

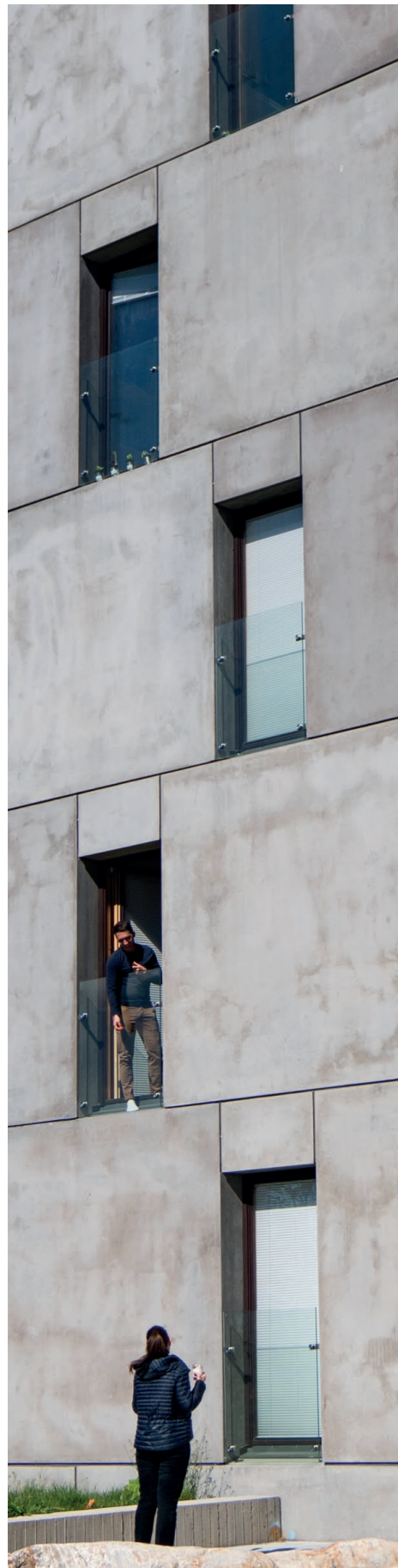


KTH Live-In Lab

Annual report 2021



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 usage of buildings. KTH Live-In Lab has proven to work as a bridge between different research areas and between academia and industry.

Research, education and collaboration

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.

The three foundations of KTH Live-In Lab are research, education, and collaboration. KTH Live-In Lab and its testbeds enables students from different study programs to contribute to the development and evaluation of ongoing research and development projects. KTH Live-In Lab also enables collaboration between different study programs and with the industry, and works as a link between students and companies, which many educational programs lack today.

Testbeds

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.

Partners and funding

KTH Live-In Lab is a competence centre 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 in collaboration with Einar Mattsson, Semrén & Månsson, Ericsson, Belkab, Grunditz Göransson Arkitekter and Pinnab Inneklimat.

KTH Live-In Lab became a competence centre in 2019, with KTH, Einar Mattsson, Akademiska Hus, and Schneider Electric. This was made possible thanks to a donation from the Einar Mattsson Group (7.5 million SEK in funds and 7.5 million SEK in co-funding) together with contributions from VINNOVA and the Swedish National Board of Housing (so far approximately 6.6 million SEK).

The center has received 1 million SEK on a yearly basis from KTH in competence centre support, a yearly amount of 0.5 million SEK from Akademiska Hus and Schneider Electric respectively, and a total amount of 1 million SEK from the KTH Digitalization Platform during the transition period. In 2021, Bengt Dahlgren Stockholm joined KTH Live-In Lab as a centre partner.

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KTH Live-In Lab for sustainable living

KTH Live-In Lab acts as a bridge between academia and industry. The centre 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.

KTH Live-In Lab is an important tool to enable the research required to answer the current multidisciplinary questions in relation to buildings and the climate. KTH Live-In Lab functions as a collaboration platform and infrastructure, generating both knowledge, 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.

Vision, purpose and goals

Live-In Lab is a platform that handles multiple testbeds for increased innovation and development of sustainable solutions in the public construction sector. 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.

Organization & management

Although KTH Live-In Lab is located within the ITM school, the centre currently has a board and management team consisting of people from both ITM, ABE (School of Architecture and the Built Environment) and EECS (School of Electrical Engineering and Computer Science).

Management groups

The board had its first meeting in October 2015 and have met approximately four times a year since then. The board decides which projects are suitable to conduct within

the framework of KTH Live-In Lab. Between 2015 and 2018, the board consisted of four people, all employees at KTH. Between 2019 and 2021, the board consisted of two employees from KTH and one representative from each industry party. In 2020, the board members changed with Karl-Henrik Johansson replacing Anne Håkansson (EECS) and Charly Lupart replacing Andreas Finnstedt (Schneider Electric).

The steering group currently consists of Per Lundqvist, professor KTH ITM, chairman, Karl-Henrik Johansson, professor KTH EECS, Martin Fors, property manager, Einar Mattsson, Susanne Malmgren, head of student housing at Akademiska hus and Charly Lupart, vice president digital energy Schneider Electric.

The executive group of KTH Live-In Lab helps carry out the centre's activities in accordance with the business plan, partner agreements and the centre'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 Johnsson (ABE), Marco Molinari (ITM), Folke Björk (ABE), Tobias Oechtering (EECS), Linda Teng (Akademiska hus), John Tankred (Einar mattsson) and Valentin Monteiro (Schneider Electric).

During 2020–2021, KTH Live-In Lab also had a full-time project manager (Safira Monteiro) and a co-director (Davide Rolando ITM) working part-time (20%).

