Back to Nature!

Modern Climate-responsive **natural buildings** in rural China

Earth houses design and research for Yantai Aone Eco-village

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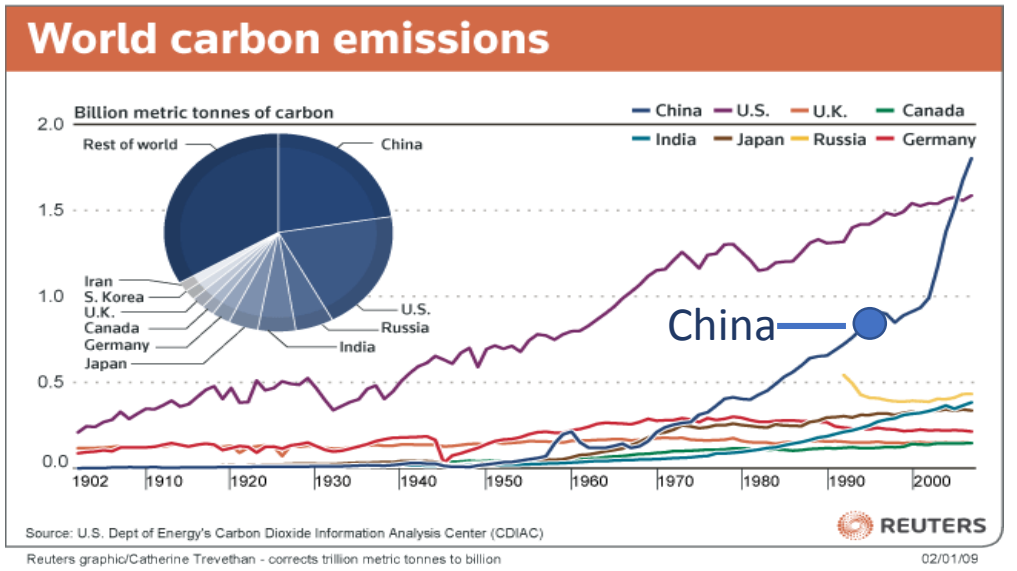
CONTEXT

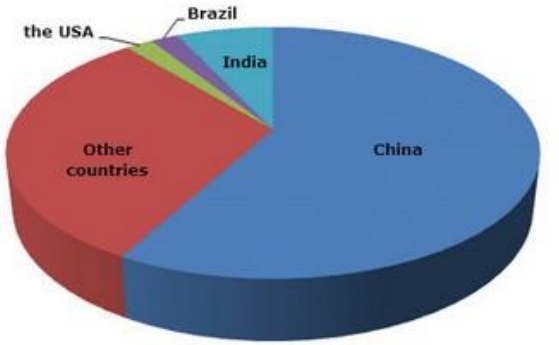
China is now in a fast pace of urbanization. There are massive construction works in both cities and countrysides.

As a results, more than half of the world concrete production is consumed in China, which brings high embodied CO2 emissions.

Meanwhile, as a fact, Chinese Co2 emission have been also skyrocketed to the first of world in just few years.



Concrete consumption



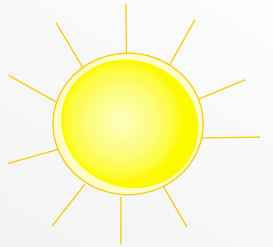
More and more urbanites now are longing for...

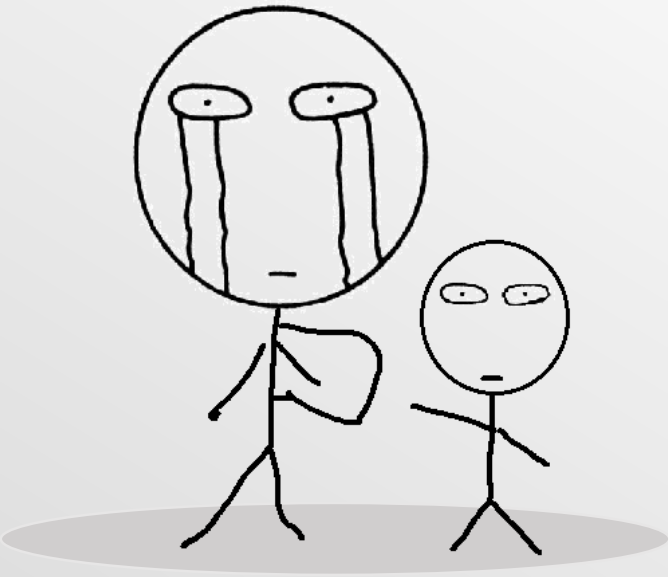
Escape from the concrete forest ~

Farm house and natural life enjoyment ~

Bearing with thee feeling of artificial environment and bad air quality, more and more urbanites are generating a strong intention to get rid of the concrete forest and go back to coutryside, enjoying the connection of the nature.

Then they probably end up in another concrete frost...

