

A SOLAR HOUSE FOR THE DUTCH

AR2AP030 - AESTHETICS OF SUSTAINABLE
ARCHITECTURE SEMINARS

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ABSTRACT

'What are the aesthetic implications of designing with nature?'¹ A question that Ralph Knowles tried to answer in his paper *Solar Aesthetics* and that immediately attracted my attention, so much that I tried to make it my aim for the project. Following the decision to design a house in northern Italy, the most direct and simple response to nature that could be proposed had to deal with the sun energy - which is abundant - and subsequently with the issues of orientation and thermal storage.

The resulting proposal is for a single-storey house, occupying the smallest footprint possible in order to minimise any impact on the surrounding landscape, which design pays special attention to the orientation of the layout in order to exploit the sun energy to its fullest. Also, the main material chosen for construction is timber (both for structure and cladding), an environmentally friendly material which is able to give a 'natural look' to the construction.

Usually a solar house utilises the sun energy through the mean of thermal mass. However the use of brick or concrete construction would result very chunky and would have a much bigger impact on the surroundings and on the embodied energy needed. In fact both brick and concrete have an higher embodied energy than timber, and this doesn't have to do only with the manufacturing of the material but also with transportation and on-site construction, as heavier materials are more difficult to transport and to assemble. In order to avoid the problem of thick walls due to the use of thermal mass, the use of Phase Changing Materials is proposed. The considered embedding of this material in internal and external walls allows for the dwelling to maintain a constant temperature of around 23 degrees without the need of a central heating system most of the time, as PCM have a melting point temperature which is close to the thermal comfort needed by people.

These materials are also embedded within a south facing glazed facade, which changes its aesthetics over time together with the changing state of the material. In fact, during the day when the PCM is melted the glazed facade allows views through to the exterior, while at night when the PCM freezes it creates a layer in between interior and exterior, obstructing the view. These 'rituals of transformation supply syntax by rhythmically connecting our experiences to special places and activities in a dwelling.'²

However, designing with nature is a difficult task; 'buildings are subject to the same natural forces that have cause differentiation in nature, but they rarely acknowledge these forces in built form'³, which is what happened to this project. The dwelling in fact responds well to orientation issues in the layout of the different spaces, but it doesn't in terms of shape and architectural representation, stuck in the archetypal form of the house, a rectangular shape with a pitched roof. On the contrary, 'the concept of a building as an ecological form, differentiated in response to natural forces, points to a new aesthetics'.⁴

1 Ralph L. Knowles, *Solar Aesthetics*

2 Ibid.

3 Ibid.

4 Ibid.



The project takes into consideration a Dutch family of four, composed by mother, father and two kids, a 16-year-old girl and a 10-year-old boy.

Tired of the unforgiving and wet dutch weather they decide to move to Italy, specifically to Lake Garda, a place where they have been on holiday multiple times and of which they love the landscape scenery and the sunny days.

LIFESTYLE



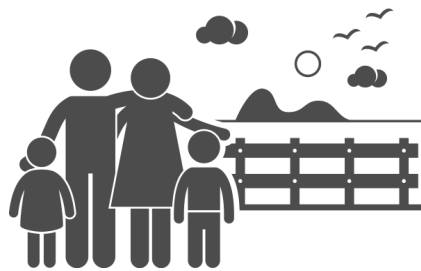
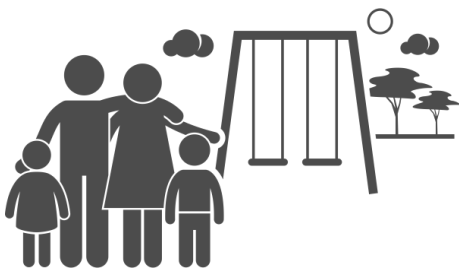
FIG.1



FIG.2

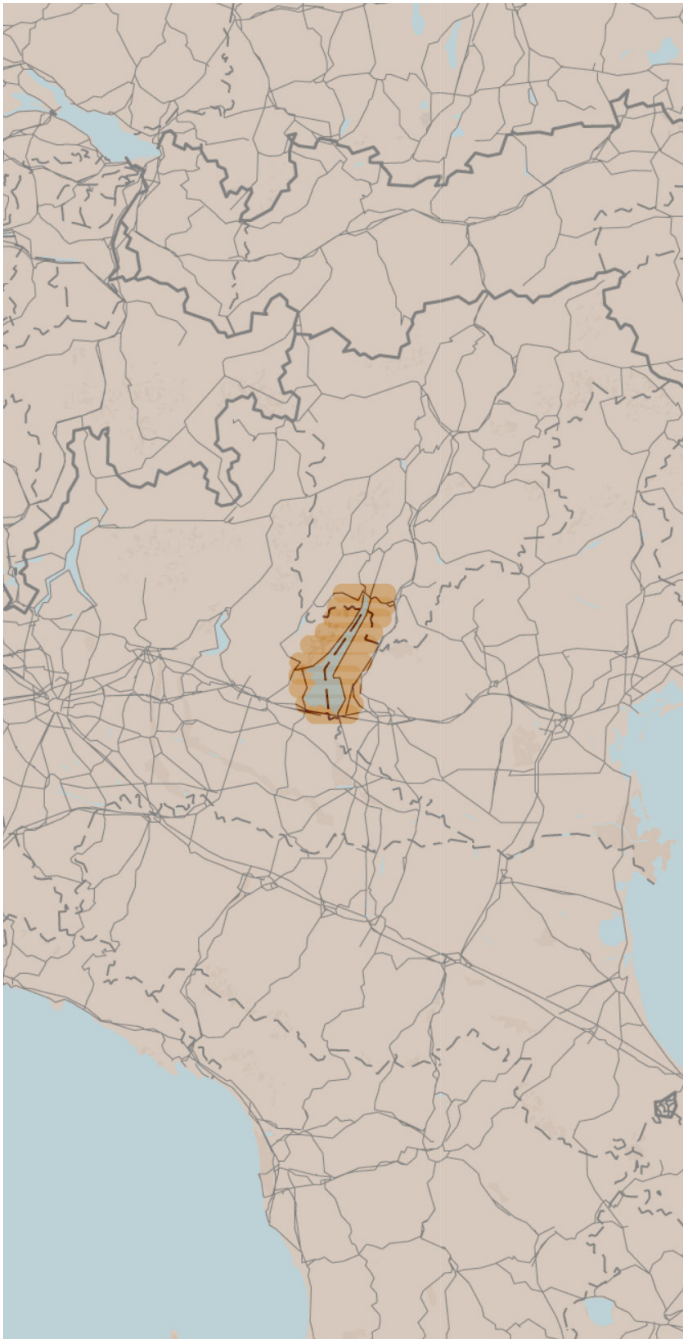


FIG.3



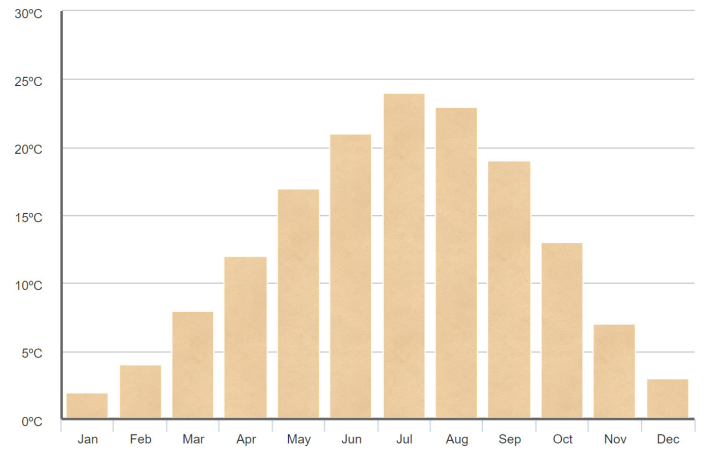
FOCUS ON CONNECTION WITH THE OUTDOOR

Their main desire for their new house is to minimise the impact on the landscape they love so much and to guarantee a connection to the outside, where they love to spend time and dedicate themselves to outdoor activities



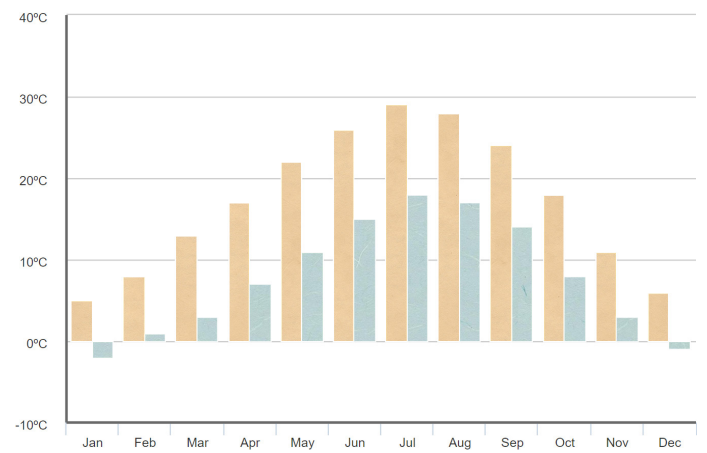
Overall, in North of Italy the temperatures are quite high (especially in summer) and there is plenty of sunshine hours for most part of the year. Therefore, the possibility of exploiting the sun as a resource for energy for the house is a natural response to the specific climate of Lake Garda.

