

# 2018

Annual  
report

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## Editorial

**The succession of unprecedented crises that continue to beset our society calls for profound changes in how we produce and use buildings. These have an impact on the environment and the climate because they consume energy and natural resources for the sake of human comfort. They can also affect our health, and raise geopolitical challenges due to issues surrounding access to raw and construction materials. Our lifestyles have dramatically changed since the COVID-19 pandemic, which has in turn led us to use the built environment in new ways. These changes require innovative technological and social solutions that are driven by scientific progress.**

The mission of the Smart Living Lab is precisely to link basic and applied research with innovation by pooling cutting-edge expertise and a broad spectrum of scientific disciplines within a unique framework to study and develop solutions for the built environment. Through its world-beating research and important European and national collaborations, the Smart Living Lab brings added value to Fribourg and its Bluefactory innovation district. It is also a dynamic academic actor with a resolutely experimental approach that ranges from prototyping and the development and delivery of solutions which are ready to scale up to the testing of innovative concepts for the built environment under real-life conditions.

Its flagship project is a building designed explicitly with experimental research in mind. This living laboratory at scale will make it possible to test not only physical components but control algorithms as well. Its design is also a tangible example of knowledge transfer as it is informed by the findings of academic research carried out over several years. One of the many benefits of this research-based design approach is that the building will be able to meet its low CO<sub>2</sub> emissions target over its entire life cycle.

The development of the Smart Living Lab dovetails with the development of the Bluefactory innovation district, a project carried by the Canton and the City of Fribourg. Counting on the parallel emergence of a stimulating ecosystem, welcoming a wide range of industrial players and start-ups, the commissioning of the building of the Smart Living Lab will enable the project to fully unfold its expected effects and to play a major role in driving growth, fostering greater openness to the world and boost interactions with private and public partners around entrepreneurship and sustainability. Construction work was scheduled to begin in 2022 but has been postponed. In the meantime, the research teams continue to work out of their temporary facilities.

*“Our flagship project is the creation of a unique building that will serve as a living laboratory at scale.”*

The annual report offers a double-page spread on each research group that details their main activities and publications over the past year. The report also spotlights some of the Smart Living Lab's cross-cutting initiatives, such as the creation of a digital twin of the planned building, for experimentation and operational purposes, as well as the Switzerland-wide SWICE project which benefits from substantial funding from the Swiss Federal Office of Energy, and ARC-HEST, the Swiss-Korean academic exchange program that deepens ties between the two countries and their respective scientific communities.

Through its multifaceted education, research and innovation activities, the Smart Living Lab plays its part in generating benefits for society, in the canton of Fribourg, in Switzerland, and beyond.

**Marilyne Andersen, Academic Director**  
**Martin Gonzenbach, Director of Operations**

## Research and development center for the future of the built environment

**The Smart Living Lab is a joint project between the Canton of Fribourg, the EPFL, the School of Engineering and Architecture of Fribourg, and the University of Fribourg. Each academic partner contributes its own resources and receives funding contributions from the Canton of Fribourg.**

In addition, the Canton de Fribourg provides the premises located on the Bluefactory site as well as funding for construction of the Smart Living Lab building. The Smart Living Lab has an annual budget for events and communication, which is funded by all four partners.

A Joint Steering Committee handles the strategic management of the Smart Living Lab on behalf of all partner institutions and an Executive Committee is in charge of implementation. The Scientific Commission brings together the academic heads of the Smart Living Lab's research groups. Smart Living Lab administrative and technical staff make sure that the research centre runs as smoothly as possible.

### Administrative and technical staff

**Véronica Cubarle**  
Administrative Assistant EPFL

**Claudia Gil**  
Administrative Assistant EPFL

**Adeline Guélat**  
Communication Manager a.i.

**Claude-Alain Jacot**  
Head of Technical Unit EPFL

**Teresa Messina**  
Administrative Assistant EPFL

**Stéphane Pilloud**  
Technical Specialist EPFL

**Laure Thorens**  
Head of Communication

**Chantal Blanc**  
Administrative Assistant HEIA-FR

**Violaine Coard**  
Coordination Deputy HEIA-FR

**Charles Riedo**  
Technical staff member HEIA-FR

**Sofia Martin Caba**  
Coordination officer  
Smart Living Lab-UNIFR

**Jenny Imboden**  
Coordination officer  
Smart Living Lab-UNIFR



From left to right: Stéphane Pilloud, Violaine Coard, Adeline Guélat, Laure Thorens, Charles Riedo, Teresa Messina, Claude-Alain Jacot, Véronica Cubarle.

# Joint Steering Committee

## Canton of Fribourg



**Olivier Curty**  
State Councillor,  
Director of Economy  
and Employment



**Sylvie Bonvin-Sansonnens**  
State Councillor,  
Director of Public  
Education and  
Culture



**Olivier Allaman**  
Fribourg Development  
Agency, Department of  
Economy and Employment  
until 9.11.2022



**Jerry Krattiger**  
Fribourg Development  
Agency, Department of  
Economy and Employment  
as of 10.11.2022

## EPFL



**Matthias Gäumann**  
Vice President for  
Operations



**Jan Hesthaven**  
Vice President for  
Academic Affairs



**Ursula Oesterle**  
Vice President for  
Innovation



**Claudia Binder**  
Dean of the School of  
Architecture, Civil and  
Environmental  
Engineering (ENAC)

## HEIA-FR



**Jean-Nicolas Aebischer**  
Director

## UNIFR



**Astrid Epiney**  
Rector

# Executive Committee

## EPFL



**Marilyne Andersen**  
Academic Director  
of Smart Living Lab |  
Co-chair of the  
Executive Committee



**Martin Gonzenbach**  
Director of Operations  
EPFL Fribourg and Smart  
Living Lab | Co-chair of  
the Executive Committee



**Corentin Fivet**  
Head of Structural  
Xploration Lab (SXL)

## HEIA-FR



**Jean-Philippe Bacher**  
Smart Living Lab  
HEIA-FR Manager



**Stephanie Teufel**  
Head of international institute  
of management in technology (iimt) |  
Smart Living Lab UNIFR Manager  
until 30.6.2022

## UNIFR



**Hans-Georg Fill**  
Head of Digitalization and  
Information Systems Group  
(DIGITS) | Smart Living Lab  
UNIFR Manager  
as of 1.7.2022

## Canton of Fribourg



**Olivier Allaman**  
Fribourg Development  
Agency,  
Department of Economy and  
Employment until 9.11.2022



**Jerry Krattiger**  
Fribourg Development  
Agency,  
Department of Economy and  
Employment as of 10.11.2022

# Scientific Commission

## EPFL



**Marilynne Andersen**  
Academic Director  
of Smart Living Lab –  
Chair of the Scientific  
Commission



**Corentin Fivet**  
Head of Structural  
Exploration Lab (SXL)



**Dolaana Khovalyg**  
Head of Laboratory  
of Integrated Comfort  
Engineering (ICE)



**Dusan Licina**  
Head of Human-Oriented  
Built Environment Lab  
(HOBEL)



**Andrew Sonta**  
Head of Civil Engineering  
and Technology for  
Human-Oriented  
Sustainability (ETHOS)



**Paolo Tombesi**  
Head of Laboratory  
of Construction and  
Architecture (FAR)



**Sergi Aguacil**  
Head of Building2050  
Group (BUILD)

## HEIA-FR



**Jean-Philippe Bacher**  
Smart Living Lab HEIA-FR  
Manager



**Patrick Favre-Perrot**  
Head of ENERGY Institute



**Séréna Vanbutsele**  
Head of TRANSFORM  
Institute



**Daia Zwicky**  
Head of iTEC Institute

## UNIFR



**Stephanie Teufel**  
Head of international  
institute of management  
in technology (iimt) |  
Smart Living Lab UNIFR  
Manager until 30.6.2022



**Hans-Georg Fill**  
Head of Digitalization  
and Information Systems  
Group (DIGITS) |  
Smart Living Lab UNIFR  
Manager as of 1.7.2022



**Denis Lalanne**  
Head of Human-IST  
Institute



**Martin Beyeler**  
Professor, Institute for  
Swiss and International  
Construction Law



**Bernard Ries**  
Head of Decision Support  
& Operations Research  
Group (DS&OR) as of  
1.7.2022

# Research domains

## Well-being and behaviours

Improve human health and comfort by optimising indoor environmental quality and influencing behaviours in a positive way.



## Construction technologies

Monitor resource effectiveness and accelerate processes of change in construction.



## Energy systems

Develop smart energy-efficient systems and technologies, improve their management, and anticipate legal and economic impacts.



## Interactions and design processes

Understand and structure dialogue among stakeholders in the building lifecycle in order to develop the tools to design, model and operate buildings.



# Research groups



## BUILT ENVIRONMENT

▶ Institute of Construction and Environmental Technologies (iTEC)  
**Prof. Daia Zwicky**



## TRANSFORMATION

▶ Institute of Architecture: Heritage, Construction and Users (TRANSFORM)  
**Prof. Sérena Vanbutsele**



## DECISION SUPPORT

▶ Decision Support & Operations Research Group (DS&OR)  
**Prof. Bernard Ries**



## DIGITALIZATION

▶ Digitalization and Information Systems Group (DIGITS)  
**Prof. Hans-Georg Fill**



## RULES

▶ Institute for Swiss and International Construction Law  
**Prof. Jean-Baptiste Zufferey**



## INTERACTION

▶ Human-IST Institute (Human Centered Interaction Science and Technology)  
**Prof. Denis Lalanne**



## INNOVATION

▶ International institute of management in technology (iimt)  
**Prof. Stephanie Teufel**



## SUSTAINABLE ENERGY

▶ Institute of Applied Research in Energy Systems (ENERGY)  
**Prof. Patrick Favre-Perrot**



## RESEARCH

▶ Academic Director of Smart Living Lab  
Chair of Scientific Commission  
**Prof. Marilyne Andersen**



## HUMAN CITIES

▶ Civil Engineering and Technology for Human Oriented Sustainability Lab (ETHOS)  
**Prof. Andrew Sonta**



## ARCHITECTURE

▶ Laboratory of Construction and Architecture (FAR)  
**Prof. Paolo Tombesi**



## INTERDISCIPLINARITY

▶ Building Innovation Research and Integration Support Group (BUILD)  
**Dr. Sergi Aguacil**



## INDOOR AIR

▶ Human-Oriented Built Environment Lab (HOBEL)  
**Prof. Dusan Licina**



## LOW E-COMFORT

▶ Laboratory of Integrated Comfort Engineering (ICE)  
**Prof. Dolaana Khovalyg**



## REUSE

▶ Structural Xploration Lab (SXL)  
**Prof. Corentin Fivet**



# EPFL - a world-class institution that puts Fribourg on the map

The Smart Living Lab was established in 2014 when EPFL created a permanent campus in Fribourg. It is now the hub of EPFL activities in the canton. EPFL is in charge of the academic leadership, operational management and administration of this research center for the future of the built environment. The EPFL Fribourg teams work out of temporary facilities on the Bluefactory site while they await completion of their permanent home, the new Smart Living Lab building.

The Smart Living Lab comprises four EPFL chairs, each headed by a professor affiliated with the Institute of Civil Engineering or the Institute of Architecture within the School for Architecture, Civil and Environmental Engineering (ENAC). Bachelor and Master's programs are taught on the main EPFL campus in Lausanne, while the EPFL in Fribourg focuses on basic and applied scientific research. Doctoral students, post-doctoral fellows and scientific staff are hired in Fribourg for these missions according to the standard EPFL selection process, which prizes excellence and is open to talented scientists from around the globe.

EPFL has also created a group that deals specifically with issues surrounding the Smart Living Lab. Known as Building2050, the group specializes in the use of the future Smart Living Lab building as an experimental tool. It ensures that the design of the building takes account of research needs, and is actively involved in other aspects of the design process. Another part of its work is providing the entire Smart Living Lab community with scientific support and services, such as the management of shared data and building information modeling.

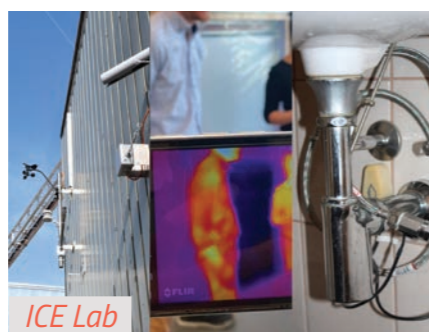
A multi-skilled technical team provides services that support a wide range of activities at the Smart Living Lab, including experiment preparation, data acquisition, prototype building and teaching.

Thanks to its large hall, "Atelier Pop Up" and outdoor construction spaces, the Bluefactory site is also a popular venue for project-based teaching workshops that have a prototype-building component.