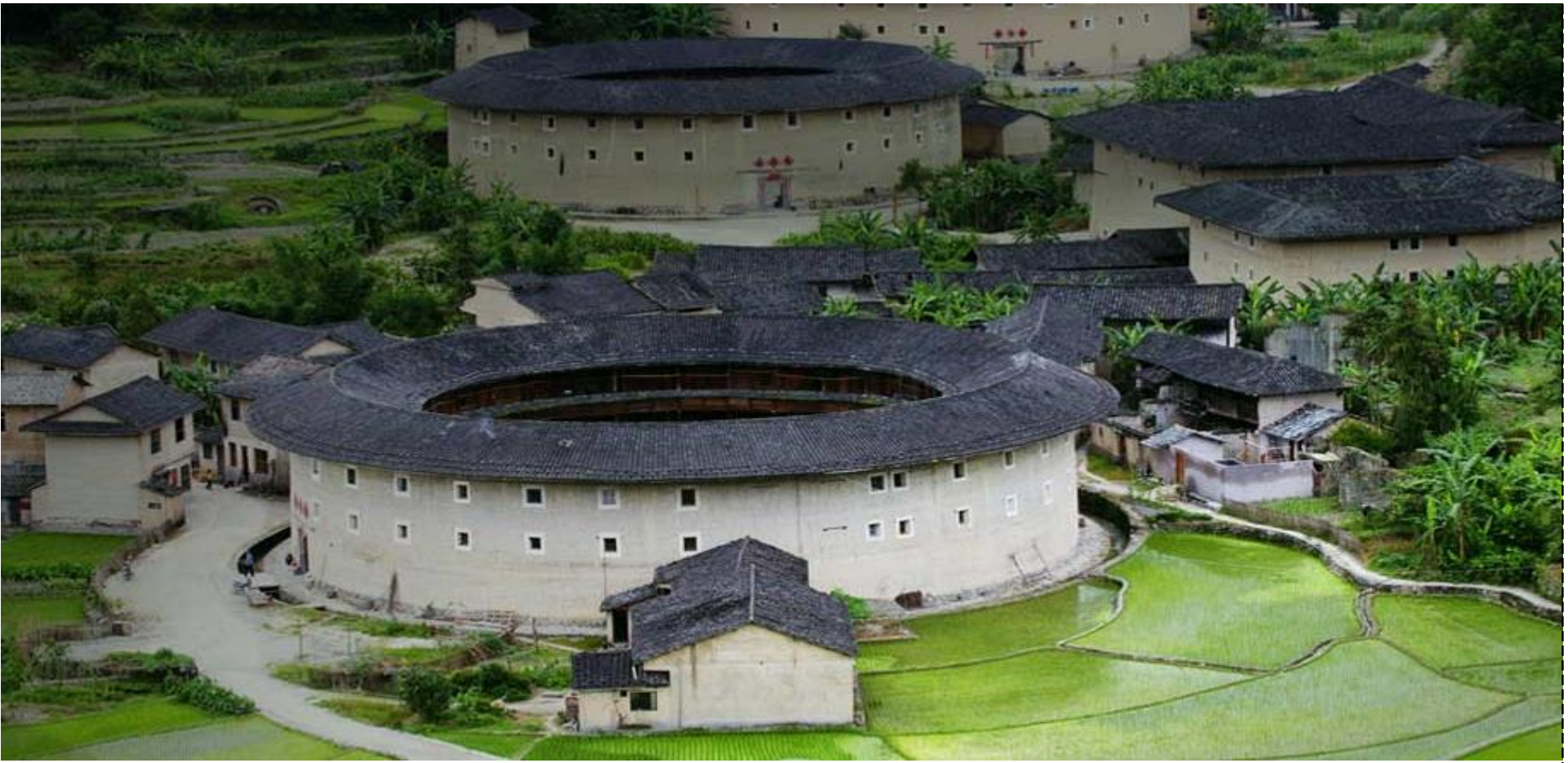




However, those escapers will be disappointed as now the rural houses are also made with concrete with no connection with local climate.

The countrysides across China is getting to the same outlook,just another small concrete forest. The government is promoting a series of building templates which will boost thsi trend.

We had it before but we lost it now



Earth buildings of Hakka, Fujian South East China

Historically, the ancient Chinese architecture emphasizes on the harmony with the nature

Earth building of Hokka show in the picture is an example of historical vernacular buildings in South China.

The building use rammed earth for its great moisure absoption in that humid clmiate.

Using the thermal mass to mitigate the hot summer days and natural ventialtion oriented design, the building has even better comfort than current concrete houses.

There are something we are losing now..

Shaping an new solution for future?

High performance houses

High tech
High cost
High embodied CO2
High comfort
Low energy consumption

Comfortable and localised modern natural houses?

Old natural buildings

Low tech
Low cost
Natural material-low impact
Hard to control the comfort
Low efficiency

The study is trying to shape a new MODERN NATURAL house combining the traditional Chinese philosophy of “natural harmony” with modern climate-responsive design and analysis technologies.

With the Key of “design”, the house should be still comfortable, environmental friendly and cost effective without using expensive high-tech concepts and building systems,

Yantai Aone eco-village

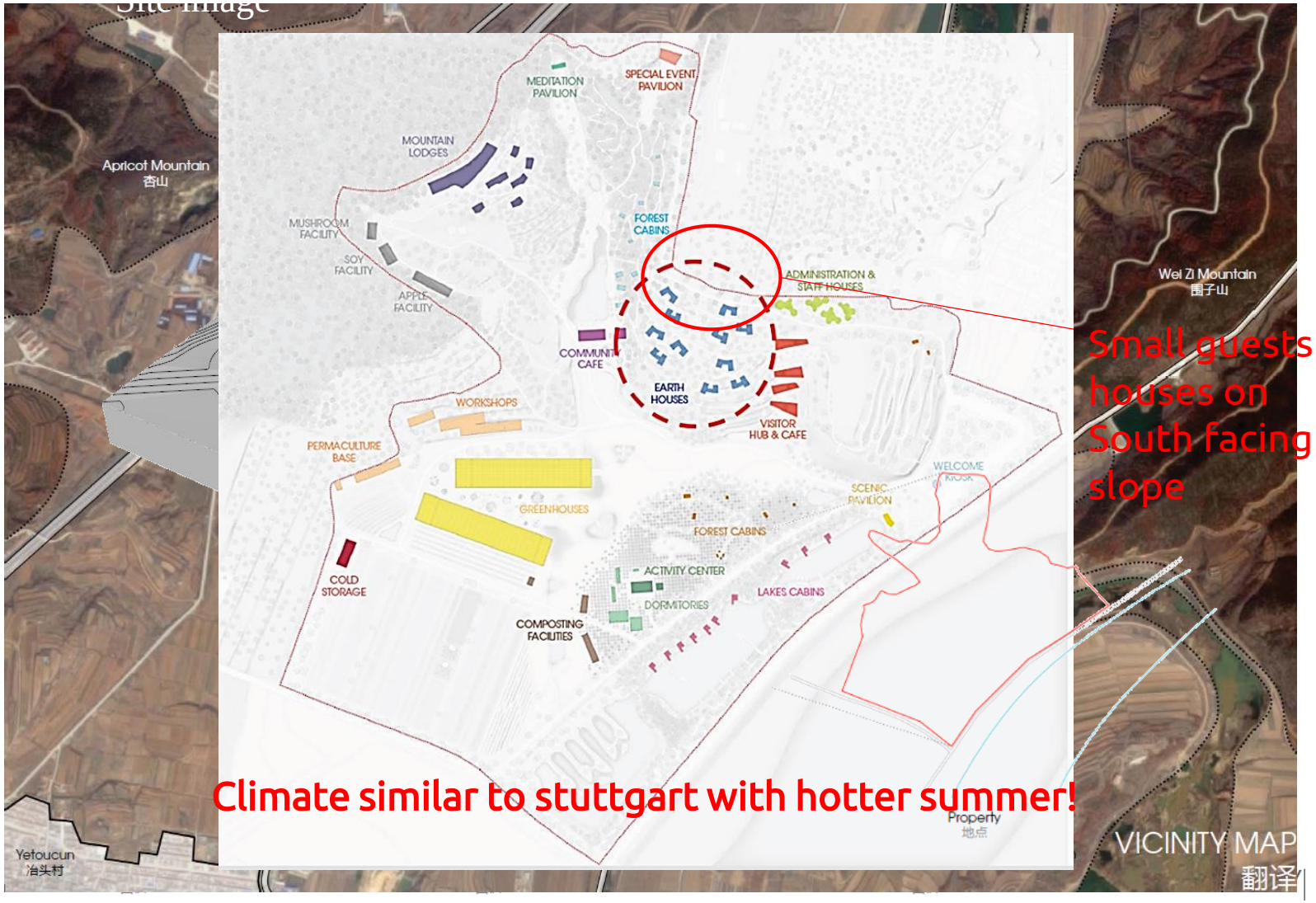
A chance to demostrate the Climate-responsive natural bulding

"DESIGN PROCESS"

Designer

Owner

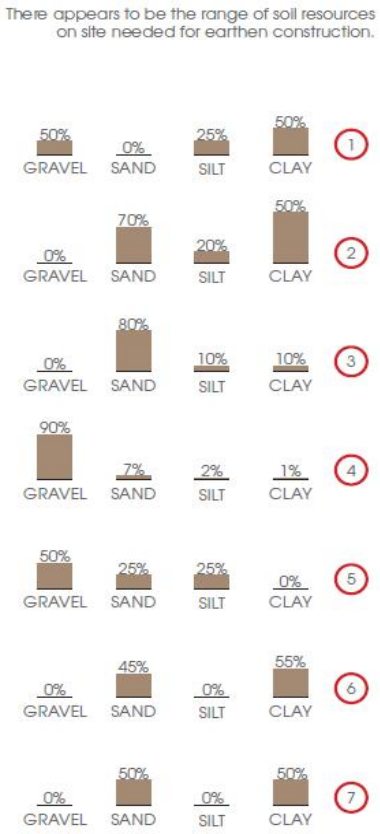
The study is took an on-going Eco-village project as platform. The owner is a agriculture tech company and designer offered us a chance to implement our idea to design some guesthouses for vistors.



The project locates in the suburban of Yantai city in North China, 100km to the BoHai See.

