Transient Boundaries

International University Architectural Competition "Next Generation Sustainable House in Taiki-Cho"
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Many approaches of sustainable architecture in cold climates are geared only towards energy-savings, disregarding non-quantifiable aspects of architectural relevance such as spatial quality and aesthetics. These approaches often create a feeling of imprisonment rather than inhabitation. In contrast to these approaches we propose an architectural concept based on the tension between open and closed spaces, between private rooms and the direct contact with the nature.

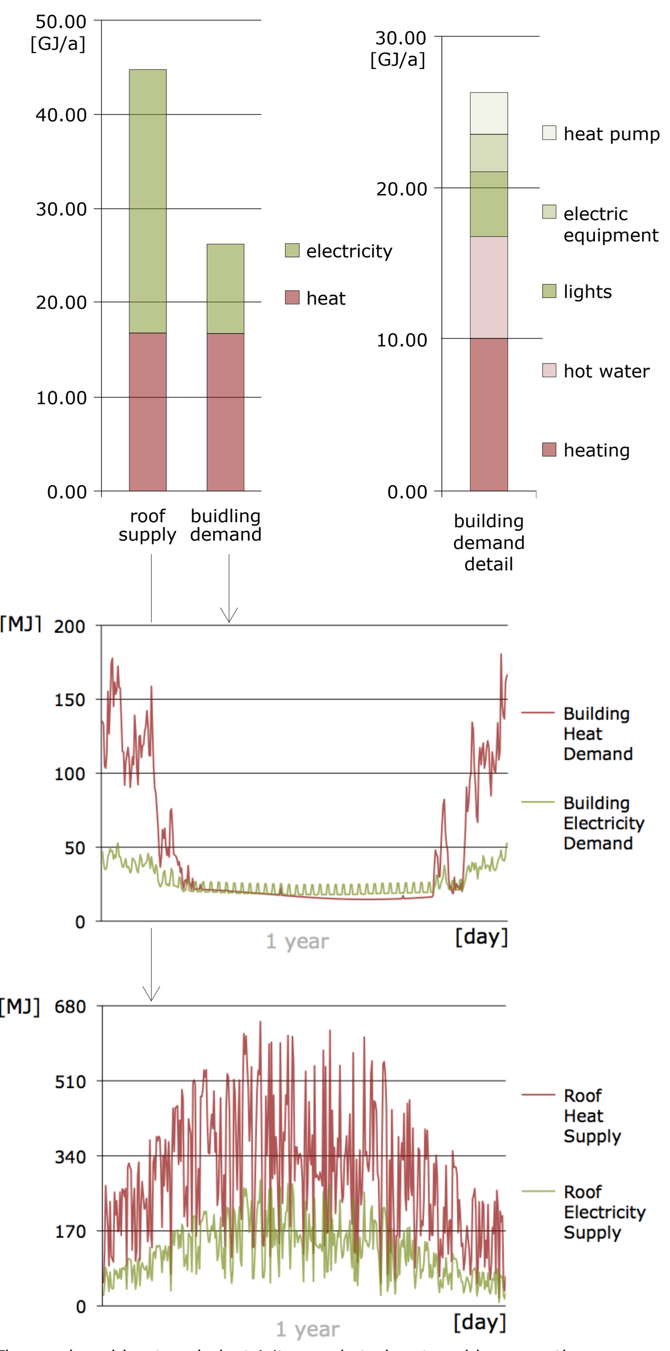
The building spaces are placed over a slab of recycled concrete. The entire building is covered by a semi-transparent photovoltaic glass roof that offers spectacular sights into the sky and extraordinary daylight qualities. Walls and beams of recycled cardboard, arranged in a structural grid, partition the space and provide a durable envelope to the exterior climate and strength against the wind and the snow.

The interior spaces achieve a high spatial diversity ranging from closed intimate rooms to public and open spaces. The rooms are defined by transient boundaries in which mobile elements allow to adjust visual and physical transparencies. The boundaries of the house are also the interface of the energetic interactions between the inner and the outer space.The interactions occur in the form of passive solar heat gains that reduce the heating demand, natural ventilation that reduces the cooling demand, and the harvesting of solar energy in form of electricity and heat.

