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Final report

Enhancing knowledge transfer through Sustainable Construction Competitions and living labs platforms (SCCplus)

A contribution to Annex 74 of IEA EBC

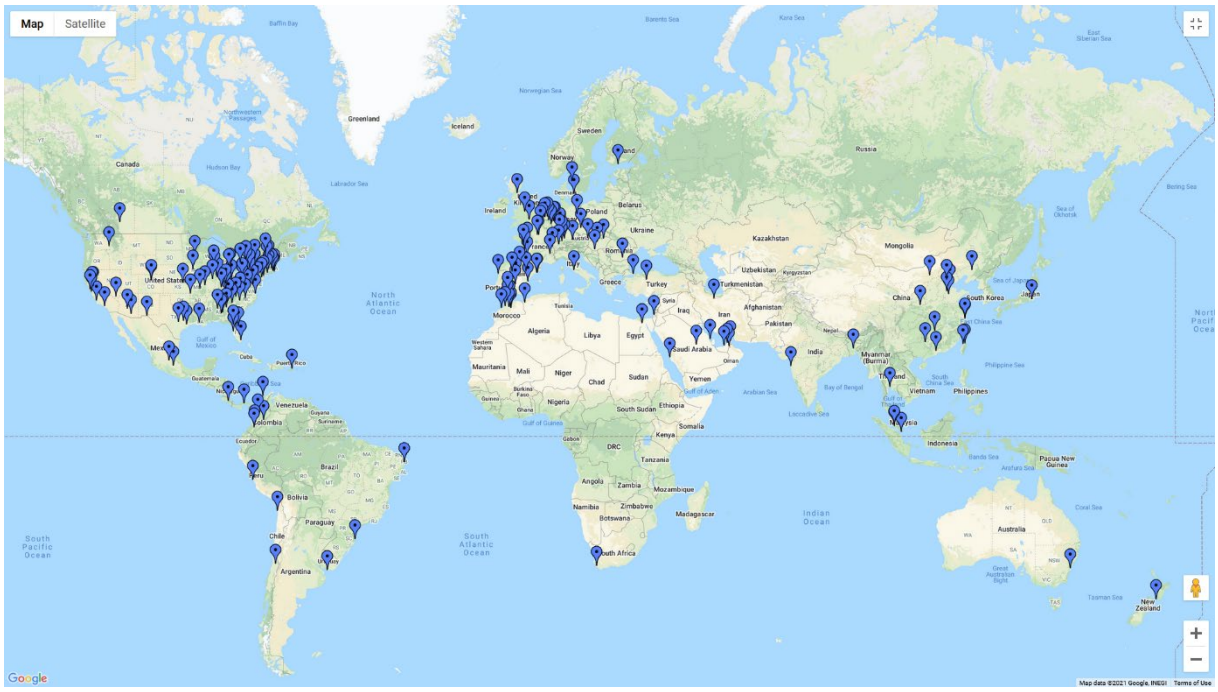

Figure 1: Knowledge Platform - Solar Decathlon Event Locations and Team Home Locations © *University Wuppertal, building-competition.org*

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Swiss Federal Office of Energy SFOE
Research Programme XY
CH-3003 Bern
www.bfe.admin.ch
energieforschung@bfe.admin.ch

Agent:
Haute école d'ingénierie et d'architecture Fribourg
Bd. de Pérolles 80
CH-1700 Fribourg
www.heia-fr.ch

Author:
Jean-Philippe Bacher, Haute école d'ingénierie et d'architecture Fribourg, jean-philippe.bacher@hefr.ch

SFOE head of domain: Andreas Eckmanns, andreas.eckmanns@bfe.admin.ch
SFOE programme manager: Rolf Moser, moser@enerconom.ch
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Summary

The SCCplus project (Enhancing knowledge transfer through Sustainable Construction Competitions and living labs platforms) has contributed to the evolution of competitions and contests focusing on sustainable construction and energy in buildings and neighbourhoods. It has laid indispensable foundations for maximizing the impact of competitions and contests such as Solar Decathlon, for knowledge transfer and for the exchange of good practices. The link with research has also been strengthened. This project covered Switzerland's participation in the International Energy Agency's Annex 74 (Competition & Living Lab Platform) - Energy in Buildings and Communities.