The climate in Yaitai is heating dominated climate but preventing overheating during hot summer days should also be considered.

The designated guests houses will be sitting on the south facing slope.



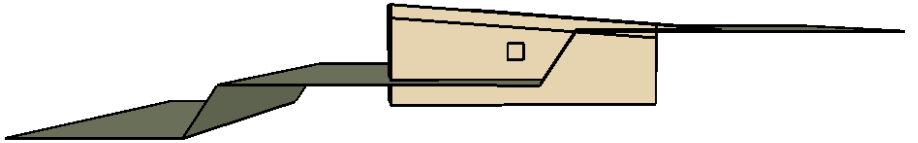
SOIL ANALYSIS

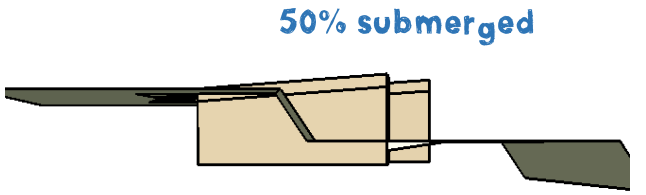
The site survey shows there are ideal local resource for rammed earth buildings.

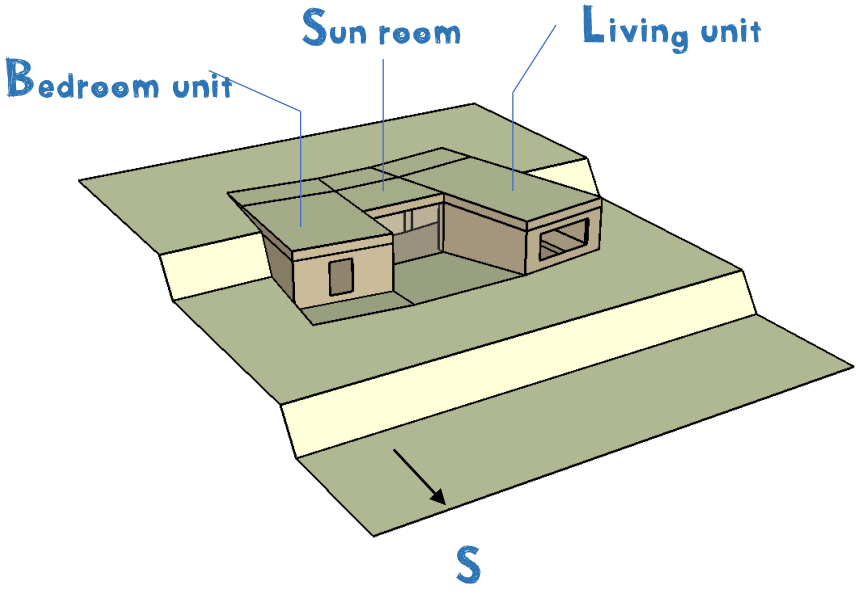
The owner and design also agree to use compressed stabilized earth block as primary building material.

The CSEB has similar thermal properties to building bricks with higher thermal capacity and advantage of better moisture absorption, the cost and embodied CO2 emission is much lower than concretes.

Original design



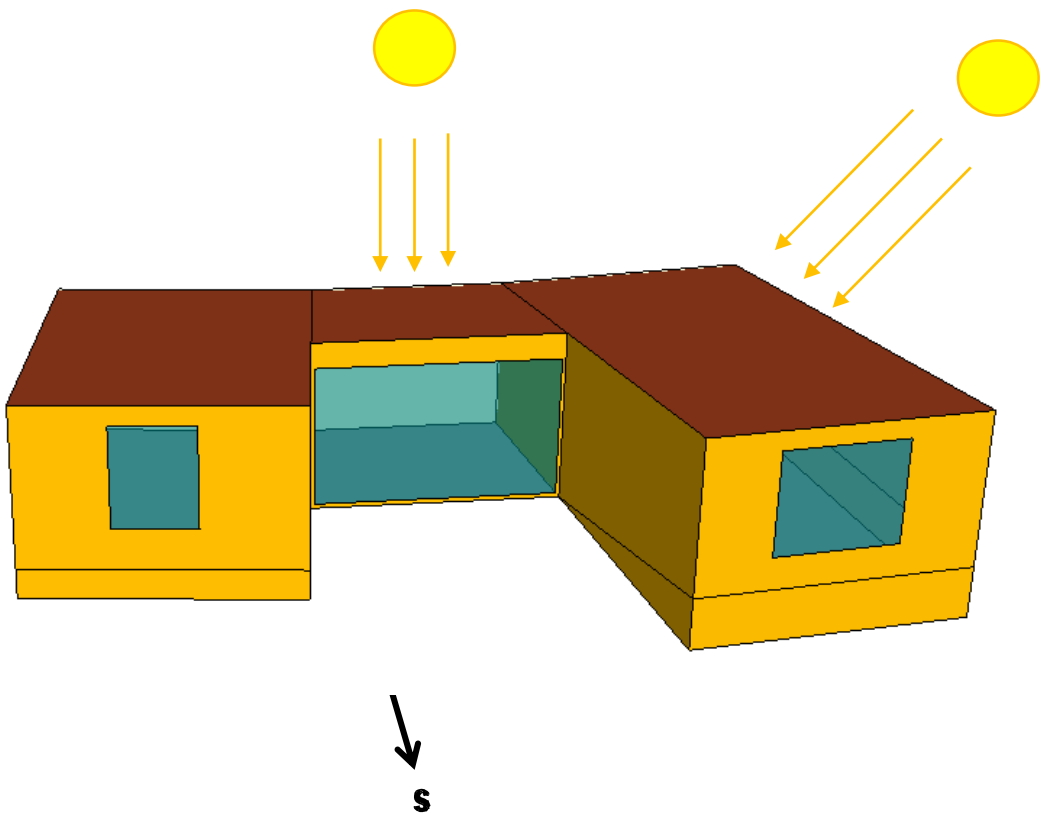




The submerging strategy is firstly decided to use the earth soil temperature as natural buffer and conditioner by submerging 50% (calculated optimized proportion) into the slope.

The design team came the first design concept of which the building is divided into 3 spaces, a sunroom (for better winter comfort) connecting a bedroom unit and living unit.

Original design analysis



✓ More than 15% reduction of heating load.

✓ 30% reduction in overheating hour.

X GH is not efficient in benefiting adjacent rooms.

X Discomfort in GH most of time.

X High heating load in spring.

