KTH Live-In Lab

Annual report 2020

"Learning happens in the course of the experiment itself"
Esther Duflo, The economist as a plumber, 2017

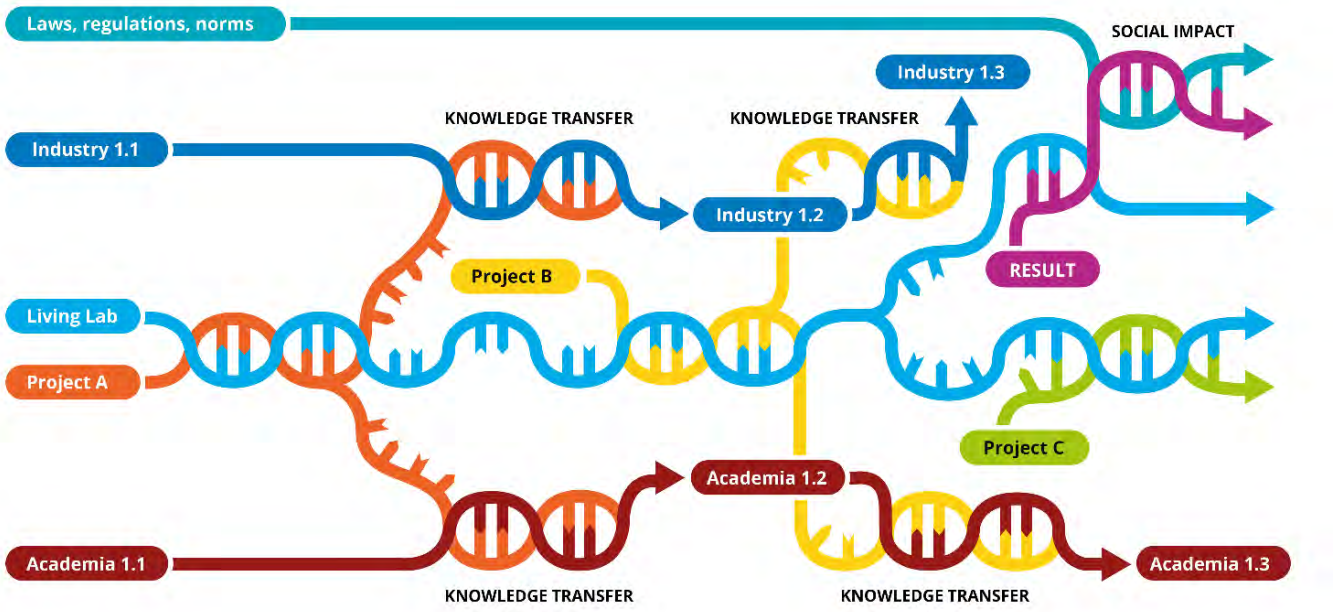


FIGURE 1: IMPACT AS DNA AND M-RNA OF KTH LIVE-IN LAB

The longevity of the organization Live-In Lab ensures stability, trust and knowledge sharing. This is illustrated in Figure 1 above. Projects performed in relation to the KTH Live-In Lab (using the infrastructure, data, management, knowledge, platform etc.) are performed as cross-disciplinary projects and most often as collaboration between industry and academia. Projects develop, learn and share result with the KTH Live-In Lab (data, reports, infrastructure or increased personal competence), then individual actors in each project bring parts of the complex knowledge back to the mother organization (be it industry or academia).

Learning then also occurs at the mother organization; much of the complex knowledge (phronesis or tacit knowledge) is practical wisdom learned through experience from working within the complex project, which can be difficult to explain in words or transferred using reports or presentations.

This type of knowledge or wisdom is transferred from person to person by learning in teams. At the same time, results and data from earlier projects are archived at the KTH Live-In Lab, resulting in unbroken information chains between earlier and subsequent projects and also minimizing the launch time for follow-up projects. Because follow-up projects also share knowledge, an increasing amount of knowledge is transferred from projects to the KTH Live-In Lab.

Finally, the KTH Live-In Lab can do something actors in single project cannot do: collect enough validated results to open up the 'DNA' of knowledge and transfer results to society. This is done by sending out a package of validated information, 'messenger rNA' from the KTH Live-In Lab. This is how we believe that the KTH Live-In Lab, and living labs in general, can accelerate innovation and make smart and sustainable buildings and cities a reality that is within our reach.

Contents

2021 through director Jonas Anund Vogel

" Making Living Labs a national interest. We collaborate with HSB Living Lab, Jamtli Living Lab, also aiming to start Lund Living Lab"

2020 has once again been a very exciting year for KTH Live-In Lab as a research center

We received 19 applications this year: 13 have been accepted, and three of them are now funded and started January 2021. However, we have room left for more cross-disciplinary R&D, and we encourage you all to join our quest to make smart and sustainable buildings a reality that is within reach.

One interesting finding from 2020 was that many of the issues related to innovation in the built environment have less to do with technology and more to do with organizational structures and competence. Hence, we have started research related to the educational needs associated with smart buildings. This is performed by post-doctoral researcher Per Fagrell. Over the winter of 2020 he has been interviewing some of the property owners and facility managers that are connected to the KTH Live-In Lab to investigate competence needs and how the KTH Live-In Lab can encourage lifelong learning.

Speaking of learning, during 2020 the KTH Live-In Lab was involved in 11 courses, reaching hundreds of students; our research affiliates also supervised a handful of excellent master's thesis projects.

2020 was a rather quiet year for the otherwise-busy KTH Live-In Lab. Our offices used to be fully booked and our coffee machine loaded from morning to late in the evening, but this year we – as so many others – have had to close down. To make up for this, we developed a 3D video in collaboration with SISAB. This video has been of great help and has been presented to hundreds of viewers: for example, at the inaugural Digital Future conference, Digitalize in Stockholm, the CETIS conference, and Open House Stockholm. Click this link for a digital tour of our facilities: 3D Virtual tour in our Testbeds

Following the digital trend, we have further developed our Datapool. Data from our testbeds have now been used in many courses, for thesis projects, for KTH research and also for projects with collaborating researchers in Europe and the United States. Data for buildings is, however, a fast-developing area, and so we are developing as well. New and updated systems will be installed in 2021, making it easier to access data and manage associated regulations and laws.

To make sure we stay atop of things, we have strengthened our team with the addition of Co-Director Davide Rolando, a database expert! Read an interview with Davide on page 29.

Most projects performed in or in collaboration with the KTH Live-In Lab have been organized by Swedish researchers and organizations. In order to reach an international audience, the Live-In Lab applied for and has been accepted as a member of the JPP ERA-Net SES Living Lab & Testbed Network. Not only that, but professor Björn Palm, in Energy Technology, is also heading up the connection between the KTH Live-In Lab and ERA-Net. Welcome aboard, Björn!

JONAS ANUND VOGEL OUTSIDE THE OFFICE AT TESTBED KTH

We are also working towards increasing national interest in living labs. Using our knowledge and collaboration with the HSB Living Lab, we are now helping to launch the Jamtli Living Lab and Lund Living Lab.

The shape-shifting of our Testbed KTH is of great value for both researchers and students. Our four separate apartments this summer were turned into a single co-living unit. Another remodeling will take place in summer 2021, all based on findings and research questions in the ongoing research project Co-Kitchen.

Lots of interesting ideas have been developed, of which the 'Virtual Mom' is perhaps the most amusing. Read an interview with Sara Ilstedt and Martin Sjöman on page 18, and more details about the shape-shifting of Testbed KTH on page 27

I would like to end this short introduction by thanking everyone who makes our daily work at the Live-In Lab possible. The board who guides me and my colleagues in the right direction. Thank you Per Lundqvist, Anne Håkansson, Martin Fors, Susanne Malmgren and Charly Lupart.

The executive group that, without any specific funding, supports the work of the Live-In Lab. You are dedicated and engaged people, and that is something that is needed to solve complex problems and challenges!

Thank you, Safira, for managing the Live-In Lab and its day-to-day activities in a fantastic and engaging manner. Great work! And thank you to all who use the Live-In Lab in your projects and courses and who live in our apartments. You all ensure that the Live-In Lab is a living lab!

Research in the KTH Live-In Lab

Projects	2015	2016	2017	2018	2019	2020	2021(until now)	Total
Applications	3	17	13	10	8	19	4	74
Started	2	1	2	9	10	7	1	32
Finished(By the end of the year)	0	0	3	3	5	4	0	15
Total Ongoing 2020(whole year)							17	

TABLE 1 – PROJECTS NUMBERS SINCE THE START OF KTH LIVE-IN LAB

Projects 2020

There were a total of 17 projects in progress during 2020. Almost all were implemented as cross-disciplinary collaborations involving both industry and academia. All projects are assigned a number consisting of the application year and month.

To read more about all the projects at the KTH Live-In Lab, please visit: KTH Live-In Lab Projects

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)
1612 - Improved borehole technology for geothermal heat pump development (two project applications as part of one overarching project: 008–Testbed for future borehole heat exchangers)	Alberto Lazzarotto, Willem Mazzotti, ITM (KTH, Akademiska Hus AB, Avanti System Aktiebolag, Bengt Dahlgren AB, Climacheck Sweden AB, Einar Mattsson, Geobatteri AB, HP-borrningar i Klippan AB, MUOVITECH AB, Nowab AB, SINDEQ Borrteknik AB, SWECO Environment AB, Stures brunnsborrningar AB, Svensk Energi & Kylanalys AB, Triopipe Geotherm AB, Tyréns AB, Wessman Entreprenad AB, KTH Live-In Lab, Thermia Danfoss, Energimyndigheten, Brugg Cables, Asplan Viak, NTNU, WellPerform)
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
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,
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

TABLE 2- PROJECTS 2020

Results from projects conducted in the KTH Live-In Lab

Improved Borehole Technology for the Development of Geothermal Heating Systems

This report presents the final results of the project Improved Borehole Technology for Geothermal Heat Pumps, whose development was financed by the Swedish Energy Agency.

The project started in May 2017 and finished in June 2020. The project was led by Dr Alberto Lazzarotto, and the work was carried out by Alberto Lazzarotto and Willem Mazzotti Pallard, both from KTH, the Royal Institute of Technology. Visiting students Adrien Vautrin from Insa Strasbourg, and Thierry Richert from École Centrale de Lyon, provided significant contributions to the project.

Riccardo Sven Risuleo, a post-doctoral researcher in machine learning at the University of Uppsala and KTH, also provided key contributions. The project benefited from in-kind contributions from Akademiska Hus, Asplan Viak, Avanti, Bengt Dahlgren, ClimaCheck, Einar Mattsson, Energi och Kylanalys, Geobatteri, HP Brunnsborrningar, Muovitech, Nowab, the Norwegian University of Science and Technology (NTNU), Palne Mogensen AB, Sindeq, Solifos, Stures Brunnsborrningar, Sweco, Thermia, Triopipe Geotherm, Tyréns, WellPerform, and Wessman Drilling Solution.

This project was conducted at the KTH Live-In Lab as part of their practical experiments.

!To read the final report, visit the following link: Improved Technology for Geothermal Heat Pumps Development

THIERRY RICHERT, ADRIEN VAUTRIN AND ALBERTO LAZZAROTTO CHANGING THEIR TEST RIG AND GETTING THEIR HANDS (AND FLOOR!) DIRTY

RESEARCHER ADRIEN VAUTRIN IN THE MECHANICAL ROOM OF TESTBED KTH

Main research questions

1. The bias linked to the traditional MSE approach was investigated theoretically
2. Input informativeness was investigated both using data and theoretically
3. Non-parametric identification methods were investigated, with an emphasis on spectral methods and the FIR model
4. Finally, parametric methods were investigated. Models were trained on a portion of one thermal response test and checked against the validation set

Results

- It was shown that the bias induced by input noise should be proportional to the Frobenius norm of the impulse response. For a set of realistic parameters, it was shown that this norm is small in comparison to the variance term of the output. Some numerical examples were used to highlight the bias induced in the estimation of the ground's thermal conductivity.

- The spectral approach was not conclusive, although it would be potentially very useful since the true response of the system is obtained. Being successful in this approach most likely requires further digital signal processing. An FIR model of a TRT system using the equations for an ILS model was derived. This can be used as an indicator of a learned model's suitability. Ultimately, this was used in the model learning step to provide a priori on the expected shape of a model's input/step response, as well as its frequency response.

- The identified models were transfer functions, ARX, ARMAX, Box-Jenkins and Output-Error models. Rather than deriving the thermal properties from the value of the parameters identified in each model, the step response for each model was computed and then interpreted using the state-of-the-art ILS model. The models showed some ability to estimate the thermal properties of the ground as compared to a time-superposed ILS using a Newton-Raphson optimisation method. Nevertheless, the results were very dependent on the chosen optimisation period; this may be partly because the behaviour of the system is different from expected, but may also be due to having finite impulse responses within the test duration. This means reaching a steady-state while performing the TRT, which does not happen in reality.

Although they were not always successful, the system identification methods showed some potential for the TRT application. Besides investigating the methods used in this study further, some other points for investigation could be explored. Using a Kernel-based regularisation procedure is one; here, it is shown that that the ILS model has an impulse response, with the behaviour A 1 t e –C t, so this could be used as a basis for Kernel regularisation. Synthetically replicating the signal or mirroring it to improve digital signal processing is one lead that merits investigation.

Our initial hypothesis – that system identification methods can be used to reduce the test duration (which at 3+ days is currently quite long) – remains to be fully assessed. To do so, we need a better understanding of the accuracy of the estimation (variance of estimated parameters). Using another set of inputs/outputs is possible and could be a sounder approach: e.g., the outlet temperature of the borehole heat exchanger as an output and the inlet temperature and flow rate as inputs. Finally, system identification could be used to better understand and characterise the short-term behaviour of heat transfer inside borehole heat exchangers.

TOP OF THE COAXIAL BOREHOLE.
SOURCE: REPORT IMPROVED BOREHOLE TECHNOLOGY

Interview

Both Dr Alberto Lazzarotto and doctoral student Willem Mazzotti Pallard answered some questions about their collaboration with the KTH Live-In Lab as part of their project:

How beneficial was it to use the KTH LIL in your research?

Having access to a test borehole was very valuable supporting theory with tests makes for a stronger research paper, in my opinion. On the other hand, I don't think our project was at a stage where we could use all the features of the KTH LIL, mainly because our system was not fully operational for use in a real building (nor was that the purpose of the research project, either). The 'Live-In' part of the lab could be used more in the next stage of the project: for instance, if the heat pump is used for heating the apartments, implementing some innovative controls such as Model Predictive Control

What is the next step?

