ANNEX 74

EBC

Energy in Building and Communities Programme

International Energy Agency

Competition and Living Lab Platform (Annex 74) Subtask B: After Competition & Living Lab Scenarios - Focus Report

November 2022

Technology Collaboration Programme by iea

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 30 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes. The mission of the IEA Energy in Buildings and Communities (IEA EBC) Technology Collaboration Programme is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research. (Until March 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)
The R&D strategies of the IEA EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshops. These R&D strategies aim to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy efficient technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five areas of focus for R&D activities:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Community scale methods
- Real building energy use

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*) and joint projects with the IEA Solar Heating and Cooling Technology Collaboration Programme by (☼):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)
Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)

Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: ☼ Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: ☼ Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: ☼ Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: ☼ Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO2 Equivalent Emissions for Building Construction (*)
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
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Annex 80: Resilient Cooling
Annex 81: Data-Driven Smart Buildings
Annex 82: Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - HVAC Energy Calculation Methodologies for Non-residential Buildings
Working Group - Cities and Communities
Working Group - Building Energy Codes
Working Group - International Building Materials Database

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1. Introduction

General context

Objectives of IEA EBC Annex 74 regarding "After Competition & Living Lab Scenarios"

Objectives
The purpose of the report is to make knowledge available about the after-competition use of Solar Decathlon projects as living labs to those who are intending to participate in a living lab competition and those who are on the way to set up their own living lab. The report should allow a compact overview for future organizers and teams about successfully implemented living labs. Main source was an in-depth analysis of former editions of the Solar Decathlon, mainly the European editions, but also case studies from the US and Africa, together with results from experts' interviews which summarize the stories and experiences behind the projects.

Contents of the report, scope, and limitations
One principal idea of this focus report is to let the project leaders speak about their personal experience in the post-competition use phase of SD prototypes. What outcomes can they report? Which successful actions could be implemented? What has been achieved during this important use phase of SD prototypes? On the other side: which challenges have they encountered? Which learnings could be achieved, and which recommendations can be given to future SD participants, teams and project leaders? All information is compiled, anonymizing individual statements of the participants in the survey and the semi-structured interviews, but transmitting as direct as possible the voice through quotations of the ones who made these experiences first-hand. This research focuses specifically on living labs which are used for educational purposes in their after-competition use phase, as this allows a prolonged positive impact in the field of higher education, with the possibility to train and educate whole generations of future professionals in and around the prototypes.

Relevance in Building Competitions & Living Labs
Solar Decathlon competitions offer to participating universities a unique opportunity for introducing into Higher Education a learning by building approach, with students as important drivers of the whole process. This positive impact can be prolonged through a well planned and executed after-competition use of prototype buildings. Every participating team must face the decision about the after-competition use of its prototype in a certain moment before or at least immediately after the competition. Tracking projects of earlier competitions shows that many of the projects lacked a solid after-competition use concept, and as a result or could not be reconstructed, or had only a limited lifespan due to a lack of financing, lack of options for a final location or a lack of use and management concept, among others. Making Solar Decathlon projects available for an intense after-competition use in the field of teaching and research multiplies their impact in the field of research and education, especially when used as educational living labs which showcase sustainability strategies for buildings in the field of efficiency, sufficiency and consistency to a broad public in and outside universities. Getting inspired by successful examples of post-competition living labs and learning about related challenges and obstacles is a useful contribution for future teams.

2. Online research, survey and semi-structured interviews on post-competition living labs

2.1 Methodology

This research has been structured in two parts. A general online research regarding the current location, operation, use and ownership of former Solar Decathlon projects on one side, and a survey and interview-based research on specific projects based on direct communication with their current directors on the other. Projects from the original US competition since 2002, the European SDE competitions since 2010, and the first African competition (SDA 2019) have been taken into consideration.
A list about US projects has been facilitated by DOE representative Joe Simon with contact details and current location of each of the SD participants in the US since the first competition in 2002. A total of 152 projects have been revised regarding their post-competition use as educational living labs. 25 projects have been selected in a first search for current operative living labs related to education. 15 projects have been further analysed and 10 resulted in educational living labs with a high interest for this research.
On a European level, competition participants since 2010 have been listed and searched through the corresponding webpages, especially the www.building-competition.org website. 12 potential current operating educational living labs have been identified and after a deeper analysis, 10 have been selected as educational living labs with a high interest for this research.
Regarding the SD Africa (SDA2019) 4 potential Living Lab projects have been recommended by Samir Idrissi Kaitouni member of the SDA 2019 organization and Annex 74 collaborator. All projects are located still at the original place of the competition, at the IRESEN installations at Rabat, Maroc, where they form part of the R&D platform Green & Smart Building Park. All 4 projects have been contacted through direct email to their current project responsible. 2 projects could be further analysed and information about current activities has been facilitated and integrated in this report.

After the selection of potential interesting projects and based on the information encountered, a data sheet has been drafted with a summarized description of each of the projects, pictures of its current state, contact details to owners or operators, as well as links to publications of current activities. Additionally, the type of living lab, the available infrastructure and the activities carried out have been described. The data sheet and the integrated graphical evaluation system regarding typical living lab characteristics are based on the PhD thesis of the author (Masseck, 2016). A total of 24 data sheets have been generated. (see Annex 1)
In parallel an Educational Living Lab Survey (see Annex 2) has been designed with 4 blocks of questions. A first block focuses on concepts of each educational living lab, asking for the educational methodologies applied, educational materials generated, target groups who benefit form the project, its impact on HE curricula and campus, and about new educational networks which could be generated.
In a second block of questions project leaders have been asked for a critical view on their living lab project, focusing on the challenges and obstacles encountered in the 3 areas of Concept and Implementation, Costs and Maintenance, and Operation and Outcomes.
The Educational Living Lab Survey has been sent out to all 24 selected projects. 4 friendly reminders have been sent out to each project, the right contact person for answering the survey needed to be searched for additionally in some cases, and personal contacts have been used for coming through to the right persons to answer the survey, mainly the former faculty advisors or responsible professors of the projects. An overall of 8 completed surveys have been received after a period of 3 month.

Based on the received surveys, a semi-structured interview has been requested to the project leaders, and 7 interviews could be held with an average duration of 1 hour, highlighting the main aspects of the answered survey and focusing on additional information about the most important experiences and learnings. This allowed gathering valuable additional information about specific success stories as well as individual drawbacks of projects, which could not be collected through the standardized survey.
In the final process, data sheets have been complemented through the information facilitated by project leaders, surveys have been evaluated and the main additional information of the semi-structured interviews has been transcribed.
In the following survey and interview results of this research on Educational Living Lab are presented.

2.2 Results I: Concepts of Educational Living Labs

According to European Network of Living Labs (ENoLL), “a Living Lab is a real-life test and experimentation environment where users and producers co-create innovations”, with four main activities typically employed by Living Labs:

- Co-Creation: co-design by users and producers
- Exploration: discovering emerging usages, behaviours and market opportunities
- Experimentation: implementing live scenarios within communities of users
- Evaluation: assessment of concepts, products, and services according to socio-ergonomic, socio-cognitive, and socio-economic criteria.

On the other hand, main characteristics of Living Labs are their multi stakeholder approach, often based on a PPP (Public-Private-Partnership); the focus on user involvement, giving a special role to the user as part of the innovation process; Open Innovation, considering innovation as an open process with multiple stakeholders; and the setting in a real-life environment, experimenting and capturing user insights in real-life situations.
In the context of Solar Decathlon competitions and higher education, a living lab can be understood as a place where construction, monitoring and evaluation can happen at one place, through a multi stakeholder approach (students, researcher, companies, administration, general public), in a co-creation or open innovation process, allowing for user-centred research under real conditions of use (house occupancy experiments) and real-time feedback about performance data, user comfort, user-building interaction, energy management, energy efficiency, and many related field of interest in the holistic search for truly sustainable housing concepts of the future.
For this report, 21 projects have been analysed and identified as Educational Living Labs with a high interest due to their successful implementation and operation, as well as the achieved and documented outcomes. For 8 projects additional information could be generated through the mentioned survey and 7 personal follow-up interviews could be held, complementing the gathered information through personal insides and reflections of the current project directors. In the following the results of this research are summarized.

2.2.1 The post-competition lifespan of SD prototypes

Analysing the post-competition use of SD prototypes, one important question is the overall lifespan of a Project. Some of the projects which appear in the data sheets (Annex 1) are no longer operative. Many of them are projects from earlier SD competitions and their after-competition use phase ended already due to their age. Others have found their use for a longer period of years within a university context, e.g., as residence buildings under permanent occupation, and still maintain their Living Lab characters due to guided visits, ongoing performance evaluation or as part of a local energy grid (Missouri).

Project leader have been asked to estimate the foreseen lifespan of their projects, and answers have been given between 3 years and “no end foreseen”, but an average lifespan between all documented projects can be estimated in around 5-6 years, with the oldest ones operating over 14 years and the newest ones starting recently their post-competition use phase.
It is worth to mentions that lifespan is an important aspect for the payback of energy, effort, and money of a project after a SD participation, but the intensity of use must also be taken into consideration for evaluating the overall success of the after-competition use. Some prototypes show very low activity during a longer period after competitions, before being activated and used again. Others get immediately reconstructed and used for ongoing research or dissemination activities. This often depends on how the after-competition use phase has been planned beforehand and important aspects like final location, use rights, maintenance and management have been clarified and corresponding agreements have been closed among partners.