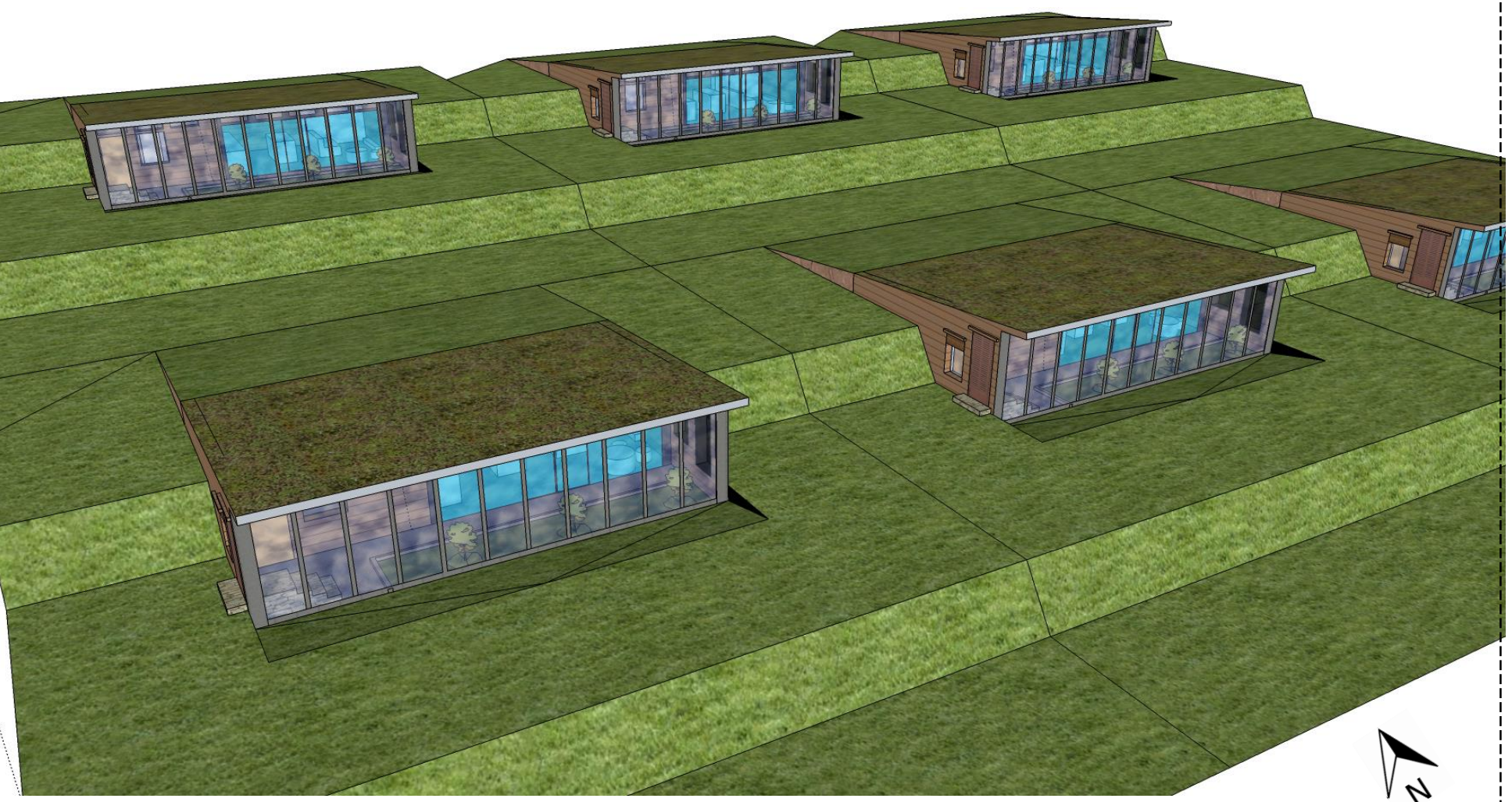
X Overheating in summer

The heating demanding is 15% lower than current common practice. However, the improvements are not as good as expected.

The sun room it shaded from the east and west, resulting in insufficient solar radiation in the morning and afternoon during winter and related problems.

Simulation indicated overheating was still a issue to solve.

Proposed design (earth houses)



To address those problems, a new layout is then proposed. The position of sun room is relocated to the south, south wall is glazed (or other high transparent) to capture more useful solar radiation.

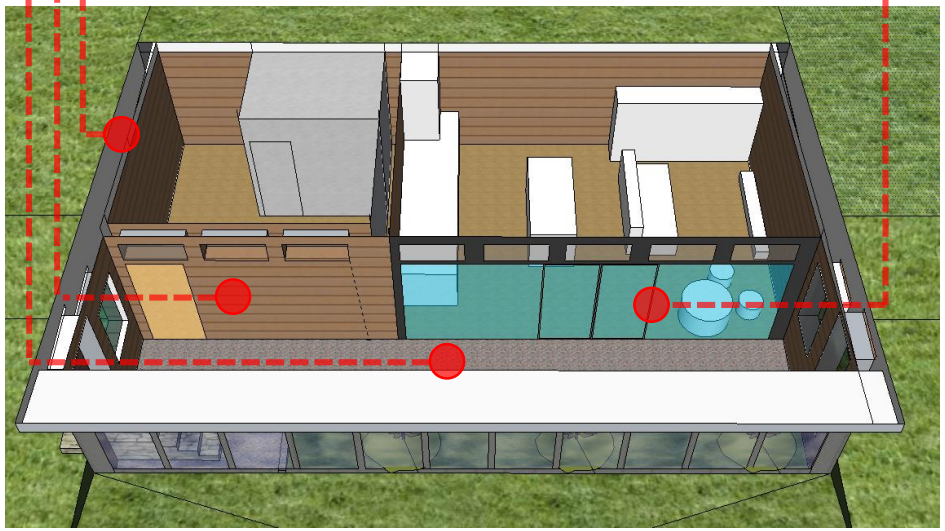
Proposed design and improvements in climate approaches

Greenhouse pre-conditioning

High thermal mass bedroom

Earth shelterred envelope

Living room glazedwall



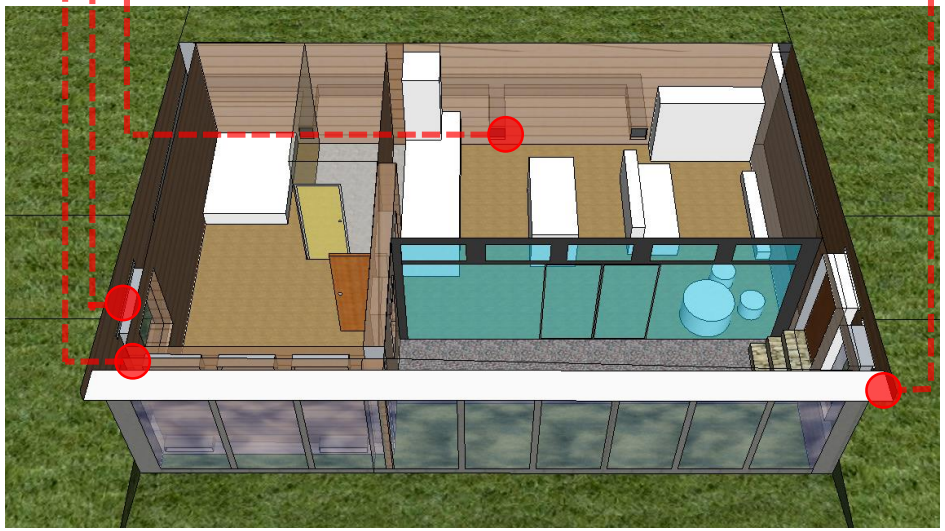
Original proposal

Move South bedroom wall, Trombe wall

Allowindow on west (Daylighting, ventilation)

Earth duct ventilation

Optimized overhang size



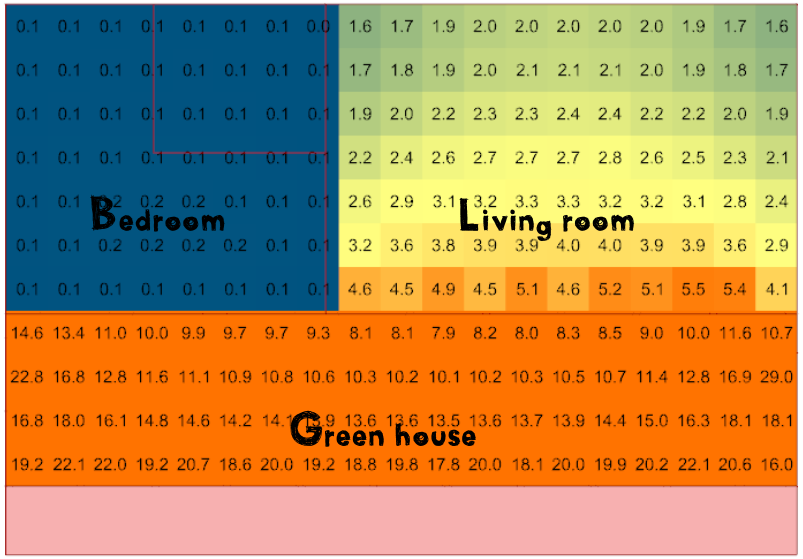
Improved proposal

In the proposed design, several climate approaches are used (picture left).