**Martin Gonzenbach, Director of Operations  
EPFL Fribourg and Smart Living Lab**



SXL Lab



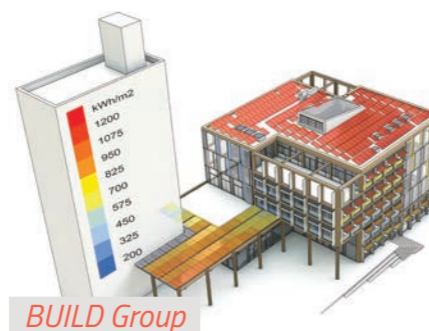
ICE Lab



HOBEL Lab



ETHOS Lab



BUILD Group



FAR Lab



## Highlights of 2022

### Young researchers

Three doctoral students from the EPFL laboratories in Fribourg successfully completed and graduated as PhDs their theses. Two HEIA-FR students are currently writing their doctoral theses under the co-supervision of EPFL professors.



### Smart ideas

The Smart Living Lab Student Incubator program has awarded two EPFL doctoral students innovation grants so that they can develop their ideas into prototypes.

### Arrivals and departures

EPFL Fribourg was pleased to welcome Andrew Sonta, who holds a PhD from Stanford (US) and was a postdoc fellow at Columbia University (US) prior to his appointment. The new EPFL tenure-track assistant professor will also develop the new ETHOS Lab within the Smart Living Lab. Professor Paolo Tombesi, Head of Laboratory of Construction and Architecture (FAR), has relocated to the EPFL main campus in Lausanne.

### Putting people at the center of the energy transition

SWICE is a large-scale national research project funded by the Swiss Federal Office of Energy (SFOE) as part of its wider SWEET program. The project is based at the Smart Living Lab and will run for eight years under the academic leadership of Professor Marilyne Andersen. The research consortium includes several members of the Smart Living Lab's three institutions, and EPFL will coordinate the project. (see page 52)

### Meeting the public

During the Energissima fair in Bulle, the public had the opportunity to learn more about the Smart Living Lab during their visit to the EPFL Energy Center stand. In November, the Smart Living Lab met the local companies during the conference "Perspectives".

### Building, programming and learning

Once again, 11- to 13-year-olds from the canton of Fribourg flocked to the Bluefactory site in 2022 to enrol in the EPFL robotics courses.

### Nordic innovation

EPFL organized an innovation camp in Sweden and Finland for Fribourg SMEs. During the week-long trip, a dozen entrepreneurs, together with members of the Fribourg Economic Development Agency, the Fribourg Chamber of Commerce and Industry and the Fribourg Building Innovation Cluster, visited innovative buildings and neighborhoods, and discovered ingenious technologies.

# Reused concrete – the latest construction material on the block

Over the last few years, the Structural Xploration Lab (SXL) has focused its research energies on identifying new opportunities to equip architectural and structural engineering practices with tools that facilitate the reuse of materials reclaimed from buildings that have been carefully 'unbuilt'. After developing optimisation tools for the reuse of wood and steel elements in new structures, and building on the success of its footbridge prototype "re:crete", the Lab demonstrates that the use of components which have been saw-cut from reinforced concrete structures is not only technically feasible but also environmentally efficient and economically viable.

Concrete is an extremely versatile building material and is the magic ingredient in many technically amazing structures. Thanks to these and many other qualities, concrete has become an ubiquitous part of our built environment, and the most widely used building material in Switzerland and around the world. At the same time, though, tons of concrete are demolished every day as the result of aggressive investment strategies and uncontrolled obsolescence. It is a process that further underlines the devastating impact of the concrete industry on the environment. Yet, in many of these premature demolition cases, the mechanical properties of the concrete elements remain unimpaired.

Given this incoherence and the likelihood that a demolition-construction-demolition cycle will continue to shape the evolution of the built environment, new development opportunities need to be explored. One particularly promising alternative is extracting (e.g saw-cutting) concrete elements from existing buildings and reassembling them to create new structures. The reuse of concrete is a pioneering circular economy approach that offers considerably more benefits than certain construction techniques and the reuse of other materials. It is a practice that can encourage new ways of thinking about the material, be financially advantageous, and lead to the creation and/or maintenance of local and sustainable jobs. The only drawback is that industry has been very reticent about adopting this approach.

SXL is currently working on several research projects aimed at demystifying and promoting the reuse of concrete slabs, walls, beams and columns. This includes identifying and analysing historical precedents, as well as establishing and testing re-usability assessment protocols. We are also developing and evaluating the impact of ad-hoc assembly techniques, digitalising industrial processes, and building prototypes. So far, every new result generated by our work is more promising than the last.



## Flagship Projects

- ▶ **Assessment Protocols for the Reuse of Concrete**  
Julie Devènes, Maléna Bastien-Masse, Corentin Fivet | Immobilien Basel-Stadt (IBS) & ENAC Interdisciplinary Cluster Grant | [sxl.epfl.ch](https://sxl.epfl.ch)
- ▶ **Reuse Potential Prediction for Construction Components**  
Barbara Lambec, Raphaël Wegmann, Maléna Bastien-Masse, Corentin Fivet | SNSF | [sxl.epfl.ch](https://sxl.epfl.ch)
- ▶ **Development of Piecewise Concrete Reuse in Architecture**  
Célia Küpfer, Corentin Fivet | SNSF | [sxl.epfl.ch](https://sxl.epfl.ch)



Corentin Fivet  
Head of SXL Lab

« Pre-used building materials are the cleanest type of building material. Let's not waste it. »

### KEY PUBLICATIONS

▶ "Matériaux rejetés cherchent nouveaux défis", C. Fivet, C. Küpfer, M. Bastien Masse, Tracés. Vol. 11, num. 3525, pp. 8-13. Nov. 2022.  
<https://www.espazium.ch/fr/actualites/materiaux-rejetes-et-nouveaux-defis>

▶ "Re:Crete - Reuse of concrete blocks from cast-in-place building to arch footbridge", J. Devènes, J. Brütting, C. Küpfer, M. Bastien Masse, C. Fivet Structures. Vol. 43, pp. 1854-1867. Sept. 2022.  
<https://doi.org/10.1016/j.istruc.2022.07.012>

▶ "Reuse of concrete components in new construction projects: Critical review of 77 circular precedents", C. Küpfer, M. Bastien Masse, C. Fivet Journal of Cleaner Production. Vol. 383, p. 135235. Jan. 2023.  
<https://doi.org/10.1016/j.jclepro.2022.135235>

READ MORE



### PARTNERSHIPS

Immobilien Basel-Stadt (IBS)  
Etat du Valais  
République et Canton de Genève  
Ville de Meyrin  
MEDAIR (NGO)  
The Institution of Structural Engineers (UK)  
Steiner  
Orlati  
Aeternum  
Cirkla

Zirkular  
Ecole des Ponts (France)  
ETH Zürich (CH)  
University of Leeds (UK)  
University of Cambridge (UK)  
Tampere University (Finland)  
Centre Scientifique et Technique du Bâtiment (France)



# Occupant-centered research on the energy sufficiency of buildings by considering indoor comfort and well-being of people

**Energy efficiency in the built environment can be achieved by understanding the demand and matching properly the energy supply.**

Buildings are currently stipulated for discomfort avoidance in favor of homogenizing the indoor environment. In addition, consideration of the human diversity factor is lacking in the design and operation of thermal systems, particularly inter- and intra-individual variability. Thus, modern occupants hardly use their capacity to adapt to the wide range of temperatures, which poses a risk in times of climate change and extreme weather events. Due to global warming, people are becoming dependent on energy-intensive indoor climatization systems with a high carbon footprint, substantially contributing toward global warming.

This creates a vicious cycle in GHG emissions and counteracts the national and international objectives of reducing global warming. Thus, commitment to reducing the GHG contribution of buildings requires, first of all, lowering the energy demand in buildings by promoting the adaptation of people to the extended range of temperatures indoors and adopting smart technologies that can help to match energy supply and demand in buildings better and reduce energy waste. As occupants and their behavior are important parameters in the energy performance of buildings, we advance studies on personalized thermal conditioning and pave the way for developing occupant-centric control frameworks balancing various building objectives (comfort, energy, hygiene, and wellbeing) considering building physics, data-driven modeling, and experimentation with humans.



## Flagship Projects

► **Impact of ventilated air-space behind traditional (passive) and BIPV (active) façades on the thermo-hydrodynamic performance of building wall structures**

Mohammad Rahiminejad, Dolaana Khovalyg | ASHRAE | [Ventair](#)

► **Reinforcement Learning for the occupant-centric operation of building energy systems: Theoretical and experimental investigations**

Amirreza Heidari, François Maréchal, Dolaana Khovalyg | EPFL and Ministry of Science of Iran | [Behavelearn](#)

► **iTHCoM: Non-Invasive AI-powered Thermal Comfort Monitoring**

Mohamad Rida, Dolaana Khovalyg, Alexander Alahi | ENAC Interdisciplinary Cluster Grants | [lthcom](#)



Dolaana Khovalyg  
Head of ICE Lab

« Energy efficiency in the built environment can be achieved by understanding the demand. »

## KEY PUBLICATIONS

► Khovalyg D, Ravussin Y. **Inter-individual variability of human thermoregulation: towards personalized ergonomics of the indoor thermal environment.** Obesity. <https://doi.org/10.1002/oby.23454>

► Heidari A, Maréchal F, Khovalyg D. **Reinforcement Learning for proactive operation of residential energy systems by learning stochastic occupant behavior and fluctuating solar energy: Balancing comfort, hygiene and energy use.** Applied Energy. <https://doi.org/10.1016/j.apenergy.2022.119206>

► Rahiminejad M, Khovalyg D. **Numerical and experimental study of the dynamic thermal resistance of ventilated air-spaces behind passive and active facades.** Building and Environment. <https://doi.org/10.1016/j.buildenv.2022.109616>

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## PARTNERSHIPS

Princeton University  
University of Fribourg  
Politecnico di Torino  
Maastricht University

# Unveiling the air quality in buildings

The Human-Oriented Built Environment Lab (HOBEL) strives to advance the knowledge of the intersections between people and buildings by ensuring high indoor environmental quality for building occupants with minimum energy consumption. HOBEL's mission is to improve the knowledge in the domains of dynamics and fate of air pollutants in buildings, human inhalation exposures, smart ventilation systems and controls, and more broadly, human comfort and energy efficiency in the built environment.

In 2022, HOBEL has made original contributions to the field of civil and environmental engineering through combination of laboratory and field experiments, modeling, data analysis, and at times numerical simulations. HOBEL's research interest centers on air quality engineering, emphasizing two main interconnected research vignettes:

- 1) Pollutant Dynamics in Indoor Air and Exposure Science
- 2) Indoor Air Monitoring and Smart Ventilation Controls

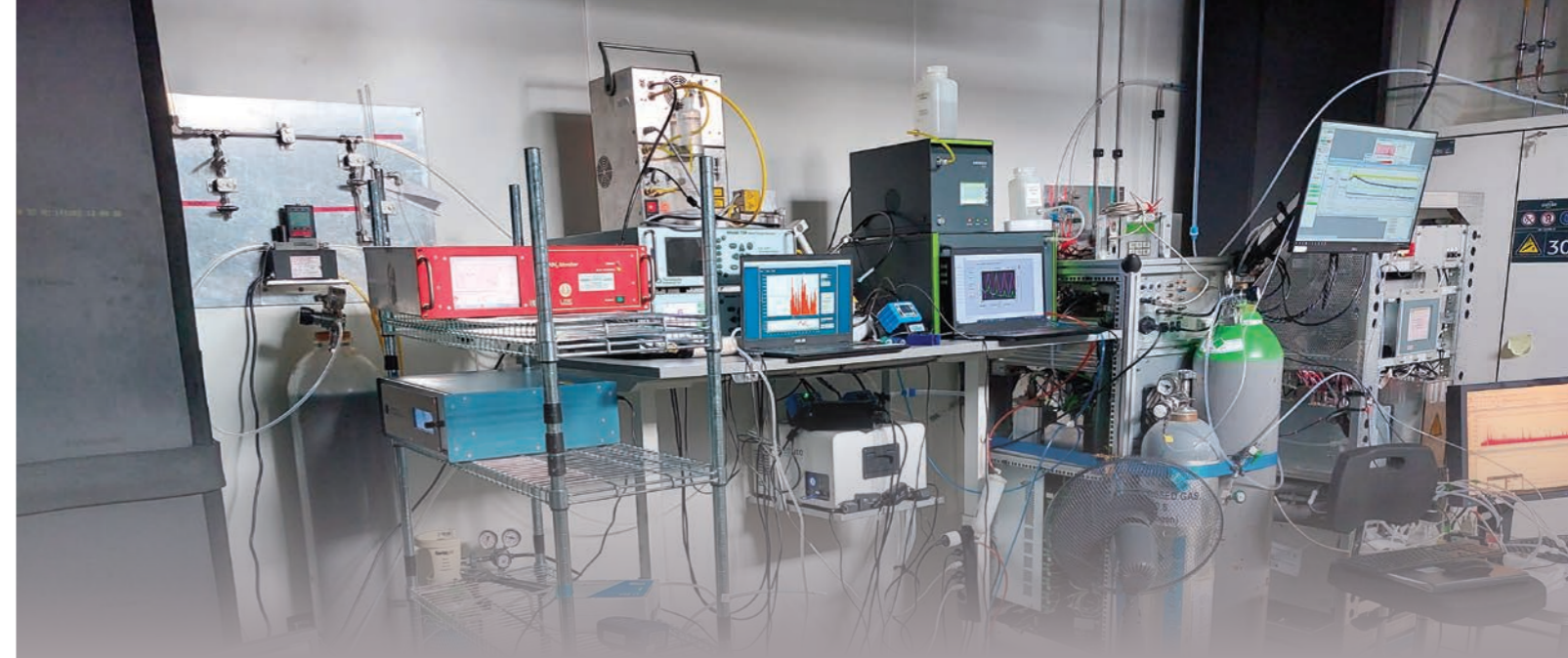
## Pollutant Dynamics in Indoor Air and Exposure Science

