NEST HiLo

[Project title]

HA14-WLYZT

[Project ID]

HOLCIM AWARDS (MAIN CATEGORY)

GENERAL PROJECT DATA

Project Group 1	Architecture, building and civil engineering
Competition region	Europe
City	Dübendorf
Country	Switzerland
Client	Empa-Eawag
Intervention	New construction
Status of planning	Final design stage
Status of permission	Application in preparation
Planned start	Jul '15
Project background	Research project
Latitude	47°24'9.33"N
Longitude	8°36'45.45"E
Elevation	432.5
Other competition	no

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PROJECT SUMMARY

HiLo is a research & innovation unit in the domains of lightweight concrete construction and smart, adaptive building systems, planned as a duplex penthouse guest apartment for the NEST building on the Empa campus. As part of a future living and working lab, it introduces five key innovations: an integrated, funicular floor system; an integrated, thin-shell roof; a lightweight formwork system for shell construction; an adaptive solar façade; and an automated, occupant-centred building system.

PROJECT DETAILS

GFA	168 cu m
GV	360 cu m
Construction costs	1600000 USD
Site area	111 sq m
Footprint area	111 sq m
Building height	18.5 m
Building depth	N/A m

FURTHER RELEVANT KEY FIGURES

Envelope surface: 157m^2 for thin shell roof, 75m^2 glazing, 34m^2 closed facade, 109m^2 dividing wall with NEST building.
NEST building height is 21.36m and building depth is 4.305m.

MATERIALS

Textile and fiber reinforced high performance concrete for the roof; Fiber reinforced high performance concrete for the floor system; silicone for the soft actuators of the thin film PV facade; etc.

SUSTAINABILITY CONCEPT

HiLo boasts an intensive and integrated engagement with innovations in material, structural and environmental technologies. The project is not a mere showcasing of its constituent technologies, rather, a demonstration of the architectural potentials and effects such technologies afford. It is an apparatus for the direct, in-situ monitoring and testing of these innovations throughout its lifetime. Results and knowledge gained from design, construction and operation are disseminated through scientific publication.

A lightweight floor system, featuring funicular vaulting and structural ribs, saves more than 70% of material and most reinforcement steel compared to traditional concrete slabs. Due to a robotic prefabrication setup, the modular floor elements are bespoke and easily installed on site. Internal cavities allow the integration of ventilation and low-temperature heating and cooling systems, further saving floor height.

The large surface area of the thin-shell roof is engaged in a similar manner. The entire roof build-up, with an average of less than 70mm, is extremely thin; load-bearing textile-reinforced concrete, combined aerogel and vacuum insulation with low thermal transmittance, and high efficiency thin-film photovoltaics for solar energy generation.A reusable and lightweight, hybrid cable-net and fabric formwork system allows the construction of the doubly curved roof, controlling the geometry within excellent tolerances to obtain the design shape that has been optimized for structural performance.

Further energy is generated by the adaptive solar envelope; movable, modular elements employing soft pneumatic actuators. They provide shading and control the transparency of the façade. The elements rotate, as they respond to changes in the outside environment and demands of the interior through sensor and occupant input.

The energy concept targets zero emissions and zero fossil fuels in operation providing a surplus of renewable energy generated on site. To achieve synthesis with the design, the system components are fully integrated into structural elements, leveraging their specific attributes. All the systems for interior climatization and energy harvesting are controlled by a user-centered building automation system to optimally balance dynamics in interaction with the district energy systems and user preferences. Adaptive learning algorithms continuously improve behavior and thus adaptation of the unit to its users and their environment.

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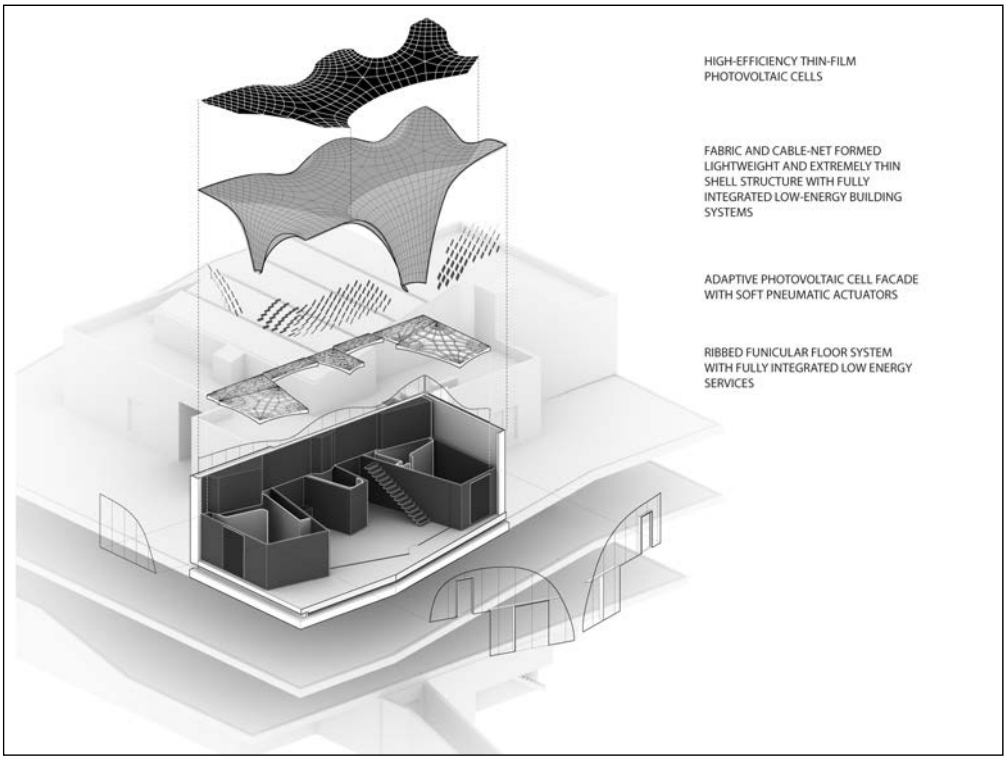
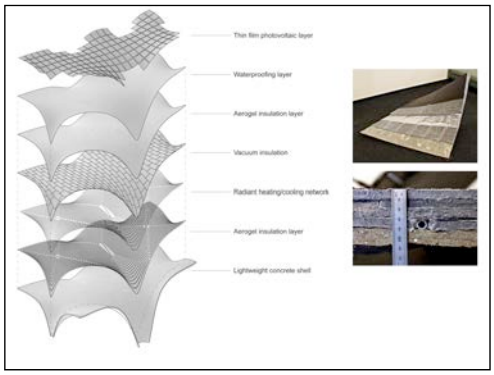
PROJECT VISUALIZATION