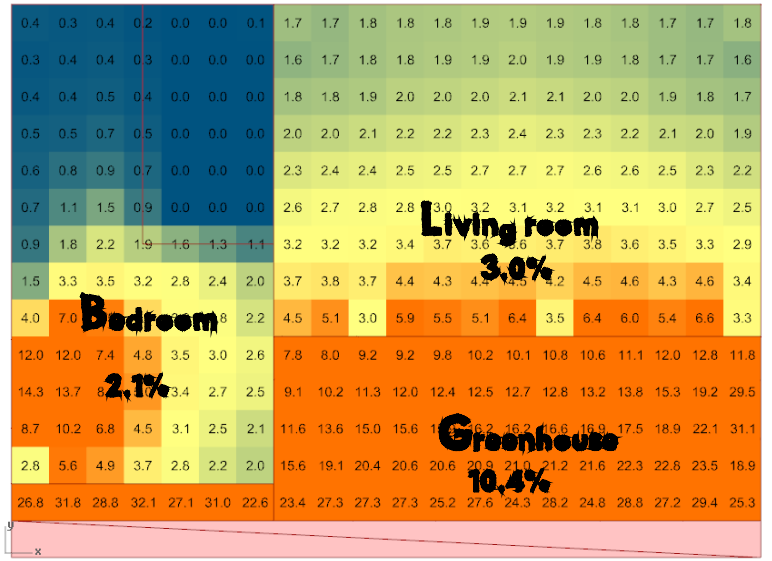
Then analysis are carried to improve the design. In improved design, the climate approach are modified and added.

Improved daylighting

Original proposal



Improved proposal



Average Daylight Factor

Bedroom=0.15%

Living room=2.7%

Greenhouse=10.2%

Average Daylight Factor

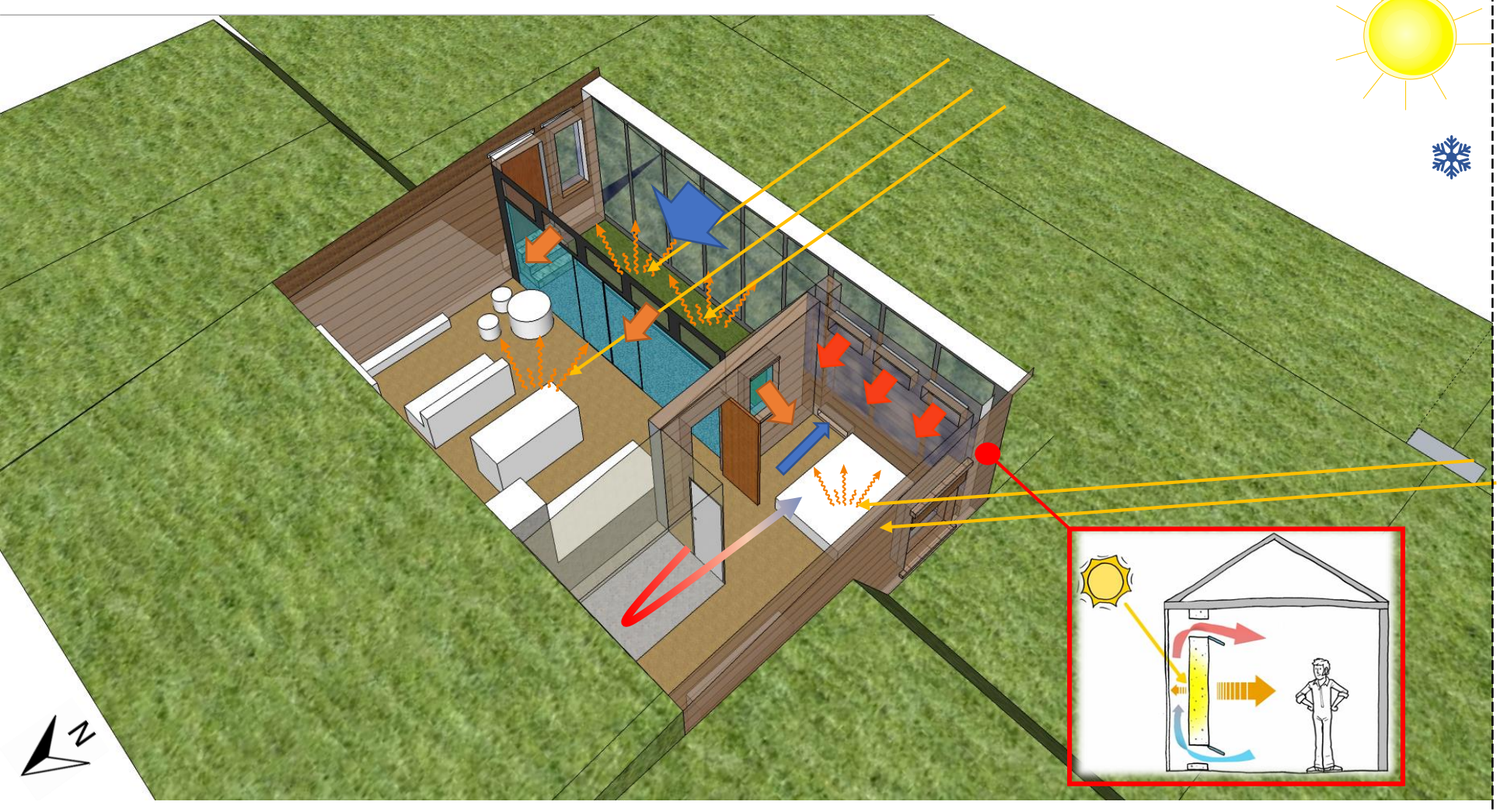
Bedroom=2.1%

Living room=3.0%

Greenhouse=10.4%

By moving the south wall of bedroom and add new window on west for bedroom, the average daylight factor in bedroom, living room and sunroom is 2.1%, 3.0% and 10.4% respectively, indicating good daylighting for all living spaces in improved proposal.

