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Solar Decathlon Europe and the Energy Endeavour Initiative

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Abstract

The Solar Decathlon is a prominent student competition on the topic of net zero energy and energy plus buildings. This competition has already taken place 12 times worldwide, three times in Europe and is under preparation for its next European edition. The unique feature is the triple of "design, build and operate" in an educational showcase addressing building designers, the industry and the general public. Over the course of the European editions, the participating teams have expressed the need for a platform to assist future competition organizers to further develop the format to confront renovation and dense urban living issues. This paper summarizes the ongoing process to establish such a platform: it is called the Energy Endeavour. It's aim is to further the continuation of the event and its evolution aimed to increased impact related to education, communication, energy policy and building science. One major element is a publicly accessible knowledge platform for the documentation and analysis of past events. The paper describes the structure and capabilities of this platform together with some analysis examples.

Keywords: *Student Competition, Zero Energy Building, Building Grid Interaction, Knowledge Platform, IEA*

1. Introduction

The Solar Decathlon (SD) is an international competition based on the initial idea of founder Richard King from the U.S. Department of Energy (DOE) in 2000. In this competition, universities from all over the world are challenged to design, build and operate solar powered houses. It is the only student competition worldwide addressing the performance assessment of realized buildings. During the competition's final phase, each team assembles its house in a common Solar Village. The final phase includes exhibition, monitoring and 10 contests, the reason why the competition was named a "Decathlon". Twelve competitions have been conducted up to 2016 (link 1,2), three of these took place in Europe (Solar Decathlon Europe, SDE), the last one being in Versailles, France, 2014. The European interest in the competition was stimulated by the award winners in the US from the universities in Darmstadt (2007, 2009) and Vienna (2013). With the background of the 2012 restructuring of the European Energy Performance of Buildings directive and the ongoing national efforts to improve national building codes for new buildings towards "nearly zero energy buildings", the Solar Decathlon Europe's importance as part of the European energy policy is raised as is its public visibility.

Tab. 1: Past and currently planned Solar Decathlons worldwide. Status October 2016

Region	Country	City	Past Events	Planned
North America	USA	Washington DC (5), Irvine (2)	2002/5/7/9/11/13/15	2017
Europe	Spain, France	Madrid (2), Versailles (1)	2010/12/14	?
Asia	China	Datong	2013	2017
Latin America	Colombia	Cali	2015	2017
Middle East	UAE	Dubai	-	2018

2. Analysis & Evolution Examples

Due to its concept, the competitions all address so called "all-electric-buildings" only. Heating and cooling are - partly assisted by ambient and solar heat - supplied by heat pumps, electricity is generated by the photovoltaic systems. The houses thereby demonstrate the ongoing European trend of the decarbonisation of the heat supply by using heat pumps instead of gas or oil boilers and a power grid based on a high saturation with renewables. Due to the small size of the houses and thereby the high surface to volume ratio (above 1 m^2/m^3) they offer much more roof space per floor area than conventional, detached, terrace and in particular apartment houses. The installed PV power per floor area for the houses in the three European competitions is in the range of 150 W_p/m^2 compared to 69 W_p/m^2 on average for detached homes in the German demonstration program for energy plus buildings (BMUB 2014) and even 45 W_p/m^2 on average for net zero energy buildings investigated within the framework of the IEA research on net zero energy buildings (Voss 2012). Due to these large installations the visual impact is high. It is much higher than in usual net zero energy building practice. The 2014 competition rules limit the PV installation to 5 kW_p per house (2010: 15 kW_p, 2012: 10 kW_p) and illustrate the development from building sizes like small cottages to more usual layouts: the rules allow for up to 70 m² floor area, and up to 110 m² for 2-storey buildings respectively (resulting in max. installed power of 70 or 45 W_p/m^2), see Fig. 1. On the one hand this increases the practical relevance of the prototypes, and on the other hand the realization process with the students is becoming more complex due to the construction efforts. Innovations for smart living on less space are becoming less important. Due to the limited roof space available it is of major importance in the early design phase of multi-story net zero energy buildings to decide upon the integration of solar thermal systems as well as a combined PV/thermal approach (hybrid installations). Solar fades are another option but are hardly brought into practice due to increased system costs, strong design implications and shading losses in dense urban environments. Fig. 3 illustrates the distribution of the active solar systems within the three European competitions. Hybrid systems are an example for the link of the Solar Decathlon to solar system research.

