Indoor Environmental Quality aspects for Plus Energy Buildings' design

Energy Atlas workshop– 16th February 2022

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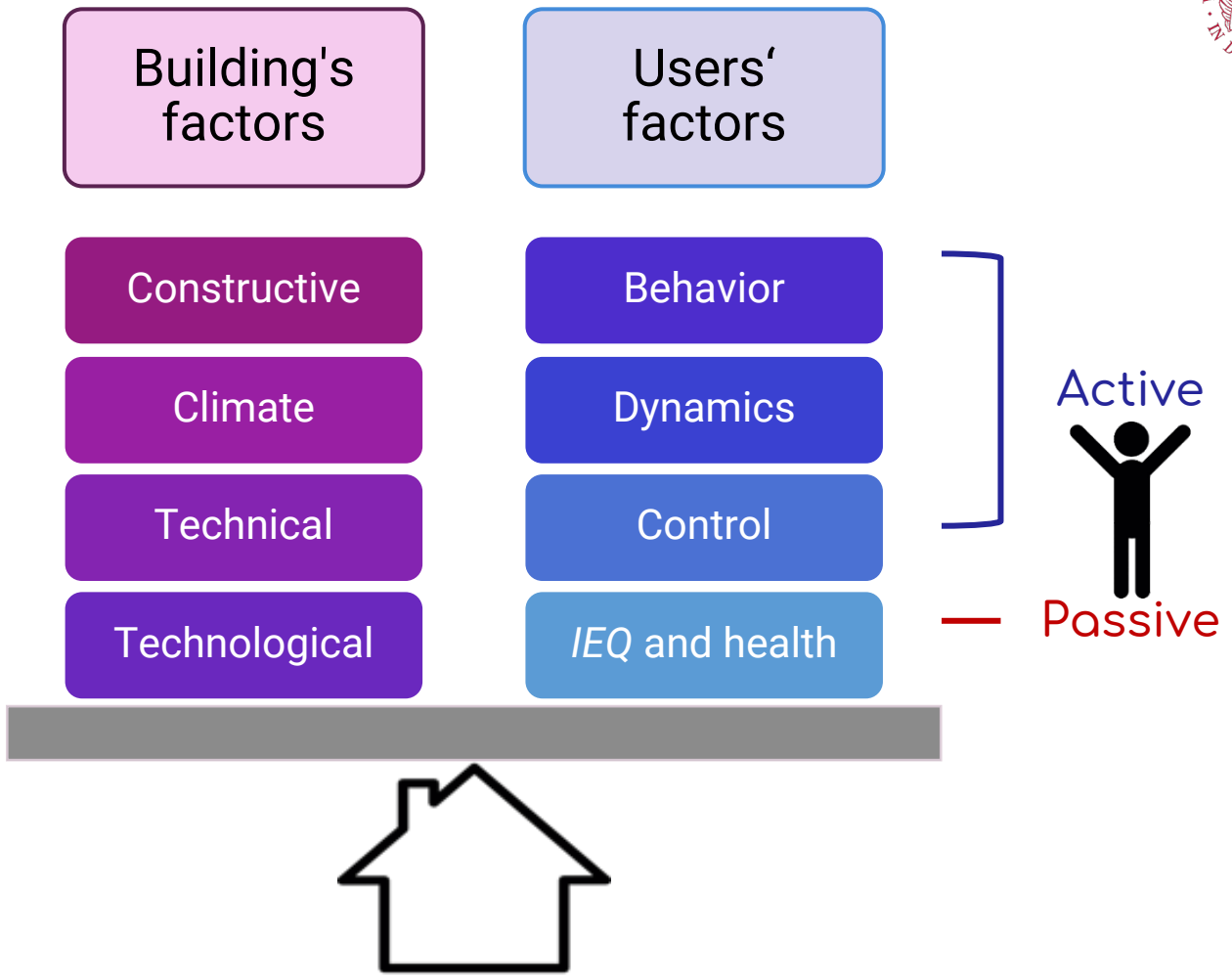
Overview:

1. The notion of comfort
2. Accounting for diversity-driving factors

3. Design inputs from existing data analysis

4. The 2CAP-Energy Atlas (after the break  !)

Accounting for the user



Elaborated from: Yoshino, H., et al., 2017. IEA EBC Annex 53: Total Energy Use in Buildings - Analysis and Evaluation Methods

ACTIVE USER: users take a more **active role** than merely being passive receivers of design strategies

Key driver
achieving comfort and convenience

Users' are interested in services not in energy

It becomes necessary to understand **how users interact with the indoor environment and furthermore to address diversity in these interactions**

The notion of *comfort*

The engineering ideal notion of comfort implies an absence of sensation, striving to create indoor environments that never vary over time or space, purposely creating a

