **Floor area: 254m²**
- **Volume: 849m³**

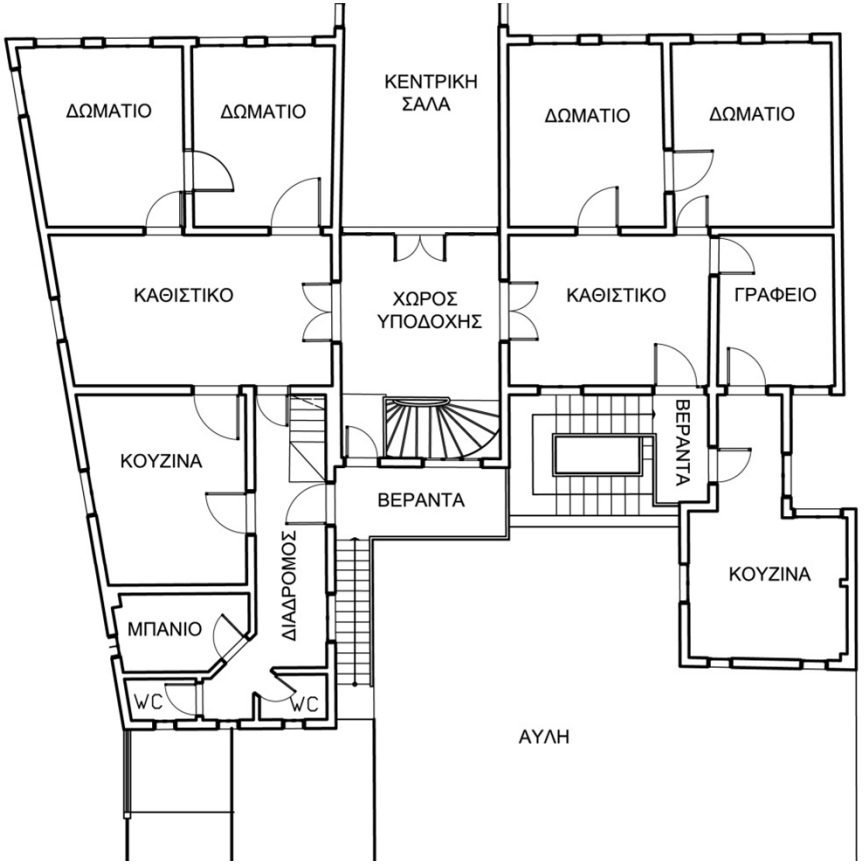
Airtightness

Chatzikou house

Drawings:
Papadopoulou Evangelia
Saskalidis Alexis



Ground floor



First floor

Airtightness

Chatzikou house interior

(photos:Kleopatra Theologidou)