2.2.2 Educational methodologies and teaching formats applied

Due to the character of the Solar Decathlon Competitions as a student-driven event, which allows in-depth learning by planning, building, and operating real prototype buildings, all projects are linking teaching, research and innovation during their development and execution.
In the after-competition use phase some projects seem to focus more on research activities, others foster specifically educational initiatives, and many of them maintain a mix between both. Therefore, a clear distinction between research and educational living labs cannot be easily made. Reality shows a huge variety of possible after-competition uses, and only a closer analysis of a specific project can reveal its unique mixture between educational and research activities. Over the lifecycle the focus and intensity of activities also tends to change, as e.g., research on technological components of prototypes is generally done in the first 2-3 years and then tents to decrease.
This might lead to the conclusion that most projects might start as a research living lab, with educational activities, shifting over time towards an educational living lab with some research activities still going on.
Regarding the specific use for education, online research and survey results allow the following description of the post-competition use of projects:

- Prototype exploration through students (materials, systems, concepts) (20 out of 22)
- Measurements and evaluation of the prototype in-situ (thermal comfort, system performance, bioclimatic solutions, comparison of measurements and simulation) (20 out of 22)
- Seminars/workshops inspired by the special place (18 out of 22)
- Co-creation initiatives for new projects, bringing together different stakeholders (students, researchers, companies, administration…) (10 out of 22)

This demonstrates that all prototypes maintain their character as showcase for innovative solutions which spreads knowledge through guided visits, prototype exploration and performance evaluation as well dissemination activities at the place.
Through semi-structured interviews with 7 project leaders the following additional information regarding generated educational methodologies and applied teaching formats could be gathered:

2.2.3 Educational materials generated

A major outcome of Solar Decathlon projects are project documentations, monitoring results and results of testing of innovative materials, components and installations regarding their energetic, constructive and aesthetic performance. Beside these technical documents, many dissemination materials are generated like leaflets, video presentations and recorded guided visits, as well as online courses like MOOCs, virtual or augmented reality presentations among others. All results are valuable educational materials, which can be generated before, during or after a competition, and used also in the post-competition phase of a project as educational materials at a faculty.

Online research and survey results allow the following description of generated educational materials:

- Documentation of the prototype used regularly as case study for teaching (16 out of 22)
- Articles published about the prototype (5 out of 22)
- MOOC course developed in or around the prototype building (2 out of 22)
- Augmented / Virtual reality representations (3 out of 22)

Through semi-structured interviews with 7 project leaders the following additional information regarding generated educational materials could be gathered:
Project leaders mention the effort to introduce materials in teaching activities, and that mainly themselves are using these materials for teaching purposes, whereas the general interest by other professors, not directly linked to the project is reported as limited. Effort is reported to motivate students to link final career projects or research exercises to the prototypes to generate consolidated knowledge regarding specific aspects of the prototypes in the post-competition use phase. This is partly successful but requires time and dedication of project leaders. In general, the novelty of the prototype and the resulting interest in its evaluation has a duration of 2-3 years maximum, especially when a university repeats its participation in a new SD edition, and a new prototype is generated. On the other side, established MOOC courses in relation to the prototypes have a longer lifespan due to the attractive, modular digital learning materials generated, which can be used independently from the access to and condition of the physical object.

2.2.4 Target groups who benefited from the projects

The post-competition use of Solar Decathlon prototypes can be focused on different target groups, depending on the type of use (education, research, dissemination, place for activities and events), the chosen location (university campus, neighbourhood, public or private ground) and the responsible entity or owner (university, municipality, public or private entity). In many projects different target groups are benefitting from the project, and diversity seems to contribute to the viability and continuity over time of many living lab concepts.
Online research and survey results allow the following description of target groups of the analysed educational living labs:

- Use through the team members of the project (19 out of 22)
- Use through Bachelor students (15 out of 22)
- Use through Master students (9 out of 22)
- Use through Researchers and academics (12 out of 22)
- Use through Highschool students and teachers (1 out of 22)
- Use through General public (12 out of 22)

Regarding the different disciplines, the following target groups could be identified:

- Architecture students (19 out of 22)
- Engineering students (12 out of 22)
- Highschool students (1 out of 22)

Through semi-structured interviews with 7 project leaders the following additional information regarding target groups who benefit from the projects could be gathered:
Quantifications of impact on different target groups have been diverse, reporting 5 Master thesis and 2 Bachelor thesis related to the Rooftop prototype of UK Berlin during the last 5 years, around 50 Bachelor students benefitting from the Selficient prototype at Utrecht University, up to 10.000 Bachelor students visiting the 2015 SD prototype at Delft University, as these kinds of visits have been installed as standard program for all new students. Other more recent projects like TO of UPC and SDA projects from 2019 had difficulties to start with impact due to pandemic restrictions during 2020 and 2021.

2.2.5 Positive impact on HE curricula and campus

Solar Decathlon projects do have a major impact on a faculty due to its duration from start to competition of around 2 years, the intensity of workload for students and teaching staff, as well as the high visibility of the project in and outside university.
Online research and survey results allow the following description of positive impact on HE curricula and campus:

- Creation of new infrastructure (19 out of 22)
- Creation of new forms of teaching focused on real project and construction (12 out of 22)

Project leaders describe the impact on HE curricula as following:

> *As I have presented the projects in my lectures at the faculty, most students now know them. What works particularly well are three films we have made: two mini-documentaries and a mini-film. Students and people across the world love these and share them in social media.*
>
> *The main impact on our curriculum is an increased ratio of practical studies and experiments with a real building. The SD protype is now used as a seminar room, in which we can descriptively discuss with the students about building energy efficiency, indoor climate and the usage of renewable energy for buildings.*
>
> *Our school is focus on acting on the reality. This kind of projects allows us to inspire to the students in order to go further than the typical classes.*
>
> *The project helped us to identify the strengths and weaknesses of the different courses of the faculty, highlighting the need for more in-depth interdisciplinary teaching. For this purpose, the teaching staff must be trained or have an interdisciplinary background. This is one of the best ways to give the different classes and respond to the questions and concerns of students.*
>
> *In general, the project has reinforced the idea of mixing students from different disciplines (architecture, civil engineering and environmental engineering) under a single course type workshop.*
> *There is more room now for collaboration between different disciplines and more collaboration with companies*
>
> *Our university is convinced of the educational value of teaching by project.*
> *The students and professor of the project continue to work together within the framework of an association they created and new research subjects related to the theme are launched: PVT, Phase change materials, ...*

Through semi-structured interviews with 7 project leaders the following additional information regarding positive impact on HE curricula and campus could be gathered:
Selficient (SD 2017) reports that its prototype is a perfect showcase at the campus, reflecting the focus on sustainability and innovation of the faculty.
The MOR prototype forms part of the Green Campus at TU Delft, a location where different kind of research infrastructures and prototypes can be constructed, operated and monitored.
UPC prototypes since 2010 had major impact on the faculty’s curricula, showing an increasing integration and synergy with regular subjects and course in each new edition.
Other prototypes have been handed over to third party institutions. WaterShed (University of Maryland) and the Easton 3E Lab (Missouri) are examples for this. In these cases the post-competition use has little or no impact on the HE curricula or campus, as these projects are located at a certain distance to university, and access and management are in hands of new entities. Some monitoring and operational aspects might still be solved in collaboration, but impact on campus and curricula is generally low.

Overall it can be stated that SD projects have a considerable impact on HE curricula, shifting mindsets of universities towards project based education, fostering interdisciplinary collaborations among faculties and generating visibility and dissemination of energy efficiency, renewable energies and sustainable housing.

2.2.6 New educational networks generated

A Solar Decathlon participation is for universities a major opportunity for building up networks of students, researchers, companies and institutions, which support the project during development and construction through contribution of material and know-how, participation in linked research projects or funding, among others. These networks across disciplines are useful for education, research and market-uptake objectives, according to the interest of each partner. Networks often persist in the post-competition phase and are valuable outcomes of the competition for universities on medium and long-term.
Online research and survey results allow the following description of positive outcomes regarding the generation of educational networks:

- Creation of student networks which persist in the post-competition phase and often result in a common profession project like a start-up or a cooperative (15 out of 22)
- Creation of research networks which allow generating research and innovation outcomes in and around the prototypes (6 out of 22)
- Creation of institutional networks which keep supporting the project in the post-competition phase, a new participation in a later competition or a similar project on local or regional level (7 out of 22)

Through semi-structured interviews with 7 project leaders the following additional information regarding educational networks could be gathered:
The MOR prototype (SDE 2019) generated a spin-off, called MOR, which currently offers the development of smart buildings, applying the MOR concept of refurbishment and conversion of old office blocks into highly energy-efficient housing. First concept work has been done for …. 4 lead students of the MOR team are business partners in this new venture, offices are located at the TU Delft Campus and the team receives support and advice by former faculty advisors.
The UPC prototypes e(co) (SDE 2012), Ressò (SDE 2014) and TO (SDE 2019) resulted in the generation of cooperative of former team members, creating sustainability focused architecture practices, as well as prolonged collaboration as operators of the respective prototypes together with public administration and university as stakeholders.
E(co) has been the core project that initiated the foundation of the Arqbag cooperative (www.arqbag.coop), which at the date of this report states of 7 founding members and 3 collaborators, developing sustainable architecture projects with a specific focus on the social innovations like neighbourhood facilities and co-housing projects. Some Arqbag members are also part of the current teaching staff at ETSAV (UPC), and through this link transmit their knowledge, attitude and experience gained in the last years to following generations of students.
Ressò (SDE 2014) gave place to the association Accio-Ressò, constituted by former SDE students, which after the competition in 2014 directed the re-building and implementation process of Ressò as a neighbourhood facility at Sant Muç (Rubí) in cooperation with the city council of Rubí. Ressò since then has served as a platform and space for multiple activities which contributed to improve the living quality of the neighbourhood. It has served as a multifunctional space for educational activities regarding energy efficiency, it supported the implementation of energy efficiency projects in the neighborhood, and it hosted other activities like yoga classes or similar offers for a neighbourhood which lacks this kind of offers. Administrative issues led to the temporary closure of the installation at the time of writing, but according to the drivers of the project, a re-activation is planned.
TO (SDE 2019) is the newest project at UPC and has been rebuilt at the UPC Campus South Diagonal in the beginning of 2020, with the aim to start activities as a Living Lab that allows guided visit and educational initiatives for UPC students and the general public. The project has received support for this post-

competition use by the city council of Barcelona and the Barcelona Energy Agency. Due to the pandemic outbreak in 2020, no specific activity could be implemented up to date.
It shows that the generation of networks among the huge diversity of participants is one of the most interesting outcomes which benefit all type of stakeholders of a project. Companies get into touch with potential future collaborators, Higher Education Institutions (HEI's) build up or improve their university-industry relationships and their collaboration with public institutions, students build up interdisciplinary networks that often allow generating a core group for a start-up initiative, or any other type of cooperative enterprise linked to the project, but also beyond. Educational networks based on a university project evolve many times towards professional relationships over time.