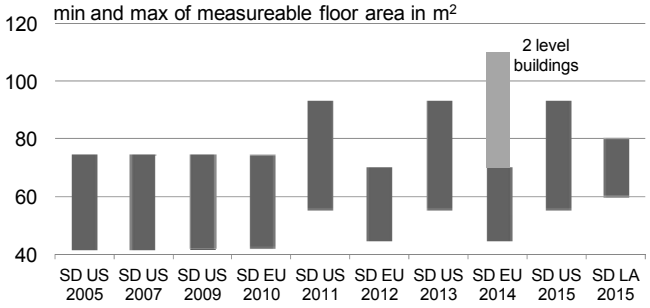

Fig. 1: Evolution of the allowable net floor area in the Solar Decathlon competition between 2005 and 2015, Source: University Wuppertal

Fig. 2: The team Luzern contribution in Versailles 2014 addresses shared spaces to decrease the individual space needs per person. Source: University Wuppertal

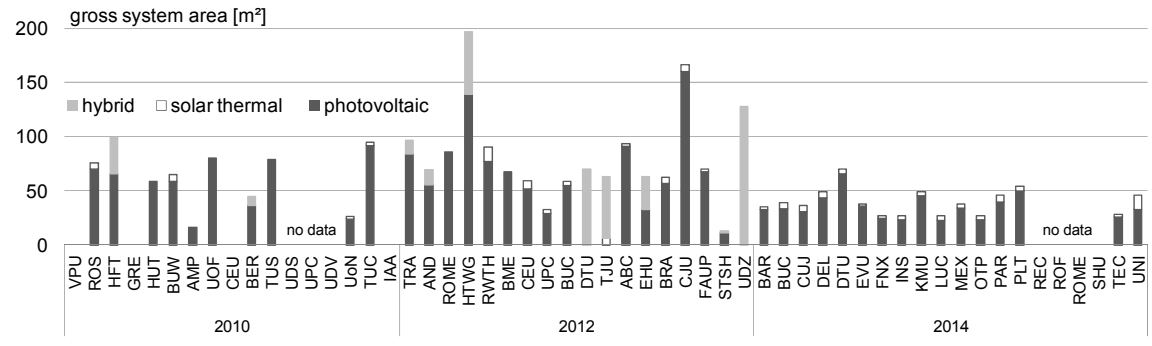

Fig 3: Distribution of the solar system gross area between solar thermal, photovoltaic and hybrid systems within the three European competitions. Source: University Wuppertal

The planned occupation of the buildings in the competitions is denser (30 m² per person) compared to real buildings in Europe (45 m² per person, Germany 2015). This addresses the enormous increase of today's life style in many countries: 3 times increased living area per person since 1950 (example Germany) is only partly compensated by the energy savings of more energy efficient buildings. Keeping this in mind, teams in the latest competitions addressed the topic of shared spaces as part of a more general shared-economy approach (Fig 2.).

Within the competition, the increased occupancy combined with energy efficient buildings resulted in an important role of appliances in the overall energy figure, Fig 4. The temporal correlation of demand and generation becomes an issue together with advanced energy storage and controls (Fig. 5 and section 3.).