Getting more funding to continue the project (still mainly focusing on the boreholes). Going into more depth with our current results and publishing them. Another option would be using the heat pump to heat the apartments and investigate control strategies for the system as a whole. As mentioned above, this would probably require teaming up with other researchers in energy technology and making a joint application.

Do you have any advice about the funding process for researchers?

KTH LIL increases the chance of getting funded, in my opinion. Make sure that your project deals with some innovative component or system that is to be tested in near-real conditions in a built environment. Plan part of the budget for the KTH LIL fees, as well as for activities to coordinate with the lab. Be ready to contribute to shared tasks to help the lab's development.

THE HEAT PUMP FROM THE RESEARCH PROJECT PARTNER, THERMIA , WHEN IT ARRIVED AT KTH LIVE-IN LAB IN 2018

Co-living & productive space usage

In collaboration with the HSB Living Lab, the KTH Live-In Lab, and several industry colleagues, Akademiska Hus ran a collaborative project to get clearer answers as to how to design the shared living and co-living environments of the future.

The entire construction and real estate sector needs to reduce its environmental impact and energy use. At the same time, there is a great need for more housing and non-residential buildings. Today, more and more people are living alone while at the same time the housing shortage is increasing. How can we reduce the need for resources and capital for new buildings by sharing more spaces? Can the collective use of our built environments be an answer to these questions and contribute to sustainability in all aspects - social, ecological and economic?

The answer is probably Yes, But then new incentives and studies are needed that can verify what works and what needs to change in order to be able to influence the current regulations in the right direction to enable increased use and more collective use of our buildings

By conducting this study based in Svergie's two most important research labs for living and building environment, HSB Living Lab and KTH Live-In Lab, there is an opportunity for effect and breadth linked to each location and university, in further studies/phases of the project and in its entirety.

Given HSB living Lab's varied and experimental nature and KTH Live-in Labs' ability to rebuild in the long term for a higher degree of 'shared space', we believe that it is useful to have a study that connects them and examines design, floor plan, common and private spaces in relation to social community and efficiency and what it generates for added value from the user's perspective.

This project led to the final Report 'Framtidens delade boende- En rapport om hållbarhet I livsstil och bostad',

CO-LIVING & PRODUCTIVE SPACE USAGE WORKSHOP [SOURCE: AKADEMISKA HUS]

When building new shared housing projects, we see that approx. 10-15 tonnes of CO2e/capita is a possible guideline value for new construction of shared housing environments.

Through conscious, efficient functional planning and a greater degree of division of housing areas and shared functions, we can increase the number of quality housing options while minimising the climate footprint per individual by more than 50%.

The most important factors in achieving more sustainable housing are:

- There are many points for interaction regarding building design, products, services and shared resources within the accommodation.
- A high degree of space utilisation and division in the housing regarding building design, interior environments, services and products.
- Opportunities for a high degree of generality, flexibility and elasticity (GFE) regarding building design, interior environments, services and products within the accommodation.

Technical structures and resources can all be divided into three categories:

1. The physical building design and the interior design of the living environment.
2. Other technical and physical assets, such as furniture, common means of transport like bicycles and cars, televisions, kitchen equipment, home gyms, etc.
3. Digital infrastructural assets such as communication platforms, booking systems, etc.

To read the final report, visit the following link: 'Framtidens delade boende- En rapport om hållbarhet I livsstil och bostad'

"Coliving provides the opportunity for a more sustainable lifestyle. The more needs the home can meet, the more the resident wants to stay in and use their home. Shared housing also leads to more social relationships. In this way, this type of housing can counteract the trend of loneliness and mental illness that we see mainly among young adults today" says Linda Teng, housing developer and innovation leader for sustainable urban and campus development at Akademiska Hus

"Coliving can make a strong contribution to sustainable social development, which is an important lesson for the construction and real estate sector where we need to significantly reduce our climate impact. The results of the study will form the basis for our upcoming research collaborations and provide guidance when designing innovative and campus-close student housing that will partly contain shared areas. We also hope that the study can provide insights and concrete tools for more people in the real estate industry who want to develop future shared living environments," says Susanne Malmgren, Head of Student Housing at Akademiska Hus.

Service layer design for pro-environmental behaviour in the built environment

This research project is led by Elena Malakhatka and contributes to increasing knowledge on how an integrated approach that iteratively delivers the right data insights will not only improve the quality of life and convenience of citizens in indoor spaces but also contribute to more sustainable cities through more efficient utilisation of scarce resources such as energy and water. Read more about the full research project here, Service layer design for pro-environmental behavior in the built environment

While carrying out the project as part of her PhD program, Elena wrote and contributed to articles and papers about services and users. The latest, co-authored by Elena, Liridona Sopjani and Per Lundqvist, is titled 'Co-Creating Service Concepts for the Built Environment Based on the End-User's Daily Activities Analysis: KTH Live-in-Lab Explorative Case Study'. The paper was published in early 2021 in the MDPI, Multidisciplinary Digital Publishing Institute , an open-access journal Sustainability as part of a special issue on Innovation Management in Living Labs.

The project focuses on the service design process, starting from the users' needs and experience, providing a systematic procedure that links data analysis to human-centred service design. It is only after we understand end users' behavioural patterns and preference that we can create potential strategies for behavioural changes and habits that are designed to be more environmentally friendly. In addition, our study is researching the role of different stakeholders in the process of changing behaviours in ways that benefit the environment. We also propose few methods for co-creation of the new services with multiple stakeholders.

To read the full paper, visit the following link: Co-Creating Service Concepts for the Built Environment Based on the End-User's Daily Activities Analysis: KTH Live-in-Lab Explorative Case Study

'This paper is a product of collaborative work between several stakeholders of the KTH Live-In Lab and the students living there. The project was realised with the support of the Swedish Energy Agency program 'Design for energy-efficient everyday life', says Elena Malakhatka.

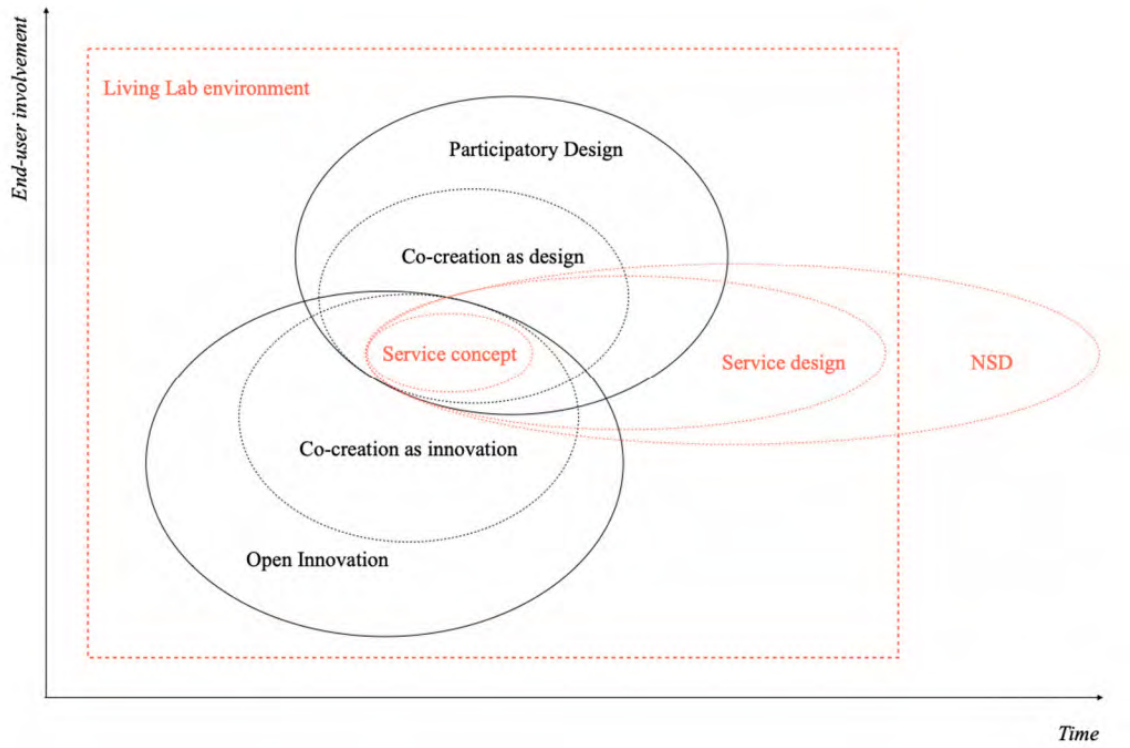
ELENA PRESENTING HER PROJECT IN THE MECHANICAL ROOM IN TESTBED KTH

The main research hypothesis:
Service design processes, tailored through analysis of users' daily behaviours in the built environment context, will give us a better understanding of users' behaviour patterns at home, in general, and point to potential areas to design for behaviours that benefit the environment in particular.

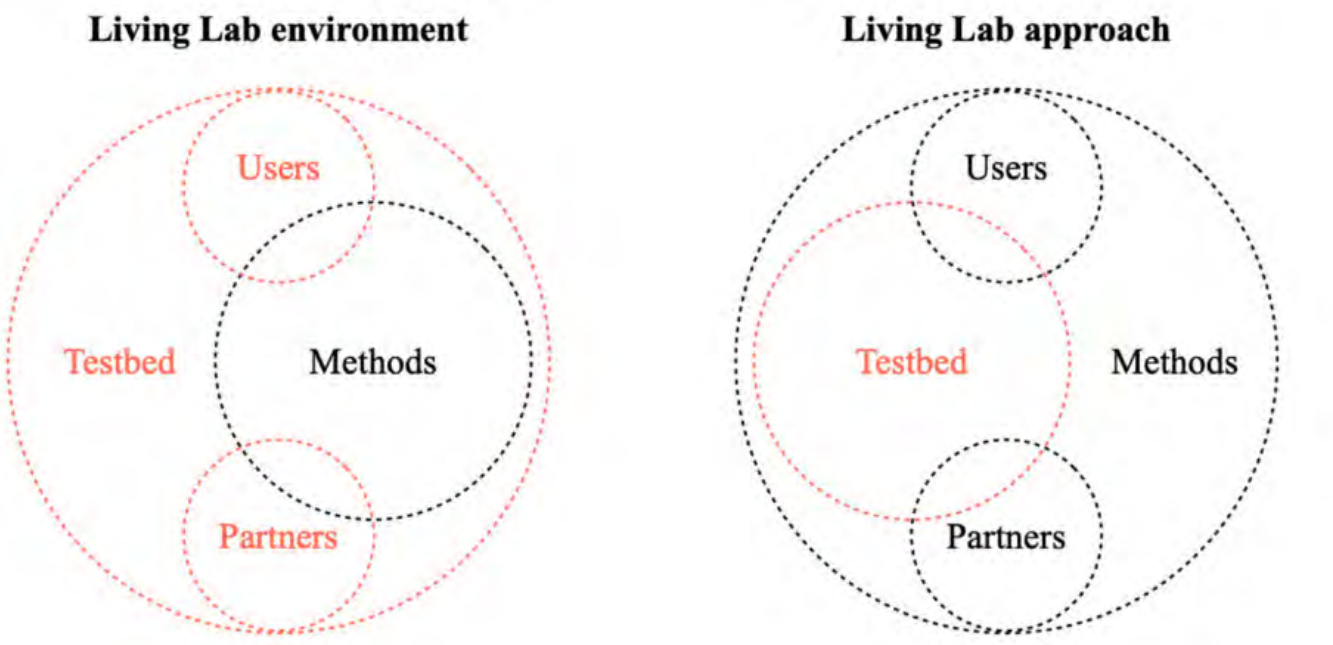
The main research questions were:
- How to implement a human-centric and data-driven approach to the service design process?
- How can services be designed to conserve resources?

Case studies
- Sustainable kitchen project: food-related behaviour analysis
- Personalised thermal comfort modelling with the use of wearable 'Oura ring' device
- Space as a service: potential to re-purpose underused spaces

Results
- New services related to sustainable food habit design can lead to 7-10% electricity reduction and 5-7% water reduction
- Services related to well-being can lead to 5-7% electricity savings and increase overall user experience (UC) 10-15%



THEORETICAL BOUNDARIES OF THE STUDY, WHICH HIGHLIGHT THE OVERLAP OF TWO CO-EXISTED SCHOOLS OF CO-CREATION: CO-CREATION AS AN INNOVATION APPROACH AND CO-CREATION AS A DESIGN PRACTICE. IN OUR STUDY WE CONSIDER BOTH SCHOOLS' THEORIES WORKING TOGETHER IN THE CONTEXT OF THE LIVING LAB AS AN ENVIRONMENT.
[SOURCE: ARTICLE 'CO-CREATING SERVICE CONCEPTS FOR THE BUILT ENVIRONMENT BASED ON THE END-USER'S DAILY ACTIVITIES ANALYSIS: KTH LIVE-IN-LAB EXPLORATIVE CASE STUDY'.]



THE LIVING LAB ENVIRONMENT VERSUS THE LIVING LAB APPROACH.
[SOURCE: ARTICLE 'CO-CREATING SERVICE CONCEPTS FOR THE BUILT ENVIRONMENT BASED ON THE END-USER'S DAILY ACTIVITIES ANALYSIS: KTH LIVE-IN-LAB EXPLORATIVE CASE STUDY'.]

Occupants' pro-environmental choices and behaviours

This project investigated the factors that affect residents' environmental decisions and behaviours, including whether the characteristics of the building play a role.

This project was based on the results from Agnieszka Zalejska Jonsson doctoral studies, which indicate that occupants initially pay little attention to the energy and environmental features of a building due to the inaccessibility of or low exposure to relevant information. Additionally, the difference between expectations and experience may contribute to the doubt towards pro-environmental choices. This disappointment is related to the dysfunction of 'hi-tech' technological solutions such as in-home displays that do not show accurate energy consumption information, operational problems with heating and/or the ventilation system and dissatisfaction with indoor environment quality, where, for example, temperatures are too low in the winter or too high during the summer.

The research study was conducted in collaboration with the KTH Live-In Lab, using a survey to examine how students' worldview varies, and the possible limitations of behaviour with respect to climate change environment. Read the full research project here, Occupant pro-environmental choice and behaviour

The project was led by Agnieszka Zalejska Jonsson. The results of the study led to a paper written by Sara Wilkinson of the School of the Built Environment, University of Technology Sydney, Sydney, Australia, and Agnieszka Zalejska Jonsson of KTH. The paper is published by Emerald publishing, one of the world's leading digital-first publishers, commissioning, curating and showcasing research.