The boundaries of the building further expand deep into the ground to exploit the constant temperature of the soil as heat source for an efficient heat pump operation in the winter and as a direct cold source in the summer. The ground is also used as seasonal heat storage to make available in the cold winter the abundant thermal energy harvested by the thermal collectors during the summer. This combination allows a building operation without any CO_2 emissions, using local, renewable energy-sources. The building even produces a surplus of electrical energy that is shared with the community through the electrical network. The positive energy balance is also exploited to allow slightly higher heat losses through the glazed roof to keep it free of snow in wintertime. In this way, high-quality daylighting, solar heat gains, and electricity generation are maintained even during the snow season.

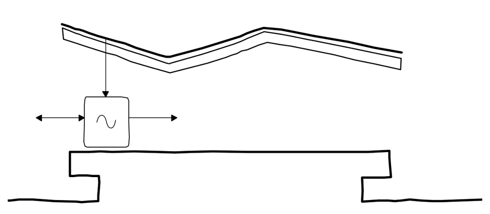
The building also features a highly sustainable materiality with low grey emissions by using recycled materials for the slab and the walls. Cardboard is made of wood fibres, a renewable resource, and is the most recycled material of the world.

Energy simulations

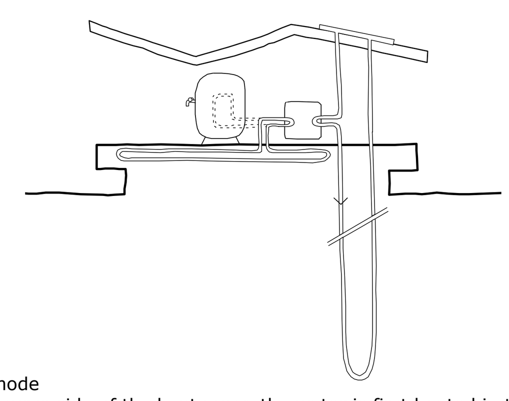


The produced heat and electricity needs to be stored because the dynamics of the building demand and of the roof supply are not matching. The heat is stored in the ground and electricity is stored in the public electrical network.

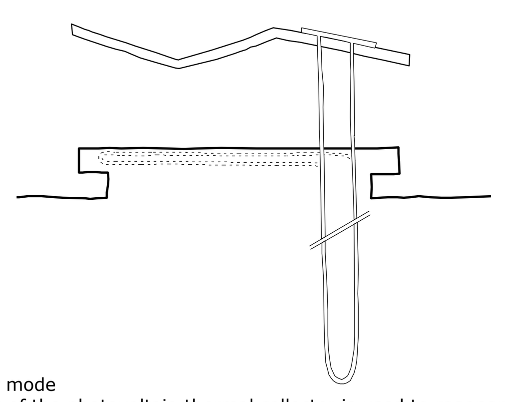
Technical systems



Electricity
The photovoltaic roof is connected to the internal appliances and to the network