Staff 2021

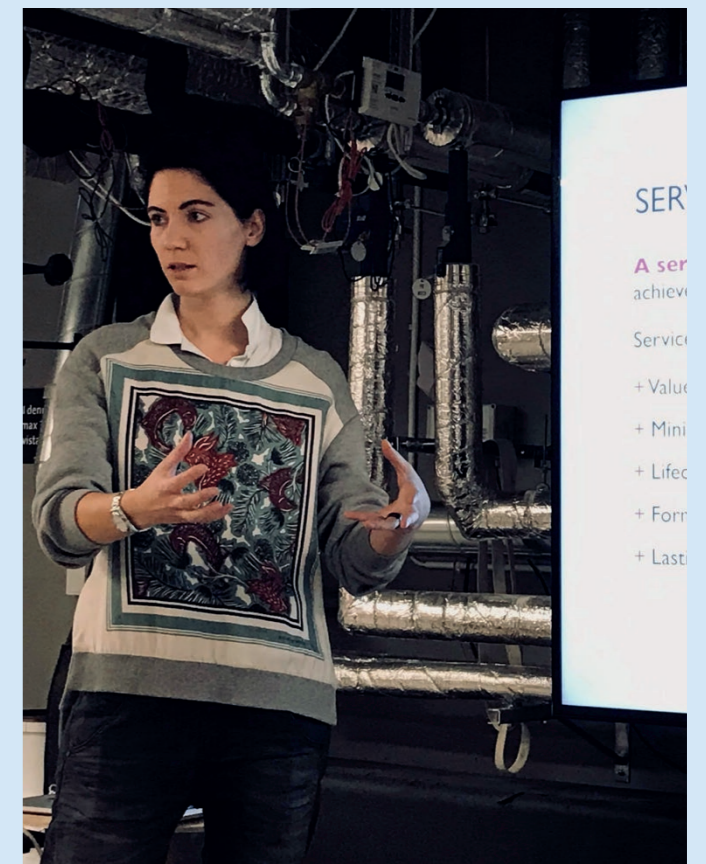
Jonas Anund Vogel, researcher KTH ITM, director
Safira Monteiro, KTH ITM, project manager
Davide Rolando, researcher KTH ITM, co-director
Marco Molinari, researcher KTH ITM, technical manager

Summary of the period 2020–2021

2021 was a year of collaboration and progress for KTH Live-In Lab.

During the centres lifespan (from 2016 to 2022), KTH Live-In Lab has enabled research to a value of at least 85 million SEK and attracted donations of a total value of at least 25 million SEK. Simultaneously, KTH Live-In Lab has received a total of 4 million SEK in financial support from KTH, hence a value-generating factor of 27.5!

In 2021, KTH Live-In Lab has also actively worked with the development of routines, models, websites and processes, and shared these with other competence centres both within and outside of KTH, nationally as well as internationally. Collaboration is the only way forward to solve the multidisciplinary challenges the built environment is facing.





Research at KTH Live-In Lab

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 exist to overcome.

KTH Live-in Lab's operation is focused on 1) acting as a platform for collaboration through enabling multidisciplinary research and 2) running testbeds and a database.

RESEARCH

Enabling research for the smart buildings of the future

In 2021 there were a total of 16 ongoing projects within KTH Live-In Lab. Almost all of them are collaboration projects between industry and academia.

Projects 2021

In 2021 KTH Live-In Lab had received 79 applications for use of the testbed. Out of these, 61 applications were approved for use of the testbed infrastructure. 39 of these projects have been initiated, 23 projects have been completed, and 16 are still ongoing.

The initiated projects at KTH Live In Lab during 2021 have an estimated total value of 85 million SEK, divided into 25 million SEK of co-funding and 60 million in applied funding.

Additionally, the centre 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 both research groups from across KTH (Architecture, Building Technology, Electrical Engineering, Energy Technology, Philosophy, Automatic Control, Real Estate and Construction Management and Information science and Engineering) and SMEs and larger corporations such as KTH Live-In Lab's strategic partners Akademiska Hus, Ericsson and other innovative companies such as Schneider Electric, Northvolt, Nordic Choice Hotels, Einar Mattsson and HSB Living Lab.

Other collaborative partners include Karolinska Institutet, Karolinska University Hospital, Stockholm University, Umeå University, Chalmers, Lund university, AMS Institute and MIT.

Table 1 – Projects in the KTH Live-In Lab

Projects	2015	2016	2017	2018	2019	2020	2021	Total
Applications	3	17	13	10	8	18	10	79
Started	2	1	2	9	13	7	5	39
Finished (by the end of the year)	0	0	3	3	5	4	8	23
Total ongoing 2021							16	

Projects	Companies / Organisations
1609 – Comparative spill-over and degradation effects from nudges and boosts	Till Grüne-Yanoff, KTH Philosophy
1611 – Smart Building Management systems	Marco Molinari & Davide Rolando (KTH, Automatic Control, ACCESS and Energy Technology, Botrygg, Tovenco, Akademiska Hus)
1703 – Energy storage for smart meter privacy	Tobias Oechtering, Daniel Månsson, Henrik Sandberg, KTH, EES
1707 – Efficient kitchen ventilation with energy recovery.	Jörgen Holmgren, Tovenco (KTH, Tovenco AB, Fläktwoods, Camfil)
1709 – USB-C for energy-efficient buildings	Ochno AB
1801 – Occupant pro-environmental choice and behaviour	Agnieszka Zalejska Jonsson, KTH ABE Institut Fastigheter och byggande

Projects	Companies / Organisations
1803 – Ensuring sustainability and equality of water and energy systems during actor-driven disruptive innovation	David Nilsson ABE and Jörgen Wallin ITM: KTH ABE/ITM, Vattencentrum, Graytec AB, HSB Living Lab, Värmdö Kommun, Sthlm Exergi, Svenskt Vatten, Akademiska Hus, Einar Mattsson, Uponor, Familjebostäder, Stockholm Water and Waste company
1806 – Social and environmental sustainability through a local social network	Hossein Shahrokni and Aram Mäkivierikko, KTH ABE (KTH and Local Life)
1808 – Service design for sustainable behaviour modelling: Smart schedule	Elena Malakhatka, KTH ITM
1810 – KTH BigDataBase	Anne Håkansson & Patrik Blomqvist & Jonas Anund Vogel (KTH EECS, ITM and Admin)
1903 – Pilot study for reduced water consumption using non-invasive ultrasound technology.	Thibault Helle, Labtrino (Labtrino AB, Skandia.Fastigheter, Connect Sverige, Stockholm School of Economics, KTH, Stockholm School of Entrepreneurship, Chalmers, HSB Living Lab, KTH Innovation, Energimyndigheten, Transfer Studio, Wistrand, Twin Mountain Group, Potter Clarkson, Almi, Vinnova)
1907 – Co-living & productive space usage	Linda Teng, Akademiska Hus (Akademiska Hus, KTH, Schneider, Nordic Choice, Einar Mattsson)
1908 – Co-Kitchen	Sara Ilstedt, Tove Malmqvist, Jonas Anund Vogel, Akademiska Hus, Savvy, TIP, Electrolux, Partab and Tovenco,
2103 – Humanizing the Sustainable Smart City (HiSS)	The research team represents the School of Electrical Engineering and Computer Science (EECS, KTH), the School of Industrial Engineering and Management (ITM, KTH) and the School of Architecture and the Built Environment (ABE, KTH). HiSS: Humanizing the Sustainable Smart City (kth.se) https://people.kth.se/~hedvig/HiSS/
2104 – Cyber-secure learning control systems (CLAS)	Alexandre Proutiere, Marco Molinari, and many more
2016 – Distributed sensing lab	Jonas Anund Vogel, Davide Rolando, Helene Lennholm, Susanne Engström (KTH)
2017 – Education and smart buildings	Per Fagrell
2018 - Sustainable walks	Safira Monteiro, Mario Romero, KTH Sustainability office

