ODOO PROJECT

# ENERGY EFFICIENCY BRIEF REPORT

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Decathletes

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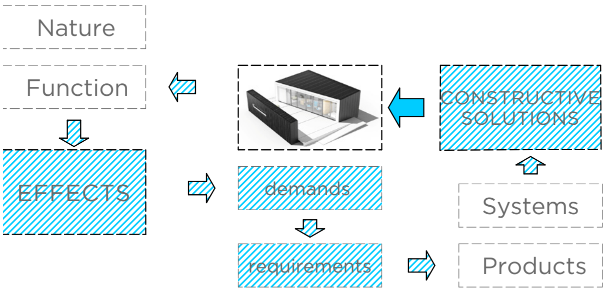
MŰEGYETEM 1782

sd europe SOLAR DECATHLON

Odooproject's energy efficient building design was mainly formed by the tight interaction of students from the Faculty of Architecture and the Faculty of Mechanical Engineering of Budapest University of Technology and Economics.




## HOLISTIC DESIGN APPROACH

A building's energy use and energy cost depend on the complex interaction of many parameters and variables. Our holistic design approach supported by energy simulation tools helped us choose the right solutions with respect for every important aspect. *(Project Manual 03.04.01)*

## PASSIVE DESIGN STRATEGY

At the beginning, our team has studied the current European standards of buildings' energy use, the EU's 2020 energy targets, the Passivhaus Institut's recommendations and the former SDE participants' houses. Following the research we have precisely set up our own passive design strategy along with required target values for every important technical aspect in order to build the most energy efficient house.*(Project Manual 03.03.02)*

## GEOMETRY

The trapezoid based prismatic shape is topped with a low pitched roof (6°), which resulted in two main energy features; a relatively good A/V ratio (1.5) and a large Southern surface (156m²) ideal for both active and passive solar energy utilization. *(Project Manual 03.03.02)*

## BUILDING ENVELOPE

| Thermal transmittance values (W/m²K) | | |
|---|---|---|
| Thermal insulation | Equally 22cm thick blown cellulose around the envelope | |
| | Hungarian standard | Odoo (calculated) |
| Roof | ≤ 0.25 | 0.141 |
| External wall | ≤ 0.45 | 0.147 |
| Floor | ≤ 0.25 | 0.134 |
| Windows and doors ($U_w$) | ≤ 2.00 | 0.73 (fixed)/ 1.05 (sliding) |
| Glazing ($U_g$) (g=46%) | | 0.6 |
| Air tightness | Our goal is to meet the $n_{50} \leq 0.6 h^{-1}$ value. Air tightness is ensured by solid glued laminated timber panels and a continuous air sealing and vapor retardant foil. Windows and doors are Class 4 (DIN EN 12207) at 1600 Pa test pressure. | |
| Vapor retardation | Continuous vapor retardant foil is applied on the glued laminated timber panels' surface. | |
| Thermal bridges | $\Psi \leq 0.01$ W/mK for standard cross sections bordering the envelope. | |
| Windproofing | Windproof façade foil is applied behind the naturally ventilated façade cladding in order to avoid microfiltration losses. | |

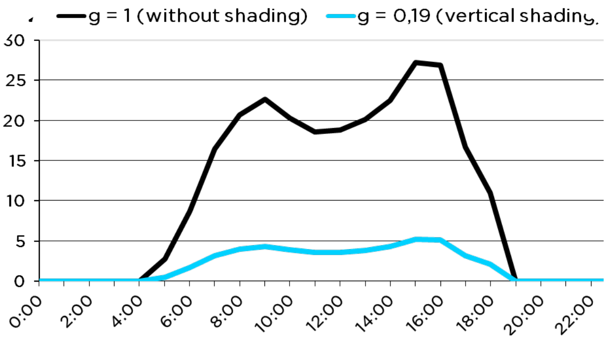
## THERMAL MASS

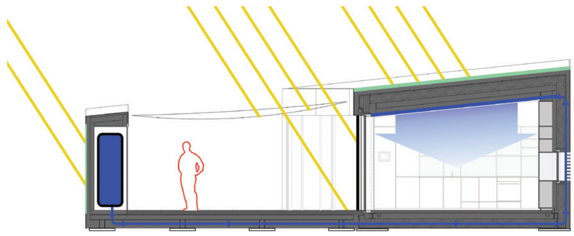
Our goal was to integrate a significant amount of thermal mass into the structure in order to provide inertia against temperature fluctuations.

| Heat storage type | Specific heat capacity [J/kgK] | Density [kg/m$^3$] | Built in volume [m$^3$] |
|---|---|---|---|
| Solid timber structure | 1600 | 530 | 22.64 |
| Floor screed | 1000 | 2300 | 2.54 |
| Circulating water | 4190 | 1000 | 3.00 |

## SHADING SYSTEM

In order to avoid summer overheating, we are employing vertical and horizontal shading systems. We have dynamically simulated 2012's hottest day relying on Madrid's weather data. Our automated vertical shading system (g=0.19) works well against the extra solar gains. In addition we designed a fixed sun sail over the terrace. *(Project Manual 03.04.0)*