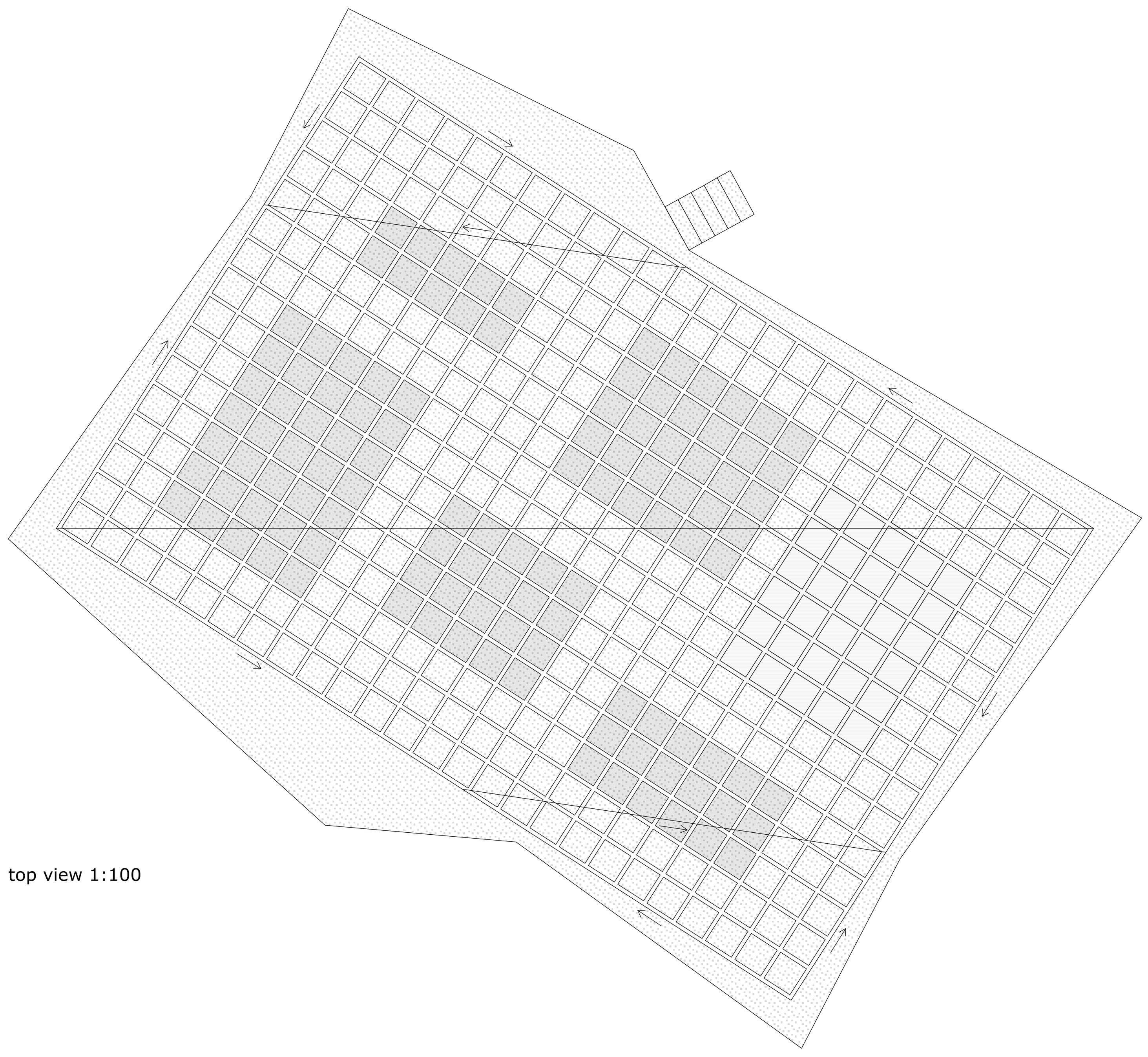
Winter mode
On the source side of the heat pump the water is first heated in the ground and successively in the photovoltaic-thermal collector if solar heat is available. On the sink side the heat pump supplies the floor heating system or the domestic hot water.