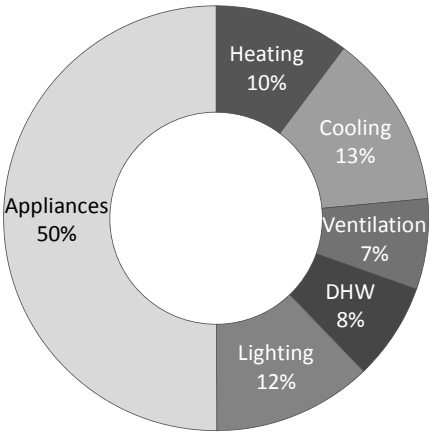

Fig. 4: Typical Distribution of the electricity demand of the solar houses presented at the Madrid competition 2012, Source: University Wuppertal

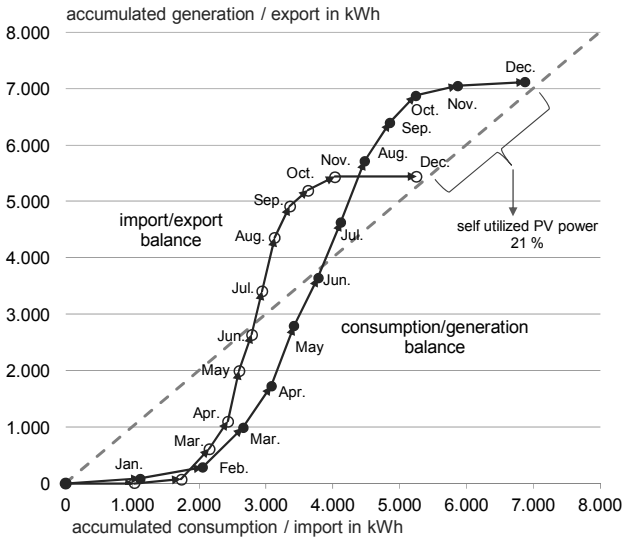

Fig. 5: The annual development of the electricity balance of the Team Wuppertal solar house during full year monitoring. The house was continuously occupied by a 2-person household (Arbach 2014). Source: University Wuppertal

The competition is made up of 10 contests and generally: five are addressed by measurements and five judged by juries, Fig. 6. As the competition constellation varies between the events, the contest evolution is illustrated by the grouping of topics to 7 main ambitions. Fig. 7 illustrates the evolution of the weighting of these ambitions over the years. Starting with a relevance of 46%, the energy contest has lost half of its importance. This is mainly affected by introducing new contests, such as "affordability" and "sustainability". Whereas in the US the organizers tried to simplify und condense the competition rules (2002: 177 pages → 2015: 62 pages), the European edition of the rules has consistently contained about 150 pages.

The latest events in Europe and China already deal with renovation of existing buildings, mainly on the level of small homes, Fig. 8. This was not the effect of changes in the rules but individual decisions of the participating teams. Some teams work on dense urban structures although building small units in the competition by adding roof top apartments on existing apartment buildings, Fig. 9. A deeper relevance of building renovation and transformation is to be increased in future competition concepts within the new Energy Endeavour initiative (section 5).

The experiences with the large efforts to set up the infrastructure for the solar village together with the request for more intensive events, communication activities and research have stimulated the organizers of the upcoming competitions in China and Dubai to extend the operation of the solar village from two weeks to about three months and connect it to a series of further events.

Usual practice after the competition is the disassembly of the houses and the transport to the home countries of the participating teams. Many of the houses are exhibited on the home university campus and used for research or as office space extensions. This is already well documented for the US competitions, Fig. 10 (link

1). The post competition activities allow to extent the impact of the efforts at the home university in interdisciplinary research and education as well as communication. The joint project "10 Action" within the EU Intelligent Europe program, the summary books edited by the organizers of the two Spanish events (Vega 2011, 2013) or the German language book publication "SolarArchitektur [4]" following the SDE 2010 serve as successful examples of a coordinated after competition publicity in Europe (BUW 2011). The post competition activities at each participating university mean further work and a local budget allocated to it. Experiences from the German teams underline the big challenge in keeping the student teams alive and securing further financial support (Voss 2014). A convincing example from SDE 2010 is the utilization of the house of the Applied University Rosenheim: After two times presentation on large public fairs it was finally placed as part of a hotel development within a zero energy district development (link 3). The house can be regularly booked and experiences with the innovative building concept can be shared. A monitoring is running. A further convincing example is placing the award winner house of the US competition 2013 from the Team Austria in a commercial exhibition site for prefabricated houses near Vienna (link 4).