Zusammenfassung

Das SCCplus Projekt (Enhancing knowledge transfer through Sustainable Construction Competitions and living labs platforms) hat zur Entwicklung von Wettbewerben beigetragen, die sich auf nachhaltiges Bauen und Energie in Gebäuden und Quartieren konzentrieren. Es hat die notwendigen Grundlagen für die Maximierung der Wirkung von Wettbewerben wie dem Solar Decathlon, für den Wissenstransfer und für den Austausch von «Best Practices» geschaffen. Auch die Verbindung zur Forschung wurde verstärkt. Dieses Projekt umfasste die Teilnahme der Schweiz am Annex 74 (Competition & Living Lab Platform) - Energy in Buildings and Communities der Internationalen Energie Agentur.

Résumé

Le projet SCCplus (Renforcement du transfert de connaissance par concours de construction durable et « living labs ») a contribué à l'évolution des compétitions et concours axés sur la construction durable et sur l'énergie dans les bâtiments et les quartiers. Il a posé des bases indispensables qui permettent de maximiser l’impact de compétitions et concours comme Solar Decathlon, de favoriser le transfert des connaissances et l'échange des bonnes pratiques. Le lien avec la recherche a aussi été renforcé. Ce projet a couvert la participation de la Suisse à l'Annex 74 (Competition & Living Lab Platform) de l'Agence internationale de l'énergie - Energy in Buildings and Communities.

Contents

List of abbreviations

SFOE	Swiss Federal Office of Energy
IEA	International Energy Agency
EBC	Energy in Buildings and Communities
SD	Solar Decathlon
DSM	Demand Side Management
UPM	Universidad Politécnica de Madrid
KPI	Key Performance Indicator

1 Context

1.1 Background

Competitions and contests focused on sustainable construction and energy in buildings and neighbourhoods are an excellent way to transfer knowledge and technology to the next generation of professionals but also to the general public. The Annex 74 is building on years of experience cumulated through several Solar Decathlon competitions. It is also based on the observation that more impact could be achieved with a wider exchange of information and closer links with the scientific community.

1.2 Motivation of the project

The motivation of the Annex 74 is to stimulate the technological knowledge, the scientific level and the architectural quality within future competitions and living labs. This should be done by linking the worldwide competition and living lab experiences and by working towards improvements. The project also provides a solid base on which to develop new formats.

Annex 74 intends to consolidate and develop a systematic knowledge platform[1], as well as to link know-how from previous and current IEA activities to competitions focused on sustainable construction.

The Annex has been intended to be a think-tank with a focus on educating the next generation of architects and engineers through the use of university-based competitions and living labs. To address the specific Annex 74 objectives (see below), the work has been structured into three subtasks, with the knowledge platform as the common information resource and repository.

1.3 Goals

In the context of the Annex and more specifically for the Swiss participation to the project, the following goals have been targeted and reached:

- To be able to share with future generations of engineers and architects the experiences accumulated in the context of Solar Decathlon projects and other associated or similar Living Labs.
- To make the competitions (in particular Solar Decathlon) evolve to guarantee the relevance of the rules with the present and future environmental and social-political challenges.
- Promote Switzerland's place in a network of experts, research initiatives and projects at the international level, in a field that is highly relevant in the context of the energy transition.
- To benefit more fully and in the longer term from the experiences conducted throughout the world, and more precisely in Europe, in the field of intelligent and sustainable housing.

[1] https://building-competition.org/

1.4 Structure of the project

The figure below presents the Annex structure with input resources, subtasks, outputs and targeted audience.