As we spend most of our time in buildings, understanding sources and composition of indoor air pollutants is fundamental for interpreting the health risks and for developing improved building control measures to mitigate human exposure. An inaccurate estimate of human personal exposure has been associated with large uncertainties in health risk assessment. This research vignette is centered on better understanding the physics and chemistry that influence concentrations, dynamics and fates of air pollutants

within buildings, as well as their transport to human lungs. The special emphasis is given to understanding physical and chemical processes influencing the dynamics and fate of air pollutants, in particular in vicinity of a human body.

## Indoor Air Monitoring and Smart Ventilation Controls

It is anticipated that evolution of smart building technology will redefine the way we work and live in the future. Despite the progress in the development of building ventilation and indoor environment standards, many studies indicate that percentage of satisfied people is significantly lower than that prescribed by the standards, whereas the level of air pollutants often exceed recommended concentrations. The current control loops that govern the operation of ventilation systems are limited and primarily focused on building energy performance. Within this research theme, HOBEL aims to generate new insights about optimal sensor deployment and suitable ventilation design and operation in order to achieve energy-efficient, comfortable and healthy indoor spaces.



## Flagship Projects

- ▶ **Probing the Dynamics of Nanoparticles and Gas-Phase Chemistry in Indoor Environments and its Influence on Human Inhalation Burden**  
Tianren Wu, Dusan Licina | EPFL Science Seed Fund | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **Constituents of Human Particle, Microbial and Chemical Emissions, Dispersal Mechanisms and Exposures in Indoor Environments**  
Shen Yang, Marouane Merizak, Meixia Zhang, Dusan Licina | FNS | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **Industrialised and Personalised Renovation for Sustainable societies**  
Sarah Crosby, Evangelos Belias, Dusan Licina + 22 European partners | Horizon Europe | [inperso-project.eu](https://inperso-project.eu)



Dusan Licina  
Head of HOBEL Lab

« Buildings of the future must not be only energy efficient, but they should also offer a "Michelin Star" air quality.»

## KEY PUBLICATIONS

▶ Yun S, Zhong S, Hamed A, Alahi A, Licina D. **Proxy methods for detection of inhalation exposure in simulated office environments.** (2022) Journal of Exposure Science and Environmental Epidemiology, 1-11. <https://doi.org/10.1038/s41370-022-00495-w>

▶ Belias E, Licina D. (2022) **Selecting air filtration strategy for outdoor PM2.5 to optimize indoor air quality and energy use.** Buildings and Cities, 3 (1). <https://doi.org/10.5334/bc.153>

▶ Gonzalez Serrano V, Licina D. (2022) **Longitudinal assessment of personal air pollution clouds in ten home and office environments.** Indoor Air, 32(2): e12993. <https://doi.org/10.1111/ina.12993>

READ MORE



## PARTNERSHIPS

- Department of Environmental and Resource Engineering, DTU, DK
- Atmospheric Chemistry, Max Planck Institute for Chemistry, DE
- Global Health Institute, Duke University, USA
- Finnish Institute for Health and Welfare, FI
- School of Mechanical Engineering, Beijing Institute of Technology, Beijing, China
- Environmental Health Sciences Dpt, School of Public Health, Yale University, New Haven, USA
- Department of Building Science, Tsinghua University, Beijing, China
- Laboratory for Biomimetic Membranes and Textiles, EMPA, CH
- Honeywell Building Technologies, CH
- Siemens Building Technologies, CH
- ESTIA SA, CH

# Integrating social and environmental goals for a sustainable built environment

**Leveraging modern computational tools to improve our understanding of interactions between human, environmental, and built systems.**

ETHOS is a new lab at EPFL Fribourg and the Smart Living Lab. Its vision is to leverage modern data and computing to design interventions across the scales of our built environment that address our social and environmental goals. Research at ETHOS focuses on developing a better understanding of human-building interaction for sustainability, starting with the individual occupant in buildings and expanding the scope to communities in cities. When we gain a clearer picture of how people use and interact with the built environment, we can develop strategies to design and manage our built world in a manner that improves both our experiences and environmental sustainability objectives. For example, using sensors to understand how people use spaces in buildings can lead to simple suggestions or retrofits that promote more effective organizational collaboration while saving energy in the building's operation. At the urban scale, data-driven techniques can help us uncover how energy-efficient walkable urban design impacts the ability of communities to form cohesive social networks.

The first projects at ETHOS kick off in 2023. In addition to our core research topics described above, ETHOS will be collaborating with economists at the University of Lausanne and the University of Zurich to leverage machine learning tools to understand the economic impacts of green building retrofits. This project is funded by the Enterprise for Society Center (E4S), a joint initiative encouraging collaborations across disciplines and institutions.

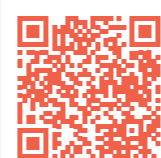
On the teaching side, ETHOS is engaged in the development of new courses complementing the EPFL-wide Teach4-Sustainability initiative, including courses on sustainability in civil engineering and computational tools that can be used to understand the behavior of complex systems.

## KEY PUBLICATIONS

▶ Sonta Andrew. **A global occupant behavior database.** Scientific Data, <https://doi.org/10.1038/s41597-022-01475-3>

▶ Sonta Andrew. **Data-driven simulation of room-level building energy consumption.** Proceedings of the International Conference on Computing in Civil Engineering, <https://doi.org/10.1061/9780784483893.141>

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## Flagship Projects

- ▶ **Occupants in buildings**  
Matteo Favero, Zhang Yufei | EPFL Funding | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **Social analysis of urban form**  
Kanaha Shoji | EPFL Funding | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **(Machine) Learning Economic Impacts of Green Residential Building Policies in Switzerland**  
Enterprise for Society Center (E4S) | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)



Andrew Sonta  
Head of ETHOS Lab

« Research at ETHOS focuses on developing a better understanding of human-building interaction for sustainability. »

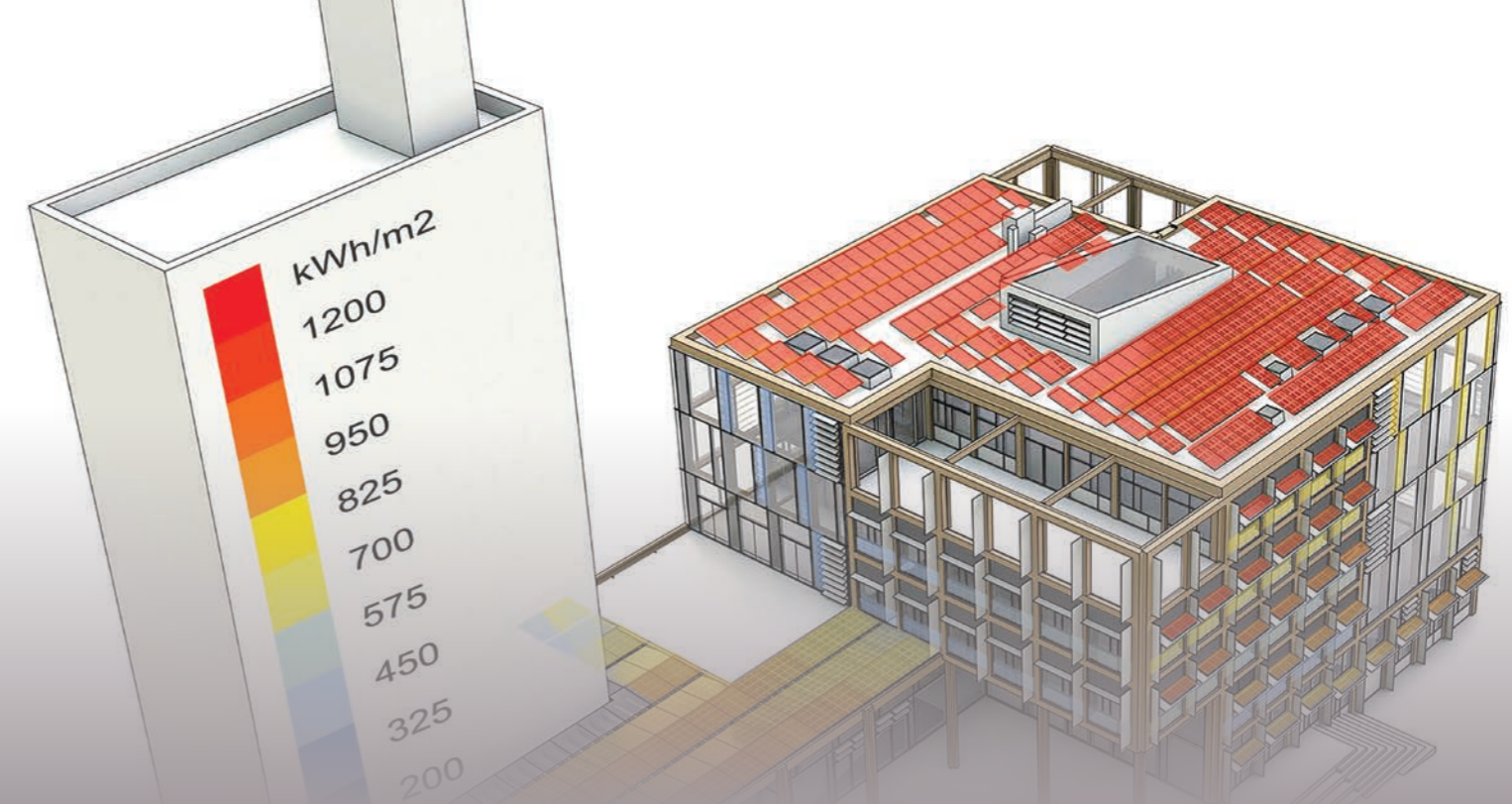
## PARTNERSHIPS

University of Lausanne  
University of Zurich  
Enterprise for Society (E4S)

# Use of open-source digital tools facilitating data exchange for more sustainable built environments

The Building2050 Group is a support research team, conducting applied research to develop innovative and sustainable solutions for the built environment, focusing on building-integrated photovoltaics, open source digital tools, 3D modeling, IoT integration, and digital twins of living labs. These research topics have the potential to significantly improve the sustainability of the building sector and contribute to mitigate climate change impacts:

- **Building-integrated photovoltaics (BIPV) and hydrogen-based electricity storage systems** are one way to achieve carbon neutrality. This approach maximizes the use of solar energy while minimizing the environmental impact of the building's electricity consumption.
- **Open source digital tools for data/geometry exchange** supporting decision making in early-design phases. These tools can enable collaboration, knowledge sharing, and resource optimization to improve building sustainability.
- **Exchange of disciplined-based 3D models** for energy, solar and daylighting simulations. The use of these models can help optimizing building design and operations, leading to improved energy efficiency and the reduction of environmental impact.
- **Integration of building operation data, sensors-data and 3D models** using Internet of Things (IoT) approaches. This integration aims at improving building management systems (BMS) by enabling real-time monitoring and human-centered control of building operations.
- **Open-source platforms (i.e. Speckle)** supporting the creation of digital twins of various living labs, including building and neighborhood scales. This approach aims to improve the understanding of building performance by creating digital replicas of built environments.