2.3 Results II: Critical view on Educational Living Labs

Learnings for a successful after-competition use of SD prototypes can be especially achieved through a critical review of processes, obstacles and success stories linked to specific projects. A critical analysis by project leaders themselves and specific recommendations out of their experiences made, are most valuable in this context. For this reason, in this chapter voice is given almost unfiltered to them, with quotations out of survey results and interviews. Only references which would allow identifying the specific projects have been eliminated for privacy reason. A closer look is given on concept and implementation of prototypes in the after-competition phase, on costs and maintenance, as well as operation and outcomes. Finally, a critical view is given on the integration of projects into the HE curricula.

2.3.1 Concepts and Implementation

The after-competition use of SD prototypes requires a concept for the implementation of prototypes, especially a place where to rebuild the house, with the possibility to stay for a certain period. Also, entities must be linked for this new phase of operation and exploitation through agreements and contracts.
Project leaders reported the following aspects and experiences through the survey and personal interviews:

> *Getting it rebuilt after the competition has proved to be very hard compared to the speed of construction during the competition, because everyone was tired and busy again with other things, and the weather was bad during winter. It was a struggle. We have also had trouble getting things arranged regarding the hand-over.*
>
> *It is very hard to find a building site on the university campus where a SD prototype can stay for several years (this process had a duration of 3 years in our case)*
>
> *To re-build it again was an achievement itself. And we started pretty well with neighbours. But city hall did not allow them to self-manage the space.*
>
> *The main difficulty is the situation (the use of the land) and the creation of a convention with the owner of the land. In this case the convention defines that the cultural exploitation of the prototype is in the hand of one entity, and the maintenance (with associated costs) is of … the two institutions that use it as research infrastructure.*
>
> *It requires a different attitude from teachers*
>
> *Here are some obstacles and drawbacks when using our SD prototype post-competition as an educational living lab:*
> *- the project is too far from our university*
> *- Lack of operating budget for the project*

- Lack of a regulatory framework for the operation of the project: after two years an agreement is still being prepared

These quotations and the additional information given through interviews, as well as the knowledge about projects which suffered from the lack of adequate location for their after-competition use and therefore had to be dismantled, show that a clear planning for location and after competition use is essential.

Overall, it can be stated that the following aspects are most relevant:

- Define well in advance the concept of exploitation and the type of post-competition use as well as the responsible parties.
- Agree as early as possible on location and duration of occupation for the post-competition use of SD prototypes as living labs.
- Location should be as close as possible to university for operational reasons.

2.3.2 Costs and Maintenance

Cost and Maintenance of prototypes in the post-competition use phase are critical aspects. After competition end resources are often limited, many teams even have accumulated debts during the whole process of development, construction and competition, and new funding is necessary to cover cost for reconstruction at a new location.
Project leaders reported the following aspects and experiences through the survey and personal interviews:

Arranging well that one party can do the maintenance, operation and eventual demolition was a struggle. The money has gone and parties taking over usually want to be paid for it, which in our case came down to dodgy arrangements for which the faculty eventually paid the bill. Better to have this arranged beforehand with people who are trustworthy.

The SDE competition format doesn't really consider the necessary costs for the re-reconstruction in the post competition phase.

The maintenance is a big issue because city hall does not want to spend money regularly. The reassembly was relatively easy. The maintenance is much more complicated.

Who takes care of it and who pays are the key questions. A usage convention has solved this.
It is difficult to find a viable business model.

Lack of operating and maintenance budget for the project.

Overall, it can be stated that the following aspects are most relevant:

- Secure financial resources for re-construction forehand, as in the post-competition phase resources are limited.
- Estimate the maintenance costs of the prototype in the post-competition phase and clarify who will take them over and for how long.

2.3.3 Operation and Outcomes

Operation in the post-competition phase might be critical. New agents might have taken over the responsibility of the project, or shared operation is agreed among several entities. Daily operation also requires personal and material resources as well as knowledge about the prototype itself. All this leads to critical situations of the operation and exploitation of prototypes which must be handled and solved.
Project leaders reported the following aspects and experiences through the survey and personal interviews:

> *You definitely need partners in the administration of your institution which love the project.*

> *The operation was thanks to good will from the team members and illusion from neighbours.*

> *Ensuring that the prototype is operational for research purposes and that the sensor data is correctly uploaded to the database etc. is a special challenge. In general, the facility management of the prototype created for a temporary competition is not an easy task due to the "test" component of its creation. Finding a balance between the needs of education and the needs of companies.*

> *Lack of a regulatory framework for the operation of the project: after two years an agreement is still being prepared.*

Overall, it can be stated that the following aspects are most relevant:

- Plan operation beforehand and clarify administrative support as early as possible to avoid delays due to necessary negotiations and missing framework.
- Consider that technical challenges might appear, as prototypes are student built and might need improvement for long-term operation and monitoring.

2.3.4 Integration in academic curricula

SD prototypes in their post-competition use phase con be valuable objects and places for new teaching formats, interdisciplinary educational formats, and innovative experience-based learning initiatives. Nevertheless, existing HE curricula are generally little flexible regarding innovations in form or content.
Based on the survey and personal interviews, project leaders described their experience regarding the integration of SD prototypes into the academic curricula as following:

> *The Idea is to integrate the prototype in some specific subjects, but COVID postponed all.*

> *I use the prototype examples in my lectures, and they are used for tours of new students coming in in August, but furthermore, there is no embedding in the curriculum. We do ask students to connect graduation projects to the prototypes, which has been done regularly.*

> *This worked very, very good in our case. No challenges.*

> *Not much. One studio was focus on this reassembly for a year and it helps to do the next SDE edition.*

> *The prototype has been very much exploited during its elaboration so at a curricular level the interest has decreased, but the willingness to make use of the prototype for a facility management via digital tools such as the BIM is now up to date.*

> *It takes time.*

> *The project is too far from our university.*

Overall, it can be stated that the following aspects are most relevant:

- Plan integration in academic curricula as early as possible as little flexibility exists generally for adapting HE curricula to new academic formats or contents.
- Consider that reconstruction of SD prototypes requires time and resources which might delay the readiness for post-competition uses, but also opens the possibility to consider reconstruction and operation itself as an academic activity to be embedded in HE curricula.
- Consider that digital tools (MOOCs, BIM) might open up possibilities for additional use in HE curricula when academic interest in the SD prototype itself decreases over time due to loss of novelty.

2.4 Discussion and Outlook: How to successfully convert SD prototypes into post-competition Living Labs

After describing the diverse impacts achieved, obstacles encountered, and conclusions drawn by the interviewed project leaders it can be stated that there also exists a certain pressure for teams to convert SD projects into high impact post-competition labs and only a view really succeed in achieving a high visibility and high impact through a holistic implementation and a strong concept.

Nevertheless, beyond the visible part of a post-competition use as living lab, almost all projects generate a huge number of distributed, small-scale benefits, which are difficult to detect and to document, but which exist. The explanations given by project leaders about the post-competition phase and resulting initiatives and activities give testimony about this prolonged positive influence on the involved participants, like new professional projects, e.g. cooperatives or jobs in companies which supported and collaborated in SD projects, or simply the human networks generated.

SDE projects are generally milestones for faculty advisors which have a high component of stress, risk, but also rewards as researchers and lecturers. Struggle with after-competition use seems to be typical, with conflicts to solve regarding the available work force, because students are exhausted or leaving university, lack of financial resources with many teams come back from the competition without resources left or even with some debts to deal with, and a lack of organizational support e.g., for finding appropriate location and operational support at university.

Finally, asked for the most important recommendations to give to others who aspire to do a similar project for an educational living lab, team leaders gave the following answers:

- *You need people to go to the challenge and win. Find friends in your organisation who can help you – e.g., subdirectors.*
- *Have a good strategy and proposal for having your sponsors attached to the prototype for the post-competition use.*
- *Political support needed.*
- *Limit the budget.*
- *Involve in a second round the partners of the competition - continuity is so important.*
- *Set up a group of professors and students to promote the after-competition use.*
- *Assure support from the university – high level decision makers should be in the boat.*
- *Make it accessible to others, opening it up!*
- *Don't give up!*

As result it can be stated that every team must solve many obstacles for a successful after-competition use of its prototype and as the review of SD projects shows, so far only some teams achieve a fully operational, well managed and financially and structurally supported living lab over a longer period right from the start. Situations of each team and each university are very individual, although some common challenges could be identified and some interesting recommendations could be gathered for supporting future teams in the transformation of their prototypes into post-competition living labs.

3. Conclusions

Research on the reality of after-competition uses of Solar Decathlon prototypes has been carried out with the aim to make knowledge available about the after-competition use of Solar Decathlon projects as living labs to those planning to participate in a living lab competition.
Principal idea of this focus report has been to let the project leaders speak about their personal experience in the post-competition use phase of SD prototypes. What outcomes can they report? Which successful actions could be implemented? What has been achieved during this important use phase of SD prototypes? On the other side: which challenges have they encountered? Which learnings could be achieved, and which recommendations can be given to future SD participants, teams and project leaders?

An overall of 22 interesting living lab projects have been identified among SD projects from the US competitions since 2002, SDE projects since 2010 and SDA projects of the 2019 competition. This does not exclude that many other Solar Decathlon projects had or still have a successful post-competition use.
This research has been focused specifically on living labs which are used for educational purposes in their after-competition use phase, as this allows a prolonged positive impact in the field of higher education, with the possibility to train and educate whole generations of future professionals in and around the prototypes.