Climate concept (winter daytime)



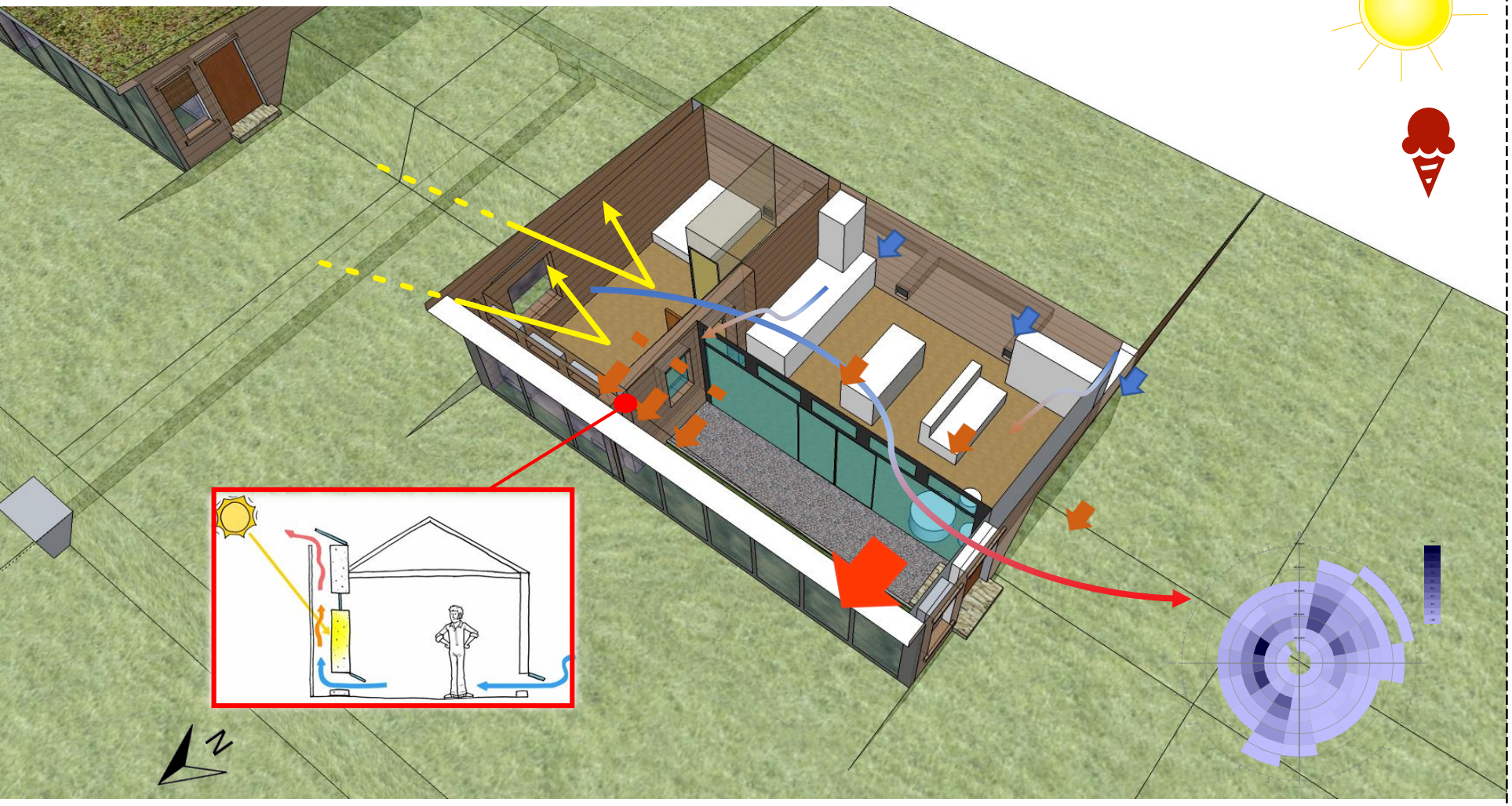
During winter days, when the sun rises up, the sunroom is quickly heat up. The preheat air is then moved to occupied room. High glazed living room wall also allows solar radiation to heat up the space quicker.

The tromble wall, at the meantime, will act as an natural heater. West facing window also allows sun to heat the bedroom in the afternoon.

Climate concept (winter nighttime)

During winter nights, heat is stored in the thermal mass and release to the space. Earth duct provide pre-heated air at the minimum flowrate, creating a good thermal comfort. .

Climate concept (summer daytime)

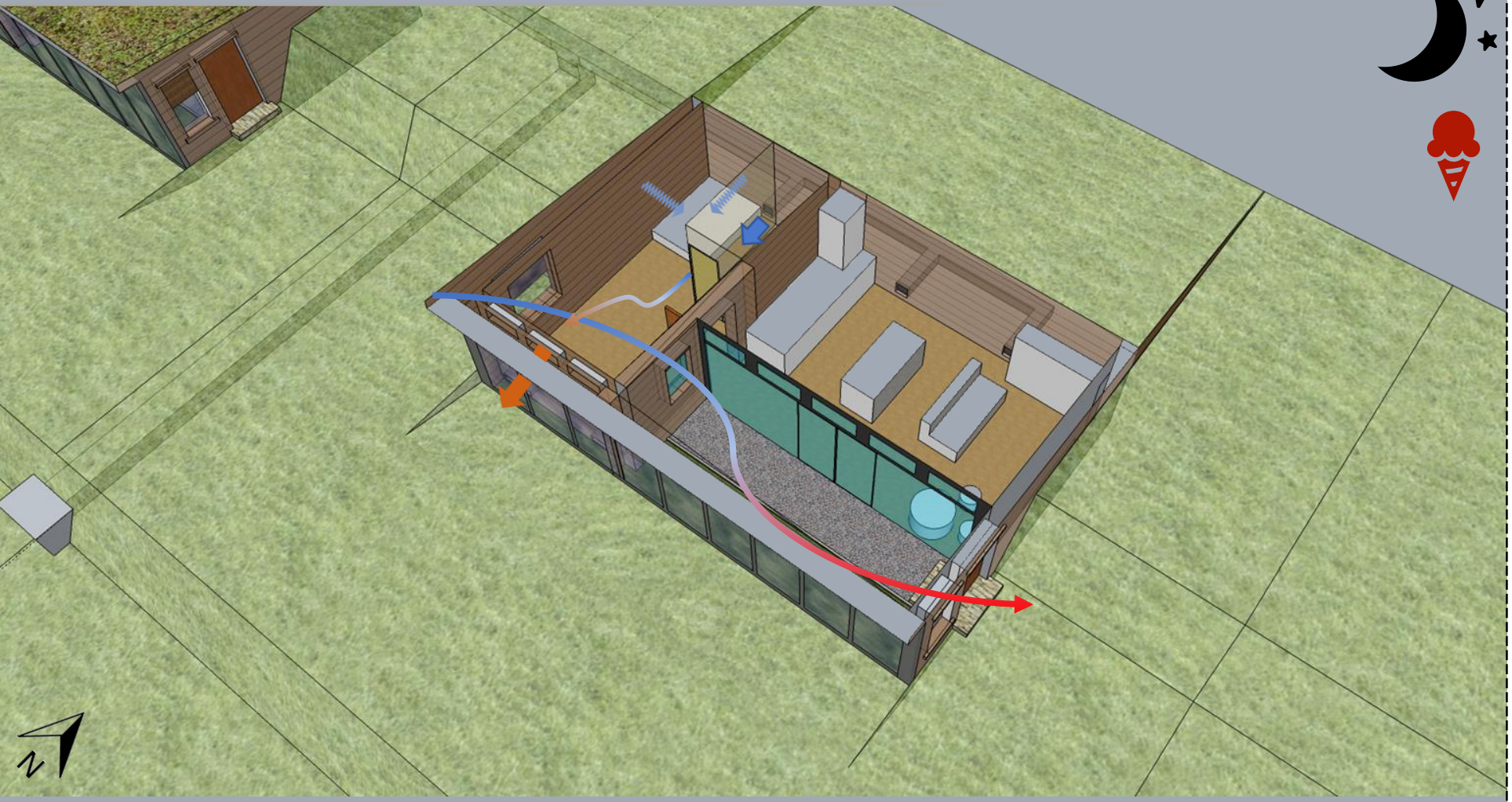


During summer days, proper solar prevention including overhang and external shades block exceed solar gains.

The earth duct supplies pre-cooled air as natural air conditioning.
The trombe wall will peform in the summer mode, bringing hot air out of the space by stack effect.

Cross natural ventilation from the prevaiiling wind form the west can be also a choice when outside air condition allows.

