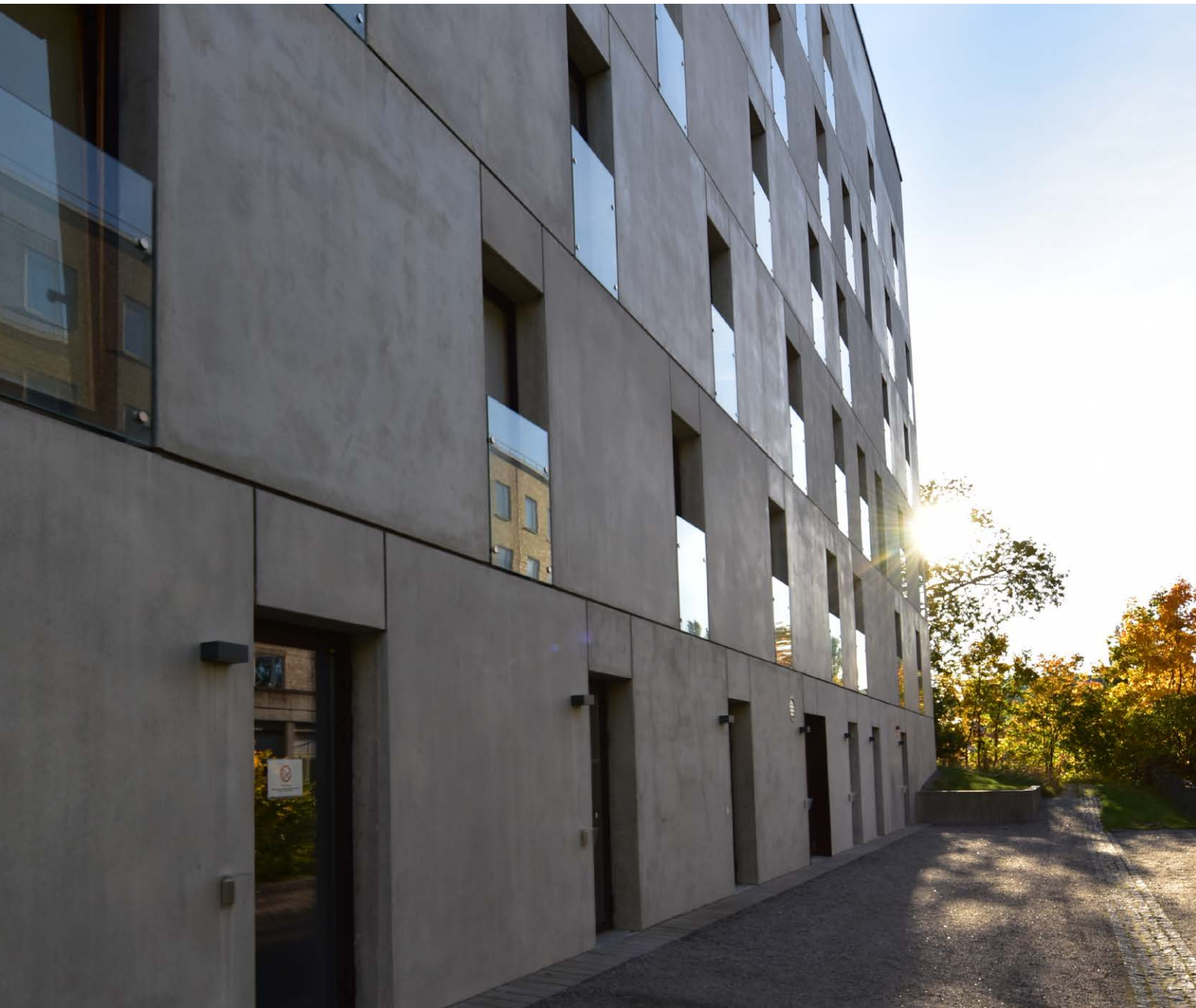
KTH Live-In Lab

Annual Report 2024



KTH Live-In Lab in short

KTH Live-In Lab was initiated in response to the multifaceted and multi-disciplinary issues regarding the construction and use of buildings and has proven to work as a bridge between different research areas as well as between academia and industry.

An platform for innovative research, education, and collaboration

The three foundations of KTH Live-In Lab are research, education, and collaboration. It offers full-scale testbeds ranging from apartments in building-exempt premises to adaptable, scalable infrastructure. As a research infrastructure, KTH Live-In Lab enables the interdisciplinary work needed to tackle challenges related to buildings, services, and climate change, generating new knowledge and practical results.

KTH Live-In Lab connects customer projects with researchers from relevant fields, creating tailored collaborations within each project's framework and supporting long-term engagement. It also facilitates collaboration between academic programs and with industry, serving as a vital link between students and companies, a connection that many educational programs lack today.

Testbeds and database

KTH Live-In Lab currently consists of three Testbeds: Testbed KTH, Testbed EM, and Testbed AH. The KTH Live-In Lab Testbeds have a joint database where data can be collected for research or educational purposes.

About KTH Live-In Lab

KTH Live-In Lab is a competence center and a research infrastructure at the School of Industrial Engineering and Management (ITM). The idea behind KTH Live-In Lab came in 2013, and the concept was established during 2016–2017, mainly thanks to a donation from Einar Mattsson-Group.

KTH Live-In Lab became a competence centre in 2019, with KTH, Einar Mattson, Akademiska Hus, and Schneider Electric. In 2021, Bengt Dahlgren Stockholm joined KTH Live-In Lab as a center partner. We are currently around 15 active people engaged in running KTH Live-In Lab and have had more than 200 people involved in different research projects over the years.

Our contribution

Over the years, KTH Live-In Lab has facilitated tests and collaboration in real-life environments, with real, working systems, including everything from incoming resources and technical systems to users and organizations. Thanks to KTH Live-In Lab, ideas, theories, and products can be tested in real-life systems resulting in validated research and test results on an unprecedented level.

Contents

KTH Live-In Lab – Testbeds for Accelerated Innovation

KTH Live-In Lab acts as a bridge between academia and industry. The center is also a neutral arena for collaboration between small to medium-sized companies and large established companies, as well as research groups from different research areas.

Our work

KTH Live-In Lab is an important infrastructure enabling necessary research required to tackle the multidisciplinary challenges related to buildings, services and climate change. KTH Live-In Lab functions as a collaboration platform and infrastructure, generating new cross-disciplinary knowledge, scientific and technical results and commitment.

Visits to KTH Live-In Lab by ministers, royalty and TV celebrities show that what we do here appeals, touches, and leads to sustainable changes in our built environment. Being asked to give an introductory speech at “Forskarfredag” in front of thousands of middle and high school students shows that what KTH Live-In Lab does is not only of academic interest, but it also affects and can influence everything from children and young people to researchers and politicians.

Our Vision, purpose, and goals

KTH Live-In Lab is a platform that handles multiple Testbeds for accelerated innovation and development of sustainable solutions in the built environment. The purpose of KTH Live-In Lab is to reduce the lead times between testing, research results and market introduction. By doing this, KTH Live-In Lab aims to enable the sustainable and resource-effective buildings of the future.

The goal of KTH Live-In Lab is to help accelerate the introduction rate of new competitive and sustainable products and services for the construction and real-estate sectors.

KTH Live-In Lab's structure

Organization and management

KTH Live-In Lab has a board and management team consisting of people from ITM (School of Industrial Engineering and Management), ABE (School of Architecture and the Built Environment) and EECS (School of Electrical Engineering and Computer Science).

Management groups

The steering group currently consists of Per Lundqvist, professor KTH ITM, chairman, Karl-Henrik Johansson, professor KTH EECS, Micke Dimadis, property manager at Einar Mattsson, Lind Teng, area manager at Akademiska Hus, Deniz Önder, Bengt Dahlgren Stockholm, and Safira Monteiro, sale manager at Schneider Electric.

The executive group of KTH Live-In Lab helps carry out the center's activities in accordance with the business plan, partner agreements and the center's rules of procedure. The executive group is also in charge of assessing received applications regarding requests to conduct research or education within the framework of KTH Live-In Lab.

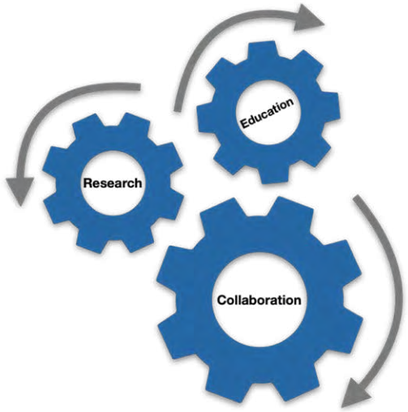
The executive group currently consists of Agnieszka Zalejska Jonsson (ABE), Davide Rolando (ITM), Marco Molinari (ITM), Folke Björk (ABE), Tobias Oechtering (EECS), Ute Besenecker (ABE), Cyril Holm (Stockholm University), Linda Teng (Akademiska Hus), Christer Larsson (Bengt Dahlgren) Micke Dimadis (Einar Mattsson) and Valentin Monteiro (Schneider Electric).

Research fields

KTH Live-In Lab acts as the intermediate link between academic research and industry, classified the lab's projects in its major fields of activity in order to effectively manage, promote and support them.

KTH Live-In Lab's projects, due to their multidimensional goals, typically cover more than one research field enabling the multifaceted work of the researchers. The projects can be categorized but are not limited to one of the following research fields:

- infrastructure and innovation
- resource management
- behavioral change and social responsibility.



Infrastructure and innovation

The experimental setup of the lab consists in both the physical and digital infrastructure. The KTH Live-In Lab physical infrastructure are the three Testbeds: Testbed KTH, Testbed EM, and Testbed AH, all equipped with state-of-the-art monitoring and control equipment. A database, where data from buildings is collected for research or educational purposes, is part of the digital infrastructure of the lab. The projects of this sector aim to upgrade the products and services of the construction and real- estate sectors.

Resource management

The second domain of KTH Live-In Lab consists of projects that focus on the sustainable consumption of resources such as water and energy. The projects in this domain are developed on the lab's physical and digital infrastructure, especially on the Testbed KTH utilizing the data of the lab's database. Modern management methods and state-of-the-art technological equipment are exploited in the optimal way with the aim of rational use of precious resources fostering innovation.

Behavioral change and social responsibility

KTH Live-In Lab has innovative projects that have social ramifications and focus on social sustainability by studying human habits and behavioral changes towards sustainability. This interesting sector of the lab puts the users of the infrastructure on the focal point examining their needs and preferences.

Management team

Marco Molinari
Director of KTH Live-In Lab,
Researcher (ITM)
marcomo@kth.se

Jonas Anund Vogel
Co-Director,
Researcher (ITM)
javogel@kth.se

Agnieszka Zalejska Jonsson
Co-Director,
Associate Professor (ABE)
agnies@kth.se

Davide Rolando
Co-Director,
Researcher (ITM)
drolando@kth.se

Summary of the year 2024

2024 has been an important year for the KTH Live-In Lab, reinforcing its founding pillars of research, education, and impact. Two major projects, together with new EU and collaborative initiatives, have been launched, and the lab has actively participated in several events and collaborations.

2024
Projects
Collaborations
& Courses

New projects

Two larger research projects have been launched, opening new research areas. The first project, PLEXE (Platform for Lighting Effects Experimentation Environments Background), deals with light quality in conjunction with occupant well-being; the second one, DOCENT (Development of Occupant-centric Control for ENergy efficienT buildings), focuses on the impact of behavior in the energy performance in buildings.

The project PLEXE aims to identify, design, implement, and validate light infrastructural components that need to be added to the living spaces at the Live-In Lab at KTH to support future lighting related studies, such as sensing and adjusting lighting qualities in the spaces. The project DOCENT focuses on the design and implementation of occupant-centric controls. With the adoption of digital tools in buildings, occupants are more and more active agents in the optimal operation of buildings to achieve better indoor climate and improved energy efficiency. This project develops occupant-centric control systems through an innovative hybrid research approach, using data-driven tools and digital twins, leveraging the state-of-the-art KTH Live-In Lab smart building testbeds.

The EU projects HYSTORE and PARMENIDES are being implemented as a good pace, with the planned installation of innovative building components developed in synergy with the Granryd lab at the Department of Energy Technology. In parallel, the Live-In Lab is used as proxy for innovative ideas and applications, with a growing number of research applications sent to the Board – the first step towards new projects running in the Live-In Lab. In 2024, active collaborations with other centers (among many, the Dig-It Lab and the Climate Action Center) and other laboratories (Granryd Lab, Architectural Lighting Design laboratory) have been initiated, to strengthen cross-disciplinary research and the TRL of projects carried out in the Live-In Lab.

Courses

The Live-In Lab projects have been used as a primer for master theses and courses, and has been frequently used by courses for data and site visits. The success of the course AI applications in Sustainable Energy Engineering (MJ2507), which uses one of the KTH Live-In Lab testbeds in a project module, has led to a new course (MJ2528).

International events and collaborations

During the year, the Live- In Lab hosted a number of international events (European Control Conference invited session, ECC2024, the Digital Futures HiSS international Workshop, and R&D Management 2024 conference) and visits of international delegations. The latest delegations visits in 2024 have been New York City delegation, co-organized with IVL and the US Embassy in Stockholm, George Washington University, CESAER network co-organized with the RSO, R&D Management 2024 conference. The dissemination was made through major events like, for instance, Effektarena 2024 organized by IQS and Energimyndigheten and boroadcast live in Sweden. The KTH LIL has been used extensively by different KTH representatives for institutional visits. When the Swedish Minister of Education, Johan Persson, visited KTH on 30 October, the KTH Live-In Lab was one of the presenters showcasing KTH's energy research and education and the current challenges in relation to digitalization and smart buildings.