Challenges and success stories could be described, highlighting the overall impact of projects regarding applied educational methodologies and teaching formats, generated educational materials, target groups who benefited from the projects, positive impact on HE curricula and campus as well as newly generated educational networks. The personal experience of project leaders could be reflected through semi-structured interviews, giving firsthand information about the experienced challenges and conflicts and valuable recommendations about how to prevent or overcome them.

A general conclusion is that the investment in terms of material, economic and human resources is immense for Solar Decathlon prototypes. To consider this effort sustainable requires maximizing its impact in all phases of the project (design phase, construction phase, competition phase and post competition phase). Not using Solar Decathlon prototypes after the competitions, or lifecycles of just 2 or 3 years limit very much their overall impact regarding the amount of people (students, researchers, visitors, professionals) who benefit from the unique, experience-based teaching and learning opportunities, the prototypes are able to offer.
On the other hand, the presented results of projects which successfully generated initiatives and activities around the prototypes in the post-competition phase are a testimony of the prolonged positive influence of Solar Decathlon prototypes, when implemented properly for a post-competition use as living labs.

Therefor organizers, competition teams and all related institutions and entities should lay their focus in a very early stage of the projects on the overall lifespan and a well-planned, intense post-competition use of Solar Decathlon prototypes which assures a prolonged educational impact, an important number or research results and an overall high impact in society in general.

ANNEX 1

Case studies – 20 fact sheets of post-competition Educational Living Labs

Projects

SDE 2019
TO, Spain
MOR, Netherlands

SDA 2019
Interhouse, Marroc
TDART, United States, Marroc

SD 2017
NeighborHub, Switzerland
Selficient, Netherlands

SD 2015
Nest Home, United States

SDE 2014
Rooftop, Germany
Ressò, Spain
Techstyle-haus, France
Cubity, Germany

SD 2013
Chameleon House, United States
ECHO House, Canada
Insite, United States

SDE 2012
SML System, Spain

SD 2011
WaterShed, United States
Cenovus Spo'pi Solar House, Canada
Self-Reliance, United States

SDE 2010
SML House, Spain
LOW 3, Spain

SD 2009
Interlock House, United States
Solar House I, United States

<table>
<tr><td colspan="2">TO (SDE 2019)
ETSAV (UPC)</td><td rowspan="5">
TO at Barcelona, 2020
Source: : https://barcelonatech-upc.eu/es/sala-de-prensa/noticias/los-estudiantes-del- equipo-to-consiguen-dos-terceros-premios-en-el-concurso-solar-decathlon-europe-2019
©Andrés Flajszer</td></tr>
<tr><td>Start:</td><td>2020</td></tr>
<tr><td>Location:</td><td>Barcelona, Spain</td></tr>
<tr><td>Contact:</td><td>Martí Obiols Galí, Project Manager
(marti.obiols@resso.upc.edu)</td></tr>
<tr><td>Main partners / stakeholders:</td><td>Universidad Politécnica de Catalunya (UPC):
Escuela de Arquitectura del Vallès (ETSAV)
Escuela de Ingeniería Barcelona Este (EEBE)</td></tr>
<tr><td>Objectives and goals:</td><td colspan="2">• Inculcate that all household activities affect the environment
• Generate awareness of resources consumption and waste production related to housing
• Use of house as an educational tool</td></tr>
<tr><td>Lab type:</td><td colspan="2">Educational Living Lab</td></tr>
<tr><td>Facilities and tools:</td><td colspan="2">Domestic equipment, for research and training projects in the field of sustainability and housing at UPC campus. Gadgets and tools to unlink activities from a space.</td></tr>
<tr><td>Concept:</td><td colspan="2">The prototype is a material, an interactive expression of it 's manifesto: the project fosters a change towards an eco-systemic future, beyond sustainable housing models.
The project proposes that this change starts with self-analysis and a critical attitude towards day-to-day habits.
"The only agent determining our habits is ourselves and that we carry out these domestic actions everywhere in the city, which has, in turn, become our home." (Project team)</td></tr>
<tr><td>Users:</td><td colspan="2">EEBE campus researchers, TO members, general public</td></tr>
<tr><td>Projects / activities:</td><td colspan="2">EDUCATIONAL
• Guided visits, workshops
• House occupation experiment
SOCIAL ACTIVITIES
• Domestic equipment for the EEBE campus researchers</td></tr>
<tr><td>Outcomes:</td><td colspan="2">House occupation experiment with students living in the prototype ongoing.</td></tr>
<tr><td colspan="3">   </td></tr>
<tr><td colspan="3">Source:http://www.sde2019.hu/to_en.html ©Andrés Flajszer</td></tr>
</table>

MOR (*SDE 2019)*
TU DELFT

MOR at the Green Village, TU Delft, 2020
Source: http://mor.tudelft.nl/
©TU Delft

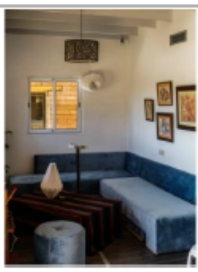
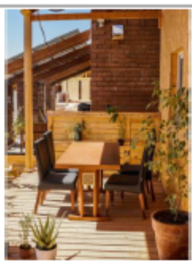
Start:	2020
Location:	Delft, Netherlands
Contact:	management-mor@tudelft.nl The Green Village (Educational Research center): info@thegreenvillage.org
Main partners / stakeholders:	**Delft University of Technology**
Objectives and goals:	• Research on rehabilitation of underperforming office buildings that will be rendered unusable by law in 2023 due to the country increasing its standard for energy labels • Research on sustainable technologies
Lab type:	Living Lab for Research and Education
Facilities and tools:	The prototype consists of an open space with sliding and hidden furniture, and a Kitchen/Bathroom module. A Green Wall is both an architectural feature and important to the climate strategy. Incoming air is filtered through the plants as it enters the home. Behind it, salt-based PCM help pre-heat the air in the winter and pre-cool it in the summer.
Concept:	The MOR strategy consists in renovating underperforming office buildings into net-positive, multi-purpose buildings that are contributors to their environment and catalysts for activities and social interactions. Using prefabrication methods with an economy of scale, MOR is able to offer affordable housing units.
Users:	Students and researchers at TU Delft
Projects / activities:	**Education:** • Regular visits of the prototype by Bachelor and Master students **Research:** • Part of the research center "The Green Village" as an ongoing test space for sustainable innovation • Monitoring to confirm the viability of the technology's innovation during a Dutch winter
Outcomes:	Not documented yet.

Source: http://www.sde2019.hu/mor_en.html

TDART *(SDA 2019)*
Abdelmalek Essaâdi University of Tangieris

TDART at Ben Guerir, 2019
Source: www.solardecathlonafrica.com/participating-teams/team-tadd-art/

Start:	2019
Location:	Ben Guerir, Morocco
Contact:	Ahachad Mohammed: ahachad_med@yahoo.fr
Main partners / stakeholders:	**Abdelmalek Essaâdi University of Tangieris**
Objectives and goals:	To become a pedagogical tool based on a 'learning by doing' approach for green building engineering and energy efficiency for Master Program of UM6P university
Lab type:	Educational Living lab
Facilities and tools:	Two floor net zero energy habitat, which uses the Internet of Things to facilitate and automate user experiences.
Concept:	Modular house based on bioclimatic architecture and a positive energy consumption
Users:	Master and PhD engineering students
Projects / activities:	**Education:** • Seminars/workshops • Prototype exploration through students **Research:** • Measurements and evaluation of the prototype in-situ
Outcomes:	• Video documentation www.youtube.com/watch?v=XfjGEBlxnJE www.facebook.com/watch/?v=609654812890968 • Publications (paper and online) • MOOC course or other type of online learning formats • Master thesis

Source:www.solardecathlonafrica.com/participating-teams/team-tadd-art/,

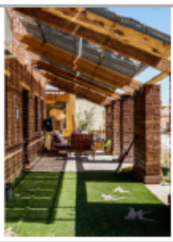
INTERHOUSE *(SDA2019)*
School of Mines of Colorado

INTERHOUSE at Ben Guerir

Source:www.solardecathlonafrica.com/participating-teams/team-interhouse/

© Solar Decathlon Africa

Start:	2019
Location:	Ben Guerir, Morocco
Contact:	Brahim Benhamou: bbenhamou@uca.ma
Main partners / stakeholders:	**School of Mines of Colorado** The National School of Architecture Cadi Ayyad University of Marrakech
Objectives and goals:	To build an experimentally validated numerical model of the house for the UM6P Master and Bachelor programs in building energy efficiency
Lab type:	Educational Living lab
Facilities and tools:	The house is structured around a courtyard, a space for welcoming and socializing, which divides the house into two main areas: a more intimate and private space oriented to the northwest, and a kitchen and living area to the southeast. The integration of these areas not only enlarges the feel of the house but connects residents with the outdoors. Build with Home Automated Control System (HACS), a sensor network that maximizes comfort and accurately measures the performance of HVAC system, containing light, motion, electrical, air quality, and environmental sensors to provide an overall perspective of the house's real-time efficiency. A custom-built black water filtration system filters the black water for reuse in landscaping and the green wall irrigation.
Concept:	Intercultural architecture design with technologies like interactive energy systems to maintain comfort in efficient way on the inside and to interact with the environment. Use of local building materials with low-and middle-income housing developers in mind.
Users:	Bachelors and Master students at University in Ben Guerir
Projects / activities:	**Education:** • Living lab for the students of GreenBEEE Master to assess the sustainability of the house • Demonstration house for Bachelor's programs **Research:** • Studies conducted by PhD student on PV system • Monitoring of indoor thermal comfort parameters for the validation of the TRNSYS based numerical model under development
Outcomes:	No documented outcomes so far.




