IEA EBC Annex 80 - Resilient Cooling

Webinar 4

Case Studies and Policy Recommendations

20/09/2022

IEA EBC Annex 80 - Resilient Cooling

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Federal Ministry
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Climate Action, Environment, Energy, Mobility, Innovation and Technology

20/09/2022

IEA EBC Annex 80

EBC Energy in Buildings and Communities Programme

Series of webinars in cooperation with AIVC & venticool

1. Indicators to assess resilience of cooling in buildings [May 10, 15:00-16:15 CEST]
2. Future weather data and heatwaves [May 31, 16:00-17:15 CEST]
3. Examples of resilient cooling solutions [September 13, 15:00-16:15 CEST]
4. **Case studies and policy recommendations [September 20, 16:00-17:15 CEST]**

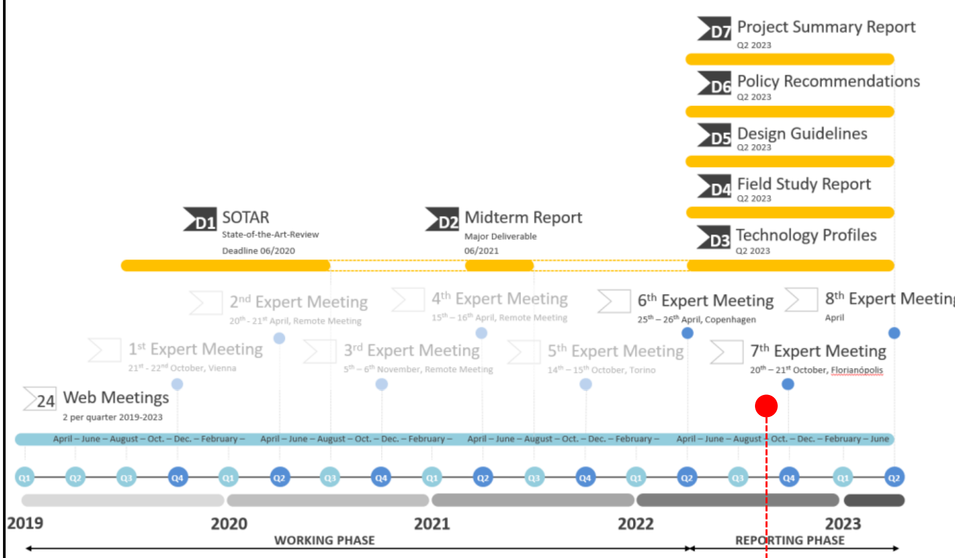
https://annex80.iea-ebc.org/

AIVC venticool the platform for resilient ventilative cooling INIVE

Today's Programme

16:00	**Introduction to Annex 80, AIVC & venticool** Peter Holzer, Operating Agent EBC Annex 80, Institute of Building Research & Innovation, AT
16:05	**Key Findings from Annex 80 Policy Actions** Ronnen Levinson, LBNL, US
16:20	**Overview of Annex 80 Field Studies** Dahai Qi, Université de Sherbrooke, CA Gerhard Hofer, e7 energy innovation, AT
16:30	**Natural Ventilation in Two Indian Case Studies** Pierre Jaboyedoff, Effin'Art, CH
16:45	**Summer comfort in Belgian dwellings without active cooling: a case study** Margot De Pauw, Thomas More, BE
17:00	Questions and answers
17:15	End of the webinar

EBC Annex 80 Roadmap



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Annex 80 Objectives

"Support a transition to an environment
*where **affordable low energy** and **low carbon** cooling systems*
are the mainstream and preferred solutions
for cooling and overheating issues in buildings."

A Assess benefits, potentials and performance indicators.
Provide guidance on design, performance calculation and system integration.

B Research towards implementation of emerging technologies.
Extend boundaries of existing solutions.

C Evaluate the real performance of resilient cooling solutions.

D Develop recommendations for policy actions.

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Annex Subtasks

The Annex is structured in four subtasks:

A Fundamentals

B Solutions

C Field Studies

D Policy Actions

Annex 80 Deliverables

D1	State-of-the-Art-Report	▪ Research community and associates ▪ Real Estate developers ▪ Urban planning experts ▪ Policy makers	OA, STA, STB, STC, STD
D2	Midterm Report	▪ Research community and associates ▪ IEA and EBC Programme	OA, STA, STB, STC, STD
D3	**Technology Profiles**	▪ Building component developers and manufacturers ▪ Architects and design agencies ▪ Engineering offices and consultants	STB
D4	**Field Studies**	▪ Building component developers and manufacturers ▪ Architects and design agencies ▪ Engineering offices and consultants ▪ Real Estate developers	STC
D5	**Design and Operation Guidelines**	▪ Architects and design agencies ▪ Engineering offices and consultants ▪ Real Estate developers	STA, STB, STC
D6	**Recommendations for policy actions, legislation and standards**	▪ Policy makers ▪ Legal interest groups ▪ Experts involved in building energy performance standards and regulation	STD
D7	**Project Summary Report**	▪ Research community and associates ▪ IEA and EBC Programme ▪ Real Estate developers ▪ Policy makers	OA, STA, STB, STC, STD

Annex 80 Publications

1. "**Developing an understanding of resilient cooling**: a socio-technical approach City and Environment Interactions" (Wendy Miller et al; published in Elsevier City and Environment 2021) https://doi.org/10.1016/j.cacint.2021.100065
2. "**Resilient cooling of buildings to protect against heat waves and power outages**: key concepts and definition" (Shady Attia et al; published in Energy and Buildings 2021) https://doi.org/10.1016/j.enbuild.2021.110869
3. "**Resilient cooling strategies - a critical review and qualitative assessment**" (Chen Zhang et al; published in Energy and Buildings 2021) https://doi.org/10.1016/j.enbuild.2021.111312
4. Report of Thermal Conditions Task Group "**Framework to evaluate the resilience of different cooling technologies**" (Shady Attia et al; published) http://dx.doi.org/10.13140/RG.2.2.33998.59208

Key Findings from Annex 80 Policy Actions

Ronnen Levinson (RMLevinson@LBL.gov)

Lawrence Berkeley National Laboratory
Berkeley, CA, USA

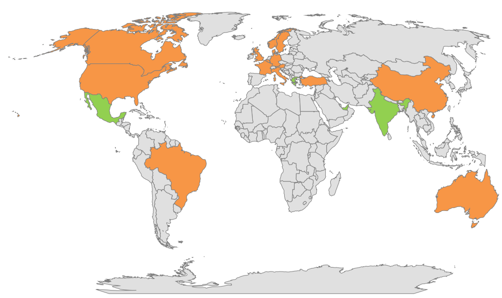
On behalf of the Annex 80 Subtask D working group

venticool webinar: Case studies and policy recommendations
September 20, 2022

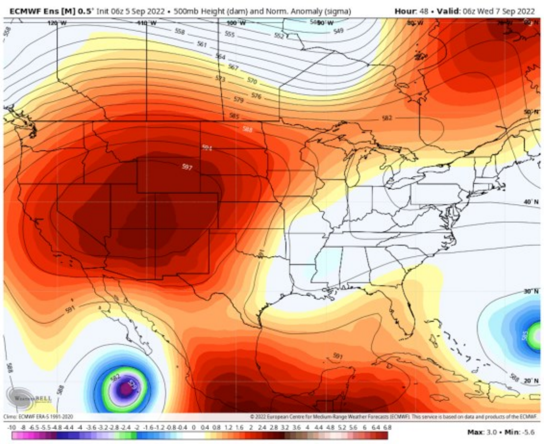
IEA Annex 80: Resilient Cooling of Buildings is a 20-nation project advancing **passive and low-energy, low-carbon cooling strategies**

Annex 80's main objective is to support a rapid transition to an environment where resilient low energy and low carbon cooling systems are the mainstream and preferred solutions for cooling and overheating issues in buildings.

iea EBC Energy in Building and Communities Programme



Annex 80 Subtask D ("Policy Actions") promotes cooling policies that **boost resilience to heat waves and power outages**



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Our approach is to **collect, review, and compare existing policies**, then **prepare recommendations**

November 2020 – April 2021
Policy collection

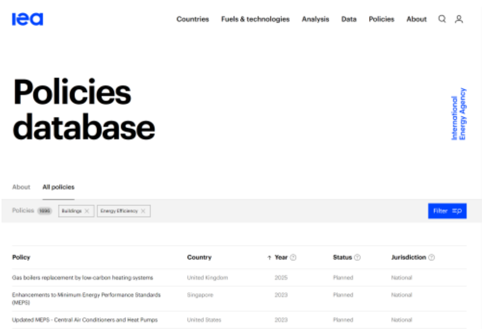
May 2021 - April 22
Policy review & comparison

May 2022 – August 2022
Recommendations

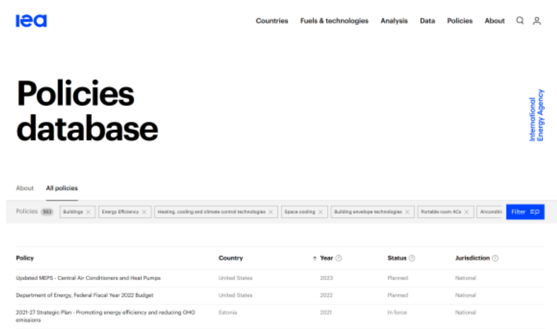
September 2022 – June 2023
Write-up

4

There are **too many building energy efficiency policies** around the globe for our team to assess all of them

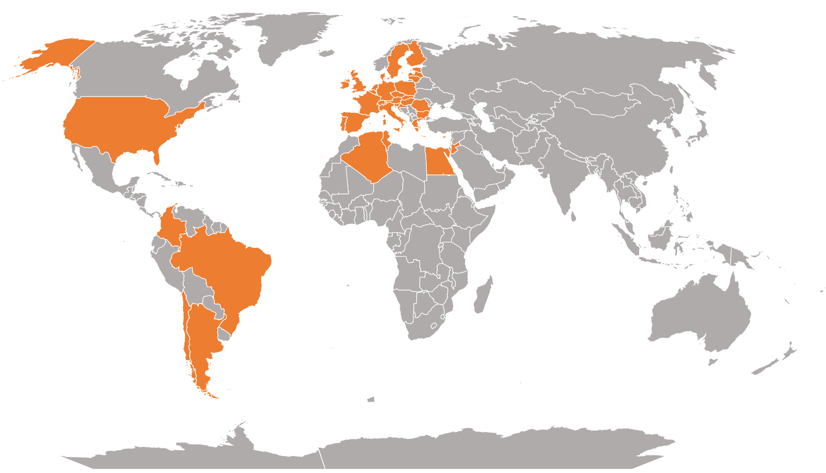


buildings AND energy efficiency
→ 1,696 policies



buildings AND energy efficiency AND (heating, cooling and climate control technologies OR space cooling OR building envelope technologies OR room portable ACs OR air conditioners) → 563 policies

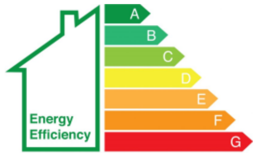
24 Annex researchers from 12 institutions **examined policies from 19 regions** to **find opportunities**, rather than review all policies worldwide

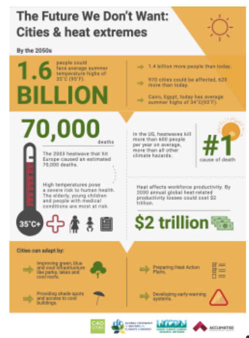


Regions
Algeria
Argentina
Austria
Belgium
Brazil
Chile
Colombia
Egypt
European Union
France
Germany
Italy
Jordan
Lebanon
Singapore
Switzerland
Tunisia
United Kingdom
United States

We considered **eight types of policies** relevant to resilient cooling

- Building energy efficiency standard
- Green building standard
- Model code (building energy efficiency or green building)
- Green building certification program
- Financial incentive program
- Law, statute, or regulation
- Extreme-heat plan
- Disclosure (label, certificate)





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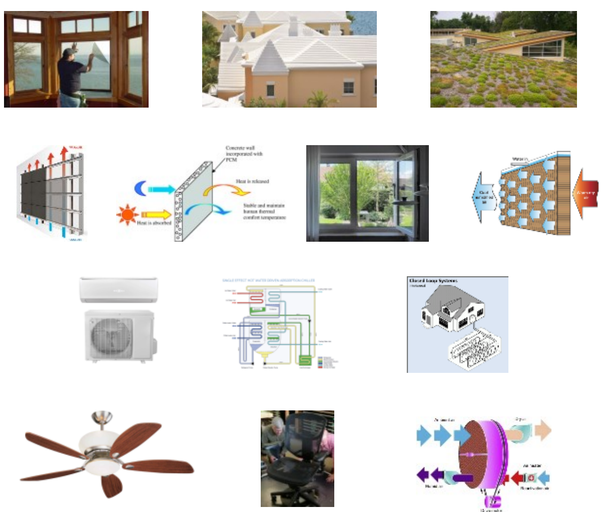
We **collected policies for cooling strategies** that (A) reduce heat gain, (B) remove sensible heat, (C) enhance personal comfort, or (D) remove latent heat; **we also reviewed whole-building performance policies**



A1: Advanced solar shading/advanced glazing
A2: Cool envelope materials
A3a: Evaporative envelope surfaces
A3b: Ventilated envelope surfaces
A4: Heat storage and release

B1: Ventilative cooling
B2: Adiabatic/evaporative cooling
B3: Compression refrigeration
~~B4: Absorption refrigeration~~
B5: Natural heat sinks
B6: Higher-temperature cooling systems

