Innovation

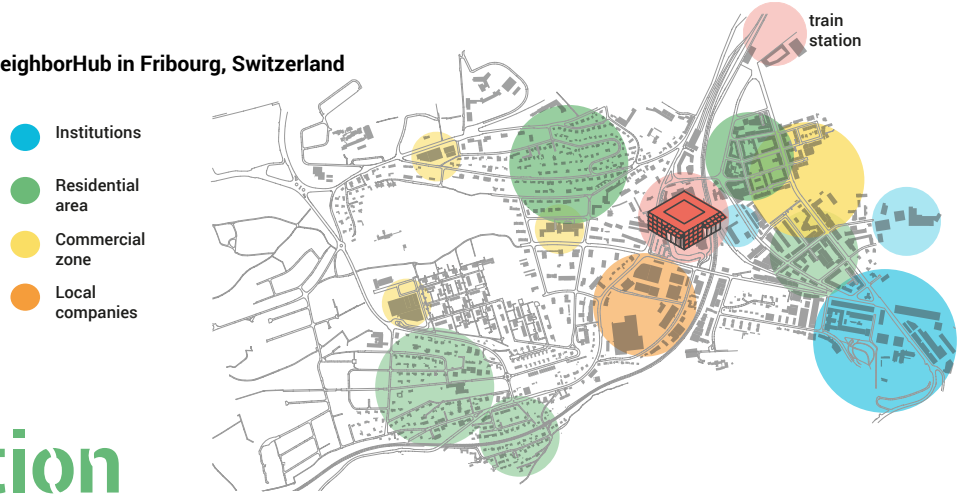
Community centered philosophy

The development of technological innovation is booming, and recently the focus has shifted towards sustainable solutions. The new challenge lies in sharing and implementing existing sustainable technologies to achieve the goals set by more than 150 countries during the Paris Agreement (COP21). In Switzerland, the subsequent objective is to reduce per capita energy consumption by half by 2035.

The Swiss Team believes that communities' potential as change leaders is tremendous and just needs a kick-start to be unleashed. To act on the global scale, citizens and cities have an important role to play. Our mission is to be a catalyst of sustainable changes in our everyday habits.

To reach a larger number of people, we have created the NeighborHub, an infrastructure located in a suburban area, which aims to act as a platform diffusing knowledge about sustainable practices within a community.

[1] Implementation of the NeighborHub in Fribourg, Switzerland



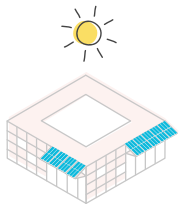
Encourage the full sustainability potential

Collaborative platform

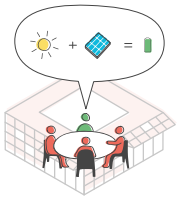
To achieve our mission, we propose a concept and a house which can adapt to different districts and to different users' needs respectively. We believe that the strength of a neighborhood comes from its diversity and that it is therefore important to bring together in one place all stakeholders: citizens, associations, institutions and local companies.

To test the viability of such an idea, the Swiss Team has been encouraging a strong collaboration during the development process with companies and institutions, such as the city of Fribourg **[1]**. We believe that this collaboration will define the future commercial and legal trends, allowing the creation of stronger links between the neighborhood's inhabitants in the fight against climate change.

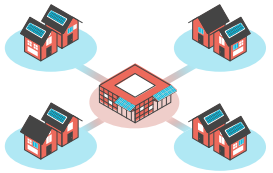
[2] Collaborative platform for the NeighborHub



a) Showcase



b) Learn by experiencing



c) Plan Collaboratively

"The NeighborHub is a place designed to encourage its users to: showcase new objects and technologies, learn by experiencing and plan collaboratively" [2]

Encourage the full sustainability potential

Innovative business model

By bringing together the different neighborhood's stakeholders, a specific business model has emerged, which fosters a public-private ownership to strengthen the bonds between the various parties. The NeighborHub will be open to all local stakeholders, with reserved time slots for planned activities.

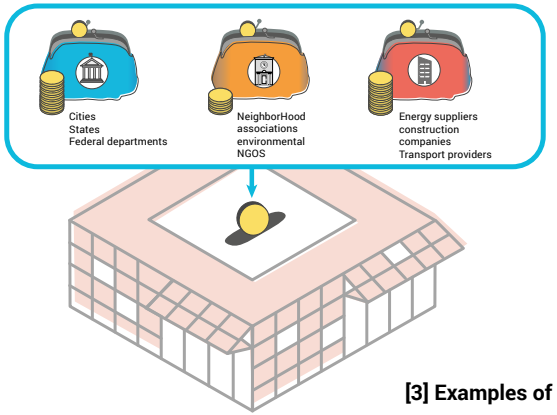
The initial investment will be shared by many partners **[3]**. As a result, individual contributions will be reduced and this will open the door to a larger diversity of usage and users.

