Africa-Europe BioClimatic buildings for XXI century

Case studies and thermal comfort assessment

POLITECNICO MILANO
eERG
end-use Efficiency Research Group

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www.abc21.eu

ABC 21 project has received funding from the EU's Horizon 2020 research and innovation programme under Grant Agreement No. 894712.

Process

1. Identification of **Key Performance Indicators** for bioclimatic buildings, used both for assessments based on measured and simulated data

2. Selection of **24 case studies** of European and African bioclimatic buildings

3. Characterization of the **building's performance** through KPIs and identification of **missing data**

4. Definition of a **monitoring plan** in some of the selected buildings and **installation** in the pilot buildings

5. Monitored **data acquisition** and collection of **Post Occupancy Evaluations** in the buildings

6. Analysis of the data

7. Input for technical guidelines

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Overview: Case studies location

ONLINE MAP

PHASE 1 (12)

Europe:3
France 1
Italy 1
Portugal 1

Africa:6
Kenya 1
Morocco 3
Senegal 1
Sudan 1

La Reunion: 3

PHASE 2 (12)

2
Italy 1
Portugal 1

7
Burkina Faso 2
Senegal 4
Uganda 1

3

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Case studies description

There is little record or literature concerning bioclimatic building in warm climate zones. One of the main goals of ABC21 project is to cover this information gap – collecting data about operating buildings that are good examples of sustainable solutions and should be replicated. An analysis of the local climate and a description of the main bioclimatic features is presented for each building:

EUROPE:

- BOTTICELLI PROJECT | ITALY

Housing complex located in Scicily

Click here to download the technical sheet

- CML KINDERGARTEN | PORTUGAL
- IZUBA ENERGIES BUILDING | FRANCE
- NIAMA | LA REUNION
- ENERPOS | LA REUNION
- MOUFIA THEATER | LA REUNION

AFRICA:

- MAISON DES ENERGIES | SENEGAL

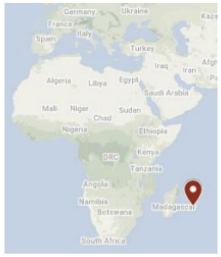
Office and housing complex located in Matam

Click here to download the technical sheet

- UNON OFFICE BUILDING | KENYA
- VILLAS DES CHERCHEURS | MOROCCO
- DAR NASSIM PROJECT | MOROCCO
- DAR AMYS VILLA | MOROCCO
- SALAM CARDIAC SURGERY CENTRE | SUDAN

Download more information on all 12 case studies here

CASE STUDY 05: ENERPOS | LA REUNION



GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	40 avenue de Soweto, Saint-Pierre, La Réunion, France
Latitude; Longitude	-21.34080841368781, 55.491067294562335
Climate zone (Köppen–Geiger classification)	Aw: Equatorial savannah with dry winter

BUILDING INFORMATION [1]	
Building Type	Educational - University
Project Type	New building
Completion Date	2008
Number of buildings	2
Number of storeys	2
Total Floor Area (m²)	739 m²
Thermally conditioned space area (m² area type)	286 m²
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	435 m²
Total cost (€)	2 372 000
Cost /m² (€/m²)	3 209.74
Performance Standards or Certification	PERENE 2004 (Local standard for efficient buildings in La Reunion)
Awards	Winner of the PREBAT ADEME award (local award)

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Thermal Comfort Assessments

Defined as '**that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation'.**

WHAT ?

ENVIRONMENTAL FACTORS

- Air temperature
- Relative humidity
- Mean radiant temperature
- Air velocity

PERSONAL FACTORS

Physiological, psychological, behavioural

- Clothing insulation (clo)
- Metabolic rate (met)
- Adaptation
  Acclimatation
  Acceptability
- Socio-cultural aspects...

HOW ?

