How Hot!

How to improve thermoregulation property using plastic and innovative materials as PCM

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Problem:

Global warming is the latest phenomenon that is rapidly increasing due to human lifestyle. We are using the sources to have a better life without thinking about the effects while we are ruining our home (the planet).

We use the sources to make chemical products that we throw on the planet during their lifetime, turning the planet into garbage, while there seems to be no more room to pollute it further.

It is time to say **STOP** to remake the world.

Try to rethink the design and use of products.

Instead of using electrical energy and producing CO_2 to run the heating and cooling system, we should find a new approach to **passive ventilation of buildings**.

Effects of climate change on the planet

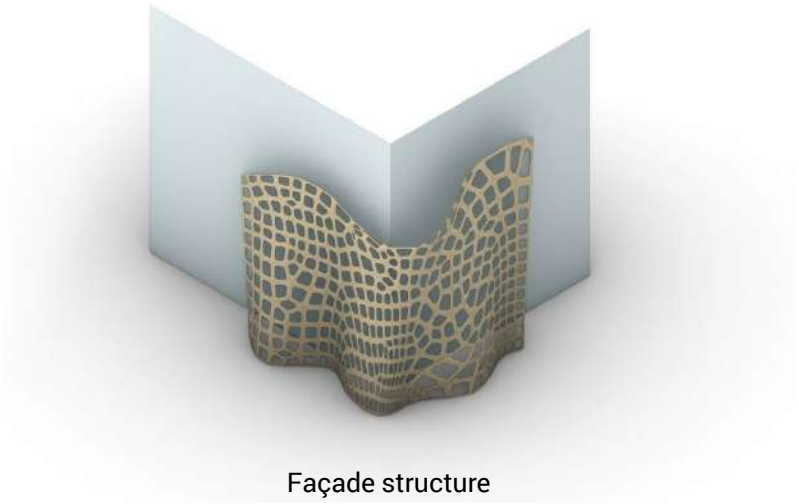
Plastic threaten animal life

Our inspiration of
Termite mounds + Dolphine blubbers:

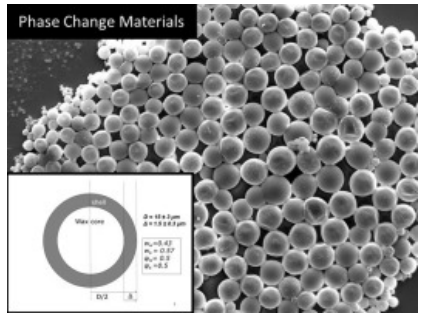
•**Solution**: a bio-inspired hybrid skin system, that combines the passive cooling and high heat capacity of termite mounds and the insulating effect of dolphin blubber.

•The PCM is a key point in the thought process where we can find a mix of these two sources of inspiration.

•We consider PCM-integrated at the same time as one component to take advantage of the insulation property of the dolphin bubbles and their shape, while proposing a ventilated façade to achieve a passive cooling system in a building.