SITE



AVERAGE TEMPERATURE

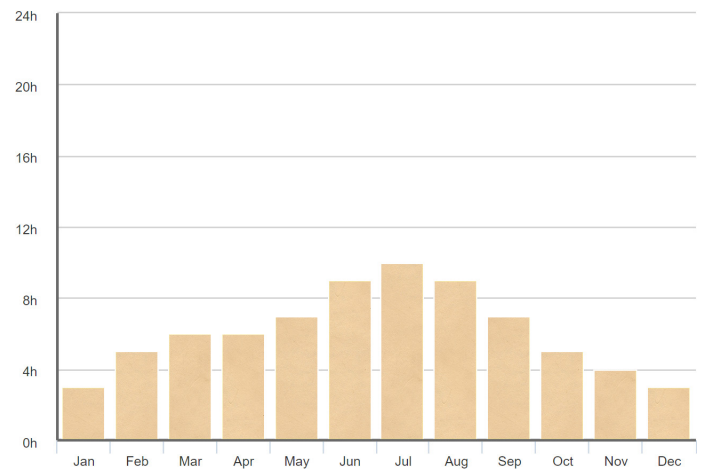
Centigrades



AVERAGE HIGH/LOW

High C

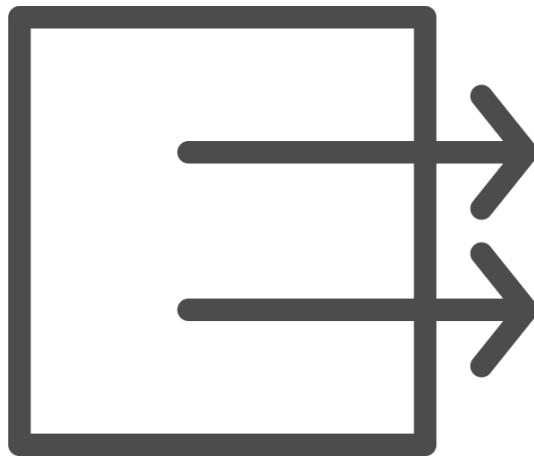
Low C



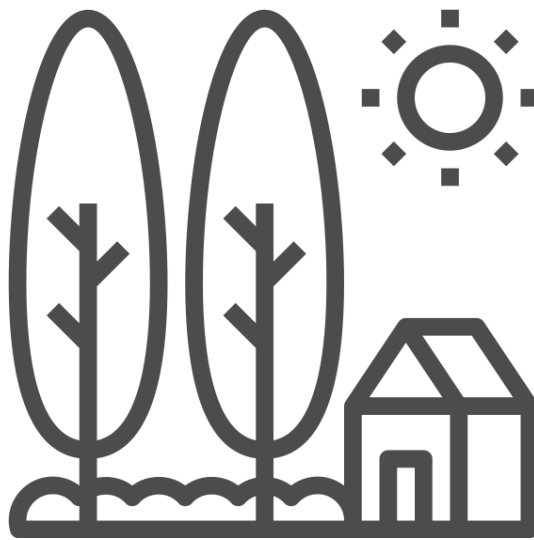
AVERAGE DAILY SUN

Hours

Information gathered from http://www.holiday-weather.com/lake_garda/averages/



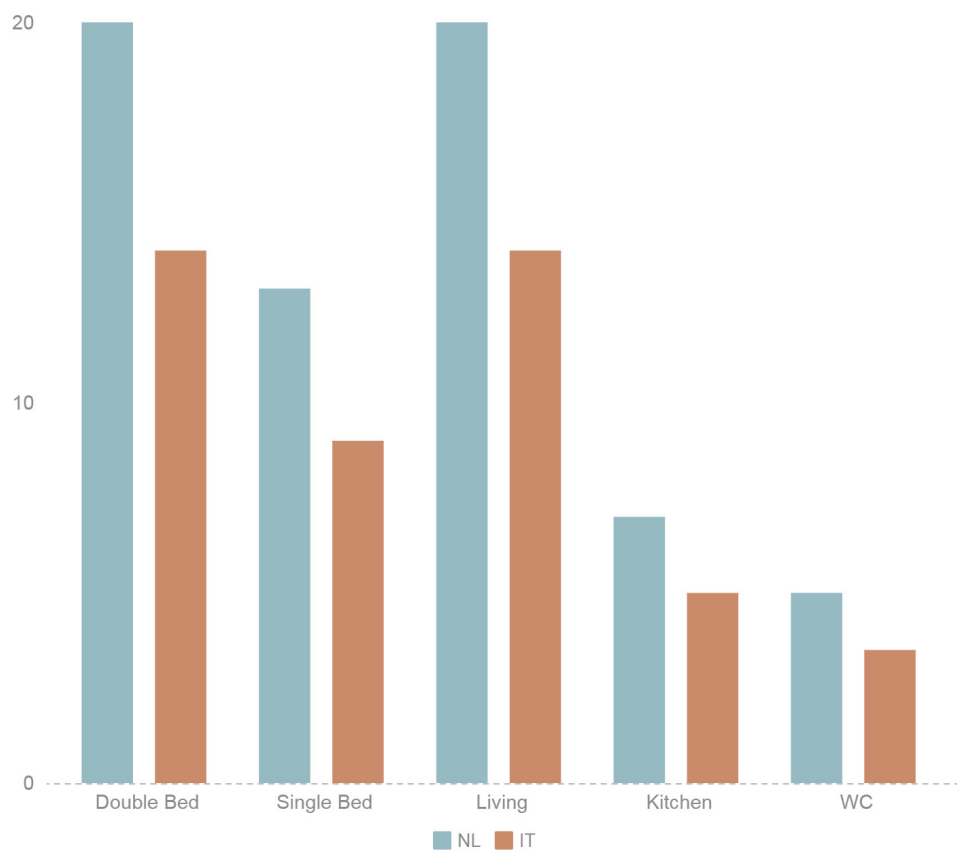
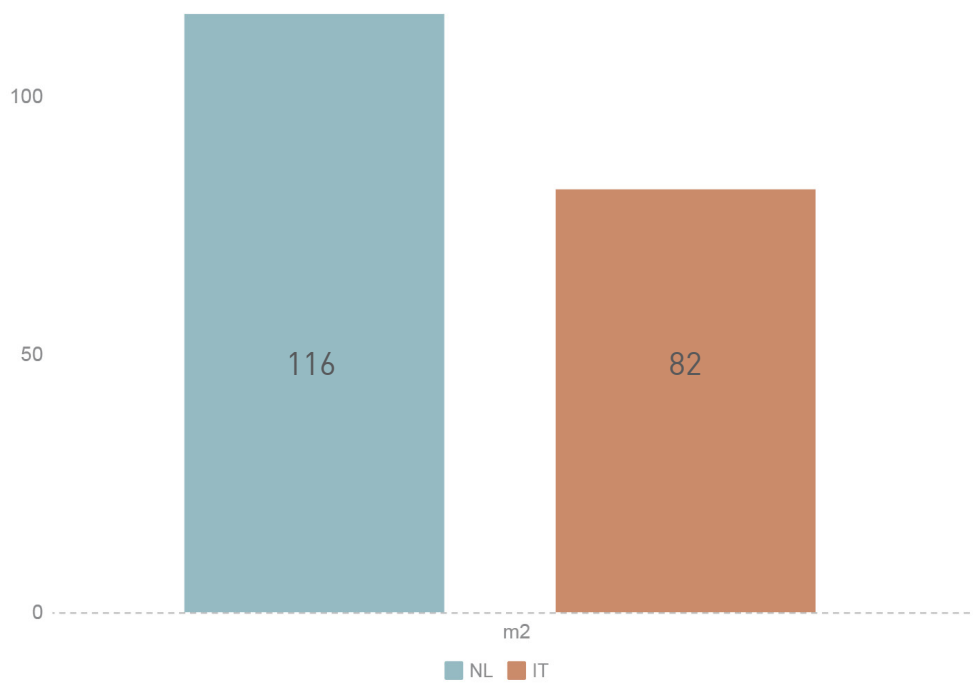
CONNECTION TO THE OUTSIDE