C1: Comfort ventilation
C2: Micro-cooling and personal comfort control

~~D1: High-performance dehumidification~~

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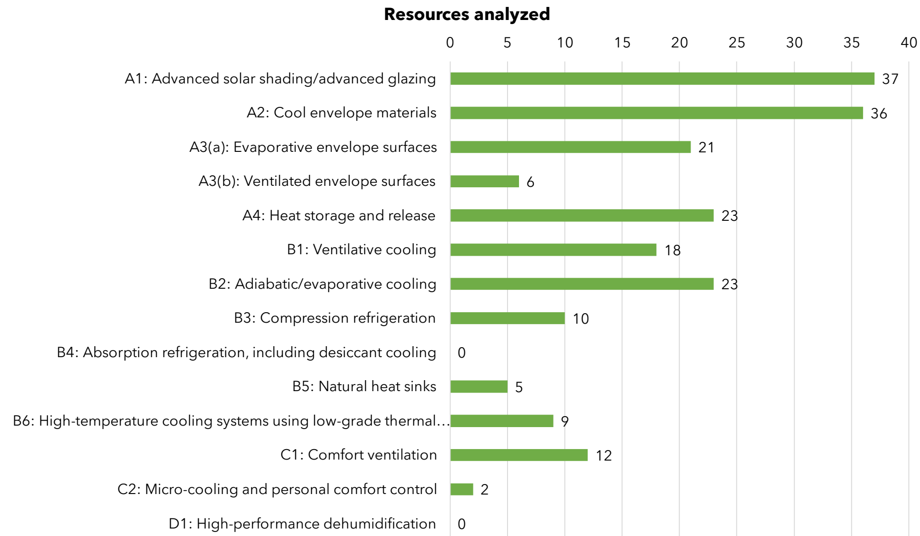
We reviewed 202 policy resources across 12 resilient cooling technologies to **find strengths, weaknesses, and opportunities**



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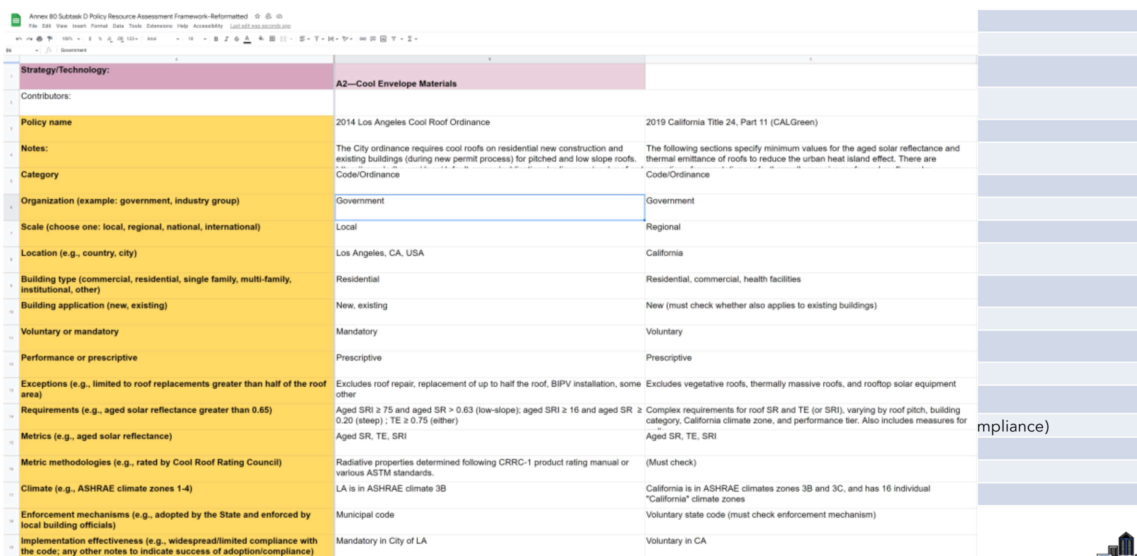
We populated a **database** detailing each policy to facilitate comparison and analysis



Strategy/Technology:	A2—Cool Envelope Materials	
Contributors:		
Policy name	2014 Los Angeles Cool Roof Ordinance	2019 California Title 24, Part 11 (CALGreen)
Notes:	The City ordinance requires cool roofs on residential new construction and existing buildings (during new permit process) for pitched and low slope roofs.	The following sections specify minimum values for the aged solar reflectance and thermal emittance of roofs to reduce the urban heat island effect. There are
Category	Code/Ordinance	Code/Ordinance
Organization (example: government, industry group)	Government	Government
Scale (choose one: local, regional, national, international)	Local	Regional
Location (e.g., country, city)	Los Angeles, CA, USA	California
Building type (commercial, residential, single family, multi-family, institutional, other)	Residential	Residential, commercial, health facilities
Building application (new, existing)	New, existing	New (must check whether also applies to existing buildings)
Voluntary or mandatory	Mandatory	Voluntary
Performance or prescriptive	Prescriptive	Prescriptive
Exceptions (e.g., limited to roof replacements greater than half of the roof area)	Excludes roof repair, replacement of up to half the roof, BIPV installation, some other	Excludes vegetative roofs, thermally massive roofs, and rooftop solar equipment
Requirements (e.g., aged solar reflectance greater than 0.65)	Aged SRI ≥ 75 and aged SR > 0.63 (low-slope); aged SRI ≥ 16 and aged SR ≥ 0.20 (steep) ; TE ≥ 0.75 (either)	Complex requirements for roof SR and TE (or SRI), varying by roof pitch, building category, California climate zone, and performance tier. Also includes measures for
Metrics (e.g., aged solar reflectance)	Aged SR, TE, SRI	Aged SR, TE, SRI
Metric methodologies (e.g., rated by Cool Roof Rating Council)	Radiative properties determined following CRRC-1 product rating manual or various ASTM standards.	(Must check)
Climate (e.g., ASHRAE climate zones 1-4)	LA is in ASHRAE climate 3B	California is in ASHRAE climates zones 3B and 3C, and has 16 individual "California" climate zones
Enforcement mechanisms (e.g., adopted by the State and enforced by local building officials)	Municipal code	Voluntary state code (must check enforcement mechanism)
Implementation effectiveness (e.g., widespread/limited compliance with the code; any other notes to indicate success of adoption/compliance)	Mandatory in City of LA	Voluntary in CA

mpliance)

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We prepared a **policy analysis report** that summarizes existing policies and policy opportunities

TYPES OF POLICIES RELEVANT TO RESILIENT COOLING

METHODS

REVIEW OF POLICIES RELEVANT TO EACH RESILIENT COOLING STRATEGY

REVIEW OF WHOLE-BUILDING POLICIES

We have generated **70+ ideas** for potential policy recommendations

Provide in-depth guidance to support the uptake of shading technologies, highlighting good practices that were found to provide effective management of solar loads.

Raise the extreme-climate adaptability of ventilated envelopes in the existing building standards, either by granting a bonus for every new technique adapted to the local climate, or by developing more general calculation procedures for building envelope that account for double-skin envelopes.

Expand cool-roof policies and programs to include cool walls, accounting for roof-wall differences in materials and physics.

Expand whole-building performance analysis beyond average mild conditions (e.g., typical meteorological years) and also account for extreme events, such as heat waves, power outages, and future climates.

Establish national standards specific for evaporative cooling (EC), with different standards for different types of EC. Only four countries in the world have done so.

Credit indoor air movement in building energy standards. ASHRAE Standard 90.1 should include content about ceiling fans use in buildings.

Each idea is tagged with its **implementation mechanism(s)**

Regulations
Building codes

Information
Training programs
Awareness campaigns
Labeling programs

R&D
Emerging technology
Demonstrations

Standards
KPIs
Extreme heat weather files

Incentives
Competitions
Rebates
Tax credits

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We also note **other characteristics**, such as where it could be applied and how long it would take to implement

Technology Type		Building Application			Implementation timeline	Geography	Cost to implement policy	Promotes resilience to disruption (heat wave/power outage)
Technology specific	Technology agnostic	New buildings (design & construction)	Existing buildings (retrofit/ renovation)	Building Operations	Short (months), Medium (1-5 years), Long (greater than 5 years)	Notes on any geographic limitations	Low, Medium, High	Yes, No

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This fall we will generate a **1-page summary** of each policy recommendation that we wish to pursue

Policy Recommendation: [list the technology/strategy; column A]

Summary: [One sentence description; similar to column D]

Policy mechanism

Regulation	Information	Incentives	R&D	Standards

Technology type

Specific	Agnostic

Promotes resilience to disruption (heat wave/power outage)

Yes	No

What: [One paragraph description of the recommendation, including notes on building application]

Motivation: [What is the motivation for the recommendation, (e.g., gap in current policies)]

How: [Describe the policy mechanisms, methods, implementation notes; include any limitations]

Who:

Implementers: [Describe who will implement]
Target audience: [Describe who is the target audience]

Where: [Notes on geography, climates, scale of recommendation; note any limitations; similar to column Q]

Implementation timeline: [Qualitative description on implementation timeline following: short (months), medium (1-5 years), long (greater than 5 years)]

Cost: [Qualitative description of cost to implement the recommendation; similar to column R]

Policy model to follow: [Optional; list any relevant model policies to follow]

The Annex will **share its technology assessments and policy recommendations** with interested organizations

Annex 80 products to support resilient cooling campaigns and policy efforts include

- Technology profiles
- Case studies
- Policy recommendations

Cool Coalition

SUSTAINABLE ENERGY FOR ALL

KIGALI COOLING EFFICIENCY PROGRAM

Thank you!

EBC
Energy in Buildings and Communities Programme

IEA EBC Annex 80
Resilient Cooling for Buildings

Case studies and policy recommendations

20 September 2022

Overview of Annex 80 Field Studies

Dahai Qi, Université de Sherbrooke, Canada
Gerhard Hofer, e7 energy innovation & engineering

Université de Sherbrooke

Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Agenda

- **Overview of planned case study projects**
- **Survey form on thermal comfort and building management**
- **Mock up for presentation of Case Study examples**
- **Structure of STC report**

Case Study examples

- **Why?**
  - Present good practise examples for resilient cooling
  - Present design and simulation results
  - Evaluation of realised buildings in operation phase
    - Energy use
    - Comfort parameter
  - Evaluation of resilient cooling parameters
    - Key performance indicator (KPI) for resilient cooling

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Overview of Case Study projects

Countries with Case Study examples:
Austria | Belgium | Canada | China | England | Italy | Sweden | Turkey

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Overview of applied technologies

1. Reduce external heat gain	**Advanced solar shading**
	Cool materials
	Advanced glazing technologies
	Double skin Facades / Ventilated facades
2. Removing heat from indoor environments	Ventilative cooling as regards night flush ventilation
	Thermal mass utilization, including PCM and off-peak ice storages
	Adiabatic cooling
	High performance compression chillers, including split and multiple split and VRV units
	High performance absorption chillers, including desiccant cooling
	Natural heat sinks, such as ground water and soil, borehole heat exchangers and others
3. Removing humidity from indoor environments	Desiccant dehumidification
4. Increasing personal comfort apart from space cooling	Ventilative cooling as regards comfort ventilation
	Micro-cooling / Personal comfort control
Other (________)	

Survey form for thermal comfort and building management

– **Questionnaire for building manager**

Operation of cooling technologies (control method, sensors for control, cooling period, operation time, indoor temperature/humidity can be controlled, etc)

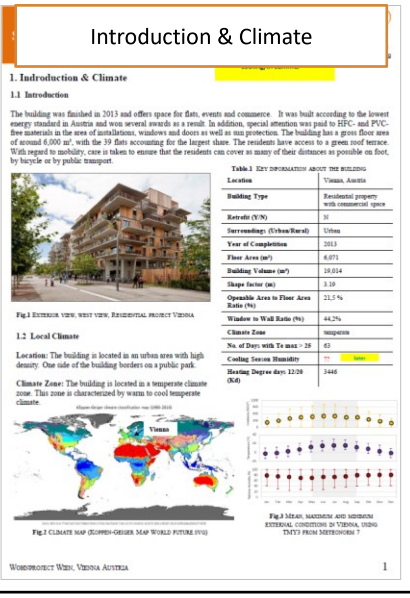
– **Questionnaire for building thermal comfort**

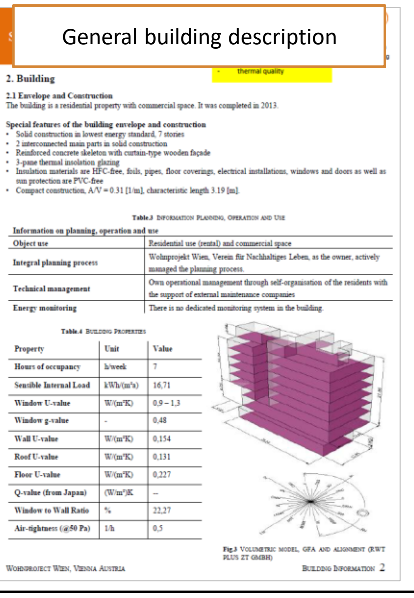
Location, orientation, windows, cloth wear, activity levels, thermal comfort survey (-3 ~3), control, etc.