Source: www.solardecathlonafrica.com/participating-teams/team-interhouse/ , © Solar Decathlon Africa

NeighborHub - The Blue House *(SD 2017)*
EPFL

NeighborHub in Fribourg, 2019
Source: https://neighborhub.ch/
©STEMUTZ.COM

Start:	2018
Location:	Fribourg, Switzerland
Contact:	The Blue House: neighborhub@bluefactory.ch
Main partners / stakeholders:	**École Polytechnique Fédérale de Lausanne** School of Engineering and Architecture Fribourg Geneva University of Art and Design University of Fribourg
Objectives and goals:	• Meeting place for citizens wishing to develop solutions for a more sustainable future • Cultural Lab for sustainable living practices, related educational activities and events • User experience Lab with temporary house occupation
Lab type:	Living Lab - Neighbourhood infrastructure
Facilities and tools:	La Maison Blue consists in a heated cube (the ***core***) with a functional kitchen bedroom and bathroom, and in a semi-outer cube (the ***skin***) with space to work and activities. Location with space and infrastructure for cultural activities.
Concept:	Modifiable building, thanks to its flexible architecture, movable fittings, convertible furniture, and an interior design that can be adapted to a variety of activities.
Users:	Neighbours of Fribourg, researchers of EPFL and associated universities
Projects / activities:	**Education:** • Guided tours • Workshops about renewable energy use, mobility, water and waste management, food, biodiversity, and the selection of materials. **Research:** • Energy management • User comfort and interactions – house occupation under real conditions of use • Monitoring of energy and water consumption **Social activities:** • Meeting room • Coffee chill and tea work • Library for objects and food
Outcomes:	Wide range of activities and services to raise awareness and facilitate a sustainable lifestyle around the following themes: Energy, water and biodiversity, social life, food, mobility, and consumption.

Source: https://neighborhub.ch/ ©STEMUTZ.COM

Selficient *(SD 2017)*
HU University

Selficient in Utrecht, 2020
Source: https://www.facebook.com/SelficientNL/

Start:	2018
Location:	Utrecht, Netherlands
Contact:	Selfcient initiative: info@selficient.com
Main partners / stakeholders:	**Hogeschool Utrecht University of Applied Sciences Utrecht**
Objectives and goals:	Research and experimentation on Plus-energy living spaces • Research on sustainable houses for the Dutch housing market • Research on construction with low environmental impact
Lab type:	Office space for construction start-up at campus location
Facilities and tools:	Modular house. Panels can be added to expand the house or removed to scale it down. Internet of Things" solutions allow connecting heat, water, and other home systems to the owner's smartphone.
Concept:	• **Modular:** The components are modular and interchangeable with each other, resulting short construction time. Components can be replaced according to their lifecycle • **Circular:** House can be dismantled without demolition; all materials and elements can be reused. • **Self-sufficient:** Solar panels, battery, heat pump, ventilation and other electrical components allow for energy self-sufficiency • **Affordable:** Standardization in production, use of existing products and techniques result in lower costs and affordable market price. • **Customizable:** The standardization in the construction method ensures that different variants of the Selficient house can be made with the same components
Users:	Team members of the Selficient Project
Projects / activities:	**Education:** • Guided tours • Lectures on sustainability issues **Research:** • Energy management • Self-building • Housing and working user experience • Monitoring of energy and water consumption
Outcomes:	• Duurzame Jonge 100 van 2019 (Award) • Virtual Tour of the Selficient prototype

Source: https://selficient.com/over-ons#wiezijnwij

Nest Home *(SD 2015)*
Missouri S&T

Nest Home on ecovillage in Rolla

Source: https://cree.mst.edu/laboratories/ecovillage/2015house/

©UM System

Start:	2015
Location:	Rolla, Missouri (United States)
Contact:	Center for research in Energy and Environment (cree@mst.edu)
Main partners / stakeholders:	**Missouri University of Science and Technology**
Objectives and goals:	• Research on renewable energy storage • Research on student housing • Experiential Learning for students
Lab type:	Living lab / Research lab
Facilities and tools:	Housing prototype as part of the Ecovillage at Rolla
Concept:	The Nest Home was inspired by the shape of a bird's nest and wants to prove that zero-net homes can be affordable and reliable. Prototype based on Shipping Containers for the main body of a modular home with two bedrooms and a full Automation System.
Users:	Missouri S&T students.
Projects / activities:	**Education:** • Managed by students **Research:** • Part of Ecovillage smart living laboratory • Microgrid in small neighbourhoods • Housing user experience • Monitoring of energy and water consumption
Outcomes:	• Missouri S&T Microgrid Industrial Consortium. • Three-year study on renewable energy sources – and storage – for communities of the future.




Sources: https://cree.mst.edu/ https://essentialenergyeveryday.com/lead-batteries-power-missourist-microgrid/

Rooftop *(SDE 2014)*
UdK Berlin

Rooftop UdK Berlin
Source: www.solar-rooftop.de/en/index.html
© UdK Berlin

Start:	2017
Location:	Berlin, Germany
Contact:	Prof. Dr.-Ing. Christoph Nytsch-Geusen (nytsch@udk-berlin.de)
Main partners / stakeholders:	**UdK Berlin** TU Berlin
Objectives and goals:	Teaching, Research on Campus for Engineering Students and students of UdK Berlin in general.
Lab type:	Living Lab – Mixed teaching and research lab
Facilities and tools:	Prototype building, monitoring infrastructure, open-source platform openHAB, equipment as seminar space.
Concept:	The building currently serves as a living laboratory for the development and testing of Smart-Building Technologies, the examination of occupant behavior, and the development of algorithms for efficient building energy management.
Users:	Faculties and students of UdK Berlin
Projects / activities:	**Education:** • The Rooftop Building is used for classes (building physics, indoor climate, heating, cooling, and ventilation, solar energy use in buildings, building automation, Smart Buildings, etc.) for students of the UdK Berlin and the TU Berlin **Research:** • Long-term monitoring (Building physics, Indoor climate, Thermal and electrical energy balances, Examination of occupant behaviour, Collection and evaluation of occupant data during the whole year, focussed examination of special use scenarios) • Digital Twin (Detailed system model of the building envelope, building services, and building automation on the basis of Modelica) • Development and evaluation of energy management and Smart Building concepts (Research on model and prognosis-based control concepts, Innovative user interfaces) • Monitoring of Outdoor Climate (Solar radiation, outdoor temperature and humidity, windspeed, direction), Building Envelope, Indoor Climate, and Occupant Behaviour (Temperature and humidity of building components, Temperature and humidity of the rooms, Positions of the 14 adaptive facade elements, Degree of opening of the 7 sliding doors) and Building Technologies (Operating conditions of the reversible heat pump, Fluid temperatures and mass flows of the hydraulic circuits, Temperatures in the hot water tank and thermal buffering tank, Electrical parameter of the PV system)
Outcomes:	• Regular use as educational laboratory




Source: www.solar-rooftop.de/en/index.html/ ©UdK Berlin

Ressò *(SDE 2014)*
Escola Tècnica Superior d'Arquitectura del Vallés (UPC)

Ressò in Rubí

Source: http://www.resso.upc.edu/eng/projecte_final/project.html

©Andrés Flajszer

Start:	2014
Location:	Rubí, Spain
Contact:	Martí Obiols Galí, Project Manager (marti.obiols@resso.upc.edu)
Main partners / stakeholders:	**City of Rubí** Neighborhood Association of Sant Muç Escola Tècnica Superior d'Arquitectura del Vallés (ETSAV) Collective Accio Ressò
Objectives and goals:	• Experimental strategies for urban development and renovation • Providing a shelter space with comfort conditions for low-income families • Teaching tool for self-construction and improvements that users can apply at their own homes
Lab type:	Living Lab - Neighbourhood infrastructure
Facilities and tools:	Prototype based on a scaffolding structure, highly flexible and changeable in order to receive the broadest diversity of activities. A perimeter ring contains all the permanent elements: structure, walls, facilities (kitchen and bathroom) and furniture that can be displaced. Exterior area associated to the building.
Concept:	RESSÒ is a strategy of urban, social and energy regeneration, and a teaching tool. A meeting place for neighbours to share resources in order to collectivize and allow them to save energy and money at home by doing activities in this collective space.
Users:	Cititzens of the neighborhood of Sant Muç in Rubí (Barcelona)
Projects / activities:	**Education:** • Workshops and conferences on sustainable practices and sustainable construction methods • Consultancy on energetic refurbishment of neighborhood houses **Research:** • New public spaces for the neighborhoo • Applied Research and Interventions projects in the neigborhood **Social activities:** • Meeting room and place for all type of neighborhood activities
Outcomes:	Intensive use as meeting space for the neighborhood of Sant Muç in Rubí.

Source: http://www.resso.upc.edu/eng/projecte_final/project.html

Techstyle-haus *(SDE 2014)*

Rhode Island School of Design & Brown University &University of Applied Sciences – Erfurt

Techstyle-haus Domaine de Boisbuchet

Source: https://www.boisbuchet.org/visit-the-domaine/architectural-park/

Start:	2014
Location:	Lessac, France
Contact:	Domaine de Boisbuchet: info@boischet.org/ Jonathan Knowles, Project Manager (jknowles@risd.edu)
Main partners / stakeholders:	**Rhode Island School of Design** Brown University University of Applied Sciences Erfurt
Objectives and goals:	• Research on passive houses • Research on construction materials at a lower cost and easier assembly
Lab type:	Temporary housing
Facilities and tools:	Prototype building, monitoring infrastructure and temporal student housing infrastructure
Concept:	A Passive-house with high-performance textile shell, which is stretched over the structure. The structure successfully attains the Passive House Standard by using 90% less energy for heating and cooling than a traditional building.
Users:	Attendees of the annual workshop at Domaine de Boisbuchet
Projects / activities:	**Education:** • Guided Tours • Living experience as student housing **Research:** • Regular analysis of indoor air quality and energy consumption; all metrics behind the architecture are constantly collected
Outcomes:	Use as living laboratory and teaching tool, temporary use as student housing when the annual workshop takes place.