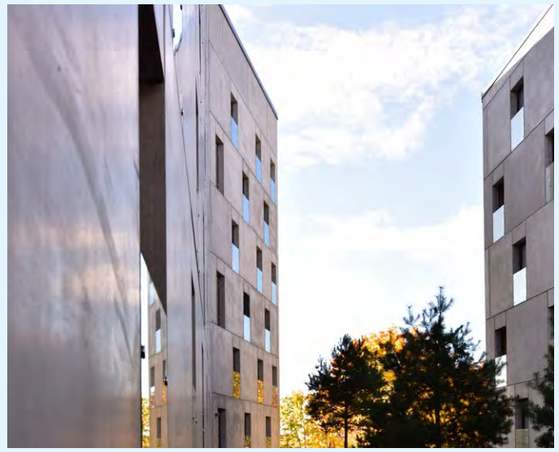
KTH LIL has initiated a collaboration with the University of Padua that led to the UniZEB, a small scale living lab for building. A decisive factor to facilitate the process was the documented workflow of the KTH Live-In Lab, recently published in a journal article. Two new such similar ongoing initiatives have been initiated with the Tokyo City University and the University of Krakow (Campus Living Lab).

New! Flagship paper on the KTH Live-In Lab and new podcast

Would you like to know more about the Live-In Lab or develop a living lab in your institution? Read our new paper deploying the Living Lab Triangle Framework and describing how we built KTH Live-In Lab, its management and governance model, infrastructure, sensors, data and business model.

The new paper *Using living labs to tackle innovation bottlenecks: the KTH Live-In Lab case study* presents results from our research platform and a SWOT analysis of the Live-In Lab platform and ecosystem. It also serves as the basis for a podcast to explore further possibilities for dissemination in interview format.

Abstract: The adoption of innovation in the building sector is currently too slow for the ambitious sustainability goals that our societies have agreed upon. Living labs are open innovation ecosystems in real-life environments using iterative feedback processes throughout a lifecycle approach of an innovation to create sustainable impact. In the context of the built environment, such co-creative innovation and demonstration platforms are needed to facilitate the adoption of innovative technologies and concepts for more energy-efficient and sustainable buildings. However, their feasibility is not extensively proven. This paper illustrates the implementation and demonstrates the feasibility of the Living Labs Triangle Framework for buildings living labs. This conceptual framework has been used to conceive the KTH Live-In Lab, a living lab for buildings. The goal of the Live-In Lab was to create a co-creative open platform for research and education bridging the gap between industry and academia, featuring smart building demonstrators. The Living Lab Triangle Framework has been deployed to meet the goals of the Live-in Lab, and the resulting concept is described. This paper then analyses the methodological and operational results introducing performance metrics to measure the economic sustainability, the promotion of multidisciplinary research and development projects, dissemination and impact. The results are completed with a SWOT analysis identifying its current strengths and weaknesses. The results collected in this work fill a missing gap in the scientific literature on the performance of living labs and provide empirical evidence on the sustainability and impact of living labs.



About the paper

The paper *Using living labs to tackle innovation bottlenecks: the KTH Live-In Lab case study* is written by Marco Molinari, Davide Rolando, Per Lundqvist and Jonas Anund Vogel, and published in Applied Energy: https://doi.org/10.1016/j.apenergy.2023.120877

To read the full version scan the QR-code:

Enabling research
for future smart buildings

Jade Mallauran, MSc student at KTH, harvesting black water in the KTH Live-In Lab.

Research at KTH Live-In Lab

In 2024, a total of 20 projects were ongoing within the KTH Live-In Lab. These projects are the result of collaboration between industry and academia. The projects that were successfully completed during 2024 fostered innovation with their transparent, validated and significant results.

Most of the projects initiated by KTH Live-In Lab are challenge-driven and explore opportunities related to new theories, products, and services. Some projects are idea-driven rather than challenge-driven. In challenge-driven projects, KTH Live-In Lab actively works with bringing forward new innovative theories, products, and services, and to enable collaboration within academia and between academia and industry. In idea-driven projects, KTH Live-In Lab actively works to manage the projects to ensure they are aligned with the challenges KTH Live-In Lab exists to overcome.

KTH Live-in Lab's operation is focused on acting as a platform for collaboration through enabling multidisciplinary research and running testbeds and a database.

How to start a project

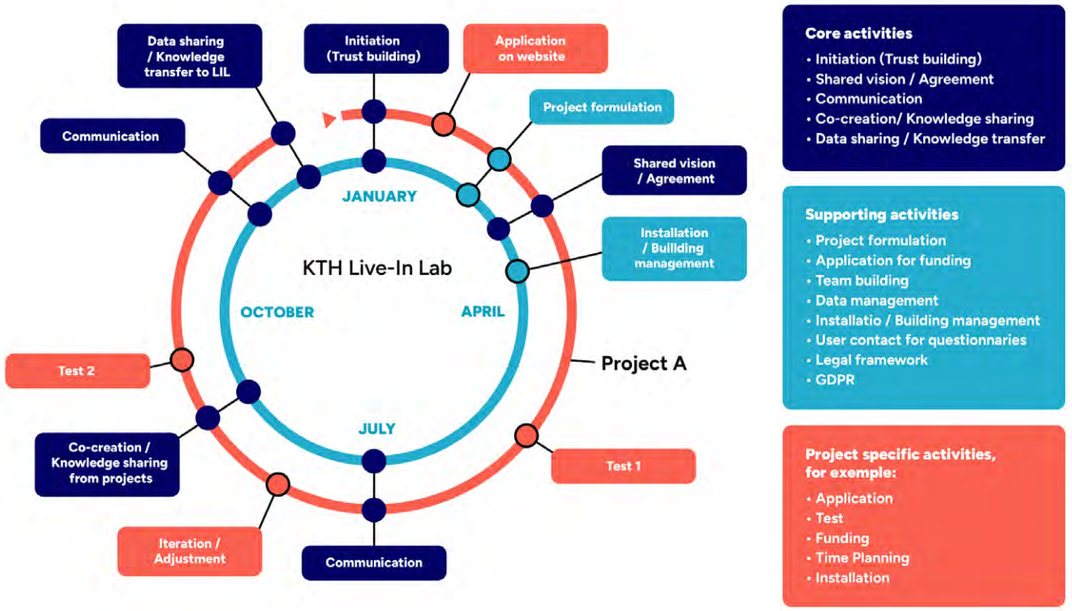
KTH Live-in Lab offers infrastructure and data to researchers and companies. If you are interested in project collaboration, you find the application form at KTH Live-In Lab's website.

Application Process

All applications must include information about the project, such as a project description and the goals and purpose of the project. Applications are reviewed by the executive group and approved by the board of KTH Live-In Lab. If a project application is approved, the applicant will receive a letter of intent (LOI) confirming that the project can be performed in KTH Live-In Lab during a specific time, and that the project will independently pay for its costs. The project must also financially contribute to KTH Live-In Lab's operating costs. This normally amounts to between 50 000 – 300 000 SEK per year.

KTH Live-In Lab's support

The individual projects apply for funding and once the projects are finished their results are saved and stored. This enables other projects to pick up where previous ones left off. KTH Live-In Lab will assist with all necessary installation, support collaboration between ongoing projects, handle communication and data storage. KTH Live-In Lab can also assist in applications for funding, ethical reviews and more.ethical reviews and more.



The KTH Live-In Lab project process.

Projects 2024

Until 2024 KTH Live-In Lab has received 126 applications for use of the Testbed. Moreover, 60 of these projects have been initiated, 40 projects have been completed, and 20 are still ongoing.

The initiated projects at KTH Live-In Lab during 2024 have an estimated total value of 206 million SEK, divided into 26 million SEK of co-funding and 180 million in applied funding. Additionally, the center has received a total of 22 million SEK through various donations as well as materials and technology to a total value of 5 million SEK.

The applicants include research groups from across KTH's Schools – Architecture and the Built Environment (ABE), Electrical Engineering and Computer Science (EECS), Industrial Engineering and Management (ITM), and Chemistry (CHE) – as well as SMEs and larger corporations, including KTH Live-In Lab's strategic partners Akademiska Hus, Einar Mattsson, Bengt Dahlgren, and Schneider Electric, along with other innovative companies such as HSB Living Lab.

Other collaborative partners include Karolinska Institutet, Karolinska University Hospital, Stockholm University, Umeå University, Chalmers, Lund university, AMS Institute, MIT, University Technology Sydney, Max Planck Institute, and Florida University.

Read more about the projects:
www.liveinlab.kth.se/projekt

Summary of projects in KTH Live-In Lab

Projects	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Applications	3	17	13	10	8	18	10	17	10	15	106
Started	2	1	2	9	13	7	5	9	5	6	53
Finished	0	0	3	3	5	4	8	5	5	6	33
Ongoing 2024										20	

To read more about the projects at the KTH Live-In Lab, please visit the KTH Live-In Lab website: https://www.liveinlab.kth.se/projekt

Projects running in KTH Live-In Lab in 2024

Projects		Project Manager	Companies / Organizations	Status
	PLEXE – Platform for Lighting Effects Experimentation Environments Background	Ute Besedeker, Federico Favero	KTH ABE, KTH ITM	Ongoing
	DOCENT – Development of Occupant-centric Control for ENergy efficienT buildings	Marco Molinari, Angela Fontan	KTH ITM, KTH EECS,	Ongoing
2309	Dig-IT Lab	Jonas A. Vogel	RISE, Umeå universitet, Uppsala universitet,Akademiska Hus, Bengt Dahlgren, Castellum, Einar Mattsson, EQUA, Myrspoven, Noss Invest, ProptechCore, Sally-R, Schneider Electric, SISAB, Swegon, Vasakronan	Ongoing
	PARMENIDES – Plug & plAy EneRgy ManagEmeNt for hybriD Energy Storage	Hatef Madani	KTH CHE	Ongoing
2304	Unlock the source of blackwater: from seperated wastewater to value added products (NEEDED)	Zeynep Ceteciogl Gurol	KTH CHE	Ongoing
2302	PV-related disturbance and safety issues: analysis of risks and mitigation measures	Makarand Kane		Completed
2215	Datasets for research	Marco Molinari	KTH LIL	Completed
2212	Optimal flow rate for maximizing ground source heat pump performance	Alberto Lazzarotto	KTH ITM, Thermia, ToM Energy Consulting Company, Unige, Sindeq borrteknik AB, Rototec, Asplan Viak, Dandelion, Bengt Dahlgren AB, NIBE, HP, Nowab, Wilo	Ongoing
2211	Boosting energy saving competences	Yavor Paunov	KTH, KTH LIL SSSB, EM	Ongoing
2206	Heat by Data cost-effective AI-driven integration of mobile network to the built environment”	Hatef Madani	KTH, Ericsson, NOWAB, ETM Kylteknik	Ongoing

Projects		Project Manager	Companies / Organizations	Status
2210	Datasets for education	Jonas A. Vogel	KTH LIL, Digitalisation platform,;	Ongoing
2209	H + Forest	Linda Teng, Agnieszka Zalejska Jonsson	Lunds Tekniska Högskola, KTH, Akademiska Hus, Boiler, Arken, Sustain Lab, Volvo cars	Ongoing
2208	Digital twins	Marco Molinari	KTH LIL	Ongoing
2207	Advanced and cost-effective indoor monitoring of school environments	Davide Rolando	KTH LIL	Ongoing
2206	Heat by Data cost-effective AI-driven integration of mobile network to the built environment”	Hatef Madani	KTH ITM, Ericsson, NOWAB, ETM Kylteknik	Ongoing
2205	Development of semantic data infrastructure for smart building monitoring system: preliminary study	Jonas A. Vogel	KTH LIL, SISAB, Schneider Electric	Ongoing
2203	Improved energy efficiency for waste recycling	Jörgen Wallin	KTH ITM	Ongoing
2202	Thermal Energy Storage Solutions	Saman Nimali Gunasekara; Qian Wang	KTH- ITM, KTH ABE	Ongoing
2108	Buildings Post Corona	Jonas A. Vogel	KTH LIL, Umeå University, Chalmers, Lund University	Ongoing
2107	Optimal drift – smart built	Jonas A. Vogel, Cyril Holm	KTH LIL	Ongoing
2104	Cyber-secure learning control systems	Marco Molinari	KTH EECS, KTH ABE, KTH ITM, KTH LIL, SSF	Completed
2103	Humanizing the Sustainable Smart City eXtended(HiSSx)	Marco Molinari	KTH ABE, EECS , ITM, KTH LIL, Digital Futures	Completed
2016	Humanizing the Sustainable Smart City (HiSS)	Marco Molinari	KTH LIL	Completed
2012	Sonic interaction design to support energy efficiency behavior in the household	Sandra Pauletto	KTH EECS Media Technology and Interaction Design	Ongoing
2003	PV+BESS in KTH Living Lab	Farzin Golzar	KTH	Ongoing

Projects and project outcomes

In 2024, the projects conducted at KTH Live-In Lab resulted in several scientific articles, including conference papers, a doctoral thesis, a journal publication, and three final reports and master theses. The scientific papers and reports cover a wide range of research areas.

KTH Live-In Lab's main areas of research.

Highlights on scientific publications in 2024

Assessing coaxial collector performances: Field data and analysis

Vautrin, Adrien, Pallard, Willem Mazzotti, Acuña, José, Lazzarotto, Alberto, 2024 Research Conference Proceedings of the IGSHPA, 10.22488/okstate.24.000040

Abstract: Since the development of Ground Source Heat Pumps (GSHPs), there have been mostly three types of borehole heat exchangers in use, single and double U-pipes as well as coaxial, the latter being seldom installed. Most earlier work has thereby been focusing on the classic U-tube solutions. This work aims at providing more information on coaxial heat exchangers. Field data from 11 installations having coaxial borehole heat exchangers has been gathered in this work and measured effective borehole resistance as well as pressure drop have been presented and compared to calculated values. The Hellström approach as well as correlations for pressure drop have been implemented. Significant deviation from theory has been observed regarding the pressure drop (75% average absolute relative error) as well as the effective borehole resistance, albeit to a lesser extent (33%). An exploration of the geometrical parameter space (length, brine concentration, fluid temperature and inner diameter) has been carried out, giving insights into potentially better coaxial designs

Life Cycle Assessment of Digitalization in Buildings: The Case of a Building Monitoring System

Shoaib Azizi; Anna Furberg; Marco Molinari; Goran Finnveden 2024 10th International Conference on ICT for Sustainability (ICT4S), 24-28 June 2024, 10.1109/ICT4S64576.2024.00028

Abstract: Digital solutions based on information and communication technologies (ICT) provide many opportunities in buildings to achieve resource and energy efficiency. In general, these solutions enable either monitoring or advanced control of buildings. The ICT solutions' overall impacts on the environment are often presumed positive without a holistic approach based on life cycle thinking. The research on energy and indoor monitoring systems usually focuses on system performance and potential benefits rather than the entire system and it thus misses the life cycle impacts of the system itself. To address this limitation, the aims of this study are to assess life cycle environmental and resource impacts of a building monitoring system (BMS) and to identify hotspots in this system. The case study of KTH Living Lab represents an extensive BMS. It was applied and assessed using Life Cycle Assessment (LCA) methodology. The results show that wires, sensors and data acquisition equipment constitute hotspots for all the environmental and resource impacts assessed in this study. Thus, the impacts of these devices are important to consider by, e.g, building managers.