## Flagship Projects

- ▶ **Sharing research results using the open-source DesignExplorer tool**  
Aguacil, Sergi (BUILD), Rey, Emmanuel (LAST) | EPFL | [design-explorer.epfl.ch](https://design-explorer.epfl.ch)
- ▶ **Sustainable Well-being for the Individual and the Collectivity in the Energy transition (SWICE)**  
Aguacil, Sergi, Duque, Sebastian, Roman, Justine, Widmer, Régis | OFEN – SWEET program | [sweet-swice.ch](https://sweet-swice.ch): Energy systems and infrastructures, interface with and integration across Living Labs, pilot project.



Sergi Aguacil  
Head of BUILD Group

« By leveraging open-source digital tools and customized scripts, we seek to establish a foundation of interoperability for human-centered research-based facility management that adapts to end-users' unique needs and preferences. »

### KEY PUBLICATIONS

▶ Ullal André; Steullet Anne; Roman Justine; Michel Kyra; Duque Mahecha Sebastian; Celentano Giulia; Habert Guillaume; Al Laham Hager; Tamvakis Pavlos; Aguacil Moreno Sergi. **Sustainable Construction in Humanitarian. Action Criteria for humanitarian building sustainability.** 36<sup>th</sup> Passive and Low Energy Architecture PLEA 2022 Conference, Santiago de Chile, Chile, November 23-25, 2022

▶ Aguacil Moreno Sergi; Lufkin Sophie; Laprise Martine; Rey Emmanuel. **Comparative approach of the environmental impact induced by different architectural visions of a new periurban neighbourhood** 36<sup>th</sup> Passive and Low Energy Architecture PLEA 2022 Conference, Santiago de Chile, Chile, November 23-25, 2022

▶ Aguacil Moreno Sergi; Morier Yvan; Couty Philippe; Bacher Jean-Philippe. **Building-integrated photovoltaics (BIPV) combined with hydrogen-based electricity storage system at building-scale towards carbon neutrality.** Proceedings of the Central Europe towards Sustainable Building (CESB22), 38.

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### PARTNERSHIPS

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RoomZ SA  
Tecphy Sàrl

# The architecture of construction

Understood as both an adjective (e.g., distant) and an acronym (For an Architecture of the Real), FAR defines the activities of a group of researchers interested in the quality of the built world and the role of construction in bringing it about. Utopian in its resolve and pragmatic in its operational tactics, the work of FAR seeks to define material solutions to building environment challenges that are grounded in their historical, social and economic realities.

In the course of 2022, FAR researchers have been working on a series of construction-related projects across the world. These include:

- the reconstruction of the design and assembly process put in place for the second stage of the Sydney Opera House in the 1960s;
- the possible modifications in building practices in Sri Lanka after the advent of the financial crisis;
- the technical legacy of a north-American architectural firm at work on four continents in the late XX century.

Within the same period, Professor Tombesi was a keynote speaker at the CIB 2022 World Building Congress in Melbourne (W078: Information Technology for Construction), and was awarded the Frontiers of Architectural Research 2022 best paper prize with his Sydney colleagues Stracchi and Cardellicchio. Together, they authored the video on the casting of the ribs of the Sydney Opera House on exhibit at the MAXXI Museum in Rome as part of Techno-scape: The Architecture of Engineers (October 1 2022 - April 16 2023).

In May 2022, Professor Tombesi was selected to organise the 2023 Latsis International Symposium, on the work of selected women-led practices, which took place at the Rolex Learning Center on March 24-26, 2023. In December, he was also chosen to deliver the 2023 Gordon Smith Lecture at Yale University.

FAR left the Smart Living Lab at the end of 2022, to continue its research at EPFL in Lausanne.



## Flagship Projects

- ▶ **The construction process of the Sydney Opera House**  
Paolo Tombesi, Paolo Stracchi, Luciano Cardellicchio | Différentes subventions pour l'infrastructure en Australie | [youtu.be/zkLDBMUFGWQ](https://youtu.be/zkLDBMUFGWQ)
- ▶ **Locating Giurgola: From Philadelphia School to Global Practice**  
Andrew Leach, Catherine Lassen, University of Sydney; Philip Goad, Anmarie Brennan, University of Melbourne; Denise Costanzo, Penn State University; William Whitaker, University of Pennsylvania; Paolo Tombesi, EPFL | Australian Research Council Discovery Project DP220101537
- ▶ **Exploiting the crisis: Concrete new languages for Sri Lanka**  
Milinda Pathiraja, University of Moratuwa; Robust Architecture Workshop, Colombo; Paolo Tombesi, EPFL | [The Lanterns](#)



Paolo Tombesi  
Head of FAR Lab

« To identify with and embrace a culture of building critically, we must learn how make the elements of that culture accessible and open to scrutiny. »

### KEY PUBLICATIONS

▶ **Not really an aftermath. The role of actual construction in the design process of the Sydney Opera House roof.** Stracchi, Paolo, Cardellicchio, Luciano, Tombesi, Paolo, Frontiers of Architectural Research, <https://doi.org/10.1016/j.foar.2022.10.005> (Winner best paper award 2022)

▶ **Comparing thermal performance of standard humanitarian tents.** Ullal, A., Aguacil, S., Vannucci, R., Yang, S., Goyette Pernot, J., Licina, D., Tombesi, P., Energy & Buildings, Available online 22 March 2022. <https://doi.org/10.1016/j.enbuild.2022.112035>

▶ **Circularity by Stock in Sri Lanka: Economic Necessity Meets Urban Fabric Renovation.** Pathiraja, Milinda, Tombesi, Paolo, Frontiers in Built Environment, 10 January 2023, Section Sustainable Design and Construction, Volume 8 - 2022, <https://doi.org/10.3389/fbuil.2022.1098389>

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### PARTNERSHIPS

- University of Sydney
- University of New South Wales
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- University of Moratuwa
- University of Minnesota
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- Università Roma Tre
- Universidad de Granada
- Università dell'Aquila
- Pontificia Universidad Católica de Chile

# HEIA-FR – a vital link between basic research and practice

The School of Engineering and Architecture of Fribourg (HEIA-FR) has been heavily involved in the development of the Smart Living Lab since its inception in 2012, and has based one of its research programs there. Together with its partners, the HEIA-FR seeks to advance the current state of knowledge and level of expertise, and use these findings to devise actionable solutions to the technical, societal and economic challenges facing the built environment. In doing so, the research program serves as a vital link between academic research and practice. Today, this bridging function is more important than ever given the myriad crises affecting the planet, from climate change to biodiversity loss.

Despite successive COPs, greenhouse gas emissions continue to rise and real transformation remains elusive. The effects of climate change are multiplying and efforts to meet the Paris Climate Accord goals are in jeopardy. The projects within the HEIA-FR and Smart Living Lab research program generate tangible solutions and opportunities, from re-using structural components and renovation to sustainable urban development ideas.

The current energy shortages have brought the issue of energy independence back into the spotlight. Making buildings more energy efficient and integrating renewables at the neighborhood level are now a matter of when, not if. Energy and climate goals cannot be met unless major adjustments are made at all levels. From the public authorities and the private sector to individual citizens, everyone bears a share of the responsibility and has an opportunity to act.

The HEIA-FR gives its researchers the chance to develop their ideas and helps them with the submission and implementation of their projects. For its part, the Smart Living Lab gives them access to the infrastructure they need to test their innovative solutions at scale, transfer their knowledge to practice, and make a contribution to addressing the challenges facing society.

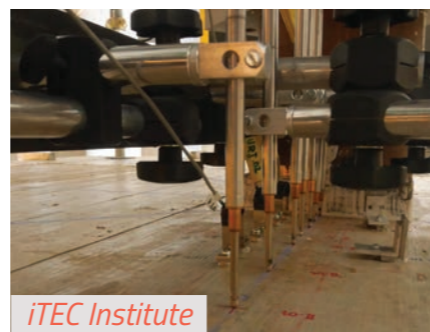
**Jean-Philippe Bacher, Smart Living Lab HEIA-FR Manager**



ENERGY Institute



TRANSFORM Institute



iTEC Institute



Haute école d'ingénierie et d'architecture Fribourg  
Hochschule für Technik und Architektur Freiburg

## Highlights of 2022

### Adapting to climate change

Extreme climate events (heat waves, drought, adverse weather) are occurring with ever greater frequency and test the resilience of the built environment. Existing and new buildings and the urban space must adapt to this new reality.



### Research program

The research program facilitates the third party-funded acquisition of projects at the internal (HES-SO), regional (NRP), and national (SNSF, Innosuisse) levels. In addition to the projects listed below, a number of new projects are in development.

### Circular economy

Two of the program's projects – ConcReTe & POLYNORM – focus on transforming the urban space by re-using existing resources.

### HES-SO projects

- BioLoop
- BAROMal

### NRP projects

- ADVENS
- BIM-UP
- DiagnoBAT
- LightBudget
- POLYNORM
- SmartTS

### SWICE: Sustainable energy transition starts with individuals

This project, which officially launched in April 2022 and is based at the Smart Living Lab, aims to reduce energy use in Switzerland by engaging with the public through "living labs". Changing individuals' behavior and habits and improving their well-being are core elements of SWICE. Five professors from the HEIA-FR are involved in this large-scale, SFOE-funded project, which will run until 2028.

# A multidisciplinary approach to energy transition engineering

The ENERGY Institute research teams focus on the management and optimization of energy use in buildings and infrastructures. They develop solutions for renewable energy integration and the energy optimization of electrical and thermal networks, and carry out analyses and audits at the building and neighborhood scale.

The ENERGY Institute is heavily involved in the SFOE Swice project, which is based on the premise that energy transition and carbon neutrality are only possible if the population, at both the individual and collective level, make changes to their habits and lifestyles. Yet, it is difficult to measure the human dimension of change and acceptance-related issues. Scientific methods and appropriate tools are needed to evaluate the effectiveness of different types of interventions, particularly in the context of "livings labs". These changes in user needs and preferences will lead to different ways of designing buildings and ultimately to changes in the energy system.

The starting premise of the BioLoop project is that our buildings, like the forests and the oceans, could soon act as carbon sinks by capturing CO<sub>2</sub> in their walls. For this to happen, bio-based—or plant-based—materials have to be widely adopted by construction professionals. Such a move would contribute to stabilizing the quantity of atmospheric CO<sub>2</sub> and would have a positive influence on the climate, ecosystems and biodiversity. BioLoop also will conduct an exhaustive analysis of bio-based materials and their use in the built environment. The project's expected results will be valuable to a variety of actors, including scientists, architects, engineers, industrial partners and public officials. The availability of a comprehensive and precise study of bio-based materials in relation to the construction market of the future will facilitate the wider adoption of these practices.

Finally, the ADVENS project aims to provide companies with a modeling tool to simulate, size and optimize thermal and electrical networks simultaneously, with a view to improving the energy efficiency of industrial installations at both the design and operational level.



## Flagship Projects

► **SWICE: Sustainable Well-being for the Individual and the Collectivity in the Energy Transition (sustainable lifestyles; living labs; energy transition; behavior change and well-being)**

Jean-Philippe Bacher, Malik Kane, Thomas Jusselme | OFEN | [SWICE](#)

► **ADVENS – Platform for modelling and simulating integrated multisource heating networks (energy networks, modeling, simulation, optimization, network design and management tools)**

Malik Kane, Lucile Schulthess, Cornelia Blanke, Sandy Ingram | NPR | [ADVENS](#)

► **BioLoop**

Thomas Jusselme | HES-SO | [BioLoop](#)



Patrick Favre-Perrot  
Head of ENERGY Institute

« The success of the energy transition depends on innovative solutions at all scales: buildings, neighborhoods, cities and territories. »

### KEY PUBLICATIONS

► Bahrar, M.; Jusselme, Thomas. **Development of a new environmental scoring methodology for building products, a French case study** IOP Conference Series: Earth and Environmental Science, vol. 1078, Berlin, Germany, 20-23 September 2022. DOI: <https://doi.org/10.1088/1755-1315/1078/1/012129>

► Aguacil, Sergi; Morier, Yvan; Couty, Philippe; Bacher, Jean-Philippe. **Building-integrated photovoltaics (BIPV) combined with hydrogen-based electricity storage system at building-scale towards carbon neutrality.** Prague, Czech Republic, 4-6 July 2022

► Brigljevic, Teo; Bacher, Jean-Philippe; Hennebert, Jean. **Flexibility shares in a low-voltage distribution grid.** Proceedings of the 6<sup>th</sup> European Grid Service Market Symposium, Lucerne, Switzerland, 4-5 July 2022

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### PARTNERSHIPS

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# TRANSFORM – a champion of low-tech innovation

The escalating climate crisis has done nothing to curb the pace of construction in French-speaking Switzerland. According to current estimates, the building industry is responsible for roughly 40% of CO<sub>2</sub> emissions, as well as soil sealing, the progressive disappearance of biotopes, and waste pollution. The TRANSFORM Institute seeks to play its part in alleviating this problem by helping to equip architects and the public authorities with the tools that allow them to shape and influence how buildings are remodelled, and adapt them to better suit changing lifestyles.