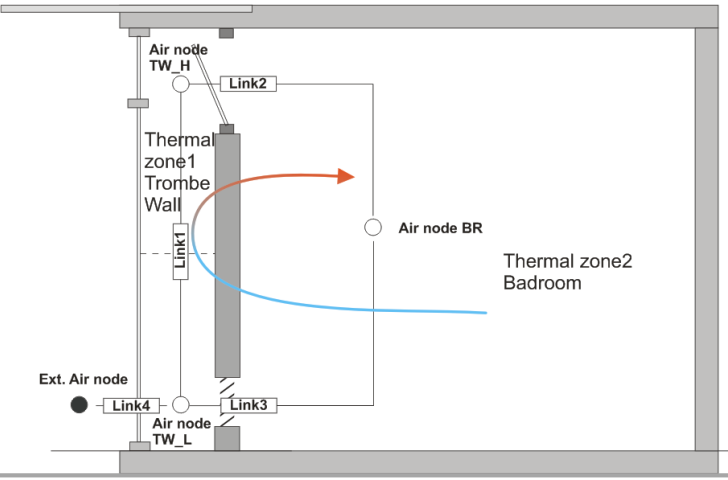
Climate concept (summer nighttime)



During summer nights, submerged part of the building has lower surface temperature which helps to creat a cooler raidiant environment.

Both earth duct or natural ventilation from west wind are available to ventilated the house.

Simulation model setup



The trombe wall is divided into 2 air nodes.

TNYflow link definition in winter operation

	Type	From node	To node	Size
Link1	L Opening	TW_L	TW_H	3m*0.5m (Hor)
Link2	L Opening	TW_H	BR	0.8m*0.25m*3
Link3	L Opening	BR	TW_L	0.8m*0.15m*2
Link4	Crack	TW_L	Ext.Node	-

Simplified method for earth duct calculation

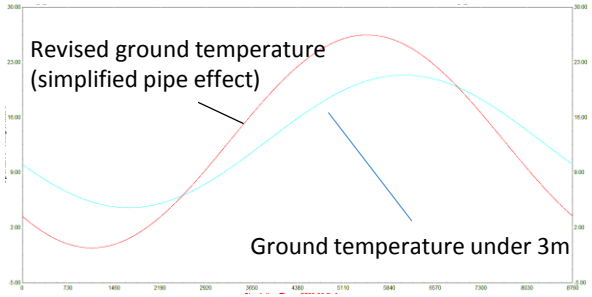
Length=20 m; Pipe radius= 0.2 m

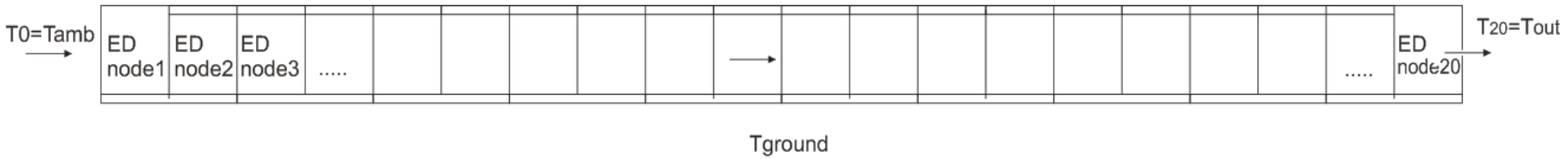
Depth in ground=3 m

Volumn flow=240 m³/h (fan assisted);

hi= 15W/m.K

The pipe is equally divided into 20 air nodes for calculation.

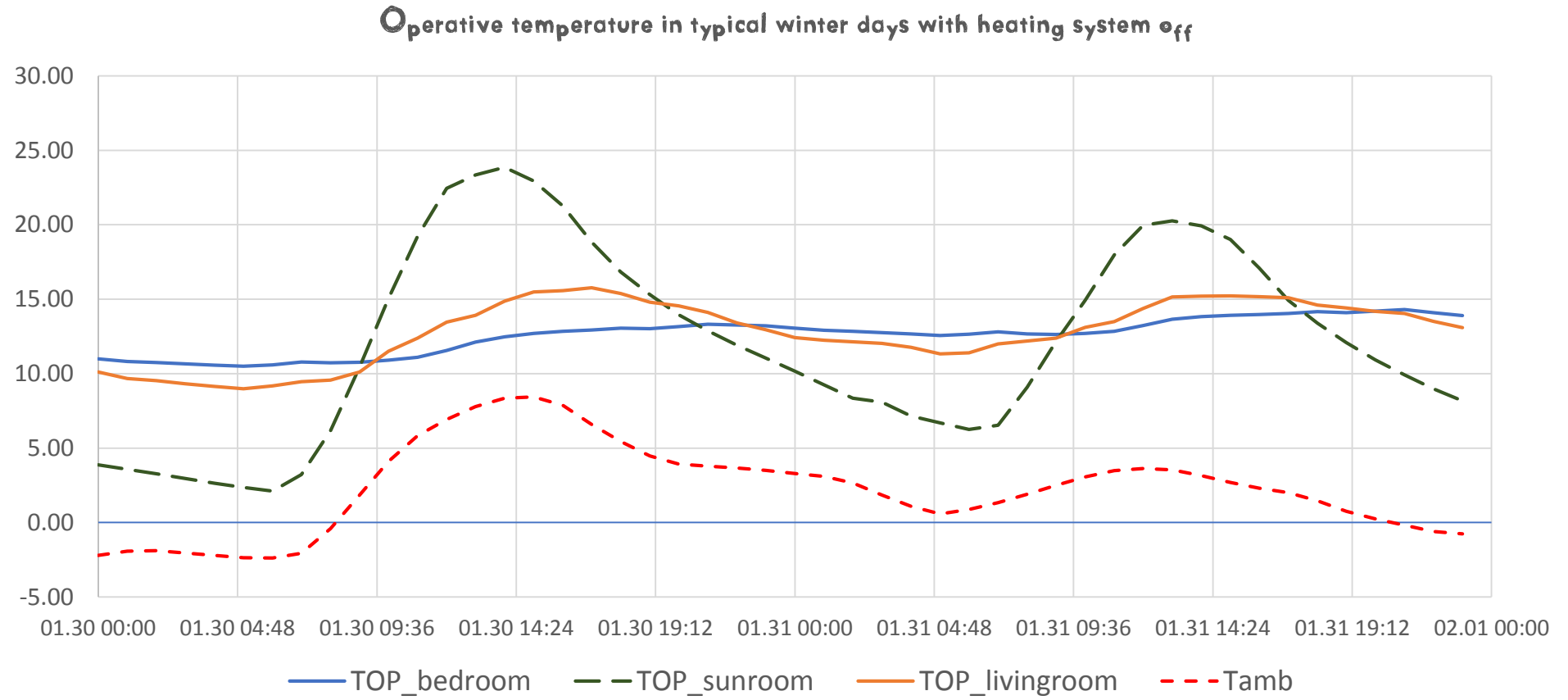




To test the design building performance, effect of trombe wall is simulated with TRNFLOW coupling with multi-zone TRNSYS model.

Earth duct is simulated by dividing into 20 thermal air nodes with simplified annual ground temperature profile.