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>

Results from projects at KTH Live-In Lab



In 2021, projects conducted at KTH Live-In Lab resulted in a total of ten scientific articles, one dissertation, three conference contributions and four final reports.

The scientific articles and reports cover a wide range of research areas:

- Cyber security
- Allergens and ventilation
- Building automation and resource efficiency improvement
- Use of buildings, behaviour and building management
- Data storage, GDPR and ethics testing
- Forms of agreement and incentives for innovation
- Ground source heating, heat transfer and energy efficiency
- Collaboration platforms and Living Labs
- Greywater re-use and wastewater heat exchange
- Co-living and sharing of spaces and services

Scientific articles and reports

Greywater reuse

Jörgen Wallin

Main research questions: Globally an increasing number of people are facing water scarcity. To address the challenge, measures to reduce water demand are investigated in the world. In this paper, a novel approach to reuse bathroom greywater for shower and bathroom sink hot water is investigated. The investigation focuses on water and energy savings, water treatment, economic benefit and investigates the main actors and institutions that are involved.

Case studies: A case study was conducted in the HSB Living Lab in Gothenburg, Sweden.

Results: The main results of the project were that greywater reuse has a significant potential for water and energy savings. It also has a positive economic effect. The results show water savings of domestic hot water up to 91% and energy savings up to 55%. Furthermore, the investigated treatment plant produces recycled greywater with a quality close to drinking water standards.

Long-term performance monitoring of GSHP systems for commercial, institutional, and multifamily buildings

Willem Mazzotti Pallard

Main research questions: This report discusses and analyses performance monitoring of GSHP systems serving buildings. The report is a contribution to Annex 52's growing library of quality long-term measurements of GSHP systems performance in buildings.

Case studies: A case study was conducted in the original testbed of KTH Live-In Lab.

Results: The buildings in the case study claims to be plus-energy buildings, supposed to produce more energy than they consume. However, the results of the study show a deficit of consumption. Besides performances, uncertainties are briefly discussed and verifications on the available data is performed. It appears that data cannot be blindly trusted and requires a minimum level of interpretation. A short investigation about the relevance of cooling the ventilation of incoming air to recharge the boreholes is conducted and it counter-intuitively appears that it can make sense to do so. Finally, a list of ten improvement measures is provided.

Read the report:

<https://www.liveinlab.kth.se/en/om-kth-live-in-lab/rapporter>



Per Fagrell has made the study 'Competence needs for the smart buildings of the future'.

consumption in its properties in a relatively short period of time, so it is not impossible.'

What skills does the building sector need to meet the requirements for digitalization and sustainability?

'The skills needs expressed by the companies in the study are very much about different combinations of skills, for example the digitalization expert who needs more knowledge about sustainability issues, and vice versa. Basically, however, there is a need for good knowledge about facilities and buildings.'

What are the biggest challenges?

'The biggest challenge is probably the inertia in the industry, paradoxically combined with the need for a long-term approach to property ownership and management. It is probably only property owners with both a long-term and visionary perspective who can manage to push through the changes required, not least in the form of investments in new solutions that contribute to digitalization and increased sustainability.'

'The second big challenge is to find the right skills, both to figure out and to implement the changes.'

What is the role of KTH Live-In Lab in this?

'KTH Live-In Lab has the potential to act as a platform for educational activities, not least in the field of further education. Based on the interviews in the study, KTH Live-In Lab can act both as an educational environment and a node for discussions with companies about educational development.'

Read the report here: https://www.liveinlab.kth.se/polopoly_fs/1.110330:1634233414!/Kompetensbehov%20of%CC%88%20framtidens%20smarta%20byggnader.pdf

REPORT

Competence needs for the smart buildings of the future

The building sector, with its long-time focus on property management, is undergoing rapid changes in areas such as digitalization, sustainability and entrepreneurship. This raises the question of how companies in the building sector, and actors such as KTH, can adapt to changes in society and meet the new needs for competence development.

Per Fagrell, postdoctoral fellow at KTH, has interviewed key persons from eight companies in the building sector about the future engineering skills required for the planning, construction and management of smart and sustainable buildings. The report from the study 'Competence needs for the smart buildings of the future' was released 2021.

In your report you mention different driving forces for the changes in the building sector. Is the sector proactive or just reacting to these changes in society?

'The whole industry has a built-in inertia that makes it very difficult to be proactive. The inertia can be found in everything from the permit process and the change of the building codes, to the almost obvious inertia resulting from the fact that a building is expected to remain in place and be used for maybe more than 100 years. All this means that processes of change can become very complex.'

'However, there are examples in the study of major changes in a relatively short period of time, for instance the company that halved the energy



EDUCATION

Educations for the future

In 2021, KTH Live-In Lab initiated a collaboration project with high schools students, designed to create value for both students and researchers.

Education at KTH Live-In Lab

The interest in using KTH Live-In Lab in courses and theses is big, and growing. So far, the involvement in courses has been limited to site visits, workshops and presentations / 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 progression 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.

