



Thermal comfort

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Contact us



We support partners before, during and after the implementation of our shelters.

Apart from technical support, we offer consultations on how you can adapt our shelters to meet your specific needs.

If you notice any inconsistencies in the content of this document or have any suggestions, please reach out.



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Thermal comfort is more than the air temperature; it is the complex mechanism between a human's body, mind, shelter and climate. Many thermal comfort adaptations have been made to the RHU over the years by users and organisations in the field. Measuring the impact is essential to determine the effect.

Results

- Order of mitigation should be followed when adjusting the RHU for thermal comfort
- There are many different solutions gathered from operations
- Active heating can be installed with local solutions.
- Both active heating and insulation improve thermal comfort during winter

Lessons learned

Solutions need further evaluation to determine their effect, and more should be gathered and shared.

Next steps

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



It is the range of environmental conditions for which minimum body heat production is needed to maintain the core temperature of 37° C

Thermal comfort

Thermal comfort is a result of

Location, climate factors and the shelter.

Thermal comfort inside a shelter is determined by

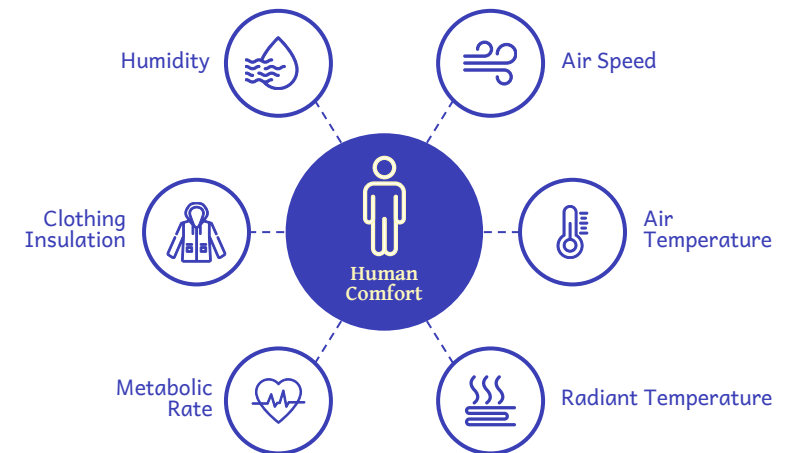
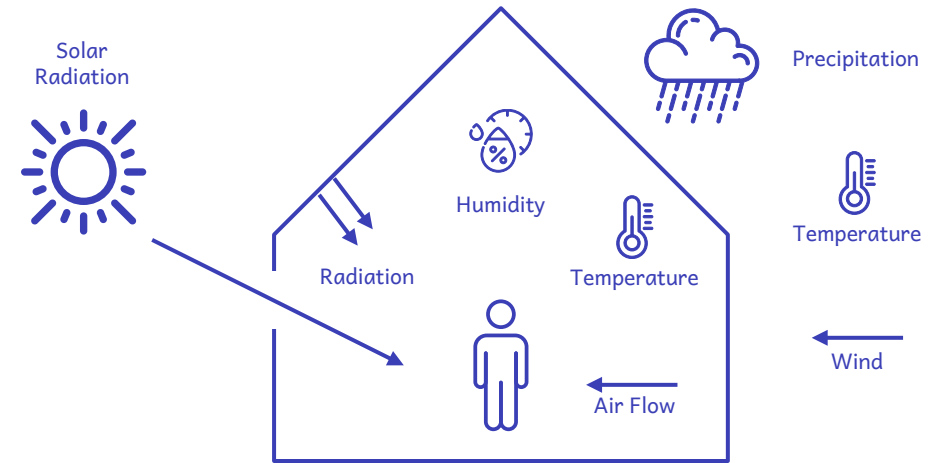
Indoor temperature, humidity, radiation, airflow and solar radiation.

The experience of comfort depends on

Clothing, metabolic rate and individual expectations.

Residents control their thermal environment by

Clothing, windows/vents, fans, personal heaters/coolers and shade.



