Thermal comfort

- Executive summary
- What was tested in the field
- Research projects
- Contact

Executive Summary

Thermal comfort is much more then just air temperature, it is the complex mechanism between a human beings body, its mind, the shelter and the climate.
A lot of thermal comfort adaptation have been done to the RHU over the year by user and organisation in the field, it is mostly anecdotal evidence that describes if they had impact. Measuring the impact is essential to determine the actual impact, therefor Better Shelter joint several research projects.

Results:

- Order of mitigation should be followed when adjusting the RHU for thermal comfort
- Different solutions gathered from the field
- Active heating can be installed with local solutions
- Both active heating and insulation improves thermal comfort during winter

Lessons learned:

Solutions from the field needs to be further evaluated to determine effect, and more solutions should be gathered and shared

Next steps:

- Continue with research projects
- Test white foil version, and shade net in the field and record data
- Produce guidelines with collected methods to improve thermal comfort

> **“that condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation.”**

Thermal comfort

Thermal comfort is a result of:
Location, climate factors and the shelters envelop.

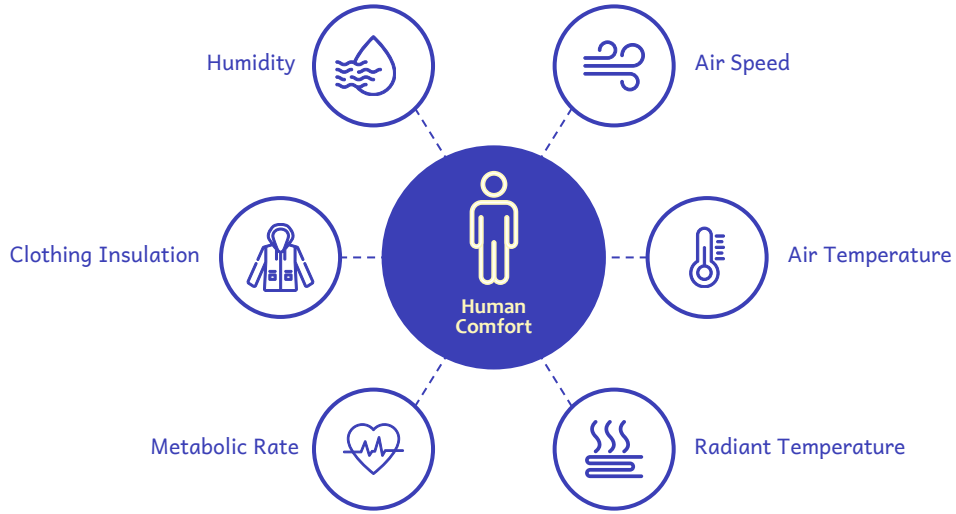
Thermal comfort inside of a shelter is determined by:
Indoor temperature, humidity, radiation, air flow and solar radiation.

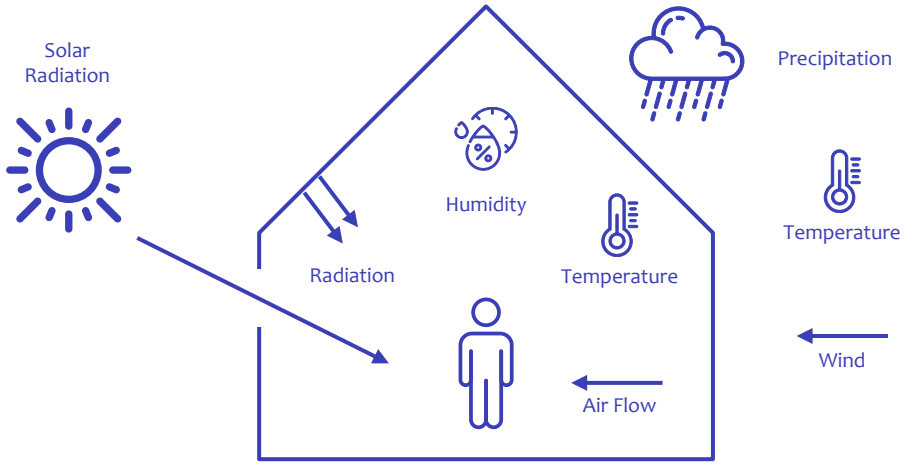
If a human being feels comfortable is depended on:
Clothing, metabolic rate and individual expectations

Occupants control their thermal environment by:
Clothing, windows/vents, fans, personal heaters/coolers and sun shades.