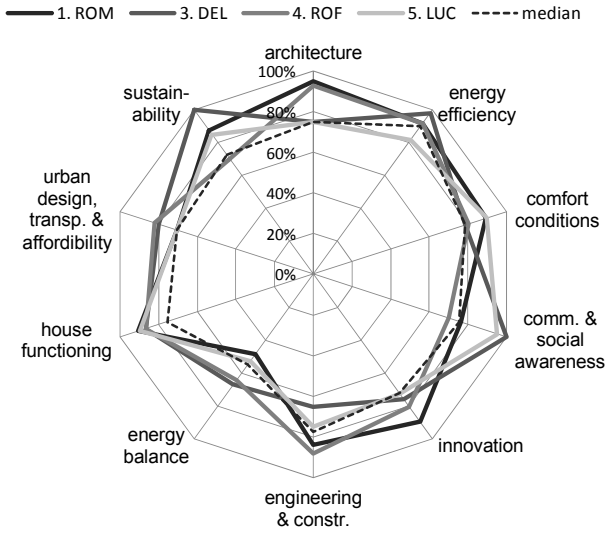

Fig. 6: Example for the contest rating in the SDE Versailles 2014 for the Delft (DEL), Lucern (LUC) and Berlin (ROF) houses in relation to the winner team from Rome (ROM) and the median of all 19 teams participating,
Source: University Wuppertal

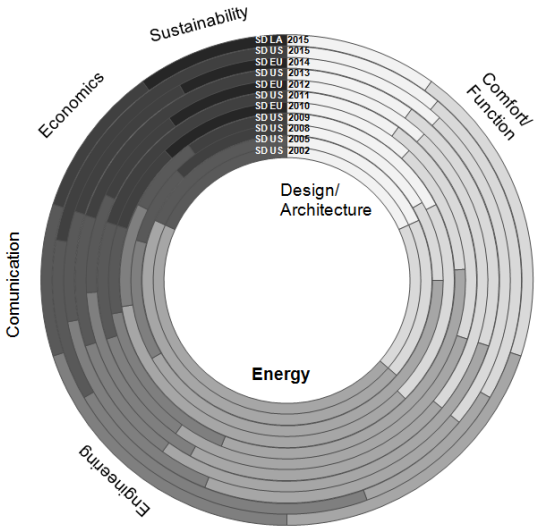

Fig. 7: Evolution of the contest weighting within the competitions worldwide between 2002 and 2015,
Source: University Wuppertal

Fig. 8: The TU Delft entry to the competition in Versailles was the retrofit of a typical Dutch terrace home.
Source: University Wuppertal

Fig. 9: The Berlin entry for Versailles addresses an apartment addition on top of a typical multifamily house.
Source: University Wuppertal