“

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

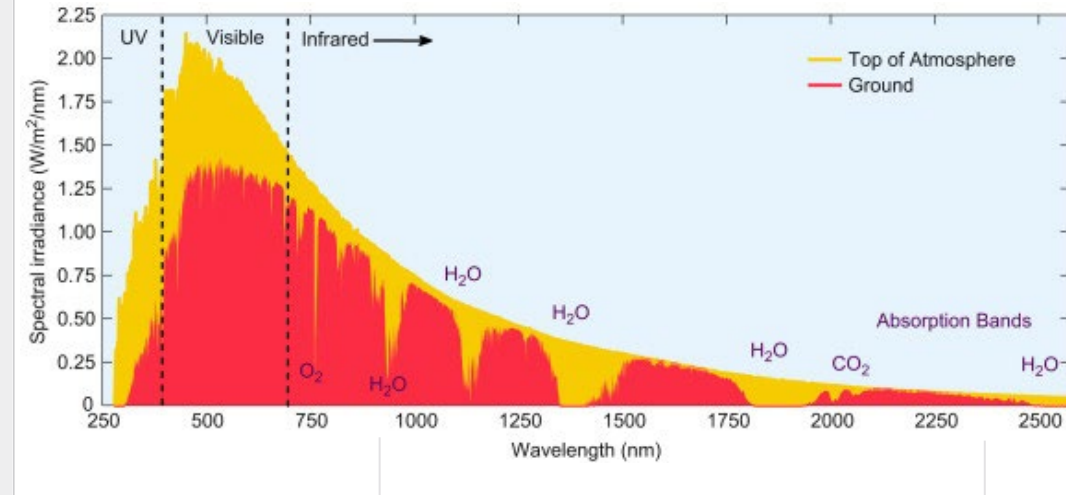
“

It is the range of environmental conditions for which minimum body heat production is needed to maintain the core temperature of 37° C”.
(Holmes et al., 2016).

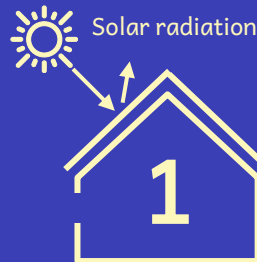
Thermal comfort

- ✓ Infrared radiation is mainly what we experience as heat.
- ✓ Overheating is when the indoor temperature becomes higher than the outdoor temperature.
- ✓ Overheating is mainly determined by solar radiation in lightweight structures (RHU).

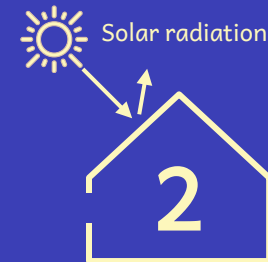
Spectrum of solar radiation



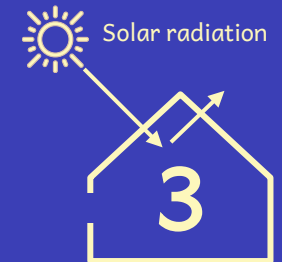
Order of mitigating infrared radiation



Blocking the sun before it reaches the shelter



Blocking the sun on/in the panel



Removing the heat already within the shelter

Thermal comfort

- ✓ A naked person starts to feel cold below 25°C.
- ✓ A human produces 85W of heat when sleeping, and a candle 100W.
- ✓ In lightweight structures (RHU), most energy losses are transmission losses through walls, roofs and floors.



Mitigating cold



More clothing



Heating



Insulating

Background



After launching RHU version 1.0, it was discovered that thermal comfort inside the RHU was inadequate in some operations.



Temperatures inside temporary shelters like the RHU can often exceed outdoor temperatures due to structural limitations.

Two more ventilation openings were added in the new version.



RHU first version – one ventilation opening on each side.



RHU second version – two ventilation openings on each side.

IMPACT initiatives assessment

Commissioned by UNHCR, IMPACT Initiatives interviewed users of the RHU about the essential functions of the shelter.

