The final design is a non-typical kind of architecture, which is the result of design by research. The aim of the final design is to be energy-flat in the heat-balance. The floor space of the building (176 m²) is equal to that of the reference design, to allow for a fair comparison with the reference design.

The design is a quarter elliptical sphere which is covered by a layer of earth. The south façade consist for 80 % of glazed surfaces. In front of the façade, there is an array of six rotating insulated solar blinds. In the back of the house, there is one shaft going through the layer of earth, providing light in the back of the house and ventilation possibilities. The house has two levels and almost all rooms oriented themselves to light of the south façade.
DESIGN ELABORATION

**Energy-flatten performance**

The overall energy-flatten performance of the final design is much better than the energy-flatten performance of the reference design. For every KPI, significant results are achieved. The total annual heating, cooling and supply loads are lower. From March till May, the surplus mismatch rises caused by lowered and shifted cooling loads as a result of much thermal mass. The other months are energy-flatten, except from December and January that cause a heating shortage.

The total heating shortage, cooling shortage and supply surplus are respectively 356.4, 425.0 and 826.9 kWh. The figure on the right shows the location of the mismatches. From March till half of May, the main supply surplus occurs. In August there is a cooling shortage and in the middle of the winter there is a heating shortage. The centralized surplus might be a potential for energy-flatten, any process that requires much supply in a short period could solve the mismatch.

**Building services**

**Heating and cooling system & ventilation principles**

In the northern side of the sphere, there is a shaft that goes through the earth layer. The shaft has two main functionalities:

- Allowing light to enter in the back of the house
- Facilitating both natural and mechanical ventilation with heat-exchange

The ventilation shaft allows for a natural draft. The integrated heat-exchanger makes effectively use of the size of the shaft. By integrating the heat-exchanger in the shaft, both natural ventilation and mechanical ventilation are possible.

**Insulated rotating solar blinds**

On the south façade, there is a big window. The window has two main functionalities; allow the passive solar heat to enter and create architectural comfort. This window has a high g-value, combined with a high insulation value. In front of the window, there is an array of six large rotating insulated solar blinds. These blinds have three functionalities:

- Insulate the window during cold nights in which transmission should be reduced
- Rotate towards the sun for optimal solar radiation penetration in the building
- Rotate against the direction of the sun to block solar radiation.

**Details**

**Top: Horizontal detail - 1:5 - facade and insulated blinds**

**Right: Vertical detail - 1:20 - ventilation shaft and roof window**
FUNCTIONALITY OF DESIGN

Energy-flatable housing - Vincent Höfte
Graduation presentation, January, 2018

Level differences, overhangs and heavy interior surfaces
- Level differences and heavy interior materials increase both the thermal mass surface area and volume

Intelligent energy-flatable control system
- The building measures energy surpluses or shortages and indoor climate, and adapts the heat and cool systems to it

Earth sheltered building for thermal mass
- The high density and heat capacity of the soil increases the ability of the building to mitigate temperature changes

Intelligent energy-flatable control system
- The building measures energy surpluses or shortages and indoor climate, and adapts the heat and cool systems to it

Low surface-to-wall area
- The spherical form of the outdoor surfaces provides a much volume and floor area per outdoor surface area. The extra volume is beneficial for ventilation

East + west supply surface
- The largest share of the supply surface is oriented to the east and west side. Amorphous PV should be used, to optimally use the diffuse lighting.

Solar orientation adaptive insulating blinds
- Large insulated blinds allow solar radiation to enter in winter, block direct solar in summer and insulate the window at night.

Big south window with high g-value
- The sun-oriented window with a high g-value provides passive heat in winter and creates a comfortable light indoor climate

Floor plans and windows allow for solar radiation penetration
- A deepened first floor allows solar radiation to enter deep in the building, in favor of the thermal mass

Ventilation shaft
- The ventilation opening provides cross-ventilation possibilities for natural ventilation. It also contains a heat exchanger to reduce ventilation losses
Energy-flat design principles

The parameter studies and preliminary designs resulted in a toolbox of design principles that can be used to improve the energy performance. The toolbox is categorized along the conclusions found with energy-flat design simulations. The elaboration can be found in the P4 thesis report, chapter 7.3 - Design toolbox. Below, all the design principles are shown next to their corresponding conclusion.

**Energy-flat design toolbox**

**Toolbox design suggestions**

Two sketch designs are shown which make use of the design principles as described in the toolbox above. For both designs, one sketch shows the (urban) context and its potentials for energy-flateness. The other sketch shows a section of the design which describes the principles used.

The upper design is a floating home. Its main potentials are the water environment and the combined grid connection. Its principles focus on thermal mass and the adaptive rotation of the building.

The lower design is a refurbishment of row houses. In this case, the potential lies in the repetition of the blocks and the principles mainly focus on adaptive installations, which are relatively easy to implement in a refurbishment.

The parameter studies and preliminary designs resulted in a toolbox of design principles that can be used to improve the energy performance. The toolbox is categorized along the conclusions found with energy-flat design simulations. The elaboration can be found in the P4 thesis report, chapter 7.3 - Design toolbox. Below, all the design principles are shown next to their corresponding conclusion.