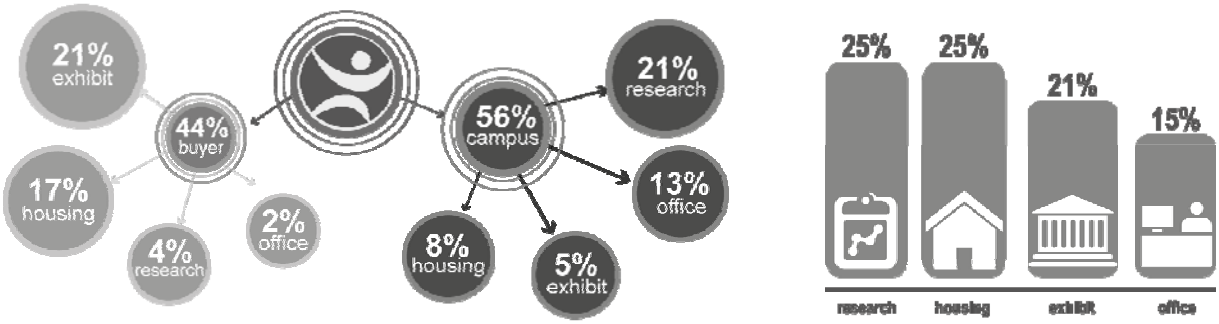

Fig. 10: Analysis of the post competition utilization of the Solar Decathlon US entries from 2005 to 2013. Source: University Wuppertal

3. Scientific Liaison

Past Solar Decathlons focused on communicating innovative energy saving solutions and solar energy utilization in buildings to the general public. A special issue of the Energy & Buildings Journal 2014 was the first set of SD publications addressing the scientific value of the event (Vega 2014). A consequent analysis of the monitoring data from the competition week was not in the focus up to now. Some teams addressed building science questions by operating the solar houses as living labs back at home, Fig. 5 (Arbach 2014).

Within the competition, each building is designed for extremely low energy use according to the competition rules. All buildings together form a temporary solar village of all-electric-homes partly linked with electric vehicles, e.g. in Irvine, USA, 2015. Beside low energy consumption and solar energy generation, the correlation of demand and supply becomes a major issue in future energy systems, Fig. 11,12. Based on former research on net zero energy buildings within the framework of the International Energy Agency (IEA Task 40 SHCP / Annex 52 EBC) a new activity was started focusing on "energy flexible buildings" (Annex 67 EBC, link 5). The solar village of the next Solar Decathlon Europe is dedicated as a case study. The energy systems will be designed under consideration of performance indicators for energy flexibility. Heat and power storage together with advanced building automation systems will play a major role. An intelligent link between buildings and electric mobility has to considered. The measurements of the solar village´s smart grid will allow the comparison with the predictions as the basis for a scientific analysis.

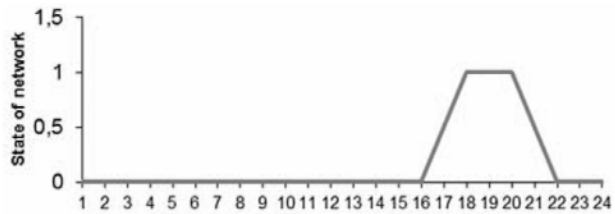

Fig. 11: Example of the energy contest rules in SDE 2014: To assess a house's energy consumption management ability at a certain time of day, the network maximum load period is simplified to a single consumption peak from 5 to 9 pm. If energy is sent to the network between 4 and 10 pm, points are won, proportionally to the amount sent. If energy is taken from the network between 4 and 10 PM, points are lost in proportion to the amount called. Source: www.solardecathlon2014.fr

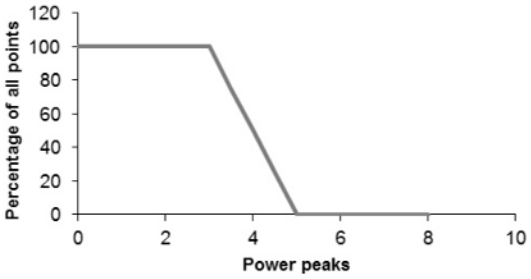

Fig. 12: The percentage of maximum points obtained by a team will depend on the average of the three highest positive peaks (electrical energy sent to the network) and three highest negative peaks (electrical energy used). Source: www.solardecathlon2014.fr

4. Documentation & Analysis - The Knowledge Platform

Currently it is an extensive effort to gain precise information from past Solar Decathlons outside the US. As the competition concept spreads worldwide and has various national organizers, the information is presented on different web portals, in different forms, with different intensities and often disappears shortly after the competition. The SD knowledge platform is a major task to secure the information, experiences and data from past events as well as to feed in the information of new competitions in one place, Fig. 13,14. The web-based platform is currently under preparation at Wuppertal University and is planned for public accessibility in early 2017.