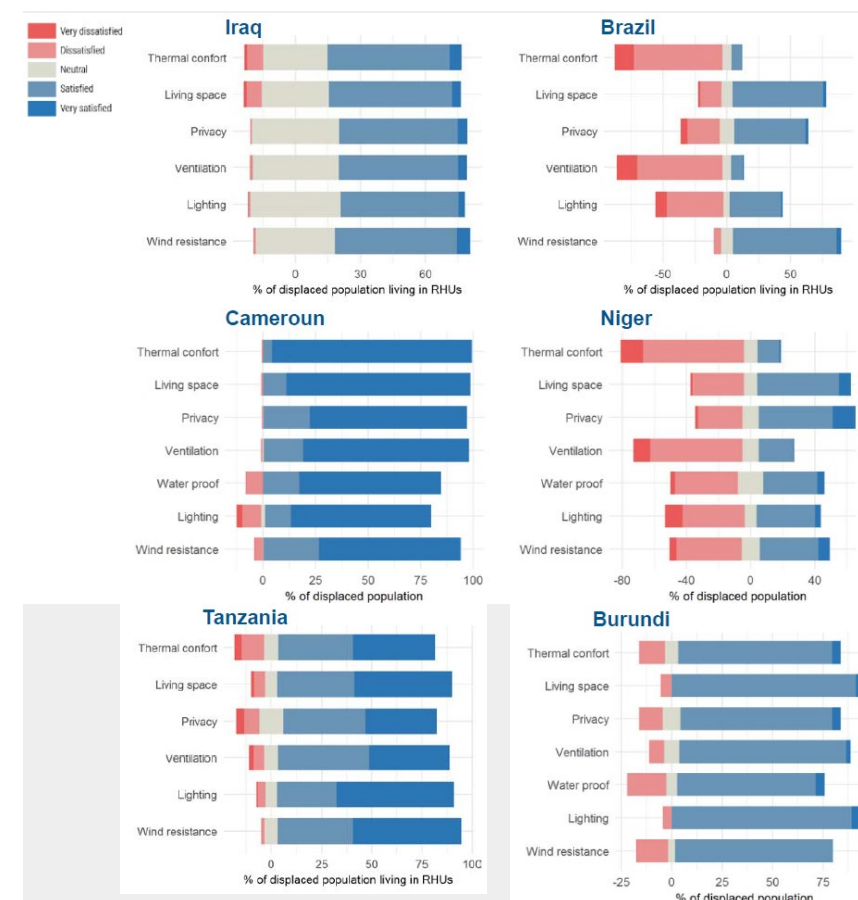


Thermal comfort was one of these functions

Results show that people in Brazil and Niger were most dissatisfied with the thermal comfort.



Female residents were less satisfied than male residents.



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

What has been tested



Shade net



Ecuador, 2020



Niger, 2019



Brazil, 2021



Additional
roofs



Rep. of Congo, 2019

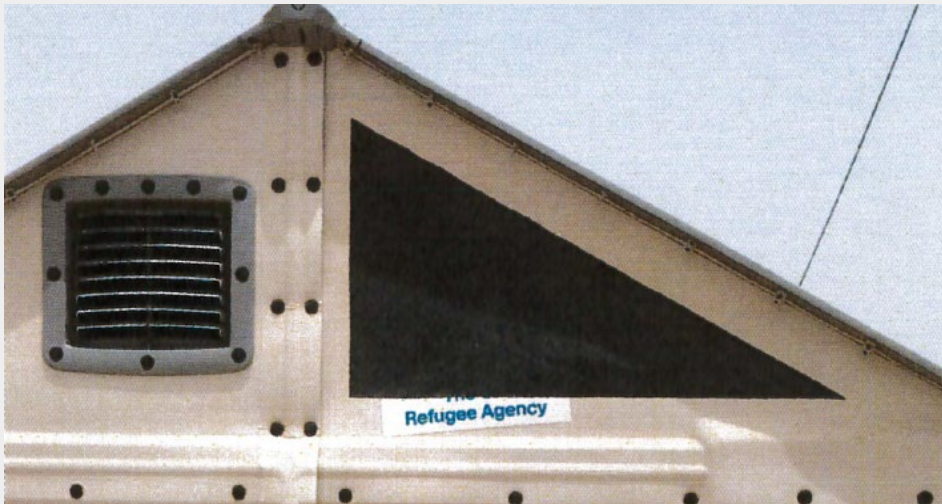
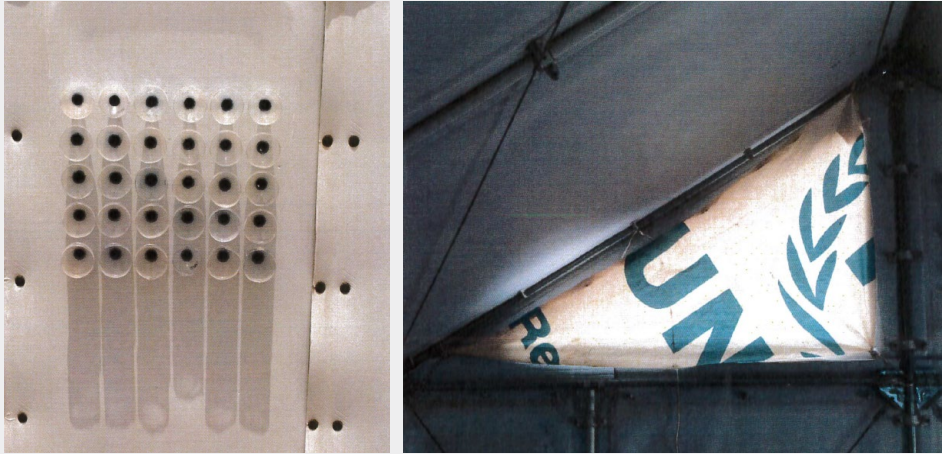