The NeighborHub aims to be financially self-sufficient, by reinjecting the profits into the house. The investment and operational costs are balanced by the initial investments and by tenancy revenues respectively, defined through specific terms of use.

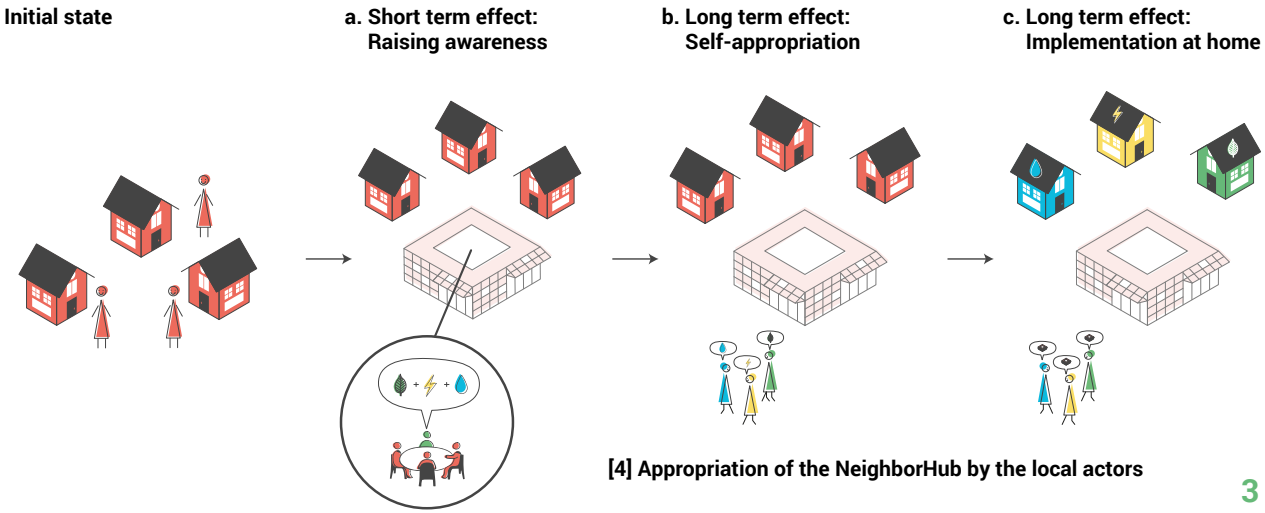
These terms include a plan to balance the operating costs during the lifetime of the house through, for example, a financial contribution of the users in the form of a membership, but also a charter specifying the nature of the activities organized in the NeighborHub. This constitutes the first step towards planning collaboratively. An initial proposal for tenancy is currently being developed thanks to the collaboration between the Swiss team students and the company blueFACTORY SA, responsible for managing the site where the NeighborHub will be implemented upon its return to Switzerland.

Towards lasting benefits

In the short-term, the NeighborHub will raise the awareness of the neighborhood's inhabitants of their role in reaching environmental goals by acting on seven driving themes: renewable energy, soft mobility, biodiversity preservation, choice of materials, local food, water and waste management **[4a]**. By planning with city officials for example, it will be possible to create a keen interest in sustainable issues and to use this opportunity to bring the community together.
In the long-term, the goal is for the community to self-appropriate the different technologies present in the NeighborHub **[4b]** and to implement them on their scale **[4c]**. To reach this objective, the NeighborHub integrates low-tech solutions such as solar dryers, self-built technologies such as homemade solar thermal panels and a self-taught approach, thanks to our interactive user interface.



[3] Examples of partners



[4] Appropriation of the NeighborHub by the local actors

Develop new design solutions

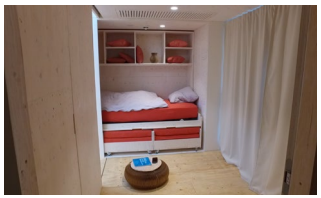
Multi-purpose spaces

To simplify the creation of several, probably different NeighborHubs, each adapted to its own environment, the biggest challenge is to ensure flexibility in the functions to ensure that the different users' needs are met. All the building's activities have been imagined in accordance with our seven driving themes.