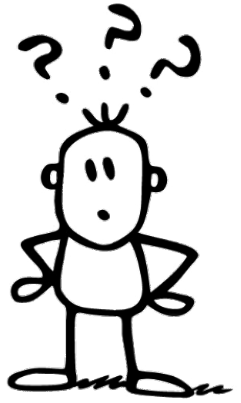
"sensationless, thermal Nirvana" (Prins, 1992)

Common target in design and standards

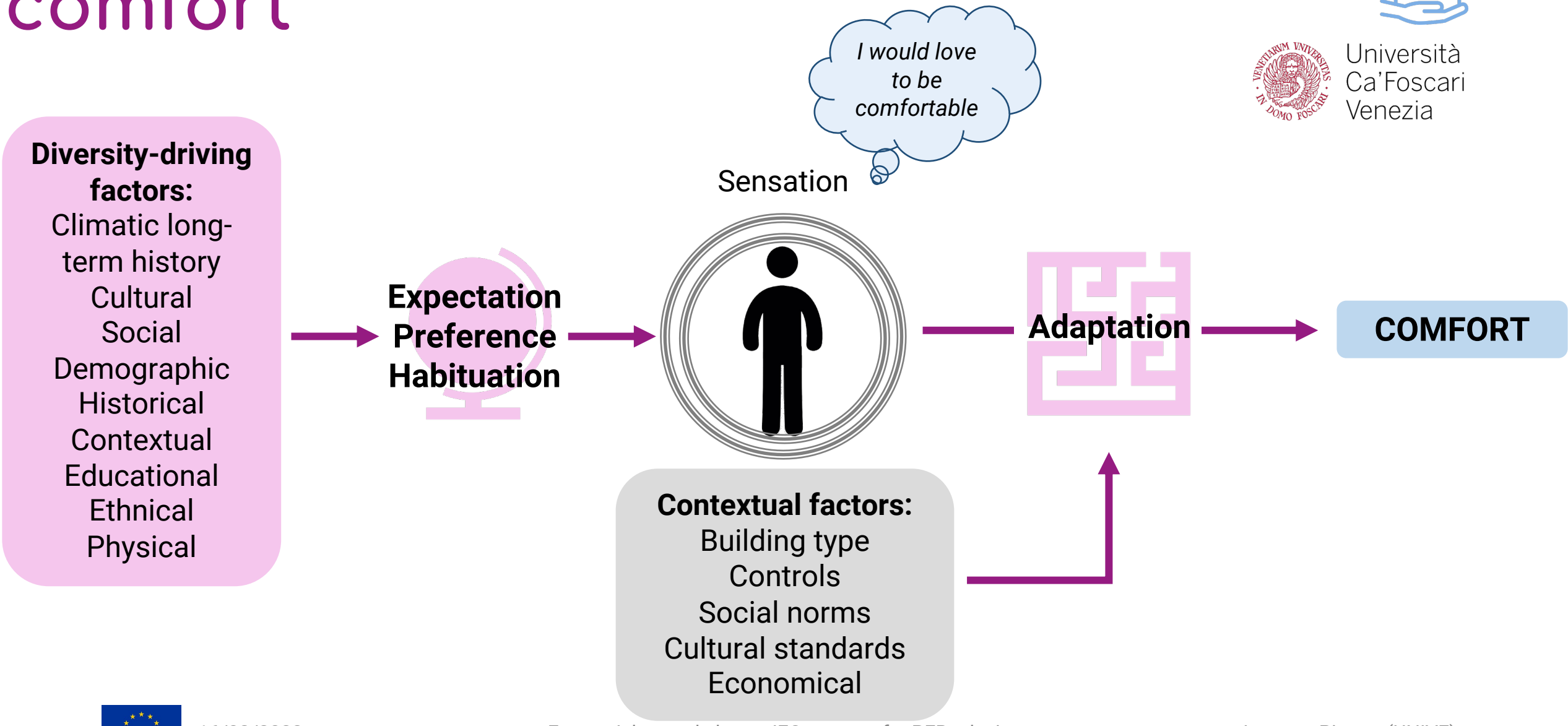
- Tight and static environments
- Transition and stimuli not admitted
- Absence of any perceptible stimuli
- Thermal imperceptibility
- Narrow ranges equal for all subjects
- «Comfort capsules»
- Standardized «ideal» format