THE RELATIVELY SLOW GROWTH OF THE GREEN RESIDENTIAL MARKET MAY BE RELATED TO CUSTOMERS' PERCEPTIONS OF SUSTAINABLE ASPECTS AND THE WEIGHT OF THOSE FACTORS ON CUSTOMERS' PURCHASING DECISIONS. [SOURCE: PROJECT PAGE AT KTH LIL HOMEPAGE]

Purpose:

Despite awareness of climate change for over 3 decades, per capita energy and water consumption increase and environmental impacts grow. The built environment contributes around 40% of total global greenhouse gas (GHG) emissions; action is vital. Whilst building code standards have increased, rating tools and technology to reduce energy and water consumption are developed; environmental impact grows because of human behaviour. In the tertiary education sector, student accommodation constitutes a large part of the property portfolio, contributing significant amounts of GHG emissions and environmental impact. Property Managers can educate and install systems and technologies to improve behaviour if they understand it.

The main research question

Explore how student's worldviews vary and the possible limitations on behaviour in respect of climate change. In total, 71 responses from international university students living in residential accommodations on Stockholm campuses were analysed.

Design/methodology/approach

This exploratory study used a questionnaire survey to explore how student's worldviews vary and the possible limitations to behaviour in respect of climate change. In total, 71 responses from international university students living in residential accommodation on campuses in Stockholm were analysed

Findings

The results show different perceptions about the environment and actions that are needed, and this leads to different behaviours. Limited knowledge and inability to relate environmental consequences to one's own actions, effective communication and risk averse behaviour, are critical in mitigating climate change. A deeper understanding of participants worldviews and the different resulting behaviours was achieved.

Research limitations/implications

This pilot study involved a small number of participants and future studies should expand participant numbers, including those with more varied backgrounds, education levels and age groups

Practical implications

If property managers gain a deeper understanding the different behaviours of their residents, they can develop effective strategies to facilitate action that will lower the environment impact and GHG emissions of student accommodation.

Originality/value

The knowledge gained about environmental attitudes and human behaviour can help property and facility managers, policy makers and regulators to develop more effective strategies to deliver improved sustainability outcomes.

Some of the conclusions

This research highlighted some of the complex, interactive barriers society faces in taking effective action to address climate change. This well-educated group of young people displayed very varied responses to the many of the dragons of behaviour. These findings suggest the urgent need to look more closely at finding ways to encourage positive behavioural change in all populations before it is too late.

Positive behavioural action in the built environment could lead to, much needed mitigation of the significant impact of this sector. The study contributes to a better understanding of the complex relationships between environmental attitudes and environmental behaviour.

To read the full report, visit the following link: Student accomodations, environmental behaviour and lessons for property managers

Scientific articles from R&D in KTH Live-In Lab

Co-Creation in Living Labs to Accelerate Innovation

Jonas Anund Vogel, Ellen Van Bueren, Leendert Verhoef, Brian Goldberg, Per Lundqvist and Emma Sarin

Abstract

Innovation in the construction sector occurs through stepwise reconfigurations of subsystems, but sometimes the effect of many systems coincides and so-called radical change is achieved. Stepwise reconfigurations of individual systems such as windows, insulation, and heat recovery systems have made it possible to heat buildings with preheated inlet air instead of water radiators. This had made buildings and construction more sustainable, cheaper and resource-efficient, and the potential for radical change has been achieved. The question, then, is why doesn't every new building use preheated inlet air? The reason is not a lack of innovation or new technologies. It is, rather, connected to malfunctioning systemic structures related to incentives, collaboration, testing and validation, leading to norms and standards that aim to reproduce existing technologies and that encourage incremental innovations over radical ones. This article argues that testbeds and Living Labs are a way to work on complex, urgent problems involving multiple stakeholders using co-creation methods. These labs offer possibilities to test technologies within systems in real buildings and cities. There are opportunities to follow up, measure and adjust, and to live, study, work and develop. Living Labs have the potential to standardise the use of new technologies in a few years instead of decades and thus minimise unnecessary use of resources linked to the construction and use of buildings. In addition, it will help to make technologies more user-friendly, considering user needs, desires, and experiences. This will contribute to the effectiveness of the technologies that are developed and tested.

Read the full article: Co-Creation in Living Labs to Accelerate innovation

ICT in the built environment: Drivers, barriers and uncertainties

Marco Molinari, Olga Kordas

Abstract

Buildings are major contributors to energy use and environmental impacts in developed societies. If the ambitious sustainability targets of modern societies are to be met, energy use in the built environment is a central issue to be addressed. Growing momentum to achieve energy efficiency in the building sector has been triggered by developments in information and communication technology (ICT). New opportunities are bringing the concept of smart building closer to reality thanks to innovative sensing techniques, extensive and cost-efficient data collection and analysis, advanced controls and artificial intelligence. However, these opportunities entail associated costs and uncertainties regarding whether investment costs will be repaid in terms of energy savings and whether indoor comfort and air quality will be improved. They also present drawbacks in terms of increased maintenance needs, complexity, reliability and resilience and may have uncertain ramifications in terms of user interaction, data security and long-term effects on society. This paper critically analyses recent research findings and reviews the pros and cons of certain promising ICT technologies being applied in the building sector. It provides examples of drivers and barriers to the implementation of advanced controls and artificial intelligence in buildings based on findings from two testbeds in Stockholm and discusses the implications of these findings for future research.

Read the full article: ICT in the built environment: Drivers, barriers and uncertainties

Ensuring Privacy of Occupancy Changes in Smart Buildings

Rijad Alisic, Marco Molinari, Philip E. Pare, and Henrik Sandberg

Abstract

Smart building management systems rely on sensors to optimise building operation. If an unauthorised user gains access to these sensors, a privacy leak can occur. This paper considers such a potential privacy leak in a smart residential building and how this threat could be mitigated by corrupting the measurements using additive Gaussian noise. The data is corrupted in order to conceal when occupancy changes in an apartment. A lower bound on the variance of any estimator that estimates the change time is derived. The bound is then used to analyse how different model parameters affect the variance. It is shown that the signal-to-noise ratio and system dynamics are the main factors that affect this bound. These results are then verified on a simulator in the KTH Live-In Lab Testbed, finding good correspondence with the theoretical results.

Read the full article: Ensuring Privacy of Occupancy Changes in Smart Buildings

End-user activity context information management framework for sustainable building operation

Elena Malakhatka, Per Lundqvist

Abstract

The concept of sustainable buildings includes not only technological aspects related to energy efficiency and optimised resource usage but also aspects related to end-users comfort, well-being, and everyday needs. To understand end-users' life activities in general, and their preferences in particular, we need to enrich standard Building Management Systems (BMS) with human-generated and personal data. In this conceptual paper, we present an end-user context information management framework, which includes a reasoning layer, an acquisition layer, and a dissemination layer. The proposed framework is currently implemented in the KTH Live-in-Lab – a fully equipped testbed for research and innovation in a build environment.

Read the full article: End-user activities context information management framework

Incentivising innovation in the Swedish construction industry

Doctoral thesis using the KTH Live-In Lab, by Jonas Anund Vogel

Abstract

Almost 40 per cent of global final energy use and CO2 emissions are connected to buildings and building-related activities; it is therefore important to incentivise the design and construction of resource-efficient buildings. Unfortunately, energy demand and associated emissions in the sector continue to grow. Such incentives will help achieve energy and environmental targets, reduce costs and make smart and sustainable buildings and cities possible at a larger scale. Because novel technologies carry risks alongside their advantages, developers, contractors, and consultants must have incentives to reduce and share those risks in a rational way if we are to meet the crucial long-term societal goals of reduced use of resources and emissions. I hypothesise that there are legal and institutional frameworks (rules, building codes, regulations, standard contracts, etc.) that result in weak or negative incentives for construction industry actors to invest in, propose and install resource-efficient technologies. If this hypothesis holds true, then the goal is to identify ways to better incentivise construction industry actors to fully engage in the design and construction of smart and sustainable buildings. To tackle this, four studies were carried out using a mixed-method approach. Paper 1 identifies 38 barriers to energy efficiency in Swedish multifamily buildings.
The next study (Paper 2) develops a categorisation framework in order to understand where to engage so as to overcome or bypass barriers to energy efficiency. Papers 3 and 4 are devoted to analysing two sets of barriers and propose possible solutions to overcome or avoid them.

Read the full Doctoral thesis: Incentivising innovation in the Swedish construction industry

Interview with Sara Ilstedt and Martin Sjöman

Sara Ilstedt is a professor of product and service design at KTH and has a background as an industrial designer. She has been working with design research and sustainability for over 20 years; in 2012 she founded the research network Green Leap, focused on design and sustainability.

Martin Sjöman is a PhD Candidate at KTH with a background as a designer. Martin investigates how design practices can be used in early-stage research to frame complex societal issues such as sustainability transitions. Sara and Martin are part of the KTH Product and Service Design Group in the Integrated Product Development unit.

How are you working to making buildings smarter and more sustainable? Why are you engaged in research and development?

We are dedicated to finding ways to speed up the transition to a more sustainable lifestyle and make it more human-centred. We believe design-methods can help frame and accelerate these complex issues.

Co-Kitchen Project – briefly, what is it about?

The goal of the Co-Kitchen Project is to develop sustainable student housing for the future, referring not only to ecological but also social and economic sustainability. Akademiska Hus is a partner in the project; they are planning to build 6,000 new student residences in the near future, and so the result of this project will feed directly into their work. The project focuses on co-living for students, and particularly on the kitchen as the centre of the home, a place of major resource consumption, social interaction and potential conflict.

What is the purpose? Why is it important?

Living together and sharing spaces and functions has the potential to save large amounts of energy, but we need to know more about how to make co-living function better, socially and practically. Which functions and spaces do people want to share, and when and how do they want to share them? Where are the largest potentials for energy savings? What are the trade-offs, and what may cause unintended side effects or rebound effects?

MARTIN AND SARA IN ONE OF THEIR WORKSHPS IN THE MECHANICAL ROOM IN TESTBED KTH

Why have you chosen to work with KTH through the KTH Live-In Lab? And how have you collaborated with the KTH Live-In Lab?

The KTH Live-In-Lab provides a unique opportunity to build and test different solutions in real life. We have rebuilt the apartment twice and currently have groups of 5–6 students live there for a year. To follow users over a long period provides us with insights about their practices over time and how they change and develop, coupled with user data, which is extremely useful. It's very rare to have this type of long-term testing environment that researchers can monitor very closely. We have already uncovered some very interesting results.

Which other project partners (if any) have you collaborated with?

As our project looks in-depth at the planning, layout and functionalities of co-living apartments, our project partner TIP, an architectural firm, has devised new plans to rebuild the lab apartment in two stages. At this point, several other Live-In-Lab partners will be involved in rebuilding the apartment and performing research based on the user data. Savvy, a service design agency, is looking at student housing as a service and how that can be developed. We also have researchers from KTH Seed that are making detailed lifecycle analyses.

WORKSHOP IN THE MECHANICAL ROOM IN TESTBED KTH

How has the pandemic affected the actual study? Have you thought about any results or goals in connection with the pandemic?

Yes. As previously mentioned, we are exploring how the social aspects of co-living may influence the concept's potential to reduce energy consumption associated with buildings and daily living. For the participants living in the project apartment, spending much more time in a shared home has likely both put more pressure on their social relationships but also offered company in a time that has caused loneliness for many. In a recent interview, our participants stressed how much they appreciate the fact that co-living is 'like a family'. It seems that some co-living concepts we have asked them to experiment with, like shared dinners and cleaning schedules, have really helped them build closer interpersonal relationships.

What is the next step?

Together with our project partner Savvy, we are investigating how some of the structures and conditions that facilitate social cohesion in a co-living context could be turned into services or scaled up in other ways by student housing providers. During the summer, the lab will be rebuilt a second time, and in August a new group of students will move in. That's very exciting!

Education in collaboration with KTH Live-In Lab

Interest in using the KTH Live-In Lab in courses and theses is strong and growing. So far, the KTH Live-In Lab has been used for courses through site visits, workshops, presentations/lectures and a week-long hackathon.

One good example of how the KTH Live-In Lab collaborates with educational programs and industry is that every year we have a case challenge in conjunction with the Energy Systems and Sustainability course, in which industry partners are invited to collaborate and formulate a case that is interesting for both students and the industry partner.

In 2020 we deviated a bit out from the traditional arrangement and held a so-called 'LiveHackLabTM 2020' together with FM Mattson as the industry partner, represented by Frank Rälg, product manager for Smart Products at FM Mattsson Mora Group AB. Page 26 of this report transcribes an interview with Frank.

The challenge takes place over a one-week period; students are divided into groups and tasked with designing an innovative product-service-system (PSS) that can be added to FM Mattson's product portfolio in early 2022. The new PSS should seek to provide something not already established on the market in Sweden or elsewhere. The concept might involve solutions for automation, time savings, communications, cost savings, energy efficiency, water savings, sustainability or coherent experiences.

The tasks included:

- Design the new service conceptually (What does it do? For whom? How does it work? Why is it attractive? etc.).
- Name it! Be creative but try to align with other products in the FM Mattson portfolio.
- Make a prototype app in adobe XD (or similar)
- Describe data and information that need to be exchanged (in all directions) among stakeholders.
- Describe your business model that provides value for end-users, real estate companies and FM Mattson, and hopefully society as a whole. Are further collaborations and partners needed?

The students started the week presenting their projects and holding a kick-off; two pitches were made during the week, and the event ended with the final presentation. A panel of judges from academia and industry judged the final presentations.

The winning group and information about this event were published in Energi och Miljö: KTH-studenter tar fram vvs-system som alla har nytta av

FM MATTSSON WATER FAUCET WITH IOT COMMUNICATION

The following courses have visited or used the KTH Live-In Lab as part of their curriculum in 2020

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

AG2805
Sustainable Planning and Design
Pernilla Hagbert KTH ABE

MJ2443
Heating, Cooling and Indoor Climate
Samer Sawalha, KTH ITM

AI1146
Property Management,
Agnieszka Zalejska Jonsson, KTH ABE

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

Ethics and Compliance Seminar,
Case: Ethical challenges in research collaboration, Jonas Anund Vogel, Live-In Lab and Barbro Fröding. Course managed by KTH RSO

Theses connected with the KTH Live-In Lab in 2020

There is a lot of interest in conducting thesis research using the KTH Live-In Lab, and every year we get more and more questions about thesis projects from students studying in a variety of fields. This is great! Courses and thesis projects often function as a first connection between industry and academia, and all the theses carried out using the KTH Live-In Lab include a one-page proposal for a possible future collaboration project that includes the KTH Live-In Lab and the company/researcher in question.