Spot measurements or **continuous monitoring**

Observations
Questionnaires surveys

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Thermal Comfort Assessments

MEASUREMENTS

Sensors

- Switchbot sensors (T, RH)
- Hubs (wifi connection, remote access)
- Hot sphere anemometers with dataloggers (Testo)
- Comfort kits (LSI-Lastem)
- Weather station – TAHMO team

3 levels of Monitoring: Basic, Intermediate and Advanced

*Consent form

OCCUPANTS' SURVEYS

	1	2	3	4	5
TYPE OF JUDGEMENT	Perception	Evaluation	Preference	Personal acceptability	Personal tolerance
Subject under judgement	Personal state			Physical ambience	
Wording	"How do you feel (at this precise moment)?"	"Do you find it…..?"	"Please state how you would prefer to be now"	"How do you judge this environment (local climate) on a personal level?"	"Is it…..?"
	7 or 9 degrees	4 or 5 degrees	7 (or 3) degrees	2 category statement form or 4 degrees	5 degrees
e.g., for assessing thermal environments	from COLD (or extremely cold) to HOT (or extremely hot)	from COMFORTABLE to very (or extremely) UN-COMFORTABLE	from (much) COLDER to (much) WARMER	"On a personal level, this environment is for me: Acceptable rather than unacceptable; Unacceptable rather than acceptable" From clearly acceptable to clearly unacceptable	from TOLERABLE to INTOLERABLE

Stress assessment according to EN ISO 10551:2019

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Thermal Comfort Assessments

Trans-African Hydro-Meteorological Observatory (TAHMO) aims to develop a vast network of weather stations across Africa

Station id	Location name	Country
TA00025	Kenya Meteorological Department	Kenya
TA00057	St. Scholastica Catholic School	Kenya
TA00066	Alliance Girls High School	Kenya
TA00182	RCMRD	Kenya
TA00779	CEMASTEA	Kenya
TA00782	Lycee Mermoz	Senegal
TA00784	Nioro	Senegal
TA00785	Mbakadou	Senegal
TA00786	Ourossogui Maison des Yvelines	Senegal

OCCUPANTS' SURVEYS

Africa-Europe Bioclimatic Collaboration 21

Africa-Europe BioClimatic buildings for XXI century

ABC21 - THERMAL COMFORT SURVEY

This survey is done in the framework of the European project titled "ABC 21 – Africa-Europe BioClimatic buildings for XXI century". ABC 21 aims to increase the energy performance, the quality of life and sustainability of West-African buildings through the identification, strengthening and effective deployment of affordable bioclimatic designs and local materials under the challenging African climate and urbanization context.
The person who gave you this questionnaire will measure physical parameters in parallel of this questionnaire, such as the temperature of the air, the relative humidity, the air velocity and the radiant temperature. This questionnaire asks you about your perception, sensation and preference of your thermal environment in your present location and in the present conditions. The survey is voluntary.

The important points are:
1) There are no right or wrong answers
2) We value your opinion
3) If a question doesn't make sense then let us know, but try to answer by choosing the most appropriate response
4) We will not ask you to identify yourself, so your answers are entirely confidential
5) You are entitled to a brief summary of the findings: you can obtain this by contacting us

THIS SURVEY SHOULD TAKE ABOUT 5 MINUTES TO FILL IN.

Thank you in advance for your help !

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Thermal Comfort: Monitoring Levels

3 different **levels** of **monitoring strategies**

Measuring instruments

Level 1: Basic

(T/RH sensors)

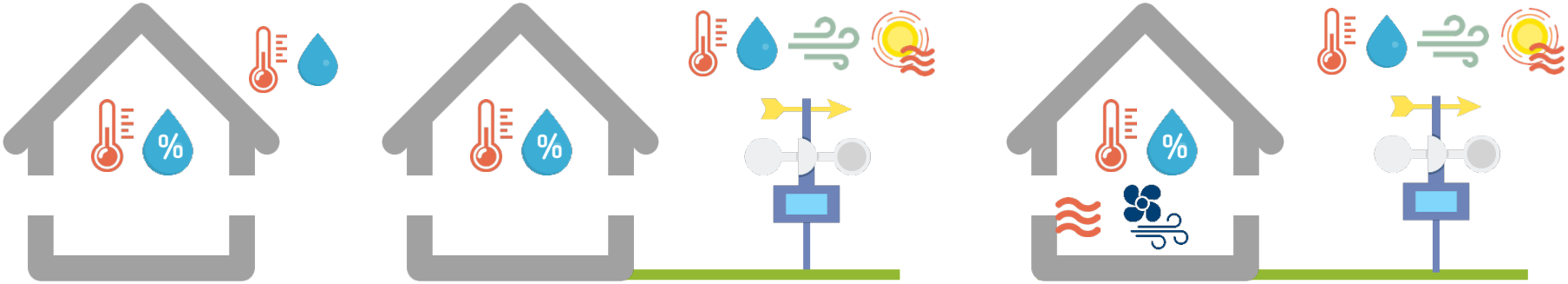
Level 2: Intermediate

(*Level 1* + weather station)