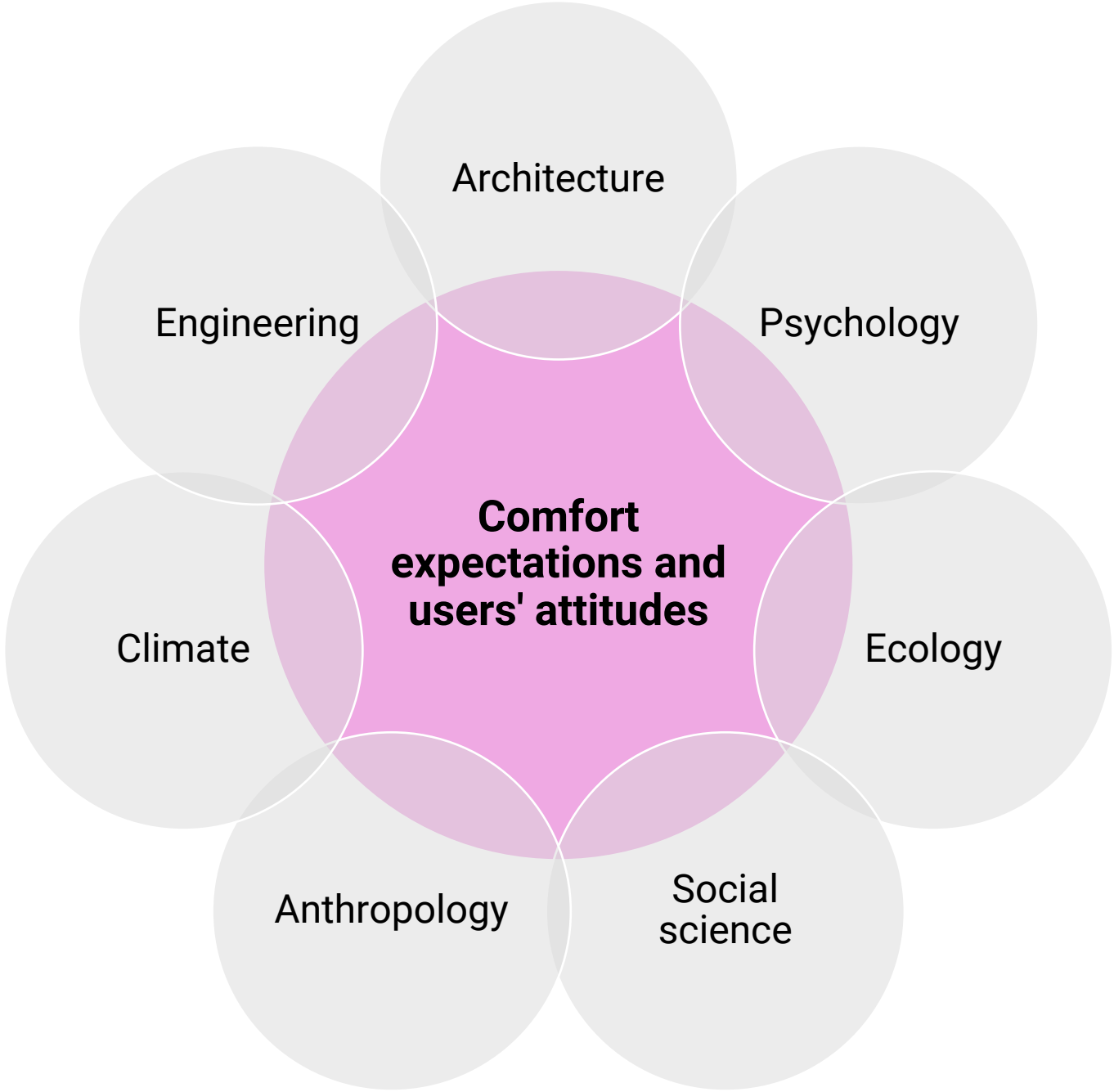
Is this «ideal» really IDEAL?

- There has not actually been a commensurate increase on building occupants' thermal satisfaction
- There is no increment in satisfaction
- It takes more energy to maintain a narrow indoor temperature range than a broader range
- People living in higher IEQ indoor spaces become “fussy” to the thermal environment
- Users have higher expectations
- Not symmetric dynamics: difficult to go back to lower IEQ conditions
- Endowment effect
- Excessive need
- Fail of the thermoregulatory system (Mechanically ventilated VS Naturally ventilated)



Roots and mechanisms of comfort




Architecture
Engineering
Psychology
Comfort expectations and users' attitudes
Climate
Ecology
Anthropology
Social science

The «PLUS» shall be also for IEQ conditions!

Shift of paradigm:
accounting for diversity

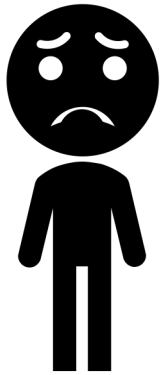
- Re-integrate external stimuli
- Dynamic environments
- Passive design/low-energy/mix-mode
- Seasonal/climatic/natural rhythms
- Building configuration and layout
- Encountering for diversities instead of homogenization
- Encountering for users' preferences and needs
- Empowering users with control more than systems

Perceived control

Improvement of comfort is also due to the psychological effects

- Subjects' perceived ability to control over thermal environment improves their thermal comfort perception, and this improvement is merely due to psychological influence
- Subjects' thermal discomforts do be reduced through even a slight improvement of thermal conditions with personal control approaches
- It is recommended that occupants should be provided sufficient opportunities to control their thermal environments
- Users like to feel part of a system, feel responsible for a change

Cultural-E attempt in addressing diversities



Standards:
An equal value for all users in all climatic/geografical areas

Cultural-E:
Could be different values for different users across Europe?