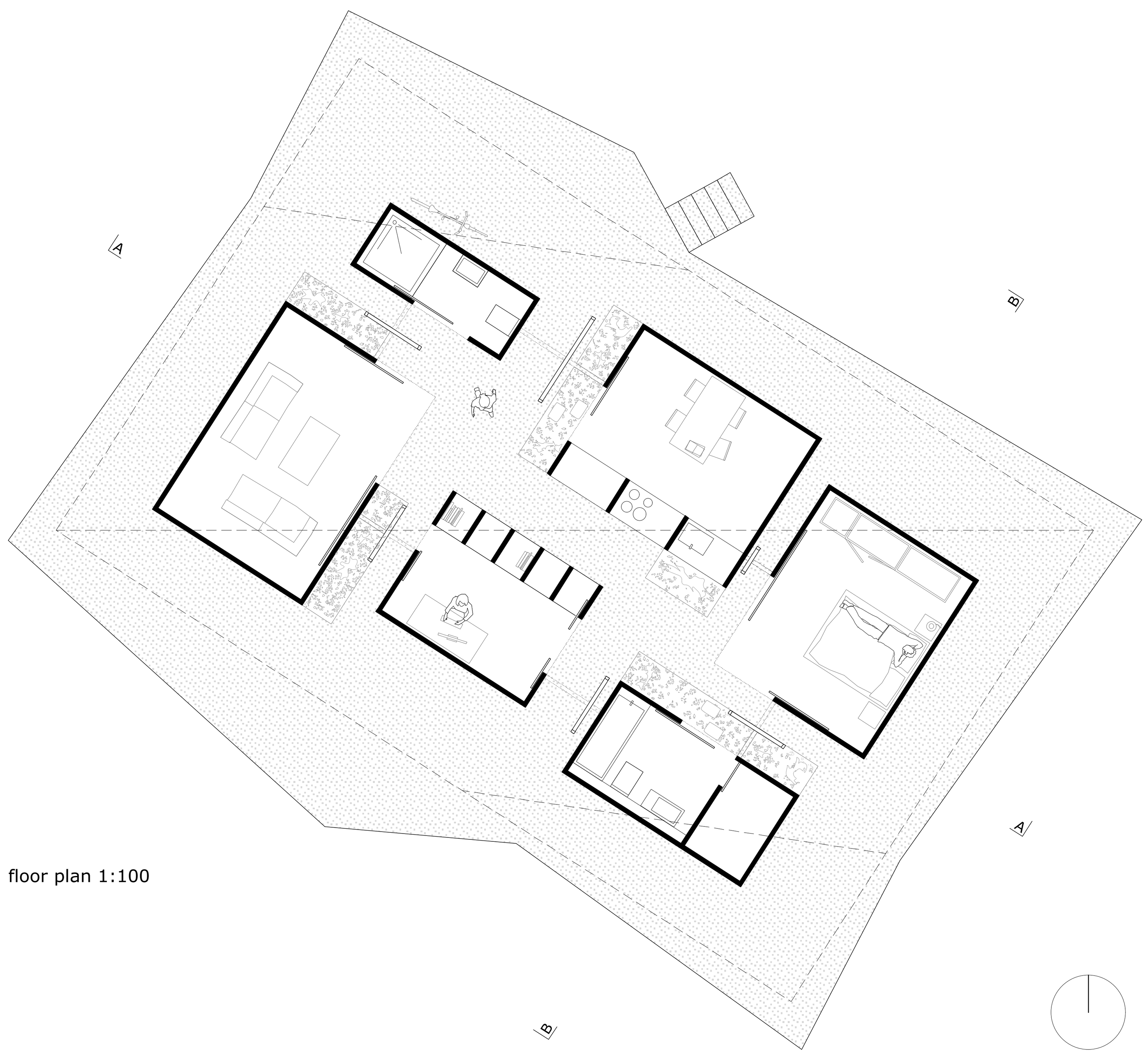
Summer mode
The heat of the photovoltaic-thermal collector is used to regenerate the ground heat in the hot season. Alternatively the ground is used as direct cold source to cool the concrete slab.

Cost estimation: 200'000 USD
based on projects realised in Switzerland

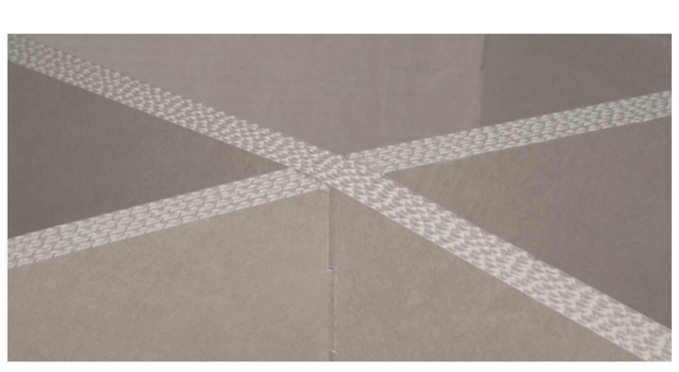
roof with photovoltaic and thermal collectors	60'000
borehole	20'000
heatpump	20'000
pipes, floor heating system, tank	10'000
concrete slab	15'000
cardboard structure	40'000
sliding and glas doors	10'000
kitchen, bathroom	15'000
electrical installation	10'000