> **That condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation."**
> (ASHRAE, 2017)

> **It is the range of environmental conditions for which minimum body heat production is needed to maintain the core temperature of 37oC"**
> (Holmes et al., 2016).

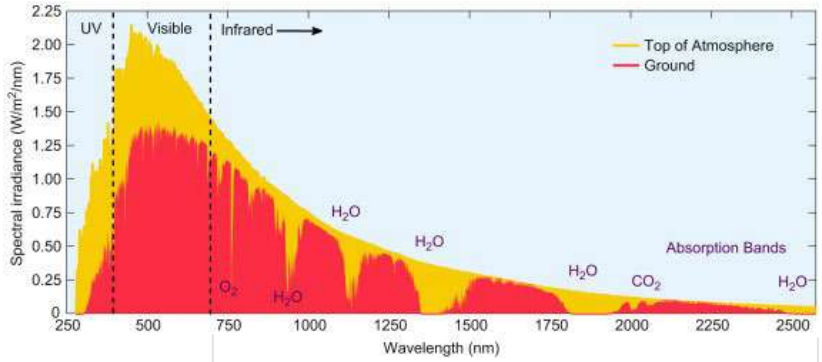




Thermal Comfort

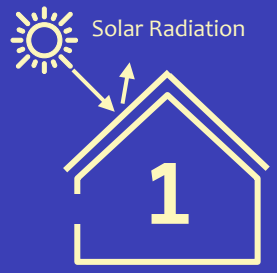
- Infrared radiation is what we mainly feel as heat.
- Overheating is when indoor temperature becomes higher than outdoor temperature.
- Overheating is mainly determined by solar radiation in light weight structures (RHU).

Spectrum of Solar Radiation (on earth)

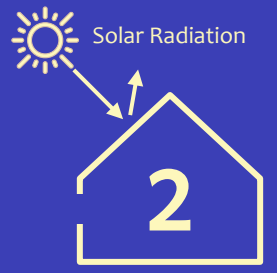


Infrared part of the light spectrum where the left part contains most energy

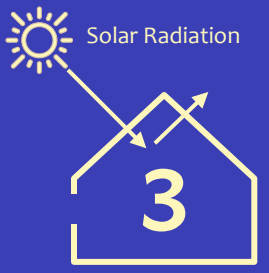
Order of mitigating infrared radiation



Blocking the sun before it reaches the shelter



Blocking the sun on/in the panel



Removing the heat after entering

ASHREA: American Society of Heating, Refrigerating and Air-Conditioning Engineers

Thermal Comfort

- A naked person start to feel cold below 25°C
- A human produces 85W of heat when sleeping and a candle 100W
- In light weight structures (RHU) most energy losses are transmission losses through walls, roof and floor.

Mitigating cold

More clothing

Heating

Insulating

ASHREA: American Society of Heating, Refrigerating and Air-Conditioning Engineers

Background

After the launch of RHU version 1.0 it became known that thermal comfort inside the RHU in some operation have been identified as an issue.

With the RHU, as with most temporary shelter, temperatures indoor sometimes reach higher values then outdoor because of limitations of the structure.

RHU 1.0 – 1 ventilation opening each side

Two more ventilation openings were added in RHU version 1.2.