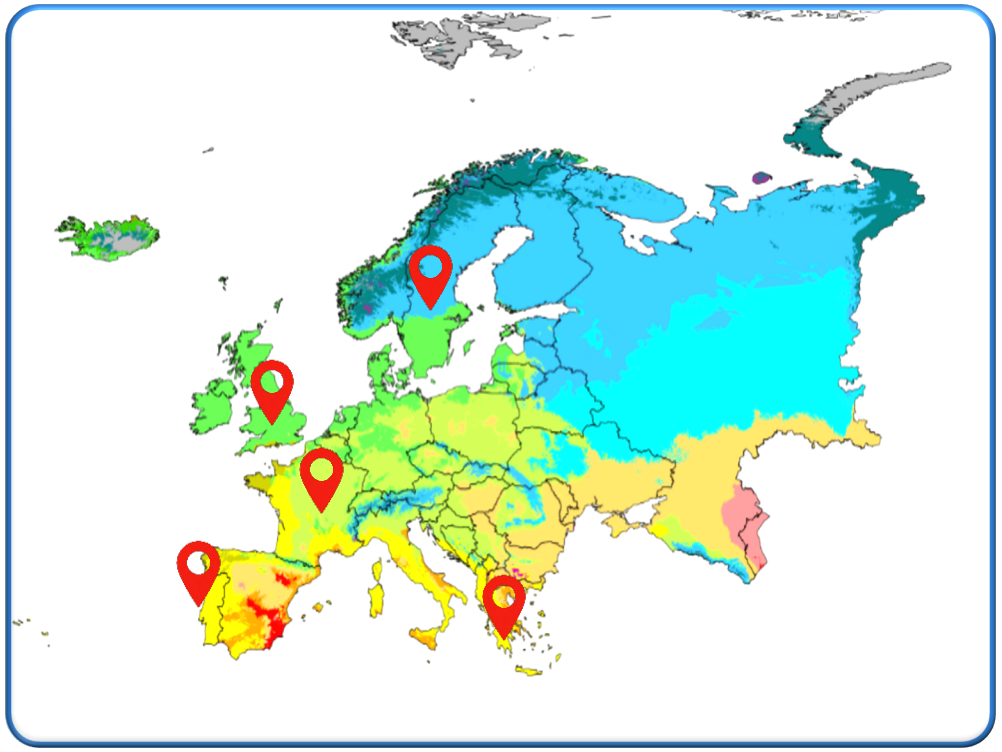
How to spot these differences?

1. Analysis of existing databases:
   i. Smart Controls and Thermal Comfort (SCATs)
   ii. ASHRAE thermal comfort II

2. Perform Post Occupancy Evaluations campaigns in buildings across Europe and democases

Cultural-E:
Could be different values for different users across Europe?

SCATS database
Smart Controls And Thermal Comfort



- **Nicol and Humphreys** (1997-2000) **for the development of the Adaptation algorithm**

- Thermal environment
- ≈ 1 400 observations country-specific:
  - France (FR)
  - Greece (EL)
  - Portugal (PT)
  - Sweden (SE)
  - United Kingdom (UK)
- **Mediterranean, Oceanic, Sub-arctic climates**

- **Outputs by means of statistical analysis**

Testing the standard

Standard UNI EN 16798-1
Design inputs **scenarios** for energy calculations

- **Ventilation:**
  - mechanically
  - naturally
- **Season:**
  - winter
  - summer

1. Thermal Feeling → ATLAS LAYER

Which is the Thermal Feeling of a user
for each Country (EL-PT-UK-FR-SE)
according to the Operative Temperatures design inputs
in each scenario given by the Standard?