The essential functions of the house, ie the kitchen, bedroom and lounge space, bathroom and toilets, are grouped around the building's perimeter, enabling the creation of a central area and contributing to the optimum use of space.

The movable furniture and partitions allow the space to be converted depending on users' needs. A sliding wall, for example, permits the lounge area to be converted into a private space, including a bed that can be unfolded when needed, with access to the bathroom **[5a]**. Other public activities can simultaneously take place in the central area, which can be reconfigurated, for example, to accommodate a conference **[5b]**. The Extended Skin, which enables a seamless transition with the exterior, offers the possibility for more hands-on activities **[5c]**.

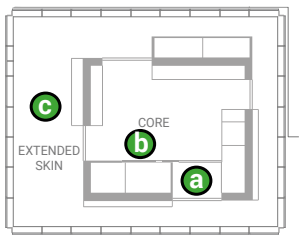
[5] Flexible and reconfigurable spaces



a) Bedroom and lounge space

b) Conference space

c) Workshop space

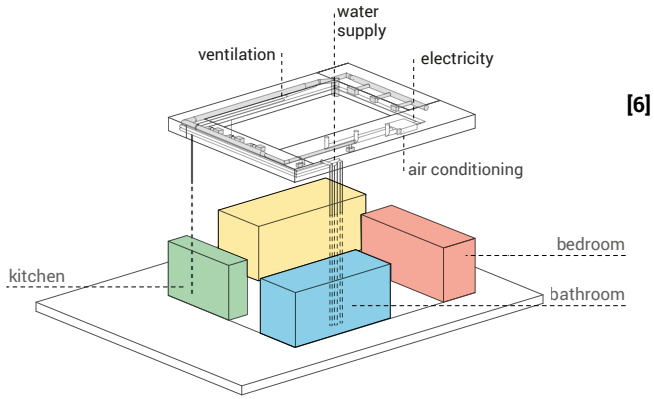


Modular construction

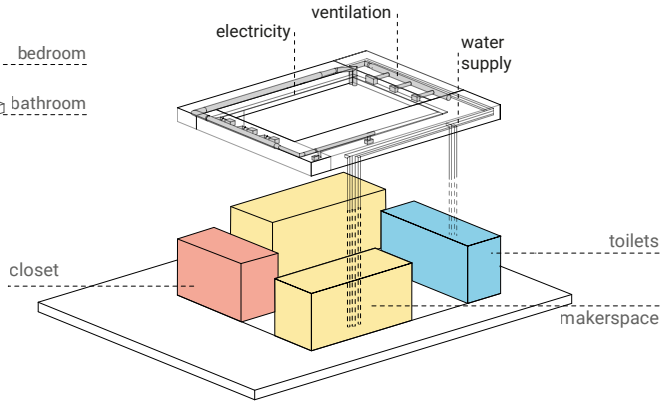
In structural terms, this flexibility of use is achieved using modular construction: prefabricated modules coupled with a technical "donut ", an empty space that distributes utilities to each module **[6a]**. Therefore, whatever the specific functions assigned to a module, the corresponding utilities (electricity, water and air) can easily be supplied **[6b]**.

All the engineering work was done keeping in mind safety measures, such as having all technical elements within a well-defined perimeter. For this reason, the technical donut cannot be accessed too easily by users but is visible in order to aid understanding of its role in the house operation.

[6] Modular construction: modules and technical donut



a) The NeighborHub

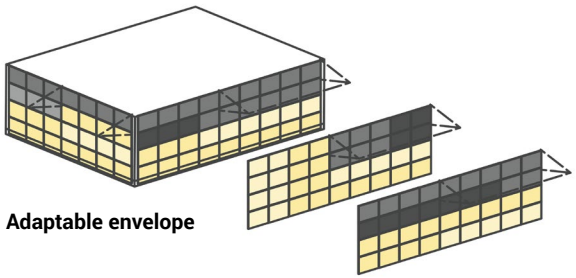


b) Other possible configuration

Develop new design solutions

Flexibility is also present in the facades thanks to the versatile filling panels. They include transparent and translucent surfaces such as solid-state dye-sensitized solar cell (DSSC) panels and opaque ones like photovoltaic (PV) and solar thermal (ST) panels.

Configuration of the facade elements can be interchanged thanks to standardization of their dimensions and a complete integrated design. In this sense, the NeighborHub could be duplicated in another suburban area with different needs, and therefore adapt the composition of its envelope **[7]**.