Courses



Cases and case studies

KTH Live-in lab recognizes the importance of an experimental learning environment. A smaller incentive package has been designed to support courses that use KTH Live-In Lab as a case study. A part of the package contains introductory lectures from KTH Live-In Lab, and contributions to the exhibition or catalogue. KTH Live-in Lab supports dissemination of knowledge and exchange of information through different channels.

Lifelong Learning

KTH Live-in Lab also recognizes the importance of continued education and is exploring forms in which Lifelong Learning could be further explored and developed within KTH Live-In Lab.

Courses that visited or used KTH Live-In Lab during 2021

MJ1141

Energy Systems and Sustainability, Per Lundqvist, KTH ITM

MJ148X

Degree Project in Energy Systems, Sustainability and Industrial Engineering, first cycle, Per Lundqvist, KTH ITM

MJ1150

Energy and Systems, Innovation and Entrepreneurship, Hatef Madani, 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

AF2511

Building Service Technologies and Systems, Sasan Sadrizadeh KTH ABE

CYL-P Cyber Law

Cyril Holm & Stanley Greenstein, Stockholm University, Juridicum

AG2805 Sustainable Planning and Design

Pernilla Hagbert KTH ABE

Ethics and Compliance Seminar, Case: Ethical challenges in research collaboration

Jonas Anund Vogel, Live-In Lab and Barbro Fröding. Course managed by KTH RSO



Petter Marklund, teacher at Vattenfallsgymnasiet, is part of the Distributed Sensing Lab project.

Distributed Sensing Lab – a collaboration between KTH and high schools

In 2021, KTH Live-In Lab initiated its first collaboration with high school students. The initiative is focused on students within the Technology Programme (Teknikprogrammet) in Swedish high schools and is designed to create value for both students and researchers.

In the project, sensor kits and boxes developed by researchers at KTH were given to the high school students for further development and exploration. Data generated by these kits and boxes can be then used and analysed by both researchers at KTH and the high school students.

The collaboration is a subproject within Distributed Sensing Lab, a project with the aim of increasing knowledge and understanding of resources and buildings through authentic learning.

Petter Marklund is a teacher at Vattenfallsgymnasiet, the first high school to collaborate with KTH Live-In Lab. We asked him what him and his students think of the project so far.

What have you done in the project so far?

‘We have done a half-day visit to the Live-In Lab site and building in Stockholm. Davide and Jonas also visited us at Vattenfallsgymnasiet and talked about Live-In Lab and the measurement box and detectors used in the research.’

‘Being able to measure and witness the carbon dioxide level rising in the classroom during the lecture made for an interesting twist! We are now in the process of getting a measuring box to Vattenfallsgymnasiet to be used in our own facilities. We have also used data from the project in our regular classes to calculate energy consumption, energy costs and more.’

What do you hope to gain or learn from this project?

‘When our measuring box is installed, we hope to use the data to perform digital analyses, possibly in real-time. We will hopefully visit KTH Live-in Lab again and perform measurements and data analysis on-site.’

What have the reactions been like from the students?

‘The response from our students has been positive. The connection to relevant environmental topics makes the project interesting.’



The buildings of the future must be more sustainable and act as an integral part of the energy system. For this to happen within a reasonable time, new sustainable technology and sustainable practices must be adopted by the market as soon as possible.”

Sustainability

KTH Live-In Lab helps strengthen the sustainability work at KTH by only approving projects aimed at increased sustainability.

The multidisciplinary nature of buildings, the ongoing digitalization and the future energy and environmental goals are all major challenges. By bringing together academia and industry, KTH Live-In Lab increases the opportunity for external funding and creates win-win situations. Increasing the pace of innovation in the public construction sector, based on excellence in research, education, and collaboration ensures that KTH becomes a sustainable campus and that Stockholm retains its leading position in sustainable urban development.



KTH Live-In Lab primarily enables projects in the following areas of the global sustainability goals:

- Health and well-being (SDG 3)
- Clean water and sanitation (SDG 6)
- Sustainable energy for all (SDG 7)
- Sustainable industry, innovation and infrastructure (SDG 9)
- Sustainable cities and communities (SDG 11)
- Sustainable consumption and production (SDG 12)
- Fighting climate change (SDG 13)
- Implementation and global partnership (SDG 17)



“

The centre is a significant puzzle piece in the work towards creating the smart and sustainable buildings of the future.”

Infrastructure & Database

The idea behind KTH Live-In Lab is to offer buildings, operations, and data to enable multidisciplinary research and development. Additionally, KTH Live-In Lab aims to accelerate the pace of innovation in the public construction sector.

KTH Live-In Lab has three interconnected functions, two of which are infrastructures.

- 1) Collaboration platform
- 2) Testbeds
- 3) Data and IoT-platform

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.

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 multifamily buildings in Uppsala, buildings owned by Botrygg.

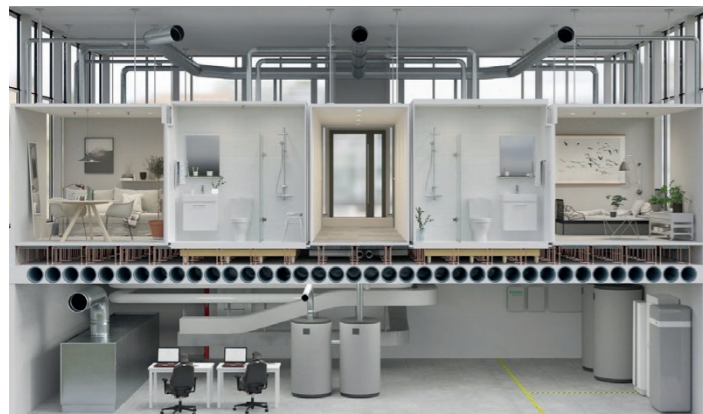
Testbeds

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.



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, CO₂ and electricity and water usage, but also moisture levels and movements in individual parts within the testbed.



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.

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.



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 have approximately 1150 square meters worth of solar panels and 64 wastewater heat exchangers. The testbed will also have electrical energy storage with a capacity of around 1000 kWh in collaboration with Northvolt. Hot water, electricity, CO₂, and light are measured in all apartments and the control and monitoring systems can be influenced for research purposes.