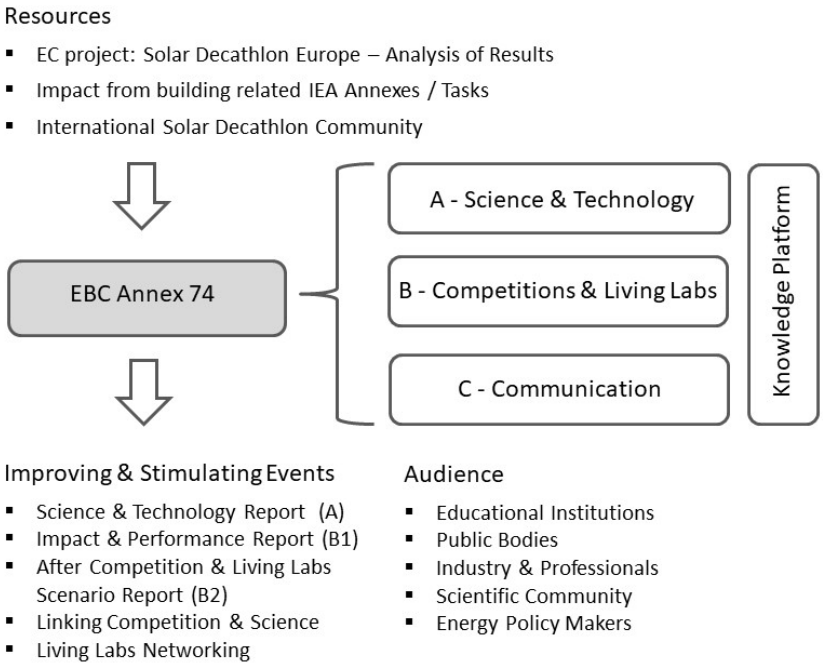

Figure 2: Structure of the project.[2]

2 Results

2.1 Subtask A – Science and Technology

The subtask was divided in the following activities:

- Analysis of past experiences and learned lessons. The analysis was based on the monitoring data at building level and competition level.
- Mapping of research fields. Typical topics of architecture, engineering and research within past competitions have been mapped. So-called “topical papers” have been written to better link competition tasks to state of the art scientific knowledge.
- Aggregation of testing protocols, templates and guidelines.

[2] Source: Karsten Voss, Nathan Van Den Bossche, Sergio Vega, Peter Russell, Louise Holloway: Competition & Living Lab Platform, Official Annex 74 description, November 2017 http://annex74.iea-ebc.org/

Specific Swiss contribution - The author and its team provided several contributions within this subtask, namely:

1. Topical paper on "**PHOTOVOLTAICS SYSTEMS**", Philippe Couty, Martin Boesiger, Jean-Philippe Bacher, *HES-SO University of Applied Sciences and Arts Western Switzerland*, March 2020.
2. Topical paper on "**BATTERY STORAGE SYSTEMS FOR BUILDING APPLICATIONS**", Philippe Couty, Dimitri Torregrossa, Jean-Philippe Bacher, *HES-SO University of Applied Sciences and Arts Western Switzerland*, March 2020.
3. Topical paper on "**BUILDING OPERATION AND USER FRIENDLINESS**", Ryan Siow, Jean-Philippe Bacher, *HES-SO University of Applied Sciences and Arts Western Switzerland*, December 2020.
4. Co-heating test "**Characterization of the thermal envelope of an experimental building**", Martin Boesiger, Mathieu Jourdan, Jean-Philippe Bacher, *HES-SO University of Applied Science and Arts Western Switzerland*, Annex 74 internal report, 2019.
5. Co-heating test "**Analytical modelling of the thermal envelope of an experimental building**", Martin Boesiger, Mathieu Jourdan, Jean-Philippe Bacher, *HES-SO University of Applied Science and Arts Western Switzerland*, Annex 74 internal report, 2019.

Summary of the main observations and outcomes resulting from the work carried out in subtask A:

- **Systematic review of the building design and construction of houses from past Solar Decathlon Europe (SDE) competitions (2010, 2012, 2014, 2019)**: the systematic review done within the subtask A (provided in the subtask report) shows the diversity of the approaches proposed by the teams in terms of (1) architecture, (2) passive design (thermal protection, windows and shading, buffer zones, passive ventilation), (3) construction systems and materials as well as (4) solar system integration. The review proved that SDE houses are compact yet relevant demonstrations of the possibility to achieve ambitious architectural goals while maximizing energy efficiency and sustainability targets. Some specificities of SDE houses appear clearly in the review: small footprint, relatively unfavourable form factor, high level of prefabrication, predominance of dry-construction. Nevertheless, the review proved that SDE houses showcase smart integration of state-of-the-art technologies and innovative technical solutions that have the potential to impact building practice.
- **Systematic review of the energy engineering of houses from past Solar Decathlon Europe (SDE) competitions (2010, 2012, 2014, 2019)**: the systematic review done within the subtask A (provided in the subtask report) gives a comprehensive overview of all questions related to energy engineering. From the solar electrical power "production" point of view, the review shows that a wide range of PV solutions were implemented (monocrystalline, polycrystalline, thin film, hybrid …). The usually well-integrated PV solutions contribute to the broad acceptance of solar energy production. The review demonstrates also the trend of the competitions to limit the peak-power of PV installations. The goal behind this is to foster optimal use of energy. From the energy storage point of view, competitions allow the use of batteries. The review shows the technology shift from lead-acid to lithium-based technologies. Again, the competitions limit the capacity of batteries to stimulate smart use of energy (e.g.