The audience for the information stored is made up of mainly the organizers as well as the participating teams of new events. The available information may stimulate scientific work and the utilization for education. The knowledge platform also will allow the user to do efficient research by using extensive filter possibilities and the full text document search. An interactive map will show all team origins and competition sites. The language of the knowledge platform is English. There will be also the possibility to use a browser built-in translator and filter documents for the language they are written in. After a test phase the teams of the Solar Decathlon China in 2017 and Solar Decathlon Middle East in 2018 will deliver their project manuals, project drawings, pictures and other media data as well as detailed information about their house directly to the knowledge platform.

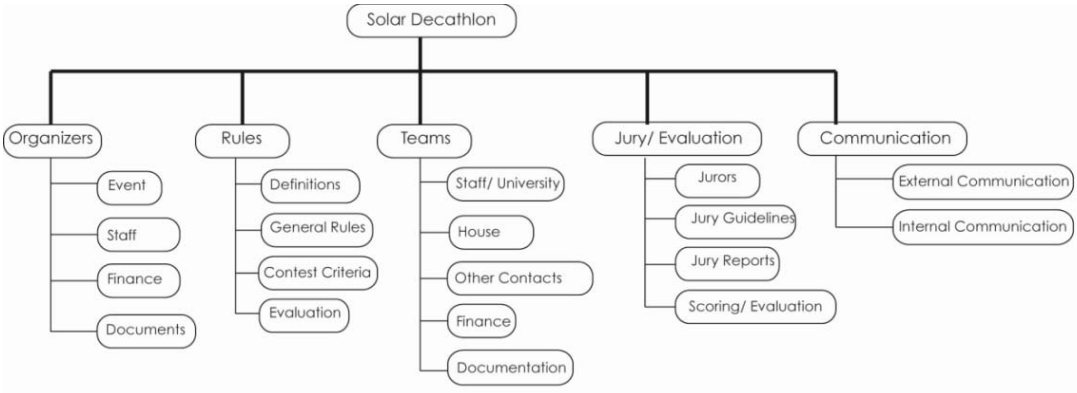

Fig. 13: Basic structure of the SD knowledge platform. Source: University Wuppertal

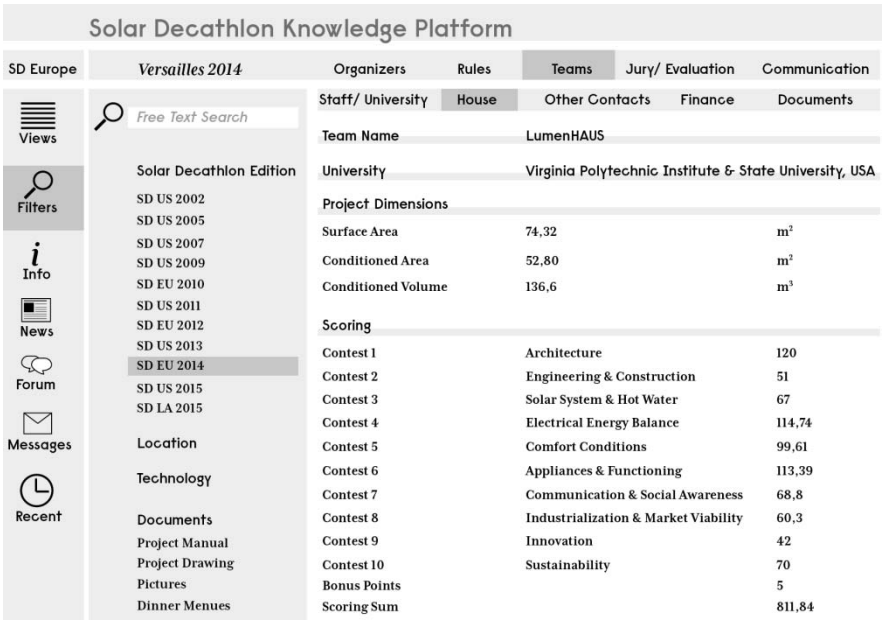

Fig. 14: Initial image of the frontend for the knowledge platform. Source: University Wuppertal