Level 3: Detailed

(*Level 2* + comfort station [Tg, Va])

Measured variables



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Thermal Comfort: Monitoring Levels

3 different **levels** of **monitoring strategies**

Legend

4 **Level 1: Basic** (T/RH sensors)

3 **Level 2: Intermediate** (*Level 1* + weather station)

12 **Level 3: Detailed** (*Level 2* + comfort station [Tg, Va] & POE surveys)

5 **None**

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Case Study 1: Botticelli House, Italy

LOCATION

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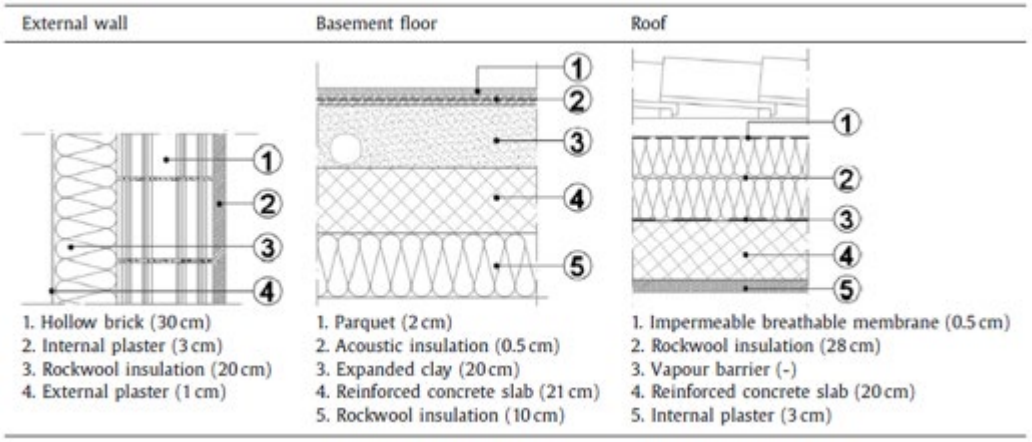
Case Study 1: Botticelli House, Italy

DESCRIPTION OF THE BUILDING

Mascalucia, Sicily
Mediterranean climate
Single family detached house
Construction year 2011
All-electric house
144 m^2 conditioned floor area
Control and monitoring system
Certified Passive House



- 0.13 W/m^2K (U-value ext. walls and roof)
- 0.90-1.10 W/m^2K (U-value windows)
- Solar thermal system
- PV system
- Earth-air heat exchenger
- Natural ventilation
- Air to water heat pump
- Building Automation CS