RHU 1.2 – Double ventilation openings each side

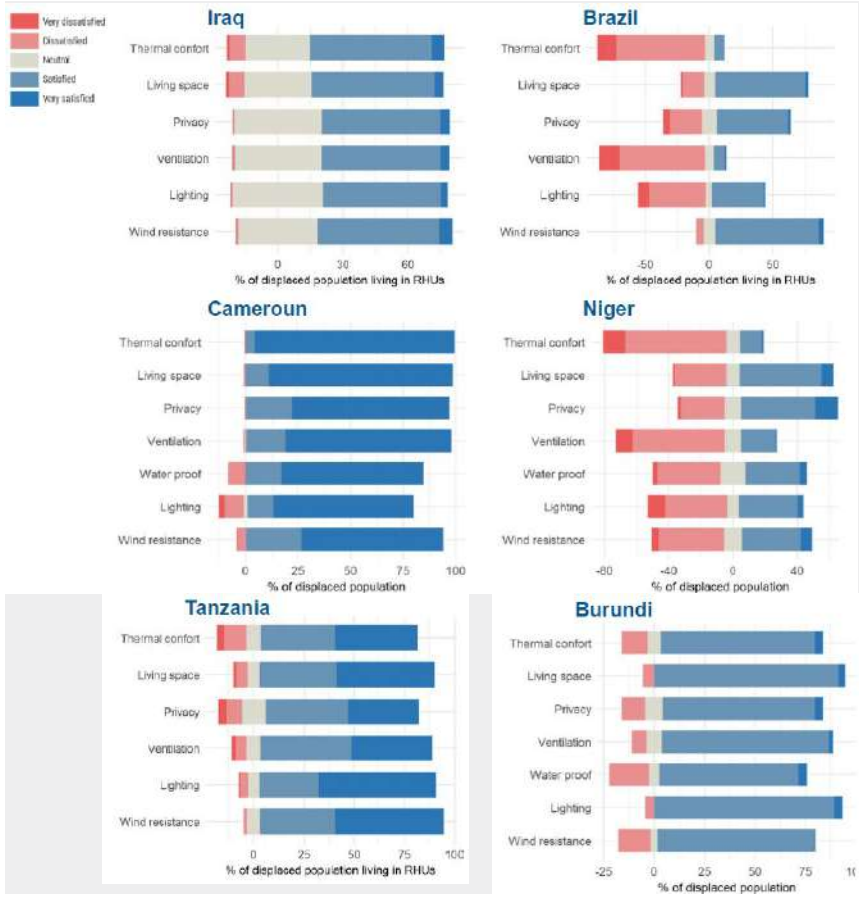
Background

IMPACT initiative assessment

ordered by UNHCR interviewed user of the 1.0 and 1.2 on important functions of the shelter.

Thermal comfort was one of these functions.
Result show that in Brazil and Niger POCs were most dissatisfied with the thermal comfort.

Female residents are less satisfied than male residents.



Feedback Iraq, Brazil, Cameroun, Niger, Tanzania and Burundi

What was tested in the field

Shade Net

Ecuador, 2020

Niger, 2019

Brazil, 2021

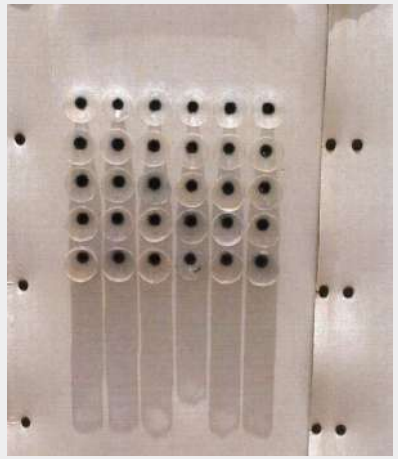
Additional Roofs

Rep. of Congo, 2019

Brazil, 2021

Rep. of Congo, 2021

What was tested in the field



Djibouti, 2016

Brazil, 2018

Ethiopia, 2014

Additional Openings

What was tested in the field

Additional Openings

NW Syria, 2021

Brazil, 2021

What was tested in the field

Insulation

NW Syria, 2020

NW Syria, 2021

Iraq, Kurdistan, 2014

Desert coolers

Iraq, Kurdistan, 2014

Iraq, Kurdistan, 2014

Watering the floor

Ethiopia, 2014

What was tested in the field

Air Conditioners

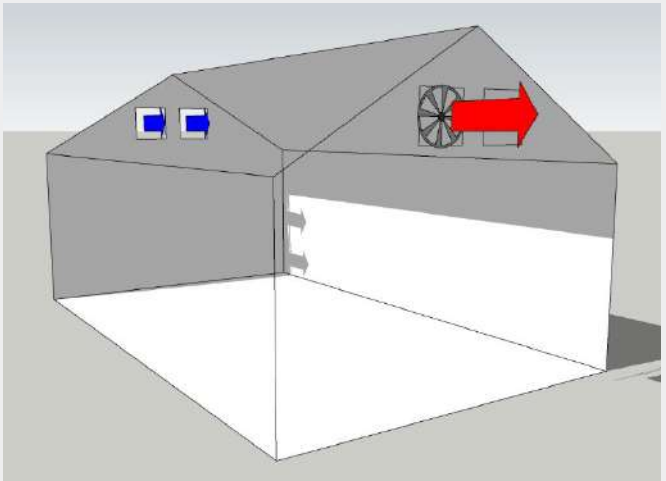
Ethiopia, 2013

Brazil?, 2020

Mexico, 2020

Mechanical Ventilation

Bangladesh, 2018



Bangladesh, 2018

What was tested in the field

Lesvos Greece, 2016

Iraq, Kurdistan, 2014

NW Syria, 2021

Winter condition

What was tested in the field

"A few women came up to us to say thank you because it's been making a huge difference. One woman has arthritis and it's been getting less painful because it's warmer inside her place. Some women don't even use their heater anymore and can live in t-shirts in the wintertime in their RHUs."