Robust Data-Driven Tube-Based Zonotopic Predictive Control with Closed-Loop Guarantees

Mahsa Farjadnia; Angela Fontan; Amr Alanwar; Marco Molinari; Karl Henrik Johansson, 2024 IEEE 63rd Conference on Decision and Control (CDC)

Abstract: This work proposes a robust data-driven tube-based zonotopic predictive control (TZPC) approach for discrete-time linear systems, designed to ensure stability and recursive feasibility in the presence of bounded noise. The proposed approach consists of two phases. In an initial learning phase, we provide an over-approximation of all models consistent with past input and noisy state data using zonotope properties. Subsequently, in a control phase, we formulate an optimization problem, which by integrating terminal ingredients is proven to be recursively feasible. Moreover, we prove that implementing this data-driven predictive control approach guarantees robust exponential stability of the closed-loop system. The effectiveness and competitive performance of the proposed control strategy, compared to recent data-driven predictive control methods, are illustrated through numerical simulations.

Showcasing a digital twin for higher educational buildings: developing the concept toward human centricity

Katarina Bäcklund, Per Lundqvist and Marco Molinari, Frontiers in Built Environment Volume 10 - 2024 | https://doi.org/10.3389/fbuil.2024.1347451

Abstract: Digital twin technology is an emerging technology within the built environment. Yet, there are many unexplored opportunities to utilize digital twins for facilitating the transformation toward a climate-neutral building stock while also meeting the expectations from the building occupants. This article presents a case study of a digital twin, developed for an existing commercial building stock of campus areas in Sweden. The overarching purpose of the digital twin is to support both building occupants and building operators. This two-fold human-centric approach represents a novel approach for building digital twins. The digital twin is based on 3D scanning, and together with geospatial data, a real-like navigational indoor environment is created. Three innovative features are presented: the building analysis module, the digital twin mobile application, and the building operations module. The results show that the digital twin improves the building occupant's experience by supporting navigation and providing access to the room booking system via this dedicated interface. Building management is also benefited by the digital twin through easier access to building data aggregated into one platform and a state-of-the-art analysis tool for optimizing the use of indoor space. The digital twin holds future potential to achieve operational excellence by incorporating feedback mechanisms and utilizing artificial intelligence to enable intelligent fault detection and prevention.

Theses and reports

MJ2146 Energy Systems, Business, and Management

A new model to compare and value innovation capacity for Living Labs; Linus Rodin, Agnes Ritzer, Alma Hammarberg, David Sigge, Elin Hartman

Theses resulting from international collaboration

Combining IDA ICE and MATLAB: co-simulation environment for advanced control strategies in buildings *

Rainò, Francesco

* This thesis was carried out within an Erasmus+ exchange program hosting a student from the University of Padua

Abstract The energy building sector is at the forefront of modern efforts to improve energy efficiency and user comfort. As buildings become more complex and dynamic, the need for advanced control strategies and precise simulation tools becomes increasingly important. This work addresses the critical challenge of developing a dedicated co-simulation environment for integrating advanced controllers. By combining IDA ICE as building energy simulation software and MATLAB for controller design, the research aims to establish a seamless integration between the designated controller and a detailed building model. The main goal is to create a dynamic co-simulation environment that improves the energy efficiency of buildings. The core methodology includes the creation of a co-simulation framework for a building energy modeling case study. In an initial study of a single room, MATLAB sets the indoor temperature as the reference input, which is transmitted to a Proportional-Integral (PI) controller in IDA ICE. The PI controller adjusts heating or cooling, effectively tracking the desired temperature and regulating the ambient conditions of the room. The MATLAB code configures the environment, sets up communication channels and initiates data exchange. The IDA ICE model is configured for dynamic control and allows for continuous information exchange between the two platforms. The aim of this research is to improve the advanced controls and establish them as reliable tools for reference tracking in the field of building energy optimization and control strategies.

RESEARCH PROJECT

New project: PLEXE – Platform for Lighting Effects Experimentation Environments

PLEXE is an interdisciplinary project studying how natural and artificial light affects human physiology, behavior, and perception in real residential contexts. Using KTH's Live-In Lab, it integrates tunable lighting, daylight treatments, and sensors to capture environmental and occupant data, creating a flexible, data-driven platform for research on well-being, comfort, and energy use.

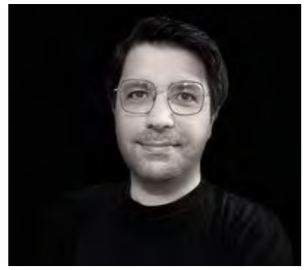
Federico Favero
Head of Division, Ph.D.
Division of Lighting Design, KTH

Ute Besenecker, Ph.D.
Associate Professor
Division of Lighting Design, KTH

Davide Rolando
Researcher, Ph.D. Department of Energy Technology, KTH

Gerhard Rehm
M.A.Lecturer and Lighting designer
Division of Lighting Design, KTH

Ken Appleman
Ph.D. (External Consultant), USA



Hamidreza Eizadi
M.A. Sustainable Architecture,
M.S. Architectural Lighting Design,
Division of Lighting Design, KTH
Lab Responsible, Research Engineer

PLEXE (Platform for Lighting Effects Experimentation Environments) is an interdisciplinary research and development project exploring how light—both natural and artificial—affects human physiology, behavior, and perception in real-world residential contexts. While numerous studies have investigated lighting effects in controlled laboratory settings, PLEXE aims to bridge the gap between theory and everyday life.

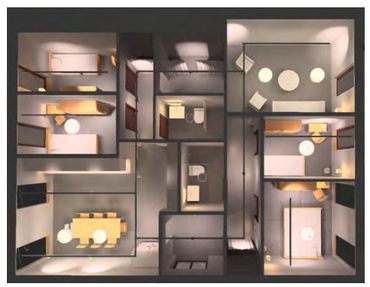
By establishing a flexible experimentation platform within KTH's Live-In Lab Testbed, the project creates opportunities to study how lighting influences human well-being, comfort, and energy use in actual living environments. The PLEXE platform integrates advanced dimmable and spectrally tunable lighting systems, daylight treatments, and a network of sensors and data logging tools to capture both environmental and occupant-related parameters.

The system's design emphasizes adaptability, enabling a wide range of experimental configurations to support ongoing research. Ultimately, PLEXE will function as a permanent, data-driven test environment for interdisciplinary research across architecture, lighting design, human factors, and smart building technologies.

Long-term, real-world studies on light exposure patterns

Light is fundamental to human health and well-being—it regulates our biological rhythms, influences mood and productivity, and shapes our perception of space. However, despite strong evidence from laboratory studies, there remains a lack of knowledge about how light exposure affects people in real-life residential settings, where variables such as routines, seasons, and individual habits come into play.

PLEXE directly addresses this gap. By enabling long-term, real-world studies on light exposure patterns, the project supports the design of healthier, more sustainable living environments. Its outcomes will:



The project wil install and test lighting, sensor, and logging systems across residential units.

- Improve understanding of how light impacts sleep quality, mood, and daily activity.
- Support adaptive lighting systems that adjust to user needs and circadian rhythms.
- Enable energy-efficient lighting strategies without compromising comfort or well-being.
- Contribute to sustainable building design and inform future housing standards.

Beyond its scientific value, PLEXE's societal relevance is clear: it advances the development of human-centered smart buildings—spaces that not only conserve energy but also actively promote occupant health.

KTH Live-In Lab collaboration

The KTH Live-In Lab is an essential partner in the PLEXE project, providing both the physical environment and research infrastructure required for implementation. The testbeds consist of real, occupied apartments where innovative technologies can be installed, tested, and refined in collaboration with residents. Within this partnership, PLEXE will:

- Install and test lighting, sensor, and logging systems across residential units.
- Collect data from various sensors (spectral, activity, environmental) to analyze how lighting affects behavior and physiology.
- Develop protocols for data handling, privacy, and system integration, ensuring secure and ethical research practices.

Project structure

The PLEXE project follows a four-phase implementation plan:

Phase 1 – Infrastructure Identification: A comprehensive survey of the existing lighting and sensing infrastructure in the Testbed KTH was conducted, identifying technological gaps and defining system requirements for the platform.

Phase 2 – Environment Design: The team is currently designing lighting layouts, specifying sensor placements, and developing secure, privacy-conscious data collection systems.

Phase 3 – Installation and Commissioning: The next major milestone involves the installation of the lighting systems, sensors, and control infrastructure—planned for the upcoming winter holiday period to minimize disruption for residents.

Phase 4 – Validation: Following installation, pilot studies will be conducted to evaluate system performance and collect initial datasets. The validation phase will analyze lighting quality, occupant activity, and physiological indicators to verify the platform's effectiveness for ongoing research.

Long-term vision of PLEXE

Once validated, PLEXE will remain as a permanent, open platform within the KTH Live-In Lab, supporting interdisciplinary studies on human-centric lighting and smart building solutions. By combining lighting technology, environmental sensing, and human behavioral science, it will continue to inform how future homes and cities can be designed to promote both sustainability and human well-being.

In summary, PLEXE represents a critical step toward understanding and designing light not just as an aesthetic or technical component of buildings, but as an essential element of human health and environmental responsibility. Through collaboration between researchers, engineers, and occupants, it paves the way for a new generation of living environments that are truly adaptive, intelligent, and human-centered.

Project webpage:
https://www.liveinlab.kth.se/en/projekt/r-d-projects/plexe-platform-for-lighting-effects-experimentation-environments-background-1.1356677

RESEARCH PROJECT

New project: DOCENT – Development of Occupant-centric Control for ENergy efficienT buildings

The building sector is a major contributor to energy use and CO_2 emissions. Understanding building dynamics shows occupants are key to energy efficiency. This project advances occupant-centric building automation by modeling human behavior, developing occupant-focused control schemes, and testing them in real-time environments to assess impacts on residential and commercial building energy use.

The building sector is a major contributor to the overall energy demand and CO2 emissions, and are central to energy and sustainability policies. The understanding of building dynamics enabled by smart buildings has led to the acknowledgment that occupants are an increasingly critical factor for low-energy buildings and that proper occupant control can lead to increased energy efficiency. Building occupants can no longer be seen as recipients of indoor environmental conditions, but instead they should be included as decision-makers in the building operation. In parallel, occupancy patterns need be taken into account for optimal building operation.

The main research objective is to advance the understanding of occupants' behavior toward occupant-centric building automation, by comprehensively assessing its impact on residential and commercial buildings. Key aspects to achieve the research objective are the characterization models of human behavior in smart buildings, the development of occupant-centric control schemes and the implementation of developed techniques on real-time testbeds and estimation of the savings in energy use enabled by occupant-centric controls.

Understanding behavioral patterns and their impact

The building sector is facing a digital revolution that is bringing new opportunities towards smart and sustainable buildings. Digitalization enables a better understanding of occupancy and behavioral patterns and their impact on energy use, but many challenges are still unsolved.

This project will address them and develop occupant-centric control systems through an innovative hybrid research approach, using data-driven tools and digital twins. Environmental, societal, and economic benefits will be demonstrated on both standard and state-of-the-art smart building testbeds.

KTH Live-In Lab collaboration

The project focuses on the KTH Live-In Lab building testbeds, exploiting the high- resolution, real-time data gathered through the advanced sensor and data infrastructure. This state-of-the-art building infrastructure has proved to overcome many past limitations to building innovation, with research projects motivated by current societal-scale challenges.

The KTH Live-In Lab features two residential building testbeds (Testbed KTH and Testbed EM) and an office building (Testbed AH), equipped with high-resolution monitoring and control systems; this data will be used to map actual behavioral dynamics in buildings preserving privacy. Sensor measurements will be used to identify common faulty settings in buildings' ventilation and heating systems, estimating their impact on the energy use and how these trigger actions from the users. Particular attention will be dedicated to the user experience, the impact of the users' energy use, and visualization techniques to promote energy-efficient behaviours. In addition, close interaction with the building occupants will be invaluable to validate the models.

Goals and future steps

The goal of the project is to improve the energy efficiency of buildings and the well-being of the building occupants by addressing critical features of building smartness. The goal will be achieved through three main objectives.

Angela Fontan is Assistant Professor at the Division of Decision and Control Systems, KTH, working in the area of cyber-physical-human systems, with applications to Live-in Laboratories collaborating closely with the KTH Live-in Lab.

Mahsa Farjadnia is a Ph.D. student conducting her doctoral thesis in collaboration with the Energy Technology Department and the Division of Decision and Control Systems at KTH. Her research area includes data-driven control, with the application in the KTH Live-In-Lab, and modeling occupants' behavior within smart building environments.