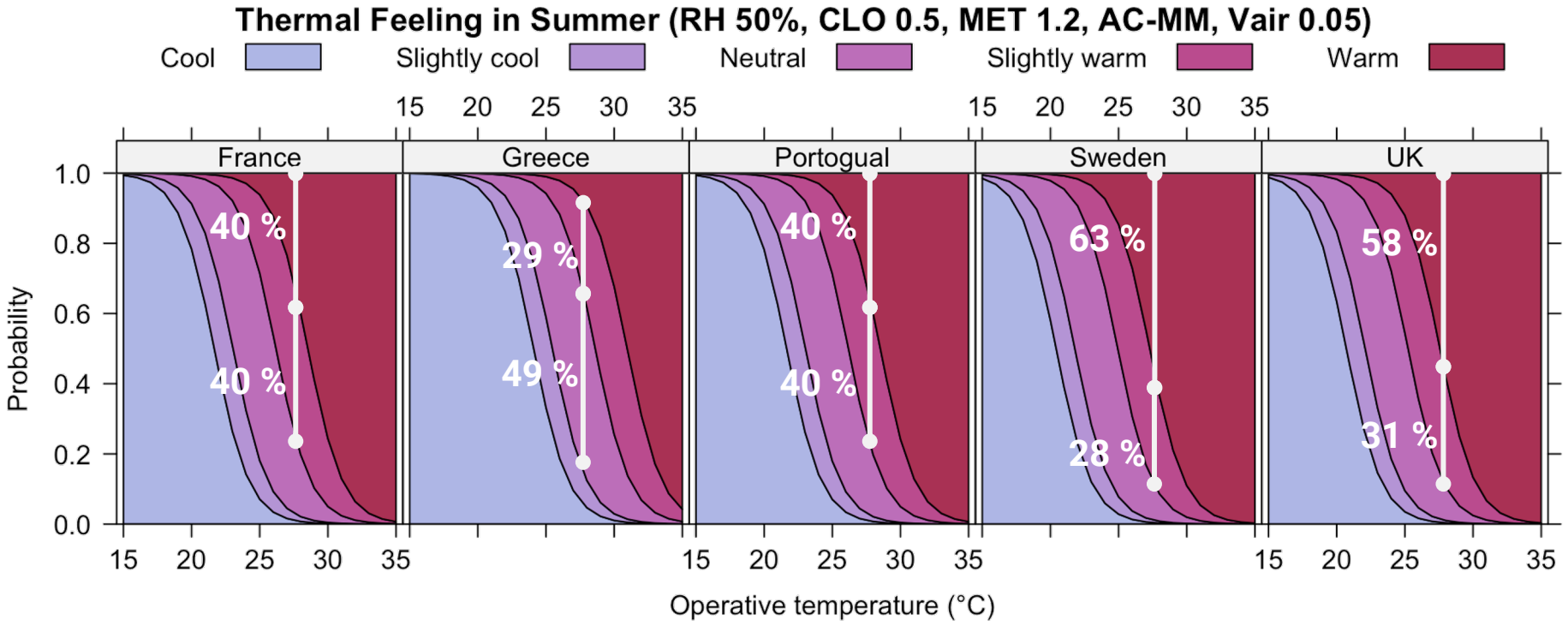
Scenario: Standard UNI EN 16798-1 Design inputs for energy calculations

	Indoor Environmental Quality categories			
Summer	**IV**	**III**	**II**	**I**
Operative Temperature	**28 °C**	**27 °C**	**26 °C**	**25.5 °C**
Mechanically Ventilated				

MET: 1.2
CLO: 0.5
RH: 50%
Air velocity: < 0.1 m/s

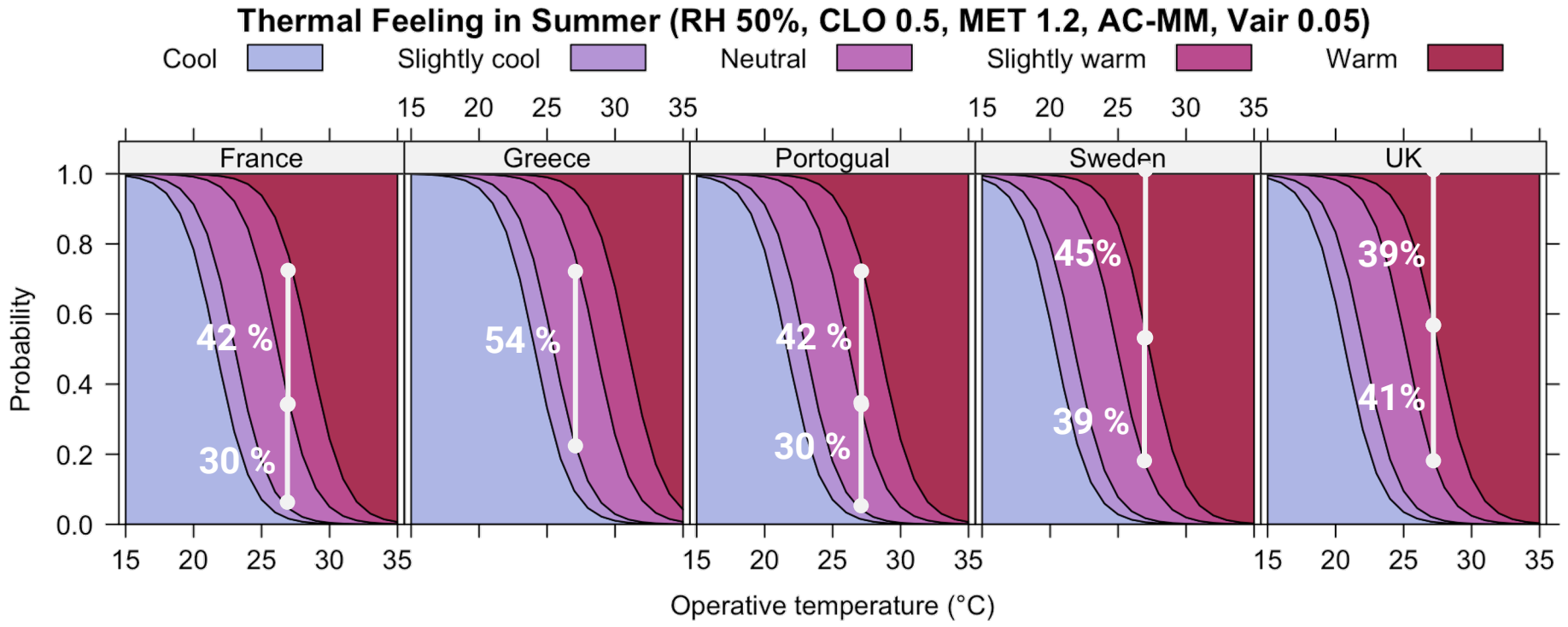
The Thermal Feeling moves...