[7] Adaptable envelope

[8] 1/7-scale mockup of the modular construction: testing of the connections and logistic planning

Durable and sustainable choices

The NeighborHub is an experimental and exchange platform whose life cycle is estimated to be 25 years, calculated by considering the expected lifetime contained in technical specifications and according to the estimated time needed for boosting the urban and social transition.

The house relies on a self-maintenance strategy, made possible by accessible repair means, as well as easy connections such as plugs for electric cables, and flexible water pipes and ventilation ducts. During the construction in Denver, this will enable a quick assembly time for the utilities. Upon the return of the house to Switzerland, such strategies will help to ensure that the house requires fewer large repairs during its life-time.

A life-cycle analysis (LCA) was performed to compare available local products and design solutions and choose the most durable and sustainable options while ensuring safety of the occupant without compromising performance and transportability.
A summary of some LCA results are presented in the Appendix.

Besides aesthetic qualities, as well as good mechanical performance, the use of cross-laminated veneer lumber (LVL) as the main construction material was encouraged for its low ecological impact across the full life cycle. In addition, the use of LVL panels to manufacture both structural and non-structural elements enabled the reduction of waste by maximizing the number of pieces produced from each panel. In terms of durability, the material's airtightness and vapor permeability prevent mold and moisture problems without the need for any additional sealing. Finally, the risk of deterioration during transatlantic shipment is reduced thanks to the minimized dimensional variation of this type of wood resulting from humidity variation.

The NeighborHub combines atypical solutions, which were developed through an iterative and multi-disciplinary process. The development of such designs relied on the development of prototypes for systems such as the modular construction **[8]**, the technical donut, the integrated facade doors and the dry toilets. In other cases, such as for the development of the dual thermal strategy, the solar installation and the electricity management algorithm, the results of modeling software were used to guide design choices. Please refer to the Appendix for more details about this.

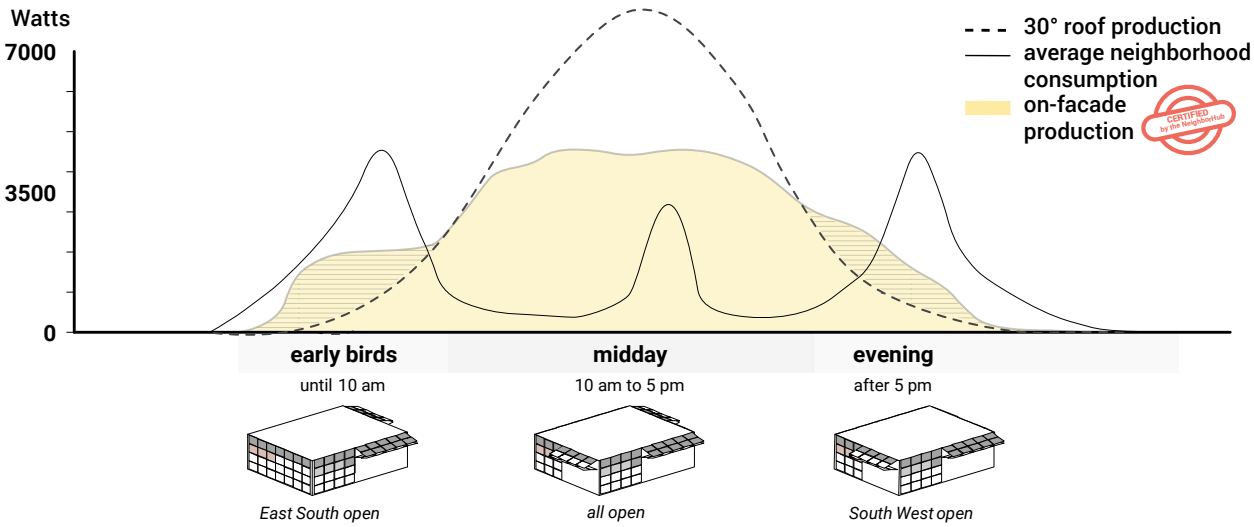
Smart use of solar energy

Productive facades : a local opportunity

One of the NeighborHub's biggest innovation proposals is the positioning of our PV panels on the facades. Instead of conventional roof positioning with optimized tilt, we want to demonstrate that other active surfaces can be the solution for more local production. The idea emerged from the Swiss context, where an urban densification process is currently occurring. Roof surfaces are not necessarily sufficient to cover all electrical needs, especially for multi-storey buildings. Local production can thus be drastically increased if facades are used to complement classic roof installations.