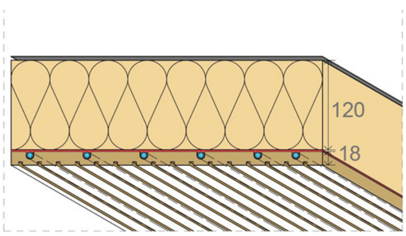


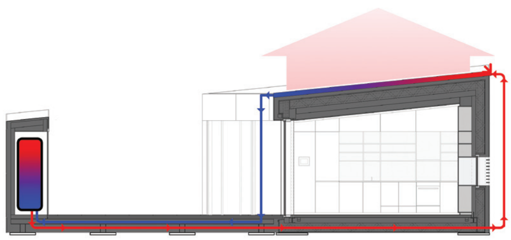
## PASSIVE WATER COOLING

The sky is used for the cooling process. The cloudless sky can be seen as a radiating surface of a constant -30°C temperature. The surface of the cooled solar panels is ideal for cooling back down the water warmed during the day. Over one night, we can produce cooling 3000 liter water of 17°C temperature or cooler and store it in thermally insulated buffer tank. That is perfectly suitable for cooling the house through circulating water in the pipes of the dropped ceiling during the day.

## DROPPED CEILING



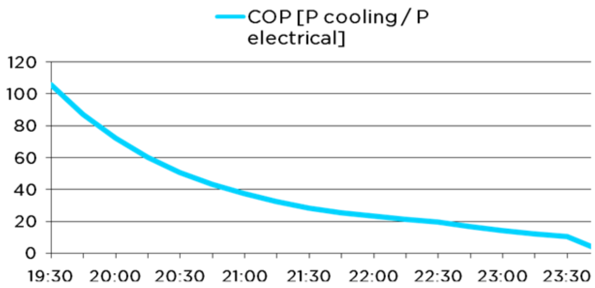

It is the individually developed dropped ceiling that we use primarily for cooling through the integrated piping system. Thanks to the thin MDF board and the thermal conductive paste slushed into the grooves, its heat transfer is 50 W/m$^2$. Above the piping there is thick thermal insulating layer.



Thanks to this system, the heat pump performs only reduced cooling functions, because it has to work in cooling mode only under high ambient temperatures (~ 35°C). This saves a significant amount of energy on the cooling side. If the water did not cool back sufficiently at night, the heat pump would help out for cooling during the night. Naturally, rain water will be filling up the tank.

The system will be set up with garden irrigation sprinkler heads. We strived for covering the roof surface with a minimum flow rate in order to reduce the pumping power demand.

In average, the cooling performance of the system is 20-times higher, then the energy consumption of the circulating pump (200W).




## FLOOR

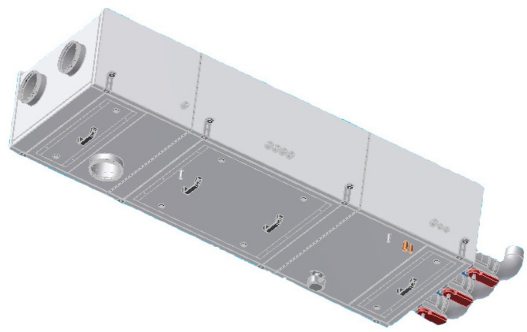
In all four building modules, two piping circuits have been installed in the floor. The first circuit is located in front of the windows, on the area which is subjected to direct sunlight, the second circuit falls closer to the north wall of the house.

The two-circuit floor system makes sense, if within a single day heating and cooling needs might emerge as well. This might happen when in the transitional period (fall or spring) the solar radiation falls on the surface before the window and heats it up. Then we have the opportunity to launch this separate circuit in the floor, and thus channel away this passive heat gain into one of the buffer tanks. If there was just one floor piping circuit, we could only distribute the heat within the premises, on the entire floor surface. In this case we could not transfer a sufficient amount of heat to the buffer tank. The heat stored in the buffer tank can be discharged at night and used for heating and tempering.

## VENTILATION

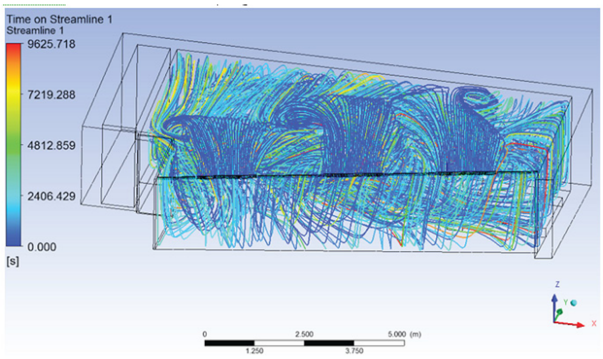
The artificial ventilation can result in an energetically suitable solution to provide the appropriate indoor air quality only if the fresh air sucked from outside is pre-heated in winter and pre-cooled in summer by the inside temperated air. This process takes places in the counterflow flat-plate heat recovery unit built into the air handling unit, allowing to reduce the heat energy entering the living space via ventilation by up to 90%.