5. The "Energy Endeavour" Evolution

Contrary to the US competition, which is centrally managed by the Federal Department of Energy (DOE), the Solar Decathlon in Europe is an independent organization for each location. The hosting organization individually works on a memorandum of understanding (MOU) with the DOE. Starting already in 2010 with the "Proclamation of Madrid" (SDE 2010) the participating teams of the Solar Decathlon Europe called for a European profile of the competition and an evolution with regard to form and content. A small team of former SDE organizers and participants was establish to develop an improved European platform for the competition with a link to the DOE (Rollet 2014). This was followed by a series of meetings with European Commission representatives to ask for political and financial support. The European Commission included a small budget for communication of the SDE in the Horizon 2020 2016/2017 budget (EC 2016, link 6). In early 2015 an organizational and financial structure was proposed including the creation of a nonprofit organization (Russell 2015). A central web portal was also created in 2016 to link all SDE events and connecting them to the worldwide movement, Fig 15.

The participating teams formulated in the proclamation of Madrid the need for an evolution of the competition to also address existing buildings and dense urban living (SDE 2010). This was readdressed in a symposium in Madrid 2012 and in the Versailles Declaration of 2014 (SDE 2014). As starting point of a discussion process, an analysis of the strengths, weaknesses, opportunities and threats of the past SDE events was compiled (Tab. 2). The analysis indicates strong potentials in the evolution of the competition itself but also in the link to other events and competitions. Not every need can be covered by the SD format itself but a wider set of competitions including the SD as its currently prime event may improve the impact of all of the events considerably. The name for this framework of sustainability competitions was coined the "Energy Endeavour" by Louise Holloway. The Energy Endeavour is being assisted by the non-profit foundation. The foundation is also negotiating the MOU with the U.S. DOE as their partner in Europe to steward the values, message and content of the Solar Decathlon in Europe.