IV Category
Operative Temperature = 28 °C



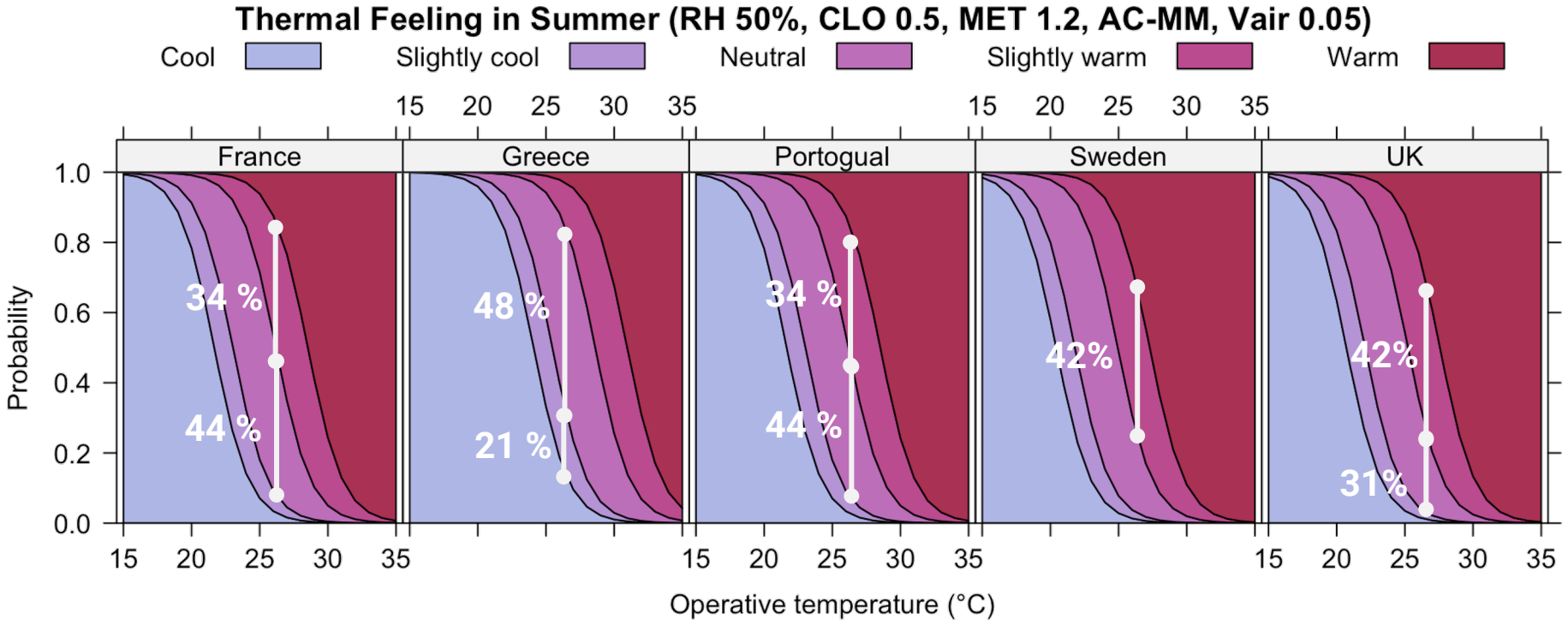
The Thermal Feeling moves...