Case Study description - Structure

– **Structure**
  – **1. Introduction, Climate:** general description, location, climate
  – **2. Building:** envelope and construction, energy system
  – **3. Resilient cooling:** Principles, structure, design simulation
  – **4. KPI evalution:** comfort, energy, others, overall
  – **5. Performance Evaluation:** energy, comfort, operation
  – **6. Discussion/Lessons learned:** summary, optimization potential
  – **7. References/Contact Person**

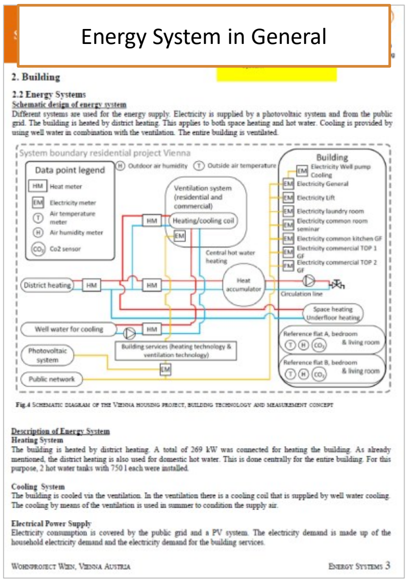
Mock Up – Example (1)





Mock Up – Example (2)

Energy System in General



2. Building

2.2 Energy Systems

Schematic design of energy system

Different systems are used for the energy supply. Electricity is supplied by a photovoltaic system and from the public grid. The building is heated by district heating. This applies to both space heating and hot water. Cooling is provided by using well water in combination with the ventilation. The entire building is ventilated.

Fig.4 Schematic diagram of the Vienna housing project, building technology and measurement concept

Description of Energy System

Heating System

The building is heated by district heating. A total of 269 kW was connected for heating the building. As already mentioned, the district heating is also used for domestic hot water. This is done centrally for the entire building. For this purpose, 2 hot water tanks with 750 l each were installed.

Cooling System

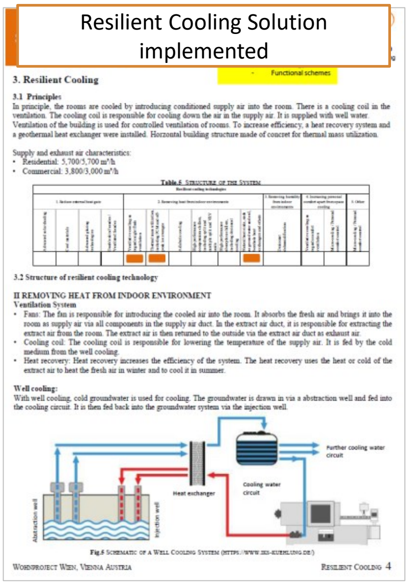
The building is cooled via the ventilation. In the ventilation there is a cooling coil that is supplied by well water cooling. The cooling by means of the ventilation is used in summer to condition the supply air.

Electrical Power Supply

Electricity consumption is covered by the public grid and a PV system. The electricity demand is made up of the household electricity demand and the electricity demand for the building services.

Wohnprojekt Wien, Vienna Austria — Energy Systems 3

Resilient Cooling Solution implemented



- Functional schemes

3. Resilient Cooling

3.1 Principles

In principle, the rooms are cooled by introducing conditioned supply air into the room. There is a cooling coil in the ventilation. The cooling coil is responsible for cooling down the air in the supply air. It is supplied with well water. Ventilation of the building is used for controlled ventilation of rooms. To increase efficiency, a heat recovery system and a geothermal heat exchanger were installed. Horzontal building structure made of concret for thermal mass utilization.

Supply and exhaust air characteristics:
- Residential: 5,700/5,700 m³/h
- Commercial: 3,800/3,000 m³/h

Table.5 Structure of the System

3.2 Structure of resilient cooling technology

II REMOVING HEAT FROM INDOOR ENVIRONMENT

Ventilation System
- Fans: The fan is responsible for introducing the cooled air into the room. It absorbs the fresh air and brings it into the room as supply air via all components in the supply air duct. In the extract air duct, it is responsible for extracting the extract air from the room. The extract air is then returned to the outside via the extract air duct as exhaust air.
- Cooling coil: The cooling coil is responsible for lowering the temperature of the supply air. It is fed by the cold medium from the well cooling.
- Heat recovery: Heat recovery increases the efficiency of the system. The heat recovery uses the heat or cold of the extract air to heat the fresh air in winter and to cool it in summer.

Well cooling:

With well cooling, cold groundwater is used for cooling. The groundwater is drawn in via a abstraction well and fed into the cooling circuit. It is then fed back into the groundwater system via the injection well.

Fig.5 Schematic of a Well Cooling System (https://www.iks-kuehlung.de/)

Wohnprojekt Wien, Vienna Austria — Resilient Cooling 4

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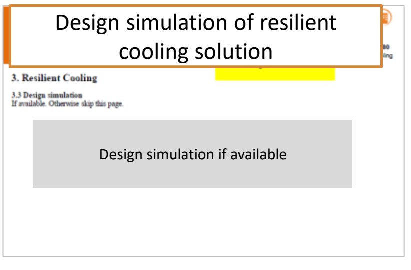
Mock Up – Example (3)

Design simulation of resilient cooling solution



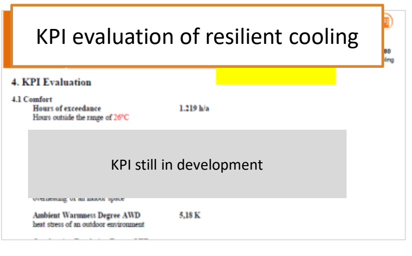
3. Resilient Cooling

3.3 Design simulation

If available. Otherwise skip this page.

Design simulation if available

KPI evaluation of resilient cooling



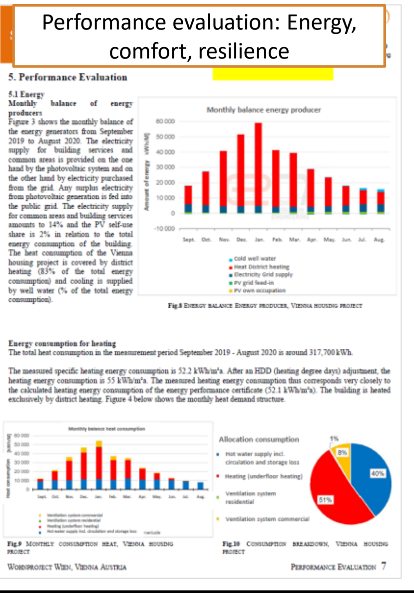
4. KPI Evaluation

4.1 Comfort

Hours of exceedance Hours outside the range of 26°C	1.219 h/a
Ambient Warmness Degree AWD heat stress of an outdoor environment	5,18 K

KPI still in development

Performance evaluation: Energy, comfort, resilience



5. Performance Evaluation

5.1 Energy

Monthly balance of energy producers

Figure 3 shows the monthly balance of the energy generators from September 2019 to August 2020. The electricity supply for building services and common areas is provided on the one hand by the photovoltaic system and on the other hand by electricity purchased from the grid. Any surplus electricity from photovoltaic generation is fed into the public grid. The electricity supply for common areas and building services amounts to 14% and the PV self-use share is 2% in relation to the total energy consumption of the building. The heat consumption of the Vienna housing project is covered by district heating (83% of the total energy consumption) and cooling is supplied by well water (% of the total energy consumption).

Fig.8 Energy balance Energy producer, Vienna housing project

Energy consumption for heating

The total heat consumption in the measurement period September 2019 - August 2020 is around 317,700 kWh.

The measured specific heating energy consumption is 52.2 kWh/m²a. After an HDD (heating degree days) adjustment, the heating energy consumption is 55 kWh/m²a. The measured heating energy consumption thus corresponds very closely to the calculated heating energy consumption of the energy performance certificate (52.1 kWh/m²a). The building is heated exclusively by district heating. Figure 4 below shows the monthly heat demand structure.

Fig.9 Monthly consumption heat, Vienna housing project

Fig.10 Consumption breakdown, Vienna housing project

Wohnprojekt Wien, Vienna Austria — Performance Evaluation 7

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Mock Up – Example (4)

Performance evaluation: Energy, comfort, resilience

5. Performance Evaluation

5.1 Energy

Energy consumption for cooling

The total cooling consumption in the measurement period September 2019 - August 2020 is around 3,800 kWh. 64% of this is attributable to the residential ventilation system and 36% to the commercial ventilation system. As expected, higher specific cooling quantities are demanded in the commercial sector than in the residential sector. This can be explained by the fact that a lower target supply air temperature of 22.2°C is set in the commercial area than in the residential area (24°C).

Figure 11 shows the monthly cooling demand structure. It becomes clear that the demand for cooling for supply air conditioning occurs predominantly in the period from June to August.

The monitoring data also show that the cooling capacities demanded for both ventilation systems amount to a maximum of 50% of the design capacity of the cooling coils. This suggests that there is still potential for more intensive supply air conditioning during hot spells.

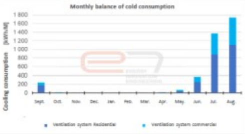


Fig.11 Monthly consumption cold, Vienna housing project

Power consumption and benchmarks

All electricity consumption for common areas and building services were recorded for the Vienna residential project. The household electricity consumption was not determined. The total electricity consumption of the common areas and building services in the measurement period is around 59,650 kWh, or 9.8 kWh/m²BGFa. The maximum reference power of the 15-minute values is approximately 19.6 kW, or 3.2 W/m²BGF. The electricity base load for common areas and building services is approx. 4.8 kW and causes an annual base load consumption of around 41,900 kWh (70% of the total electricity consumption). A significant portion of the base load is caused by the ventilation systems, which have constant electricity consumption throughout the year.

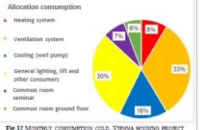


Fig.12 Monthly consumption cold, Vienna housing project

A photovoltaic system with a nominal output of 9.9 kWp is located on the flat roof of the building. The system generated a specific annual yield of 1,044 kWh/kWp during the measurement period (Sept. 2019 to Aug. 2020). For the present module inclination of 15°, the yield can be rated as very good.

The PV yields are used to supply the building services (65% of the PV yield), the electricity surplus (35%) was fed into the public grid.

Wohnproject Wien, Vienna Austria Performance Evaluation 8

Performance evaluation: Energy, comfort, resilience

5. Performance Evaluation

5.2 Comfort

The bedrooms and living rooms of 2 flats were used as reference rooms for the comfort and CO2 monitoring:

- No. 1 living room and No. 2 bedroom: 1st floor flat A, north/west orientation, useful living area approx. 100 m².
- No. 3 living room and No. 4 bedroom: 1st floor flat B, south orientation, useful living area approx. 50 m².

In general, it can be stated for all reference rooms that the comfort parameters during the heating period are largely in the comfortable range. However, the indoor air humidity is often below the optimal range for living rooms and bedrooms (40-60%).

Table.6 CO2-Conzentration

Measurement period: 01 September 2019 - 31 August 2020					
Reference room	No. 1	No. 2	No. 3	No. 4	
Average room temperature in the heating period (temperature outside<12°C)	23,1	22,5	23,8	22,4	°C
Average room temperature in the summer months (temperature outside>12°C)	24,4	25,3	25,5	25,2	°C
Average indoor air humidity in the heating period (temperature outside<12°C)	28,1	28,2	31,7	33,1	%
Share of overheating hours (T > 26°C) in the total number of annual hours	7%	18%	16%	15%	%
Share of CO2 concentration (CO2 >1000ppm) in the total number of annual hours	4%	26%	1%	1%	%

CO2 monitoring

Figure 7 shows the CO2 concentration of the reference areas as a box plot. The green field delimits the range between the first and third quartile, the lines show the range between the minimum and maximum value.

The CO2 monitoring shows that the living rooms have good indoor air quality all year round. When comparing the bedrooms, it is noticeable that in bedroom A (reference room no. 2) there is regularly an increased CO2 concentration (800 to max. 1,600 ppm) during the night hours. The indoor air quality is thus to be rated as moderate during the night hours

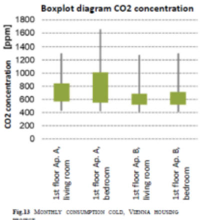


Fig.13 Monthly consumption cold, Vienna housing project

Wohnproject Wien, Vienna Austria Performance Evaluation 8

Mock Up – Example (5)

Discussion, lessons learned

6. Discussion, Lessons Learned

6.1 Summary

Easy and effective cooling method

When a ventilation system is in place in the building, it is easy and very cost efficient to expand the ventilation with a free cooling unit based on a water well.

6.2 Optimisation potential

Reduction of heating energy demand

- By lowering the heating limit temperature in the room heating control, it is possible to save heating energy in the transitional periods of spring and autumn. It is recommended to check the current setting and to make adjustments in the course of a test phase. Furthermore, it is recommended to lower the supply air temperature of both ventilation systems for commercial and residential buildings by 1 to 2 K during the heating period.

Operating time ventilation system commercial

- The monitoring data shows that the commercial ventilation system is in operation all year round without a timer programme. According to the type of use, the possibility of switching off this ventilation system outside the hours of use (night hours, weekends and holidays) should be considered. Electricity savings of 50% can be expected by converting the system to demand-based operation. In addition, the district heating consumption and the expenses for maintenance and servicing of the system are reduced.

Cooling with well water

- When considering the electricity costs for the well pump of the cooling system, it becomes clear that the annual performance factor of the cooling solution (ratio of useful cooling to electrical energy used over the period of one year) is relatively low at 0.4. This is due to the high running time of the well pump. It is recommended to optimise the control of the well pump. The well pump should only be activated when one of the two ventilation systems requires cooling. Otherwise, the pump should be switched off.