The new design of KTH Live-In Lab.

in the coliving, from the single unit of 20 sqm to 70 sqm in the coliving. With more functions possible, the space has expanded the home environment and added value to the students' life.'

The students have lived in the apartment for a few months now. What are the results so far?

'We met with the students sometime after they had moved in, and they expressed that they enjoyed living together and that they felt at home. Many expressed the benefits of everyday socialising and helping each other with small tasks. We talked about the design and all were appreciative of the large kitchen. They would often eat together and it was easy to socialise casually in the space. Cohabiting the space seems to have been without friction. There was plenty of storage space in the kitchen and in the home in general.'

What is the next step?

'The next step for us is to share the findings with more housing developers interested in shared living, and implementing more social ways of living in the Swedish context. We now have a lot of knowledge on how to design shared homes. We know how to make more resource efficient choices and add more value for the residents, a win-win situation. We have the quantitative data of the savings in resources and soon also more data on the savings from shared living, which will be very interesting for developers that want to take sustainability to the next level.'

Read more about the project: <https://www.greenleap.kth.se/en/projekt/cokitchen-sustainable-co-living-for-students-1.944762>

Co-Kitchen – Sustainable and flexible co-living for the future

Co-Kitchen is a project with the aim of creating more sustainable and flexible co-living apartments for the future. Co-living apartments has the potential of being a more sustainable and energy efficient way of living, but this requires more research and knowledge on how to make co-living both practically and socially viable.

The KTH Live-In-Lab provides a unique opportunity to build and test different technologies and solutions in a real-life environment. Testbed KTH functions as a co-living apartment for students where researchers can monitor the residents' practices as well as the infrastructure solutions over longer periods of time.

In 2021, the KTH Live-In Lab testbed was rebuilt for a third time. Anna Sundman is an architect at Theory into Practice, and we asked her some questions about co-kitchen and the new design of the testbed.

KTH Live-in Lab was rebuilt in 2021. Can you tell us a little about the testbed's new infrastructure and design?

'Our aim was to develop a living space that would be more sociable and

functional for the students, and at the same time reduce the carbon footprint. We focused on maximising space for easy social gatherings, creating a large kitchen where friends can easily be invited for dinner. The large dining table can also be used for more social activities and studying. The kitchen is designed so people can cook together easily, but also individually at the same time. In the opposite corner of the home we placed a more relaxing living space. You can study or watch a film, or just have some alternative to the more busy kitchen area.'

'Each student has their own bedroom, fitting a bed and your personal belongings. We strived to maximise shared space, and plan for privacy and integrity in the shared home. The living-space for each student has increased



Collaboration

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.

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

Project collaboration

Companies and researchers use the testbeds for research and postgraduate education, basic education, assignment research or assignment training. Companies and / or researchers proceed with a project description including budget and agreement. Project collaboration can then take various forms.

Letter of Intent

Small companies, start ups or researchers can obtain a ‘Letter of Intent’ with the aim of facilitating project collaboration, if their idea, product or service is considered relevant to KTH Live-In Lab.

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 / or postgraduate education.

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

Start a project

KTH Live-in Lab offers buildings and data to researchers and companies. Those interested in collaborating with KTH Live-In Lab on a project can apply on KTH Live-In Lab's website.

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.

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.



Jonas Anund Vogel with a CO2 meter.

Buildings Post Corona – Creating virus-proof buildings through collaboration

How can buildings be designed to create a healthy indoor environment and minimise the risk of transmission of airborne diseases such as Covid-19? Buildings Post Corona is a project that aims to answer this question.

The project Buildings Post Corona was announced and initiated in late 2021 and is a collaboration between KTH and KTH Live-In Lab, Chalmers, Umeå university and Lund University. The four universities will work together to create a roadmap of how future buildings can be made virus-proof. Buildings Post Corona is not only a collaboration between four universities, but also involves several project partners, which provides the project with a wide range of expertise. This means the project will be able to cover the necessary perspectives and methods to create a good indoor environment regarding sustainability, energy usage, health, and risk of infection.

The project takes an interdisciplinary approach and is carried out in close collaboration between researchers and the industry. The project method is

based on the establishment and activation of collaboration networks.

We asked KTH Live-In Lab's director, Jonas Anund Vogel, some questions about Buildings Post Corona.

Why is this an important project?

'The overall purpose of the proposed research is to support the building sector for future scenarios of impending climate change; to design, build and operate buildings that are healthy, use limited resources, and are climate resilient. Previous research has identified how extreme temperatures, with periods characterized by extreme cold and heat, place completely new demands on the climate systems in the buildings. Additionally, including the perspective of changes in the Earth's ecosystem, it is found that we likely will experience new types of airborne

diseases beyond the COVID-19 pandemic. Further, the escalating global increase in CO2 emissions calls for radical energy use reduction from the building sector.'

What are the advantages of the project's interdisciplinary and collaborative approach?

'The research will establish new knowledge development by applying an interdisciplinary methodology with researchers utilizing their disciplinary perspective, collaborating with stakeholders with the societal connection providing knowledge, systems, and indoor spaces. The methodology will utilize a collaboration network that will be established and activated. With the support of the network, the project will set up and evaluate a methodology to design sustainable buildings with healthy indoor air and minimal risk of disease transmission. The results suggest best practices for the design of future sustainable buildings with a healthy indoor environment.'

What is happening right now?

'Right now we are focusing on building up the actor network and to understand how different actors have tackled the pandemic. A survey is to be found on buildingspostcorona.se where we ask how different actors have used the recommendations from different authorities. This to identify if actors have found the recommendations of value or not, and if they have implemented any building related changes, such as changed ventilation flows, operating schemes etc. We have also sent in a new larger application to Formas to start a research school on the topic of sustainable and healthy indoor environments. Also here we see that collaboration is key to success. Hence we have divided the research school on KTH, Chalmers, Umeå and Lund Universities.'