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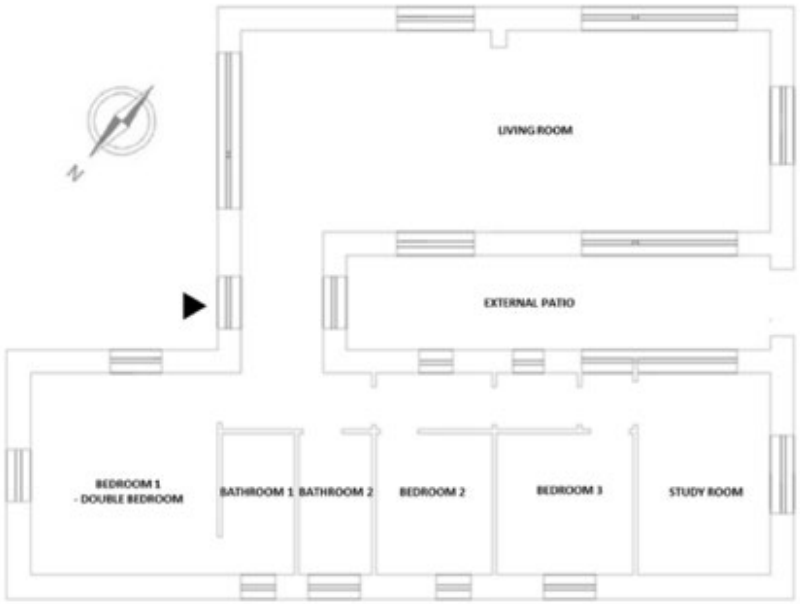
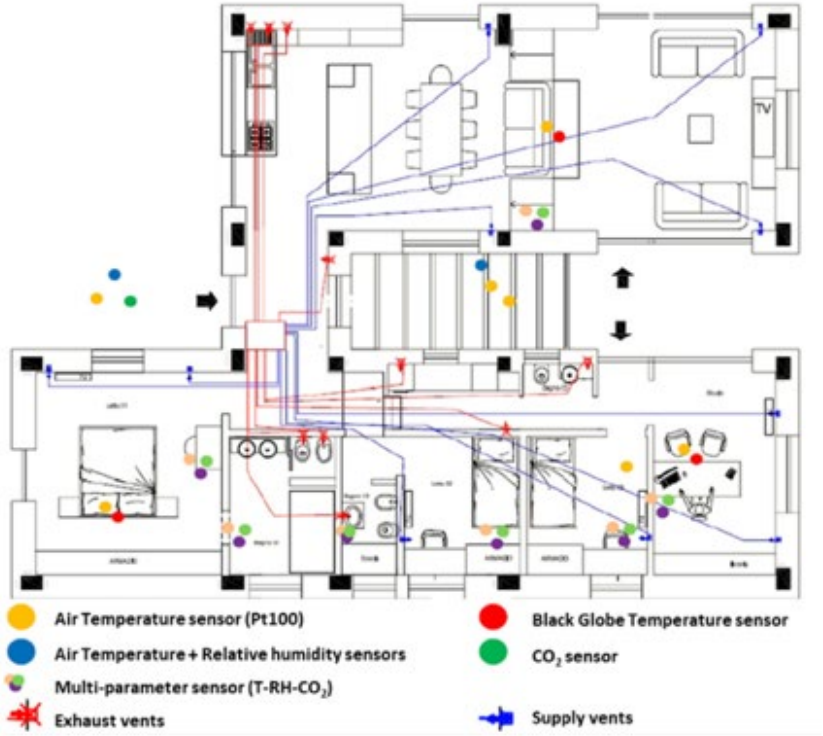
Case Study 1: Botticelli House, Italy

IEQ MONITORING SYSTEM

- Thermal comfort (air temperature, globe-thermometric temperature, RH, air velocity)
- Indoor air quality (CO_2)
- Visual comfort (illuminance)