The TRANSFORM Institute specialises in applied research on architecture and urban planning. Thanks to the combined expertise of its multidisciplinary team of academic and specialist architects, urban planners, geographers and building physics engineers, the Institute helps to create a vision for the sustainable built environment and advance its delivery.

The institute deals with multiple scales – from the assembly of building elements to territorial planning. It explores every aspect of the development process: design, construction, building use and associated cultural values, as

well as renovation and transformation at the end of the building's life. In architecture, transformation is often synonymous with renovation, particularly energy renovation. The projects carried out by the TRANSFORM Institute team show that an integrated approach to built environment research requires a wide range of skills and expertise on many different subjects such as housing production and delivery, mixed urban development, typo-morphology, healthy buildings, indoor air quality, digital tools for built heritage, right through to the reuse of building materials.

TRANSFORM's research groups think critically about building technologies and their sustainability. For the Institute, innovation is less about the invention of new technologies and more about the reappropriation, assembly and combination of traditional, even ancient building techniques.

In 2022, the TRANSFORM Institute and the Smart Living Lab organised two roundtables which explored the transformation concept. Discussions focussed specifically on the energy- and heritage-related challenges of renovation, cooling strategies for public spaces and the issues surrounding urban greening.



## Flagship Projects

- ▶ **POLYNORM, pilot project for the reuse of an industrial hall**  
Séréna Vanbutsele, Nicolas Grandjean, André Jeker, Reto Mosimann, Agnès Collaud | [Polynorm](#)
- ▶ **BIM-Ren, data transfer method for heritage buildings**  
Sandra Rihs | HES-SO | [BIM.REN](#)
- ▶ **TypoRENO-VD, development of a set of roadmaps for the energy retrofit of buildings in the canton of Vaud**  
Stefanie Schwab, Jean Luc Rime, Yanaëlle Sciboz, Jean-François Gaudard, Theo Perrelet, Anne-Valérie Narath (DIREN), Alberto Corbella (DGIP), Blaise Perisset (HEIG-VD), financement état de Vaud, Direction générale des immeubles et du patrimoine (DGIP), DIREN (Direction de l'énergie) | [TypoRENO-VD](#)



Séréna Vanbutsele  
Head of TRANSFORM  
Institute

« The city of the future is already largely in place. The challenge is transforming and adapting existing buildings in a way that improves our collective well-being and protects our planet's resources. »

### KEY PUBLICATIONS

▶ Rey Joan Frédéric, Goyette Stéphane, Gandolla Mauro, Palacios Martha, Barazza Fabio, Goyette Pernot Joëlle (2022). **Long-term impacts of weather conditions on indoor radon concentration measurements in Switzerland.** Atmosphere, <https://doi.org/10.3390/atmos13010092>

▶ Mosimann Reto (2022). **Pour une «Umbaukultur» sensible: un outil d'aide à la décision.** Tracés, <https://www.espazium.ch/fr/actualites/pour-une-umbaukultur-sensible-un-outil-daide-la-decision>

▶ Vanbutsele Séréna, Brahimllari Schaffner Estela (2022). **Vides urbains à Fribourg.** Pro-Fribourg, vol. 3, no. 216, pp. 30-35, <https://arodes.hes-so.ch/record/11487>

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### PARTNERSHIPS

Etat de Fribourg (Promotion économique, Plan Climat, Service de l'énergie)  
Morand SA construction métallique  
Office Fédéral de la Santé Publique  
Canton de Vaud, Direction générale des immeubles et du patrimoine (DGIP), Direction de l'énergie (DIREN)  
Centre de compétence en rénovation des bâtiments (CCRB), Fribourg  
HEIG-VD, HES-SO Valais, HSLU Hochschule Luzern

Office fédéral de la culture  
Patrimoine Suisse  
Tracés  
La ressourceurce  
UNIGE  
ETH Zurich



## Top-shelf projects in research on built environment

2022 has been marked by obtaining some prestigious and innovative projects. They excellently reflect the range and importance of research in civil engineering, ranging from new approaches to construction materials and structural elements, over multi-functional building components to solutions for larger-scale challenges in the built environment.

The iTEC researches on all aspects of the built environment, from construction materials and elements in buildings to networks and infrastructures on territorial scale. The developed solutions contribute to the environmental impact reduction of construction, to mitigate effects of natural hazards, and to positive effects on the local, urban and regional climate. Recently obtained projects provide a glimpse on iTEC activities:

### Alternative construction materials, structural elements and building components

The ORCADEMO project, funded by the research program HEIA@SLL, aims at developing the methodological basis for predicting recycled aggregate concrete performances through an image-based machine learning approach.

The F-R Inno project, funded by Innosuisse and an industrial partner, targets the development of a new reinforcement system against punching in concrete flat slabs, a structural system very frequently used in building construction.

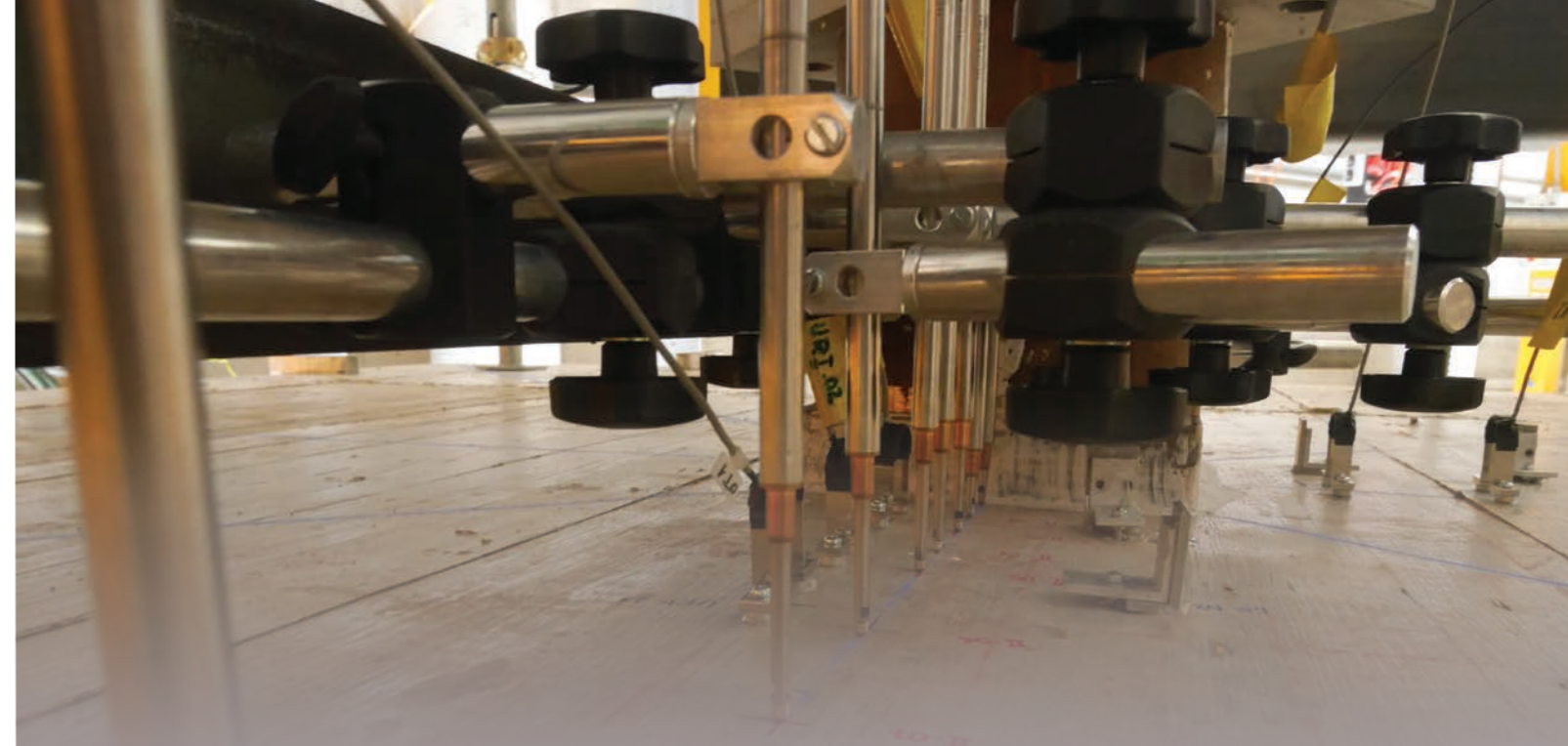
The TTV project, funded by the Fribourg NPR scheme, evaluates the use of biochar-based substrate in green roofs for rainwater retention, re-irrigation (instead of drinking water consumption), and biomass production.

### Larger-scale challenges in the built environment

The URBA-SOIL project, funded by SNSF, focuses on performances of urban soils for ecosystem services (water and heat regulation), by understanding the feedback mechanisms between soil properties, heat and water transport and the role of earthworms.

The AutoDepot project, funded by the Federal Office of Transport, aims at defining the technical and legal prerequisites for the implementation of an autonomous bus depot, with a focus on the automated traffic on site, and at estimating its economic viability.

The HydrO2power project, funded by the HES-SO Engineering & Architecture domain, explores the interactions between water quality (oxygen and temperature) in the reservoir, energy production and environmental aspects of the downstream river.



## Flagship Projects

### Sanitation 4.0

Devaux, Mylène et al. | Research program HEIA-FR/SLL | [Assainissement 4.0](#)

### TISLA 2D-Fx – Multifunctional two-axis hybrid wood floors

Zwicky, Daia et al. | Research program HEIA-FR/SLL | [TISLA 2D-Fx](#)

### Use of wood biochars for wastewater treatment and groundwater re-infiltration (SYLVO)

Favre Boivin, Fabienne et al. | INTERREG, Canton FR | [SYLVO](#)



Daia Zwicky  
Head of iTEC Institute



*The built environment is not only a burden for the net-zero carbon target but can also provide crucial contributions to its achievement.»*

### KEY PUBLICATIONS

► Serpell, Ricardo; Zwicky, Daia. **Low-energy lightweight aggregates by cold bonding of biomass wastes: effects of raw material proportion adjustments on product properties.** Construction and Building Materials, <https://doi.org/10.1016/j.conbuildmat.2022.128392>

► Favre Boivin, Fabienne et al.. **Real wastewater micropollutant removal by wood waste biomass biochars: a mechanistic interpretation related to various biochar physico-chemical properties.** Bioresource Technology Reports, <https://doi.org/10.1016/j.biteb.2022.100966>

► Sandoval, Santiago et al.. **Conceptual stormwater quality models by alternative linear and non-linear formulations: an event-based approach.** Environmental Modeling & Assessment, <https://doi.org/10.1007/s10666-022-09838-1>

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ECAB

Industrial partners from the planning and construction sector

# University of Fribourg - interdisciplinarity and innovation

The University of Fribourg (UNIFR) strives for excellence in teaching, research and innovation. An important way it seeks to achieve this goal is the promotion of interdisciplinary collaboration with a view to building a sustainable future. Here, UNIFR can rely on input from its research Centers of Excellence, collaboration with other universities and higher education institutions in Switzerland and abroad, as well as its participation in the Smart Living Lab.

The Smart Living Lab is home to four UNIFR entities: the Human-IST Institute; the Institute for Swiss and International Construction Law; the International Institute of Management in Technology (iimt); until June 2022); and the research groups Decision Support and Operations Research (DS&OR) and Digitalization and Information Systems (DIGITS). The integration of DS&OR and DIGITS in July 2022 consolidates UNIFR's strategy of sustainability, innovation and interdisciplinarity. The 14 UNIFR

research projects aim to advance our understanding of how humans and technologies interact with the built environment, and therefore pave the way for innovative solutions that tap into multiple perspectives, including digitalization, logistics, decision support and the law.

In 2022, UNIFR embarked on a series of major structural changes within the Smart Living Lab. In the first half of the year, iimt took charge of the organization and coordination of the UNIFR research groups based in the Smart Living Lab. During the second semester, Professors Hans-Georg Fill and Bernard Ries took over these duties. Thanks to this co-chairmanship, the Smart Living Lab can now benefit from UNIFR's broader expertise. The co-chairs will also strengthen interdisciplinary collaboration, bring new ideas and offer different and innovative perspectives.