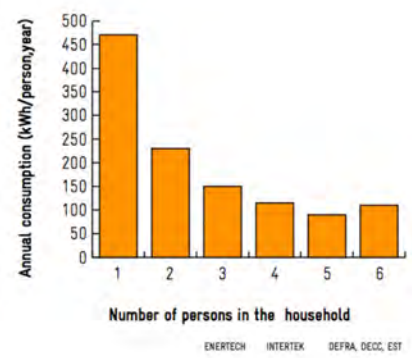
Living together and sharing spaces and functions has the potential to save large amounts of energy, but we need to know more about how to make co-living function better, socially and practically. Which functions and spaces do people want to share, and when and how do they want to share them? Where are the largest potentials for energy savings? What are the trade-offs, and what may cause unintended side effects or rebound effects?

Holistic and Sustainable KPIs for Food Systems

Food is one of the biggest influences on both human health and sustainability. The food sector is responsible for a substantial share of all greenhouse gas emissions in the world, and the demand for more sustainable diets has increased. Individuals are starting to realise their own potential to contribute to a more-sustainable society, and people are willing to change their habits to make them more sustainable. Therefore, the purpose of this study was to create holistic and sustainable KPIs for food systems that encourage improvement. The KPIs aim to measure and quantify sustainability from three perspectives; environmental, economic and social.

Hanna Borgefeldt & Emma Svensson

Download the thesis Holistic and Sustainable KPIs for Food Systems



ANNUAL CONSUMPTION FOR COOKING PER PERSON PER FAMILY UNIT SIZE (OWEN, 2012) - (SOURCE: FIGURE 6 FROM THE THESIS)

Home Energy Management Systems

Global energy consumption has more than doubled since 1990, making energy efficiency and management increasingly important topics on the sustainable development agenda. Home Energy Management Systems (HEMS) are a solution that combines hardware and software for managing, measuring and analysing residential energy consumption and addressing the issue of increased energy expenditure. This report aimed to assess the current market for HEMS in Europe and the Nordic countries and how these markets might develop in the future. It also sought to put the KTH Live-in Lab at the forefront of smart building development by providing them with potential strategic business partners.

Emil Adeli & Gustav Hedman

Download the thesis Home Energy Management Systems

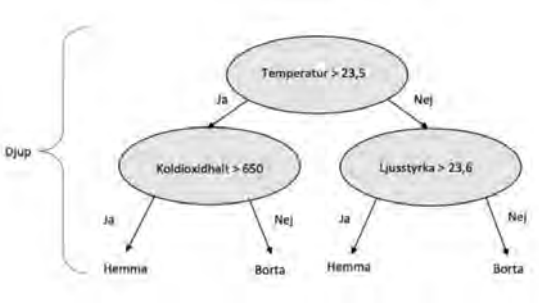
THE FIVE FORCES THAT SHAPE INDUSTRY COMPETITION- (SOURCE: FIGURE 2 FROM THE THESIS)

Application of machine learning to introduce automatic adaptive heating through a study at the KTH Live-In Labs apartments (in Swedish)

The purpose of this study was to investigate whether it is possible to decrease Sweden's energy consumption through adaptive heating that uses climate data to detect occupancy in apartments using machine learning. The study was implemented using environmental data from one of the KTH Live-In Labs apartments. The data was first used to investigate the possibility of detecting occupancy through machine learning and was then used as input into an adaptive heating model to investigate the potential benefits on energy consumption and heating costs.

Emil Vik & Ingrid Åsenius

Download the thesis Tillämpning av maskininlärning för att införa automatisk adaptiv uppvärmning genom en studie på KTH Live-In Labs lägenheter



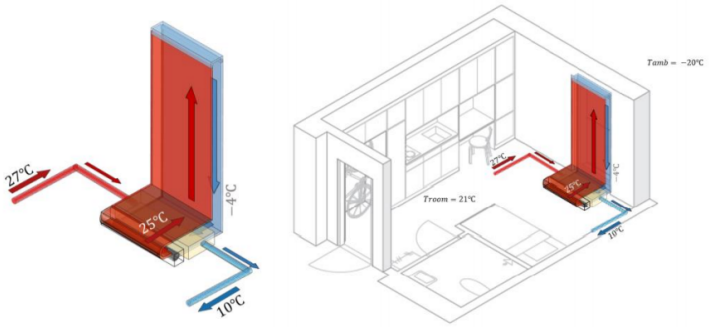
VISUALIZATION OF TREE STRUCTURE FOR THE DECISION TREE ALGORITHM (SOURCE: PICTURE 2 FROM THE THESIS)

LCC and LCA for Low-Temperature Heating Integrated with Energy Active Envelope Systems

Windows have always been considered heat sinks and can account for more than 25% of a building's envelope. For this reason, the design and performance of residential windows play a major role in regulating indoor environments. The construction sector has been investing in better-insulated envelope systems in recent decades to reduce heat transmission losses and household energy consumption.
LOWTE is a Swedish firm specialised in low-energy building components, and the issues above led it to recently developed a double-slot energy active envelope window (EAW) to improve energy savings in buildings. EAWs are a window prototype that integrates low-temperature heating and energy active systems, and they are planned to be installed in the KTH Testbed in Stockholm (Sweden). Waste heat from the current heating systems will be used during their entire operation.

Esther Buitrago Villaplana

Download the thesis LCC and LCA for Low-Temperature Heating Integrated with Energy Active Envelope Systems



EAW DURING COLD PERIOD ACTING AS HEATING RADIATOR UNDER NOMINAL PARAMETERS (SOURCE: FIGURE 18 FROM THE THESIS)

Interview with Frank Rälg-FM Mattsson

Who is Frank Rälg?

I'm the product manager for Smart Products at FM Mattsson Mora Group AB, which is a faucet manufacturer and product developer.

How are you working to make buildings smarter and more sustainable? Why are you engaged in research and development?

As a traditional manufacturing industry, we took a big step into the future a few years ago by launching our IoT-connected faucets, which are part of the smart building trend.

Why have you chosen to work with KTH through the KTH Live-In Lab?

It's a unique facility where we can test our smart products together with users. At the same time, it is also an arena where we can create smart ecosystems together with other actors within the facility.

What products/systems are you testing/developing for the KTH LIL?

We test our smart connected faucets for bathrooms and kitchens.

What is the most interesting aspect of the products/systems you are developing and testing in the KTH LIL?

So far, we have mostly tested the properties of the product itself, but what we want to do in the future is see how we can work together with other systems in the building to further reduce water and energy use.

FRANK RÄLG, PRODUCT MANAGER FOR SMART PRODUCTS AT F M MATTSSON MORA GROUP AB

Recently you participated in a course connected to the KTH LIL and the LiveHack-LabTM 2020, a hackathon for the Energy Systems and Sustainability course.Could you describe the aim of this hackathon?

The goal was to find a new business model for FM Mattsson's connected mixers, targeting a new customer group.

Could you describe what it was like to work together with students to solve a complex task?

For us as a company, and for me personally, it was incredibly inspiring and rewarding to work closely with your students during this week. Seeing how they approached the task and then quickly got started and worked out different proposals was awesome. I can really recommend other companies work this way more often.

What was your most valuable take-away from the event?

In addition to all the good ideas we got for our new business model, I took with me the insight into how this generation of students think and look at the concept of smart systems and smart buildings. I believe that within a few years, we will see completely new approaches to these concepts, and then we, as a company, will make sure to be at the forefront with the help of the insights we gained from the LiveHackLabTM 2020.

Selected news - Research app to help students thrive even better in their apartments

Text by Akademiska Hus

Is the sound from the shared kitchen too loud? Is the room too hot or too cold? At the KTH Live-In Lab, where Akademiska Hus is one of the members, a project is currently being carried out in which residents of Akademiska Hus's Draconis student housing units (a trusted building) can give feedback on their indoor environments in real time.

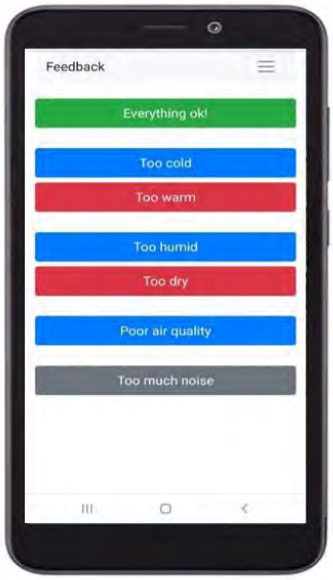
The research project uses a small box containing a handful of sensors placed in the apartments, and an associated web application where residents report their experiences and perceptions related to the indoor environment. With the help of the box, the researchers can measure the apartment's temperature, humidity and noise level.

'I think this project should be implemented in all apartments, along with information about your own energy consumption,' says one of the students involved in the study.

When the tenants participating in the study feel like their apartment is too cold, they can note this in the application. The researchers can then compare the tenant's input against data from the sensors in the box and then analyze how the space's different systems are working at the time in comparison to the perception of the indoor environment. This way they can hopefully learn more about how people feel in their homes.

Do you want to make us more attentive and energy efficient?

It is researchers Marco Molinari and Davide Rolando at KTH who are the driving force behind the research project, together with Akademiska Hus industrial doctoral student Katarina Bäcklund. They are interested in how people are affected by the buildings they live in and how to build houses that encourage residents to become more energy efficient.



WEB-APP INTERFACE

'We have previously researched the field of energy use, where we looked at data from buildings. We have long noted that the indoor climate in buildings is not as good as it should - and could - be. We believe that sensors and data will be central to achieving more sustainable buildings. Sensors can help us use resources more efficiently and improve the indoor climate in a cost-effective way,' says Marco Molinari.

Having a web application that is both simple and meaningful to use has been an important part of this research project, says Davide Rolando:

'We usually get feedback from study participants when there are problems with the indoor climate: for example when we can observe low temperatures from the sensors. There seem to be different types of users - some are more active, others less active.

Read more about the project here: Cost- and Energy-Efficient Control Systems for Buildings

Infrastructure and database

There are many interesting things to discuss regarding infrastructure and the database. It is not possible to describe everything that's going on, but here we present some features that were changed or added during 2020. For more information, visit our website and navigate to the 'Datapool' and 'About us' pages.

Testbed KTH – Rebuilt from four separate apartments into a co-living unit

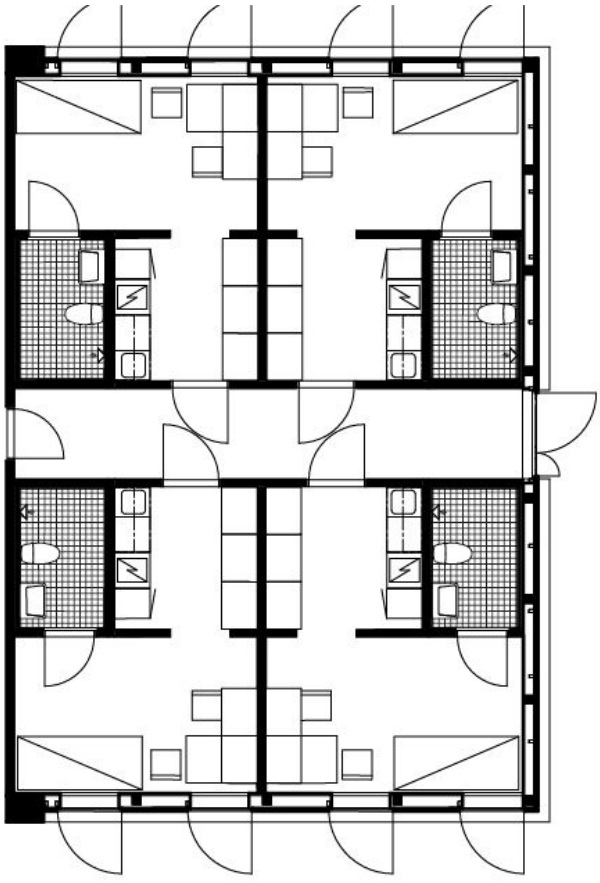
The four one-bedroom apartments at Testbed KTH were rebuilt during the summer of 2020 into co-living units with a shared kitchen and living room and four single bedrooms with private bathrooms. The flexible infrastructure at Testbed KTH made this shape-shifting easy. A few walls and two kitchens were removed, doors were moved, and walls were painted in appealing colours.

The reconfiguration was carried out based on findings from the research project 'Co-living and efficient space usage', as well as input from researchers and partners in the Co-Kitchen project led by KTH professor Sara Ilstedt, PhD candidate Martin Sjögren, and Linda Teng, a developer at Akademiska Hus.

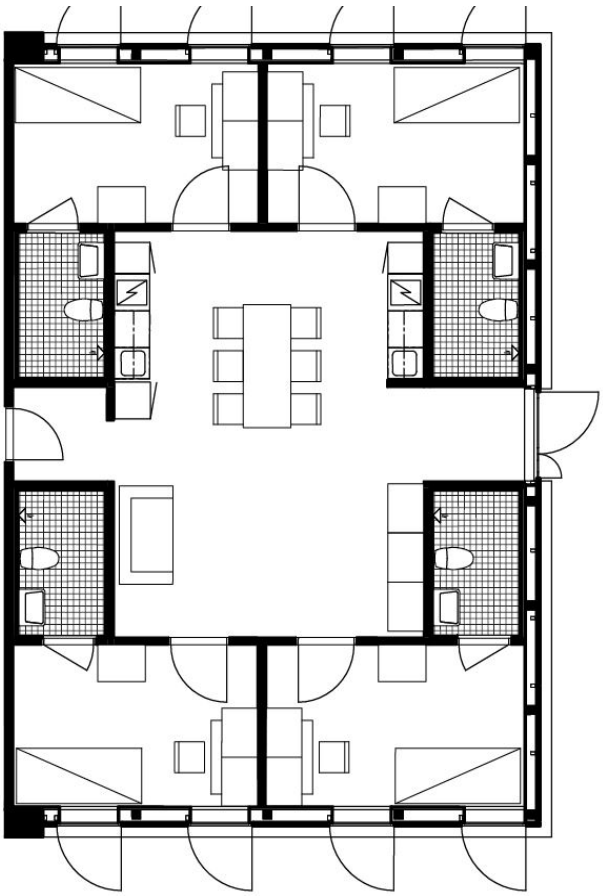
The interior design was developed in collaboration with industry partners Savvy and TIP. The aim of the project is to study social interactions and requirements from the tenants' perspective with the aim of developing standard layouts for future co-living. You can read more about the project here: Co-Kitchen

WALLS WERE REMOVED, AND SENSORS, LIGHTS AND VENTILATION WERE MOVED TO NEW POSITIONS.