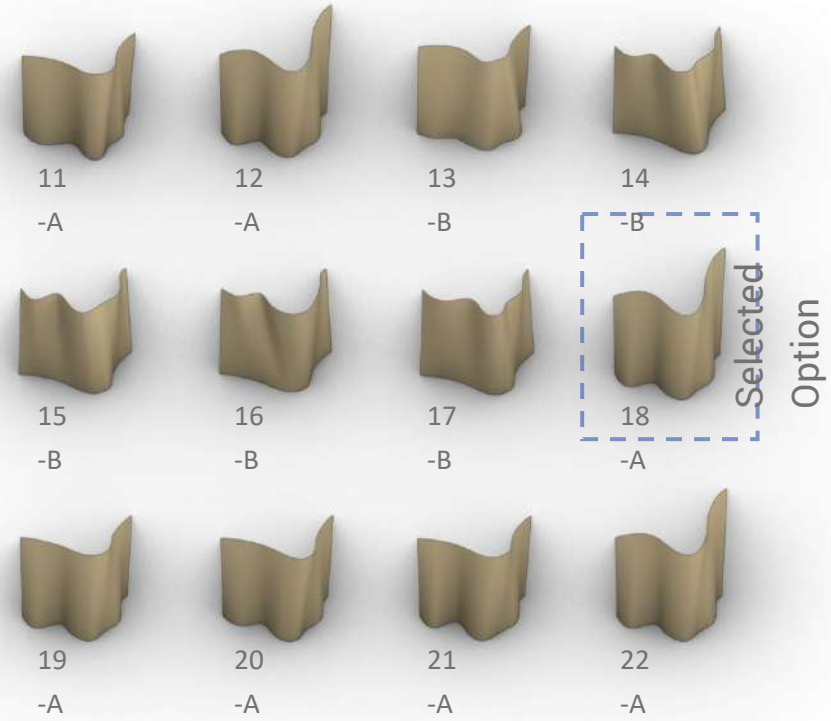
Façade structure



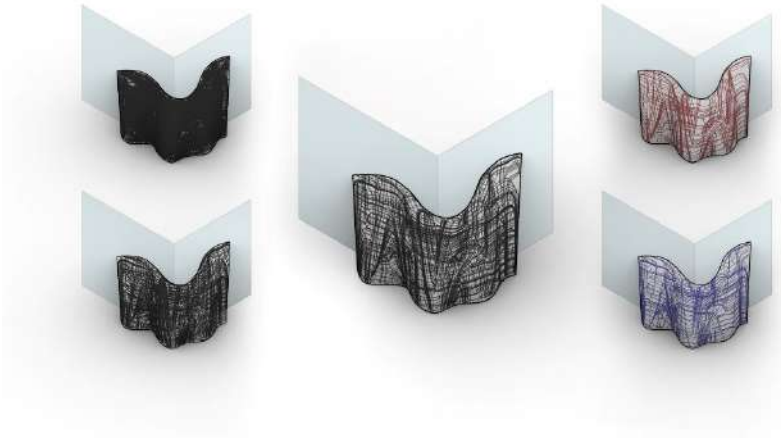
Paraffin encapsulated inside a shell of polyethylene

Ventilated façade design:

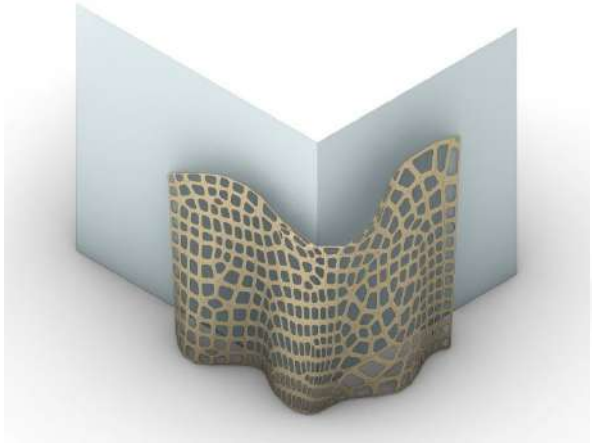
Inspired design of façade can work as a lunge of the building, it keeps the temperature and releases when it is needed **(high thermal capacity)**. In this innovation we can expect the air ventilation due to its structure (**passive ventilation**).



Generated options for doubly-curved shell surface

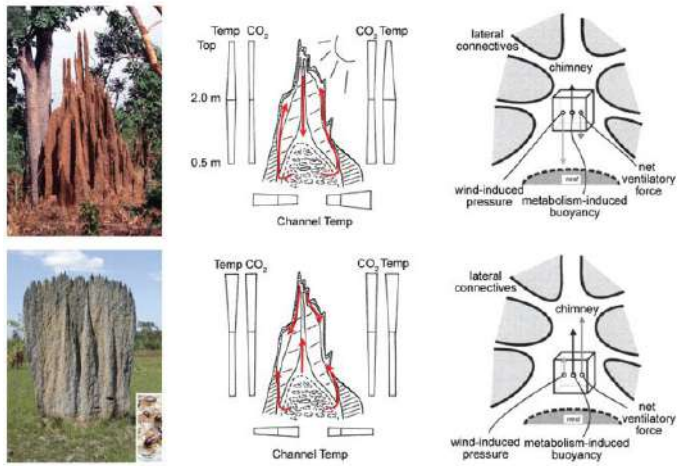


Identifying stress lines. These are to be translated into geometry for defining panel boundaries

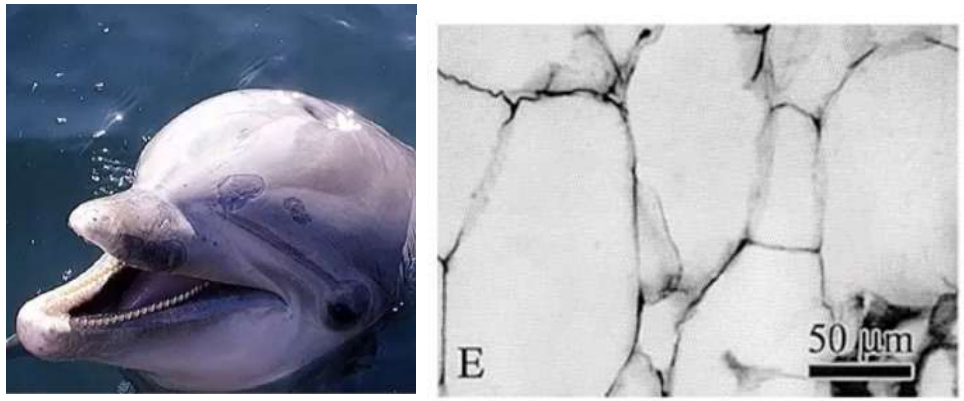


Optimal Divisio`n of panels with location of transparent part and structural framing