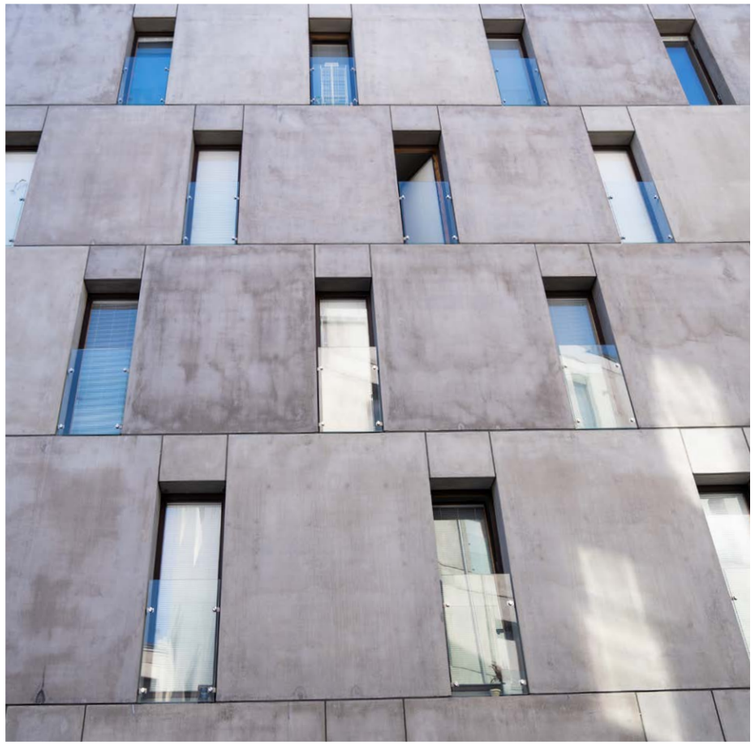
Marco Molinari is Researcher at the KTH Energy Department and director of the KTH Live-In Lab. His research interests focus on smart buildings and on the integration of Information and Communication Technologies in the built environment, including energy monitoring and deployment of advanced control approaches.

First, the project will advance the knowledge of the complex interaction between building systems and building occupants with improved, scalable, and generalizable behavioral models derived from empirical data.

Second, the behavioral models will be integrated into innovative adaptive control approaches tailored to the needs of the occupants, minimizing the risk of energy-inefficient behaviors and interference with the optimized operation and control; in parallel, occupancy-based controls will be designed and tested.

Third, incentives in the form, e.g., of tailored and contextualized information, will be developed to increase the energy-awareness of building users.

Project webpage: www.liveinlab.kth.se/en/projekt/r-d-projects/docent-development-of-occupant-centric-control-for-energy-efficient-buildings-1.1356004



RESEARCH PROJECT

”Värme genom Data” project – Invention of A Miniaturized Heat Pump Recovering Waste Heat from 5G Base Stations Demonstrated in KTH Live-In Lab

As 5G networks expand, base stations consume more energy and release low-temperature waste heat. This project, funded by the Swedish Energy Agency, recovers this heat for building hot water systems using a miniaturized “heat pump door.” The system cools electronics while producing hot water at 55°C with a low-GWP refrigerant.

The global expansion of 5G networks corresponds with a significant increase in the energy consumption of telecommunication infrastructure. Telecommunication base stations (TBS) dissipate a substantial amount of energy as low-temperature waste heat, representing an unexploited energy resource. This is particularly relevant in Sweden, where 5G base stations are widespread in urban areas where many residential buildings with domestic hot water (DHW) circulation systems can act as adjacent heat sinks.

A research project funded by the Swedish Energy Agency via the E2B2 programme is investigating a solution for recovering this low-grade waste heat for direct integration into building DHW systems at KTH Energy Technology Department and Live-in Lab. The project is led by Professor Hatef Madani and performed by postdoctoral researcher Tianhao Xu.

The project’s core innovation is a novel, miniaturized “heat pump door”, which is a compact unit engineered to replace the standard air-to-air heat exchanger door of an outdoor TBS cabinet. This design facilitates direct integration without requiring modification of the cabinet’s internal component layout and exterior appearance. The prototype utilizes a natural, low-Global Warming Potential (GWP) refrigerant, R600a (isobutane) with a small charge, and transforms the cabinet’s thermal management system from a cooling-only device to a combined heating and cooling unit. It simultaneously provides the necessary cooling for the electronic components while producing hot water at 55°C at least with the air-to-water heat pump.

Project goals

The goal of the project is to improve the energy efficiency of buildings and the well-being of the building occupants by addressing critical features of building smartness. The goal will be achieved through three main objectives. First, the project will advance the knowledge of the complex interaction between building systems and building occupants with improved, scalable, and generalizable behavioral models derived from empirical data. Second, the behavioral models will be integrated into innovative adaptive control approaches tailored to the needs of the occupants, minimizing the risk of energy-inefficient behaviors and interference with the optimized operation and control; in parallel, occupancy-based controls will be designed and tested. Third, incentives in the form, e.g., of tailored and contextualized information, will be developed to increase the energy-awareness of building users.

Results

The project has yielded principal results from three aspects: 1) successful prototype performance validation, 2) improved airflow management within cabinet for better heating and cooling efficiency, and 3) proved economic viability for the integration and renovation.

During laboratory testing, the heat pump prototype was proved to produce domestic hot water at least 55°C, achieving a high total heating Coefficient of Performance (COP) of 3.1 and a waste heat recovery ratio of up to 85%. Through a combination of Computational Fluid Dynamics (CFD) modeling and experimental investigation, the project established that internal airflow management through blanking and guiding panels could significantly reduce the undesirable mixing of hot and cold air streams within the cabinet. A comprehensive techno-economic analysis, based on current energy market conditions in Sweden, has proven the economic feasibility of the proposed renovation.

The study concluded that the heat recovery system represents a justifiable capital investment of 66 thousand SEK over a seven-year operational lifetime by replacing demands for district heating, while the heat pump prototype’s initial capital investment can be maintained below 20 thousand SEK.

This research has successfully demonstrated the design, fabrication, and performance validation of a novel heat pump system that is both technically effective and economically viable for waste heat recovery from 5G base stations. This technology provides a scalable solution for improving energy efficiency and reducing carbon emissions in the ICT and residential heating sectors, aligning with national decarbonization objectives.

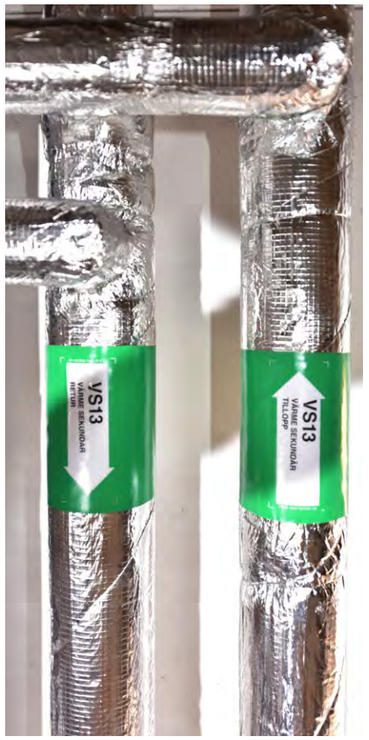
Project webpages

Recovery of waste heat from base stations in the mobile network | KTH

www.e2b2.se/forskning-sprojekt-i-e2b2/energit-illforsel-och-distribution/atervinning-av-varme-fran-basstationer-i-mobilnatet/

Project postdoc
Tianhao Xu is a postdoctoral researcher at the KTH Department of Energy Technology and he is responsible for the project. His research areas focus on technological development of heat pump and thermal energy storage systems aimed at heating decarbonization. He received his PhD at KTH in 2021, and he has worked as a postdoctoral researcher at Tsinghua University and KTH, participated in a number of research projects funded by international research programmes (e.g., EU H2020, EU FP7) and national key research programmes in Sweden and China.

Project leader
Hatef Madani is full Professor and Head of Division of Applied Thermodynamics, Department of Energy Technology at KTH Royal Institute of Technology, Sweden. Beside research management and teaching in Academia, Hatef is working closely with research institutes and industries in Europe, and he is currently Senior Scientist at Austrian Institute of Technology. Hatef is also a member of the steering committee at Renewable Heating and Cooling European Technology and Innovation Platform (RHC ETIP) as well as the strategic council of School of Industrial Engineering and Management



Building education for the future

Education at KTH Live-In Lab

KTH Live-In Lab provides essential input to courses and theses internationally. The growing interest in the work of the laboratory is reflected in the increasing number of site visits by students and researchers from all over the world.

The interest in using KTH Live-In Lab in courses and theses is big and growing. The involvement in courses includes site visits, workshops, presentations and lectures. The aim is to develop course packages that can be included in already existing courses at KTH, focusing on cross-disciplinary co-creation.

KTH Live-In Lab provides a natural point of contact between students and the industry. KTH Live-In Lab can therefore be used as a case or project assignment in course curricula at KTH. This gives students from different study programs the opportunity to contribute to the evaluation and validation of tests currently in progress in the Testbeds. Students are also given the opportunity to collaborate with the team designing the constellation of the innovation-area in the Testbeds for the coming year.

Course highlights

KTH Live-In Lab serves as a dynamic platform for education and experiential learning, supporting courses, projects, and student engagement. By providing access to real-world data, testbeds, and collaborative environments, it enables practical learning, fosters innovation, and promotes the application of emerging technologies in energy and building systems.

In 2023, a new course focusing on the application of AI to the energy and building sector was initiated using the KTH Live-In Lab as a case study. The course, MJ2507 AI Applications in Sustainable Energy Engineering, led by Assist. Prof. Farzin Golzar, aimed to teach students key AI concepts and their applications in sustainable energy engineering. It also covered implications for energy businesses and ethical aspects of AI. Students learned to manage data for machine learning, and in the project part, eight groups applied machine learning algorithms to Testbed AH data to forecast energy demand. The course was extremely successful and a new parallel course, MJ2528 AI applications in Sustainable Energy Engineering, was launched in 2024.

Cases and case studies

KTH Live-In Lab recognizes the importance of an experimental learning environment. A small incentive package supports courses using the Lab as a case study, including introductory lectures and contributions to exhibitions or catalogues. The KTH Live-in Lab also promotes knowledge dissemination and information exchange through multiple channels.

Lifelong Learning

KTH Live-In Lab is exploring ways to further develop Lifelong Learning. Collaboration with Fastighetsbranschens Utbildningsnämnd highlights the strong need for technical competence to manage a smart, sustainable future—needs not fully met by higher or vocational education. Harnessing digitalization also requires collaborative approaches to education.

Courses visiting or using KTH Live-In Lab 2024

- MJ2507 AI applications in Sustainable Energy Engineering, Farzin Golzar, KTH ITM
- MJ2528 AI applications in Sustainable Energy Engineering, Farzin Golzar, KTH ITM
- MJ1141 Energy Systems and Sustainability, Per Lundqvist, KTH ITM
- MJ1150 Energy and Systems, Innovation and Entrepreneurship, Hatef Madani, KTH ITM
- MJ2146 Energy Systems, Business and Management, Per Lundqvist, KTH ITM
- MJ2423 Applied Refrigeration and Heat Pump Technology, Samer Sawalha, KTH ITM
- MJ2443 Heating, Cooling and Indoor Climate, Samer Sawalha, KTH ITM
- MJ2460 Green Building – Concept, Design, Construction and Operation, Jaime Arias, KTH ITM
- MJ148X Degree Project in Energy Systems, Sustainability and Industrial Engineering, first cycle, Per Lundqvist, KTH ITM
- AI1145 Property Management with a Financial Perspective, Agnieszka Zalejska Jonsson, KTH ABE
- AI1146 Property Management, Agnieszka Zalejska-Jonsson, KTH ABE
- AF2511 Building Service Technologies and Systems, Sasan Sadrizadeh KTH ABE
- AG2805 Sustainable Planning and Design, Pernilla Hagbert KTH ABE
- AF2507 Sustainable Buildings - Concept, Design, Construction and Operation, Ivo Martinac, KTH ABE
- AL1523 Digitalisation and Innovation for Sustainable Development, Anna Björklund, Mattias Höjer, ABE
- CYL-P Cyber Law, Cyril Holm & Stanley Greenstein, Stockholm University, Juridicum
- Ethics and Compliance Seminar, Case: Ethical challenges in research collaboration, Jonas Anund Vogel, Live-In Lab and Barbro Fröding.
- Course managed by KTH RSO

Institutes and organizations visiting or using KTH Live-In Lab 2024

- GECKO EU Marie Skłodowska-Curie Training Network
- New York IVL Smart City Sweden
- Amsterdam Institute for Advanced Metropolitan Solutions (AMS)
- Delft University of Technology
- Engineering school ECAM LaSalle
- Lund University
- Swedish Real Estate Association's Education Committee
- UNITE! University Network for Innovation, Technology and Engineering
- Uppsala University
- New York City delegation, co-organized with IVL and the US Embassy in Stockholm,
- George Washington University,
- CESAER network co-organized with the RSO
- R&D Management 2024 conference
- ECC2024 conference- invited session.

Creating value for teaching and theses: Datasets for education

In a continuous effort to simplify the access to data in buildings for research and education, the project Datasets for Education involved researchers and teaching staff at KTH to identify needs and opportunities liked to data availability in buildings. Using a co-creative approach, the project established a framework to create useful datasets. This enables easy and efficient access to data for use in education, lifelong learning, and further education courses. By doing so, students can enhance their digital skills, learn how to use digital tools effectively and contribute to achieving global sustainability goals and KTH's sustainability objectives.

As a tangible outcome of the project, sample datasets from the three KTH Live-In Lab testbeds (Testbed KTH, Testbed EM and Testbed AH) have been created. The datasets are GDPR-compliant and have been checked against current best practices for privacy. To maximize the outreach, the files are openly available at the Live-In Lab website in an accessible and common format, .csv and .xlsx files. The datasets are provided with additional information, like the layout of the testbeds, and are available in time spans ranging from one day to three months.

https://www.liveinlab.kth.se/en/datapool/datapool/download-sample-datasheets-1.974705

DISSERTATION

Katarina Bäcklund, PhD in 2024: A framework for human-centric digital transformation

Katarina Bäcklund's research indicates that smart buildings are not yet smart enough, and that not all data is smart data. There is still much to be done before the digital transformation can be fully used to operate buildings with better indoor comfort and lower energy consumption.

Katarina Bäcklund's PhD thesis is based on four articles, each focusing on distinct research areas: building occupants, smarter higher educational buildings, smart building systems and the digital transformation of real estate organizations. Rather than concentrating on a specific research area, the objective was to provide a comprehensive view of the broader system by exploring these four key research areas. These areas are interdependent and require equal attention to facilitate the digital transformation of the commercial real estate sector, enabling a more climate-neutral built environment while ensuring high quality indoor comfort.