Increasing the use of own photovoltaic power

- The photovoltaic yields are used to supply the building services. During the measurement period, 65% of the PV yield was used internally. The electricity surplus of 35% of the yield was fed into the public grid. By changing the well pump connection to the building services supply line, the PV internal electricity use can be increased to approx. 85%. Furthermore, the power supply for the lift could also be connected to the building services billing meter and the "lift" billing meter could be disconnected from the electricity grid operator.

Optimising indoor comfort in summer and increasing energy efficiency by adapting ventilation behaviour

- In order to reduce the overheating of flats in summer, the existing shading devices should be used in a targeted manner.
- The measurement data of the reference rooms suggest that in one reference flat in particular, window ventilation is very frequent for several hours in the morning during the heating period. This leads to strong cooling of the rooms and thus to heat loss. In terms of energy efficiency, ventilation by means of intermittent ventilation (5 to 10 minutes) is recommended.
- The monitoring data of the summer months show that the cooling capacities requested for both ventilation systems amount to a maximum of 50% of the design capacity of the cooling coils.
- By lowering the target supply air temperatures during hot spells, a higher cooling contribution could be realised by the ventilation systems in the residential and/or commercial areas.

Wohnproject Wien, Vienna Austria Lessons Learned 10

Reference, Contact data

7. References & Key Contacts

7.1 References

Lampersberger, P.: WOHNPROJEKT WIEN
Lampersberger, P.: Demo light Impact-Monitoring und messtechnische Untersuchung von energieeffizienten Gebäuden
Web: https://nachhaltigwirtschaften.at/en/sdz/projects/delight-monitoring.php
Download: https://nachhaltigwirtschaften.at/resources/sdz_pdf/schriftenreihe-2021-10-delight-monitoring.pdf

7.2 Interesting links and Downloads

Website of Wohnprojekt Wien,in German: https://wohnprojekt.wien/

Website of Wohnprojekt Wien by architects einszueins architecture, in German: https://www.einszueins.at/project/wohnprojekt-wien/

Website of non-profit architecture website nextroom, in German: https://www.nextroom.at/building.php?id=36753&inc=datenblatt

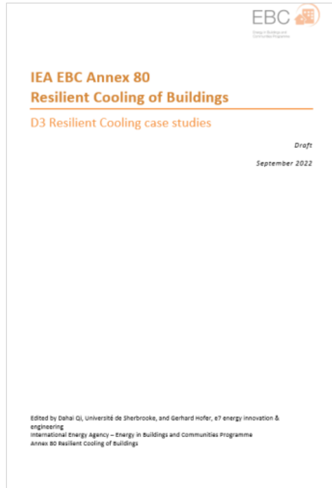
7.3 Contacts

Company	Role	Contact
e7 energy innovation & engineering	Consultant Measuring energy use during operation of building	Paul Lampersberger paul.lampersberger@e-sieben.at www.e-sieben.at +43 1 907 80 26 - 68
einszueins architektur ZT GmbH	Project Architect	office@einszueins.at www.einszueins.at
RWT Plus	Structural design, building physics, building technology	office@rwt.at www.woschitzgroup.com/
DnD Landschaftsplanung	Landscape architecture	office@dnd.at www.dnd.at
Raum & Kommunikation	Project controlling	office@raum-komm.at www.raum-komm.at

Wohnproject Wien, Vienna Austria References / key contacts 11

STC report: report structure

- **Introduction**
- **Structure and definition of case study examples**
  - Structure of building description
  - Definition of technologies applied
  - Definition of Key performance Indicators
  - Methods for performance evaluation
  - Lessons learned and references
- **Case Study examples**
  - All Case Study examples


EBC

IEA EBC Annex 80
Resilient Cooling of Buildings

D3 Resilient Cooling case studies

Draft

September 2022

Edited by Dahai Qi, Université de Sherbrooke, and Gerhard Hofer, e7 energy innovation & engineering
International Energy Agency – Energy in Buildings and Communities Programme
Annex 80 Resilient Cooling of Buildings

Subtask C

Thank you for your attention !

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Federal Ministry Republic of Austria Climate Action, Environment, Energy, Mobility, Innovation and Technology

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The Art of Energy Efficiency

BEEP
BUILDING ENERGY EFFICIENCY PROJECT

Natural ventilation, some case studies in India

1) Natural ventilation in low and affordable housing multi-storey buildings
2) Design and testing of a very low energy ventilative cooling system for low wind availability
3) Natural ventilation with and without external shading in a residential tower

Indo-Swiss project on Building Energy Efficiency (BEEP)
Pierre Jaboyedoff, Effinart, Lausanne, Switzerland
Greentech Team, Delhi, Dr. Sameer Maithel, Prashant Bhanware, Mohit Jain

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BUILDING ENERGY EFFICIENCY PROJECT

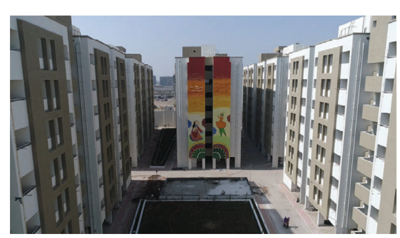
1) Thermally comfortable and climate friendly affordable housing in India: The Smart Ghar 3 project natural ventilation tests, in Rajkot, Gujarat

Background
- Generally, most of dwellings are not equipped with any active cooling system (80-90% in India today.

Resilience issues
- The building design has been developed with the main assumption that there would not be any active cooling at least for the next decade

Objectives
- Demonstrate passive natural ventilation efficacy to keep the temperature much below outdoor peak by night cooling in a hot climate

Features
- Very low heat gains envelope
- Good opaque envelope with AAC blocks
- Low window to wall ratio



Monitoring system
- CO_2 as tracer gas, cheap and simple solution, constant flow with a flow meter controller, measurement of the CO_2 concentration day and night, calculation of the AIR change
- Night and day constant flow, Guarded zone for the data acquisition → Avoid the CO_2 by human CO_2 production

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Monitoring methodology

Determine data monitoring period ➡ **Selection of test flat**

5th May to 31st May 2019
(period when the maximum temperature would be consistently above 40°C)

Selection of test flat
Located on intermediate floor and should not have "first access" to wind

⬇

Determine parameters to be measured
Ambient DBT, RH, wind speed & direction;
Indoor (Bedroom & Living room) DBT, RH, CO_2 concentration (for ACH calculation)

⬅ **Test set-up & operation**

⬇

Data logging ➡ **Analysis (including calculation of ACH)**

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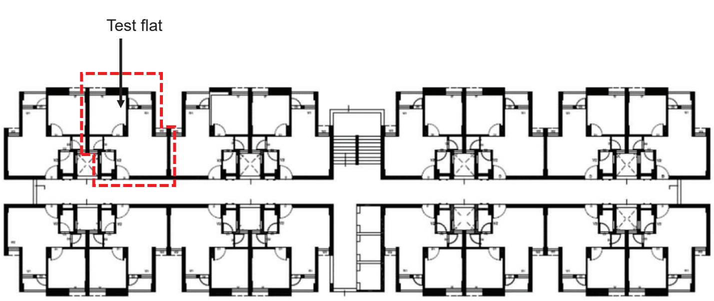
Selection of test flat



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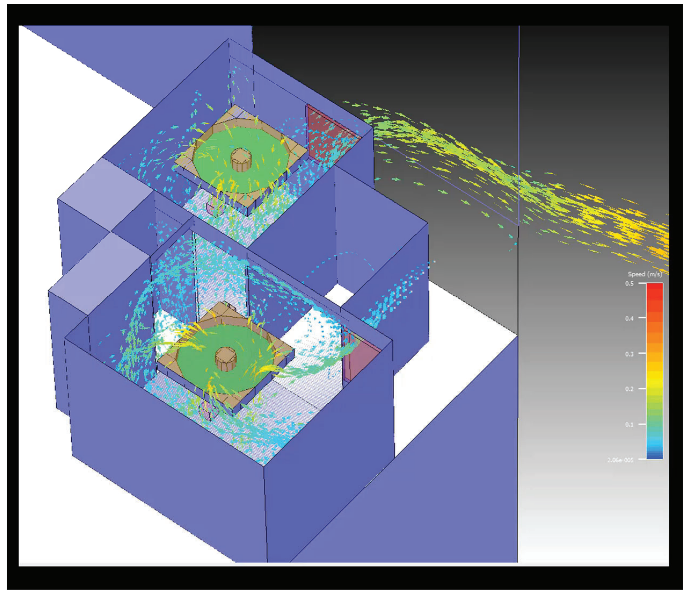
Measurement planning

- Reverse flow due to the geometry of the recess (identified by CFD modelling and confirmed with smoke and velocity measurements)
- Analysis to locate the sensors for the best "averaged" values
  - CFD modelling to find the locations most representative of the average
    - Temperature
    - CO2 sensors



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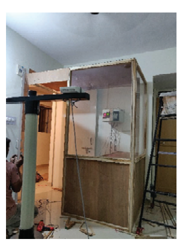
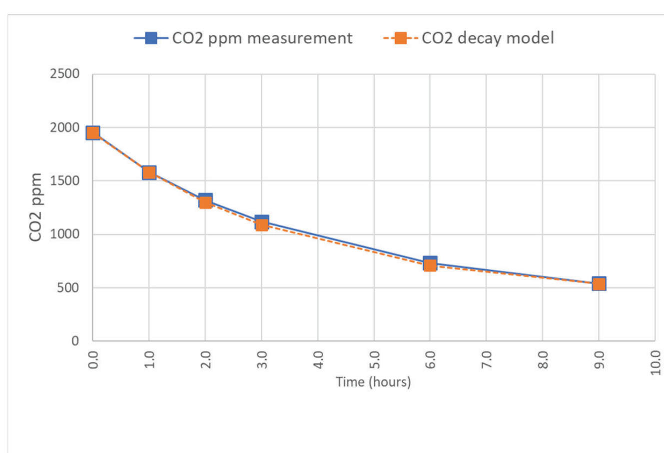
Test of the CO2 decay with the bedroom "sealed"

- Instead of use of tracer gas
  - Use of CO2 flow controlled
  - Use of CO2 sensors
  - Guarded zone for the data acquisition to avoid the human produced CO2



- In order to validate the method
  - Comparison between the measured CO2 concentration and a calibrated decay model
  - → ACH = 0.27 with the "sealed" bedroom



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Monitored results: Outdooor temperature

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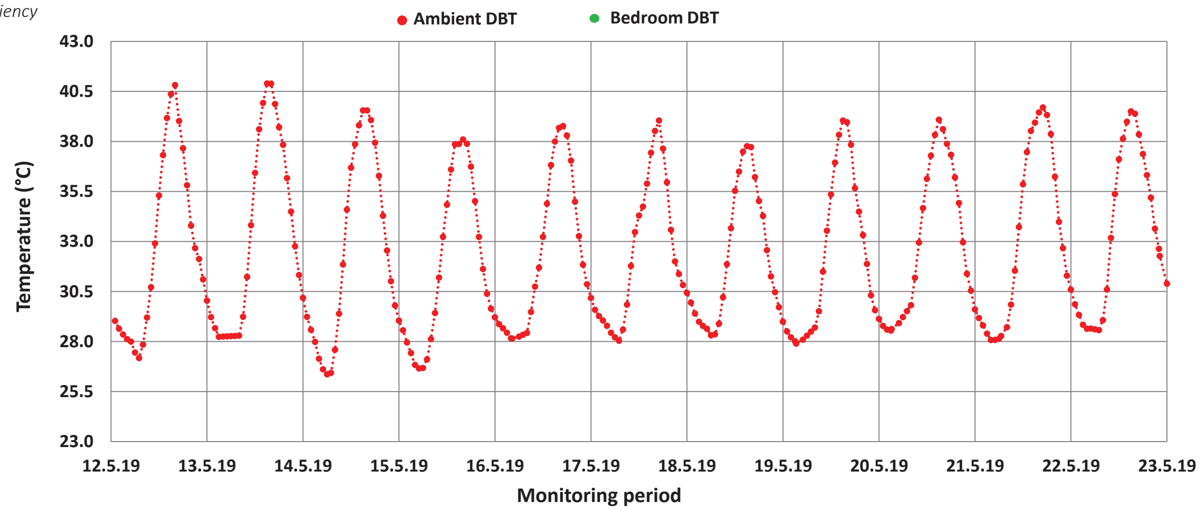

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Monitored results: Indoor temperature