Source: www.dgcs.unam.mx/boletin/bdboletin/2015_680.html, © JULIA HASSE

Cubity Student Residence *(SDE 2014)*
TU Darmstadt (TUD)

Cubity Student Residence TU Darmstadt
Source: https://cubity.de/en/cubity/

Start:	2014
Location:	Darmstadt, Germany
Contact:	Prof. Dipl.-Ing. M. Arch. Anett-Maud Joppien
Main partners / stakeholders:	**Technische Universität Darmstadt (TUD)** Deutsche Fertighaus Holding AG(DFH) Ministry of Economy Land Hessen ArchitecturaVirtualis GmbH Bollinger + Grohmann GmbH hhp Berlin GmbH INNIUS GmbH Technische Universität Braunschweig
Objectives and goals:	• Research and Experimentation regarding living space for students • Research on affordable student housing with Plus-energy standard • Evaluation of the prototype building under real conditions of use regarding energetic and social aspects
Lab type:	Student residence prototype building
Facilities and tools:	Modular student housing for 12 inhabitants, consistent of minimized private space of approx. 7m2 per individual unit and a jointly used hall of 16m x 16m, as shared space with kitchen unit, living area and semi-private access areas to the individual modules.
Concept:	The title of CUBITY unites the main themes: cube, city, and entity. The experimental residential project explores co-housing concepts with shared equipment and a central “marketplace”. The project attends aspects of flexibility, modularity, transportability, new types of living, renewable energy systems and favorable building costs. After participating in the 2014 Solar Decathlon in Versailles, Cubity has been reconstructed as student housing in Frankfurt.
Users:	Students living in the residence and possible visitors to the building participate actively in the evaluation of the project.
Projects / activities:	**Education:** • Guided visits, living experience by students **Research:** • Evaluation of social and energetic aspects during a 3-year monitoring period at Frankfurt under real conditions of use as student housing. • 3-year monitoring period under real conditions of use.
Outcomes:	• Research project reports: https://cubity.de/en/cubity/ • Monitoring results: https://cubity.de/en/stage-2-livinglab/#monitoring




Source: www.solardecathlon.tu-darmstadt, ©Thomas Ott

Chameleon House *(SD 2013)*
Missouri University of Science and Technology

Chameleon House on ecovillage the in Rolla
Source: https://cree.mst.edu/laboratories/ecovillage/2013house/
UM System

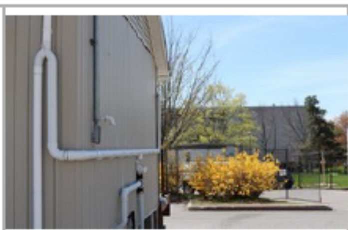
Start:	2013
Location:	Rolla, Missouri (United States)
Contact:	The Center for research in Energy and Environment: cree@mst.edu
Main partners / stakeholders:	**Missouri University of Science and Technology**
Objectives and goals:	• Research on renewable energy storage • Research on student housing • Experiential Learning for students
Lab type:	Living Lab – Research lab
Facilities and tools:	South facing Solarium expands the floor plan and take it to outside, French doors separate it from the kitchen and Dining area and serves as a buffer to the outside. A partition wall separates the bedroom and main living area. It can also be rolled into a closet for additional space.
Concept:	The concept, Engineering and Adaptable Environment, was established in conjunction with the name: Chameleon House. Embracing this concept in the architectural design of the home by utilizing an open floor plan with a partition wall to allow the space to adapt to the needs of the residents. The concept is furthered by features such as the grid-storage system, transforming table and reconfigurable kitchen cabinets.
Users:	Missouri S&T students.
Projects / activities:	**Education:** • Managed by students **Research:** • Part of Ecovillage smart living laboratory • Microgrid in small neighbourhoods • Housing user experience • Monitoring of energy and water consumption
Outcomes:	• Missouri S&T Microgrid Industrial Consortium • Three-year study on renewable energy sources and storage – for communities of the future

Source: https://cree.mst.edu/
https://essentialenergyeveryday.com/lead-batteries-power-missourist-microgrid/

ECHO House *(SD 2013)*
Queen's University

ECHO House in Queen's University
Source: https://www.qsdt.net/
©Queen's Solar Design Team

Start:	2016
Location:	Kingston, Canada
Contact:	Queen's Solar Education Centre (QSEC): business @qsdt.net
Main partners / stakeholders:	**Queen's University** Carleton University Algonquin College
Objectives and goals:	• Student research and experimentation of off-grid structure. • Educational workshops about sustainable living solutions.
Lab type:	Living Lab – Research lab
Facilities and tools:	The building has photovoltaic solar panels, solar thermal collectors, a rainwater collection system, a greywater recycling system, a radiant floor heating and live-data collection system to experiment, and a space for developing the workshops.
Concept:	Since 2016 partnership with Bullfrog Power for the use of the house as the Queen's Solar Education Centre (QSEC).
Users:	Students of Queen's University and visitors of the Queen's Solar Education Centre.
Projects / activities:	**Education:** • Guided tours • Children's camp & school workshops • Workshops for educators • Sustainability Talks • Community events & Conference **Research:** • Autonomous housing • Complex energy system • Monitoring of energy and water consumption
Outcomes:	• Live data of the QSEC: https://www.qsdt.net/live-data



Source: https://www.qsdt.net/

InSite *(SD 2013)*
Middlebury College

Insite in Middlebury

Source: http://www.middlebury.edu/student-life/community-living/residential-life/housing-information/flr_plans/insite

Start:	2013
Location:	Middlebury, Vermont (United States)
Contact:	Solar Decathlon Housing Plan: solar@middlebury.edu
Main partners / stakeholders:	**Middlebury College**
Objectives and goals:	• Student Housing • Learning about energy-consumption habits through experience
Lab type:	Temporary housing - Living lab
Facilities and tools:	The InSite house offers a large living space with a kitchen, dining room, and spacious living room to encourage interaction and shared experience, a bathroom and two single rooms. A centralized energy hearth mechanical chimney consolidates the mechanical, electrical, and plumbing systems into one modular unit to increase efficiency. The building-monitoring system allows residents to visualize their energy use and better understand the environmental impacts of their lifestyle.
Concept:	Targeted to young Vermont families, InSite is a house for local living and was designed as one piece of a larger human and natural ecosystem. InSite can be integrated into an existing walkable community—suggesting a model of living applicable on any scale. It symbolizes the team's belief that community is a natural resource, that sustainability is as much about people as it is about energy.
Users:	Students of Middlebury College
Projects / activities:	**Education:** • Guided tours conduct by the students. • Outreach events • Transformative learning trough experience **Research:** • Energy consumption monitoring
Outcomes:	• Outreach program • Tours provided to students, peers, and community members • http://www.middlebury.edu/sustainability/operations-and-action/sustainable-design/solar-decathlon-houses/solar-decathlon-housing-plan

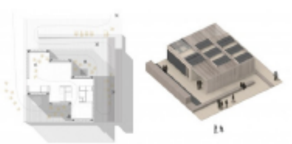
Source: https://www.solardecathlon.gov/past/2013/team_middlebury.html

SML System *(SDE 2012)* CEU-UCH

SML System in Valencia

Source: http://inforuvid.com/index.php?edi=2189&con=8432&sec=26

Start:	2012
Location:	Valencia, Spain
Contact:	Fernando Sánchez López : fernando.sanchez@uchceu.es
Main partners / stakeholders:	**Universidad CEU Cardenal Herrera**
Objectives and goals:	• Research and experimentation on Plus-energy living spaces • Educational tool
Lab type:	Living Lab – Research lab.
Facilities and tools:	The prototype has an open floor plan and two close units: the kitchen and bathroom, and the system units. In the CEU-UCH Campus as a test bench for the development and monitoring of technological innovations in the teaching fields of the CEU Cardenal Herrera University related.
Concept:	SML system allows the user to configure the space according to their needs by making a catalogue of prefabricated elements available. The inclusion of the courtyard is not part of the constructive unit as an element, but it is projected in guidance and relationship between modules, so it varies in length, being an extension from the facades and acts as a passive system of energy-saving and using the facades horizontal louvres, increases its effectiveness.
Users:	CEU-UCH students and researchers
Projects / activities:	**Education:** • Guided tours **Research:** • New energy cogeneration system adapted to homes, to meet domestic needs for electricity and heating • Monitoring of the new energy cogeneration system adapted to homes
Outcomes:	• Test bank of various sustainable technologies.



Source: https://medios.uchceu.es/actualidad-ceu/hidrogeno-para-la-cogeneracion-de-electricidad-y-calor-en-los-hogares/

WaterShed *(SD 2011)*
University of Maryland

WaterShed in Rockville

Source: https://www.pepco.com/SmartEnergy/InnovationTechnology/Pages/WatershedSustainabilityCenter.aspx

Start:	2013
Location:	Rockville, Maryland (United States)
Contact:	Scott Tjaden (WaterShed Sustainability Center): watershed@pepco.com. Amy Gardner (SD Contact): turbine@umd.edu
Main partners / stakeholders:	**University of Maryland**
Objectives and goals:	• Educate the public about energy-efficient and environmentally-friendly practices. • Showcase that operate solar-powered houses are cost-effective, energy-efficient, and attractive.
Lab type:	Living Lab – Educational Center
Facilities and tools:	The Pepco WaterShed Sustainability Center serves as a living classroom and laboratory, and features real-life demonstrations of: • Solar PV Panels (roof and ground mounted) • Solar Thermal Hot Water System • Residential Micro-Grid System • Liquid Desiccant Dehumidifier Waterfall • Greywater treatment system • Vegetated Green Roof and Walls • Sustainable Building Materials
Concept:	Inspired by the Chesapeake Bay ecosystem, the house is a model of how the built environment can help preserve watersheds everywhere by managing storm water onsite, filtering pollutants from greywater, and minimizing water use. The photovoltaic and solar thermal arrays, effectiveness of the building envelope, and efficiency of the mechanical systems make WaterShed less dependent of fossil fuels than standard homes.
Users:	Visitors of the Pepco WaterShed Sustainability Center
Projects / activities:	**Education:** • Guided tours • Virtual Tours • Life demonstrations of the technologies feature in the house • Interactive displays that educate visitors with energy-saving ideas they can apply in their own homes
Outcomes:	• Virtual tour: http://explorer360.org/spheres/md/watershed/demo10.html