Energy efficient Ecofit EC-motorized, infinitely controlled fans are used for the blowing and the suction side as well. The dust and other solid pollutants are filtered by an F5 category filtering panel installed in the exhaust air and fresh air branches. The appliance contains both cooling and heating elements, the cooling energy is provided by the air-to-water heat pump via a direct evaporation cooler. This solution allows skipping a heat transfer step (refridgerant to water), thereby making air cooling more efficient. With an electric heater drying out air can be also achieved if necessary.



The ventilation air tempered to the desired internal temperature is delivered to the main air space by three slot diffusers installed above the sliding doors of the southern glazed surface. The suction from the main air space is also done above the southern glass surface, through the gaps between the slot diffusers. This way, the heat entering through the glass can be channeled away immediately via the ventilation system, which reduces the summer heat load of the interior. In normal operation mode 90m$^3$/h fresh, tempered air diffused to indoor, in the one hour after the public tour the diffused air volume is 300m$^3$/h to provide the required indoor air quality.

We simulated the air movement (CFD) in the livingroom in order to find out the velocity and temperature distribution, and to discover if there is any stagnant zone.




## OTHER ENERGY EFFICIENT SOLUTIONS

Our team has designed and manufactured special wooden ladder frames, which are built into the envelope working as space holders in the line of the cellulose thermal insulation.

We are employing high density Purenit cubes as load transmitting elements between the floor slab and the mobile footing system, thus minimizing thermal bridges occurring from material change in the cross section.

In order to create a solid, continuous thermal envelope with as less thermal bridging as possible; we apply singular Purenit elements as window lining (blind frame) at the installation of windows and doors.

We are using long lifespan LED lights in order to minimize relative lighting energy demand.

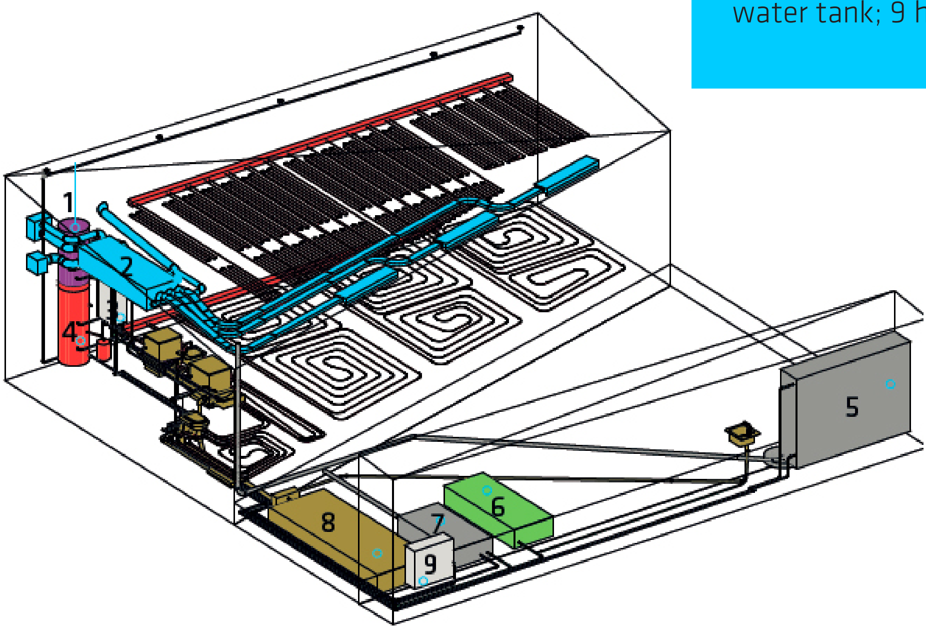
In order to decrease thermal losses of the mechanical system we apply plastic foam thermal insulation on pipe surfaces.

We are positively balancing our structure's and BIPV systems' performance by creating naturally ventilated air spaces both on facade and roof surfaces.

## PROJECTED PERFORMANCE FEATURES

Our team has developed a MATLAB–Simulink based dynamic simulation environment. We modeled the building structure's heat losses, solar gains, occupancy behavior, internal heat loads, using Madrid's meteorological parameters. We could accurately predict our building's annual and competition time behavior.

| Aspect | Odoo |
|---|---|
| Heat loss coefficient [W/m³K] | 0.44 |
| Annual space heating demand [kWh/m²a] | 11.5 |
| Annual heating demand [kWh] | 520 |
| Annual cooling demand [kWh] | 1986 |




1 DHW tank; 2 Air Handling unit; 3 Heat pump indoor unit; 4 surface heating buffer tank; 5 cooling buffer tank; 6 domestic cold water tank; 7 rainwater tank; 8 waste water tank; 9 heat pump outdoor unit