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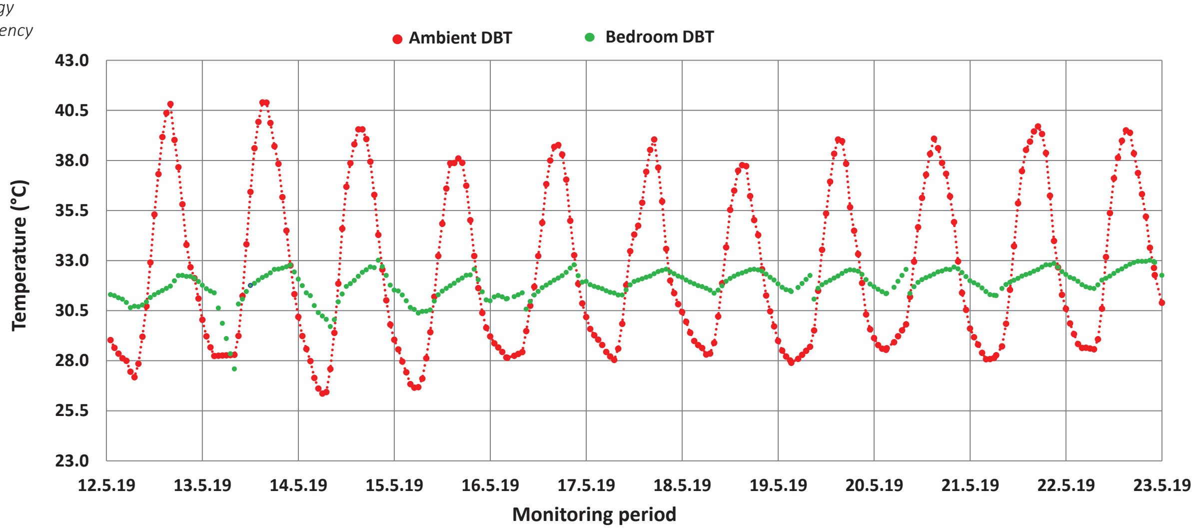

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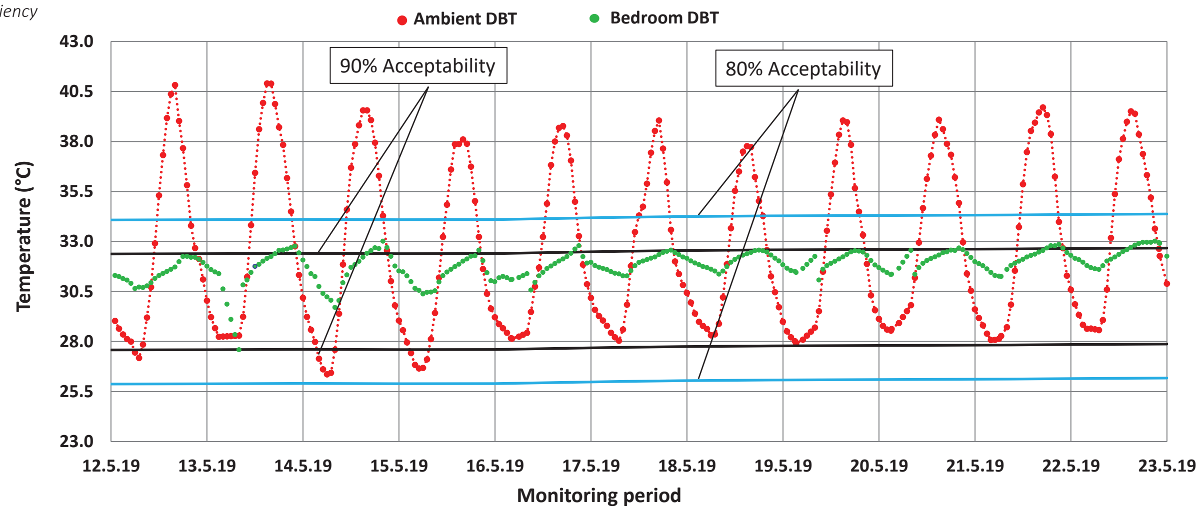
Monitored results: Indoor temperature



- Acceptability calculated using the IMAC (Indian Adaptive Thermal Comfort Model https://cept.ac.in/news/carbse-cept-thermal-comfort-research-included-in-national-building-code-2016)

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Conclusions for case 1)

- In affordable housings, it is possible to have an acceptable comfort level in residential non-AC at the same cost as business as usual with properly designed building envelope and natural ventilation openings
- Typically on hot days
  - Peak outside > 40 °C
  - Inside temperature < 33 °C
- This monitoring exercise shows measured quantification of the impact of building envelope on internal temperatures
- This resulted in a significant increase in comfortable hours duration and potential reduction in the need for air-conditioning

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2) Rajkot Smart Ghar III: assisted low energy ventilative cooling design and test

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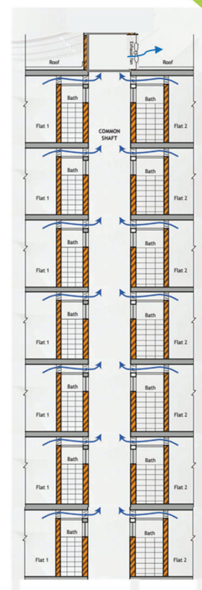

Background

- If the air movement between buildings is insufficient to generate 12-15 ACH, then very low energy ventilative cooling is a possible solution

Objectives

- Development of a balanced very low energy ventilative cooling system

Design options and development

- CFD comparison of different soluitions → no flow rate controller, constant resistance for balancing
- Mockup model testing
- Testing in real scale
- Balanced low negative pressure
- High performance fans

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Concept design, CFD development, lab scale mock-up testing

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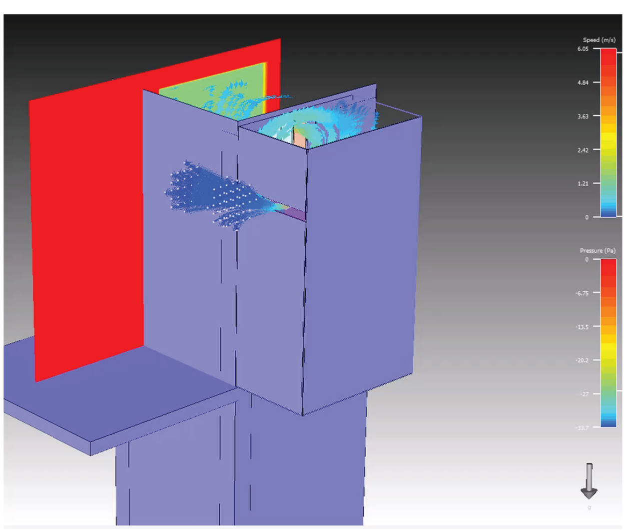

Set-up with the model scale 1:1

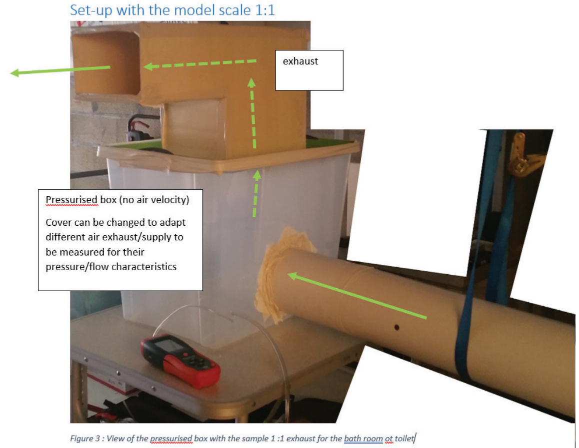

Figure 3 : View of the pressurised box with the sample 1 :1 exhaust for the bath room ot toilet

- Flow rate of 430 m3/h per exhaust
- Differential pressure of 30 Pa

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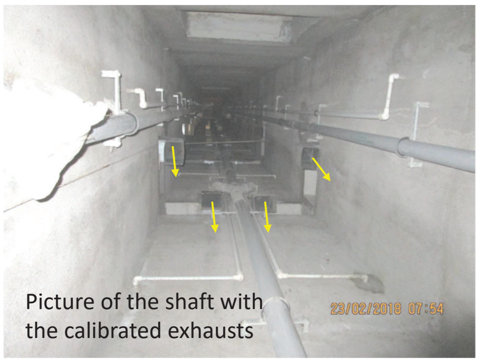
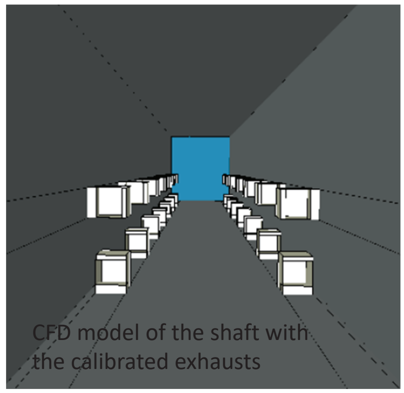
View of the balancing exhaust element

- The exhaust balancing elements (keeping the ~ same flow in all flats) are designed so that nothing can enter → downward physical opening, air blown downwards



Picture of the shaft with the calibrated exhausts



CFD model of the shaft with the calibrated exhausts

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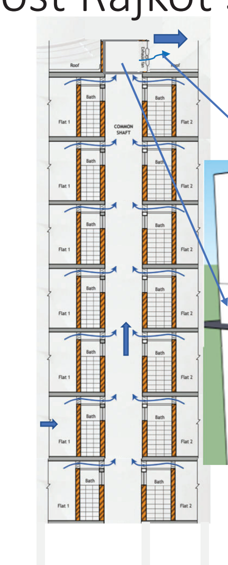
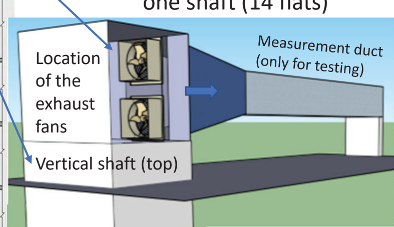
BEEP BUILDING ENERGY EFFICIENCY PROJECT

Low energy assisted ventilation for night cooling: testing of the aeraulic performances in the low cost Rajkot Smart Ghar III project

- Low energy assisted night cross-ventilation system
- Objectives: efficient night cooling
  - Test and confirm the design values of the overall system performance on one shaft (14 flats)





Vertical shaft on site (top) With extended duct for accuracy of air flow measurment

Exhaust fans inside the metallic top

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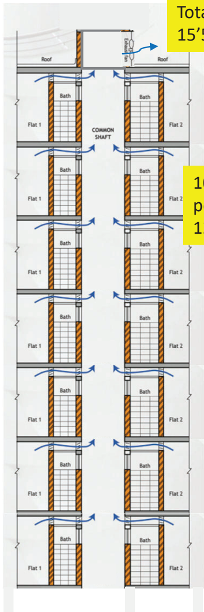
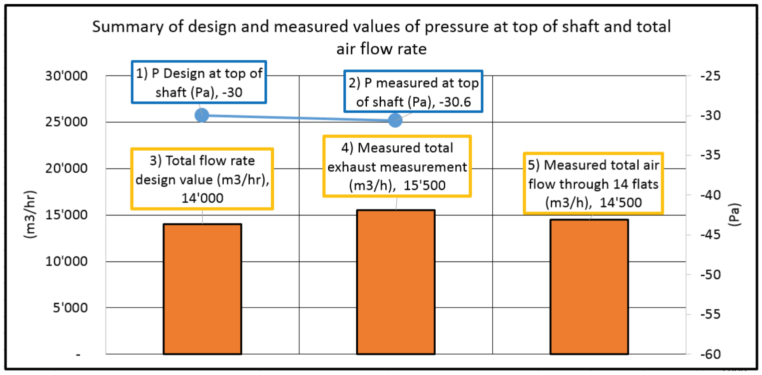
Results



Total air flow 15'500 m3/hr

1036 m3/hr per flat 12-15 ACH

- Measured values against design
  - Actual flow rate slightly > design values
  - The aeraulic concept is validated (optimal fan ~1.1 W/m^2 (floor area) at full flow)



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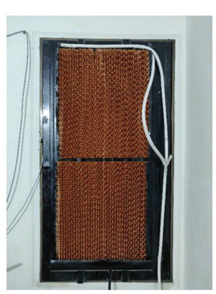
BEEP BUILDING ENERGY EFFICIENCY PROJECT

Conclusions for case 2

Low energy ventilative cooling

- If the air movement between buildings is insufficient to generate 12-15 ACH, then very low energy ventilative cooling is a possible solution
- Testing in real scale has demonstrated the aeraulic performance
- Balanced low negative pressure (30 Pa)
- High performance fans (efficiency of 27%)
- Specific power to ensure 12-15 ACH in 14 flats ~ 1.1 W/m2
- Potential to increase the comfort by adding evaporative cooling on the windows
  - Short test has shown that the balancing was hardly affected by a low differential pressure wet pad →



Global results		
negative pressure	30	Pa
flow rate	14000	m3/hr
flow rate	3.89	m3/sec
height	2.8	m
total volume	1097.6	m3
ACH	12.8	h-1
Aeraulic power	117	Watt
Fan efficiency	27%	
Electric power	432	Watt
Carpet area per flat	28	m2/flat
number of flats	14	
total carpet area	392	m2
specific power	1.10	W/m2

3) Gurugram tower natural ventilation with and without external shading

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Gurugram tower natural ventilation with and without external shading

Background

- External movable shading used very rarely in India in new buildings

Objectives

- Quantify the impact of External shading and single sided natural ventilation on a typical modern building

- Development of the comparison methodology
  - Selection of two adjacent flats with exactly the same solar exposure
  - Checking the initial conditions (same temperature in non shaded mode)
  - Actual testing
  - Results obtained

The building and its location in Gurugram (satellite city of Delhi)

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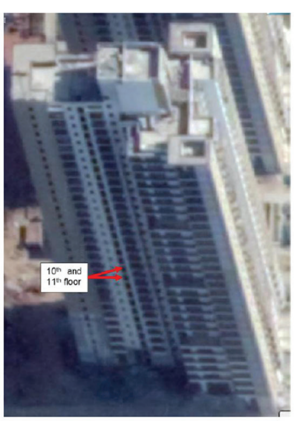
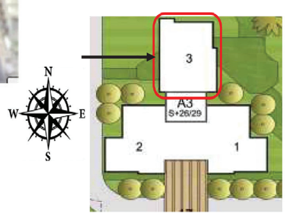