INTERIOR OF TESTBED KTH AFTER REMODELLING AND PAINTING



LAYOUT OF TESTBED KTH FROM 2018 TO SUMMER 2020. FOUR SEPARATE STUDENT APARTMENTS WITH THEIR OWN KITCHENS AND BATHROOMS.



LAYOUT FROM SUMMER 2020 TO SUMMER 2021. CENTRAL WALLS WERE DISMANTLED, AND TWO KITCHENS WERE REMOVED.

Datapool and data management

Our Datapool, developed in collaboration with the KTH Digitalization Platform, was released in the summer of 2020. The idea was to make it easier for researchers, students, teachers and collaborating industry partners to get their hands on real data. Why? Well, it is not easy for anyone to access data that can be used to develop new systems, tools and appliances that can make buildings and cities smarter and more sustainable. Our aim was to deliver that data, either as historical GDPR-compliant datasets or as real-time data through apps or systems.

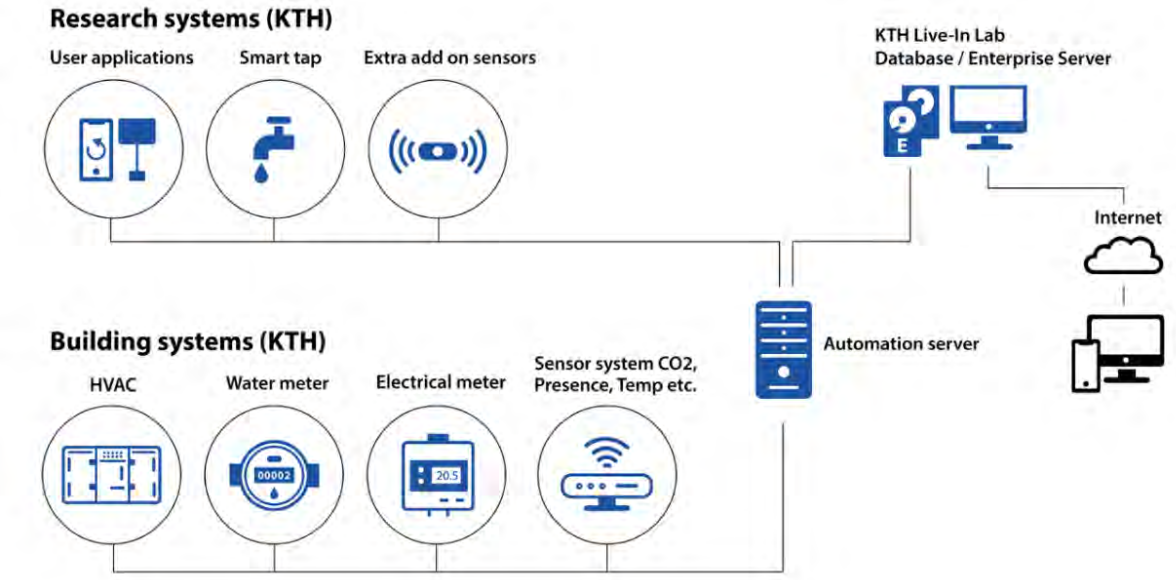
KTH Live-In Lab's Datapool is the new section on our website for research data from our Testbeds (buildings), research results, smart systems information, sample data, data visualisation and information about the data structure of all our Testbeds.

There are two ways of accessing data from the KTH Live-In Lab:

- Students and teachers can request data for projects, bachelor's theses and master's theses.
- Researchers and industry partners can access data from our Testbeds by applying to undertake a project with us

In addition to data, we also present information about the sensors and systems that deliver the data. Building management systems and databases are constantly being updated and developed, and so is our Datapool.

If you would like to see what types of data we can deliver, you can download sample data at Download Sample datasheets



TESTBED KTH DATA SYSTEM

Davide Rolando, the new Co-Director of the KTH Live-In lab

Right now, we are working on a web interface that will automate the process of storing and sharing data to and from projects. This vision for a more automated process demands the right resources and skills, and so we have expanded our team and added Davide Rolando as Co-Director, with the focus on data management and implementation. But who is Davide? We asked him, and here is what he said:

My name is Davide Rolando, and I have been a researcher in the KTH Energy Technology Department since 2016. My experience at KTH started in 2014, though, when I was a visiting PhD student for about seven months, working on a heat extraction thermal response test in Hammarbyhöjden, Stockholm. During my PhD at the University of Genoa, Italy, I worked with modelling and design of ground source heat pump systems; my collaboration with KTH led to my post-doctoral project 'Smart Control Strategies for Heat Pump Systems (1)

Since my post-doc project, my research focus has been broadening, moving from the ground level to the building system level, and my direct involvement with the KTH Live-In Lab started in 2018. In 2018, together with my colleague Marco Molinari, we started to develop a project proposal on 'Cost- and Energy-Efficient Control Systems for Buildings' (2) . The project is currently ongoing, funded by the Swedish Energy Agency as part of the E2B2 Research Program (3) .

My interest, curiosity and passion for IT, programming and electronics have driven me throughout my engineering and research career. I therefore feel that being involved in the KTH Live-In Lab platform is an exciting and challenging experience that feeds those interests.

The KTH Live-In Lab is, of course, an exciting platform that can inspire innovative research projects and bridge the gaps between the academy and the construction industry. Data infrastructure is a fundamental part of the Live-In Lab platform, and its challenges and complexity require constant efforts and supervision.
Since November 2020 I have been a 20% Co-Director at the KTH Live-In Lab, with the role of supervising the ambitious plans for the Live-In Lab data infrastructure, so it will stand as a reference and example for the research community and the Swedish construction industry.

The sensor network installed at the KTH Live-In Lab is a unique example of state-of-art sensing technology through which researchers can develop projects that can shape the future of the Smart Building sector at the national and international levels. For this reason, it is important that the data infrastructure built 'around' the sensor network provide a solid, secure and versatile experience to all researchers and stakeholders interested in growing together with the KTH Live-In Lab.

Although a lot of hard work has already been done, many efforts are still in progress, and I hope to positively contribute to achieving the ambitious goals set for the near and long-term future. Ad maiora!

1-https://www.energy.kth.se/applied-thermodynamics/current-projects/smarta-kontrollstrategier-for-varmepumpsystem-1.669013
2- https://www.liveinlab.kth.se/en/projekt/r-d-projects/kostnads-och-energi/cost-and-energy-efficient-control-systems-for-buildings-1.945916
3- https://www.e2b2.se/

Since we released Datapool we have gotten more and more data requests, as researchers understand that in order to have a complete picture of data usage, user behaviour and future trends, they need to look at different data types and understand how they can affect each other.

One of the data requests was from students working with Elena Malakhatka and her Oura Ring project. We decided to ask them some questions so we could better understand their perspectives on the KTH Live-In Lab and the data that they requested, please read the following interview:

Please present yourselves

Our names are Anas Al Rahis and Osman Osman, and we're both seniors in the Information and Communication Technology bachelor's program at KTH. We've worked together on multiple school projects in the last three years, and now we're doing our thesis project together.

How did you get in contact with KTH LIL?

I was introduced to the KTH LIL and Elena through Osman after he asked me to become his thesis partner in December. Osman, on the other hand, has known Elena for a while now. He's a member of the VR_Sci_Team, and he's been working with Elena in organising VR_Sci_Fests for three years. Recently, Elena introduced Osman to the KTH LIL and offered to let him work on the tenant thermal comfort thesis.

What kind of research/analysis are you doing?

Our project title is Occupant Thermal Comfort Evaluation with the Use of the OURA Ring. In short, the project aims to observe the quality of the data collected from the OURA ring and whether it could be used to supplement data from the building automation system to model an appropriate algorithm for calculating the PMV (predicted mean vote). The PMV then can be used to achieve and maintain thermal comfort/equilibrium for tenants.

What is your role in Elena's project?

Our role includes the following:

- Creating a database with a data structure from the OURA ring and building data.
- Data analysis and quality management for the data collected.
- Building the model for the thermal comfort evaluation from the data.

How is the data going to be used?

The building data, along with the OURA data, will be used to model the algorithm for finding the PMV for each tenant.

How will the data you receive help in your research?

The data provides insights into the living conditions for each tenant. This is crucial in building models related to their thermal equilibrium.

What do you know about living labs?

As we understand it, the KTH LIL works as a testbed for new technologies that help improve innovation in the construction and residential sectors. Its apartments are used to test different geometries and new technologies in order to improve the quality of housing for tenants.

In your opinion, how can living labs help the construction industry, change social behaviour at home and improve housing quality?

By reducing the lead time between research and deployment, living labs can provide the construction industry with quick and continuous improvements. Building improved residences that meet today's tenants' requirements could help tenants feel more satisfied with their homes and therefore improve their overall living conditions.

OURA RINGS MEASURING TEMPERATURE AND PULSE, USED BY RESEARCHERS TO DEVELOP NEW SERVICES.

Interview with Emma Sarin, Manager of the HSB Living

It might seem odd for us to interview the manager of the HSB Living Lab in the annual report for the KTH Live-In Lab. However, it is actually not that strange. During 2020 we had four meetings between the KTH Live-In Lab and the HSB Living Lab to share ideas and resources and help each other. This resulted in one publication and in cross-disciplinary collaboration in the Co-Kitchen project, as well as the forthcoming sonic interaction project, which now has the opportunity to use both the KTH LIL and the HSB LL infrastructure to test its research questions. Also, the HSB Living Lab and Chalmers have shared their database and data management structure with researchers and IT personnel from KTH, with the long-term goal of sharing data between different living labs. But enough of this introduction: here comes Emma.

Briefly describe the HSB Living Lab operations and focus?

The HSB Living Lab is a portable four-storey building that welcomed its first residents on 1 June 2016. Three of the floors offer accommodation, and the ground floor provides shared spaces consisting of offices, meeting rooms, a showroom for research projects and a modern laundry facility. There are 29 apartments in the HSB Living Lab, and the building is located in Chalmers' Johanneberg Campus in Gothenburg.

Research is in progress around the clock at the HSB Living Lab, which now has some 40 permanent residents are living in the building. Everything in the building can be replaced and altered. And 2,000 sensors measure everything going on, around the clock, seven days a week, 52 weeks a year.

The infrastructure at the HSB Living Lab is designed to facilitate an extraordinary level of research, development and testing.

The focus is on future sustainable housing and includes research on materials and technology, as well as on sustainable behaviours. The HSB Living Lab is arranged as an open forum. Everyone with ideas about the sustainable housing of the future is welcome to apply for the opportunity to research, test and innovate at the HSB Living Lab.

How is HSB Living Lab working to making buildings smarter and more sustainable? Why is HSB LL engaged in research and development?

We are facing huge sustainability challenges. The housing sector needs to lower its climate impact, and we need to start taking action now. The research activities at the HSB Living Lab are intended to speed up the process of disseminating research findings in society and deploying new sustainable solutions.

Do you see value in living labs for the industry? How do you see the future of living labs?

I clearly see the value in living labs for speeding up the transformation to more-sustainable future housing. Living labs are free zones where new ideas and techniques can be tested in a risk-free environment. That itself speeds up innovation. Living labs will also be important arenas for different stakeholders to meet in order to attempt to solve complex problems together.

And of course, the opportunity to test technologies using systems in real buildings is a very valuable and unique feature of living labs – to be able to see the whole picture, from testing the technology itself to trying out and learning about real-world installation and maintenance and learning more about users' experiences. We also shouldn't forget the importance of developing new business cases around innovative technologies; here, a living lab can serve as an important platform to work out those issues among stakeholders.

Why has the HSB LL chosen to collaborate with KTH in the KTH Live-In Lab?

We see big opportunities in collaboration with the KTH Live-In Lab. We are both living labs with almost the same purpose, just with a slight difference in settings. To be able to share ideas, knowledge and projects makes us better and allows both of us to scale up our opportunities.

And how have you collaborated with the KTH Live-In Lab? In what ways?

We regularly meet to discuss and share ideas, upcoming projects and possible collaborations and mutual projects. We have run some projects together and will definitely collaborate more in the future.

How has the pandemic affected ongoing projects? Have you thought about any results or goals in connection with the pandemic?

Normally, the HSB Living Lab is an open arena where we welcome several study visits every week. That, of course, has been changed during the pandemic, since the facility also is our tenants' homes. The unit is now closed for all external study visits, meetings and workshops. We have also tightened up our routines for all ongoing and new projects in the building. But otherwise, we have not seen any decrease in interest in doing research and development at the HSB Living Lab. In fact, we have seen the opposite –increased interest in starting new projects in our living lab.

What is the next step for HSB LL?

The HSB Living Lab is a 10-year project, and 2021 will mark the halfway point in that cycle. This will be a year where we will summarise the first five years of experiences and set the goals for the next five. We are planning a 24-hour event in April where we will show off our impressive project portfolio and offer a wide variety of other interesting activities.

KTH Live-In Lab Team

Executive Group

Tobias Oechtering
Professor & Director of the KTH Digitalisation Platform.