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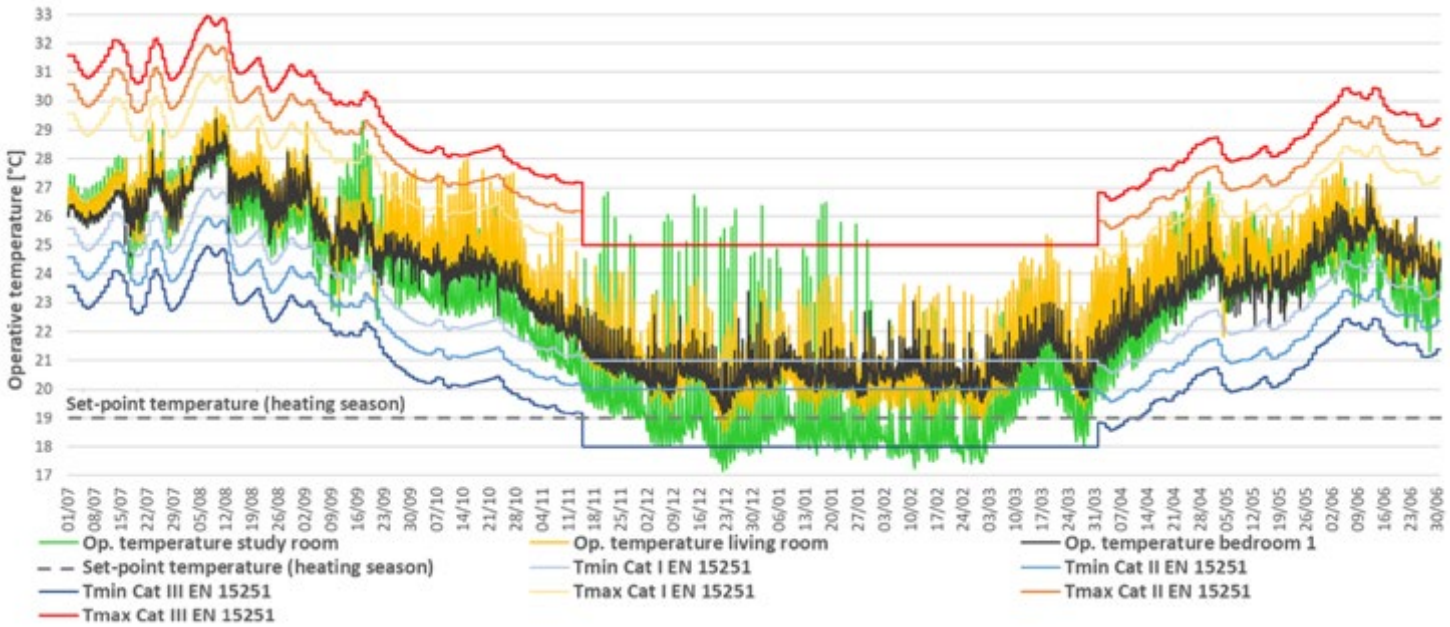
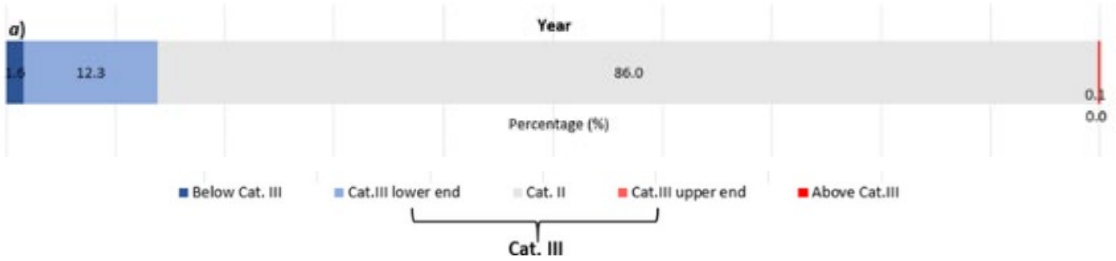
THERMAL COMFORT ANALYSIS