With a maximum 10kWp installed power during the competition, the Swiss Team decided to focus only on the alternative of facade production and prove the viability of the concept. Our PV installation is composed of 29 panels, positioned on the East, South and West facades. Daily average production is not fully concentrated at midday and follows a smoother curve throughout the day **[9]**. Efficient production requires the electrical supply to be increased in the morning and evening, when peak consumption occurs. In this sense, our local facade production with differently-oriented surfaces better fits household consumption.

[9] Matching production and consumption



Each facade of the house has a string of PV panels and combines fixed and opening doors. The same string of panels can have different tilts **[10]**, meaning production may vary from one PV panel to the other and influence the overall production of the string. For this, each PV panel is equipped with a power optimizer for maximum individual production. Thanks to these power optimizers, our installation is less sensitive to local shading and variable production, and our combination of fixed and opening doors gives flexibility for daily production.

[10] Facade integrated solar technologies

A 1/1 mockup of one facade's section was built to test the vertical doors' functionality and safety [see Appendix].The technical elements are located high on the facades for efficiency but also security purposes. Finally, positioning PV panels on a building's roof surface can provide higher on-site production if required.

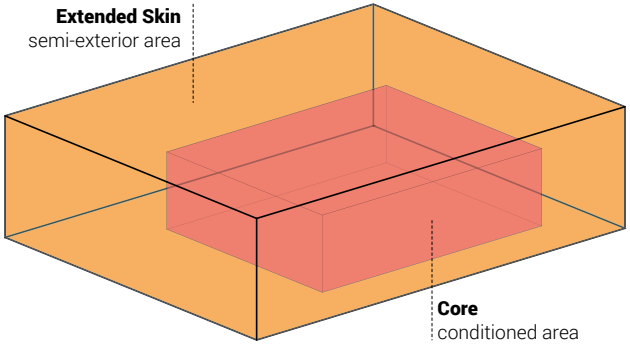
Smart use of solar energy

Synergies between passive and active systems

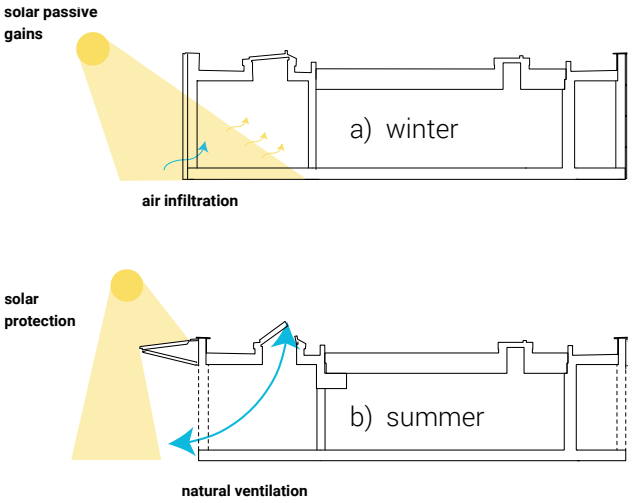
The NeighborHub's comfort strategies aim to maximize the use of space and the harvesting of free solar energy and to minimize energy consumption.
The permeable building is composed of two distinct zones: the Core and the Extended Skin which offer different architectural features, energy performance, levels of comfort and intended uses **[11]**.

The Extended Skin is a semi-exterior space offering improved comfort conditions compared to the exterior for 51% of the year [see Appendix]. Our strategy relies on the fact that a too high level of indoor comfort generally leads to an excess of energy consumption. Comfort should be considered according to the activities a person or group wishes to perform. For example repairing a bike does not require a heated room.

The Extended Skin's impact on the building's overall energy performance and comfort was determined based on energy modelling and lighting simulations [see Appendix]. Through an iterative approach, various passive strategies were tested and the results led to integrated solutions providing a space which can adapt to the users' needs during the day and throughout the seasons.



[11] Differenciated thermal concept



[12] Passive strategies

One of the main features of our passive regulation concept are the custom-made folding doors which enable easy transition with the exterior, natural ventilation and shading, while serving as a productive envelope element. In winter, closing the facades allows the solar passive gains to be maximized, while in summer the folding doors are used to shade the space from excessive solar radiation and to maximize natural ventilation **[12]**. These elements' impact is complemented by modular roof skylights providing additional natural daylight and ventilation.