III Category
Operative Temperature = 27 °C



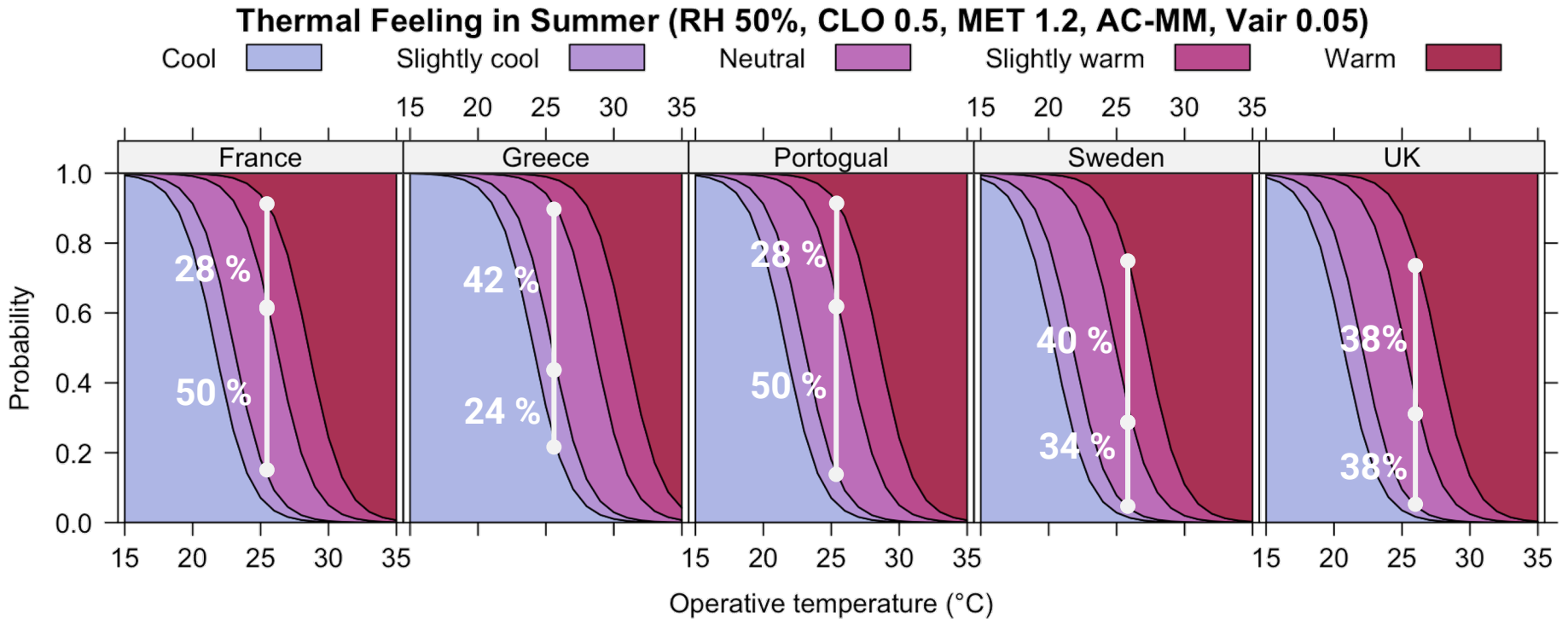
The Thermal Feeling moves...

II Category
Operative Temperature = 26 °C



The Thermal Feeling moves...