- Two flats at 10th and 11th floor, test room with west orientation



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The test room
A bedroom (normally the first room to have AC)

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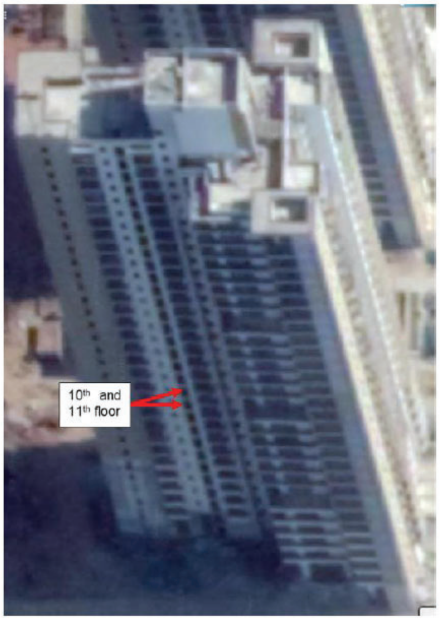

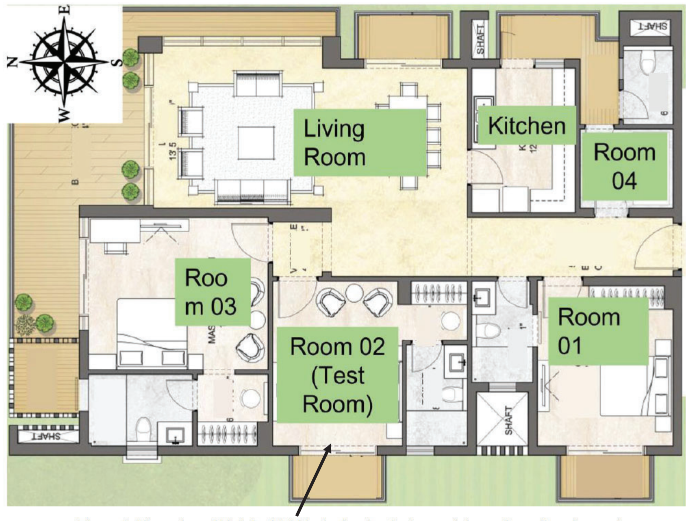

Figure 6: Floor plan of Unit 3 of A3 block showing test room (planned monitored space)

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Checking the comparison procedure → checking if the same temperature in the two bedrooms with the same window system is obtained

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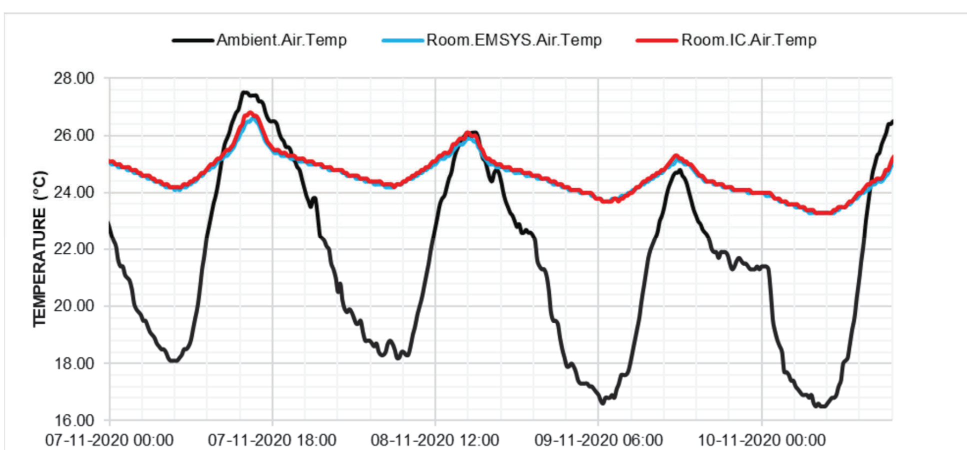
- The temperature in both the bed rooms without any shading
  - Conditions good for the comparison



Testing in summer without AC, with natural ventilation (opening during the night)

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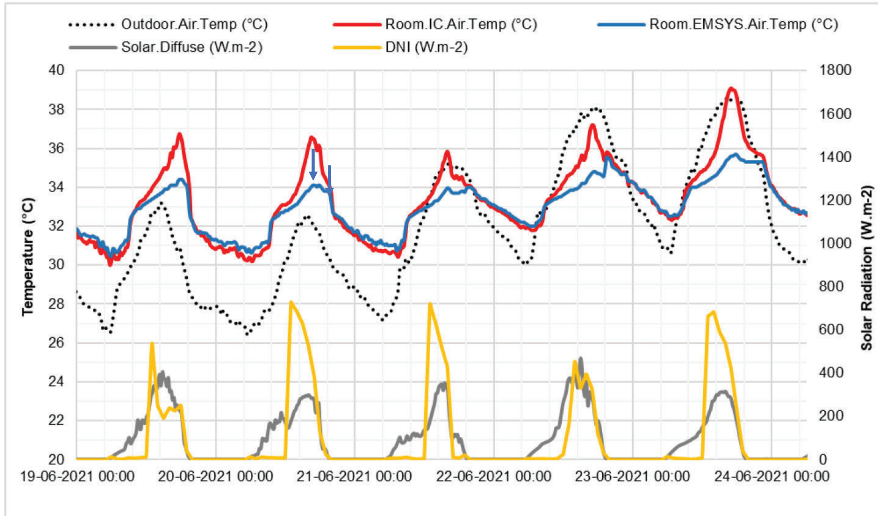
- In red
  - Usual internal curtains
- In blue
  - With external movable shading (SHGC ~ 18% with glazing)



Conclusions for case 3

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- Natural ventilation is very efficient in tandem with external movable shading
- The peak temperature is reduced by 3-3.5 °C when using external movable shading → very signification reduction of the duration of discomfort (e.g. hours per years)
- This test confirms the relevance of external movable shading systems in the hot Indian Climates

Summer comfort in Belgian dwellings without active cooling: case studies

Margot De Pauw
Thomas More, Energy Knowledge Center

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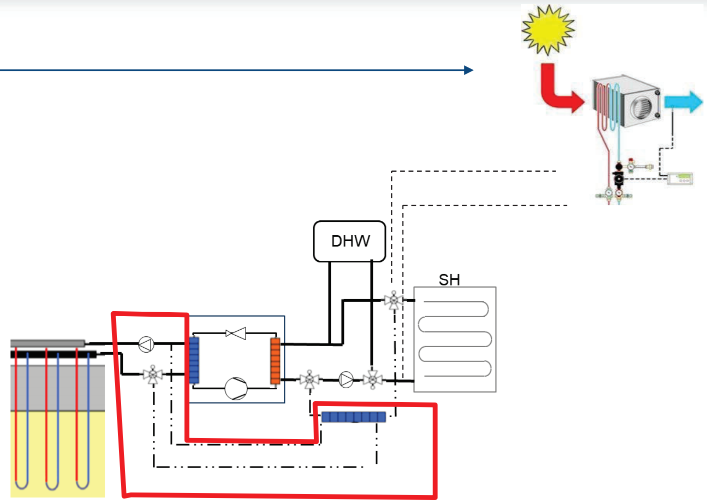
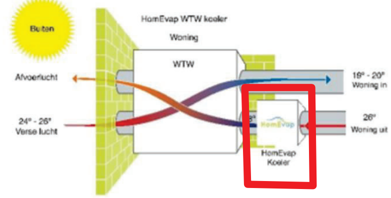
kce.thomasmore.be
www.cornet-scools.com

Case1 (Geel)

Case2 (Mol)



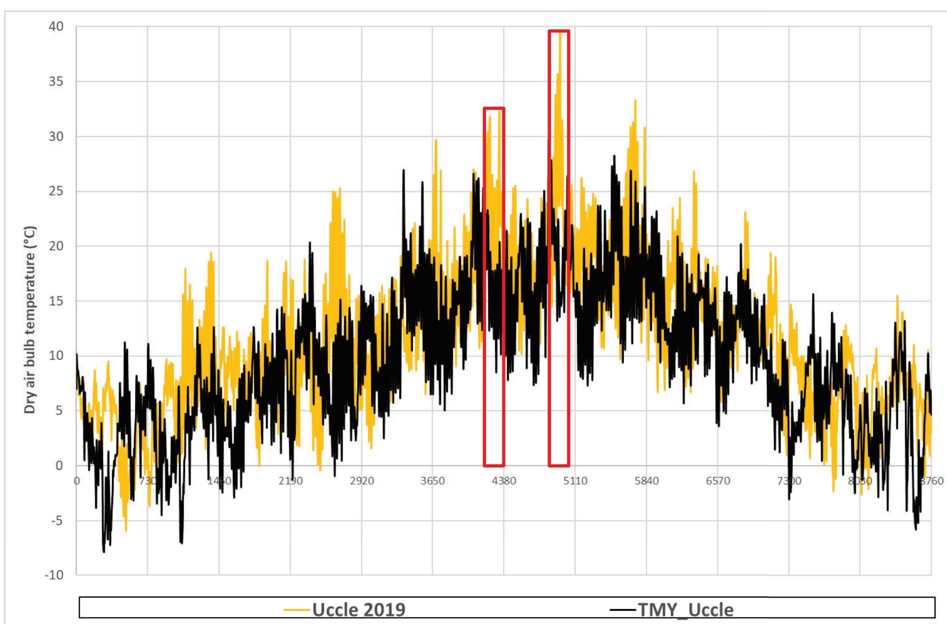
free cooling (geothermal source)



evaporative cooling

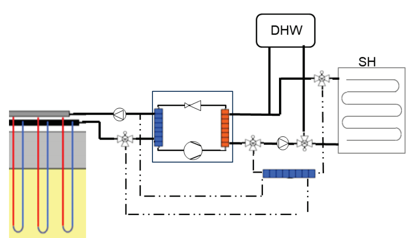
Cases were measured during summer 2019 and 2020

Heat waves:
23/06-30/06/2019 mean Tmax 28,4°C
22/07-26/07/2019 mean Tmax 33,8°C
05/08-16/08/2020 mean Tmax 31,3°C



Case1 (2015, Geel)

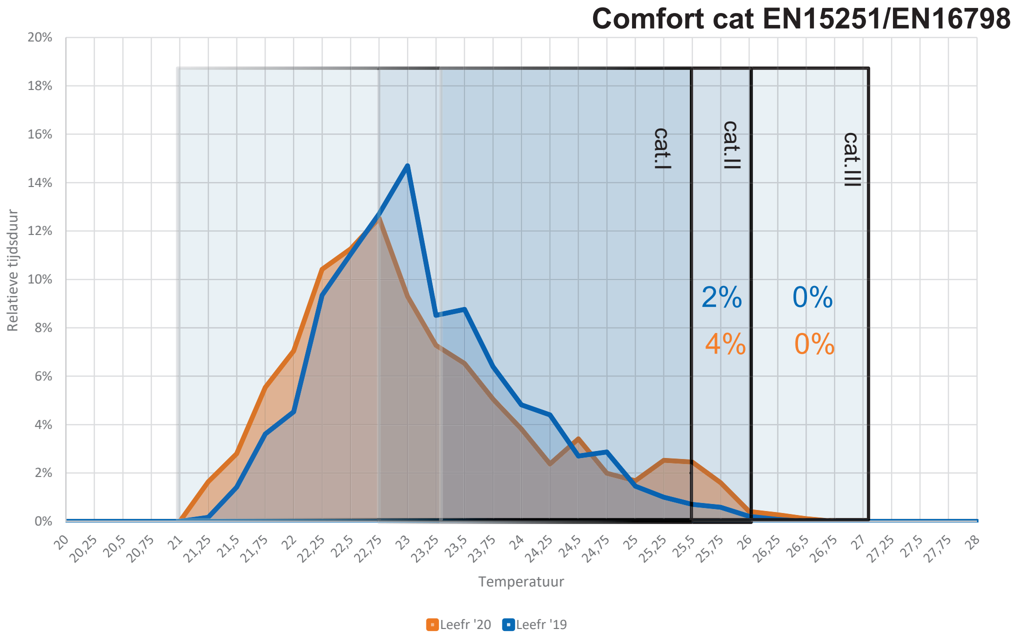
- 2015
- orientation facade: SW
- glass to floor ratio: 14%
- No screens



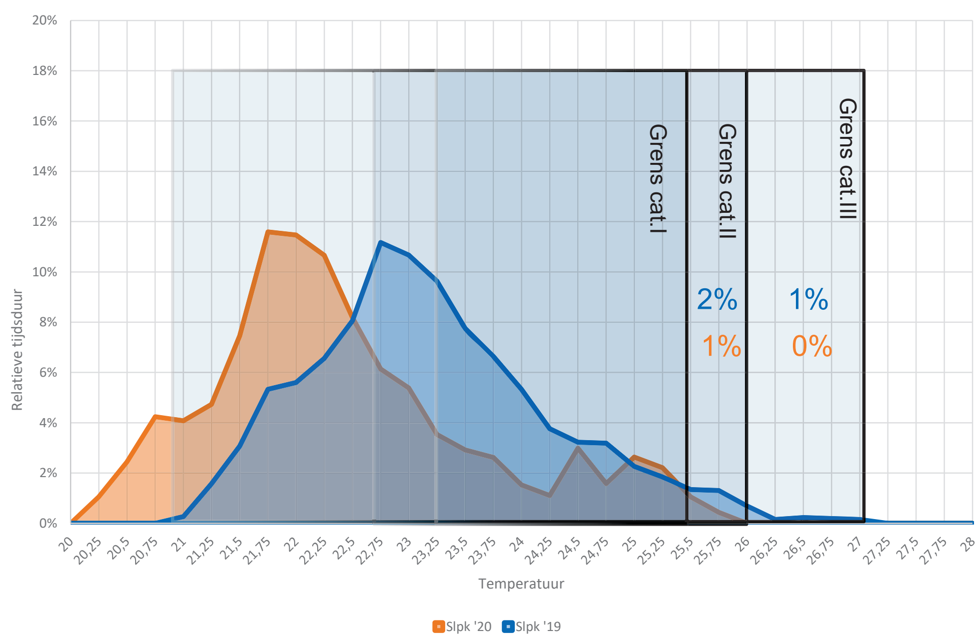
- boreholes 2*100 m

- floor cooling (all floors)
- cooling coil in supply air (2020)