MINIMUM IMPACT ON LANDSCAPE



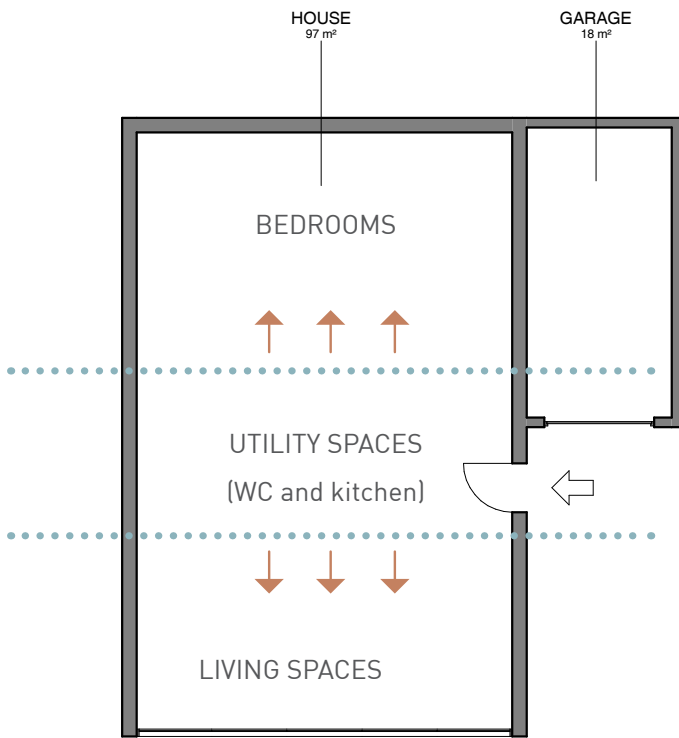
USE OF SOLAR ENERGY



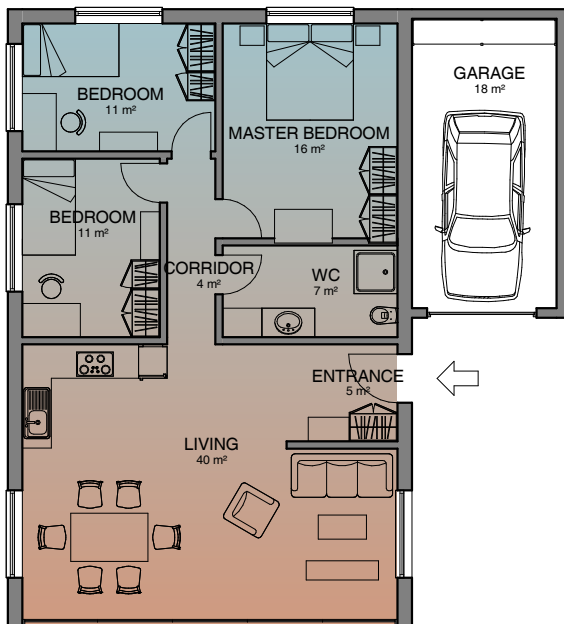
Information gathered from <http://demographia.com/db-intlhouse.htm>

The averages of new built houses in the Netherlands and in Italy are quite different, the Italian averages being around 30% lower than the Dutch ones. However, having to deal with a Dutch family living in Italy, the sensible choice was to concentrate on a solution considering both standards: a 95 m2 house.

THE STANDARDS



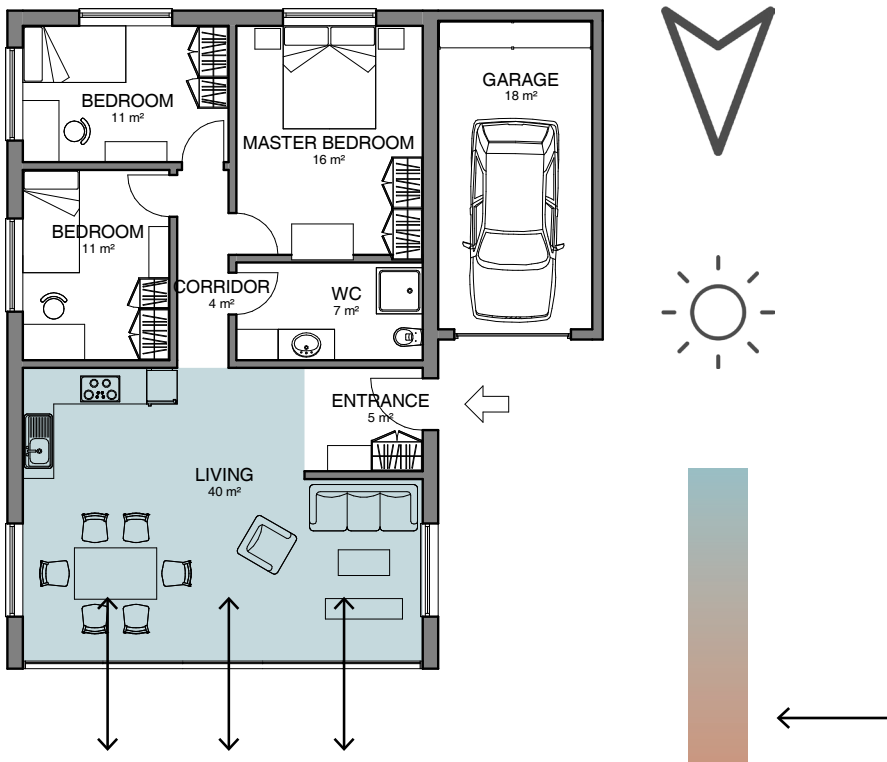
In order to minimise the impact on the landscape, the house will feature only one floor, keeping the living spaces to the south, the utility spaces like kitchen and bathroom in the middle of the floor plan, so that the heat produced by the activities taking place in these spaces can be used and dispersed within the living spaces and the bedrooms, and the bedrooms in the north portion of the plan.



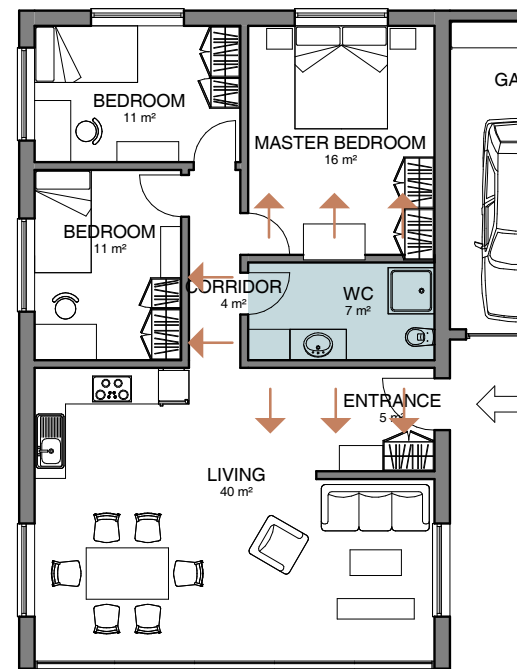
As a consequence the heat gained from the south facing orientation is dispersed throughout the whole depth of the dwelling.