**Hans-Georg Fill, Smart Living Lab UNIFR Manager**



Human-IST Institute



LAW Institute



DS&OR Group



DIGITS Group



iimt

**UNI  
FR**  
UNIVERSITÉ DE FRIBOURG  
UNIVERSITÄT FREIBURG

## Highlights of 2022



### High impact publications

Two books were published in conjunction with the Swiss Conference on Public Procurement Law, which was held in Fribourg and Zurich respectively. Other publications include multiple academic papers by members of the UNIFR research staff.

### International collaborations

Human-IST Institute and the MIT media Lab have developed AirSpecs, customized smart eyewear that collect information about the user's environment, context and physical well-being in real time.

### Departures

The International Institute of Management in Technology (iimt) said goodbye to the Smart Living Lab and will now concentrate its expertise within the University of Fribourg.

### New co-chairs

In July 2022, Professors Hans-Georg Fill and Bernard Ries took over responsibility for the organization and coordination of the UNIFR entities within the Smart Living Lab.

# Human-Building Interaction

## Understanding/Augmenting in-the-wild Human Comfort.

Applying its expertise in Human-Computer interaction (HCI), the Human-IST Institute develops methods and tools to understand and improve Human-Building Interactions (HBI). Using both user-centered design approach and computational tools to observe occupants' behavior, it develops human-centered and sustainable technology to empower building's occupants, in particular to better control their environment to make it healthier, more comfortable, more efficient and sustainable. In addition to the projects described on the right, Human-IST actively participated the ARC-HEST Swiss-Korean Academic Exchange, and the SCAI project (swisscai.ch).

Combining the expertise of smart sensing from the Responsive Environments group in the MIT Media Lab, and user experience research from the Human-IST Institute in Fribourg, a series of user studies will be performed in Boston, Fribourg, and Singapore from March 2023 to June 2023. These studies aim at investigating a new way to survey users' perception of comfort in-the-wild and to understand climatic as well as cultural differences, using custom

smartglasses called AirSpecs developed in 2022 by MIT and Human-IST for this project. Further, Human-IST worked on the Lucideles project which aims at optimizing light management by leveraging natural daylight and to carry out user testing on a smart control device. Results included a better understanding of user acceptance mechanisms, as well as a testing infrastructure. Finally, within the SWICE project, which aims to reduce Switzerland's carbon footprint and energy consumption, the Human-IST Institute studies the human dimension of change. It aims to propose a comprehensive framework for understanding and fostering social and behavioral change. To assess the effectiveness of interventions aimed at sustainability, in-the-wild behavioral data acquisition techniques are developed and applied in various living labs to detect lifestyle groups, individual behavior change processes, and spillover effects.



Hye Jun Youn, a master student from the Harvard School of Design, using our wearable comfort perception platform AirSpecs for her project.

## Flagship Projects

### ▶ Understanding the Perception of Comfort with Smart Eyeglass In-the-Wild

Sailin Zhong, Patrick Chwalek | UniFr Doc.Mobility | [airspecs.resenv.org](https://airspecs.resenv.org)

### ▶ Lucideles

Julien Nembrini, Moreno Colombo, Denis Lalanne | Swiss Federal Office for the Environment FOEN | [lucideles.human-ist.ch](https://lucideles.human-ist.ch)

### ▶ Sustainable Well-being for the Individual and the Collectivity in the Energy transition - The human dimension of change

Julien Nembrini, Moreno Colombo, Denis Lalanne, Jean-Philippe Bacher, Florinel Radu, Bernadette Sütterlin, Evelyn Lobsiger-Kägi, Timo Ohnmacht | Swiss Federal Office of Energy SFOE | [sweet-swice.ch](https://sweet-swice.ch)



Denis Lalanne  
Head of Human-IST  
Institute

« Understanding users' perception of comfort and cultural differences with smartglasses. »

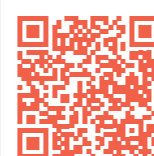
## KEY PUBLICATIONS

▶ Zhong S, Rosset L, Papinutto M, Lalanne D, and Alavi HS, 2022. **Binaural Audio in Hybrid Meetings: Effects on Speaker Identification, Comprehension, and User Experience** Proc. ACM Hum.-Comput. Interact. 6, CSCW2, Article 279 (November 2022), 24 pages. <https://doi.org/10.1145/3555170>

▶ Papinutto M, Boghetti, R, Colombo M, Basurto C, Reutter K, Lalanne D, Kämpf J. H. & Nembrini J. Energy and Buildings, 268, 112176 (2022). **Saving energy by maximising daylight and minimising the impact on occupants: An automatic lighting system approach.** <https://doi.org/10.1016/j.enbuild.2022.112176>

▶ Alavi H, Zhong, S. & Lalanne D (2022). **Indoor Air Quality Forecast in Shared Spaces: Predictive Models and Adaptive Design Proposals.** SPOOL, 9(1), 57-64. <https://doi.org/10.47982/spool.2022.1.05>

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## PARTNERSHIPS

MIT Media Lab  
National University of Singapore  
Regent Lighting, Basel  
ZHAW - Institut für Nachhaltige Entwicklung  
ENERGY Institute, HEIA-FR  
TRANSFORM Institute, HEIA-FR  
HSLU – Hochschule Luzern  
SFOE – Swiss Federal Office of Energy  
FOEN – Swiss Federal Office for the Environment

# Legal issues around sustainability in public procurement, cyber security and alliance contracts

In the year 2022, the LAW group's research focus was aimed on public procurement law (general and sustainability topics), critical infrastructure law (legal cybersecurity obligations) and contract law (developing Project alliance contracts within the Swiss legal framework). On June 24, the biennial Swiss Public Procurement Conference was organised in Zurich, gathering over 400 scholars and practitioners. Besides, numerous teaching activities were deployed at UNIFR as well as in CAS programs on public procurement, BIM and mediation.

Since 2019, several Swiss public procurement law acts have been successively revised, and in some cantons, their respective revision is still under way. The LAW group closely follows and analyses this evolution, in particular the new rules aimed at enhancing the ecological and the social dimensions of sustainable procurement.

Contemporary societies rely on manifold physical infrastructures in order to enable and to maintain the way of life people have adopted as well as the activities they and their economy want to deploy. The functioning and the safety of such infrastructures has always been an important legal issue. Up to recently, this could be addressed by sole constructive and organisational measures, but nowadays, as control and surveillance of constructions go

more and more electronic and online, new threats for the functioning and the safety of infrastructures arise from cyberspace, that claim for further measures to be taken. The LAW group aims to analyse the current legislation pertaining power grids under the light of these threats.

Traditional design and construction contracts are structured in such a way that the risks and opportunities associated with the convened operation are all exclusively assigned to one or to the other party to the contract. This approach creates strong incentives for non-constructive, egoistic and potentially project-threatening behaviours on each side. This is because, whenever a problem arises or a risk realises, it is economically reasonable for each party to deny any fault and responsibility and to blame the other party respectively. As a result, a lot of money, much time and numerous chances of optimisation of construction projects are lost. So-called Project alliance contracts (or Integrated project delivery contracts) have been developed in Australia, the USA and elsewhere and are aimed at setting the economic incentives in a fundamentally different way. In substance, most of the risks and chances are born jointly by all parties, which eliminates most incentives for obstructive behaviour. The LAW group contributes its expertise to a SIA workgroup that aims at adapting this type of contract for Swiss law and that elaborates a guideline as well as a model contract.



## Flagship Projects

- ▶ **The Concept of Sustainability in Swiss Public Tender and Public Procurement Law**  
Martin Beyeler | conferences and publications | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **Preparing the Ground for Project Alliance Contracts under Swiss law (collaboration of Martin Beyeler in the SIA Working Group 2065)**  
Elaboration of a technical guidance (SIA) and a contract model (SIA) | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)
- ▶ **Critical Infrastructures in the Electricity Sector and Information Security (Clea Simon)**  
PhD thesis project | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)



Martin Beyeler  
Professor of Law

« Partnership in contracts relies on culture at least as much as on economic incentives and clear rules. »

### KEY PUBLICATIONS

▶ Beyeler, Martin, [traduction]. **"Public Procurement Law 2022"**. Zürich 2022 (ISBN/ISSN 978-3-7255-8440-6)

▶ Zufferey, Jean-Baptiste/Beyeler, Martin/Scherler, Stefan (rédacteurs). **Aktuelles Vergaberecht 2022 / Marchés publics 2022**. Zürich 2022 (ISBN/ISSN 978-3-7255-8439-0)

▶ Beyeler, Martin/SCHERLER, Stefan, [traduction]: **"Public Procurement Law 2022: New Topics, New Rulings"**. Zufferey/Beyeler/Scherler (rédacteurs), **Aktuelles Vergaberecht 2022 / Marchés publics 2022**, Zürich 2022, pp. 33 seq.

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# Supporting complex decision-making with quantitative methods

At the DS&OR Group, we develop mathematical theories, models and algorithms to support decision making in complex situations, mainly in logistics and transportation. In particular, we have recently been involved in an industrial project in the context of waste collection.

Both profit and non-profit organizations are constantly facing complex problems that need to be addressed with mathematical tools. To be successful in practice, one must have a good and profound understanding of the problem at hand, translate it into mathematical language, implement and solve the resulting formulation on a computer, and be able to communicate the results to the organization. At the DS&OR group, we collaborate with industrial partners in projects that comprise some or all of the above-mentioned steps. This is why our research interests span graph theory, mathematical programming and heuristic and metaheuristic methods.

In 2022, we have concluded a 3-year project funded by the Swiss Innovation Agency on making waste collection more efficient and sustainable. Together with Schwendimann AG and iimt (University of Fribourg), we have developed a

prototype of a user-friendly web-based decision-support tool that helps municipalities in finding the waste collection system that best suits their needs. A waste collection system comprises the strategy put in practice and the technology used to gather and transport the waste. To determine a system, we have designed and implemented algorithms that optimize the associated decisions, such as the location of collection points and the routes performed by the collection vehicles to gather the waste.

These algorithms are called by the decision-support tool as soon as the user specifies the characteristics of the municipality under consideration. The tool then displays several sustainability, performance and cost indicators, allowing a direct comparison between the current system and the suggested one. This provides a solid basis for long-term decisions thanks to the well-founded reported key figures.



## Flagship Project

► **Decision support for efficient and sustainable waste collection**  
Vera Fischer, Meritxell Pacheco, Bernard Ries | Innosuisse | [smartlivinglab.ch/projects](https://smartlivinglab.ch/projects)



**Bernard Ries**  
Head of DS&OR Group

« Our goal is to support complex decision making in logistics and transportation. »

### KEY PUBLICATION

► Fischer V, Pacheco M.  
**A Facility Location Problem with Minimum Workload and Penalties for Waste Collection.**  
Operations Research Proceedings 2021. [https://doi.org/10.1007/978-3-031-08623-6\\_13](https://doi.org/10.1007/978-3-031-08623-6_13)

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### PARTNERSHIPS

Schwendimann AG  
iimt UNIFR

# Foundations for AR-based Metamodeling

## Conducting Fundamental Research for Joining Conceptual Modeling and Augmented Reality.

In July 2022 the research group Digitalization and Information Systems became part of the Smart Living Lab. The goal of the group's participation is to contribute to the further digitalization of the built environment. In particular, we aim for contributing methods established in the field of business informatics and adapt them in the course of interdisciplinary research activities. Thereby, one core method in business informatics are so-called conceptual modeling methods. These are based on a pre-defined schema, i.e. the modeling language, which specifies semantic concepts for representing knowledge on process flows, IT architectures, or software systems. Based on the created visual models, different kinds of algorithms can then be applied to such models, e.g. for conducting simulations or generating code in programming languages.

In a current research project, we investigate how this modeling approach can be joined with augmented reality technologies. In particular, we are interested to anchor the knowledge expressed in traditional 2D models with objects in the real world, i.e. in 3D physical environments. Potential use cases include the flexible creation of augmented reality-based applications, e.g. for dynamically guiding visitors through the built environment based on individual preferences or for projecting knowledge about the maintenance or assembly of physical infrastructure or machines into the real world. In the current stage, we are about to investigate the fundamental requirements and technical feasibility on the level of metamodeling, which is a sub-field of conceptual modeling concerned with the provision of the theoretical foundations and technical infrastructure for conducting AR-based modeling.