Tove Malmqvist Stigell
Senior researcher and docent, KTH

Folke Björk
Professor, KTH

Agnieszka Zalejska Jonsson
Researcher, KTH

Valentin Monteiro
Director Business Development & Sustainability Schneider SE

Nike Hansen
Innovation coordinator , Akademiska Hus

Linda Teng
Housing Developer, Akademiska Hus

John Tankred
Operations technician, Einar Mattsson AB

Marco Molinari
Researcher, KTH

Board

Martin Fors
Property Manager, Einar Mattsson

Susanne Malmgren
Head of Student Housing , Akademiska Hus

Charly Lupart
Vice president Digital Energy Sweden, Schneider

Per Lundqvist
Professor, KTH

Anne Håkansson
Associate professor, docent

Operations

Jonas Anund Vogel
Director KTH Live-In Lab

Davide Rolando
Co-Director KTH Live-In Lab

Marco Molinari
Technical Director KTH Live-In Lab

Safira Figueiredo Monteiro
Project Manager

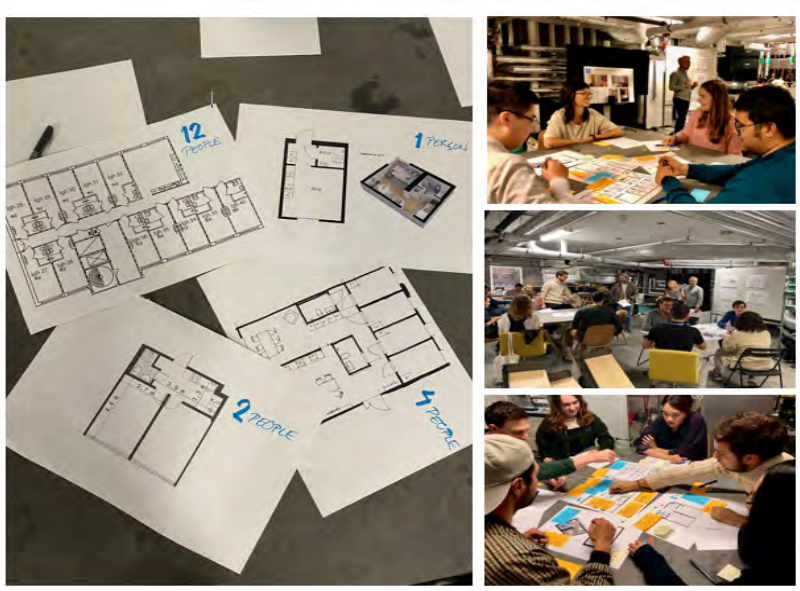
Per Lundqvist
Research and education

Impact & Outreach

Here we present a selection of workshops and conferences that have been held at the KTH Live-In Lab or that researchers from the KTH Live-In Lab presented during 2020.

Workshops

Co-Kitchen Workshop



CO-KITCHEN WORKSHOP

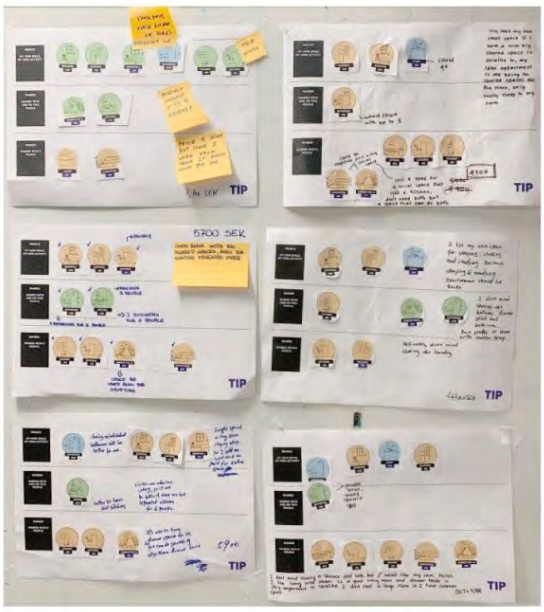
In September 2020, two workshops were held as part of the Co-Kitchen project. The first workshop was held with students from the Testbed EM, and the second was held with the students living in the Testbed KTH.

workshop with KTH + students from testbed EM

In this workshop, students created their own housing programs for co-living using area and function games. The main goal was to identify what the student's value most with respect to their homes.

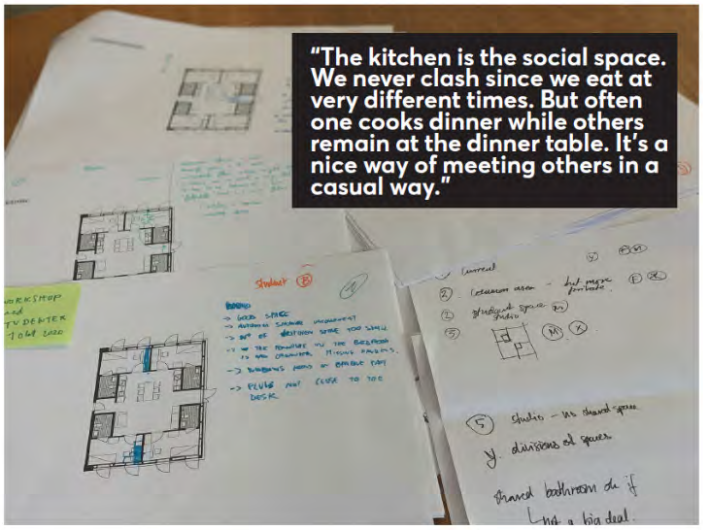
workshop with KTH and students in testbed KTH

Workshop with the students living in the Testbed KTH. We worked with the students and the floor plan of the co-living unit. This was partly based on how they experience the current layout and what they would prioritise in a future layout.



Comments

- Exchange students' tolerance for increased costs was higher than expected, as many demand more functions and living space even if this entails a higher price. Only a few of the participating students prioritized keeping rent low (below 4500/ month)
- Great interest in cooking; many participants mentioned the advantage of being able to eat together more often as the main advantage of living in a shared apartment.
- Many of the students liked the idea of sharing a kitchen with about 4 people.
- None of the students likes dorm form, but they say it's not too bad.



Comments

- Understanding of co-living for smaller units, similar in size to a family at 4-6 people. All students agreed that they were not interested in living with more than 6 people. as it becomes more difficult to create a 'home environment'.
- Knowledge of how they use the current solution, what things they like, what shortcomings they found, and what else they want.
- The students appreciate the current layout and the 65% private/35% shared division of space.
- More daylight to the common areas would be appreciated
- The shared bathroom is OK
- The Rent level of 5500-6000 SEK/month is the maximum

Conferences Participations

Jamtli Living Lab – Workshop on how to set up a new living lab in Östersund

Living Labs and testbeds have the potential to accelerate the transition to sustainable communities. The KTH Live-In Lab is an example of a living lab that has enabled over 30 multidisciplinary research and development projects since its start in 2016. However, the need for more living labs is great, and collaboration between these infrastructures is crucial for success. For a year now, the KTH Live-In Lab has been involved in discussions with Jamtli and Mittuniversitetet in order to increase collaboration through the Jamtli Living University initiative. The KTH Live-In Lab participated in a few workshops during 2020 and shared experiences on how to start and manage a research platform that handles both physical infrastructure and cross-disciplinary research projects.

Riksbyggens videopod 'Öppet Fönster'

Section 6 of Risksbyggen's video podcast 'Open Window' hosts guest Jonas Anund Vogel, director of the KTH Live-In Lab. He discusses whether and how the coronavirus pandemic will affect the way we build and live. Jonas addresses, among other things, the importance of creating a resilient society that is not based on a few large infrastructural plants (water treatment plants, power and thermal plants, etc.) but rather on a decentralised system that is stronger under different external stresses. Other guests are Karin Andersson, senior advisor at Karios Future, and Johanna Frelin, CEO of Riksbyggen. The moderator is Håkan Andersson, Press Officer at Riksbyggen. See the full section below. Intervju i branschtidningen Volt

To watch the interview follow the link
Öppet fönster del 6 - Kommer coronakrisen påverka hur vi planerar & bygger samhällen & bostäder?

Living Lab Summit

The KTH Live-In Lab were one of the presenters at the Living Lab Summit hosted by the AMS Institute in Amsterdam. The KTH Live-In Lab shared experiences on how to achieve impacts from activities in living labs. The main message is that living labs can both store and share results and knowledge. Once sufficient validated research results and knowledge have been gathered, it is possible to communicate this and achieve societal impacts.

Coliv Nordic morning session

The KTH Live-In Lab presented our way of working towards increased dissemination of the co-living concept. Why? As described above and in the final report from the 'Co-living and productive space usage' project, co-living has the potential to reduce climate impacts by up to 50% compared to traditional single units.

Conversations within the Digitalisation for urban sustainability

The KTH Live-In Lab presented how we work with digitalisation in order to accelerate innovation in the built environment. The focus was on making data accessible for students, researchers and collaborating industry partners.

Digital Futures

The KTH Live-In Lab was one of the demonstrators that presented at the inaugural Digital Futures conference at KTH. The audience was guided through our 3D video and also got to learn about ongoing and finished projects. See the 3D video here: 3D Virtual tour in our Testbeds

Digital Futures — Digital Futures

Cetis – Gymnasiemässa

The KTH Live-In Lab held a guided tour using our 3D video model for high school teachers all around Sweden. The audience was very interested and asked how the KTH Live-In Lab could be used to strengthen collaboration between KTH and high schools. As a result, plans are in progress to develop a 'Distributed Sensing Lab', an idea that was presented in the CETIS newsletter.

Read the whole text in Swedish here: Möjlig samverkan - KTH och gymnasium

Open House

In 2020 the organisation Open House Stockholm celebrated their fifth anniversary. During the event, the public was invited to seminars and tours of unique buildings and places. Aligned with the objectives of the Open House concept, the aim of the festival was to involve the public in discussions about the city's development and growth to and stimulate interest in good architecture and the built environment. Open House Stockholm is a part of the Open House Worldwide global network and is organised by a non-profit organisation of the same name. The KTH Live-In Lab was one of the buildings that was open to the public during the event.

Read about the festival here: Open House Stockholm

Digitalize in Stockholm

Digitalize in Stockholm is an annual conference and meeting place for global thought leaders and rising stars engaged in transformation through digitalisation in academia, industry, government and civil society. The 2020 edition was totally digital and free of charge.

The event took place on 9–10 November 2020 and was arranged by the research centre Digital Futures (KTH Royal Institute of Technology, Stockholm University, Research Institutes of Sweden RISE), with Ericsson as a main sponsor.

The KTH Live-In Lab hosted a session in which it gave the audience a tour using our 3D video model.

Årskonferens design för energieffektiv vardag

The Swedish Energy Agency's research and innovation program 'Design for Energy-Efficient Everyday Life' held its annual conference digitally on 12 November 2020. The conference included presentations, debates, and digital socialising/networking opportunities.

Design for Everyday Energy Efficiency is a program from the Swedish Energy Agency coordinate by the Swedish Industrial Design Foundation (SVID). Read more about the program here: Design for Everyday Energy Efficiency

Elena Malakhatka, one of the researchers using the KTH Live-In Lab, presented her work. See the full video here: Årskonferens - Design för energieffektiv vardag , you can find Elena's presentation from 33:44 minute.

Meta Inspirationsevent 2020

Jonas Anund Vogel, Director at the KTH Live-In Lab, presented the development of projects for the audience at the 2020 META Inspirational event. See the full video here: Meta Inspirationsevent 2020

Interview with Susanne Malmgren

Who is Susanne Malmgren?

Akademiska Hus takes overall responsibility for the development of several of the country's campus areas, including student housing, which is a very important factor for universities' future competitiveness. As head of student housing, Susanne Malmgren is responsible for active work at Akademiska Hus' to enable housing projects on or in connection with campus areas around the country.

"My job is to run this large and important undertaking of developing student and research housing close to campus throughout Sweden, but with a focus on seven cities. I often travel two or three times a week to Lund, Gothenburg, Linköping, Stockholm, Uppsala, Umeå and Luleå. There I meet actors and partners who, for example, help us produce documents for new buildings and detailed plans. I also meet customers who rent blocks for our student housing and have contact with the students who will live there".

Briefly describe Akademiska Hus's aim and focus?

In collaboration with academia, industry and the community, we develop and manage sustainable and attractive knowledge environments. Together we boost Sweden as a nation of knowledge.
Our mission:

- Akademiska Hus Aktiebolag will own, develop and manage properties for colleges and universities where the primary focus is on education and research, and it will conduct operations compatible with this task.
- Akademiska Hus will contribute to the creation of more student accommodations by making it clear that the company's focus includes the construction and management of student accommodations.'

How is Akademiska Hus working to making buildings smarter and more sustainable? And why is Akademiska Hus engaged in research and development?

Akademiska Hus has a vision for a zero-carbon footprint, which will be achieved through climate-neutral internal operations and property operations by 2025 and climate-neutral project operations by 2045. We also seek to collaborate more with our customers in order to join forces and invest in sustainable choices. We are also working to reduce the amount of delivered energy by 50 per cent by 2025, using 2000 as the comparison year, through more energy-smart buildings. We currently have nearly 70 solar parks on our campuses that generate 6 million kWh of sustainable electricity annually for Swedish educational institutions. In 2021 we will take additional measures and install more solar power facilities.

We also strongly focus on social sustainability. We will develop products, services and practices through innovation partnerships, thereby contributing to sustainable development in the community. We implement our core values to counteract bullying, harassment and discrimination. Akademiska Hus has zero-tolerance for all forms of impropriety and corruption.

Why did Akademiska Hus choose to be a central partner in the KTH Live-In Lab?

KTH is one of Sweden's most respected universities, and we already had a productive relation, but our cooperation has ramped up through our involvement in the KTH Live-In Lab. The KTH Live-In Lab is an important testbed for the future of living and an important platform for learning and interacting with scientists.

How have you collaborated with the KTH Live-In Lab?

During 2019 and 2020, we conducted a study about productive space usage and shared living for the future. The project was carried out in collaboration with a group of industry partners and universities. One major finding was that by producing shared spaces, we can lower CO2-emissions from production by up to 50%.

The whole report, 'Framtidens delade boende' it available here: Framtidens delade boende - En rapport om hållbarhet i livsstil och bostad

That project is now being followed by the ongoing Co-Kitchen study, whose findings will be used to further investigate kitchens and bathrooms in shared and co-living spaces.

As a centre partner with the KTH Live-In Lab, we are also actively engaged in both the board and the executive group and are thus strongly involved in the developments of the KTH Live-In Lab.

How does collaboration contribute to the development of Akademiska Hus projects and operation?

The collaboration contributes in so many ways! We want to create as many sustainable living spaces as possible. We discuss co-living a lot and want to make progress on all the key issues related to that, together with the KTH LL.

How has the pandemic affected ongoing projects? Have you thought about any results or goals in connection with the pandemic?

In our recently released report 'Framtidens delade boende' that I mentioned above, we discuss the effects that the coronavirus has had on students' living conditions. The full text can be found in section 6, but I would like to highlight what Erik Stenberg, one of the project participants, wrote:
"Ja, den har påverkat som ett förstoringsglas. De studenter som har en bra boendemiljö har klarat pandemin bra och till och med sett fördelar med att vara hemma och läsa på distans. Men, de studenter som har en sämre bostadssituation (till exempel ofrivillig trångboddhet) har fått det mycket sämre med mindre tid och energi för att fokusera, återhämta och prestera. För lärare och forskare har situationen varit liknande."(Erik Stenberg, Professor i Arkitektur)

What is the next step?