top view 1:100

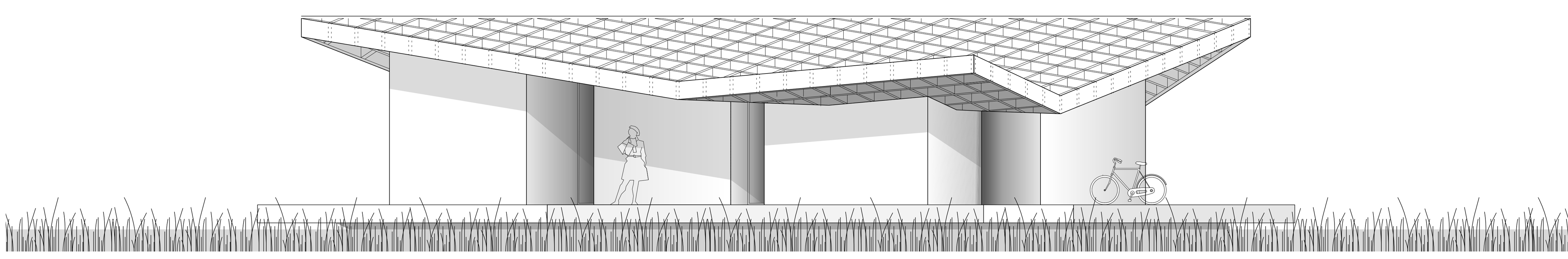


floor plan 1:100



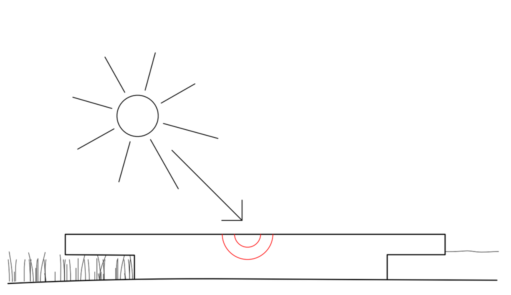
humidity and solar radiation resistant cardboard

semi-transparent photovoltaic glass

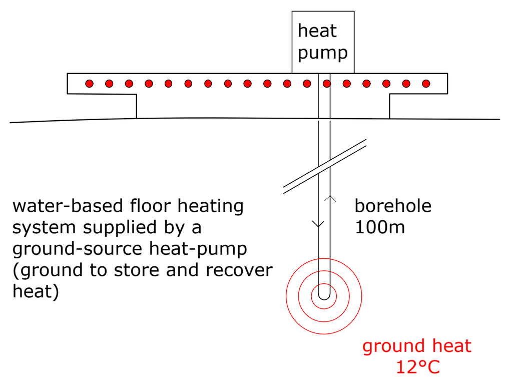


south-east elevation 1:100

Zero emission local energy sources

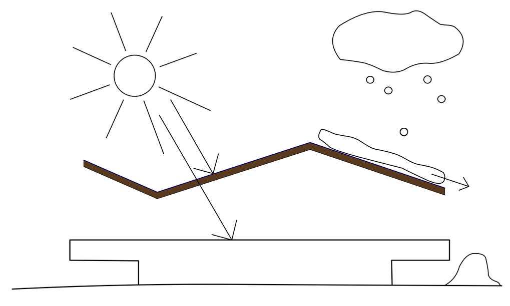


recycled concrete slab
(thermal mass, elevation from ground)



water-based floor heating system supplied by a ground-source heat-pump (ground to store and recover heat)

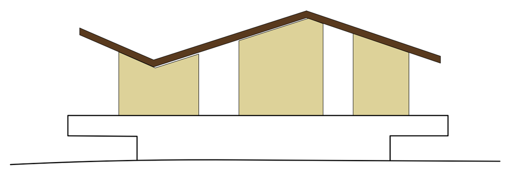
borehole
100m



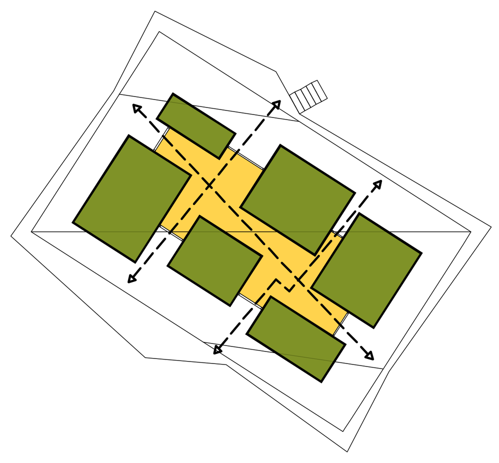
semi-transparent photovoltaic-glass roof, the sleeping room is covered by opaque photovoltaic-thermal collectors

solar heat gains to reduce the heating demand

sliding of the snow due to low-friction material (glass) and melted patina due to internal heat