To ensure that the stringent conditions of comfort for the house's essential functions are met, the Core is fully-controlled with active strategies. Active systems of the NeighorHub were technically designed for the house in Fribourg, with specific adaptations for a better performance in Denver. The air conditioning in the Core is based on a forced air system. A double-flow mechanical ventilation is used to provide fresh air to the Core in order to regulate the relative humidity and CO_2 levels. A bypass system allows the fresh air to come from either the exterior environment or the Extended Skin, depending on the air temperature of both spaces. This allows the incoming air to be pre-heated in winter, whereas in summer the warmer outdoor air is cooled thanks to stale indoor air.

Holistic strategies

Broader vision of water management

Our unique vision sees water management challenges linked with topics such as soil impoverishment, energy consumption, maintenance of infrastructure and the increase in pollutants. Our concept aims to reach a broader vision of water management and, using a holistic approach, proposes strategies answering the challenges mentioned previously.

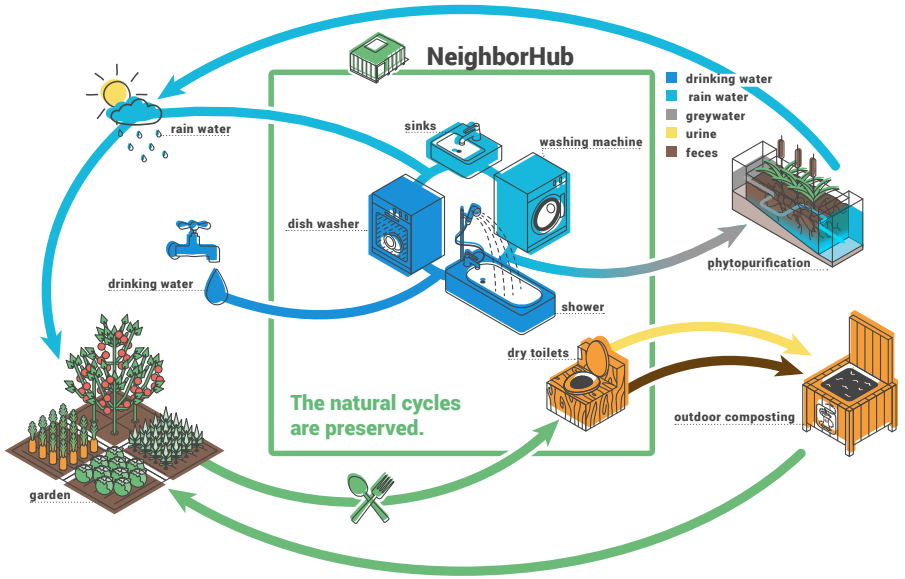
On a global scale, water strategies include effects on runoff management, the livelihood of cities (comfort and biodiversity) and the production of food. The ground's imperviousness is a major concern, causing floods and increasing the concentration of water pollutants. In addition, runoff dilutes wastewater which causes pollution during storms by overflowing treatment plants.

The Swiss team wishes to show the advantages inherent in the implementation of green roofs: reduction of the runoff coefficient but also the prolongation of roof life for a similar cost and the development of green pathways in cities[1]

On the building scale, our approach consists of restoring natural water and nutrient cycles, reducing water and energy consumption and replanting multifunctional vegetation.

As such, the shower integrates two innovative systems: (1) an affordable heat recovery system which allows to pre-heat the water using the waste heat from the used shower water and (2) an intelligent shower head which encourages users to reduce their hot water consumption during your shower time. The expected reduction in hot water demand is 20 to 25%.

Water and nutrient cycles strategies include the separation of water types and the revalorization of nutrients showcased, for example, with our custom-made dry-toilet, as well as the on-site treatment of water with our phyto-purification system. All these systems have been developed to work together to close two natural cycles **[13]**.
Our dry-toilet system, which eliminates use of water and separates urine and feces, was developed in collaboration with a local cooperative and an independent biologist. The final design was achieved thanks to an iterative process and the use of different prototypes [see Appendix]. We feel very proud of the successful integration of boxed vermi-composting in a house which, to our knowledge, represents one of the first attempts worldwide at such a system.



[13] Water and waste cycles strategies: restoring the natural and nutrients cycle

1Toitures végétalisées: des fleurs sur le béton. (2016). [television program] Directed by C. Sommer. Geneva: Mise au point, RTS.

Holistic strategies

Integrated approach to energy management

The approach taken by the Swiss Team not only recognizes the importance of the integration of innovative and sustainable solutions on the building scale, it also emphasizes the importance of smart grid exchanges in electrical management rather than only focusing on electrical self-sufficiency.