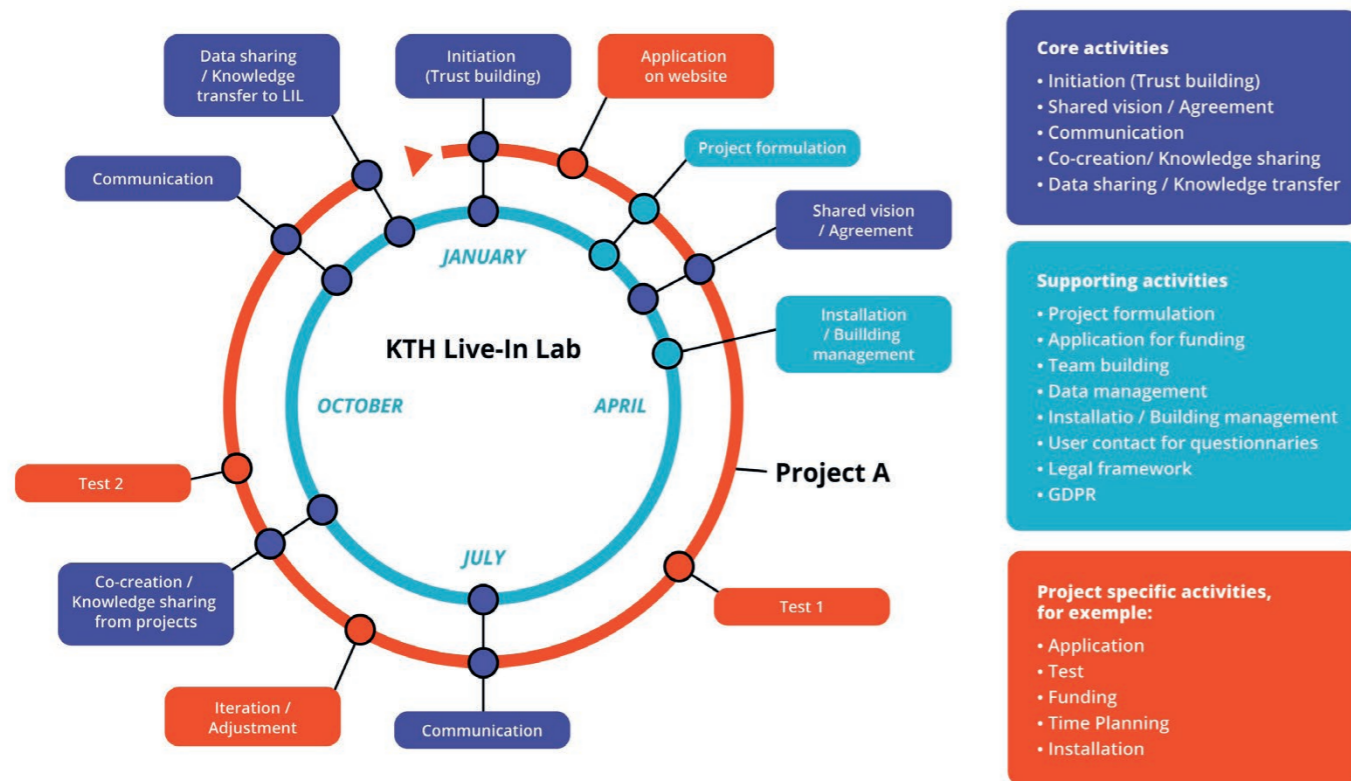


Figure 1: The KTH Live-In Lab project process.



“

KTH Live-In Lab functions as a collaboration platform and infrastructure, generating both knowledge, results and commitment.”

THE IMAGE IS A MONTAGE

Impact & Outreach

Examples of KTH Live-In Lab's impact and outreach during 2021

1. KTH Live-In Lab has supported and played an important role in the start-up of Jamtli Living University as well as the initiation of the future 'Lund Living Lab'.
2. Recommended by the sustainability manager of MIT, KTH Live-In Lab was presented to the vice-counsellor of MIT with the idea that MIT should build similar labs and share resources and data with KTH.
3. KTH Live-In Lab's concept of testing and sharing results and data has been presented in national TV, radio, Dagens Nyheter, Svenska Dagbladet and industry press such as Kyla & Värme, Energi & Miljö, Byggindustrin, Ny Teknik, Elektrikern, Filter and Fastighetstidningen.
4. Representatives from KTH Live-In Lab were involved in the development of Modernare Byggregler (modern building regulations) and proposed the introduction of a building requirements committee that could accelerate the pace of innovation by transferring responsibility from individual municipalities to the state. The proposal has been well received by most of the public construction sector. The rest of the suggestions in Modernare Byggregler, however, has not been as well-received which is why the Swedish National Board of Housing, Building and Planning is revising the proposal at the time of writing.
5. KTH Live-In Lab is featured on IVA's list of 100 current research projects with the potential to be beneficial, for example through industrial commercialization, business and method development or social impact.
6. KTH Live-In Lab is a test bed in ERA-Net Smart Energy Systems: eranet-smartenergysystems.eu/II/708/preview.html
7. KTH Live-In Lab is actively collecting and sharing data from the test beds and projects carried out within the framework of KTH Live-In Lab. KTH Live-In Lab's database (or Datapool) is used by researchers, collaborators, teachers and students. Many degree projects and courses have used data regarding everything from ventilation and water studies to cyber security and user behaviour.
8. Through research projects, KTH Live-In lab has contributed to three buildings, containing 305 student apartments on KTH Campus, built as plus energy buildings.
9. KTH Live-In Lab has initiated projects with upper secondary schools and the development of the courses "Technology 1 and 2" in collaboration with Vattenfallsgymnasiet in Forsmark.
10. KTH Live-In Lab has held presentations during Swedish Research Night (Forskardag) with the message that sharing everything from data to physical spaces and services is a resource-efficient way to operate.
11. KTH Live-In Lab has initiated a series of "Live-sessions" where companies and researchers discuss various problem areas related to a specific theme, with the aim of creating solutions and formulating projects.
11. KTH Live-In Lab has inspired and contributed to Akademiska Hus initiating its project on digital twins on campus. The project has the potential to have a major impact on the utilization of premises and resource optimization and may also contribute to future new services.

Key performance Indicators

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-creating 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

Develop methods for knowledge transfer from project activities to society. In this project, two processes have been developed: the project process (see figure 1) and the dissemination of knowledge and impact (see figure 2 below). Commitment and knowledge are partly linked to the project participants, which is why a model for trust and collaboration has been developed (figure 1) and a model for disseminating so-called implicit knowledge (figure 2). It is of utmost importance that the project members' knowledge from collaboration as well as from project implementation is managed and followed up to ensure that it is disseminated within the organizations. Further collaboration, joint activities and follow-up studies lead to societal change and real impact.