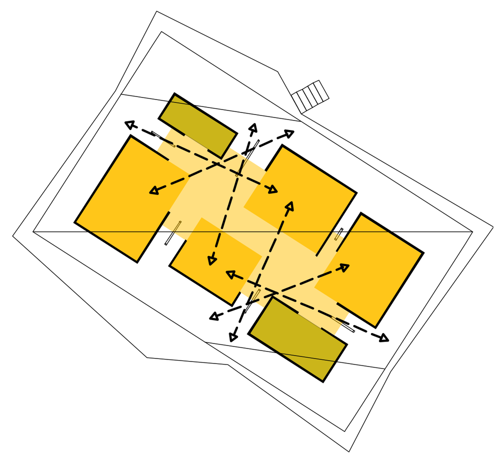


walls of recycled cardboard (low cost)
humidity and radiation resistant cardboard



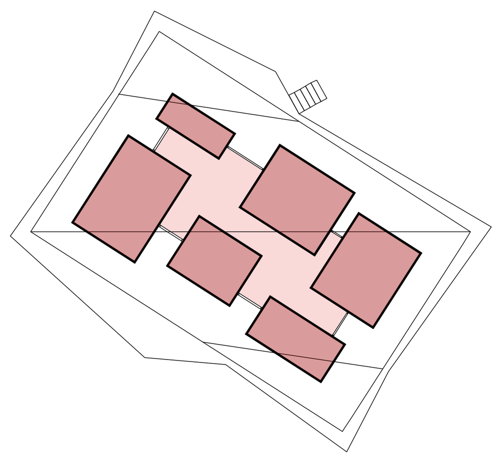
closed situation

intimate spaces, private rooms and inner garden, views into nature



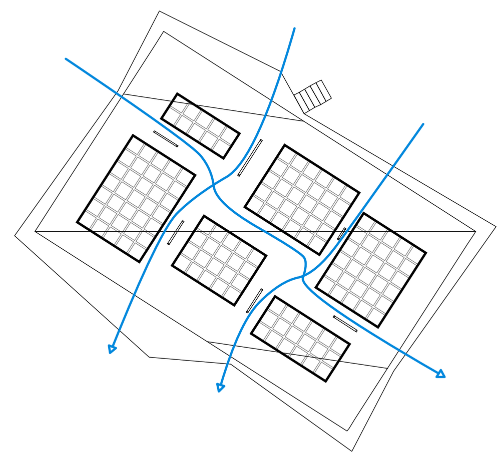
open situation

blurry spaces, public, physical transparency, open garden, views into nature