I Category
Operative Temperature = 25.5 °C



2. Thermal Neutrality → ATLAS LAYER

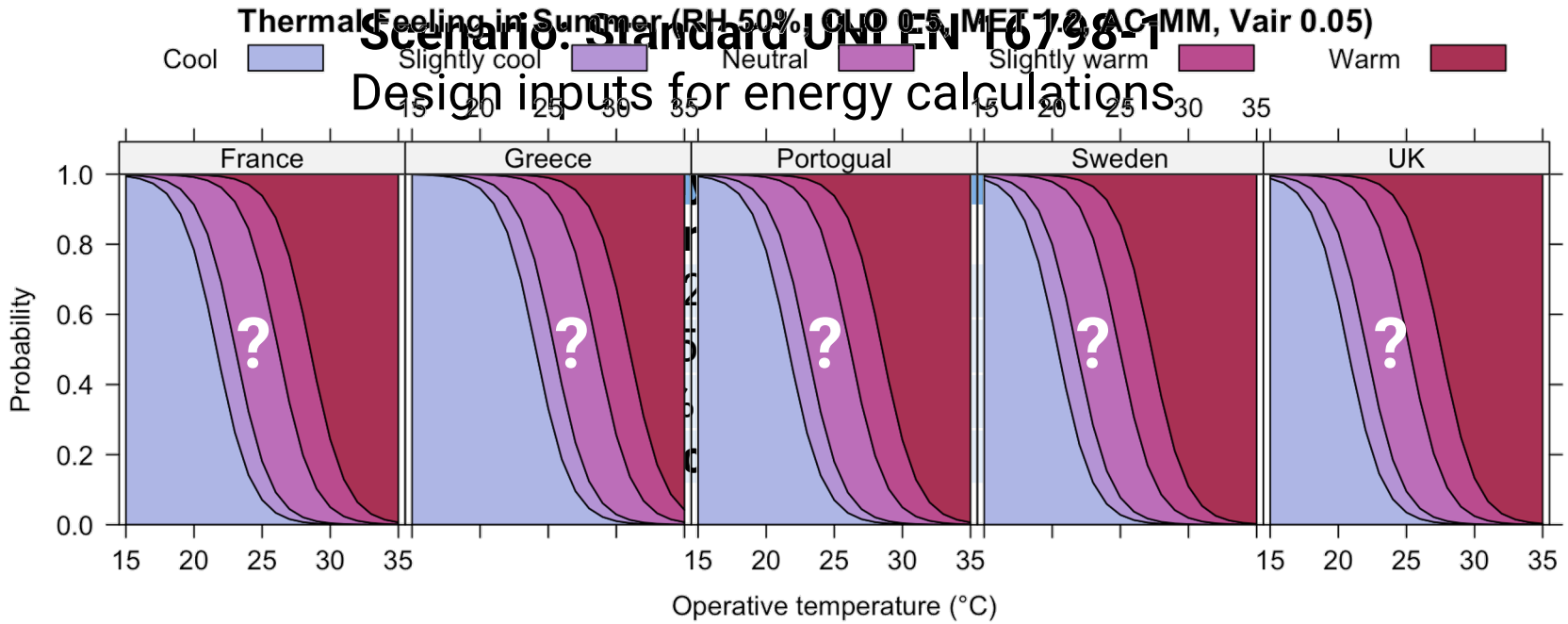
Which is the Operative Temperature (Top) value that maximizes

the "I am feeling neutral" TF (thermal feeling) vote of a user

for each Country (EL-PT-UK-FR-SE)

in each scenario given by the Standard?

And the Top value ranges from "I am feeling slightly cool" to "I am feeling slightly warm"?



Thermal Neutrality

Greece			France		
Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm
25.3 °C	27.6 °C	30.3 °C	22.9 °C	25.2 °C	27.9 °C

UK			Portugal			Sweden		
Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm
21.9 °C	24.2°C	26.9 °C	22.9 °C	25.1 °C	27.9 °C	21.6 °C	23.9 °C	26.7 °C

3. Thermal Preference → ATLAS LAYER

Which is the Operative Temperature (Top) value that maximizes

the "I want no change" TP (thermal preference) vote of a user

for each Country (EL-PT-UK-FR-SE)

in each scenario given by the Standard?

And the Top value ranges from "I would like it a bit cooler" to "I would like it a bit warmer"?

Scenario: Standard UNI EN 16798-1

Design inputs for energy calculations

Thermal Neutrality does not necessarily mean Thermal Preference

Naturally Ventilated
Summer
MET: 1.2
CLO: 0.5
RH: 60%
Air velocity: < 0.1 m/s

Naturally Ventilated

Summer

MET: 1.2

CLO: 0.5

RH: 60%

Air velocity: < 0.1 m/s

Thermal Preference

Greece			France		
A bit cooler	No change	A bit warmer	A bit cooler	No change	A bit warmer
29.2 °C	25.2 °C	21.0 °C	28.4 °C	24.4 °C	20.2 °C

UK			Portugal			Sweden		
A bit cooler	No change	A bit warmer	A bit cooler	No change	A bit warmer	A bit cooler	No change	A bit warmer
27.2 °C	23.3 °C	19.1 °C	28.3 °C	24.3 °C	20.1 °C	18.8 °C	23.0 °C	26.9 °C

Thermal Neutrality

Greece			France		
Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm
25.3 °C	27.6 °C	30.3 °C	22.9 °C	25.2 °C	27.9 °C

UK			Portugal			Sweden		
Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm	Slightly cool	Neutral	Slightly warm
21.9 °C	24.2°C	26.9 °C	22.9 °C	25.1 °C	27.9 °C	21.6 °C	23.9 °C	26.7 °C

Limits and further integrations

- Presented results are the outcome of the analysis of the SCATs database
- Generalizations are based on this sample of observations
- The aim is proposing a new approach in order to account for diversities
- Results need to be validated and integrated with analysis of other databases

The 2CAP-Energy Atlas: what you can find?

- **4. Indoor Environmental Quality Aspects**
  - 4a. Environmental Parameters
  - 4b. Operative Temperature – Thermal Feeling
  - 4c. Operative Temperature – Thermal Neutrality
  - 4d. Operative Temperature – Thermal Preference

Thank you for your attention!

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WP5 leader

“Co-benefits of Plus Energy Buildings”

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