load shifting). The competitions were also an opportunity to showcase different types of solar thermal systems. From the consumption side, solar decathlon houses show excellent performances in relation to current practice. Consumption segmentation is made between appliances, lighting, media, HVAC system. The points awarded in the competitions for the energy balance are meant as a strong incentive to choose the most efficient market-available solutions. It fosters also lean solutions in terms of HVAC systems, metering and building automation. Overall, the evolution of competition rules does enable the design of the most efficient and state of the art solutions. The analysis showed that progress can and should be made in the monitoring of the houses energy systems to get a more accurate view of the subsystems efficiency. Moreover, as competition period are limited over time, no long-term assessment is possible in this context. Thus, living lab approaches on the competition site or in another relevant context should be promoted.

- **Monitoring – system design and data**: the monitoring system is a key element guaranteeing a fair competition. It must be robust and reliable, accurate, transparent. The review provides an overview of the monitoring systems used in the competitions (US, EU, ME, China, Africa).
- **Stimulating building science in competitions**: the work of the annex has shown that there are numerous opportunities to improve or deepen building science topics in the context of competitions. As already mentioned above, monitoring of sub-systems could bring more insight on the energy efficiency of the houses. From the documentation point of view, a broader use of standard documentation templates by all the teams would made benchmarking easier. Current research themes can be addressed by the competitions. For instance, (1) building-grid interaction and DSM, (2) dynamic co-heating tests to assess building thermal performance and (3) user-friendliness are new topics specifically addressed for the 2021 SD European competition.

2.2 Subtask B – Competitions and Living Labs

The first goal of subtask B was to gather all the information available about previous SD and similar competitions and to analyse the evolutions that occurred. The broader aim was, based on this knowledge, to improve and influence the direction and content of future editions of such competitions.

The subtask was divided into the following activities:

- Competition & living labs Evolution and New Developments. Gathering existing experiences about competitions and living labs to understand the evolution and prepare future evolutions.
- Event Organization aimed to identify key success and impact factors for competitions.
- Competition Rules & Regulations. Work on the definition of appropriate, fair and transparent rules and regulations.
- After Competition and Living Lab Scenarios. Fostering post-competition use and impact.

The results of the subtask B are reported in two parts: “impact and performance” on one side and “after competition and living lab scenarios”. Final report of subtask B will be available in winter 2022.

The Swiss Party did contribute to the “after competition and living lab survey questionnaire” and to the revision of the “subtask B” report.

Summary of the main observations and outcomes resulting from the work carried out in subtask B:

- **Evolution of Solar Decathlon Competitions**: the systematic review done within the subtask B (provided in the subtask report) shows the international expansion of the SD competitions since the first one (US2002). Since then, SD has established itself in Europe, China, Latin America, Middle east and Africa. Beyond the goal of promoting solar energy, the SD competitions aim at promoting innovation and knowledge generation as well as raise awareness of environmental and energy issues in society. The evolution of SD rules follows and anticipate the technology and market evolutions.
- **Post competition use and living labs**: the use of SD houses after the competition is of key importance, from an environmental point of view but also to maximize impact in terms of knowledge creation, communication and awareness raising. As designing and building a SD house is a tremendous investment in terms of time, materials, knowledge and money, the after competition use on the competition site or/and in the context the house has been designed for is of paramount importance and must be included in any future competition.
- **Evolution of rules and regulations**: the systematic review of the evolution of the core concepts as well as the rules and regulations show the shift from an initial concept of “self-sufficient solar-powered houses” towards more elaborated concepts and focusses such as: grid-interaction, renovation, density and community development, connection to heating and cooling networks … This evolution is mainly made possible by the “call for city” process and by some latitude given to the organisers of each competition. It is essential to ensure long-term alignment with the evolving needs of society.
- **Organization and project management of competitions**: the detailed and critical analysis of the material produced by the SD competition organisers shows the complexity of such an endeavour. Many aspects have to be considered and taken care of. The most important ones are (1) clear objectives and strategies to reach them, (2) an appropriate and well-structured organisation with clear roles and attributions, (3) an adequate and attractive competition location, (4) a realistic budget with a well-managed accounting system, (5) a competition and events planning and scheduling that is under control, (6) an efficient internal and external communication, (7) risk management and (8) building on lessons learned from previous competitions.
- **Evaluations of SD competitions**: several surveys have been conducted by organizers or agent companies to assess impacts and performance of SD competitions. An additional survey has been made by UPM in the course of the annex. A comprehensive set of KPI, provided in the subtask report, has been defined covering many aspects, if not all. It covers specific indicators regrouped in 4 categories: (1) the competitions and teams’ performance, (2) the organizing performance, (3) the outreach performance and (4) the global assessment.
- **Qualitative assessment and critical analysis**: the surveys confirm the substantial contribution of SD competitions in terms of education (of the next generation of architects and engineers), professional and personal skills development and industry-university collaboration. To a broader scale, SD competitions have a clear impact on people awareness.