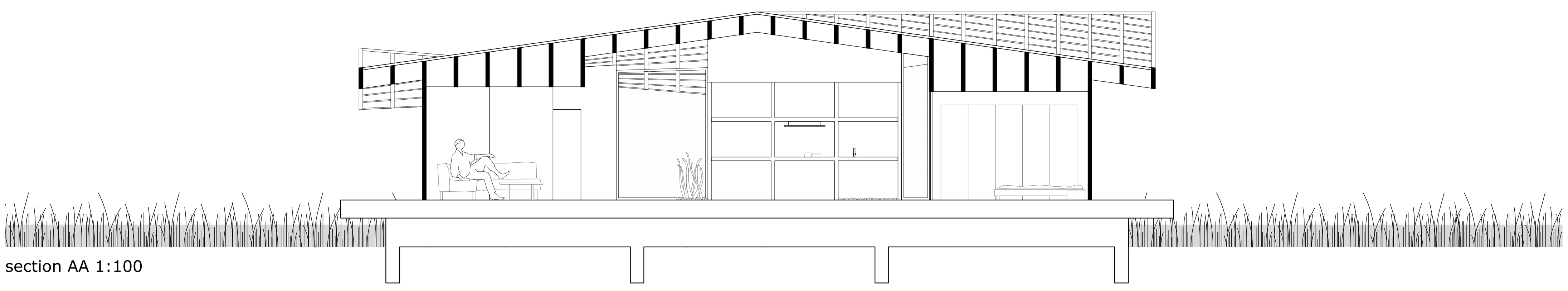
winter

solar heat gains and floor heating system to heat the interior

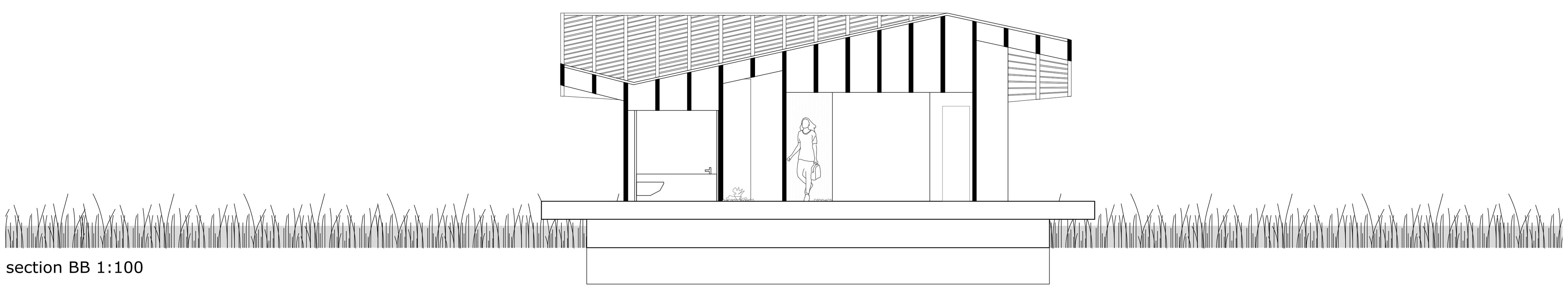


summer

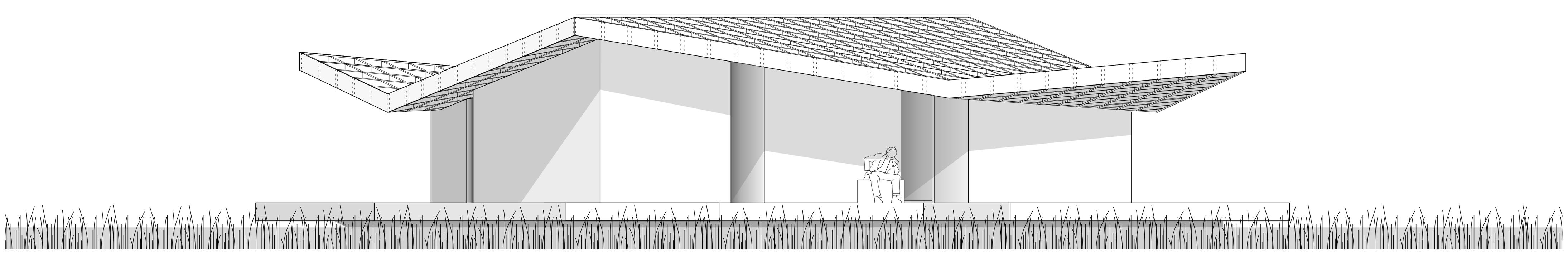
natural ventilation to reduce cooling demand and floor-ground coupling to provide cooling



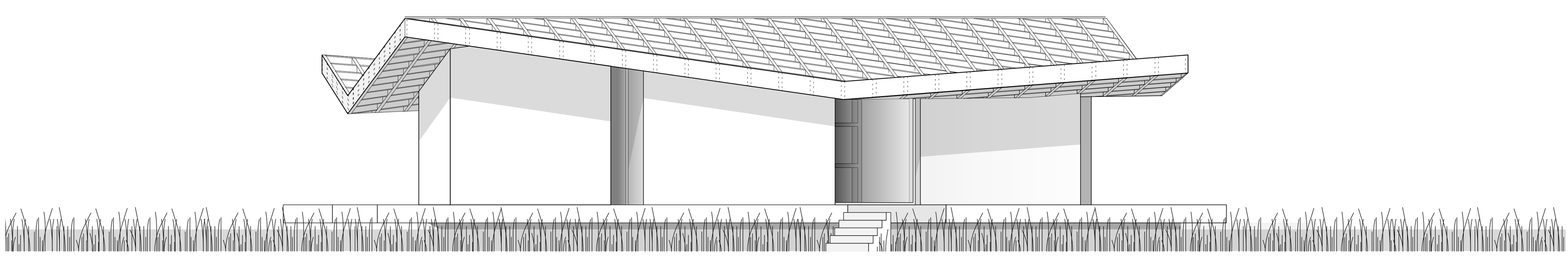
section AA 1:100



section BB 1:100



south-west elevation 1:100



north-east elevation 1:100