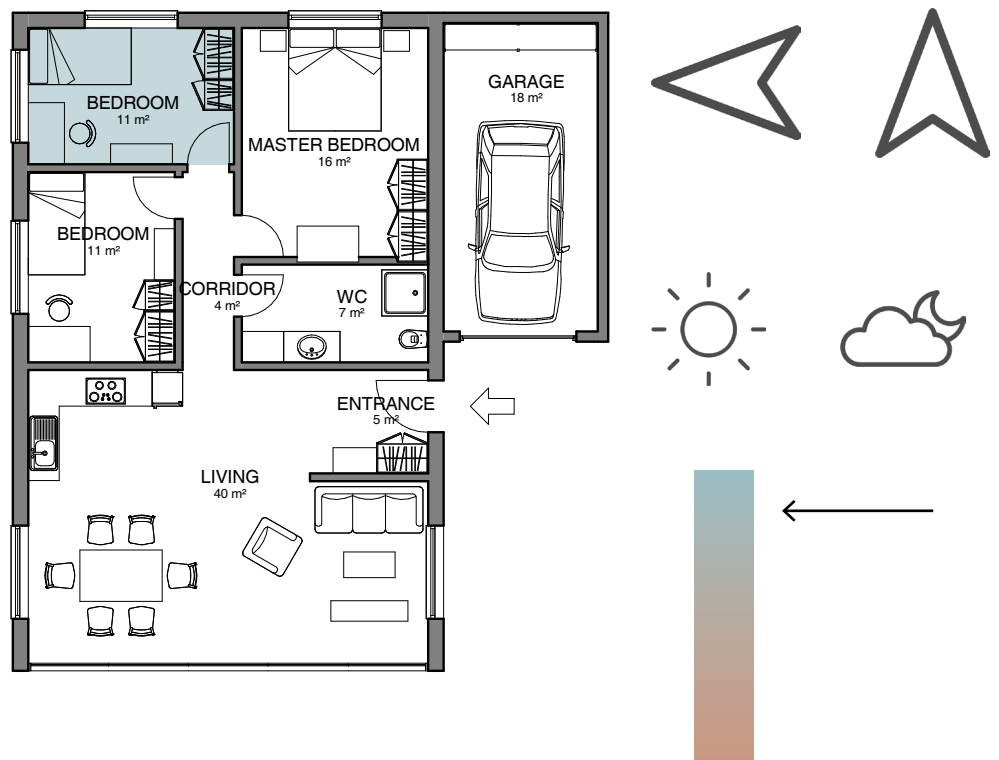
ORIENTATION AND LAYOUT



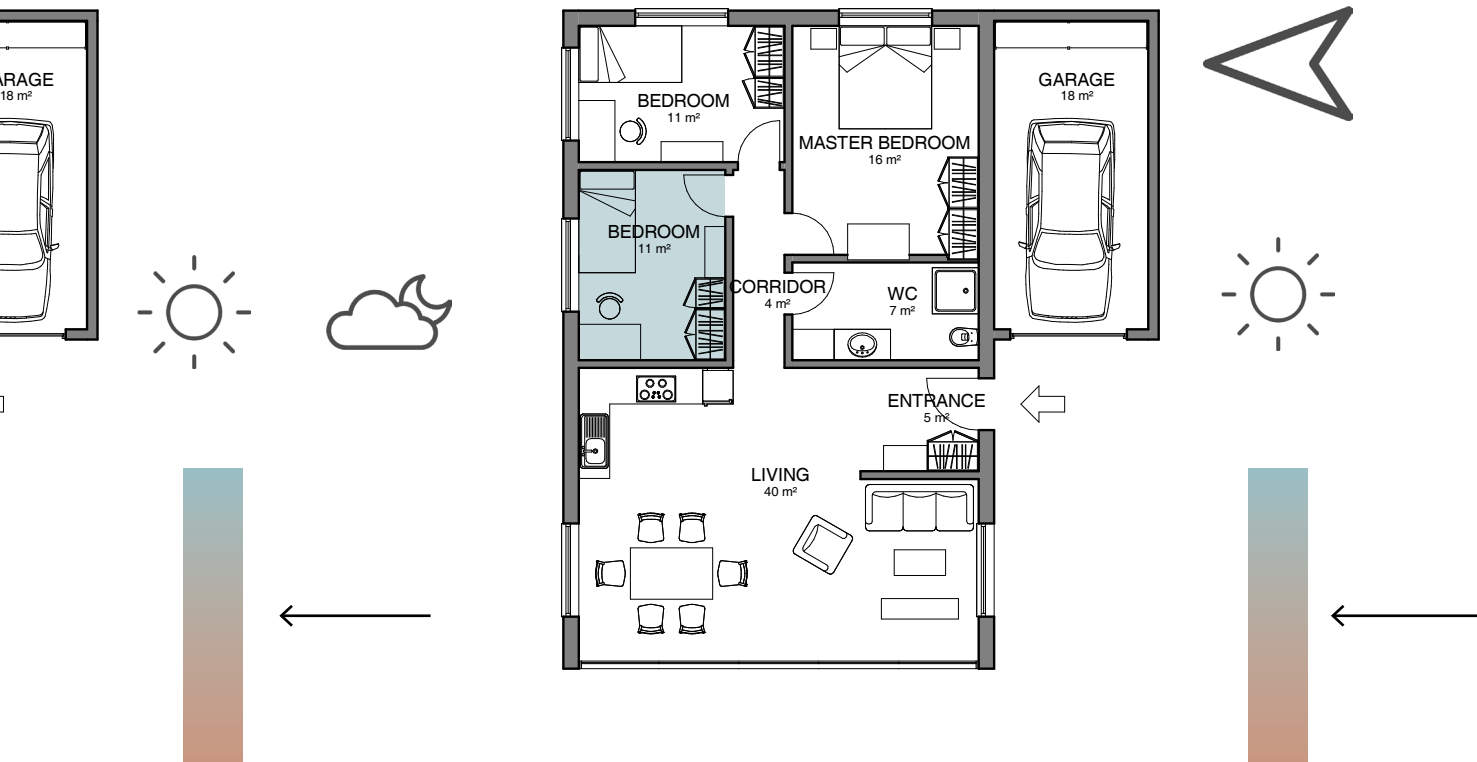
The distribution of spaces sees the living area as an open plan, south-facing space, greatly gaining from sunlight.



The bathroom occupies the centre of the plan, so that heat gains from the interior activities (i.e. shower) can disperse to the bedrooms.

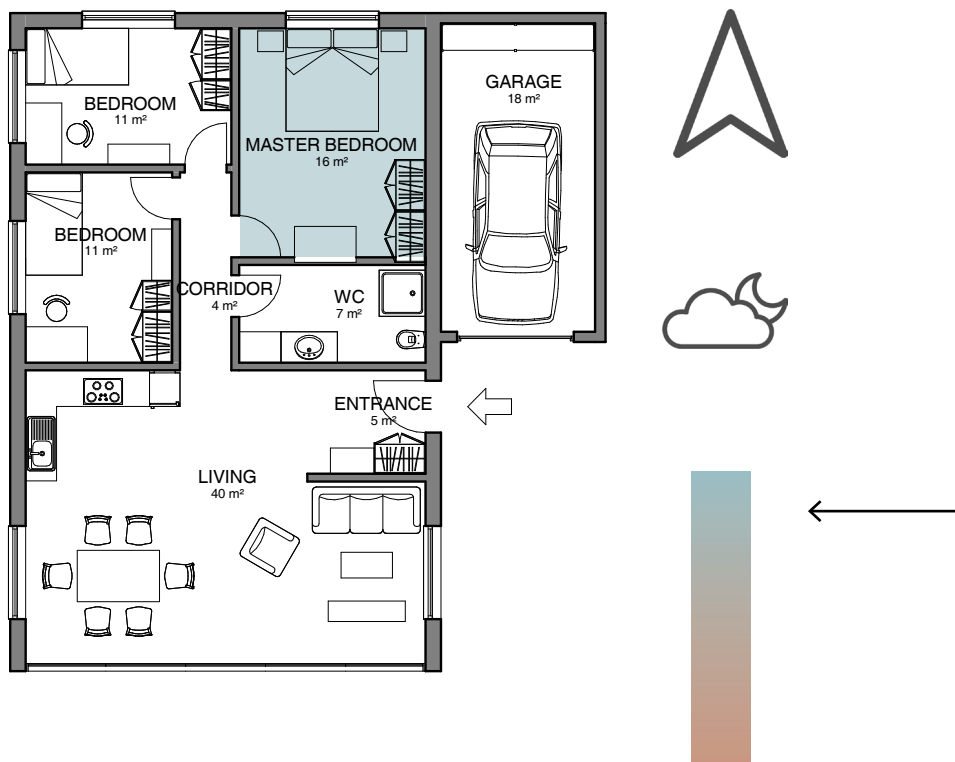


The boy's bedroom is both west and north facing, because the time he needs to spend into his room is limited. However a nice sun exposure is suggested.



the floor
for activi-
rooms.

The girl's bedroom is west facing, because she would need to spend more time in there doing homework and studying. Therefore a nice sun exposure is suitable.



The master bedroom is north facing, as the parents will use this room almost exclusively during the night and therefore don't need any particular sun exposure.