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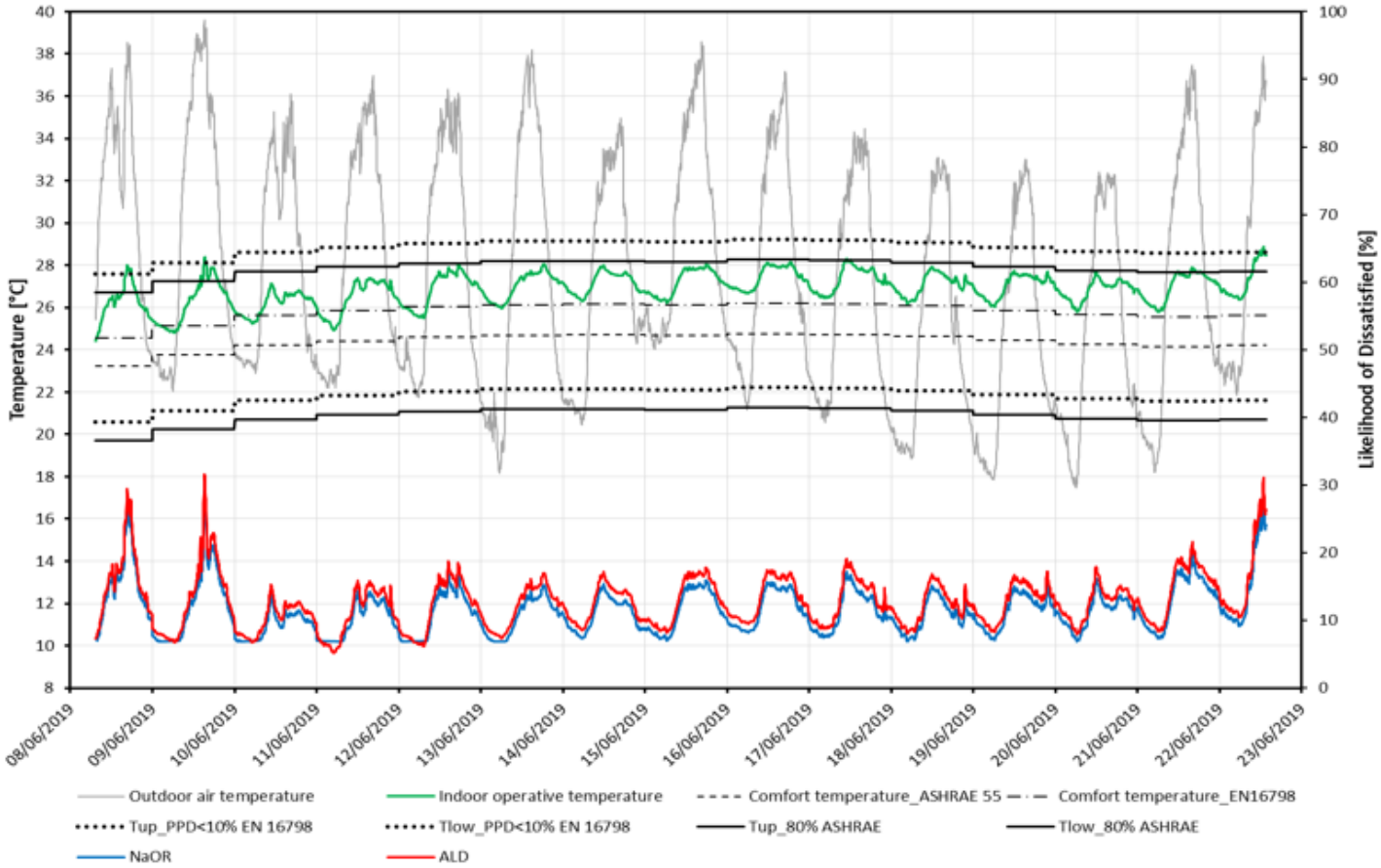

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Carlucci S, **Erba S**, **Pagliano L**, de Dear R. ASHRAE Likelihood of Dissatisfaction: A new right-here and right-now thermal comfort index for assessing the Likelihood of dissatisfaction according to the ASHRAE adaptive comfort model. Energy Build 2021;250:111286. https://doi.org/10.1016/j.enbuild.2021.111286.

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THERMAL COMFORT ANALYSIS

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS	
Thermal comfort indicators	1. Percentage of time outside an operative temperature range (Adaptive, II category EN16798-1, cooling season): **3.9%**
	2. Percentage of time outside an operative temperature range (Fanger, II category EN16798-1, heating season): **23.3%**
	3. Degree-hours (Adaptive, II category EN16798-1, cooling season): **108**
	4. Degree-hours (Fanger, II category EN16798-1, heating season): **303**
	5. Percentage of time inside the Givoni comfort zone of 1m/s: Whole year: **88%** (Figure 15) Cooling season: **96%**
	6. Percentage of time inside the Givoni comfort zone of 0m/s: Whole year: **44%** (Figure 15) Cooling season: **41%**
	7. Number of hours within a certain temperature range (Figure 13):

Heating season (15th-11 to 31th-03)		
Range	N° of Hours	frequency
T≤19	26	0.8%
19≤T<24	3201	98%
T≥24	38	1.2%

Cooling season (1st-04 to 14th-11)		
Range	N° of Hours	Frequency
T≤20	0	0%
20≤T<26	3526	64%
T≥26	1969	36%

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Reference

Task 3.1 - Review and choice of performance indicators for energy, demand flexibility and comfort

- Report on indicators of overall building energy performance
- Report on comfort indicators and scenarios

Task 3.4 – Case studies of European and African Bioclimatic buildings

- https://www.abc21.eu/case-studies-2/
- Report on 12 Case Studies of European and African Bioclimatic Buildings
- Report on additional 12 Case Studies of European and African Bioclimatic Buildings (D3.9) – under publication

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Thank You!
Q & A

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