The next step is to continue with the Co-Kitchen project in the KTH Live-In Lab. We will also keep on developing sustainable student housing in six cities, using new insights partly developed in collaboration with the KTH Live-In Lab.

"In collaboration with academia, industry and the community, we develop and manage sustainable and attractive knowledge environments. Together we boost Sweden as a nation of knowledge"

Key Performance Indicators

KPI - Research	Target 2020	Results 2020	Target 2021
Number of ongoing projects	10	17	10
Number of new projects	5	7	6
Number of new collaborations leading to applications involving the KTH LIL	4	5	5
Number of projects initiated by the KTH LIL management group	1	3	1
Number of scientific publications made possible through KTH LIL	2	5	3
Number of cross-disciplinary scientific publications	1	4	2
School-wide project collaboration	50%	47%	50%
Number of spin-off projects	1	2	1

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

KPI - Finance	Target 2020	Results 2020	Target 2021
Total amount of funding, both in-kind and cash, made possible through KTH LIL (MSEK)	15	42	15
Total industry co-founding (MSEK)	5	9	5
Number of new companies/organisations associated with KTH LIL.	10	6	10

Collaborating Partners

Center Partners

On the KTH Campus, Einar Mattsson has built 305 high-quality student housing units totalling 6,329 sq m. These include the KTH Live-in Lab testbed, which was 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 is an important part of the city of science, together with Stockholm University and the Karolinska Institutet, among others. 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 durability over time. The boundary between the landscape and the built environment is important and sharp. Outdoors, simple, 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 an creating an attractive and sustainable city.

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.'

AKADEMISKA HUS

Akademiska Hus has built 230 student apartments at Teknikringen on the 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 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 Vinnovas 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.

Project Partners- 2020

1. Akademiska Hus AB
2. Anders Byggare
3. Arkitektkopia
4. Asplan Viak
5. Avanti System Aktiebolag
6. Bengt Dahlgren AB
7. Bosch Siemens
8. Botrygg
9. Boverket
10. Brugg Cables
11. Climacheck Sweden AB
12. Danfoss
13. Ecophon/Saint Gobain
14. Einar Mattsson
15. Energimyndigheten
16. Equa
17. Ericsson
18. Familjebostäder
19. FM Mattsson
20. Geobatteri AB
21. Graytec AB
22. Grunditz Göransson Arkitekter
23. Gustavsberg
24. HP-borrningar i Klippan AB
25. HSB
26. HSB Living Lab
27. Hyllteknik
28. IKANO Bostad
29. Invisense
30. Karolinska Institutet
31. Karolinska Universitetssjukhuset
32. Labtrino
33. LifeAir
34. Lindner Group
35. MUOVITECH AB
36. Myrspoven
37. Nordic Choice
38. Nowab AB
39. NTNU
40. Ochno AB
41. Oneday Wall
42. Podcomp
43. Saint-Gobain
44. Schneider Electric
45. Semrén & Månsson
46. Silver Life
47. SINDEQ Borrteknik AB
48. Stockholm Exergi
49. Stockholm Water and Waste Company
50. Stockholms Universitet
51. Stures brunnsborrningar AB
52. Svensk Energi & Kylanalys AB
53. Svensk Vatten
54. SWECO Environment AB
55. Telia
56. Tosibox
57. Tovenco
58. Triopipe Geotherm AB
59. Uponor AB
60. Värmdö Kommun
61. Vasakronan
62. Vinden
63. VINNOVA
64. WellPerform
65. Wessman Entreprenad AB
66. Green Leap
67. KTH SEED
68. Savvy Design Collaborative
69. Theory Into Practice (TIP) arkitekter
70. Elektrolux
71. Space interior.

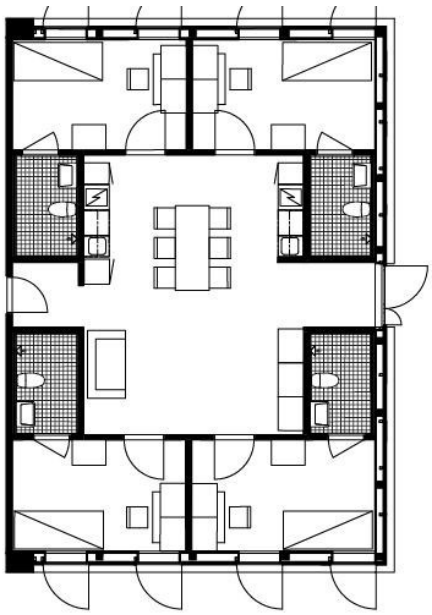
Newsletter

Sign up for the newsletter here to get updates on current and coming projects, seminars and more.

Annex 1

In Annex 1 we present posters of projects that were not finished by the end of 2020. Projects that were finished during 2020 are further presented in the yearly report.

Co-kitchen- sustainable co-living for students



Project manager: Sara Ilstedt

Schools: ITM, Department of Machine Design

Partners: Akademiska Hus AB, Green Leap, Savvy design, TIP arkitekter, KTH-Live-In Lab, Elektrolux, Seed

Research areas: Sustainable, energy-efficient and social student housing, Co-living, creative solutions both in terms of energy and resource efficiency.

Time frame: 2 years

Our vision is to develop a co-living that will be at the forefront in terms of social, economic, and ecological sustainability.

Background

There is today a large shortage of student housing in several places of study, Akademiska Hus was given an expanded mission in 2014 to develop, build and manage long-term student and research housing, then identified the possibility of a total of 10,000 new properties on land owned by Akademiska Hus.

Project description

The project focuses on the target group of students and researchers on campus. Students are a change-prone group because they move to a new place and a new phase of life. They are more flexible in their lifestyle and open to new ways of life and to environmental issues. There is also a widespread loneliness among young people, not least among guest students and those who move to a new place. The result will also be transferable to co-living for other groups who want to live more socially, such as older people where loneliness is also a widespread problem.

Project goals

The goal is to create a coliving that:

- Supports positive social interaction
- Offers a good balance between private and social space
- Supports sustainable lifestyles like sharing, diets, recycling.
- Saves maximum energy, water and resources
- Provides maximum satisfaction/ square meter
- Is resilient from a management perspective

We work with explorative and creative solutions in terms of energy and resource efficiency, socializing, learning, cooking and hygiene, as well as developing knowledge to influence building regulations.

To read more please visit our website, current projects.

AKADEMISKA HUS
savvy Design Collaborative
TIP THEORY INTO PRACTICE
Electrolux

Comparative Spill-Over And Degradation Effects Of Nudges And Boosts

Project manager: Till Grüne-Yanoff

Schools: KTH, Philosophy Unit

Research areas: Resident behaviour and communications

Time frame: 1–2 years

This project compares two types of non-coercive and non-incentivizing policies that aim to change households' energy

Background

The goal of behavioral policies in this area is to decrease standby power, without coercing people or changing their incentives.

A possible nudge for this purpose would be to fit power outlets with timing devices, with timer defaults set at 15 or 20 min, so that continuous users would regularly have to switch power back on, while standby power use is automatically stopped after the timer runs out. A boost, in contrast, would combine equipment fitting and competence training.

Project description

This project compares two types of non-incentivizing, non-coercive behavioral policies that aim to affect residential end-use energy and resource efficiency.

The project focus in two dimensions: (i) the respective degradation of these policy types over time, and (ii) the respective- spill-over effects towards adjacent domains. By degradation, we mean a systematic lessening of the intervention's effectiveness when the intervention is continuously performed over an extended period of time under stable environmental conditions.By spill-over effects, we mean a systematic influence on behavior in domains different than the one intervened on.

Project Implementation

We test our theoretical hypotheses with data obtained from randomized field experiments in the Live-in-Lab.

Project goals

- Investigate effective interventions on end-use behavior in a realistic long-term field exper ment.
- Gather evidence for the effectivness of different types of policy interventions-

Ensuring sustainability and equality of water and energy systems during actor-driven disruptive innovation – SEQWENS

Project manager: David Nilsson

Schools: KTH, Watercenter

Research areas: Technical systems for DHW

Time frame: 2-4 years

This project compares two types of non-coercive and non-incentivizing policies that aim to change households' energy

Background

A transformative shift in water and energy toward a low-carbon and resource efficient society is necessary for achieving the global sustainability agenda. Transformation of macro-scale infrastructures has already started, through for example, increased number of on-property installations for solar power generation. A new logic emerges within large-scale energy systems, spurred by decreasing renewable energy prices, which has very recently resulted in dramatically changing economic realities.

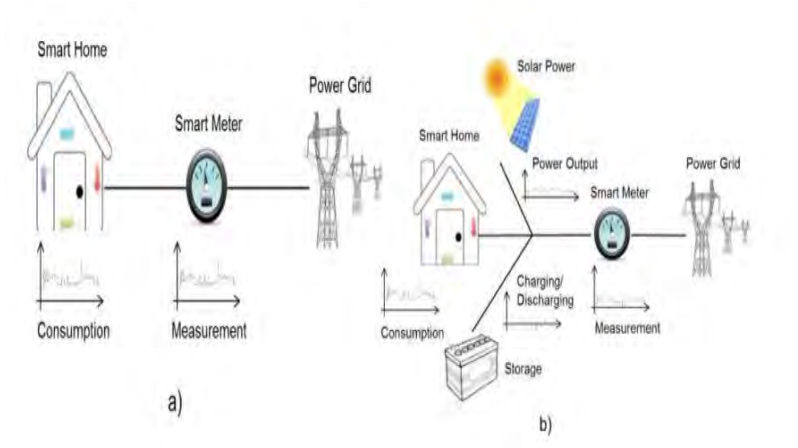
Project description

Essentially, the aim is to understand how different corporate actors influence the transition process of regional water and energy systems in the Swedish urban setting, and how their individual strategies create aggregated effects at the system level. This calls for a combined knowledge-set from energy systems and infrastructure engineering, sociology and innovation studies, as well as business management

Project Implementation

1. Explore and assess the state of the art in on-property water and energy reclamation through three case studies focusing on actors at meso-level and their strategies.
2. Build a system model of water and energy in Stockholm region to describe and assess the related system effects in a large urban Swedish city region.
3. Evaluate future scenarios, using the model to analyse the outcome for the various actors and assess possible system disruptions and social inequalities.
4. Initiate public-private dialogues on how to manage the societal transition process in the interest of all.

Energy Storage for Smart Meter Privacy



Project managers: Tobias Oechtering

Researchers: Daniel Månsson and Ramana Reddy Avula

Schools: KTH Royal Institute of Technology – School of Electrical Engineering and Computer Science

Collaborators: Imperial College, Ínnía, ETH

Time frame: 4 years

The project aim is to study and develop the technology of a physical approach to enhance user privacy.

Background

Smart meters (SM) are needed in the modern power grid for many reasons. They made it possible for a two-way communication between user and electric utility, and they facilitate modern smart services such as financial plans for the user, distributed renewable energy and grid status. However, in essence, the power consumption profile data also contains privacy-sensitive information of the user. In particular, the profile data reveals the usage behaviour of appliances that enable exhaustive conclusions on one's private life.

Project description

Based on the collected dataset, we aim to investigate how using the battery as an intermediary between the tenant and the electricity supplier can help to optimize the electricity usage, and raise the tenants' awareness of their energy consumption, thus, making it easier to reduce. Furthermore, with a smart electricity meter coupled to the battery that changes the tenant's consumption pattern through an algorithm, we can protect the personal integrity, while maintaining a high optimization rate in terms of energy use.

In this project, we will develop a method where a battery in a household is charged during periods of the day when the total load on the power line is low.

Project Implementation

There will be two measurement campaigns implemented in the KTH Live-In Lab. In both we will collect the smart meter readings and the power usage data of four apartments over a period of one year.

The datasets will be made publicly available to enable re-use of the data and verification of research results.

Efficient Kitchen Ventilation with Energy Recovery

Project manager: Jörgen Holmgren, David Södergren

Schools: KTH Energy Technology and KTH Building Technology

Partners: Tovenco, Fläktwoods, Camfil and KTH Live-In Lab

Research areas: Technical systems for DHW, heat or ventilation

Time frame: 1–2 years

A collaboration between KTH and Tovenco for more efficient ventilation in apartments through coordinated flow in the exhaust air ventilation and a developed kitchen hood.

Background

In Sweden, housing accounts for about 40% of total energy use. A large part of the housing's energy is used for heating and ventilation. Studies show that there are still great opportunities to save energy in buildings while increasing health and comfort. When inspecting air quality in apartments, air quality defects are frequently found due to insufficient ventilation.

Project description

The project aims to test and develop more energy-efficient and environment-friendly ventilation of buildings. This is done through a coordinated outflow to the exhaust air system through a new type of kitchen / cooker hood that provides more efficient energy recovery and reduces odors by means of a cyclone filter and a customized rotary heat exchanger.

The great potential of the project lies in the fact that by validating the effect of existing technologies in a real-life environment in KTH Live-In Lab, it can present technical solutions, assembly instructions and financial evaluations linked to both construction and operation, which can be used to enhance energy performance and improve the indoor environment in different types of buildings and operations.

Project Implementation'

Based on existing ventilation systems, an increased air flow is installed and tested using a developed kitchen / cooker hood in selected apartments at KTH Live in Lab. The project is monitored continuously through various checks of measurements and weighings.

USB-C for Energy-Smart Buildings

Project manager: Olof Eremis

Schools: ITM ETT

Collaborators: Ochno AB

Research areas: Electricity distribution, power management, IT system

Time frame: 1–2 years

Ochno is developing a platform for simplified integration of USB C sockets in buildings.

Background

The smart and energy efficient buildings of the future contain a very large amount of controllable electronics, LED lights and a lot of power consumption is also being used to charge different devices and batteries.

Today's infrastructure based on single-directional alternating current between 120V - 230V and different parallel wired and wireless standards for communication and control, is not optimal from a number of perspectives. USB Type-C (or USB-C) is a new standard from the consumer electronics industry for stearable power distribution and high-speed communication, which, through volume, future penetration and powerful features, could provide a better option more suited to future needs.

Project description

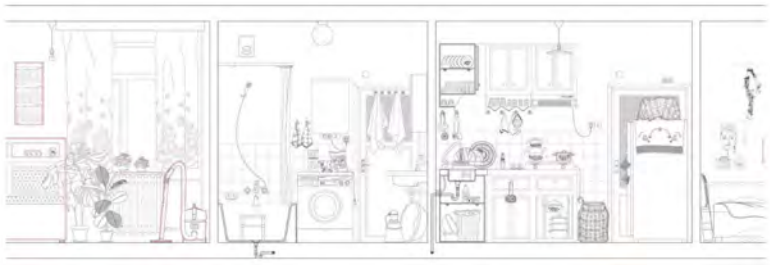
Ochno is developing a platform and cloud service that makes it easy to integrate USB-C sockets into house properties, measure all power distribution, control connected devices, and even connect them directly to l local solar panels via DC, reduce power consumption by 5% –15% by reducing conversion losses.