Pictures from Pinterest



FIG.4

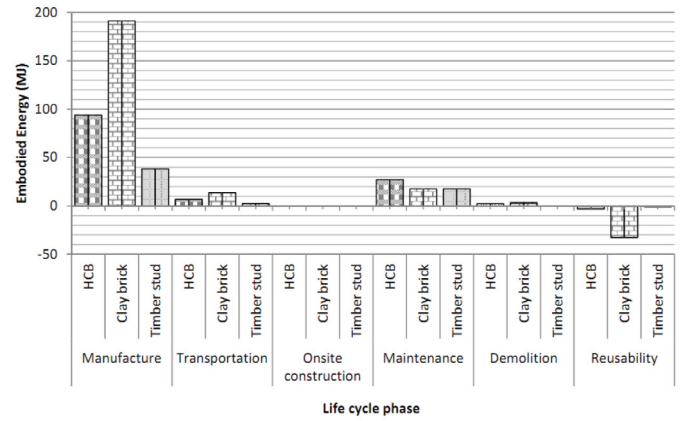
MATERIALS

The main material chosen for the dwelling is timber. The aims achieved with this material are:

- Avoid thermal mass translation into very thick brick or concrete walls;
- Achieve a 'natural look' that blends with the landscape;
- Use of environmentally friendly materials;

EMBODED ENERGY

MATERIAL	EMBODED ENERGY (MJ/kg)
Cement (Portland)	6
Lime	5
Steel	25 - 40
Aluminium	237
Glass	15
Stone Block (locally sourced)	5-6
Raw	0.5 - 4 (depending on drying technique)
Engineered	11 - 15 (depending on final product)
Particle Board	8
Fibre Board	12

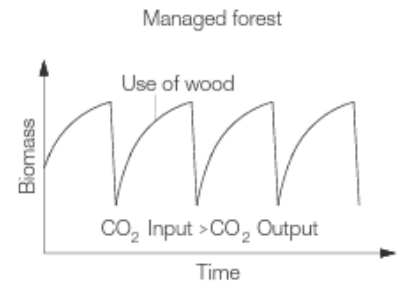
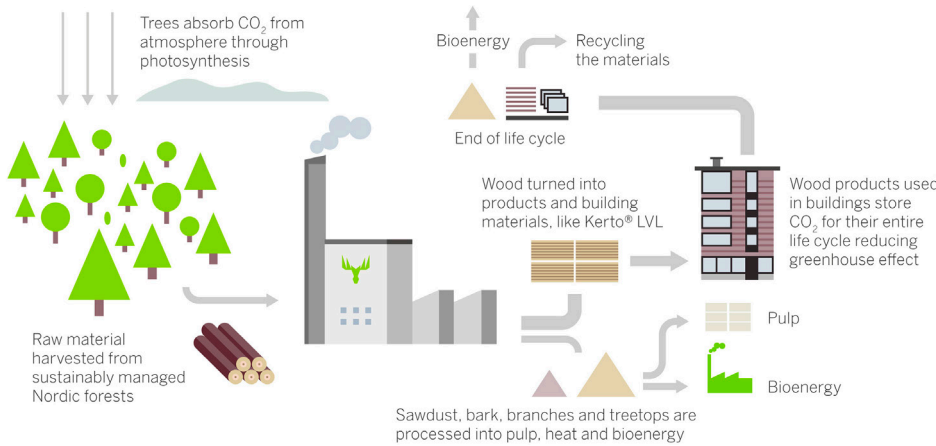


DURABILITY AND RECYCLING

Property	Durability class
Larch	3-4
Spruce	4
Pine	3-4
Douglas fir (European)	1-2
Iroko	1-2
Oak	2
Teak	1-3

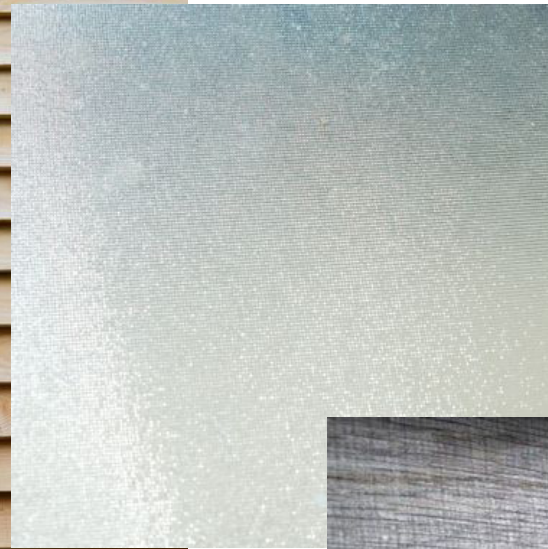
Wood type	Expected service life in contact with the ground (yrs)
Alder, birch	Less than 5
Alder, birch	10
Larch	15
Oak	15-25
Teak	More than 25

CARBON CYCLE



- The manufacture of roughly sawn timber requires less fossil fuels than other materials;
- Performs better in terms of energy use and ease of construction;
- Products are generally light and easy to handle, which means they require less energy to be transported and positioned compared to heavier materials like concrete;
- When benefits and costs of various housing solutions are considered, lightweight timber constructions are usually rated as best performers;
- Intact timber elements can be used for other building applications, while heavily worn timber can reappear in furniture, flooring, landscaping and fuel;
- All timber products can generally be recycled, even the smallest waste can be used as fuel to produce

- bioenergy;
- In order to be durable, timber needs to be treated and protected from moisture and insects. Durability depends on the type of wood used;
- Timber doesn't have the same relationship between embodied energy and carbon cycle as other materials, because of the capacity of trees to store CO₂;
- The capacity of a tree to absorb CO₂ decreases with its age, therefore regrowth forest are more efficient in this task as they are maintained in a state of net growth due to repeated harvesting;
- Converting cleared land to forests creates a sink capable of accumulating carbon dioxide;
- Also timber used in the building industry is capable of retaining carbon from the atmosphere, at least as long as the building stands;



SAMPLE BOARD

Pictures from Pinterest



PCMs

INORGANIC
(salt hydrates)

ADVANTAGES:

- High latent heat storage capacity;
- Low price;
- Sharp melting point (easily controllable)
- Good availability;
- Not flammable;

DISAVANTAGES:

- Corrosiveness;
- Tendency towards incomplete re-solidification;

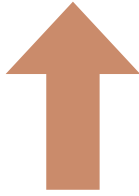
ORGANIC
(waxes, paraffins)

ADVANTAGES:

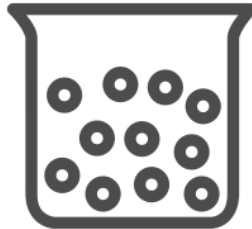
- Large temperature range;
- Chemical stability;
- Congruent melting behaviour;
- Recyclable;

DISAVANTAGES:

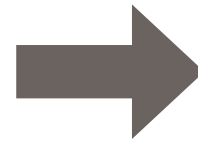
- Low latent heat storage capacity;
- Higher price;
- Inflammability;



Environmental/interior temperature rises



PCM becomes liquid
(extracts heat)



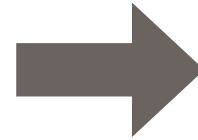
Managed temperature remains constant



Environmental/interior temperature falls



PCM becomes solid
(releases heat)



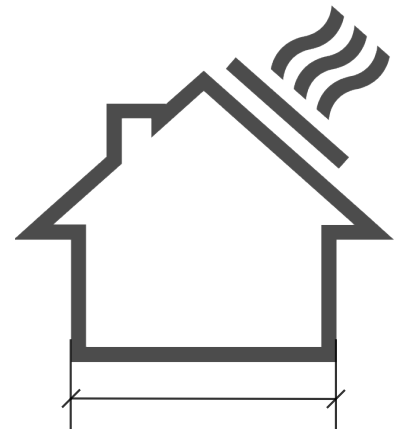
Managed temperature remains constant



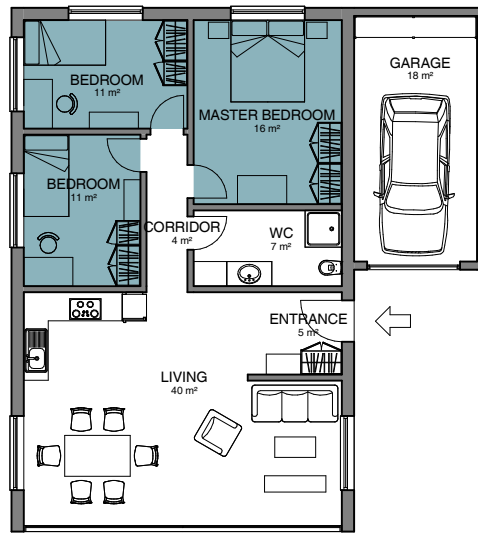
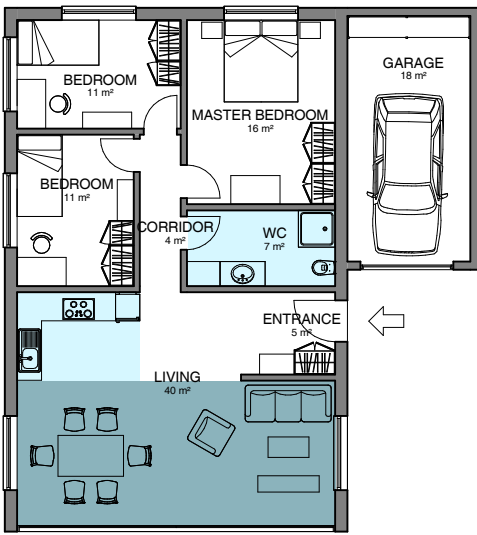
PROVIDES THERMAL MASS EFFECTS AND STABILISES INDOOR TEMPERATURES BY REDUCING TEMPERATURE FLUCTUATIONS