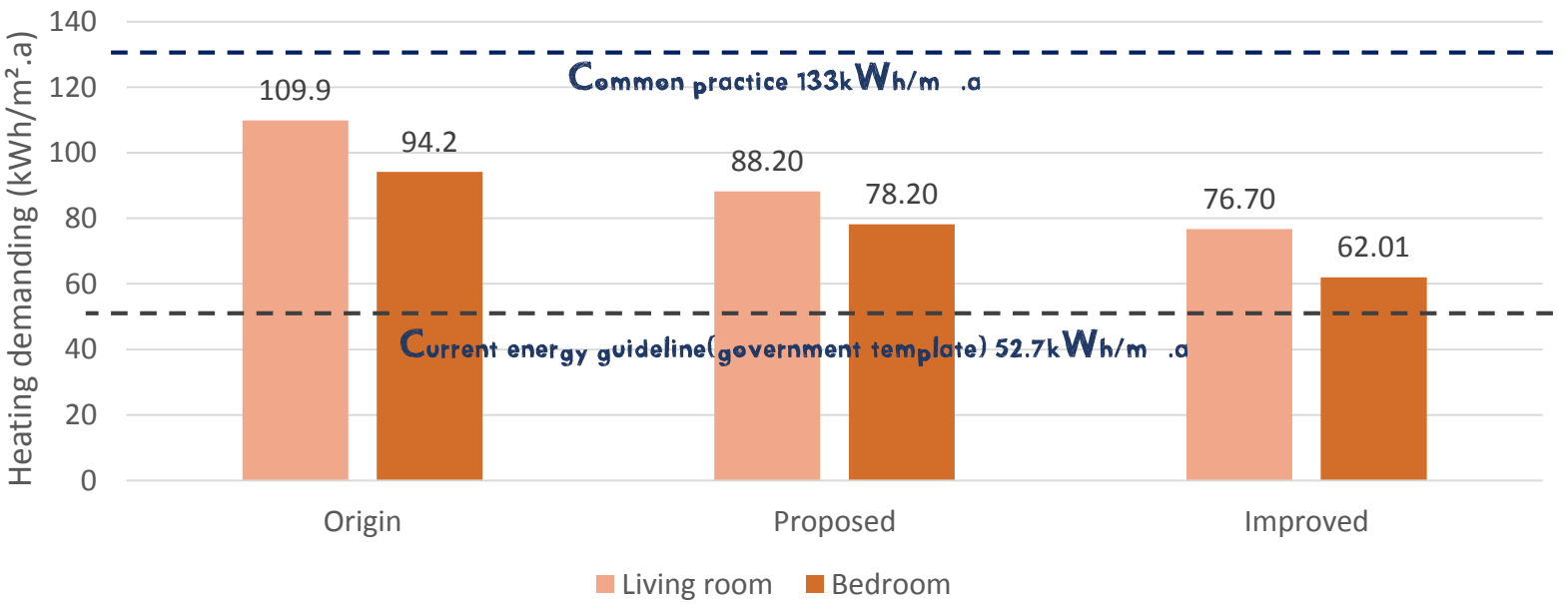
Winter performance (without heating)



The graph shows the hourly temperture swings in two typical winter days.
The swing accord with the design intention.
The sunroom heat up very quickly with the sun rise. The sun room temperature is almost 10°C higher than ambient temperature during daytime.

The bedroom maintains it operative temperature durign night from thermal mass.

Winter performance (with heating)



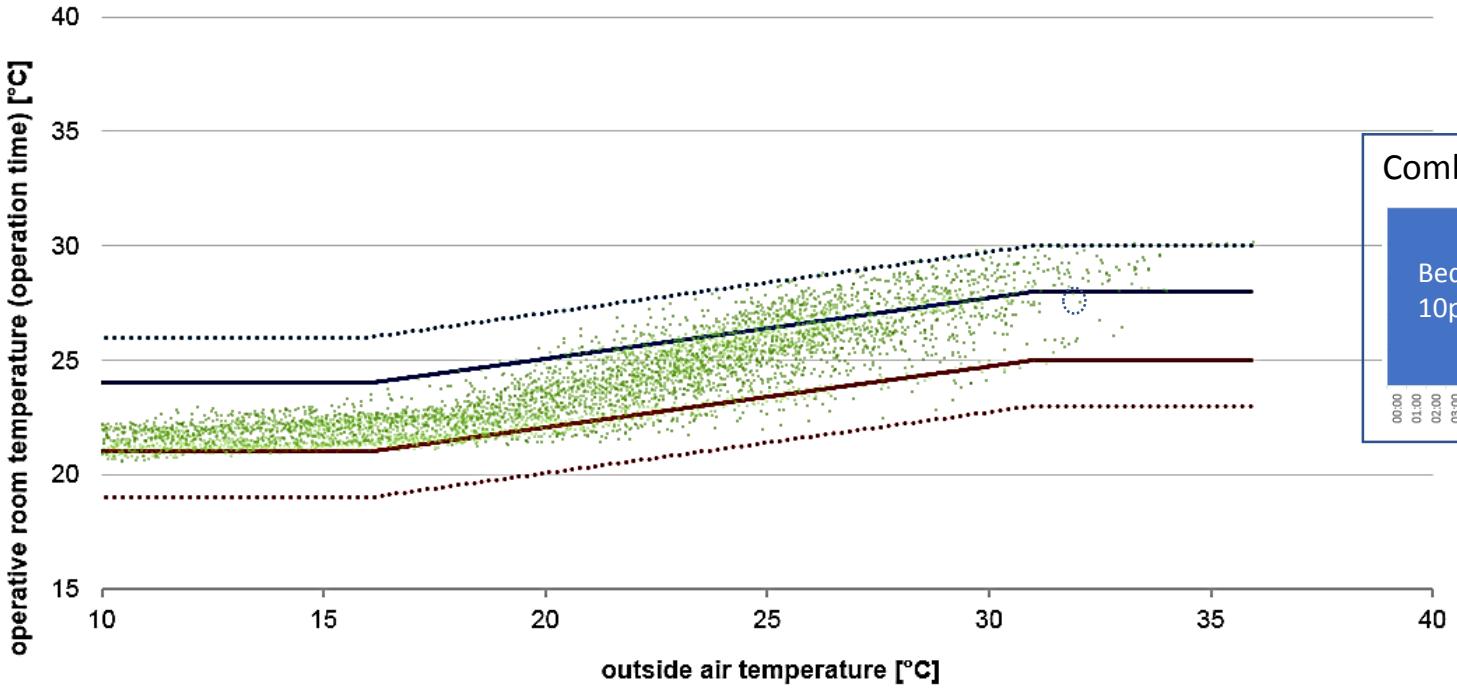
- Nearly 50% reduction in heating demand compared with normal houses.
- 25%+ improvement than original design.
- Expected better performance than government template if adding wall insulation.

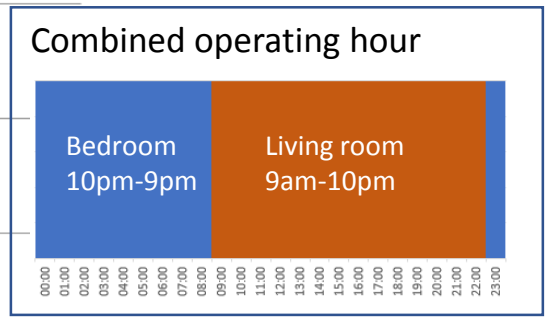
The energy consumptions on heating has also been largely reduced with the design improvement,

the final design (improved design) has nearly half heating demand to current common practice of conventional rural houses.

The should be mentioned the design house only use insulation for the roof to minimize the environmental however heating demanding is close to energy guideline based on new highly insulated government template.

Summer performance (overheated operating hour)





Hours over 26°C	Hours over 28°C	Hours over30°C	Top_max
19.8%	7.4%	0.1%	30.3°C

- With earth duct ventilation.
- No active cooling.
- Good thermal comfort in summer.

No active cooling but no overheating.

Operative temperature in both bedroom and living room during summer are controlled in the comfort zone

Detailed design and construction in near future!

謝謝！