Brazil, 2021



Rep. of Congo, 2021

What has been tested



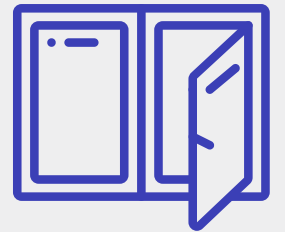
Djibouti, 2016



Brazil, 2018

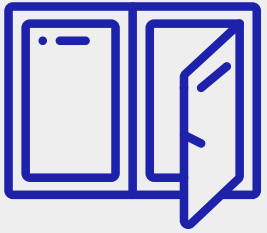


Ethiopia, 2014



Additional
openings

What has been tested



Additional
openings



NW Syria, 2021



Brazil, 2021

What has been tested

Insulation



NW Syria, 2020



NW Syria, 2021



Iraq, Kurdistan, 2014

Desert coolers



Iraq, Kurdistan, 2014



Iraq, Kurdistan, 2014

Watering the floor



Ethiopia, 2014

What has been tested



Air Conditioners



Ethiopia, 2013



Brazil, 2020



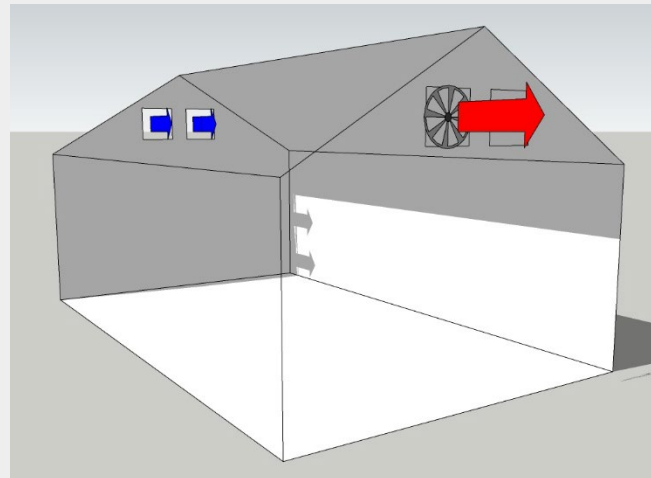
Mexico, 2020



Mechanical ventilation



Bangladesh, 2018



Bangladesh, 2018

What has been tested



Lesvos, Greece, 2016



Iraqi Kurdistan, 2014



NW Syria, 2021



Winter
condition

What has been tested



“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 wear t-shirts in the wintertime in their RHUs.”

- Refugee statements through EuroRelief January 2022



Lesvos Greece, 2021



Winter
condition

What has been tested

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

Passive interventions, such as shade nets and roofs, are preferred over active interventions as they use less energy. How much these interventions contribute is unknown. To understand this, we need to measure it.



Research projects 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 research projects