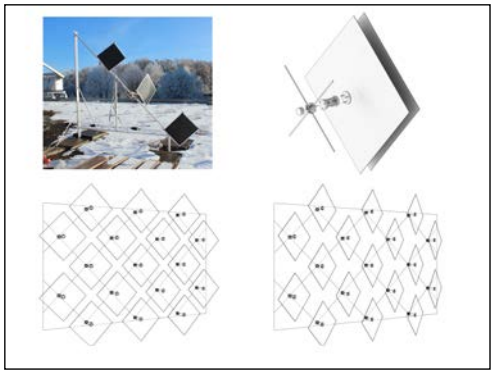
The innovations consist of high-efficiency thin-film photovoltaic cells; a cable-net and fabric formed, lightweight and thin shell structure with integrated low-energy building systems; an adaptive photovoltaic cell facade with soft pneumatic actuators; a ribbed funicular floor system with fully integrated low energy services for the mezzanine level; and an occupant centered control system that extracts recurring behavioral patterns through a high density non-intrusive sensor network.

Doubly curved concrete shells can cover large spaces at minimal material cost; their use at a domestic scale is largely unprecedented and as such so is the possible spatial quality it offers: smooth, free-flowing and loosely demarcated spatial territories, with 'swooping' curvature and structural 'touch-down points'. This establishes a gradient of informal living and collaborative spaces across two levels, visually and physically connected by a continuous 'landscape'.



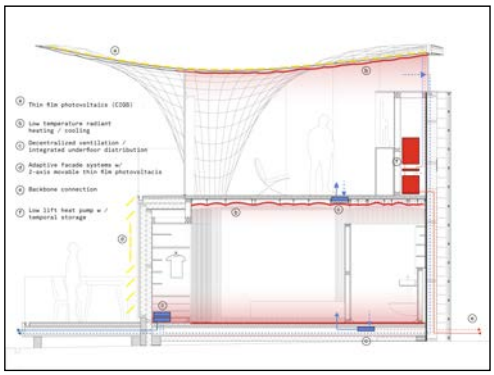
Integrated shell layers, with a U-value of 0.22 W/m2K and a local weight as low as 60 kg/m2.

Prototype of the modular, vaulted, unreinforced concrete construction, no more than 2 cm thick.

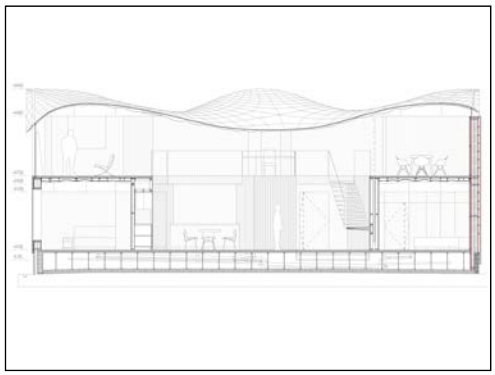


Flexible photovoltaic cells mounted on a cable net, rotated using soft robotic, pneumatic actuators.

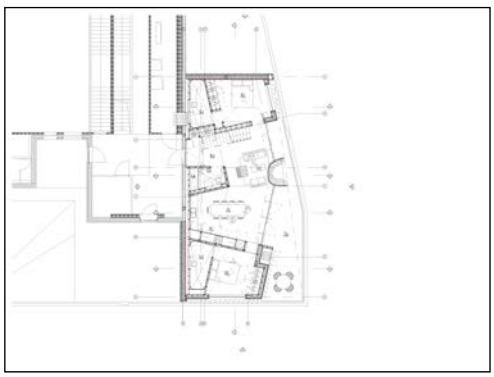
Prototype shell built using the new hybrid cable-net and fabric formwork.



HiLo is able to produce excess electricity over the year as well as excess heat in spring and fall.



The apartment conceals its domesticity when required for formal working scenarios such as meetings.



Formally conceived of as a two bedroom apartment, alternate configurations are possible.

HiLo constructed on top of the NEST backbone. (image credit: Empa / Gramazio & Kohler)