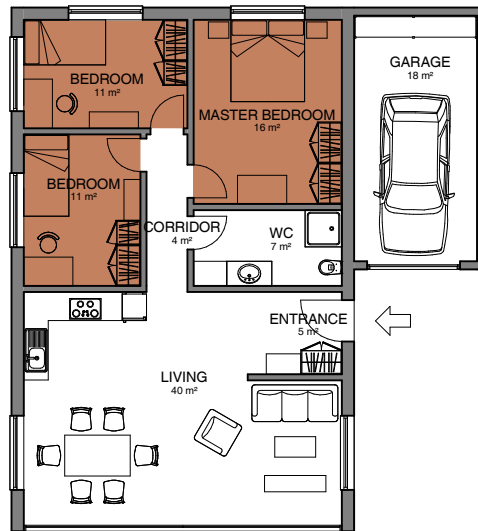
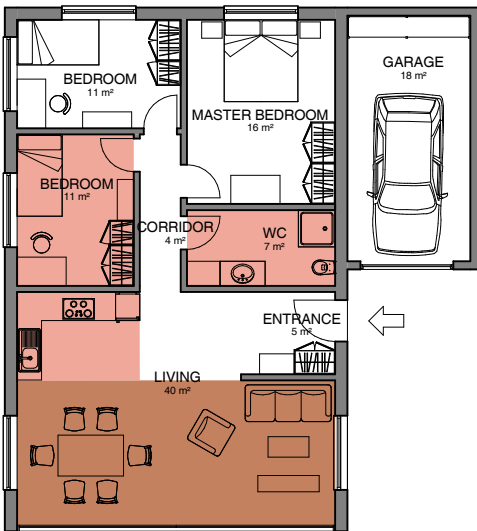
LATENT HEAT STORAGE PROPERTIES ENHANCE THERMAL MASS EFFECTS ACHIEVING BETTER THERMAL COMFORT AND ENERGY SAVINGS
HEAT IS STORED AND RELEASED AT A CONSTANT TEMPERATURE



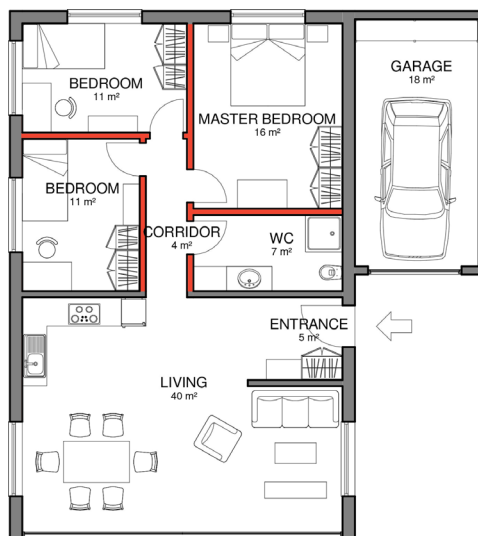
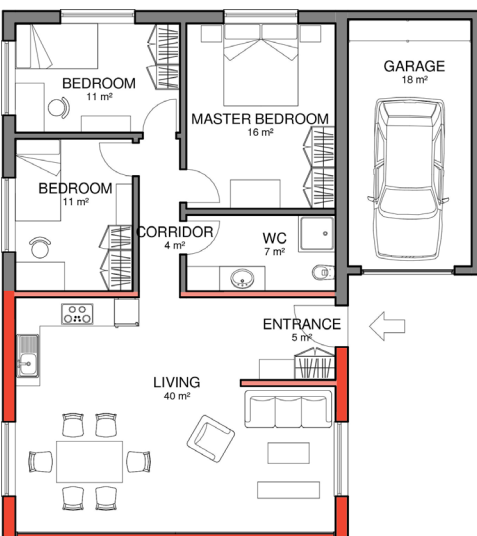
EFFECTIVE HEAT STORAGE WITH LESS AMOUNT OF MATERIAL AND STRUCTURAL MASS



SUMMER USE
NEED FOR COOLING



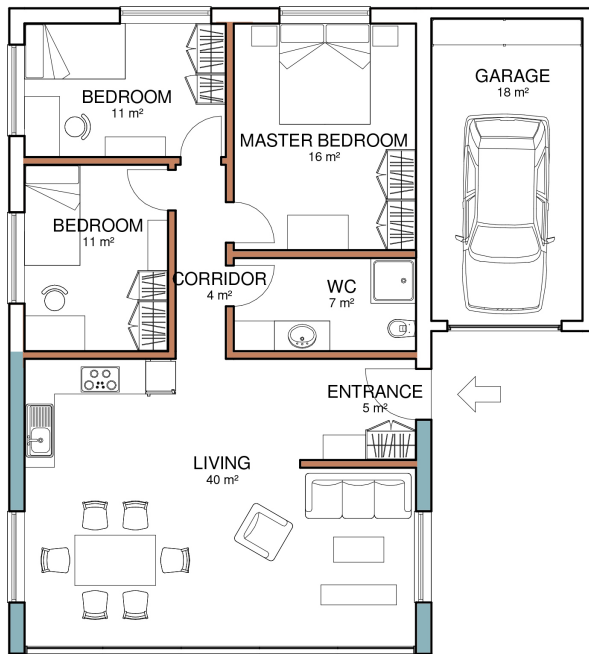
WINTER USE
NEED FOR HEATING





CONCENTRATION OF
PCM EMBEDDING
ACCORDINGLY

Based on the higher or lower need for cooling and heating, PCMs are embedded within the south facing external walls and the internal partitions between the bedrooms.

USE OF SPACES



 PCM embedding within external wall (E / W)

 PCM embedding within internal walls

HOT DAY

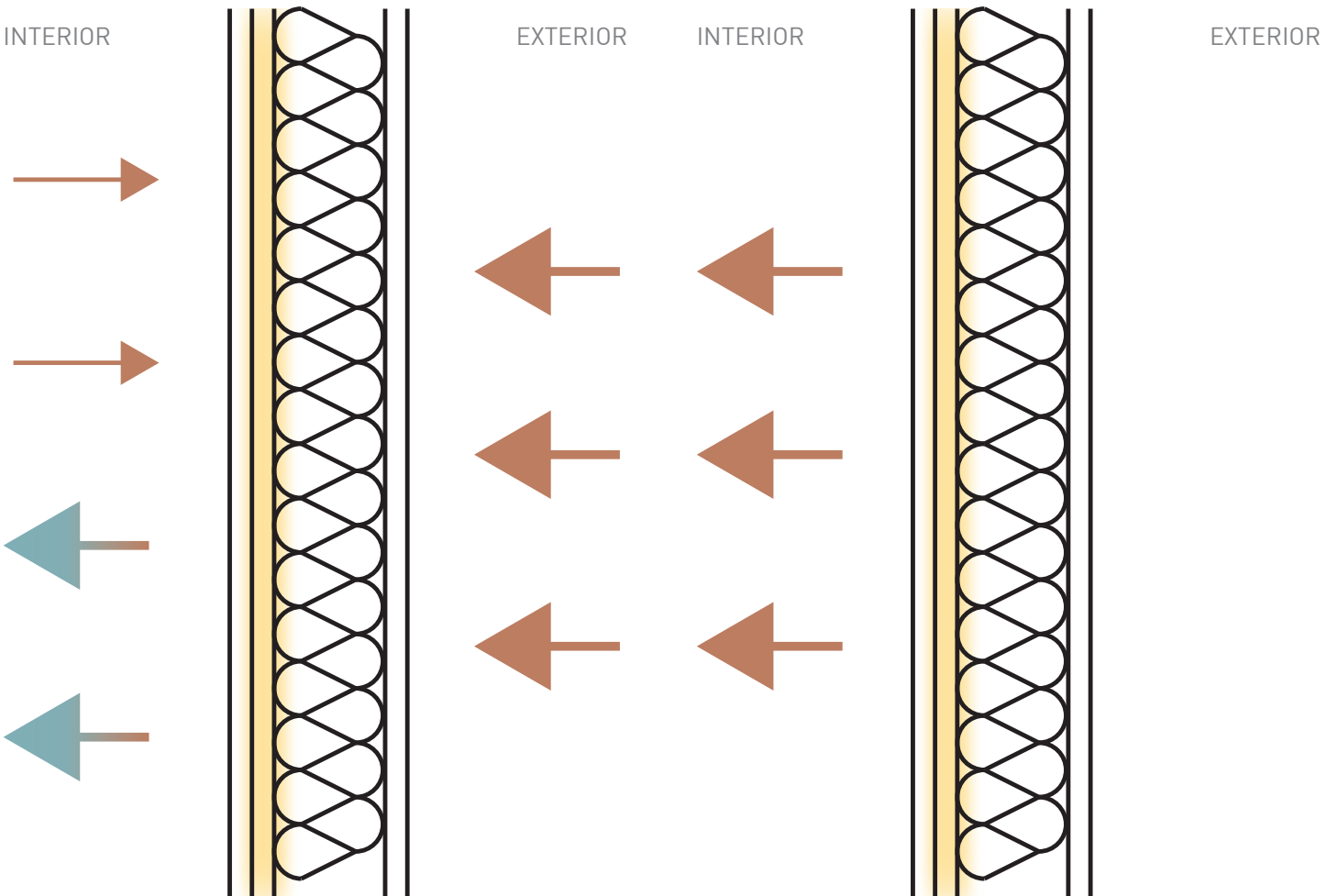
COLD DAY

INTERIOR

EXTERIOR

INTERIOR

EXTERIOR



The embedding of PCMs is particularly effective for what it concerns cooling (diminishing the demand for cooling up to 48%). When the temperature around the material rises, the PCM extracts the heat, it becomes

solid and keeps the temperature stable.