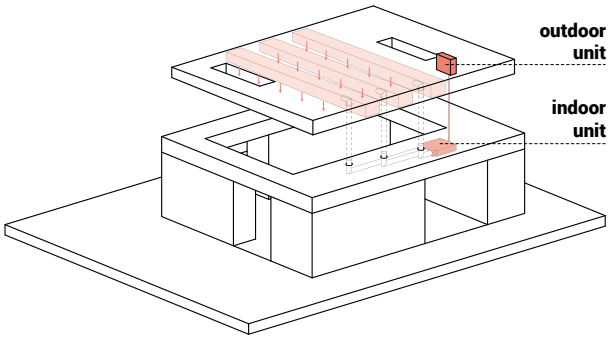
On the building scale, in addition to the synergies between passive and active systems, our concept relies on a holistic approach, integrating structural, electrical, mechanical and water systems.

In this respect, the technical donut integrates the house's electrical, water and air distribution systems. The Core's conditioned air is distributed through three custom-made, self-supporting ceiling elements, which are directly used as distribution ducts **[14]**.This integration is particularly innovative as it avoids the use of typical vents in favour of holes which are directly drilled in the wooden panels to supply the conditioned air. This integration highlights the strong multidisciplinary collaboration of our team.

In order to create a synergy between all these systems, the NeighborHub has an integrated control system. This centralization allows the house's elements to communicate with each other and work together to reach optimal performance **[15]**. Students developed all the control algorithms in a close partnership with an EPFL start-up. Through real-time management and monitoring of a large range of connected devices, we are able to send the users real-time information about the building's energy consumption. In accordance with our aim to bring knowledge and highlight possibilities of action for everyone, an educational application, "Talk to the NeighborHub ", is available on a tablet in the house to show the user the status of the batteries and of the car. Moreover, the application suggests when, for instance, it is better to turn off the Core lights by taking into account natural lighting levels. The idea is to raise house users' awareness of how energy is consumed, produced and stored.

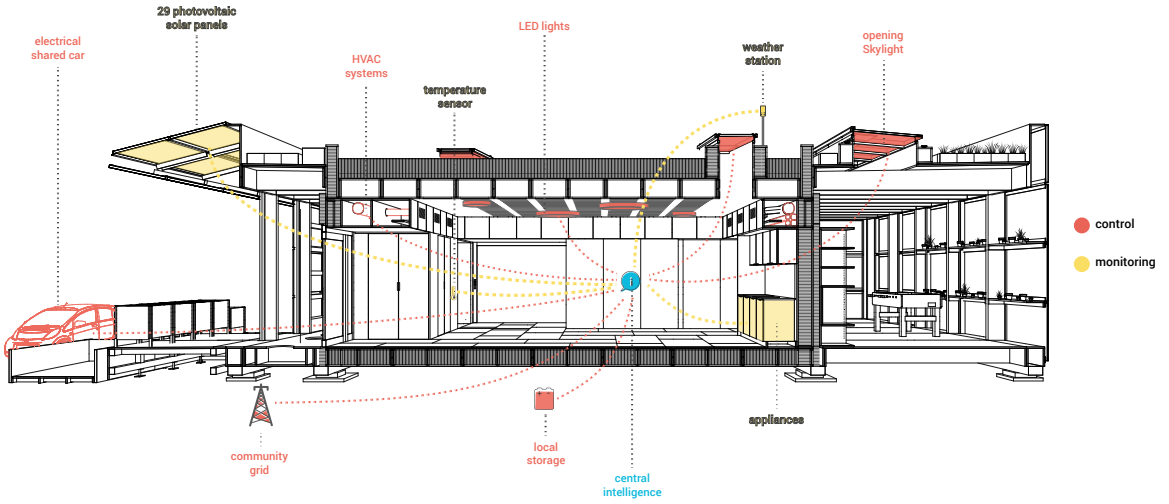
A full set of tests was performed in the fully-built house to ensure all these integrated features worked correctly.

On the global scale, our solution is to produce smartly rather than excessively, to help maintain a reliable and secure electricity infrastructure that can meet future demands. The NeighborHub is designed to be an electrical hub for a neighborhood, aiming to help that neighborhood's electrical network reduce peak demand thanks to optimal grid exchanges.