Inspired by nature:



Termite mounds structure



Dolphin blubber composed of lipids

Termite mounds:

Inside the mound is an extensive system of tunnels and conduits that serves as a ventilation system for the underground nest. The soil inside the mound guarantees **high thermal capacity** and **passive cooling.**

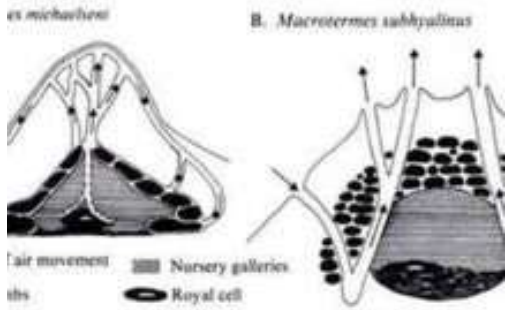
Dolphin blubbers:

The bottlenose dolphin blubber is a subcutaneous layer of fatty tissue, also called adipose tissue, which is necessary for store energy and to insulate heat thanks to the presence of PCM like lipids.

Biological models:

Ventilation:

During the day, temperature fluctuations in the nest are less extreme than those of the outside temperature, but over the course of a year, the temperature in the nest fluctuates and closely follows the temperature of the surrounding soil.



Ventilation system inside termite mound

Insulation:

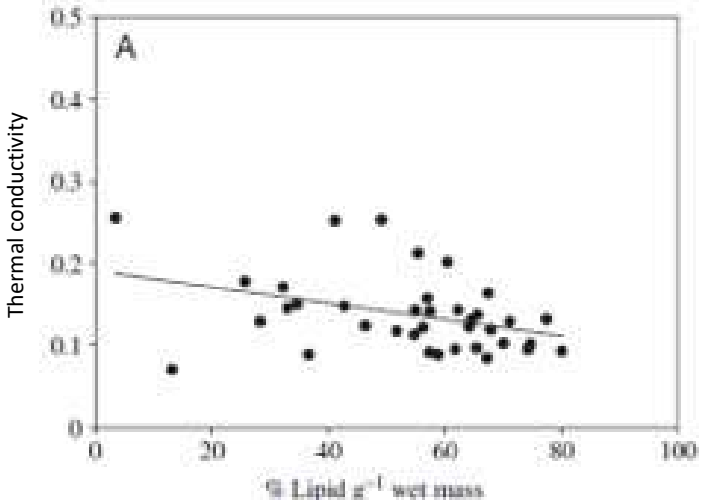
Thermal insulation (reciprocal of thermal conductivity) is a parameter that measures thermal resistance to heat flow. The efficiency of heat transfer correlates with the degree of lipid unsaturation. This is because the fabric becomes more fluid and can reach colder temperatures for a long time without solidifying.

High Thermal Capacity:

The soil inside the hill has a high thermal capacity, which allows it to store and release the heat extracted from the environment, to exchange and improve thermoregulation.

Passive cooling:

Termite mounds maintain a stable internal climate by having a physical structure that allows passive internal airflow. They function like the lungs of mammals and serve as auxiliary organs for gas exchange in the underground nest.

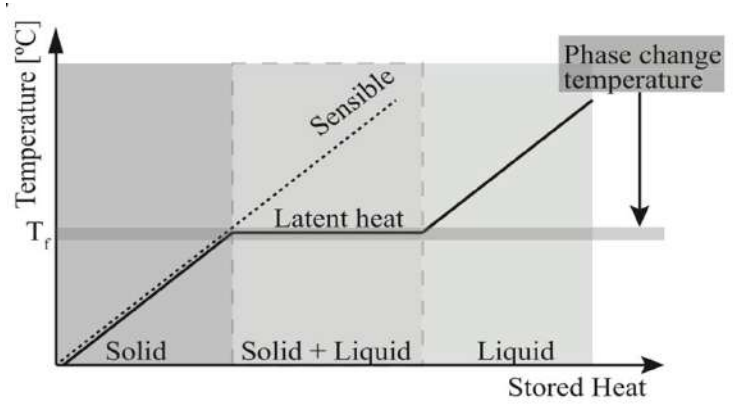


Thermal conductivity – lipid content graph

PCMs:

A phase change material (PCM) is a substance that releases/absorbs enough energy during phase transition to provide useful heat/cold. Generally, the transition occurs from one of the first two basic states of matter - solid and liquid - to the other.