Source: https://www.pepco.com/SmartEnergy/InnovationTechnology/Pages/WatershedSustainabilityCenter.aspx

Cenovus Spo'pi Solar House *(SD 2011)*
University of Calgary

Cenovus Spo'pi Solar in the University of Calgary campus

Source: https://asc.ucalgary.ca/building/cenovus-spopi-solar-house/

© University of Calgary

Start:	2013; last information available: 2015
Location:	Calgary, Canada
Contact:	Johann Kyser
Main partners / stakeholders:	**University of Calgary** Environmental Design Schulich School of Engineering Haskayne School of Business
Objectives and goals:	• Representation of net-zero energy building • Space for sustainability research programs
Lab type:	Living Lab – Educational Center
Facilities and tools:	A 93 m^2 dome shape space with two bedroom and 37 photovoltaic panels on the roof that power the building trough all year.
Concept:	From a traditional perspective, inspired by the tipi, the house's rounded form, east-facing entrance, and south-facing windows relate to the sun as a traditional source of energy and life. From a technological perspective, green building materials and renewable energy technologies result in a house that is healthy, safe, durable, and affordable.
Users:	Students and faculty of Schulich School of Engineering
Projects / activities:	**Education:** • Private and school tours • Teaching space
Outcomes:	Not documented
	  

Source: https://asc.ucalgary.ca/building/cenovus-spopi-solar-house/

Self-Reliance *(SD 2011)*
Middlebury College

Self-Reliance in the Middlebury College campus

Source:http://www.middlebury.edu/student-life/community-living/residential-life/housing-information/flr_plans/self-reliance-house

Start:	2011
Location:	Middlebury, Vermont (United States)
Contact:	self-reliance@middlebury.edu
Main partners / stakeholders:	**Middlebury College**
Objectives and goals:	• Student Housing • Learning about energy-consumption habits through experience
Lab type:	Living lab - temporary housing
Facilities and tools:	A 90 m^2 and 100% solar-powered living space for 3 people, with a master bedroom, one bunk-bed room, one bathroom, a living room, a dining area, and a kitchen (with all the appliances). In the exterior a green wall to grow vegetables and a deck area.
Concept:	Giving a traditional New England farmhouse a novel design for the 21st century, with an environmentally conscious and efficient architecture.
Users:	Students of Middlebury College.
Projects / activities:	**Education:** • Guided tours conduct by the students • Outreach events • Transformative learning trough experience **Research:** • Energy consumption monitoring.
Outcomes:	• Outreach program, and provide tours to students, peers, and community members • http://www.middlebury.edu/sustainability/operations-and-action/sustainable-design/solar-decathlon-houses/solar-decathlon-housing-plan



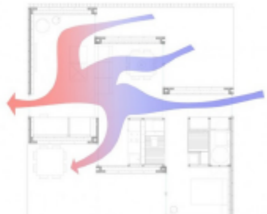

Source: http://www.middlebury.edu/student-life/community-living/residential-life/housing-information/flr_plans/self-reliance-house

SML House *(SDE 2010)*
CEU-UCH

SML House

Source:https://medios.uchceu.es/actualidad-ceu/hidrogeno-para-la-cogeneracion-de-electricidad-y-calor-en-los-hogares/

Start:	2010, last information available: 2017
Location:	Valencia, Spain
Contact:	Fernando Sánchez López (Project Manager)
Main partners / stakeholders:	**Universidad CEU Cardenal Herrera**
Objectives and goals:	• Research and experimentation on Plus-energy living spaces • Educational tool
Lab type:	Living Lab – Research lab
Facilities and tools:	The modular nature and ease of transportation allow it to be used in fairs and events to raise awareness about the use of clean energy. Test bench for the development and monitoring of technological innovations in the teaching fields of the CEU Cardenal Herrera University.
Concept:	The abbreviations SML correspond to the letters used for clothing sizing (Small, Medium and Large) in allusion to a modular composition that can be configured at the user's request depending on the spaces they need and the purpose they want to give (family, second home, workplace, etc.)
Users:	CEU-UCH students and researchers
Projects / activities:	**Research:** • New energy cogeneration system adapted to homes, sized to meet domestic needs for electricity and heating • Measurements of the new energy cogeneration system adapted to homes install in the SML House
Outcomes:	• Test bank of various sustainable technologies.

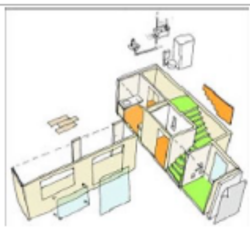


Source:https://medios.uchceu.es/actualidad-ceu/hidrogeno-para-la-cogeneracion-de-electricidad-y-calor-en-los-hogares/

Nottingham HOUSE *(SDE 2010)*
UON

Nottingham HOUSE at University of Nottingham's Park Campus

Source: https://www.nottingham.ac.uk/creative-energy-homes/?fbclid=IwAR3XpbVIkENePYq03EpZstpglsQ8znPha0FJBdxzzR_zWR94pwgWYJ96d4Y

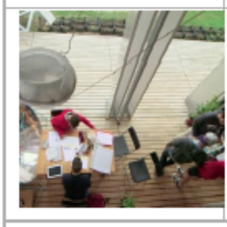
Start:	2010
Location:	Nottingham, UK
Contact:	Creative Energy Homes (ceh@nottingham.ac.uk)
Main partners / stakeholders:	**University Of Nottingham**
Objectives and goals:	• Research and test centre on micro-smart grids, energy storage, demand-side management and occupants' acceptance of innovative technologies. • Educational tool
Lab type:	Living Lab – Research lab
Facilities and tools:	The project is integrated as one of the seven houses of the Creative Energy Homes Projects. The goal of the Department of Architecture and Built Environmental is to collect data of this test-sites for research and feed in their findings into the UK government's Green Deal strategy and the Nottingham Community Climate Change Strategy.
Concept:	The H.O.U.S.E stands for home optimising the use of solar energy; it adopts a cradle-to-cradle approach to 'use, reuse, recycle'.
Users:	UON students and researchers and visitors of the campus.
Projects / activities:	**Education:** • Guided tours • Lectures on sustainability issues **Research:** • Energy management and storage • Housing user experience • Micro-smart grids • Monitoring of occupancy, weather, environmental conditions, energy consumption and use, water consumption, building fabric performance and renewable energy contributions
Outcomes:	• Events of the Creative Energy Homes project: • https://www.nottingham.ac.uk/creative-energy-homes/houses/saint-gobain-nottingham-house/nottingham-house.aspx
	  

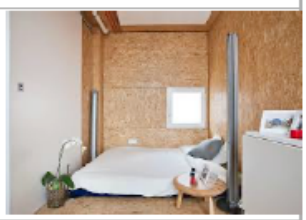
Source: https://www.nottingham.ac.uk/creative-energy-homes/?fbclid=IwAR3XpbVIkENePYq03EpZstpglsQ8znPha0FJBdxzzR_zWR94pwgWYJ96d4Y

LOW 3*(SDE 2010)*
ETSAV (UPC)

LOW 3 Living Lab ETSAV
Source: http://livinglab-low3.blogspot.com
© UPC

Start:	2011
Location:	Sant Cugat del Vallès, Spain
Contact:	Torsten Masseck, Project Manager: (torsten.masseck@upc.edu)
Main partners / stakeholders:	**Escuela de Arquitectura del Vallès (ETSAV)** **UPC**
Objectives and goals:	• Living Lab about sustainable housing and lifestyle, that allows learning though experimentation about energy-efficient and environmentally friendly practices. • Showcase that solar-powered houses can be cost-effective, energy-efficient, and attractive.
Lab type:	Educational Living Lab
Facilities and tools:	LOW3 consist in 74m² interior space with 2 rooms that now serve has meeting space/ classroom, a kitchen and a bathroom, and 42m² of the intermediate spaces (green house terraces) that connect the interior with the outside terrace. The upper floor space can be used as working area.
Concept:	LOW 3 stands for: • Low energy: A passive solar architecture in conjunction with bioclimatic optimization like the exploration of the habitability of the intermediate spaces minimizes the energy demand of the LOW3 solar house. The photovoltaic technology and the solar thermal systems integrated into the building allows it to be energy self-sufficient. • Low impact: The environmental impact is minimized both in its construction and operation through the use of sustainable materials and the high energy efficiency of the project. Material and water cycles are closed as much as possible. • Low cost: Modular and flexible prefabricated construction system allows for project versatility throughout its life cycle.
Users:	Researchers and students of UPC
Projects / activities:	**Education:** • Guided tours for schools, professionals, students • Summer workshops and Innovation Seminars for undergraduates and Master students • Teaching space about renewable energy and solar architecture • Workshops with citizens and municipality **Research:** • 10 days monitoring of real time consumption with 2 students living in the house
Outcomes:	• Master and PhD thesis on bioclimatic evaluation of LOW3 and its use as Living Lab • MOOC online course ***LOW3: Living zero!***: mooc.upc.edu • Follow-up Solar Decathlon projects 2012, 2014, 2019





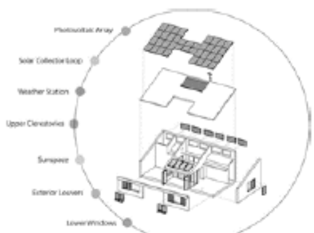
Source: http://livinglab-low3.blogspot.com/search/label/0.1.Living%20Lab%20LOW3_About