By addressing challenges within the real estate sector and leveraging the unique attributes of campuses, this study focuses on a selection of opportunities brought by digital transformation. The goal is to provide knowledge and recommendations for such building owners as well as for related academic research, on the pathway toward operating a climate neutral building stock.

The framework

The findings reveal a paradox within smart building systems: building occupants are often treated as passive agents, and interactions are intentionally reduced. I argue that certain interactions can be beneficial, as considering building occupants as active agents could lead to more sustainable building operations. I also argue that smart buildings are not yet smart enough and the investigation into what constitutes a smart building led to the identification of key features of smarter higher educational buildings. Furthermore, the concluding section of this study delved into the organizational challenges associated with digital transformation, pinpointing potential solutions to enhance innovation processes. Based on these findings, a framework for human-centric digital transformation is proposed

"The findings reveal a paradox within smart building systems: building occupants are often treated as passive agents, and interactions are intentionally reduced."

Relevance for higher education buildings

This study targets higher educational buildings, their building occupants, building systems, and building owners. This focus is motivated due to the following considerations: the energy-intensive nature of activities accommodated within higher educational buildings makes them a critical reference point for understanding and addressing sustainability challenges. Also, demographic trends depict a predicted increase in enrollments in higher educational studies. Consequently, universities across the country are investing in new buildings or undertaking extensive renovations, underscoring the importance of higher education institutions in contributing to a climate-neutral built environment. Furthermore, campuses are often viewed as small-scale cities due to their diverse range of buildings and vibrant atmosphere. Therefore, campuses are ideal as demonstrators, models, testbeds and Living Labs where innovative technologies can be tested in a controlled environment as part of an innovation system before realizing large-scale implementations of successful innovations.

It should also be considered that the rapid pace of digitalization requires the existing workforce to reskill, compelling universities and higher education institutions to adapt their educational offerings accordingly. Finally, higher educational buildings should also serve as formative structures where students can learn to adopt an energy aware and sustainable behavior, preparing them for their future roles shaping a smarter and more sustainable built environment.

Katarina Bäcklund posting her dissertation Human-Centric Operations of Smarter Higher Educational Buildings in Sweden.

KTH Live-In Lab collaboration

The testbed Undervisningshuset at KTH Campus, part of the KTH Live-in Lab, was used as a case study building. This green-rated higher educational building is equipped with smart building systems, including a smart HVAC-system with Digital Room Panels, a smart lighting system controlled by presence sensors, and a smart control system for the solar blinds. Building occupants were interviewed about their interactions with these smart building systems and their understanding of them. The aim was to address the identified research gap regarding the interactions between building occupants and smart building devices, an area that has been underexplored in existing research.

Future research

Four suggestions for future research was proposed. Firstly, smart retrofitting. This strategy involves transforming existing buildings to meet climate-neutral standards. Smart retrofitting will be a key enabler in transitioning the current building stock toward decarbonization, which is essential for addressing the challenges of a sustainable built environment. Secondly, mastering the complexity of smart building systems. Predicted to increase both in quantity and relevance, more research is needed to fully understand their impact. This should include a particular focus on energy and resource demand, as well as ensuring these systems meet the expectations of building occupants. Thirdly, there is a need to optimize space utilization by reducing the amount of empty space and maximizing the occupied area in buildings. Therefore, it is crucial to define appropriate Key Performance Indicators. Lastly, to differentiate between smart and unsmart data. Not all data generated within smart building systems is smart data. Throughout this study, it was noted that there is a need for better strategies to manage smart building data and ensure data due diligence. Currently, data with no further application is managed and stored. This especially applies to near real-time data from IoT-sensors, which produces substantial data volumes that require energy for processing and storage.

How is your life after the PhD and the new job?

"After the Ph.D. I joined Vattenfall Customer & Solutions, where I work with Nordic energy intensive industries such as mining, steel and pulp and paper. This role involves close collaboration with these industries, particularly focusing on ancillary services in the physical power market, which play a crucial role in making large resources available to stabilize the grid."

"Additionally, my work centers on digitalization and energy efficiency, helping people and organizations adapt to a rapidly changing landscape. The goal is to improve processes for greater efficiency and resilience, all while advancing towards climate neutrality and a more robust electricity system."

Title: Human-Centric Operations of Smarter Higher Educational Buildings in Sweden.

Supervisors: Professor Per Lundqvist and Dr. Marco Molinari

Industry supervisor Akademiska Hus: Peter Karlsson

Enabling a sustainable built environment

“ The buildings of the future compose sustainable cities where people actively and vibrantly engage with their physical and non-physical environment meeting the challenges of climate action ”

Sustainability

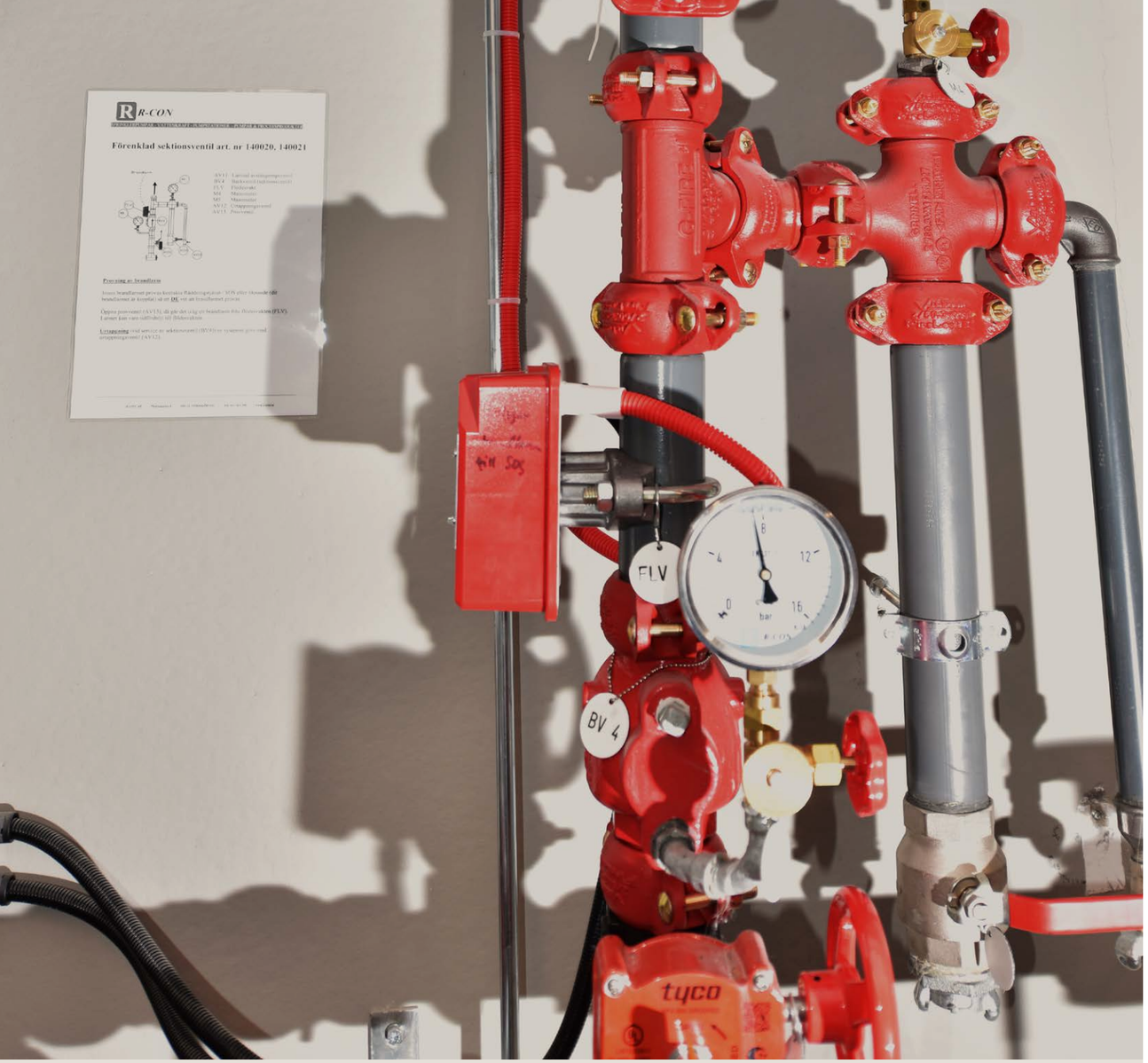
KTH Live-In Lab enables sustainability transformations and fosters the sustainability joint effort at KTH.

The multidisciplinary nature of buildings, the ongoing digitization process and upcoming energy and environmental goals are major challenges for both industry and academia. The buildings of the future must become more sustainable and an integrated part of the energy systems, and for this to happen within a reasonable time new technologies and practices for sustainability need to be taken up by the market as soon as possible.

KTH Live-In Lab is a unique node for collaboration between industry and academia that creates synergies for both. The challenges related to innovation, sustainability and smartness are complex and related to multiple knowledge domains. To make an impact on the society, the KTH Live-In Lab follows an holistic approach to research in buildings, covering all research domains relevant to smart and sustainable buildings and cities and in a continuous effort to launch new ones.

Through the opportunity to bring academia and industry together, KTH Live-In Lab increases the opportunity for external funding and creates win-win situations. By prioritizing projects with a special focus on sustainability, KTH Live-In Lab strengthens KTH commitment to sustainability. KTH Live-In Lab is part of the KTH vision for a sustainable campus and that Stockholm maintains its leadership in sustainable urban development, by increasing the pace of innovation in the civil engineering sector, based on excellence in research, education and collaboration. KTH Live-In Lab is a platform for enabling projects mainly in the following areas of the global sustainability goals:

- SDG3: Good health and well-being
- SDG4: Quality education
- SDG6: Clean water and sanitation
- SDG7: Affordable and clean energy
- SDG9: Industry, innovation and infrastructure
- SGD11: Sustainable cities and communities
- SDG12: Responsible consumption and production
- SDG13: Climate action
- SDG17: Partnership for the goals



Infrastructure for multidisciplinary research and development

Infrastructure: **testbeds and database**

KTH Live-In Lab is a significant puzzle piece in the effort to create the smart and sustainable buildings of the future. Its purpose is to provide buildings, operations, and data to support multidisciplinary research and development, accelerating innovation in the public construction sector.

KTH Live-In Lab has three interconnected functions. The first is a collaboration platform, while the other two are infrastructure components: Testbeds and the Data and IoT Platform.

Testbeds

There are currently three Testbeds in KTH Live-In Lab: Testbed KTH, Testbed EM, and Testbed AH. There are also some trusted buildings that deliver data to KTH Live-In Lab, for example multi-family buildings in Uppsala, buildings owned by Botrygg.

The testbeds in KTH Live-In Lab can be used for innovative environmental technology – for research, development or education. KTH Live-In Lab offers workplaces, space for necessary installations and the infrastructure and context needed for research and development of technology in a real residential environment.

The KTH Live-In Lab Testbeds are open for all who wish to conduct research and tests on products, services or processes within an area that has bearing on the real estate and construction sectors. Research on new business models and collaboration structures are also possible.

Database and data management

Data from the Testbeds are collected and shared via KTH Live-In Lab's data pool. The database is located on KTH's servers. Our data pool consists one of the most valuable infrastructure that supports research and innovation not only for KTH but also for other institutions. The interest in our data pool continuously increases, creating the opportunity to build new partnerships with other institutions and laboratories.

The testbeds

KTH Live In Lab offers a seamless integration between the physical and the digital. A full-scale test environment is combined with a datapool for research data from the testbeds.

There are currently three testbeds connected to the KTH Live-In Lab: Testbed EM, Testbed AH and Testbed KTH, the latter also featuring a database collecting and sharing testbed data via KTH Live-In Lab's data pool.

Testbed AH (Akademiska Hus)

Testbed AH consists of Undervisningshuset on KTH Campus Valhallavägen and is equipped with hundreds of sensors. These sensors measure relatively common values such as ventilation flows, CO_2 and electricity and water usage, but also moisture levels and movements in individual parts within the test bed.

Testbed EM (Einar Mattsson)

Testbed EM consists of 305 student apartments in three plus-energy buildings, located on KTH Campus Valhallavägen. Hot water and heat are generated via heat pumps connected to 12 boreholes of a total length of 3600 meters. The Testbed has approximately 1150 square meters worth of solar panels and 64 wastewater heat exchangers. The Testbed will also have a battery energy storage system connected to the solar panels with a capacity of around 300 kWh in collaboration with Northvolt. Hot water, electricity, CO_2, and light are measured in all apartments and the control and monitoring systems can be influenced for research purposes.