Airtightness

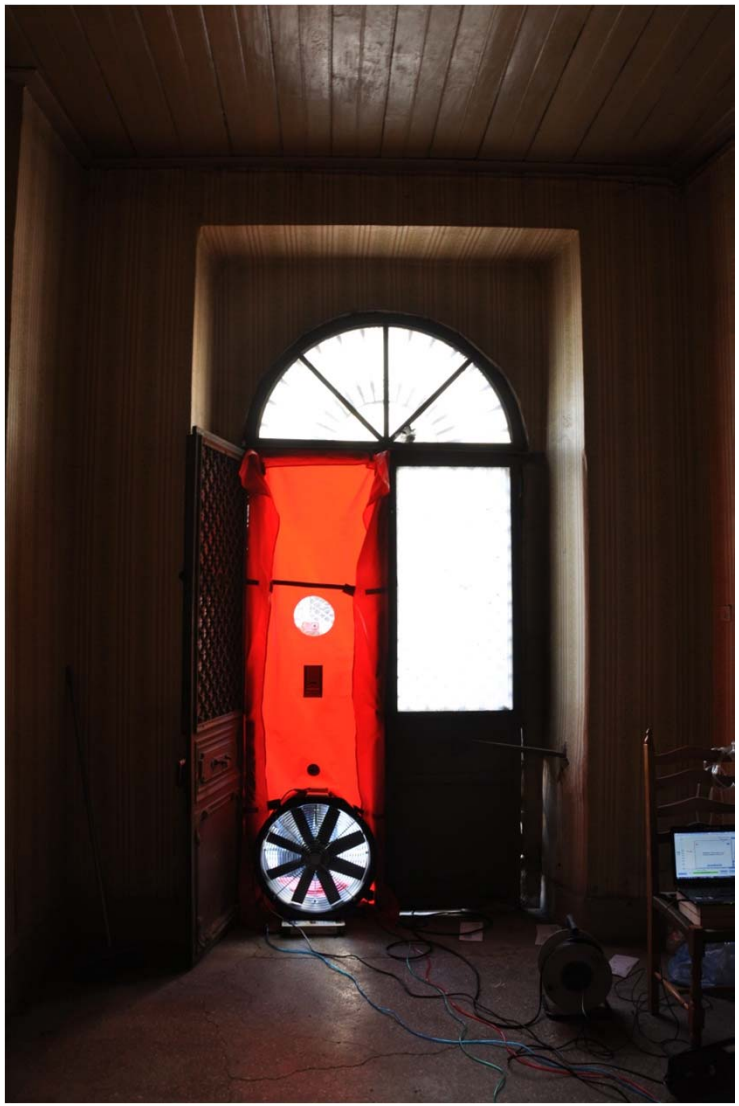
Blower Door Test – Chatzikou house

Views from outside (photos: Kleopatra Theologidou)

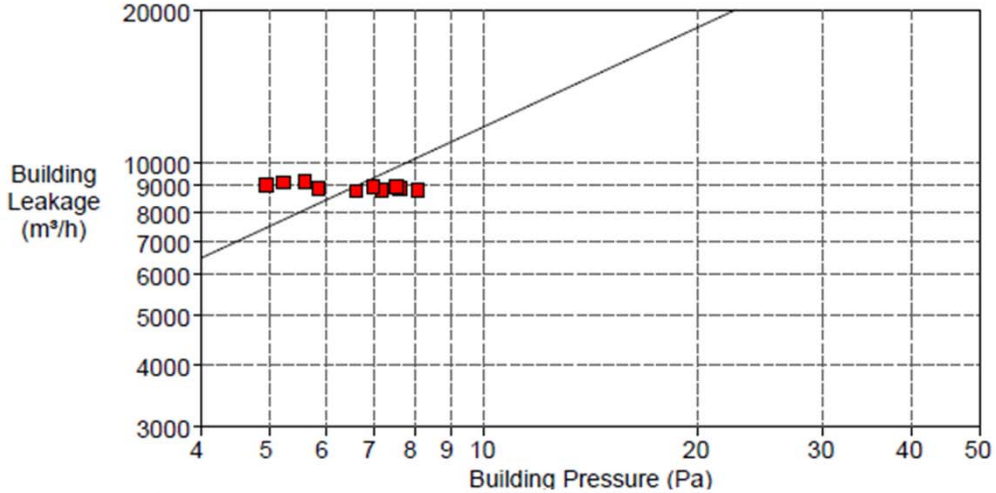
Airtightness

Blower Door Test – Chatzikou house

- **EN 13829**
- **Placement of the Blower door panel system on the one sheet of the door (door width:1.4m)**
- **Large air losses through cracks**



Blower Door Test – Chatzikou house



Test Results at 50 Pascals:

V50: Airflow (m³/h)	33492
n50: Air Changes per Hour (1/h)	39.44
w50: m³/(h*m² Floor Area)	132.01
q50: m³/(h*m² Surface Area)	44.04

Leakage Areas: 13130.5 cm² Canadian EqLA @ 10 Pa or 17.27 cm²/m² Surface Area
6981.9 cm² LBL ELA @ 4 Pa or 9.18 cm²/m² Surface Area

Building Leakage Curve: Air Flow Coefficient (Cenv) = 2645.8
Air Leakage Coefficient (CL) = 2634.0
Exponent (n) = 0.650 (Assumed)

Test Standard:	EN 13829	Test Mode:	Pressurization
Type of Test Method:	A	Regulation complied with:	
Equipment:	Model 4 (230V) Minneapolis Blower Door		

Inside Temperature:	20 °C	Volume:	849 m³
Outside Temperature:	21 °C	Surface Area:	760 m²
Barometric Pressure:	100091 Pa	Floor Area:	254 m²
Wind Class:	2 Light Breeze	Uncertainty of Building Dimensions:	3 %
Building Wind Exposure:	Highly Exposed Building	Year of Construction:	
Type of Heating:			
Type of Air Conditioning:			
Type of Ventilation:	None		