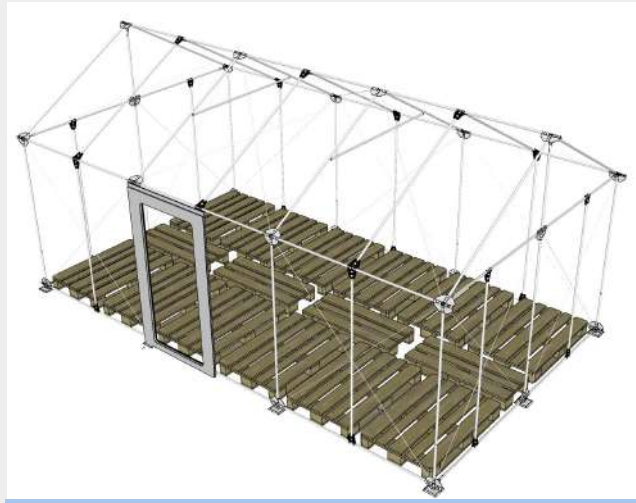
Refugee statements through EuroRelief January 2022

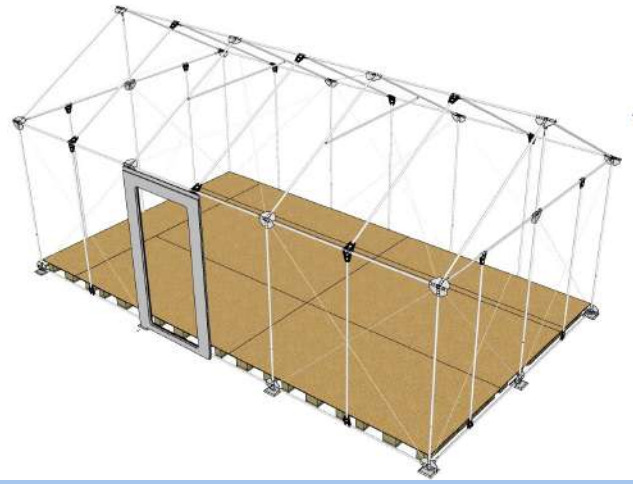
Lesvos Greece, 2021

Winter condition

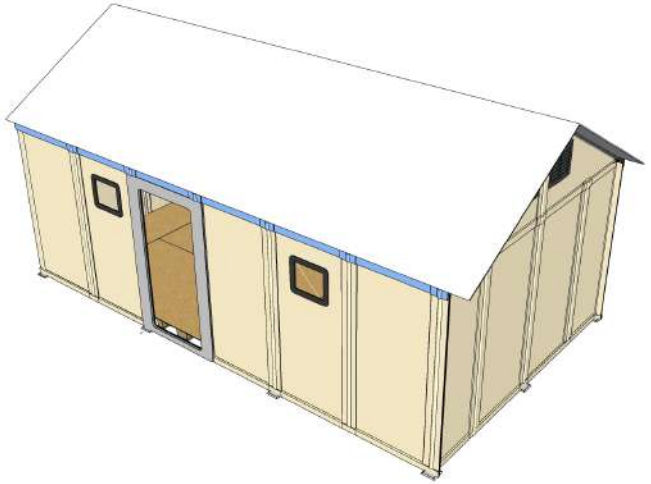
Adaptation for basic winter condition

Adaptation for basic winter condition





FLOOR:
A raised floor made out of pallets and covered with plywood



ROOF:
Covered with plastic sheeting

HEATING:
A 2kW heater

Bill of Materials for Insulation

			Quantity/RHU	
Solution 1 – RHU with roof tarpaulin, pallet/plywood floor and heater				
Plastic sheeting (4m role width)	1 sheets	6 m	6 m1	10% roll
Pallets (Euro size)			16 pcs	16 pcs
Plywood (1220x2440mm) 15-18mm			6 pcs	6 pcs
Heaters 2kW min			1 pcs	1 pcs
Woodscrew 4.5x40mm	6 per pallet		88 pcs	88 pcs
Solution 2 – RHU with full tarpaulin cover, insulation/plywood floor and heater				
Plastic sheeting (4m role width)	3 sheets	6 m		18 m1
Hard pressed insulation material min. 30mm				17,3 m2
Plywood (1220x2440mm)				6 pcs
Heaters 2kW min				1 pcs
Woodscrew 4.5x40mm				40 pcs