Testbed KTH

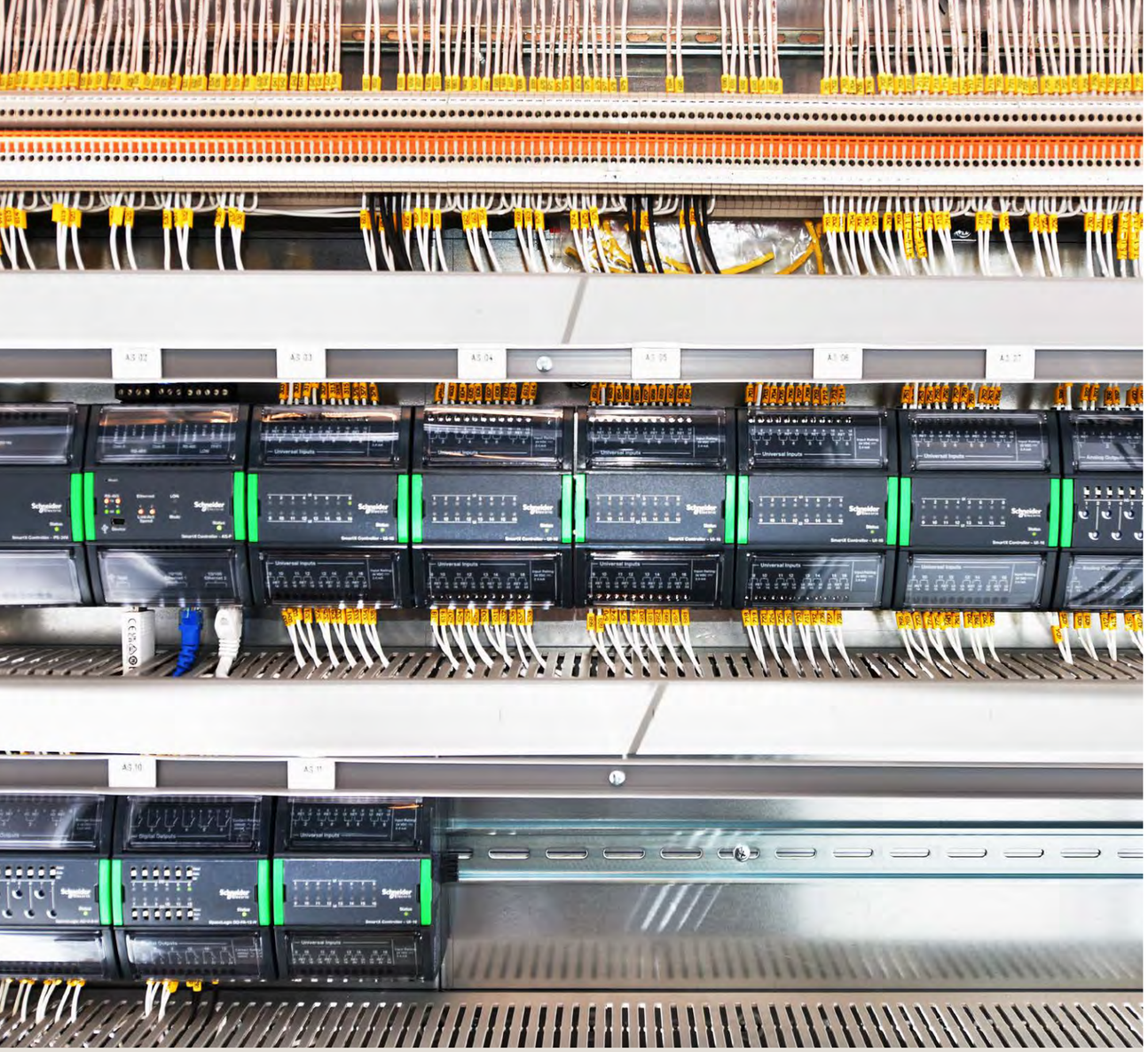
Testbed KTH is in building-permit exempt premises in one of Einar Mattsson's three plus-energy buildings on KTH Campus Valhallavägen. The premises are a total of 305 square meters divided into a living area distributed over approximately 120 square meters, a space for the technology of about 150 square meters and a project office of roughly 20 square meters. Within Testbed KTH, various apartment configurations are built on an annual basis and KTH sublets these to students who have applied to live in the test apartments.

The KTH Testbed is fully flexible regarding both geometry and installations. Moreover, the Testbed has its own solar panels and a borehole making it possible to change the collector. The premises are rented by Einar Mattsson on a ten-year contract, 2017–2027, but everything in the premises (the apartments, substation, and office) is owned by KTH.

During 2024 the Testbed KTH continued to be one of the most effective shared living experiments in a smart apartment. Testbed KTH provides significant results in a wide range of research fields. In essence, this Testbed creates a channel for direct communication between researchers and students / tenants. Reliable and valuable results are produced in a fast rate thanks to the direct feedback of the tenants and their active participation.

The multidimensional lab

KTH Live-In Lab's Datapool is a portal to research data from the Testbeds (physical buildings) and research results. The idea is to collect, store and share data to accelerate innovation in the built environment. The Datapool is open for KTH students and teachers as well as collaborating researchers from industry partners.



Partnerships and multidisciplinary collaboration

Collaboration

KTH Live-In Lab bridges academia and industry promoting collaboration between research projects and research fields. The testbeds in KTH Live-In Lab can be used for innovative environmental technology, for research, development or education.

KTH Live-In Lab offers workplaces, space for necessary installations and the infrastructure and context needed for research and development of technology in a real residential environment. Moreover, KTH Live-In Lab promotes collaboration between research projects supporting multidisciplinary cooperation, offering different levels of collaboration.

1. Project collaboration

Companies and researchers use the testbeds for research, postgraduate and basic education, as well as assignment-based research or training. They submit a project description, including budget and agreement, after which collaboration can take various forms.

2. Letter of Intent

Small companies, startups or researchers can obtain a ‘Letter of Intent’ to facilitate project collaboration if their idea, product or service aligns with the goals of KTH Live-In Lab.

3. Strategic collaboration

Companies may also want to collaborate with KTH Live-In Lab at a strategic level, outside the scope of the application. The purpose of a strategic partnership is to create collaboration between KTH and the business community. Strategic partners are also involved in undergraduate, research and postgraduate education.

Application

After the application process, collaboration between researchers / companies and KTH Live-In Lab is formulated and formalized.

Read more about the project process on our website:
liveinlab.kth.se/en/samverkan/projektprocess-pa-kth-live-in-lab-1.1064763

How projects upgrade the research infrastructure

The Horizon project HYSTORE shows how projects can contribute to the Live-In Lab enriching and upgrading its research infrastructure. The project leverages the infrastructure of the Granryd lab for prototyping and testing of the thermal storage system, and the KTH Live-In Lab, to test and demonstrate the optimized heat pump with storage system in real operating conditions

HYSTORE is a four-year project focused on designing, manufacturing, and testing four modular, plug-and-play compact TES systems for heating, cooling, and domestic hot water, covering daily to monthly storage needs. The project also aims to develop optimized control strategies at device, aggregation, and community levels to enable efficient TES operation and integration with building systems and grid-responsive energy management. All technological and ICT tools will be validated across four demonstration sites, including KTH Live-In Lab, representing diverse building types and climates. TES provides low-cost flexibility for peak shaving, load shifting, waste-heat recovery, and renewable integration, often at lower cost than batteries. By elevating TES from component to network level and adopting flexible sector coupling with heat pumps and chillers, HYSTORE enhances building and system performance while reducing costs and emissions.

The project addresses key barriers, such as system complexity, lack of real-scale data, and absent standards, by developing compact PCM/TCM solutions and control methods, validating them in operation, and providing engineering guidance. HYSTORE also increases technology readiness and demonstrates TES as a flexible sector-coupling enabler between thermal and power systems.

"The PCM HEATING solution will reduce heat pump operation during peak electricity hours while providing significant peak heat demand shaving."

KTH Live-In Lab collaboration

Stakeholder involvement and partnerships are central to the project. KTH Live-In Lab hosts a pilot PCM Heating solution (PCM-TES) integrating a dedicated heat pump and smart controls for space heating, supporting installation, optimization, and BMS/HVAC integration, and providing a real-building testbed for performance, techno-economics, and control strategies.

Advances in the project

At the Energy Technology Department, bulk-scale PCM cycling tests were conducted on two shortlisted bio-based PCMs from the project partner RUBITHERM, both showing satisfactory cycling properties. From these, RT57HC was selected for the implementation of the PCM HEATING solution at KTH Live-In Lab. Using Computational Fluid Dynamics (CFD) simulations, various PCM-TES heat exchanger configurations were analyzed.

Ultimately, based on CFD results, material compatibility, and existing experimental evidence, a packed-bed configuration with encapsulated PCMs was selected for implementation. The PCMs are used in slab-shaped encapsulations (HeatSel Quad, from KraftBoxx), submerged in water as the heat transfer fluid (HTF) within a cylindrical stainless-steel tank of approximately 500 L.

This is the PCM-TES. In parallel, a dedicated 18 kW nominal heat pump, sponsored by NIBE, was acquired and customized with a special heat exchanger between the compressor and condenser, termed desuperheater, exclusively for charging the PCM-TES. Additionally, control algorithms were formulated to smoothly control the PCM HEATING solution charging and discharging, as well as the heat pump's heat supply from a dedicated KTH Live-In Lab borehole.

The lab-scale characterization of the PCM-TES has been successfully completed in the Granryd Lab at KTH. It provides 38–42 kWh TES capacity (depending on the initial and final temperature range) and 5–22 kW charging/discharging power (based on HTF flow rate). This exceeds the minimal design capacity of 20 kWh, with up to 5 kW discharging and 3 kW charging, ensuring the intended peak shaving can be fully achieved. The PCM-TES and heat pump will be moved to KTH Live-In Lab.

What are the next steps?

The ongoing tasks include the installation of the PCM HEATING solution, ensuring proper connection of the PCM-TES and heat pump along with auxiliaries, measurement equipment, and, most importantly, the smart control hardware.The Energy Technology and Civil and Architectural Engineering teams are working closely together, with the next immediate steps being the Low-level commissioning (i.e., at the PCM HEATING solution level) and High-level commissioning (i.e., at the building energy system level), along with troubleshooting.

Our goal is to commission the PCM HEATING solution in time for this winter to support the space heating demand at the KTH testbed. It will reduce heat pump operation during peak electricity hours while providing significant peak heat demand shaving. The PCM HEATING solution will thus take its first operational steps this winter, hopefully marking the beginning of many years of robust and reliable performance.

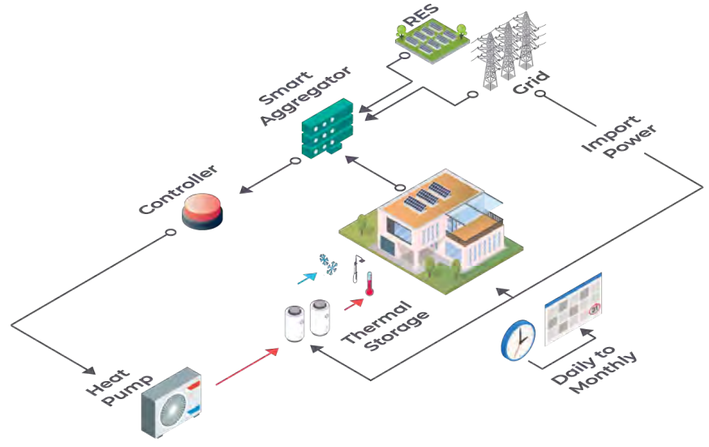


Image from project website:
https://www.hystore-project.eu

Aditya Singh Suswal is a Ph. D. student at the KTH Department of Energy Technology

Mustapha Hadid is a Researcher at the Department of Civil and Architectural Engineering

Saman Nimali Gunasekara is an Assistant Professor at Energy Technology (with specialization on Thermal Energy Storage) at KTH, collaborating with KTH-Live-in-Lab in the Horizon project HYSTORE (project web).

Qian Wang is a Researcher at the Department of Civil and Architectural Engineering at KTH, with specialization on HVAC control and smart buildings. He is the KTH project leader in HYSTORE, and works in close collaborations with KTH Live-In lab for system integrations and data semantics.

"Knowledge, results and commitment"

Impact & Outreach – highligts from 2024

KTH Live-In Lab functions as a collaboration platform and infrastructure, generating knowledge, results, and commitment, while enabling interdisciplinary research, industry partnerships, and the practical testing of innovative solutions in real building environments.

National and international collaborations

In 2024, KTH Live-In Lab co-organized two ad-hoc workshops, the HiSS 2024 International Workshop and the European Control Conference (ECC2024), focusing on the role of living labs in developing smart cities and open innovation. These events aimed to establish an international network of living labs in buildings. KTH Live-In Lab is leading this initiative, with the working group currently involving KTH Live-In Lab (SWE), HSB Living Lab (SWE), Intelligent Human-Buildings Interaction Lab, Umeå University (SWE), NEST Empa Lab (CH), Sisslerfeld Living Lab (CH), Lillestrom City Lab, Oslo University (N), and UniZEB, University of Padua (IT).

KTH Live-In Lab has initiated a collaboration with the University of Padua, resulting in UniZEB, a small-scale living lab for buildings. A key factor in facilitating this process was the documented workflow of KTH Live-In Lab, recently published in a journal article.

Two similar ongoing initiatives have been launched with Tokyo City University (Assoc. Prof. Genku Kayo) and the University of Krakow (Assoc. Prof. Beata Jałocha, Campus Living Lab). Previously, KTH Live-In Lab played a major role in establishing Jamtli Living University and has also initiated the future "Lund Living Lab."

Representatives from KTH Live-In Lab contributed to the development of Modern Building Regulations, proposing a Building Requirements Committee to accelerate innovation by shifting responsibility from municipalities to the state. While this proposal was well received in the civil engineering sector, other proposals were less accepted, prompting a new revision by the Swedish Housing Authority.

Dissemination and visibility

KTH Live-In Lab actively disseminates its work and approach through major events. For example, Micke Dimadis from Einar Mattsson, and Marco Molinari from KTH Live-In Lab were invited to the yearly Effektarena 2024, organized by IQS and the Swedish Energy Agency, and broadcasted live in Sweden. The recording is available on YouTube.

The KTH Live-In Lab has also been extensively used for institutional visits. In 2024, delegations included representatives from New York City (co-organized with IVL and the US Embassy in Stockholm), George Washington University, and the CESAER network (co-organized with RSO), as well as participants from the R&D Management 2024 conference.

When Swedish Minister of Education Johan Persson visited KTH on 30 October, KTH Live-In Lab was among the presenters, showcasing KTH's energy research, education, and current challenges in digitalization and smart buildings. The event was held in the large Reactor Hall at Campus Valhallavägen.

KTH Live-In Lab's concept of testing and sharing results and data has also been featured in national TV and radio, major newspapers such as Dagens Nyheter and Svenska Dagbladet, and industry publications including Cooling & Heating, Energy & Environment, Byggindustrin, Ny Teknik, Elektrikern, Filter, Fastighetstidningen, and Digitala Fastigheter.