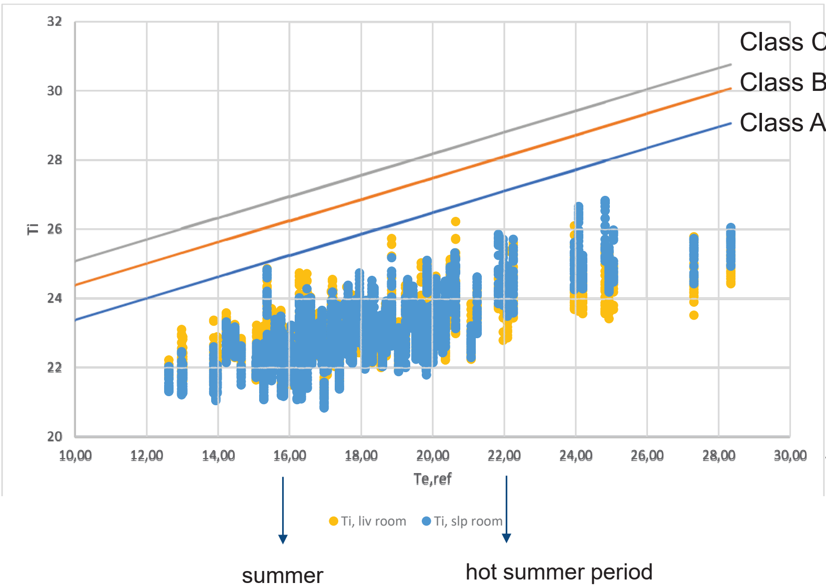
Temperature measurements living room (2019 and 2020)



Temperature measurements sleeping room (2019 and 2020)



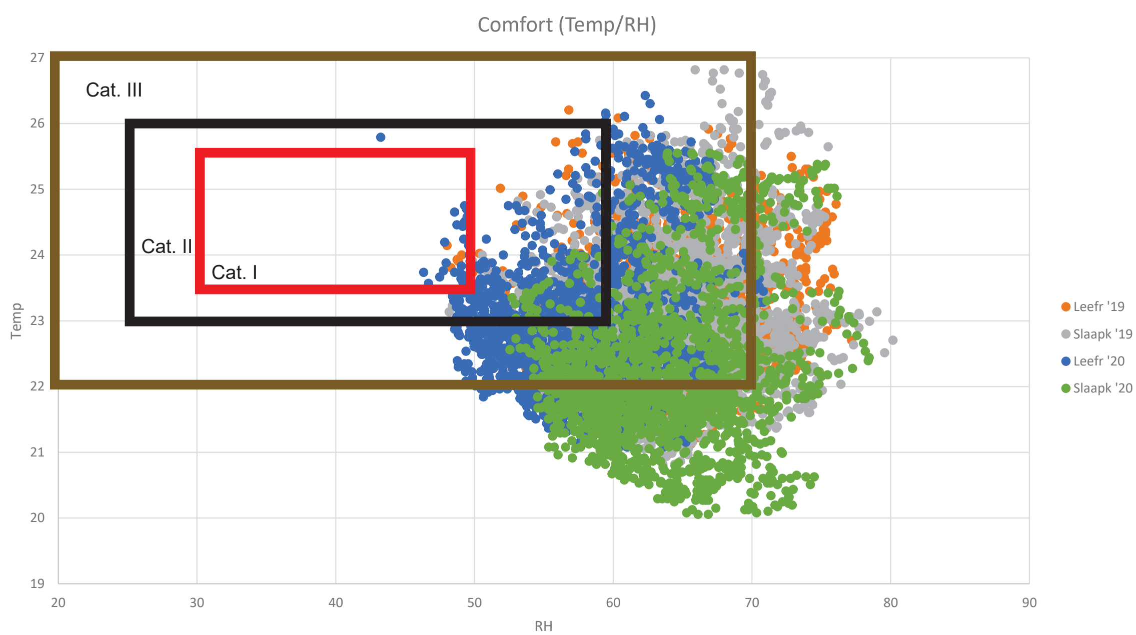
Temperature measurements (2019)



Alpha building =>
Adaptive temperature limits
A.C. van der Linden et al

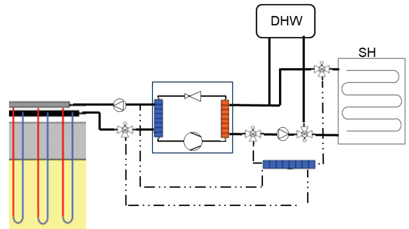
running mean outdoor temp

Temperature and relative humidity



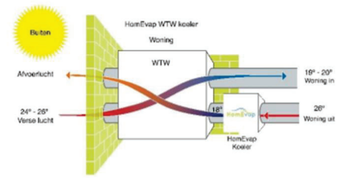
Case2 (2016, Mol)

- 2016
- orientation facade: W
- glass to floor ratio: 12%
- External, automatic solar shading S & W



borehole 1* 120 m

floor cooling (all floors)



ventilation system D with adiabatic cooling

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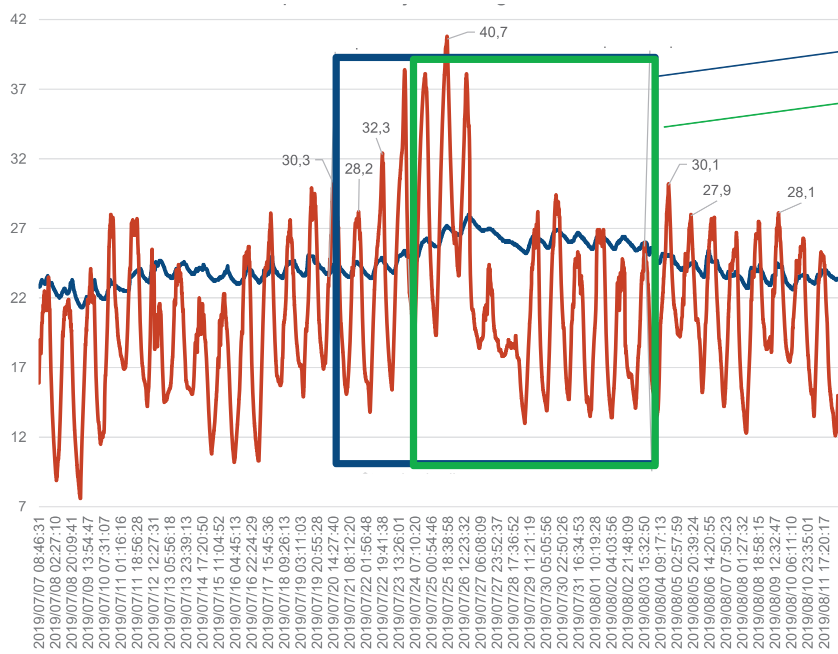
Case2 (2016, Mol)

Temp 8/07 – 8/0//2019



no sun shading

no floor cooling

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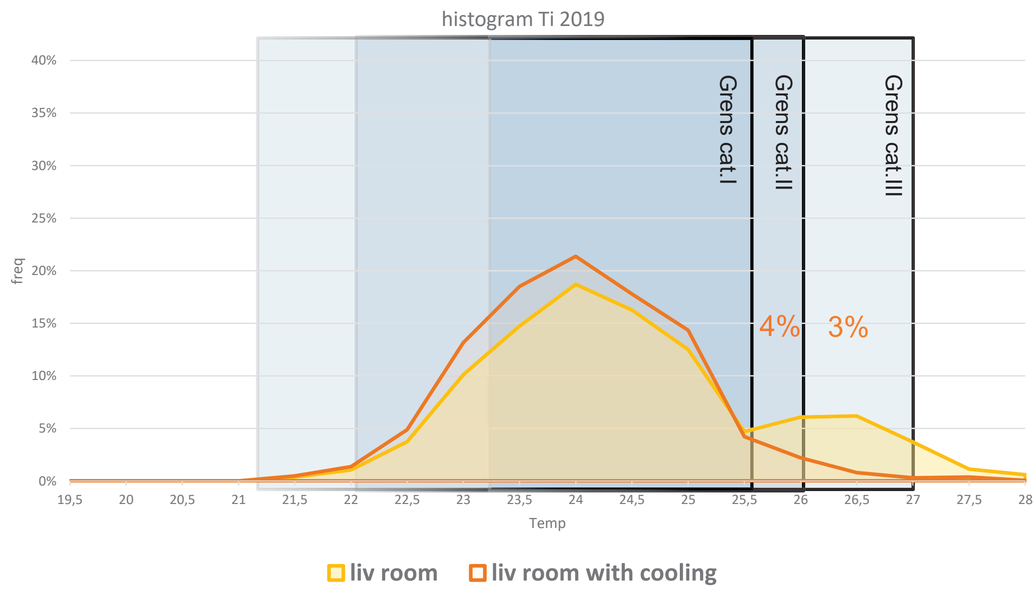
Temperature measurements living room (2019)



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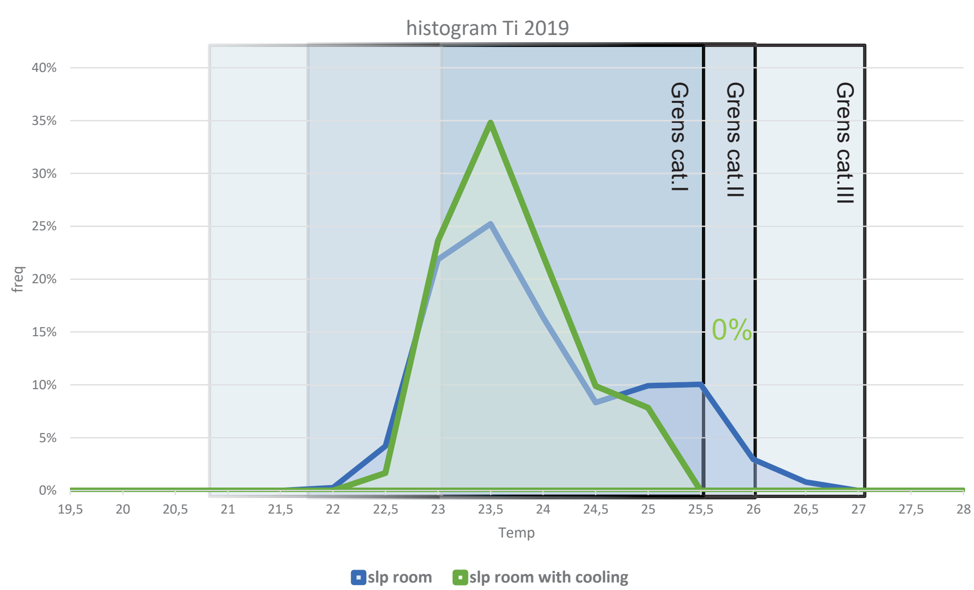
Temperature measurements sleeping room (2019)



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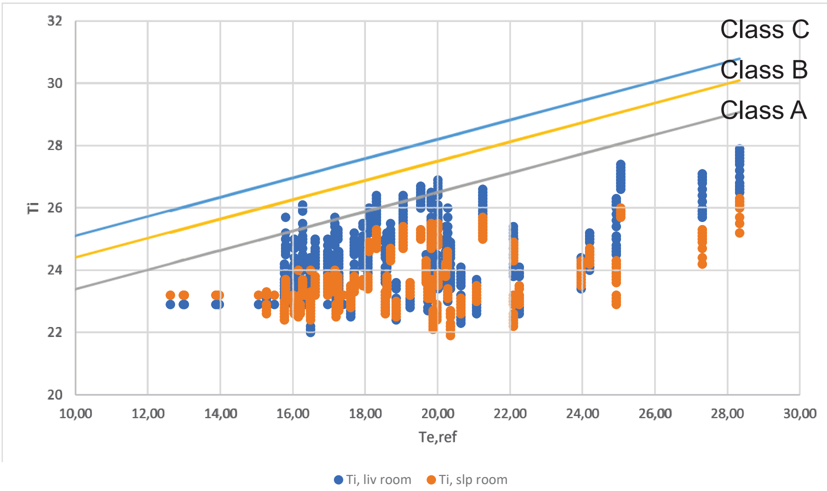
Temperature measurements (2019)



Alpha building =>
Adaptive temperature limits
A.C. van der Linden et al

Case2 (2016, Mol)