Value making data from buildings

KTH Live-In Lab collects data from testbeds, so called 'trusted buildings', and from completed projects and makes this data available to others. KTH Live-In Lab also ensures that the data made available is in accordance with current rules and laws, such as GDPR. The work revolving around data management has been carried out in collaboration with the centre partners Schneider Electric and Akademiska Hus, as well as partly in collaboration with KTH IT, Stockholm University and HSB Living Lab. The work has been partly financed by Digitaliseringsplattformen. The work has resulted in KTH Live-In Lab being able to collect and make data available, and that aspects such as GDPR and ethics reviews have been investigated by two consecutive research projects funded by Smart Built Environment (see table 7a).

Education 2021

The focus of this project lays on developing an education operation linked to the project operation and the utilization of knowledge. This project has resulted in proposals for the design of future education linked to KTH Live-In Lab, and several ongoing and completed activities such as week-long case studies in collaboration with the industry.

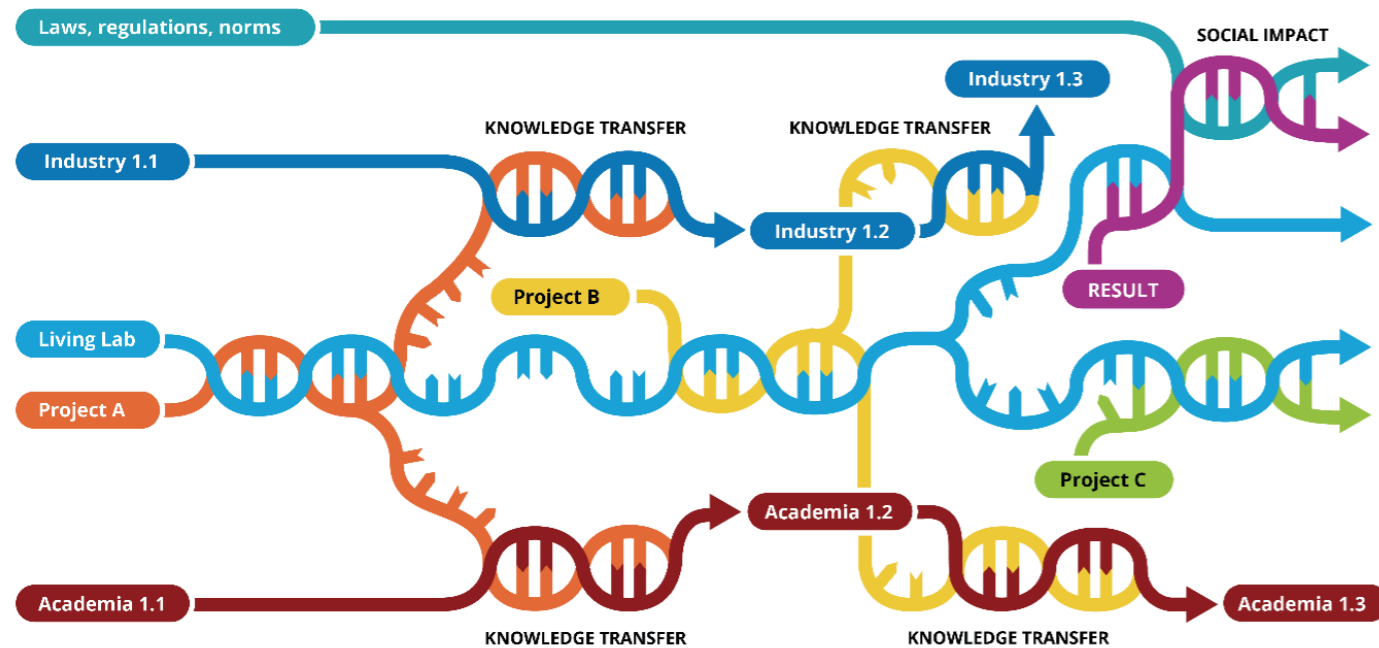
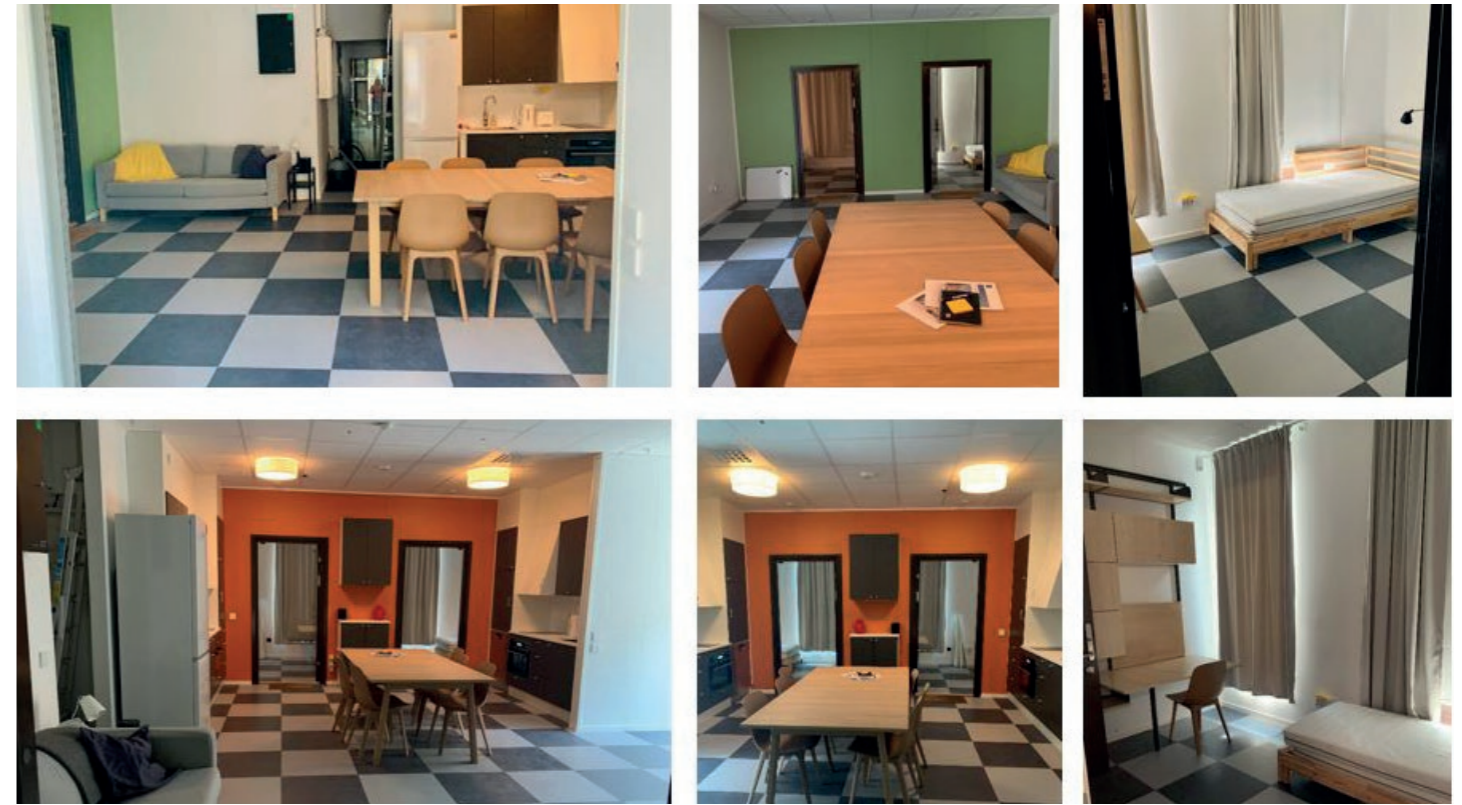