Other highlihgts

- Since 2019, KTH Live-In Lab has produced annual reports to illustrate its concept and approach, highlight young researchers, showcase synergies in industrial collaborations, and present new projects and ideas developed within the Lab. The latest report is available on the KTH Live-In Lab website.
- Project workshops and seminars involving representatives from the quadruple helix: national and international researchers, industry representatives, policymakers, municipalities, and civil society. For example, at the international workshop of the Digital Futures project HiSS, KTH Live-In Lab led a session on the role of living labs in developing smart cities. The workshop, co-organized with Digital Futures and Tekniska Museet, was attended by more than 100 participants over two days.
- During its second mandate period, KTH Live-In Lab initiated a series of "Live-Sessions," where companies and researchers present various problem areas around a specific theme, aiming to formulate new projects.
- KTH Live-In Lab has explored experimental approaches for efficient, lean dissemination. A paper describing the Lab's concept and operation addressed a research gap on building living labs and served as the basis for scientifically sound dissemination. To increase impact, the paper was also adapted into a popular science audio interview created with generative AI, a method KTH Live-In Lab aims to further test for project dissemination.
- KTH Live-In Lab has been included on IVA's 100 list of research projects with high potential to generate benefits through industrial commercialization, business and method development, or social impact.
- KTH Live-In Lab is a test bed in ERA-Net Smart Energy Systems: https://www.eranet-smartenergy-systems.eu/ll/708/KTH-Live-In-Lab.html
- KTH Live-In Lab actively collects and shares data from its testbeds and projects. Its database (Datapool) is used by researchers, collaborators, teachers, and students. Many degree projects and courses have used this data, covering topics from ventilation and water systems to cybersecurity and user behavior.

Regulations changes for better housing

Linda Teng interviewed by Fastighetstidningen

Linda Teng believes that housing innovation is needed. She herself contributes research on how changes to the regulations for student housing can result in higher resource efficiency, better quality, reduced climate impact and lower rents.

Linda Teng, concept manager for student and researcher housing at Akademiska Hus, believes that the new regulations open up the possibility of creating more housing functions.

The Home Research Institute, HFI, was founded in 1944 with the aim of rationalizing the working conditions of housewives in public housing. The general urgency of newsreels may contribute, but it is easy to giggle at the diligent studies and tests of that time to determine suitable working heights in the efficient and practical home.

“We could use a little more of that today,” says Linda Teng.

It is best to be clear here. No, she does not have any general functionalist or public housing craze. And no! She really does not want to go back to a time when a woman’s place was in the kitchen. But she believes that a little more innovation is needed in the housing sector.

However, there are contemporary examples, although not at all on the scale of Hemmen’s research institute. One is the housing lab Live-In Lab. There, Linda Teng is currently working closely with the four students who live here. But with freedom also comes greater responsibility

In the debate surrounding the recently proposed change in regulations for student housing, many have warned of the effects if the accessibility regulationss are removed. Linda Teng says that she can certainly understand the concern.

“But it does not have to be that way. Of course, both the new regulations for student housing and the general building regulations place greater responsibility on developers and property owners. But with freedom also comes greater responsibility. And I think that the long-term property owners, which are usually those who build student housing, will take that,” says Linda Teng.

If you apply a slightly more constructive approach to the new regulations, you can create “more quality and housing functions” at both a lower cost and with less climate impact, Linda Teng points out. The biggest change in the proposal presented by the government is that it will be sufficient for 20 percent of student housing to meet current accessibility requirements for people with reduced mobility. When building a 16 square meter student apartment today, the requirement is that you can turn around with a wheelchair in the bathroom. The effect is a floor plan where almost a quarter is a toilet.

“It sets the framework for what we can build and at what cost,” says Linda Teng.

At the Kth Live-In Lab, which is a test bed, Akademiska Hus is experimenting in collaboration with other actors on new solutions, for example by testing what a smaller bathroom with “good visitor accessibility” can mean.

With the new regulations, we can actually create more housing functions on the same surface area.

Does this mean that a wheelchair user should be able to visit a friend, even if not all apartments meet the highest accessibility standards? Or should it be okay to back into a bathroom, or that a large accessible bathroom should be nearby. That remains to be seen.

“We want to explore the possibilities of the new regulations in a correct and creative way while ensuring housing quality,” says Linda Teng.

In recent years, Akademiska Hus has worked a lot with conversions and has had to handle these reasoning through deviations in building permits, such as Språkskrapan at Humanisten in Gothenburg and Remus in Frescati, Stockholm. With the new regulations, this will instead become the standard going forward.

“With the new regulations, we can actually create more housing functions on the same surface area. We can fit a larger kitchen, a dining area and a study area in a 16 square meter apartment, which is not possible today,” she explains.

Linda Teng, konceptansvarig för student- och forskarbostäder på Akademiska Hus.
Foto: Akademiska Hus

Linda Teng emphasizes that the concept of accessibility should be seen from multiple perspectives, it is also about financial accessibility.

“Every fourth student is forced to choose not to study due to a housing shortage, and if you come from a family with poor family finances, the housing situation plays an even greater role. It is also an accessibility issue,” she says.

According to her calculations, the rent could be reduced by up to ten percent if you compare a student residence of 22 square meters to 16 square meters, according to the standard rent. At the same time, the climate impact can be reduced by fitting more apartments within the same building volume. Since such a large part of the built stock is accessible, while the relocation rate of student housing is high, Linda Teng believes that there will be good opportunities to solve the need for accessible housing.

“I also see that we must work together to ensure that there is a clear system for priorities for these homes.”

Linda Teng also sees great opportunities in shared housing.

“One third of students today suffer from mental illness and many are asking for more social connections. But at the same time, people are a little unsure about living with others. So we need to spread knowledge about this type of housing. By sharing spaces, we can create better community and at the same time use the spaces more efficiently,” she says.

This means that a student who lives here has access to 70 square meters of common space and more living qualities – but you share them with others. This can be compared to living alone in about 20 square meters, as the apartment looked before.

“With these changes, Akademiska Hus hopes to create the student housing of the future: more social community, sustainable and at a more reasonable cost.”

Translated from Fastighetstidningen: *https://fastighetstidningen.se/nyhet/planlosning-for-okad-gemenskap/*

Text: Erik Hörnkvist

Key performance indicators

In 2024 KTH Live-In Lab has developed according to the business plan and established Key Performance Indicators (KPI). KTH Live-In Lab has decided on three focus areas: methods for knowledge transfer, value creation of data from buildings and education connected to KTH Live-In Lab. Results from all three areas are used in the daily operations of KTH Live-In Lab.

KTH Live-In Lab's method for knowledge transfer

This focus area aims to develop methods for transferring knowledge from project operations to society. Two processes have been developed: the project process and the knowledge dissemination and impact process (Figure 4).

Since commitment and knowledge are closely tied to project participants, models for trust, collaboration, and the spread of implicit knowledge have been developed. Capturing and sharing project members' expertise is crucial for effective management, follow-up, and dissemination within organizations. Continued collaboration, joint activities, and follow-up studies help drive social change and generate tangible impact.

Value making data from buildings

KTH Live-In Lab collects data from testbeds, "trusted buildings," and completed projects. All data is quality-checked and made available in compliance with current regulations, including GDPR. The data management work has been carried out in collaboration with center partners Schneider Electric, Akademiska Hus, Einar Mattsson, and KTH IT, with additional contributions from Stockholm University and HSB Living Lab.

In 2024, a new data management platform based on ProptechOS was installed by Einar Mattsson in Testbed EM to address challenges with the previous system. The platform enables the creation of user credentials and project-specific profiles managed by the KTH Live-In Lab team. Well-documented APIs support efficient data extraction and the development of third-party services. KTH Live-In Lab has also taken over the KTH sensor equipment in Undervisningshuset (Testbed AH).

Education 2024

The goal of this focus area is to develop education connected to research projects and the knowledge they generate. This effort has helped shape future education at KTH Live-In Lab and includes ongoing and completed activities, such as week-long case studies in collaboration with industry.

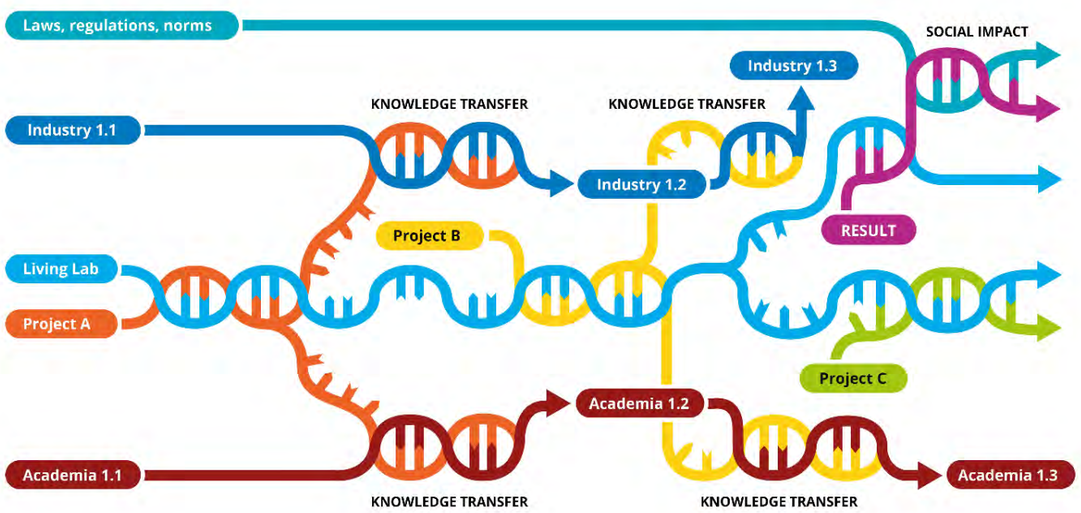


Figure 4. Knowledge transfer and impact in the form of DNA and m-RNA in relation to KTH Live-in Lab.

KPI - Research

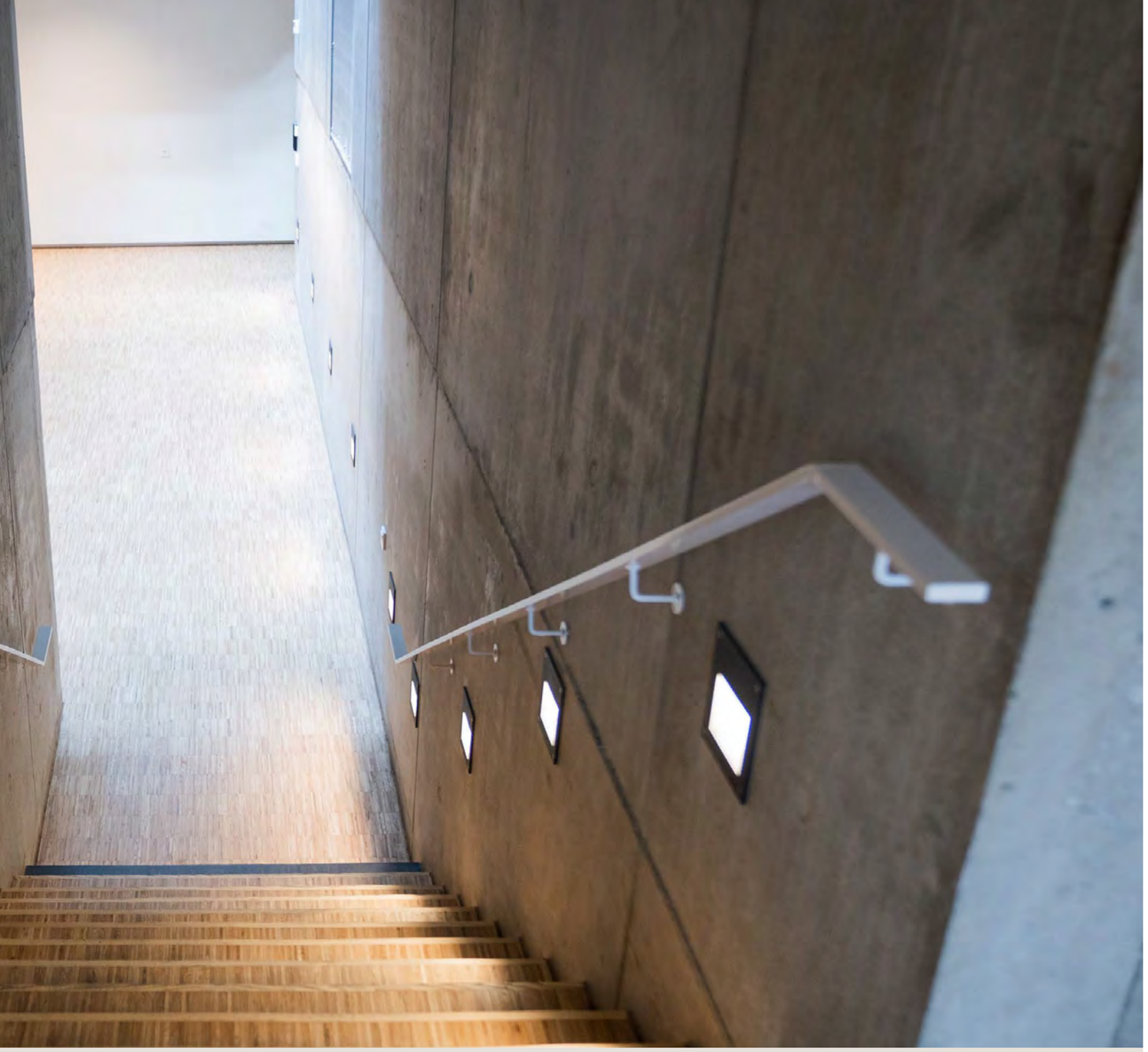
Table 3 – Research targets and results of KTH Live-In Lab for 2021 – 2024

KPI	Target 2021	Results 2021	Target 2022	Results 2022	Target 2023	Results 2023	Target 2024	Results 2024
Number of ongoing projects	10	16	12	16	12	21	14	20
Number of new projects	6	5	6	10	6	10	6	8
Number of projects initiated by the KTH LIL management group	1	3	4	5	4	5	4	5
School-wide project collaboration	50%	56%	50%	56%	50%	56%	50%	56%
Number of spin-off projects	1	3	6	6	6	6	6	7

KPI – Impact and Communication

Table 4 – Impact and communication targets and results of KTH Live-In Lab for 2021 – 2024

KPI	Target 2021	Results 2021	Target 2022	Results 2022	Target 2023	Results 2023	Target 2024	Results 2024
Public presentations (discussion articles, newsletters, communication activities, study / site visits)	10	15	15	48	15	40	15	55
Seminars and Workshops	6	10	6	3	6	7	6	10



Strengthening industry–academia partnerships

Center partners

Since 2019, KTH Live-In Lab has grown into a competence center with four core partners: Einar Mattsson, Akademiska Hus, Schneider Electric, and Bengt Dahlgren. Over the years, KTH Live-In Lab has developed projects with more than 150 partners, establishing collaborations between academia and industry. Currently, it maintains four central partners and around 50 additional partners involved in ongoing projects.