Material	Melting point (°C)	Latent heat (kJ/kg)	**K** (W/mkg)	Price (euro /kg)
C20H42	36.7	246	0.15	4.00-8.00
C18H38	28	244	0.11	4.00-8.00
Paraffin Rt27	28	179	0.2	4.00-8.00
C17H36	22	240	0.21	4.00-8.00



Representation of PCM behavior during change of temperature

Properties	Organic paraffines
Flammability	V
Thermal conductibility	low
Corrosive	X
Supercooling	X
Phase segregation	X
Processability, Non toxic	V
Range of melting	X

The advantages and disadvantages of polyethylene:

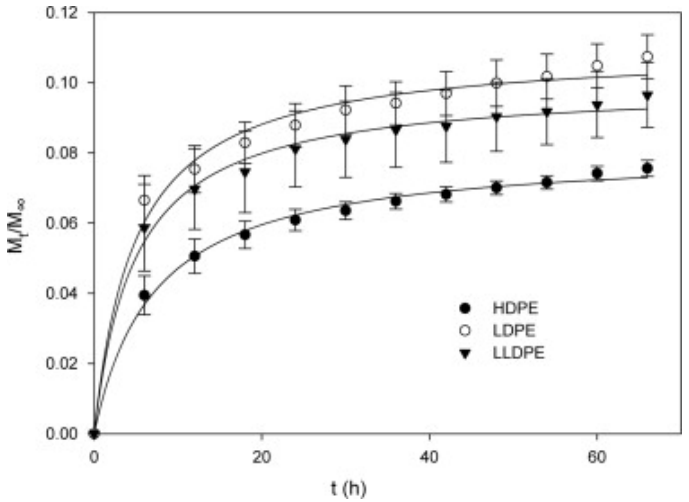
- Thermoplastic polymer with chemical stability and insulating property.
- Cheap and easy to process.
- Tensile modulus of 240 MPa, flexible.
- Water resistant.
- Melting point of 130°C.
- Latent heat of 161.31 J/g with a dispersion of 60% of paraffin.

It could be flammable to solve the problem, use intumescent materials such as inorganic hydroxide:

- low toxicity
- cost efficiency
- minimal corrosion
- contribution to reducing smoke during the combustion process.

Polyethylene-paraffin:

- HDPE in PE/paraffin form-stable phase change materials to maintain the energy saving behaviour of
  paraffin in building applications for reducing interior temperature fluctuations.
- There are no chemical reactions among paraffin and PE.
- The melting point of PE is 130°C, which is lower than 280°C, degradation temperature of paraffin.

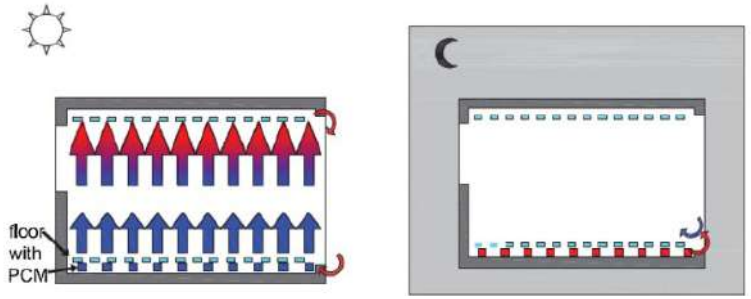


Paraffin leakage in release test according to time. (All samples contain 30% PE and 70% paraffin. H: HDPE, L: LDPE, LL: LLDPE)

PCM in building envelope:

- **PCM integrated:**

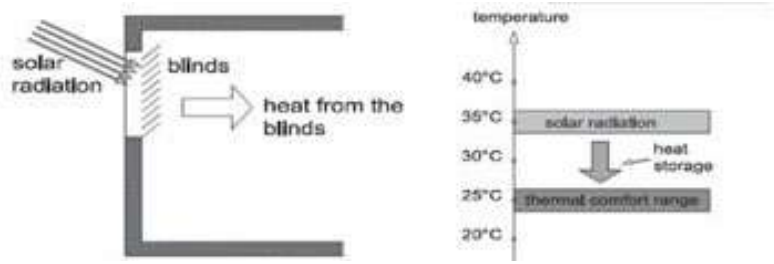
The main advantage of PCM -enhanced insulation is its ability to significantly reduce and shift peak thermal loads in the building envelope.



General concept for cooling with PCM integrated into the floor

- **PCM as a component:**

A component can be manufactured before the building is built and have a specific design. Blinds with integrated PCM are an example of a PCM component.



General concept for PCM use as a component

Production method:

For emulsion polymerization it's necessary a twin screw extruder.

First, the solid PE powder was mixed with molten kerosene in a beaker by hand before mixing. Then extrusion was carried out at a temperature of 180 °C and a screw speed of 80 rpm.

After that, the material is cooled (3% shrinkage) so that it can processed in drop form.

Twin screw extruder

Who are we?

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