## Flagship Projects

- ▶ **Knowledge-based Augmented Reality**  
Fabian Muff, Daniel Borcard, Hans-Georg Fill | Smart Living Lab | [Read more](#)
- ▶ **Domain-Specific Conceptual Modeling for Distributed Ledger Technologies**  
Hans-Georg Fill, Felix Härer, Simon Curty | FNS | [Read more](#)



**Bernard Ries**  
Head of DIGITS Group

« Integrating business informatics methods and augmented reality to revolutionize user experiences in built environments. »

## KEY PUBLICATIONS

▶ Fabian Muff & Hans-Georg Fill. **Use Cases for Augmented Reality Applications in Enterprise Modeling: A Morphological Analysis.** BMSD 2022. [https://doi.org/10.1007/978-3-031-11510-3\\_14](https://doi.org/10.1007/978-3-031-11510-3_14)

▶ Fabian Muff & Hans-Georg Fill. **Past Achievements and Future Opportunities in Combining Conceptual Modeling with VR/AR: A Systematic Derivation** BMSD 2023, (forthcoming)

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## PARTNERSHIPS

EPFL  
HEIA-FR

# iimt, a leading Swiss competence centre for management in technology

The international institute of management in technology (iimt) is a leading Swiss competence center for management in technology and is committed to excellence in continuing education and research. Its research activities are focused on analyzing changing consumer

behavior and habitat studies, as well as energy system management, cybersecurity, innovation, and technology. Prof. Stephanie Teufel retired in 2021 and was director of the iimt until then; she still supervised final works of her Smart Living Lab activities in 2022.



## KEY PUBLICATIONS

► Cunha J, Teufel S, Bas E, Guillo M. **Distance Learning: Student's Perception of the Substitution of on-site Classes by Online Tools during the COVID-19 Pandemic.** December 2022. International Journal of Social Science and Humanity 12(4):231-235. [DOI:10.18178/ijssh.2022.12.4.1096](https://doi.org/10.18178/ijssh.2022.12.4.1096)

► Teufel, B., and Sentic, A. **Blockchain in Energy.** In: Asif, M. (ed.): **The 4Ds of Energy Transition: Decarbonization, Decentralization, Decreasing Use, and Digitalization.** Wiley-VCH GmbH, Weinheim, Germany, 2022. ISBN: 978-3-527-34882-4. <https://doi.org/10.1002/9783527831425.ch18>

► Teufel, S., Lischewski, C., and Teufel, B. **Barriers for hydrogen powered vehicles - a status report for Germany and Switzerland.** iimt Institute Report, 2022, ISBN 978-3-905814-84-2.

READ MORE



# Three new groups joined the Smart Living Lab



**HANS-GEORG FILL**  
DIGITS GROUP – UNIFR

Hans-Georg Fill is Full Professor for Digitalization and Information Systems in the Department of Informatics of the University of Fribourg. He joined the Smart Living Lab in July 2022 and coordinates the activities of the research groups of the University of Fribourg in the Smart Living Lab.

My current research focuses on the development of new types of visual modeling methods and languages for eliciting requirements and transforming them into digital solutions – we call this “metamodeling”. This involves for example the development of new visual languages for designing and analyzing blockchain-based applications, where I received an SNF grant in 2020.



**BERNARD RIES**  
DS&OR GROUP – UNIFR

The Decisions Support & Operations Research Group from the University of Fribourg is affiliated to the Smart Living Lab since September 2022. Prof. Bernard Ries, his co-head tells us more about his academic career and research schemes.

Together with my group, we are bringing expertise in decision support, i.e. we support decision makers in complex situations using several quantitative methods and tools like graph theory and mathematical modeling. One of our main projects is about efficient and sustainable waste collection.

*“The Smart Living Lab represents a perfect environment for tackling some of the most challenging problems our society is currently facing.”*



**ANDREW SONTA**  
ETHOS LAB – EPFL

Andrew Sonta joined the EPFL School for Architecture, Civil, and Environmental Engineering (ENAC) as a Tenure Track Assistant Professor of Civil Engineering on 1st September 2022. He leads the new Civil Engineering and Technology for Human Oriented Sustainability Lab (ETHOS) at the Smart Living Lab in Fribourg.

The effects of our buildings and cities on energy systems and the environment are well-known, but it is also important to recognize that what we build impacts our social and human systems. Unfortunately, our understanding of these complex interactions between complex systems (built, environmental, and social) are nascent. These questions will drive my lab’s research going forward.

*“My academic career so far has led me to understand that our built environment affects society in many ways.”*

*“The built environment is a fascinating environment due to its tangibility and the physical interaction with research objects - which we often miss in computer science due to the focus on software.”*

## Smart Living Lab and its digital twin: a centre for and object of research

Scientific teams from academic institutions affiliated with the Smart Living Lab will share the nearly 5,000 m<sup>2</sup> building and its comfortable and efficient work spaces. The building will also offer facilities that support a wide range of research activities and experimental work. The construction phase will run from 2023 to 2025. Once completed, the new Smart Living Lab building will be a flagship of the Bluefactory innovation district in the heart of Fribourg.

In 2019 Behnisch Architekten won the collaborative Parallel Studies Mandate (in French: MEP Mandat d'études parallèles) to design the new Smart Living Lab building. The budget for the construction project is CHF 25 million and is covered by the Canton of Fribourg. Made from locally sourced timber, the building will comprise both low-tech and high-tech design solutions that will minimise its life cycle carbon footprint.

Sensors will permanently monitor energy consumption, environmental quality and the use of space. These data will be continually fed into a shared database and a building information modelling (BIM) system, which, in the interests of data access and information sustainability, will function according to the 'openBIM' principle.

What emerges from this data is a digital twin, which will serve three main purposes. The first and most important are post-occupation assessments. These will make it possible, for example, to verify whether the building has reached its target



*"The objective of a BIM system is to allow all of the trades involved in a construction project to communicate and share information with one another".*

performance levels or not. The digital twin will also be helpful during the planning and research phases as a number of its modular elements enable the in situ testing of future innovative solutions for the construction industry. Finally, the digital twin will optimise the construction process and the monitoring of how the building evolves with use. Even after its construction is complete, the Smart Living Lab will continue to grow and mature so that it serves the needs of research and science as best as it possibly can, improves its performance, safeguards its longevity and secures its place at the forefront of innovation.



**Sergi Aguacil**  
Head of Building2050  
Group (BUILD)



### *openBIM – an essential collaboration tool*

*As well as using openBIM to deal with the very pragmatic issues connected with the construction of the new Smart Living Lab (building process, materials, technologies), the Building2050 Group is actively helping to improve this technology which aims to facilitate and improve interoperability, collaboration, and the sustainability of information by relying on open data formats rather than proprietary ones.*

[building.smartlivinglab.ch](http://building.smartlivinglab.ch)



- ▶ September 2022: building permit issued
- ▶ 2<sup>nd</sup> semester 2023: construction begins
- ▶ 2<sup>nd</sup> semester 2025: building commissioning

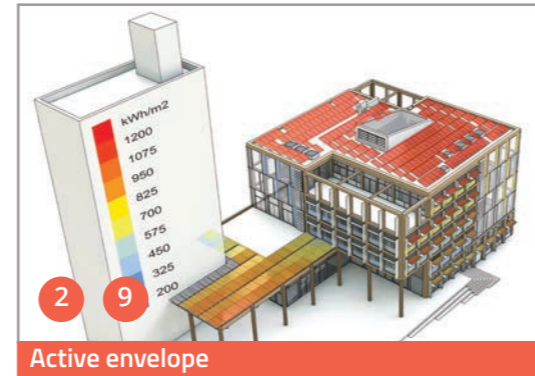
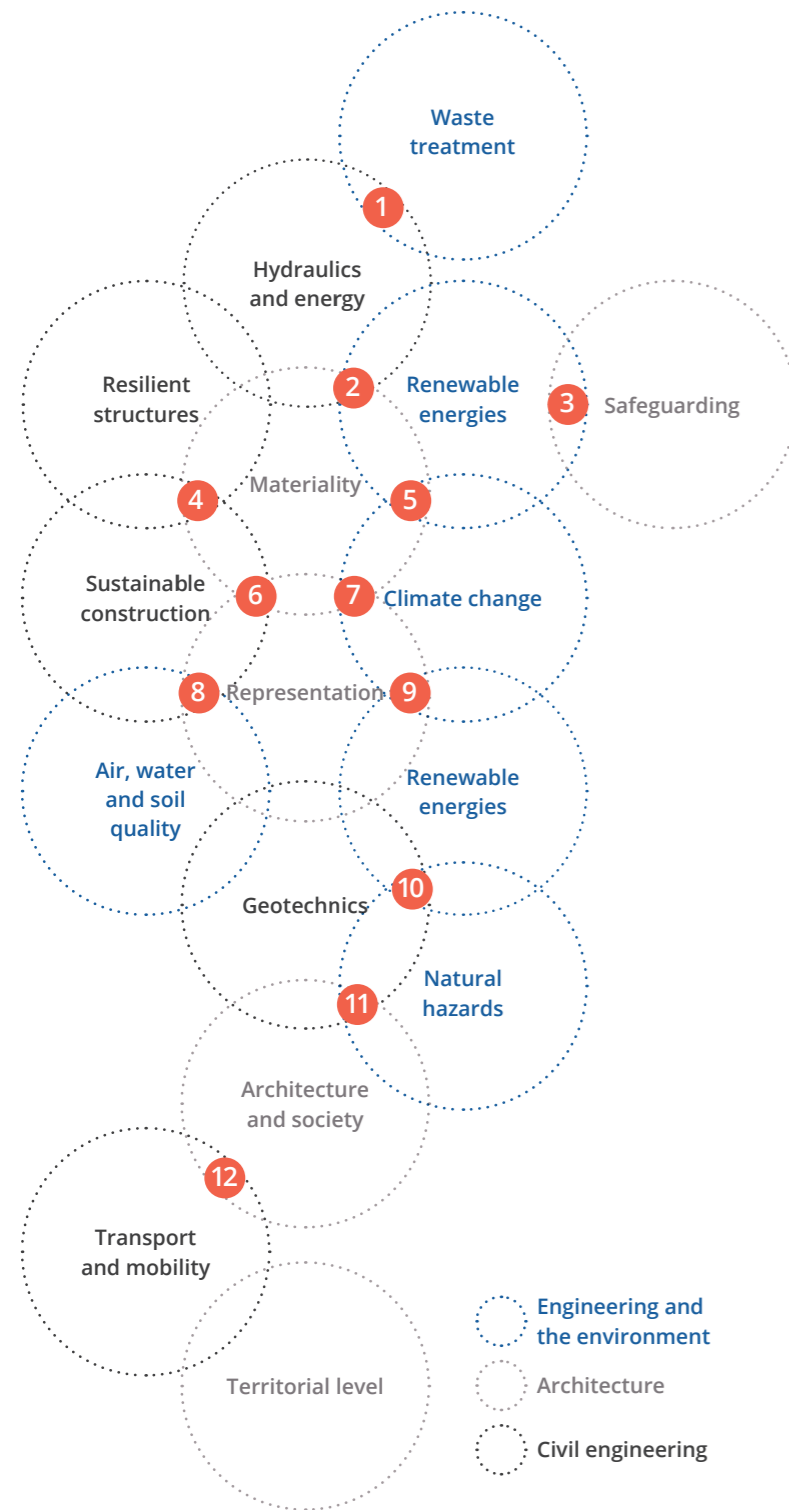
General contractor: JPF SA | Project owner: BFF SA



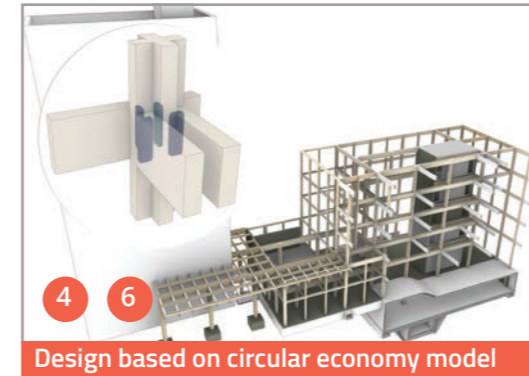
Smart Living Lab building by 2025  
© BFF SA / Behnisch Architekten



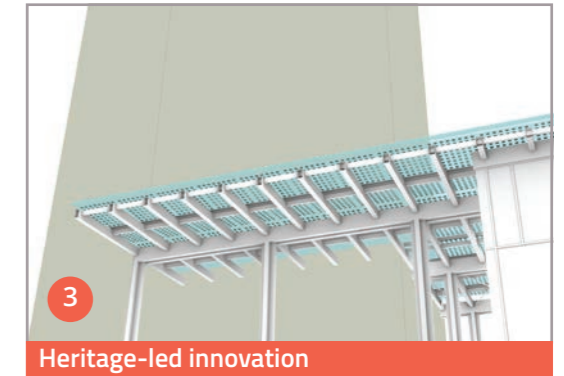
# Smart Living Lab building: an example of interdisciplinary practice to address climate challenges



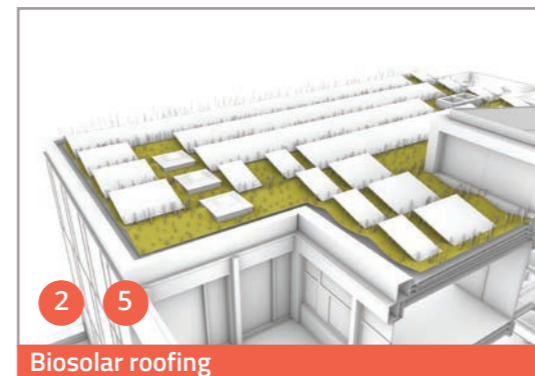
**Active envelope**  
Cumulative annual solar irradiation on the photovoltaic modules integrated in the building envelope.