3 Conclusions and outlook

Despite the complications caused by the COVID pandemic and the related extension of the original timeframe, the proposed Annex 74 plan was successfully implemented.

For the Swiss party, the chosen implementation path for the project could be respected. This included the following main undertakings:

- Participation in the Annex 74 meetings (in person and online) to integrate the network of actors who define the future of the Solar Decathlon competition. Contribute to the evolution of the rules of the competition, in particular for the 2021 (→ June 2022) edition.
- Writing topical papers on some of the main topics addressed in the competitions. These summaries are now available to students who will participate in future competitions.
- Contribution to the development of monitoring protocols to validate performance of buildings, more specifically co-heating tests to assess building envelope performance.
- Contribution to the living lab survey questionnaire and, still to be done, the revision of the subtask B2 report on after competition and living labs.

Summary of the main conclusions of the work carried out in the Annex 74:

- **About the competition and its contests**: the influence and impact of the competition on students, professors and professionals who participated is well recognised and undeniable. 100% of the surveyed participants consider at least SD as a positive experience overall. Of course, a successful competition needs a well structured and organized team, clear rules, fair evaluation. Organising a SD competition is a major commitment that should not be underestimated. Integrating and benefiting from experienced people in the organization of a new SD edition is a key success factor.
- **Events and activities**: the competition must be seen in a broader context, taking advantage of the opportunity to integrate numerous events and activities
- **Organization experience**: many critical aspects must be managed by the organization team. Leadership, well-organized and well-trained team, budget and cost management, risk analysis and contingency planning are essential elements to take into consideration.
- **Performance and impact**: SD competitions are a very effective tool to foster education, training and the development of the professional skills of the next generation of architects and engineers. Moreover, SD competitions have a high capacity to increase citizens' awareness towards sustainability and energy efficiency issues in buildings and cities. Knowledge transfer and innovation are also promoted by such endeavours.
- **Uniqueness**: SD is a quite unique example of competition that differs from other architectural design competition by the fact that prototypes are actually built on the same site and that the performances of the houses and teams are measured and evaluated.

The work of the annex has made it possible to gather and structure a large amount of very useful information for future competitions and to consolidate a common understanding. They have also helped to strengthen and, for the Swiss party to integrate, the network of active SD stakeholders.

3.1 Next steps after end of project

The work of the Annex 74 will continue to bear fruit in the short term in the context of the Solar Decathlon competitions in Wuppertal (2022) and Bucharest (2023). In the longer term, the impact will be seen in the evolution of the competitions and in the projects' post-competition use be it on the site of the competition - in order to conduct monitoring or post-occupancy studies - or on a new site, as a support for training, research or awareness.

4 Publications

HES-SO_2020	Topical paper on "PHOTOVOLTAICS SYSTEMS", Philippe Couty, Martin Boesiger, Jean-Philippe Bacher, HES-SO University of Applied Sciences and Arts Western Switzerland, March 2020.
HES-SO_2020	Topical paper on "BATTERY STORAGE SYSTEMS FOR BUILDING APPLICATIONS", Philippe Couty, Dimitri Torregrossa, Jean-Philippe Bacher, HES-SO University of Applied Sciences and Arts Western Switzerland, March 2020.
HES-SO_2020	Topical paper on "BUILDING OPERATION AND USER FRIENDLINESS", Ryan Siow, Jean-Philippe Bacher, HES-SO University of Applied Sciences and Arts Western Switzerland, December 2020.
UNIWUP_2021	Competition and Living Lab Platform (Annex 74), Science & Technology (Subtask A) Main Report, Karsten Voss and al., University Wuppertal 2021.

5 References

Knowledge Platform	building-competition.org
Annex 74 Webpage	https://annex74.iea-ebc.org/
Solar decathlon 21»22	https://sde21.eu/
Call for teams 2023	https://solardecathlon.eu/sde23-callforteams/
Energy endeavour foundation	https://energyendeavour.org/