When there is need for heating, the material can act as a thermal mass, releasing the heat stored in the previous phase change while freezing again.

WALLS EMBEDDING



FIG. 5 - Glass pane with embedded PCM in its changing state



FIG. 6 - Glass pane with embedded PCM in its crystal state

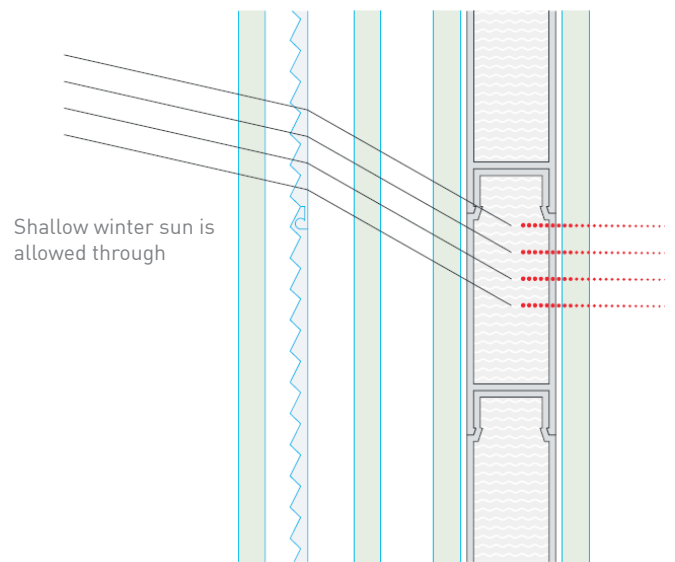
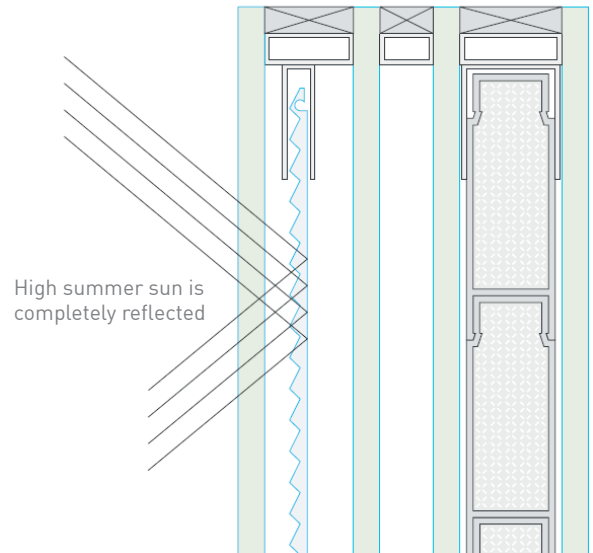


FIG.7

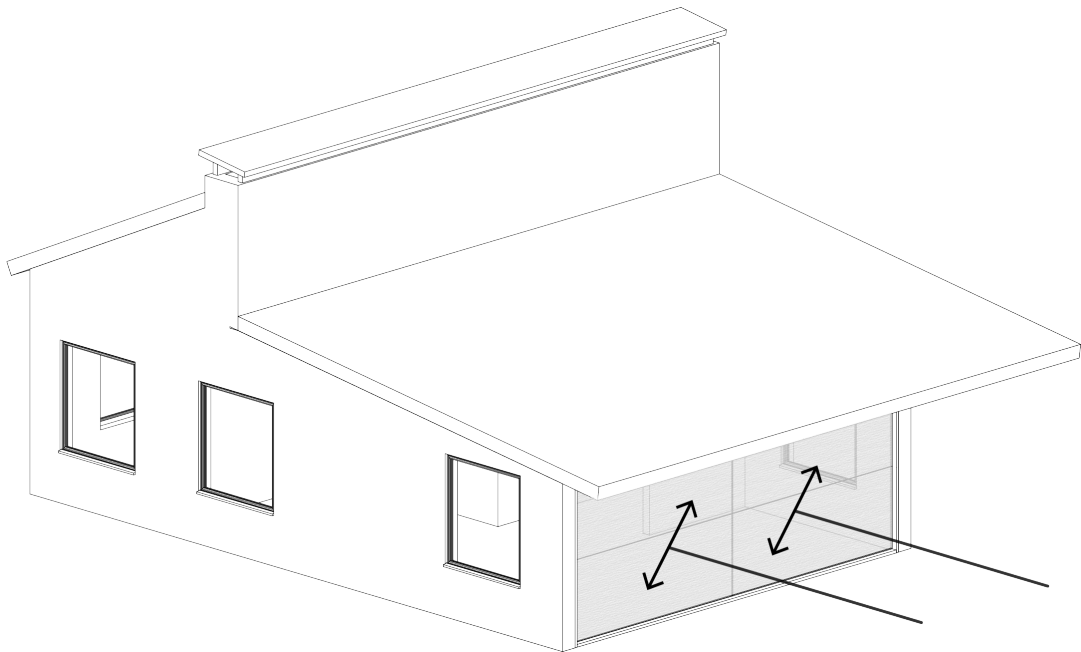
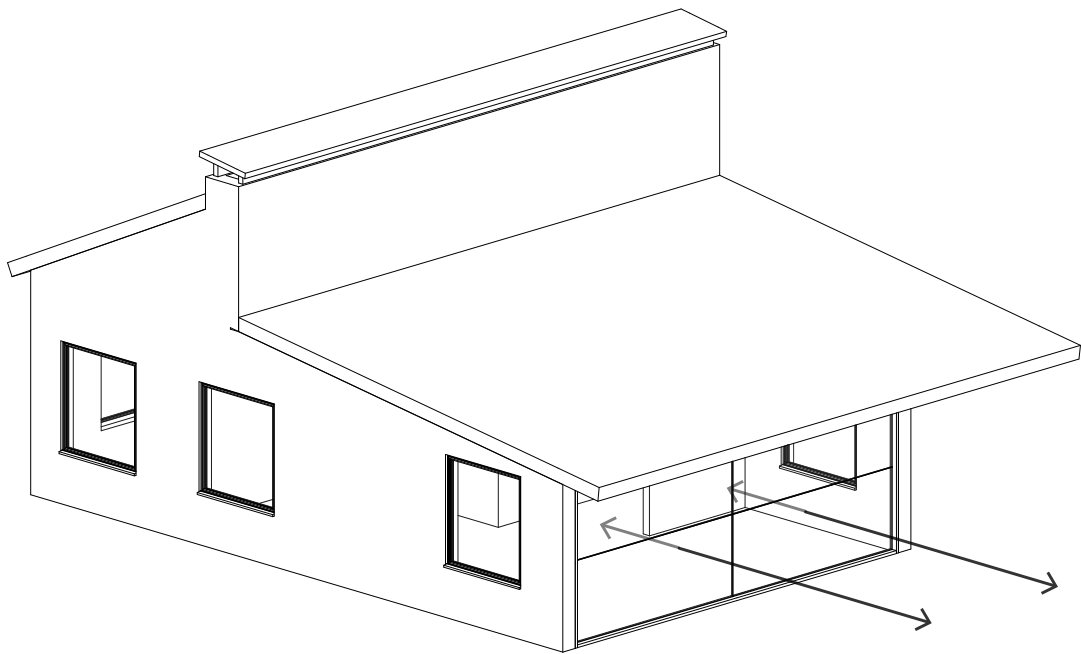
TRIPLE INSULATING GLAZING UNIT

- Combination of:
 1. TRANSPARENT HEAT INSULATION
 2. PROTECTION FROM OVERHEATING
 3. ENERGY CONVERSION
 4. THERMAL STORAGE
- A prismatic pane in the outer-most air-gap reflects solar radiations in summer (high altitudes)

and transmits them in winter (low altitudes)

- In the inner-most air-gap there is a slim storage module of salt hydrates PCM (equivalent to 200 mm of concrete) stored in a polycarbonate box
- Solar heat is stored in the PCM by means of a melting process. During night time and the following days the heat is delivered to the interior during recrystallisation

GLAZING EMBEDDING



Using the aesthetic quality of the PCMs embedded within the south facing glazing means that during the day, when it is warmer and the glazing is exposed to sunlight, the material is melted and allows views through. At night, on the contrary, when the temperatures drops below the PCM melting point, the material freezes, creating a shading in between interior and exterior.