Blower Door Test – Chatzikou house

- Extremely leaky building
- Contemporary diagnostic tools may face difficulties in practice in traditional buildings

Next steps

Occupant Behaviour

- subjective survey (questionnaires)

Building shell

- Airtightness
- Blower Door Test
- Case study

Dynamic Thermal Simulation

- Case study
  Tool: Energyplus
- Traditional Construction techniques – Estimation of current thermal behaviour
- Parametric and sensitivity analysis

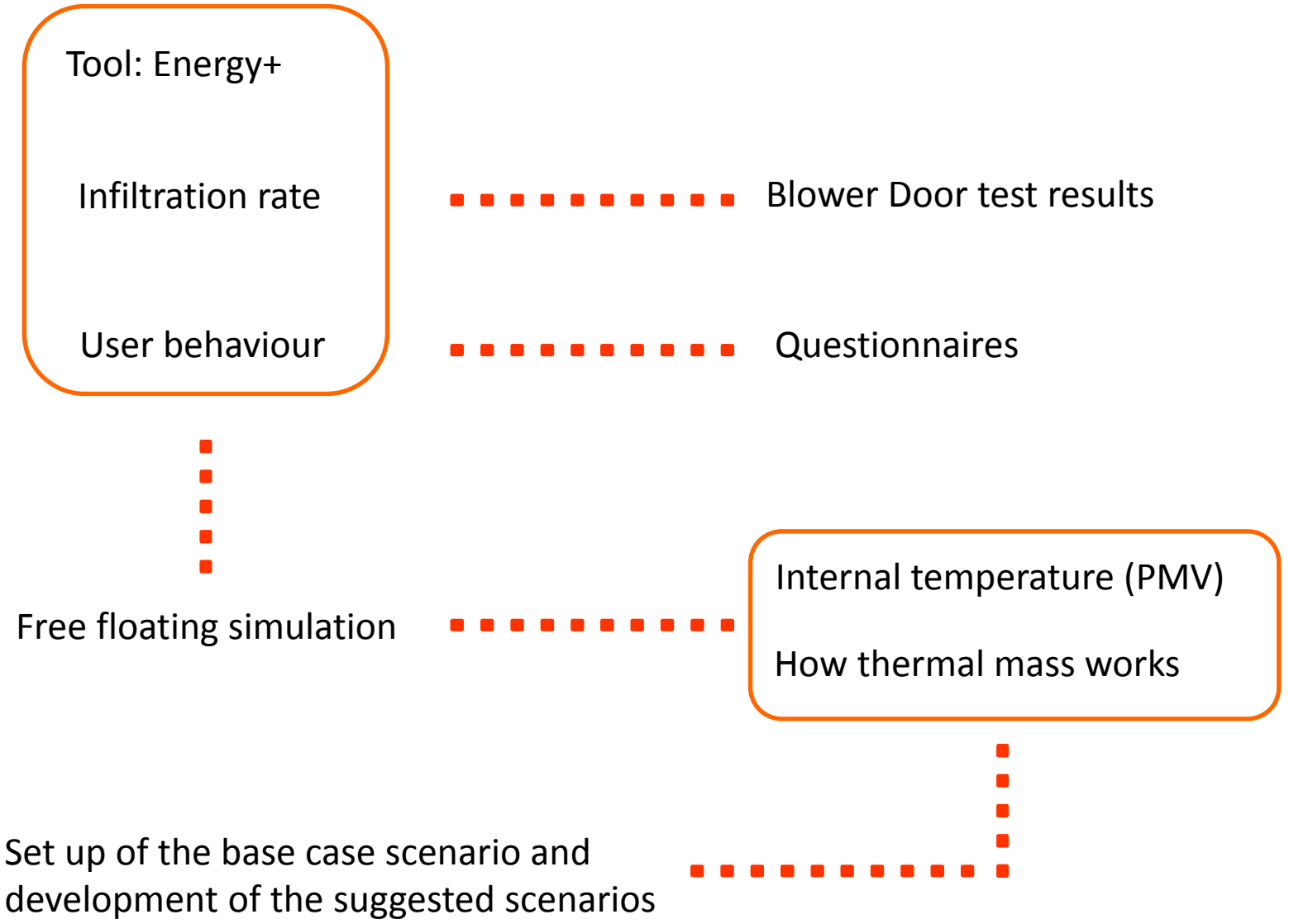
Results

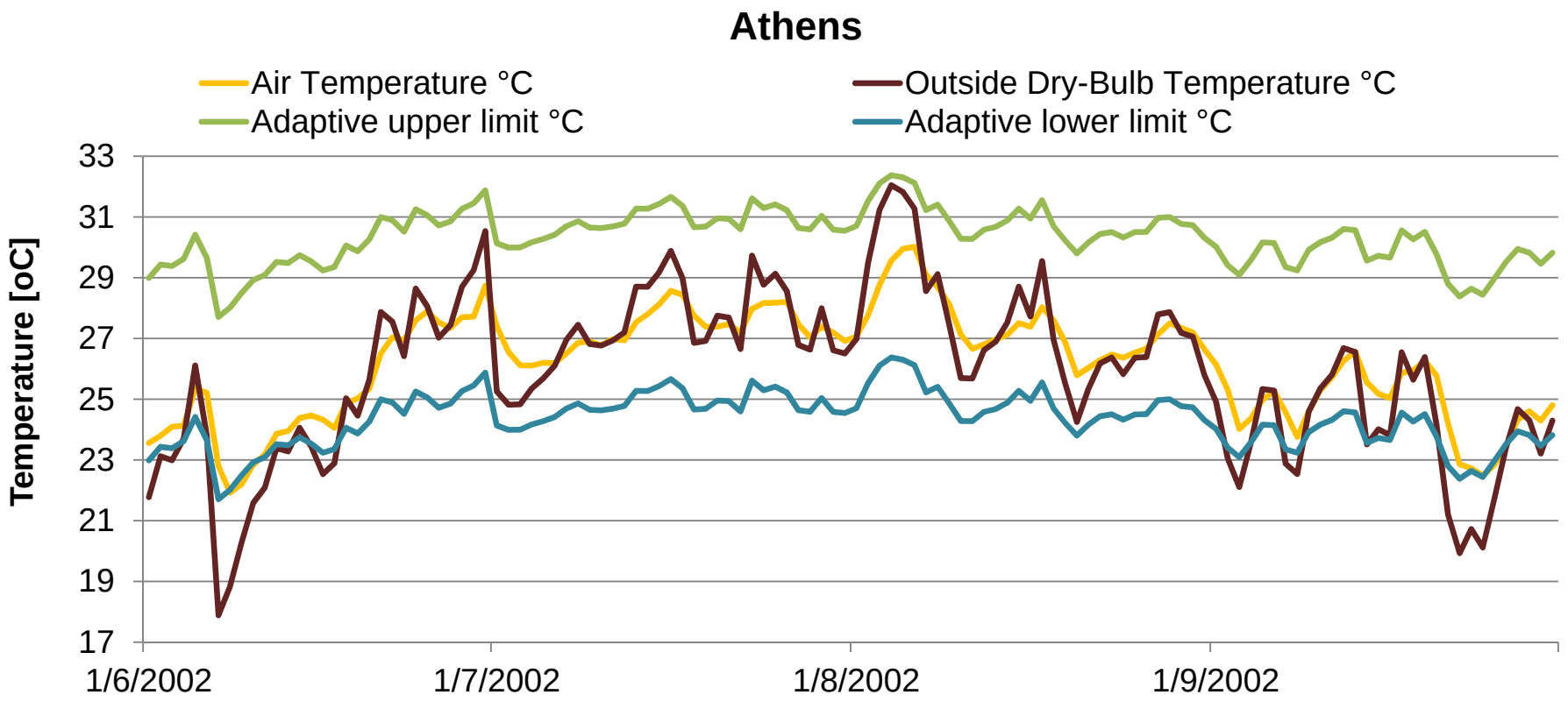
- Suggestions for improvement of construction techniques

Dynamic Thermal Simulation

Mansion House Sarafoglou

Dynamic Thermal Simulation





an **indication** of the temperature range for a building with high thermal mass

Thank you for your attention