What was tested in the field

Almost all interventions contribute to increased thermal comfort but this is mainly backed by anecdotal evidence.

Passive interventions such as shade nets and additional roof are preferred above active interventions because they use energy.

How much these interventions contribute is unknow.
To understand this, measurement are needed.

Research project initiated or joined:

- Healthy Housing For The Displaced
- Waste 4 Warmth
- Eindhoven University Technology
- University of Baghdad

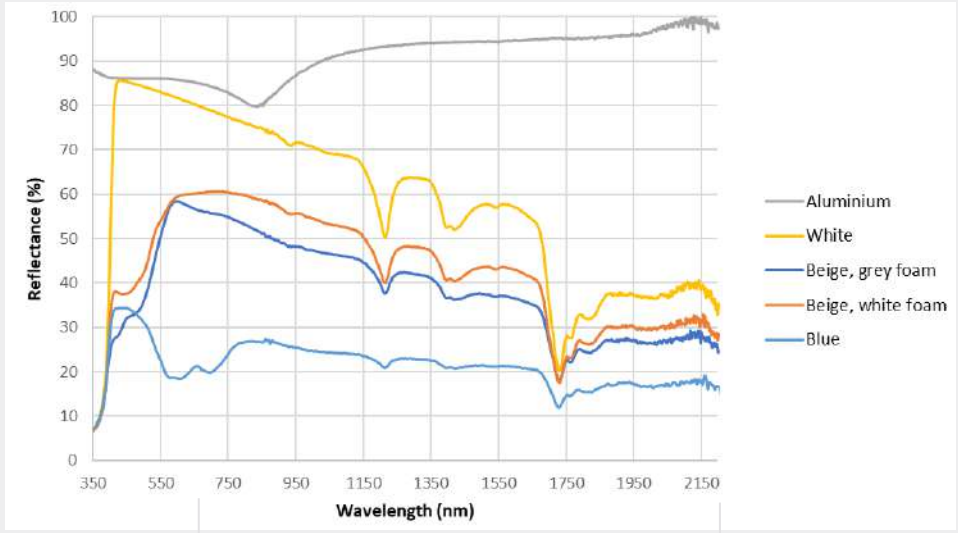
Temperature logging 2020-2021 (Gaziantep, Turkey)

Results from the research projects

Improvements suggested

- Addition of thermal mass (walls and floor slab)
- Addition of roof insulation
- Aluminium colour for all panels
- Lower infiltration (40 to 10 ACH)
- Roof shading
- Increased cross-ventilation (window/vent open)
- White colour for all panels

More realistic



Lessons learned

To high temperatures during summer time seems more of an issue for the RHU then to cold temperatures during winter. Focus has therefore been on overheating.

Winter

- A stove solution on wood, olive pit fuel or kerosene increases the temperature significantly.
- Adding insulation reduces energy needs but requires fire risk analysis and potentially fire risk mitigations.
- Guidance can be given with heating modalities together with fire risk mitigations.

Summer

- Blocking of solar energy should be done as early as possible e.g. with shade nets or reflective panels.
- Forced ventilation by a fan in front of a ventilation opening can decrease the temperature inside the shelter more then natural ventilation.
- Window and door placement should be selected on predominant wind-direction.
- White or aluminium foil on outside panels reduces indoor temperature.
- Blocking most IR-radiation means limited natural lighting trough the panels.

Contact us

We encourage you to contact us to ensure a right implementation!

The purpose of this document is to show implementing partners the options for using structures or RHUs.

If you find any inconsistency in the content of this document or have any suggestions, we would love to hear from you.

We facilitate a phone number to make technical communication as quick and easy as possible.

Miguel Acebron Garcia de Eulate

Technical Support Manager

miguel.eulate@bettershelter.org

+46 702 99 18 24