Figure 2: Knowledge transfer and impact in the form of DNA and m-RNA in relation to KTH Live-In Lab.



Testbed KTH.

KPI – Research

KPI	Target 2020	Results 2020	Target 2021	Result 2021
Number of ongoing projects	10	16	10	16
Number of new projects	5	6	6	5
Number of new collaborations leading to applications involving the KTH LIL	4	5	5	5
Number of projects initiated by the KTH LIL management group	1	3	1	3
Number of scientific publications made possible through KTH LIL	2	5	3	7
Number of cross-disciplinary scientific publications	1	4	2	4
School-wide project collaboration	50%	47%	50%	56%
Number of spin-off projects	1	2	1	3

KPI – Impact and communication

KPI	Target 2020	Results 2020	Target 2021	Result 2021
Public presentations (discussion articles, newsletters, communication activities)	10	19	10	15
Seminars and workshops	6	8	6	10



CENTRE PARTNER

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, rock heat 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: 0,64- W/(m²*K)

The energy system

- 3 heat pumps x 60kW
- 667 solar panels
- 4+1 ventilation units (FTX)
- Geothermal heating, 12 bore holes, 3 185 meters
- 315 Building Controller Transmitters (BCT) for smart management of technical systems



CENTRE PARTNER

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.

More housing also 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.

Akademiska Hus provides the Teaching House at the KTH Campus as a testbed to enable testing and research in collaboration with the KTH Live-In Lab. The Vinnova initiative aims to make it possible for new competitive environmentally sound and sustainable products and services to reach the market more quickly.

Akademiska Hus, together with Einar Mattsson, Nordic Choice Hotels and Schneider Electric, have cooperated with KTH to enable an increase in the

number of testbeds within the KTH Live-In Lab. Thus, in 2018, the KTH Live-In Lab went from being associated with a physical testbed to becoming a platform that coordinates multiple testbeds.

The Akademiska Hus testbed

- Inaugurated October 2017
- Total area about 3500 m²
- Designed according to the wishes of teachers and students
- Educational tool for aspiring architects and community builders
- floors, 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).



CENTRE PARTNER

Schneider Electric

Schneider Electric wants to contribute to a more innovative construction sector and therefore deepened its cooperation with the KTH Live-In Lab in 2019. Schneider Electric will actively participate in research and development at the KTH Live-In Lab for three years through consulting, services, and technology.

‘With an increasing world population, digitalization and increased energy use, especially in buildings, the demand for innovation and sustainable solutions for buildings is greater than ever,’ says Andreas Finnstedt, Vice President, and Head of the Digital Energy business area at Schneider Electric. ‘We need to collaborate and together create solutions for sustainable buildings and cities that utilize our resources in a smart way.’

‘Our ambition is to contribute to this development and create tomorrow’s buildings and projects that can meet new demands and needs. The KTH Live-In Lab is an opportunity for

us at Schneider Electric to test new solutions, products and services that contribute to more sustainable development.’

‘So far, Schneider Electric has installed smart home solutions (Wiser Energy, KNX), the IoT platform EcoStruxure™ Buildings Operation, which is open, secure, and scalable, the connected security system Security Expert and electric car charger EVlink. The installations are monitored and optimized and can be adapted by 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:

- Smart home solutions (Wiser Energy, KNX)
- IoT platform EcoStruxure™ Buildings Operation
- Connected security system Security Expert
- Electric car charger EVlink



CENTRE PARTNER

Bengt Dahlgren

The technology consulting company Bengt Dahlgren wants to contribute to a more sustainable and innovative construction sector and is therefore joining KTH Live-In Lab as a center partner in 2022.

Bengt Dahlgren will provide KTH Live-In Lab with knowledge about among other things, digitalisation, 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 test bed made to enable research into the potential of digitalisation for the design, production, and management of smart and sustainable buildings.

‘The digitalisation of the construction sector is one of the major challenges the industry is currently facing. A digital test bed increases the legitimacy and credibility of the research that is going on at KTH Live-In Lab and 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, 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 will play an important part in the development of KTH Live-In Lab’s new, digital testbed: Testbed X.

Bengt Dahlgren’s collaboration with KTH Live-In Lab will run from 2022 to 2024.

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!**

Get our newsletter

For updates on current and upcoming projects, seminars and more,
sign up for the KTH Live-In Lab newsletter:

kth.se/en/2.88186/nyheter/nyhetsbrev-1.894666

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