Average of cloudy days in a year



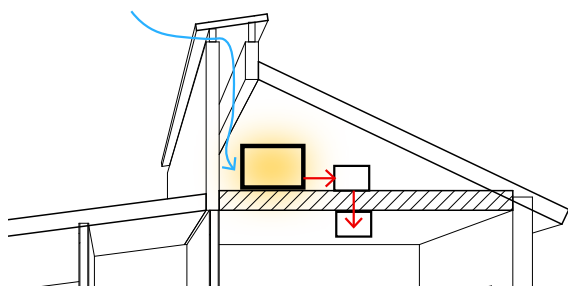
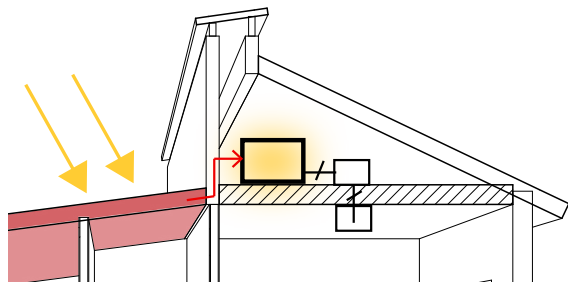
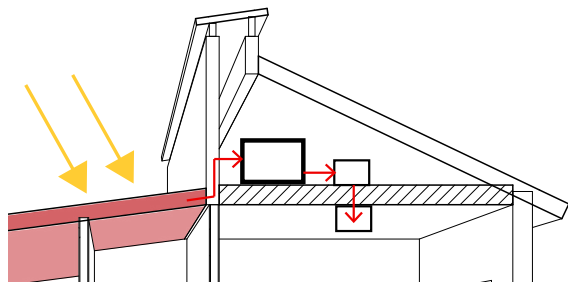
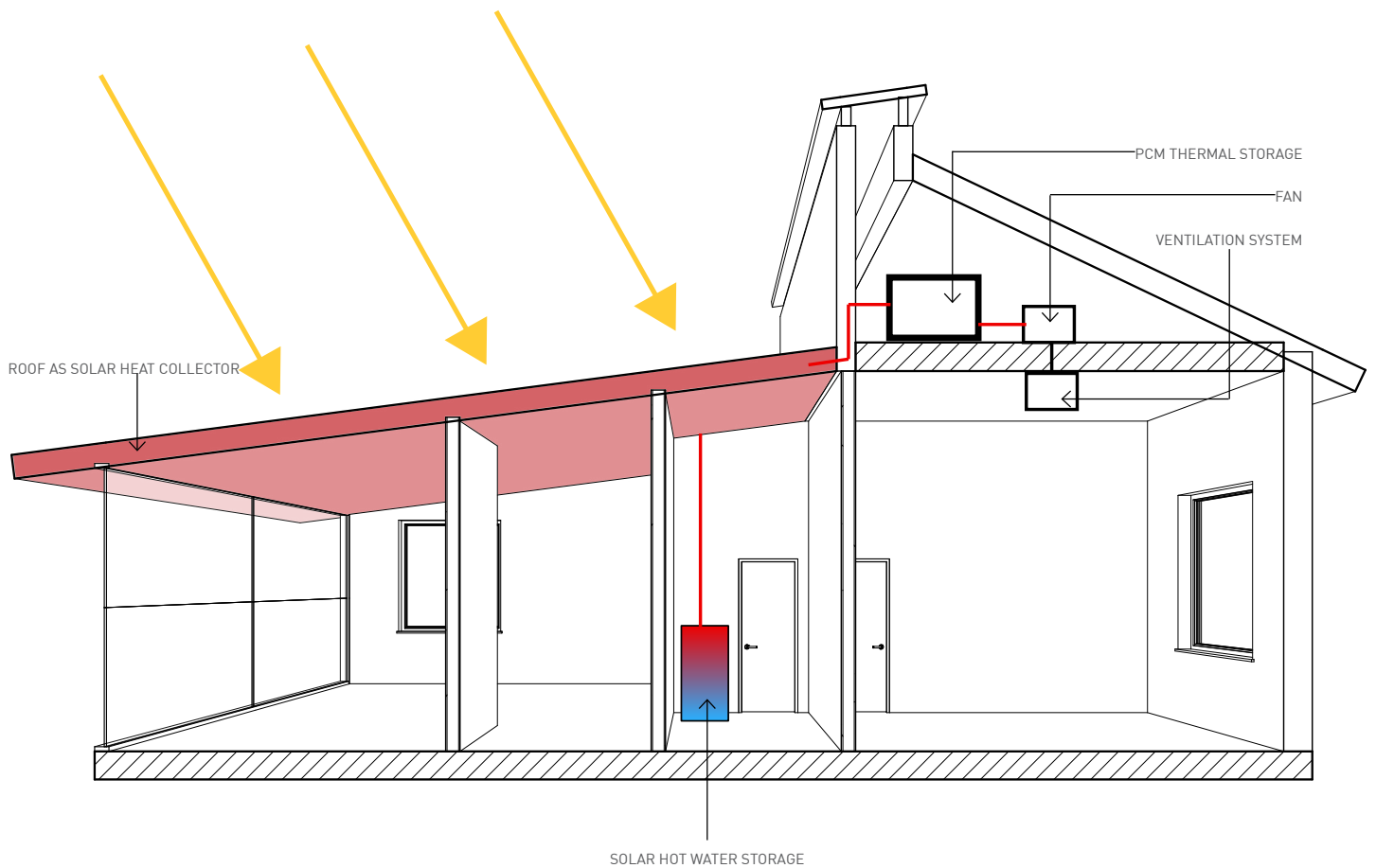
Average of sunny days in a year



NEED OF A THERMAL STORAGE
FOR CLOUDY/COLD DAYS

An analysis of the number of sunny days around Lake Garda, highlights that only a little more than half of the days in a year is sunny. This leads to the need of storing the sun energy obtained during the sunny days for the colder or cloudy days.

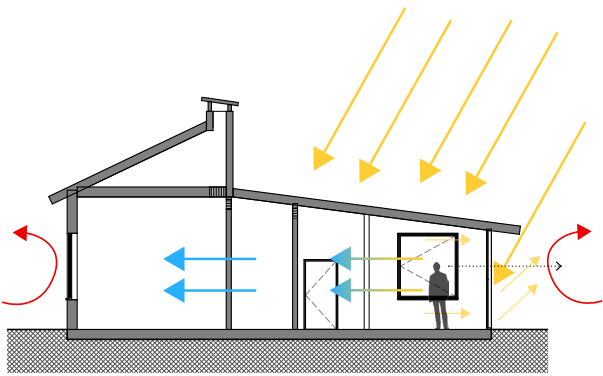
SUNNY DAYS ANALYSIS



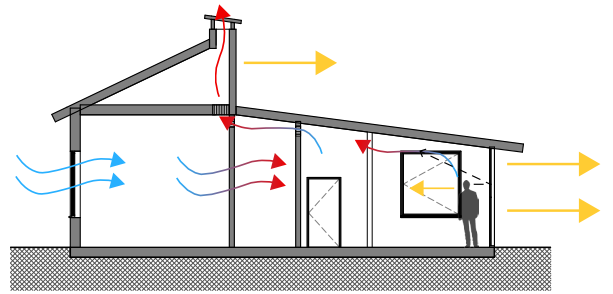
The roof is used as a solar energy collector, which is attached to a solar hot water storage and a ventilation system attached to a PCM thermal storage

ROOF AS SOLAR STORAGE

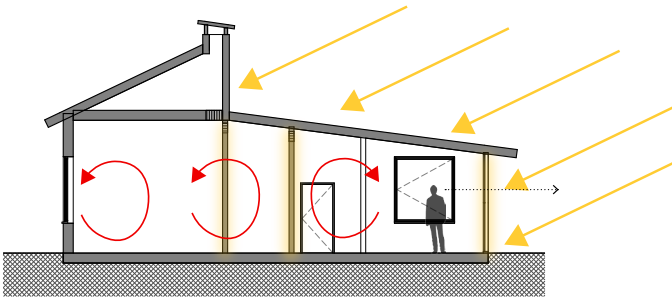
SUMMER DAY



SUMMER NIGHT



WINTER DAY



WINTER NIGHT