Project Partners 2024

Akademiska Hus
Arken
Asplan Viak
Bengt Dahlgren AB
Boiler
Castellum
Chalmers University of Technology
Charles Strand Design AB
Dandelion
Digital Futures
Einar Mattsson
EQUA
Ericsson
ETM Kylteknik
HP
KTH ABE
KTH Digitalisation platform
KTH EECS
KTH Green Leap
KTH ITM
KTH Media Technology and Interaction Design
KTH Sustainability
KTH
Lund University
Lunds Tekniska Högskola
Myrspoven
NIBE
Northvolt
Noss Invest
NOWAB
Padua University
ProptechCore
RISE
Rototec
Sally-R
Schneider Electric
Sindeq borrteknik AB
SISAB
SSSB
Stockholm University
Sustain Lab
Swegon
Thermia
ToM Energy Consulting Company
Umeå universitet
Unige
Uppsala Universitet
Vasakronan
Volvo cars
Wilo

Einar Mattsson

On the KTH Campus, Einar Mattsson has built 305 high-quality student housing units totaling 6,329 square meters. These include the KTH Live-in Lab testbed, built in collaboration with KTH with Einar Mattsson as the main financier.

The units are rented to KTH and owned and managed by Einar Mattsson. The first students moved in in September 2017. KTH Campus plays an important part in the city of science, together with Stockholm University and Karolinska Institutet. Nature and green spaces are prominent parts of the area's character, including a steep slope with visible hills and mountains.

The design of the three detached buildings, which are located at KTH's highest point, was inspired by this natural setting. The houses, designed by Semrén and Månson, have a smooth concrete facade with French glass balconies that can be likened to sculptural stone blocks. They are built of solid materials for long-term durability. The boundary between the landscape and the built environment is important and sharp.

Outdoors, simple but powerful materials are used that relate to the materiality and feel of the buildings. Meeting places, in the form of a common bicycle room, a large laundry room with a study area and the common post room, have large windows to create safer outdoor environments.

The houses constitute a 'plus energy' property, which is made possible by, among other things, waste heat exchangers, geothermal heating and solar panels on the roofs. Einar Mattsson is a long-term property owner who sees the investment on the KTH Campus and the KTH Live-in Lab as an investment in creating an attractive and sustainable city.

The Einar Mattsson Testbed

The building

- Built in 2016-2018
- 305 apartments
- 10 590 m2 (Atemp)
- Concrete exterior wall elements outer wall: 0.11 W/(m2*K)
- Windows U-value: 0.64 - W/(m2*K)

The energy system

- 3 heat pumps x 60kW
- 667 solar panels
- Battery Storage System from Northvolt (186 kWh) connected to PV
- Microgrid system that enables energy sharing between the three buildings
- 4+1 ventilation units (FTX)
- Geothermal heating, 12 bore holes, 3 185 meters
- Data collection units in all apartments for smart management of technical systems

Akademiska Hus

Akademiska Hus has built 230 student apartments at Teknikringen on the KTH Campus in Stockholm, with room for more than 400 students. The need for student housing in Stockholm is strong, and housing availability is crucial for the city's future attractiveness.

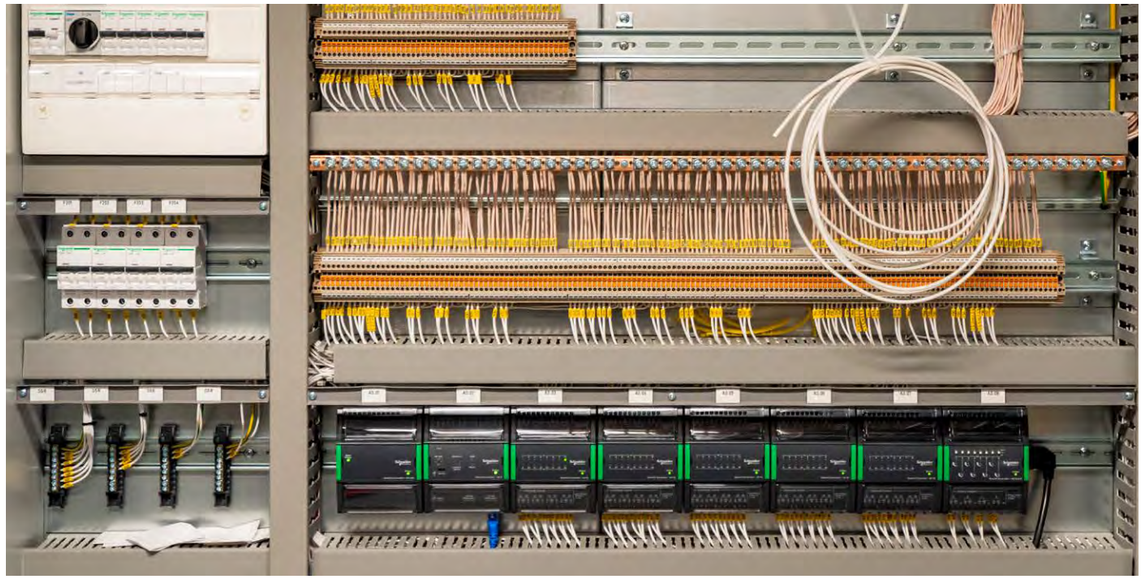
Akademiska Hus provides the Teaching House at the KTH Campus as a testbed to enable testing and research in collaboration with KTH Live-In Lab. More housing contributes to a more vibrant campus as people are present, living their lives at all hours of the day, something that both Akademiska Hus and KTH strive for.

The engagement of Akademiska Hus in KTH Live-In Lab aims to make it possible for new competitive, environmentally sound and sustainable products and services to reach the market more quickly, in the end resulting in smart and sustainable buildings and campus areas.

Akademiska Hus, together with Einar Mattsson, Schneider Electric, and Bengt Dahlgren cooperated with KTH to enable an increase in the number of testbeds within KTH Live-In Lab. Also, to ensure impact from the research being performed at KTH and other universities. The sand-boxing methodology, going from ideas to physical installations within years instead of decades is Akademiska Hus way to solve problems for the future.

The Akademiska Hus Testbed

- Inaugurated October 2017
- Total area 3500 m2
- Designed according to the wishes of teachers and students
- Educational tool for aspiring architects and community builders
- 363 study places + 6 exercise rooms + 11 group rooms & break-out areas
- Undervisningshuset is built according to the environmental certification Miljöbyggnad Guld, which is the highest ranking (Gold, Silver, Bronze).



Schneider Electric

Schneider Electric wants to contribute to a more innovative construction sector and therefore deepened its cooperation with KTH Live-In Lab in 2019. Since then, Schneider Electric has been collaborating with KTH Live-In Lab to support innovation in the construction sector. The partnership includes contributions to research and development through selected consulting efforts, services, and technology.

With a growing global population, rapid digitalization, and rising energy consumption — particularly in buildings — we see an increasing need for innovative and sustainable solutions." says Charly Lupart, Building Market Vice President at Schneider Electric.

"To meet these challenges, collaboration is key. Together, we can develop smarter, more resource-efficient buildings and cities."

"Our goal is to support this progress by exploring new approaches and technologies. KTH Live-In Lab offers a valuable environment for testing solutions, products, and services that contribute to sustainable development."

Schneider Electric has installed several smart building technologies, including the IoT platform 'EcoStruxure™ Buildings Operation', the connected security system 'Security Expert', and the electric vehicle charging solution 'EVlink'. These systems support ongoing monitoring and optimization, contributing to efficient and reliable building operations for property owners, partners, and residents.

Schneider Electric at KTH Live-In Lab

Schneider Electric tests new solutions, products and services at KTH Live-In Lab. So far they have installed:

- IoT platform and building management system - EcoStruxure Building Operation (EBO)
- SpaceLogic Automation Server (AS-P)
- SpaceLogic Room Purpose Controller (RP-C)
- Access control system - EcoStruxure Security Expert
- Smart home solutions - Wiser

Bengt Dahlgren

The technology consulting company Bengt Dahlgren wants to contribute to a more sustainable and innovative construction sector and therefore joined KTH Live-In Lab as a center partner in 2021.

Bengt Dahlgren provides KTH Live-In Lab with knowledge about among other things, digitalization, and digital twins. A key activity and area where Bengt Dahlgren's competence as a technology consultant is of the utmost importance is the development of Testbed X – a virtual Testbed made to enable research into the potential of digitalization for the design, production, and management of smart and sustainable buildings.

'The digitalization of the construction sector is one of the major challenges the industry is currently facing. A digital test bed will enable the necessary development of tools for planning, production, and operation of smart and sustainable buildings.At the same time, the test bed will be a neutral platform where various universities and companies can test and develop the systems and services of the future for smart and sustainable buildings and cities,' says Jonas Anund Vogel, co-director of KTH Live-In Lab.

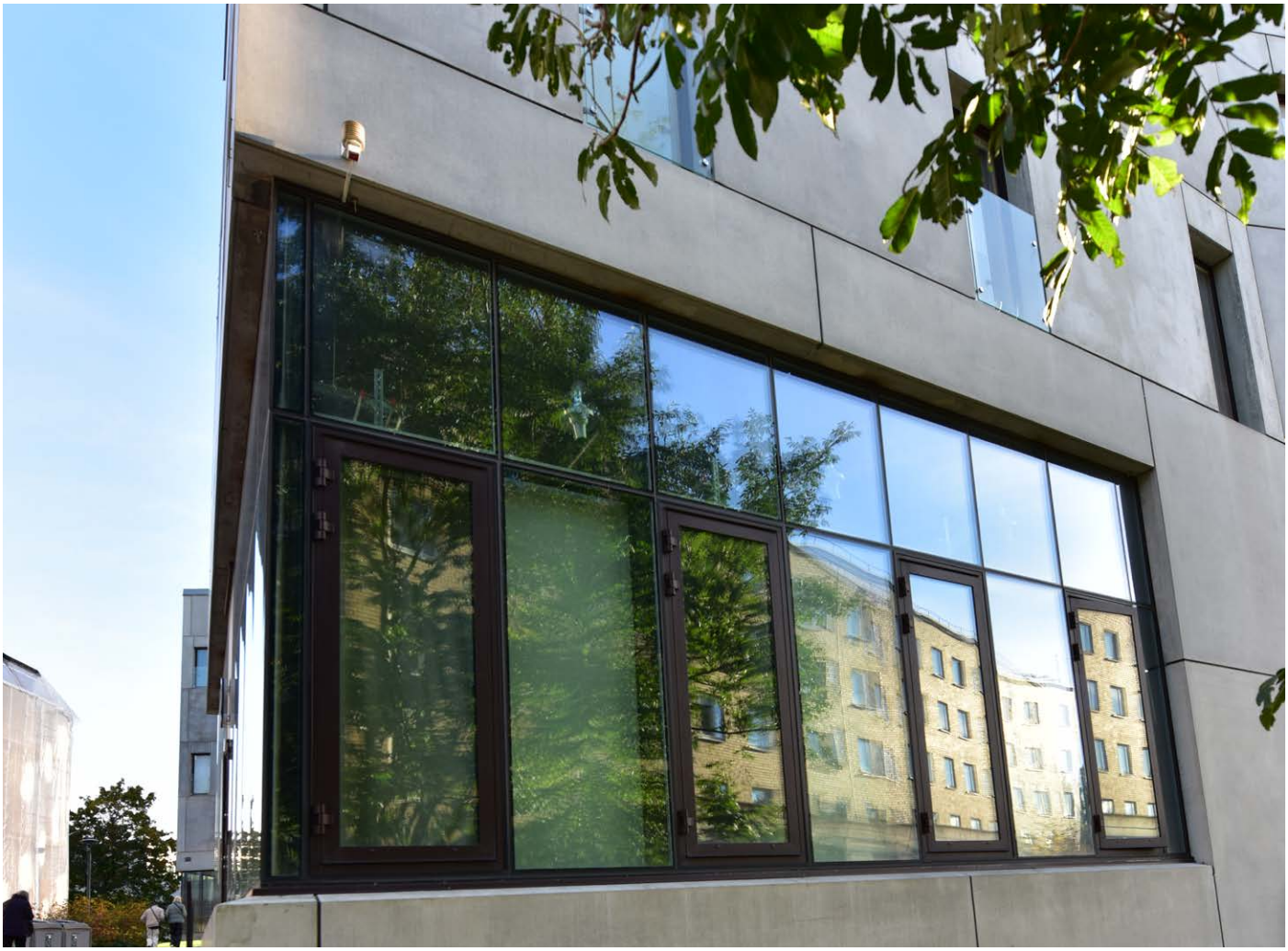
For Bengt Dahlgren, this means that the company will invest in research and development at KTH Live-In Lab during a three-year period through consulting, services, technology and more.

'Research and development are an important part of Bengt Dahlgren's work and permeate our entire business. It therefore feels very exciting and important for us to expand the collaboration with KTH and contri bute with our knowledge within KTH Live-In Lab, and thereby enable future systems and services for a sustainable society,' says Erik Bolander, CEO of Bengt Dahlgren Stockholm AB.

The Bengt Dahlgren testbed

Bengt Dahlgren's collaboration with KTH Live-In Lab will run from 2023 to 2024. Bengt Dahlgren plays an important part in the development of KTH Live-In Lab's new, digital testbed: Testbed X.

Bengt Dahlgren operates in the public construction sector and works with installation, fire and risk, construction, real estate, energy and the environment.



Thank you all for the great year!

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Contact

info-liveinlab@kth.se

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