**Design based on circular economy model**  
Prefabricated components made from local timber that can be re-used at the end of the building's life cycle.



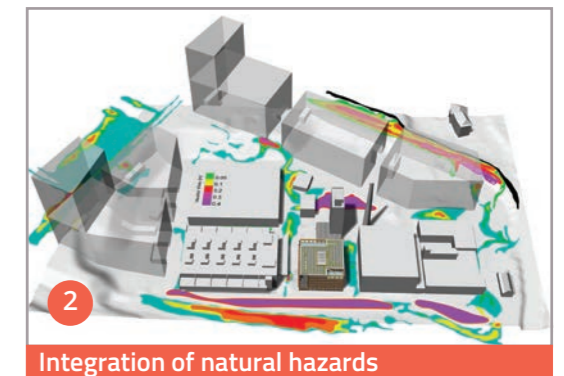
**Heritage-led innovation**  
Harmonious relationship between the silo, a protected monument and a witness to the site's industrial past, and the pergola, an active structure that generates clean energy on site.



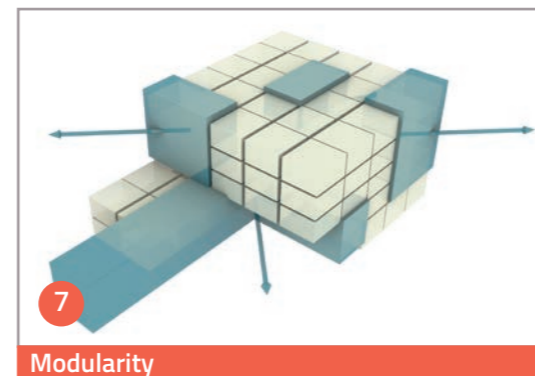
**Biosolar roofing**  
The shade from the solar panels protects the plants while evapotranspiration from the plants boosts the performance of the solar panels.



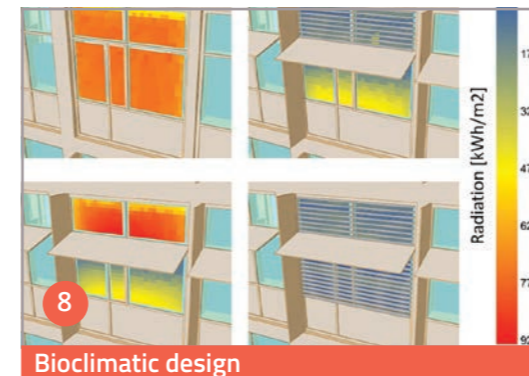
**Rain and wastewater management**  
Harvesting of rainwater to flush urine-diverting toilets. The urine is converted into fertiliser, and vermicomposting is used to treat brown water.



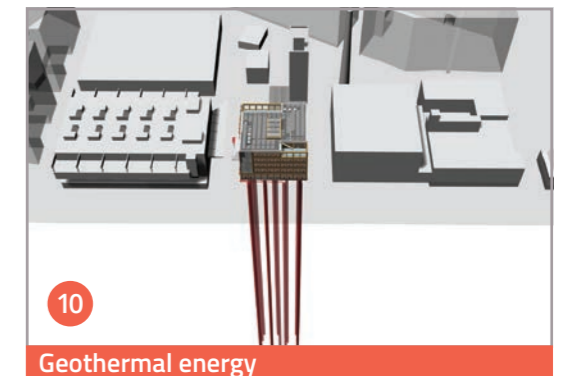
**Integration of natural hazards**  
Surface runoff risks are factored into the landscape design of the Bluefactory district.



**Modularity**  
A flexible and modular system that makes it easy to swap out and re-use materials.



**Bioclimatic design**  
Management of hygrothermal comfort through passive strategies like mobile solar protection and natural ventilation thanks to air circulating between the conservatories and central atrium.



**Geothermal energy**  
Principal source of energy for the district heating and energy network on the Bluefactory site.



**Radon risk control**  
Innovative monitoring concept and use of preventive structural measures to mitigate radon-related risks.



**Human-powered mobility**  
Landscaping of the Bluefactory district based on mobility study findings.

# Media coverage

**RÉGIONS | 11**  
MARS 30 AOÛT 2022

A Bluefactory, des chercheurs analysent la qualité de l'environnement dans des bâtiments  
**L'air intérieur passé au crible**

08/09/22  
LA CÔTE  
www.lacote.ch

**IMMOBILIER 21**

**Energie: une solution locale face à un enjeu global**

**SCIENTES** Le solaire évolue et devrait s'étendre aux façades en plus de la toiture. L'autre impératif à terme concerne le stockage. Réflexions.

**LA CHRONIQUE IMMOBILIÈRE**  
SERGI AGUACEL  
CHÉF DE GROUPE BUILDING 2050,  
SMART LIVING LAB, EPFL FRIBOURG

Freiburger Nachrichten  
FRONT NEWS SPORT FORUM AGENDA E-PAPER AKTIONEN

Bluefactory AG erhält Baubewilligung für fünfstöckiges Forschungsgebäude

One step closer to providing customized climate control in the office

EPFL researchers have shown that people's perception of office temperatures vary considerably. Personalized climate control could therefore help enhance workers' comfort - and save energy at the same time.

# Events

► 2022-04-05  
Research project SWICE | Kick-off event



► 2022-04-5/26  
"Vivre plus mieux" and "Habiter demain" Double Exhibition



► 2022-05-01  
Sustainable construction Forum | Energissima



► 2022-08-31  
INVITED TALK | Architecture without air-conditioning



► 2022-09-02  
EPFL ENAC 20<sup>th</sup> anniversary



► 2022-11-02  
Perspectives | Research and innovation with the Smart Living Lab



# Living and working in an era of transition

Supported by the Swiss Federal Office of Energy SFOE, the Smart Living Lab has embarked on an eight-year research project called SWICE (Sustainable Well-being for the Individual and the Collectivity in the Energy transition). Bringing together a range of different disciplines ranging from Sociology and Social-Psychology to Transportation and Architecture, and through a participative involvement of stakeholders in eight Living Labs across Switzerland, the project will support the implementation of Switzerland's Energy Strategy 2050.

Following new processes of digitalization and flexibilization accentuated also by the COVID-19 pandemic, urban areas have witnessed a shift in people's behaviour when it comes for example to their consumer attitudes, mobility patterns, and living and working habits. Can these changes in lifestyle and social dynamics help pave the path towards the Swiss energy transition? The unique characteristic of the SWICE project is that it aims to study, for the first time, how new social, technological and design models can be implemented together into actual Swiss policy measures to promote a sustainable high-quality living combined with minimized resource use.

While people and socio-material dynamics are considered the main "agents of change" of the energy transition, three main "sectors of change" are identified in terms of impact on energy demand and supply management: the built environment, open spaces and mobility.

For these distinct - yet strongly interrelated - areas of research, the project leverages on the synergies between 10 Swiss Higher Education Institutions and 4 Research and Consultancy Companies spread across the Country supported by

an extensive collaboration network with more than 25 Cooperation Partners from the public and private sectors.

Throughout the project duration the Smart Living Lab, along with seven others Living Labs located in different cantons, will serve as a core observation space for the SWICE research activities as well as for pilot and demonstration projects where scientists will test ideas and apply new research hypotheses by directly involving residents and different stakeholders in order to explore ways of making lasting changes to behavior.

*"The wellbeing of people is a crucial component of the energy transition, which, to be successful, must be socially embraced and implemented in the physical spaces we inhabit."*



The SWICE consortium is under the academic direction of EPFL Prof. Marilyne Andersen. The project is coordinated by Luisa Pastore.

## People as the agent of change

The SWICE project proposes to reconsider past approaches to the energy transition, moving beyond pure technological development and implementation and building upon the evidence that energy demand is, first and foremost, an outcome of social dynamics, involving complex patterns of energy usage, service needs for well-being and material demands.

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# Swiss-Korean academic exchange program

After a one-year hiatus, the Swiss-Korean academic exchange program was up and running again in 2022. With support from the Science and Technology Office of the Swiss Embassy in Seoul, the Swiss (EPFL, HEIA-FR and UNIFR) and Korean academic partners (SungKyunKwan, Ewha and Hanyang universities) selected a group of 30 students to work on projects that explore ways of optimising co-working spaces.

The team brings together young scientists from different countries, institutions and disciplines (civil engineering, architecture and IT). It is this interdisciplinary thinking that is the real strength of the Summer School, which ran from 22 August to 1 September in Fribourg. The educational adventure continues in 2023, with the Winter School in Seoul.



## Project partners



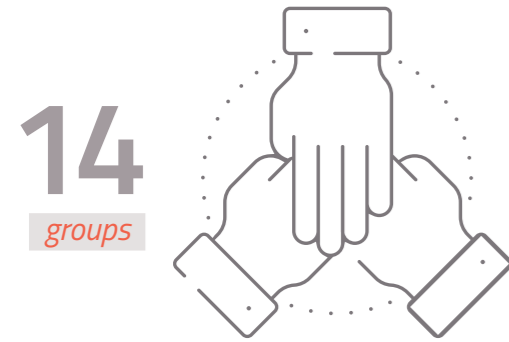
[smartlivinglab.ch/partenariats/arc-hest](https://smartlivinglab.ch/partenariats/arc-hest)

# Facts & Figures 2022

## STAFF



## RESEARCH



## EVENTS

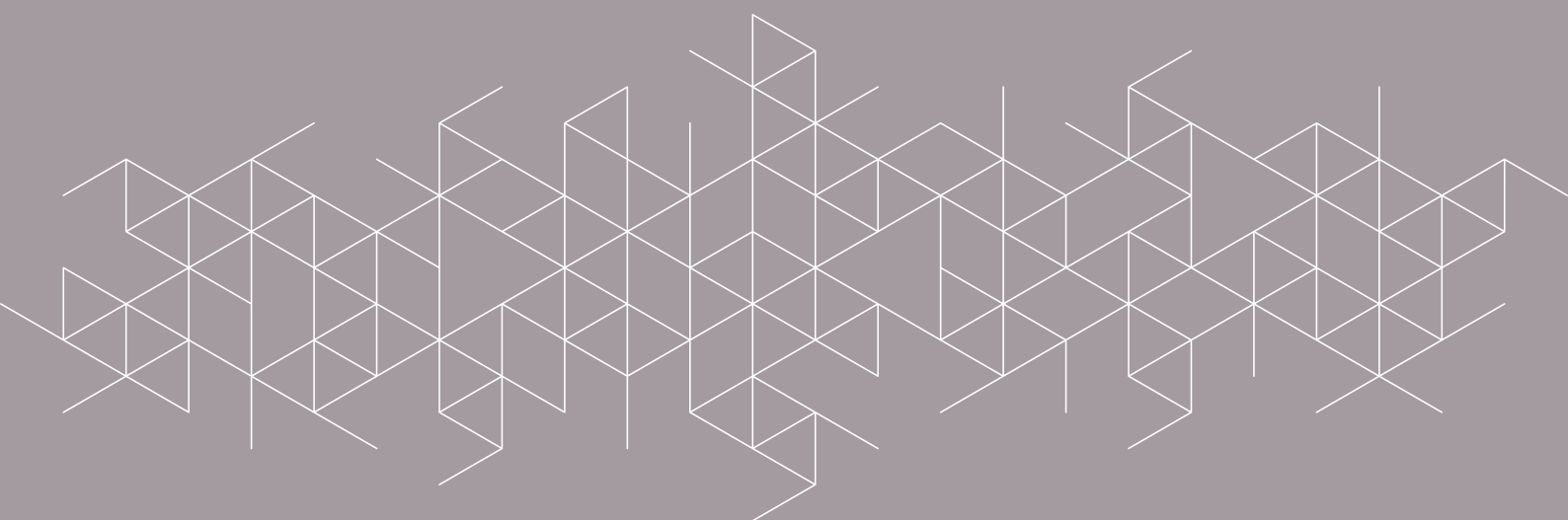


## COMMUNICATION | PRESS



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