Interlock House *(SD 2009)*
Iowa State University

Interlock House in Queen's University

Source: http://interlockhousedata.com/about-the-house/

Start:	2013
Location:	Moravia, Iowa (United States)
Contact:	Center for Building Energy Research (CBER): cber@iastate.edu Research team: http://interlockhousedata.com/contact/
Main partners / stakeholders:	**Iowa State University**
Objectives and goals:	• Improve and become a more efficient passive home. • Representation of net-zero energy living is affordable. • Validate the design prediction and to develop prediction models investigating the impact of human behaviour on building energy consumption.
Lab type:	Living Lab (Activities Building and Nature Center at Honey Creek Resort State Park)
Facilities and tools:	The core of the house is an enclosed sun porch on the south side, where occupants can relax during all seasons. The sun porch is surrounded by specially designed rated, easily movable glass walls that slide open in good weather to increase ventilation and extend the living space. Sun blinds covered with photovoltaic (PV) materials use dampers and balancing fluids to passively track the sun. The louvers also act as shades for the sunspace, allowing only diffuse light through for occupant comfort. A basement below the house provides additional education space.
Concept:	The house is designed to "interlock" into existing communities instead of taking over undeveloped land—a much more sustainable approach to building. So, interconnectivity—among disciplines and ideas on the team, systems and elements in the house, and houses and people—was the focus.
Users:	Researchers of the Iowa National Science Foundation EPSCOR and Iowa State students and faculty for the ongoing monitoring and research.
Projects / activities:	**Education:** • Public guided tours • Demonstrations of sustainable products and energy-saving active and passive solar design **Research:** • Collecting data • Study the collected data to improve efficiency • Monitoring of energy consumption
Outcomes:	Data of Interlock House available under: https://www.qsdt.net/live-data



Source: http://interlockhousedata.com/

Solar House I *(SD 2009)*
The Ohio State University

Solar House I in New Albany
Source: https://www.pastfoundation.org/past-partners-with-igs-on-e3-innovation-lab-at-napl/
© Easton E3 Learning Lab

Start:	2012 / 2018 (reassembled)
Location:	New Albany, Ohio (United States)
Contact:	Easton E3 Learning Lab - NAPLS: reed.11@napls.us/ Solar New Albany:whresch@aol.com
Main partners / stakeholders:	**The Ohio State University**
Objectives and goals:	• Educate young students about sustaining our energy needs, today empowering future leaders • Space to test innovative technologies and learn more about energy concepts and sustainability
Lab type:	Living Lab - Learning centre (Easton E3 Learning Lab)
Facilities and tools:	The house is used as a classroom space for the New Albany school. The open interior layout has facilitated the conditioning of the rooms to classrooms and labs.
Concept:	The passive design has been constructed with local materials and appliances, with reclaimed barn wood on the façade to honour the agricultural heritage of the state.
Users:	Primary and secondary students of the New Albany school community.
Projects / activities:	**Education:** • The facility supports and leads innovation in STEM education and exploration in the region.
Outcomes:	• Intensive use as an educational Laboratory • Digital, web-based and classroom lesson plans, based on the collection and curation of energy usage data, created by the 40-teacher cohort.

Source: https://www.pastfoundation.org/past-partners-with-igs-on-e3-innovation-lab-at-napl

CASA SOLAR *(SD 2007) - Campus Montegancedo* UPM

Casa Solar in Montegancedo Campus

Source: https://www.solardecathlon.gov/past/2007/where_is_madrid_now.html

©UPM

Start:	2007
Location:	Madrid, Spain
Contact	Sergio Vega, Project Manager: sergio.vega@sdeurope.org
Main partners / stakeholders:	**Universidad Politécnica de Madrid (UPM)** Instituto de Energía Solar (IES) Collaborating companies
Objectives and goals:	• To offer a multidisciplinary laboratory for research and training on sustainable buildings, renewable distributed generation and intelligent control. • To facilitate the use of a SD prototype as research lab and demonstration site for solar energy in buildings and the possibilities of electric demand management.
Lab type:	Prototype solar house
Facilities and tools:	The prototype allows testing and evaluation of technological innovations in the field of energy generation, use, management and storage in buildings. Montegancedo Campus: University research area fostering the creation of an open innovation ecosystem, applying science-driven and open innovation strategies. The Experience Labs and Living Labs of the GESLAB (Global Energy and Sustainable Laboratory in Building) allow prototype development and testing including user-centred research.
Concept:	The concept of the Solar House is the integration between technology and design in order to achieve an optimum relationship between beauty and performance.
Users:	Academic community and visitors are users of the prototypes. No user-centred or user-driven research under real conditions of use.
Projects / activities:	**Education:** • Educational videos • General visits • Practical activities for the undergraduate students **Research:** • PhD research in the field of energy generation, use, management, and storage in buildings. • Collection of all type of performance data for research
Outcomes:	• A distributed system for the active demand side management of domestic electricity demand: the "GeDELOS-PV" system. • 3 PhD thesis.
	  

Source: UPM ©UPM

Magic Box *(SD 2005)*
UPM

Magic Box in Moncloa Campus
Source: UPM
©UPM

Start:	2005
Location:	Madrid, Spain
Contact	Estefania Camaño, Project Manager estefania.cmartin @upm.es
Main partners / stakeholders:	**Universidad Politécnica de Madrid (UPM)** Instituto de Energía Solar (IES) Escuela Técnica Superior de Ingenieros Industriales (ETSI) Collaborating companies
Objectives and goals:	• To offer a multidisciplinary laboratory for research and training on sustainable buildings, renewable distributed generation and intelligent control. • To facilitate the use of a SD prototype as research lab and demonstration site for solar energy in buildings and the possibilities of electric demand management.
Lab type:	Prototype solar house
Facilities and tools:	The prototype, allows testing and evaluation of technological innovations in the field of energy generation, use, management and storage in buildings.
Concept:	The prototype name comes from its versatility. A set of moveable walls allows it to be divided into three (bedroom/office, dining room/kitchen, living room) or five spaces, or to be totally open. The living room also moves to create an internal patio: this purely Spanish courtyard configuration enhances ventilation and makes a very enjoyable living space.
Users:	Academic community and visitors are users of the prototype. No user-centred or user-driven research under real conditions of use.
Projects / activities:	**Education:** • General visits • Practical activities for the undergrade students **Research:** • Research in the field of energy generation, use, management and storage in buildings • Collection of performance data for research
Outcomes:	• A distributed system for the active demand side management of domestic electricity demand: the "GeDELOS-PV" system. • Educational videos: https://www.youtube.com/watch?v=fEz5v1EpZXw
	  

Source: UPM

ANNEX 2

Educational Living Lab Survey – UPC 2020

Secció 1 de 11

EDUCATIONAL LIVING LABS_ANNEX 74 SURVEY

Dear colleague and SD/SDE expert. In this survey, we would like to ask you about educational experiences, methodologies, innovations, and outcomes you can report as a result of the post-competition use of an SD/SDE prototype for educational purposes. Thank you very much in advance for your valuable contributions! This survey consists of 8 questions and might need 15-20 min of your attention.

Basic information

Please give us some general information about your project

- Your name, position and current role regarding the project
- Your email address
- University / Higher Education Institution / or other institution or company
- SD/SDE Project name
- SD/SDE Competition in which your project participated
- Current project name (if different to original one)
- Current location of the prototype
- Currently responsible persons/entities (if different to original ones)
- The foreseen lifespan of the project (if foreseen or if the project ended already)

1. **Educational materials generated**

   Please indicate the educational materials generated in relation to the SD prototype especially during the post-competition phase

   1.1. Video documentation

   1.2. MOOC courses or other types of online materials / courses

   1.3. Publications (printed or online)

   1.4. Master thesis work

   1.5. PhD thesis

   1.6. Research reports, patents or similar

   1.7. Others

   Please describe how the SD prototype allowed for the generation of these materials and how materials are made available / used in teaching (now or in the past). Please also give links to currently online available materials.

2. **Educational methodologies/formats applied**

   Please indicate the educational methodologies or teaching formats applied in the post-competition phase

2.1. Prototype exploration through students (materials, systems, concepts)
2.2. Measurements and evaluation of the prototype in-situ (thermal comfort, system performance, bio-climatic solutions, comparison of measurements and simulation)
2.3. Seminars/workshops inspired by the special place
2.4. Co-creation initiatives for new projects, bringing together different stakeholders (students, researchers, companies, administration…)
2.5. Others: please indicate below

Please describe how the SD prototype allowed for the implementation of innovative educational methodologies and formats

3. **Target groups I**

   Please describe the target groups which participated or benefited otherwise from the SD prototype post-competition use

   3.1. BSc students
   3.2. MSc students
   3.3. PhD students
   3.4. Professionals
   3.5. Highschool students
   3.6. General public
   3.7. Others

   Please describe how many persons of each target group have been benefiting from activities related to the SD prototype in its post-competition phase and in which period of time (e.g. 3 PhD thesis in 5 years).

4. **Target groups II**

   Please indicate the disciplines which participated or benefited otherwise from the SD prototype post-competition use

   4.1. Architecture
   4.2. Civil Engineers
   4.3. Other Engineering
   4.4. Others: please indicate below

   Please describe shortly the proportion among different disciplines and the different ways of participating / benefiting from the SD prototype during the post-competition use phase.

5. **New educational formats and their influence on the universities' curricula**

   Please describe how innovative educational formats and activities linked to the SD prototype development and post-competition use influenced your universities' curricula activities. Has there been a lasting influence or contribution to the curricula?

6. **New educational networks generated**

   Did the post-competition use of your SD prototype lead to the establishment or maintenance of a network (students, faculties, companies, administration, universities) linked to it? Which type of network and with which kind of results?

7. **Other positive impacts on education**

   Please feel free to mention any other educational experience or outcome you consider relevant to share (generation of spin-offs, cooperatives, professional perspectives of participants, similar prototype projects, faculties recognition and networks, new research lines, new MSc programs, …)

8. **Finally: We all learn from challenges we have to solve, so please share with us some information about obstacles and drawbacks in the post-competition use of your SD prototype as Educational Living Lab**
    8.1. Challenges regarding Concept and Implementation as Educational Living Lab. Please describe shortly.
    8.2. Challenges regarding Costs and Maintenance. Please describe shortly.
    8.3. Challenges regarding Operation and Outcomes. Please describe shortly.
    8.4. Challenges regarding Integration in academic curricular. Please describe shortly.
    8.5. Others or any other comment you would like to make

End of survey. Thank you very much!
We really appreciate your support of our Annex 74 work on Living Labs and will come back to you with results!

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