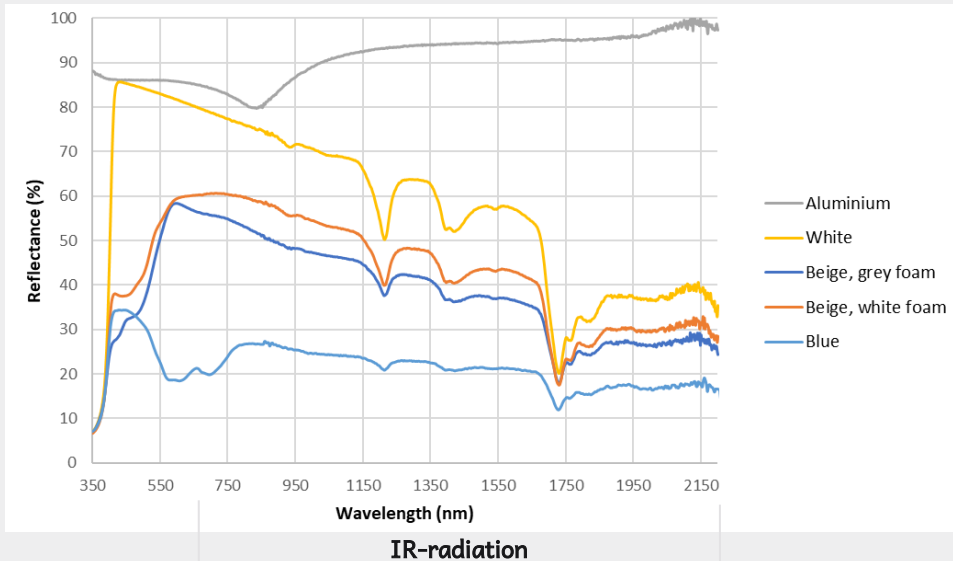


Suggested improvements

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

More realistic

Less realistic



Lessons learned

For people living in the RHU, high temperature is a more significant concern than cold temperatures. Therefore, our focus has been on preventing overheating.



Low temperature

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

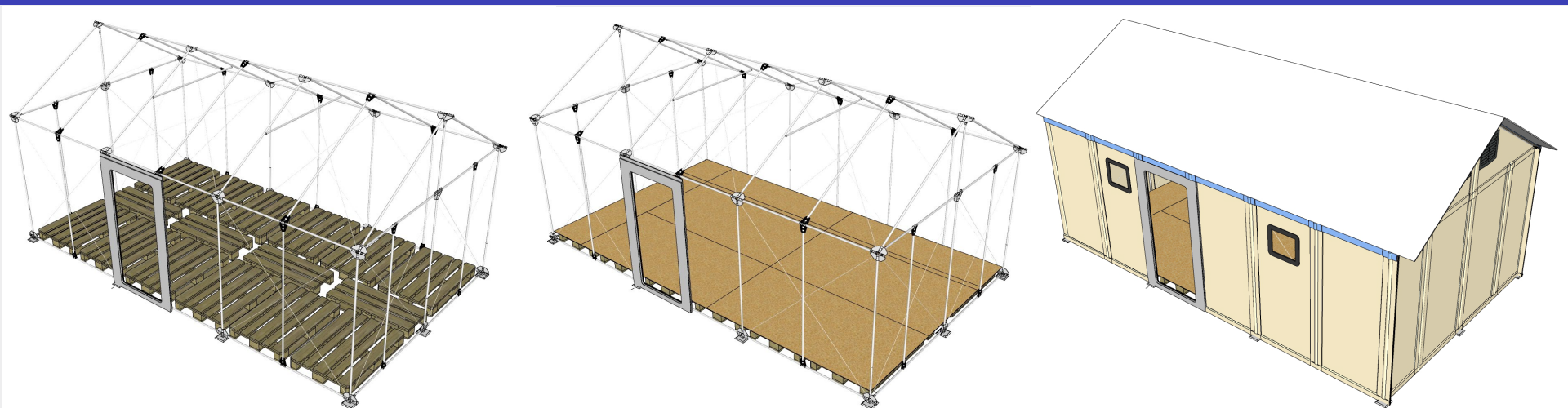


High temperature

- 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 than natural ventilation.
- Window and door placement should be dependent on the predominant wind direction.
- White or aluminium foil on the outside panels reduces indoor temperature.
- Blocking most IR radiation means limited natural lighting through the panels.



UNHCR's adaptations for basic winter condition



FLOOR: A raised floor made from 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 |

UNHCR's adaptations for basic winter condition



A human-centered design approach



We believe shelter is not just a product but a dynamic process. To that end, we embrace a human-centred design approach.

Every stakeholder's perspective is invaluable in our design process, and the people who inhabit our shelters are at the heart of our design philosophy.

We consider the intricate humanitarian landscape, the logistical challenges of UN agencies, INGOs and NGOs, and on-ground realities, cultural nuances, and climatic conditions.

We aim to develop shelters that seamlessly integrate with the diverse needs of the communities they serve.