[14] Air conditioning ceiling distribution

[15] The NeighborHub's centralized system



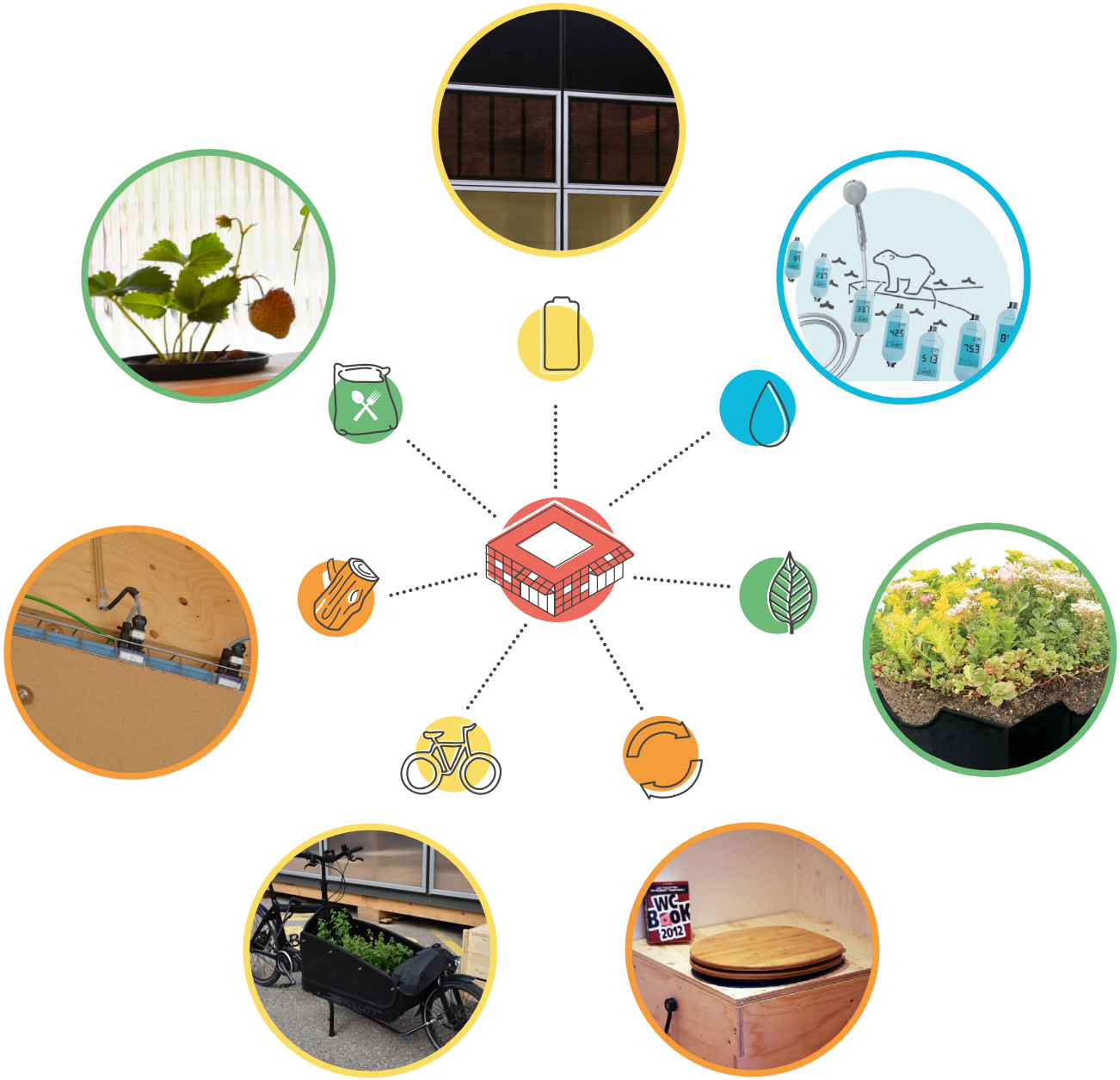
Conclusions

The Swiss Team believes a more community-centered approach is needed to meet the goals of the Paris agreement.

The NeighborHub demonstrates how smart changes can be adopted by communities and lead to the long-term maximization of the sustainability potential of an entire neighborhood. Recognizing the diversity of needs of the neighborhood's stakeholders, our approach aims to raise awareness about environmental questions while creating stronger links between those involved.

The NeighborHub, with its flexible interior, modular construction, productive facade, holistic water management and integrated energy management, showcases user-centered innovative solutions that can help neighborhoods decrease their consumption of resources and adopt more sustainable practices.

In the long-term, the aim is to extend this concept to encourage greener cities.



Sources of images:
1) water management: goo.gl/JXbdQ8content_copyCopy short URL
2) green roof: goo.gl/n3NrRp