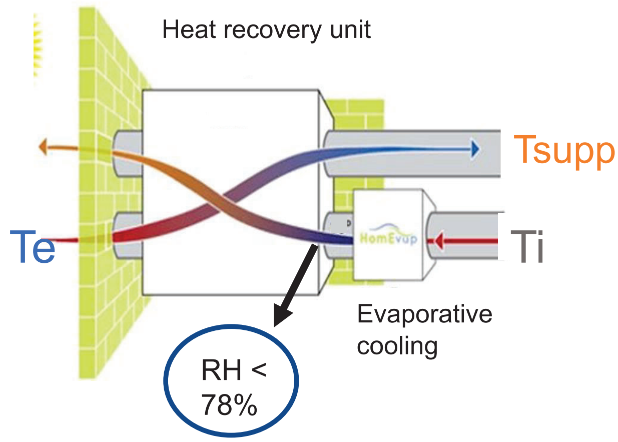
Temp 8/07 – 8/0//2019

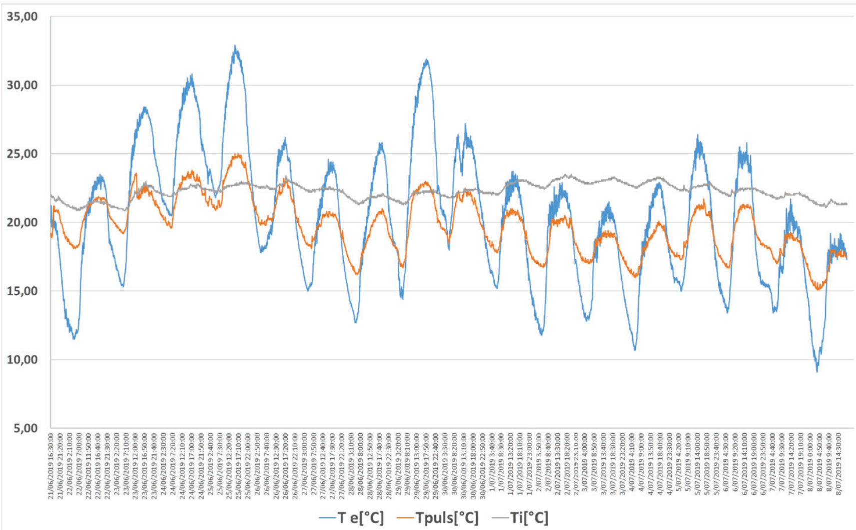
Comfort under future weather scenario's?

Ref:
Abantika Sengupta et al.
Impact of future climate on the performance of ground source cooling system.

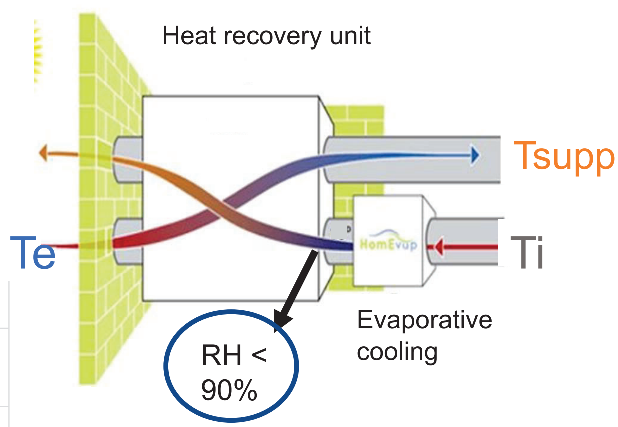
2020 versus future mid-term scenario (2050)?

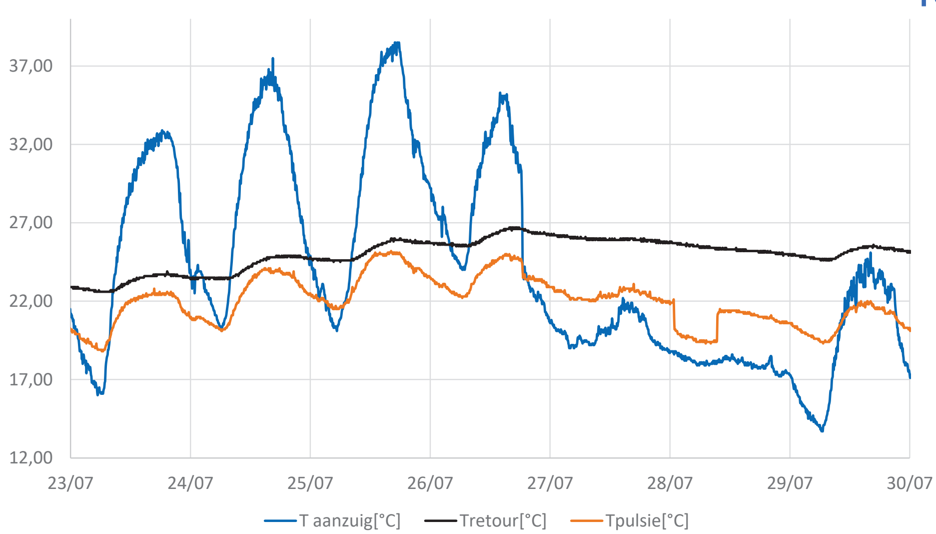
Condensation risk & evaporative cooling



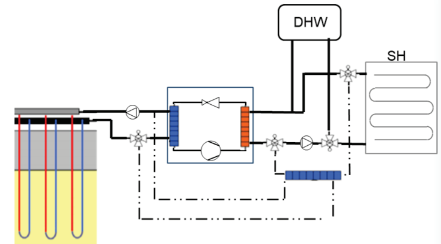


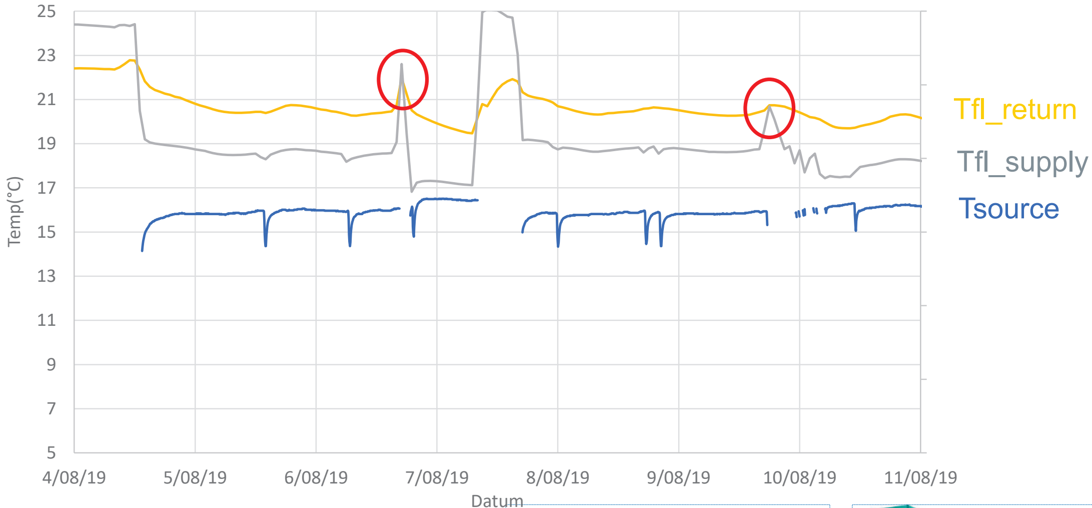
Condensation risk & evaporative cooling





Floor cooling & risk of condensation: dew point control





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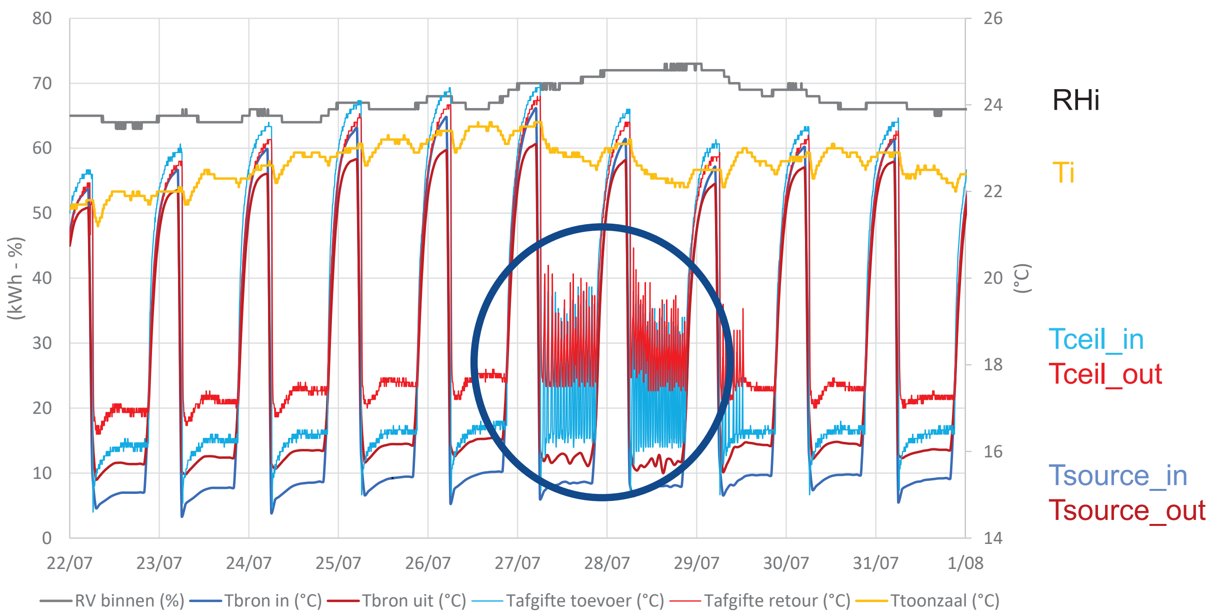
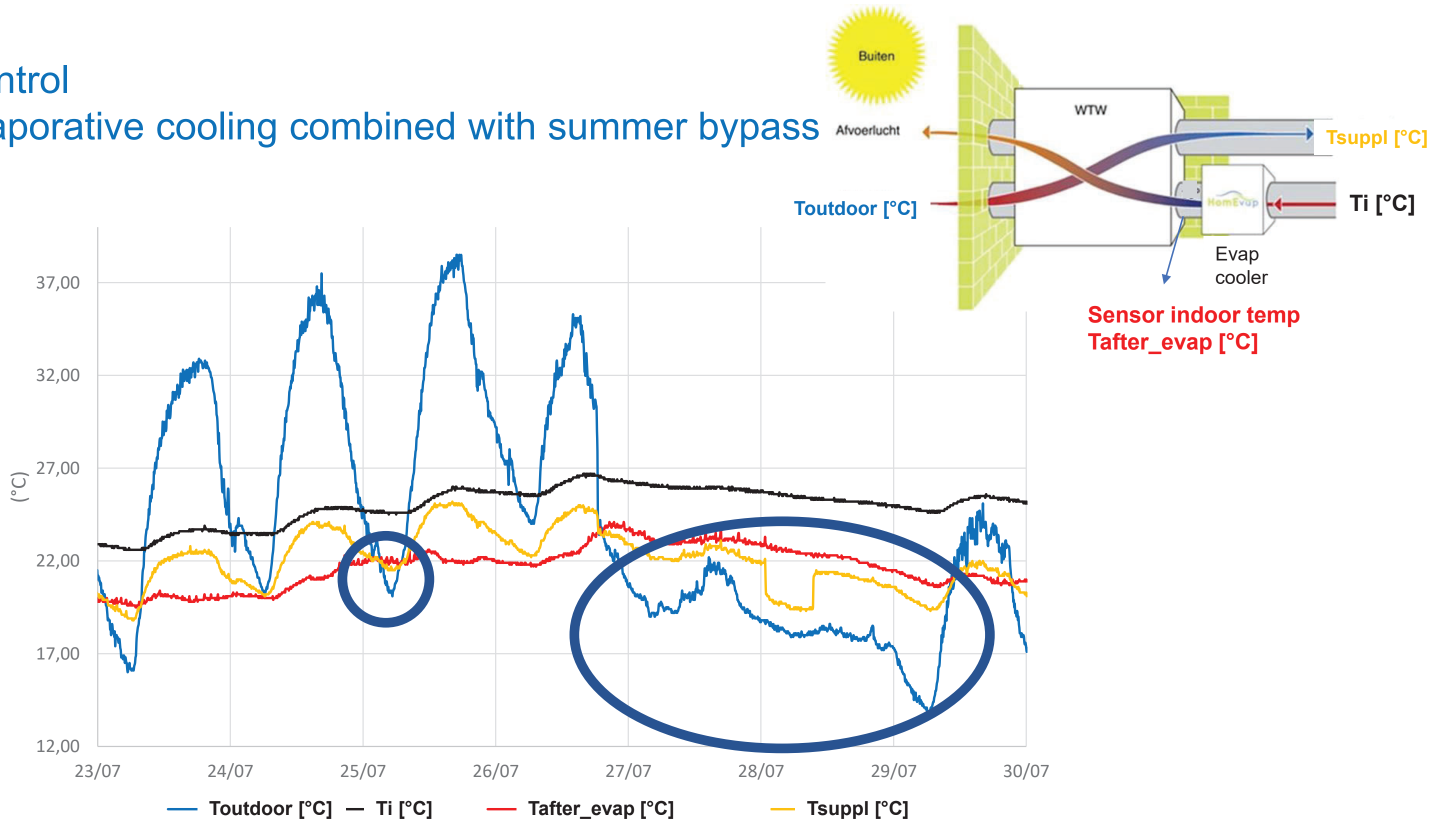
ceiling cooling with dew point control in office room



Control
evaporative cooling combined with summer bypass



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