Project Implementation

In the KTH Live-In lab, each student room receives 6 integrated USB-C jacks that can deliver up to 100W / socket and are used for power supply without the need for a charger or AC adapter and internet connection for computers, mobiles and tablets.

Using a mobile application, users can choose to control device charging to only charge when there is an abundance of power generation from the solar panels, helping to balance local power generation and power consumption.

Service layer design for pro-environmental behavior in the built environment



Project manager: Elena Malakhatka

Schools: KTH

Collaborators: Schneider Electric, Electrolux, Akademiska Hus, Ouraring

Research areas: Resident behaviour and communications, Monitoring and steering

Time frame: 2-4 years

The project focuses on service design starting from the users' needs and experience, providing a systematic procedure that links data analysis to human-centered service design.

Background

The concept of sustainable buildings includes not only technological aspects related to energy efficiency and resources usage optimization, but also aspects related to end-users' comfort, wellbeing, and everyday needs support. To understand the end-users' life activities in general and their preferences in particular, is necessary to enrich standard Building Management Systems (BMS) with human-generated and personal data. In this conceptual paper, we present an end-user context information management framework, which includes a reasoning layer, an acquisition layer, and a dissemination layer. The proposed framework is currently implemented in the KTH Live-in-Lab – a fully equipped testbed for research and innovation in the build environment.

Project description

Living services design with big data applications for sustainable built environment brings together Service Design, Data Science and Behavioral Science to tailor service experiences to the expectations and habits of individuals by using different types of data. This research project contributes with increased knowledge on how an integrated approach that iteratively delivers the right data insights will not only improve the quality of life and convenience of citizens in indoor spaces, but also contribute towards more sustainable cities through more efficient utilization of scarce resources such as energy and water.

Project Goals

Living services, tailored with the sustainable behaviour modelling will systematically increase the motivation of the users to behave in the more pro-environmental way.

Our goal is not only improve the quality of life of the residents in indoor built environment, but also contribute towards more sustainable building operation.

This research project aims to develop a living service design process, which will include the endusers' needs and stakeholders' expectations by using different types of data.

Pilot study for reduced water consumption by non-invasive ultrasound technology

Project manager: Thibault Helle

Project board members: Ramtin Massoumzadeh, Olle Henning

Collaborators: KTH Innovation; Connect Sverige; Stockholm School of Economics, Twin mountain group, Almi, Wistrand, ProvideU

Research areas: Housing behaviour and communication, Technical systems for hot water

Time frame: 1–2 years

Installation of Labtrino's water measurement technology provides improved knowledge of how measuring water consumption at the individual level can curb overconsumption

Project description

The project aims to investigate the possibility of reducing water, energy consumption and having leakage detection in apartment buildings using Labtrino's innovative water measurement technology. In connection with this, significant knowledge of the measurement technology and consumption patterns of residents will be mapped, which can give rise to several new innovations, products or processes in the industry.

In the long term, there are hopes that the project will lead to a significant reduction in the consumption of water, reduced energy consumption and thereby a reduced environmental impact of multi-family houses.

The results of the project will also help to increase the interest of other players in the industry to work with other solutions to reduce water and energy consumption and strengthen the interest of users of the product to curb their overconsumption.

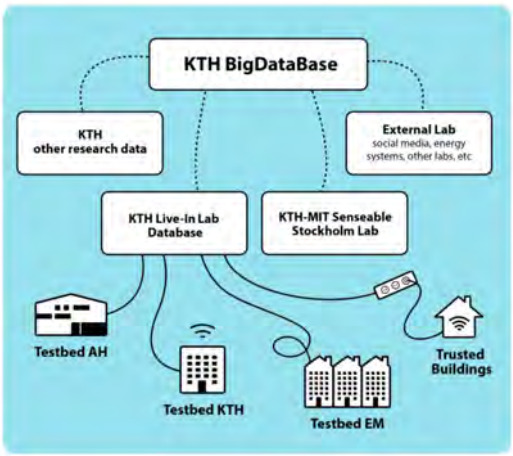
Project Implementation

The project is carried out as a major pilot study where the entire value chain from producer to customer is evaluated. The product is installed in homes in such a way that statistical significance of the evaluation can be achieved and used by end customers for a longer period of time so that data can be collected. The effects of the product on water consumption are evaluated.

Project updates and millestones

- Started production with a manufactering partner, ProvideU, in Estonia.
- Patent granted in Sweden, January 2020
- Product certification ongoing
- App for tennants in 2020
- Version 2.0 for copper pipes

KTH BigDataBase and Enabling Data Sharing



Project Managers: Jonas Anund Vogel, Anne Håkansson, Anders Karlström

Schools: KTH, Stockholm University

Research areas

Data sharing, Open Database, GDPR Data

Project duration

2 years

This project aims to set requirements for and implement a database that in a scalable way can handle large amounts of data with an initial focus on property and user data as well as data from cities.

Background

Cities and buildings with sensors and connected devices are often available, however, structures, routines and systems for efficient and secure handling of data, and information connected to data, are lacking. Companies and organizations often also have large datasets stored, but relevant legal structures for how data can and should be used are often lacking. In order to be able to use data and understand cities, buildings and businesses better, an open and transparent data management system is needed: an open database.

The development of an open database also raises questions about integrity and data security. KTH Live-In Lab (LIL) has already carried out a project on GDPR and smart buildings in collaboration with the Law and Information Technology department at Stockholm University (SU), and an ongoing project on ethics testing and smart buildings is underway. Furthermore, talks with SU are underway regarding a national research database.

Project description

This project aims to set requirements for and implement a database that in a scalable way can handle large amounts of data with an initial focus on property and user data as well as data from cities. It is about designing and developing a big data database that collects data from other existing databases which, in turn, handle sensor data from different activities. The database will also handle Internet of Things and artificial intelligence technologies, such as machine learning, to provide data to various stakeholder groups, researchers, students, and to small and medium-sized enterprises and property owners, for the purpose of enhancing innovation and, thereby, strengthening the competitiveness of Sweden.

Project goals

The project objective is a scalable and open database prototype that supports the users' needs, and collects and provides data and information. A long-term objective is to be able to model and predict events, by using methods such as machine learning, and thereby automate processes in new areas by linking data from previously separate datasets / activities. Another long-term objective is improving the technology (sensor behaviors, products and services), the methods and the behavioral patterns.

Distributed Sensing Lab – Collaboration between KTH and High schools

Project group:

Jonas Anund Vogel, Director KTH Live-In Lab

Davide Rolando, Researcher ITM

Marco Molinari, Researcher ITM

Helena Lennholm, Associate professor ITM

Susanne Engström, Associate professor ITM

The project aims to increase knowledge and understanding of resources and buildings.

Background

This project is based on a collaboration with high schools. KTH Royal Institute of Technology plans to develop a sensor kit that students in The Technology Program ("Teknikprogrammet") can explore and further develop. Students will also have the opportunity to bring home boxes with different sensors, and KTH Live-in Lab (LIL) will try to arrange a data transfer to their own database. Data that is generated can thereby be used by both LIL and in the high school courses Teknik 1 and Teknik 2, with the aim of creating a connection to what is going on in our homes, and creating commitment around resources and our way of life. Such authentic learning is also expected to increase students' interest in further education in technology.

Project description

As part of the entire project, we will carry out a sub-project in research and development aimed at teaching within The Technology Program. This teaching part aims to develop a working material that relates to the mentioned sensor kits and boxes. In addition, the teaching part aims to examine students' learning, in connection with them working with the material.

The syllabi for the Technology 1 and Technology 2 courses include both breadth and depth within a rich content. Energy issues can be related to a large part of the content. The working material that is to be developed within the framework of the project will be based on the syllabi in terms of abilities and content. Another starting point is the sensor kit and the box that KTH Royal Institute of Technology will develop and provide to the students. They will be able to work with and further develop the sensor kit, analyze and evaluate the data material, and they will be able to relate their reflections and knowledge to energy facts and the 17 Sustainable Development Goals (Swedish Energy Agency, 2021; CETIS, 2021; 2030 Agenda for Sustainable Development).

Who can operate and manage smart buildings?

Picture: Semrén & Månsson

Project managers: Per Fagrell, Jonas Anund Vogel

Schools: KTH

Research areas: Management of smart buildings, building operation, engineering skills, sustainable buildings

The study aims to map the engineering skills that will be required for planning, construction, and management of the smart and sustainable buildings of the future.

Background

KTH Live-In Lab (LIL) has so far focused on research and innovation, and we have achieved fantastic results in the relatively short time we have been around. In the long-term planning, there has also always been an ambition to link research to education and competence needs, and in our business plan for 2021 this has been formulated for the first time.

An insight that has emerged during the ongoing work within LIL, for example in discussions with property owners and property managers, is that smart and sustainable buildings of the future will probably require a different and innovative property management.

Project description

This study aims to map the engineering skills that will be required for planning, construction, and management of the smart and sustainable buildings of the future. It is primarily LIL's partner companies that are included in the study, which will be conducted with the help of in-depth interviews.

Some current keywords are digitalization, sustainability, innovation, entrepreneurship, and intrapreneurship. But what do these concepts mean for our industry and how do they affect future skill and competence needs? How can different areas of competence be combined, and is it deeper knowledge in specific areas that will be required or broader and more interdisciplinary knowledge that will be crucial?

Project Questions

The underlying questions are about how today's education matches these needs and to what extent the existing staff at the companies have a need for further training in these areas of competence. The results of the study could form a basis for the support of and the influence over future education programs, if it turns out that there is a gap between supply and demand.

Sustainable walks KTH Live-In Lab

Project managers: Safira Monteiro, Mario Romero, Sandra Pauletto

Schools : KTH Royal Institute of Technology

Collaborating partners: KTH Live-In Lab, KTH Sustainable office, Department of Computational Science and Technology (CST) , School of Electrical Engineering and Computer Science (EECS)

Time frame:1 year.

This project exploits high resolution data gathered in KTH Live-in Lab research testbeds through an advanced, modular and flexible monitoring set-up.

Background

There is a relation between an inactive lifestyle and health issues. KTH Live-In Lab has over the years started and managed several large projects, and for that also built an office and rooms for discussion and dialogues. These rooms are perfect for the getting things done, but for longer meetings and ideation there is a need for something else, for movement and new sceneries. In order to promote movement, and also to promote sustainability projects around KTH Campus, the project "Sustainable Walks" were initiated. The aim of the project is to develop a handful of walks for talks, that inspire ideation and also guides the walkers to different locations of interest, to rest places, to cafes etc. This is a way to combine social engagement, fresh air, activity and learning all in one.

Project Implementation

The first set-up of walks are divided into three lengths:

- 15 minutes (Coffee pause walk)
- 30 minutes (After lunch walk)'
- 1 hour (meeting walk)

The walks can have multiple themes, and information during the walks can either be accessed thru QR-codes or geotags. The walks will be regularly updated with new information connected to the different locations, for example research results, questionaries', quiz, or more static information related to buildings or art. Ideas of themes could be:

- Art walk
- Innovation walk
- Environment walk
- Education walk
- Inspirational sustainable walks

Social and environmental sustainability through a local social network

Project managers: Hossein Shahrokni, Aram Mäkivierikko

Schools: KTH, SEED

Collaborators: Einar Mattsson

Time frame: 2-4 years

LocalLife is a social network for neighbourhoods developed at KTH to strengthen social sustainability, and is already used to solve local problems in many properties in Stockholm.

Background

There are many ”clean” energy apps that unfortunately are not used. The idea behind the locallife social network is to use a needs-driven approach where we provide energy feedback that users benefit from in a local context.

Project description

During this time, the students create various campaigns to make residents participate in load shifting during so-called pause hours and also reduce their overall electricity consumption. The campaigns include launch events, surveys that measure social capital and energy behaviors, information campaigns, feedback and award distribution (for example, in the form of food trucks/ farm parties for the best stairwell). In order to be able to become part of the students' project work, the project will start as early as October, but definitely no later than November. It would be desirable to have access to historical data for the apartments so that we can make fairer calculations.

After that, data is collected for about 1-2 months. During this time, the students create various campaigns to reduce electricity consumption and to participate in load shifting with the help of LocalLife. The impact of the campaigns is then evaluated and compared with existing literature in the field. Preliminary findings have demonstrated a cost-effective method to reduce peak loads on a building level

Project Implementation

The methods we use are transdisciplinary:

•Behavioral psychology in energy behaviors and social capital (survey-based)

•HCI research (evaluation of different types of feedback)

•Design Development Fra-mework

Cost- and Energy-Efficient Control Systems for Buildings

Project managers: Marco Molinari, Davide Rolando

Schools: KTH-Department of Energy Technology

Collaborators: This project is financed by the Swedish Energy Agency (Energimyndigheten) under the E2B2 program. Botrygg, Akademiska Hus, Tovenco

Time frame: 2 years

This project exploits high resolution data gathered in KTH Live-in Lab research testbeds through an advanced, modular and flexible monitoring set-up.

Background

Monitoring data is currently collected without exploiting the inner potential for innovative solutions. This is typically due to, among other reasons, the lack of efficient and dedicated sensor network design and data structures.

Recommendations for a cost efficient implementation of monitoring and control systems depending on the building and the energy supply system characteristics are strongly necessary but not yet available as common practice.

Project description

This project exploits the high resolution real-time data gathered in the KTH Live-in Lab research testbeds through an advanced sensor and data infrastructure in order to evaluate the cost-effectiveness of smart buildings. As a result, the operative definition of smart building will be enabled. Sensor measurements are used to identify common faulty settings in buildings ventilation and heating systems, estimating their impact on the energy use. Particular attention is dedicated to the user experience, the impact of the users on the energy use and visualization techniques to promote energy efficient behaviors.

Project Implementation

Three building facilities are used as implementation and prototypes: the KTH Live-In Lab Testbed KTH, the Undervisning Hus and the neighborhood of Uppsala Backe.

Project goals

- Assess the quality of data generated in the testbeds.
- Enhance existing features and improve the exploitation potenti-al of existing databases.
- Test and implement advanced control strategies
- Detect and identify the most common faulty settings in the heating and ventilation systems.