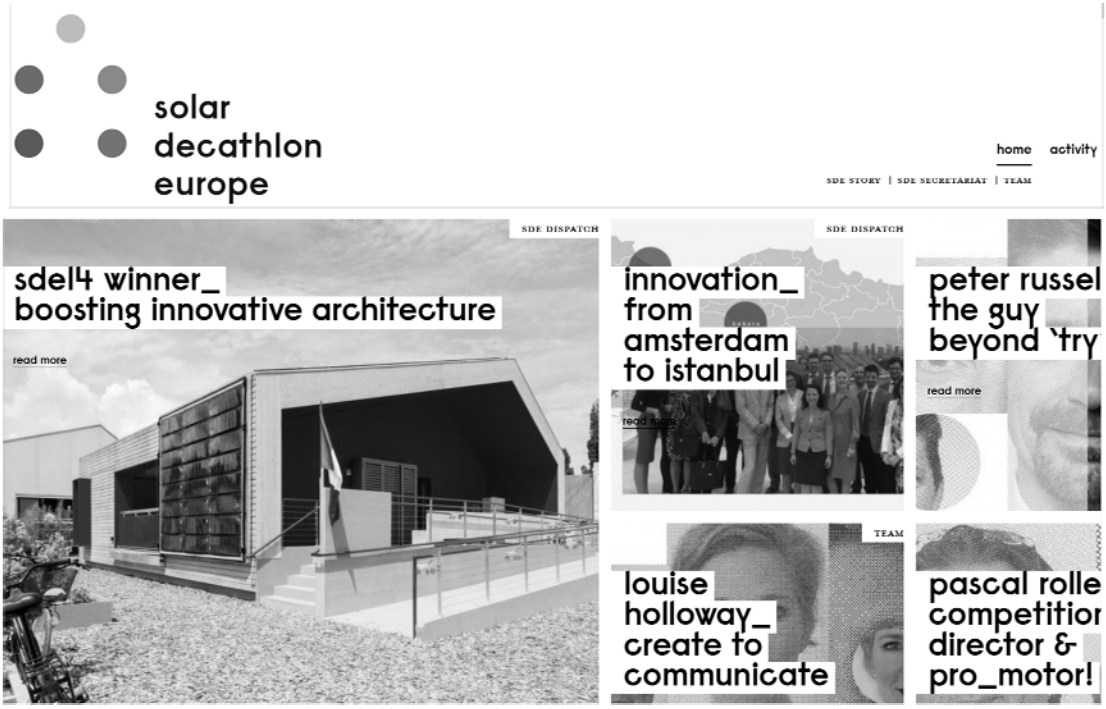

Fig. 15: The new home page of the Solar Decathlon Europe describes the Energy Endeavour initiative and links to the worldwide events, Source: www.solardecathlon.eu

Tab.2: SWOT analysis focusing on the three European competition editions.
Source: University Wuppertal

Strengths	Weaknesses
• topic of high relevance in society, policy, economy & building science • innovative show cases for communication of ZEB to the general public • unique "design-build-operate" approach for educating students • interdisciplinary work stimulates cross boarder education at the universities	• „insider event“, lack of links • no strong & harmonized communication outside the event weeks • limited market relevance by focus on new and small buildings • lack of links to building energy policy • missing scientific approach & relevance
Opportunities	**Threats**
• collaboration of all actors in the building sector • link to e-mobility • linking craftsmen and academic education • increased impact in research and energy policy • focus on existing buildings and dense urban structures • continuous evolution of topics, rules and form • continuous, harmonized communication and networking	• lack of interest of the general public, depending on location • decreasing degree of innovation (copy & paste) and interest • loss of organizational know-how from one event to the next • non secured financial foundation • risk of sufficient industry support

All past Solar Decathlon events underline the professional approach needed for the success of such an event. If the organizer cannot benefit from previous experience, even minor details can jeopardize success. The essential infrastructure for the competition phase demands considerable effort, from shuttle bus services to measurement technology. This in turn requires an adequate budget (in Europe about 10 million €). In many ways, in form, content and financially as well, new competitions profit from a certain continuity of know how. The Energy Endeavour network will serve as a know-how platform linking the experiences worldwide. This requires a certain financial foundation itself. On the other hand, the network service reduces the budget needed per event.

6. Outlook

An IEA annex addressing the Energy Endeavour initiative will be formally proposed within the program on Energy in Buildings and Communities (EBC) and discussed at its board meeting until the end of 2016. It will depend on the international support with regard to the content and shared funding, whether this new network can start work in 2017. The discussion on a follow up Solar Decathlon in Europe is still ongoing. In the case of successful installation of the Energy Endeavour network, it is intended that the location will be selected by a call for cities in 2017.

Acknowledgements

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7. References

Literature

Arbach, S., Otto, J., Voss, K.: Nullenergiehaus im Praxistest, Sonne, Wind und Wärme, 10/2014

BMUB: What makes an Efficiency House Plus? Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, brochure, 2014

BUW 2011: SolarArchitektur 4, Detail, ISBN 978-3-920034-48-5, 2011

Rollet, P., Russell, P., Voss, K.: Solar Decathlon Europe - Beyond 2014, A position paper, 2014

Russell, P.: Solar Decathlon Europe Secretariat - Project Description, Structure and Finances, 2015

SDE 2010: Solar Decathlon Europe Proclamation, signet by the faculty advisors, 27 June 2010

SDE 2014: Versailles Declaration, signet by the faculty advisors, 12 July 2014

Vega, S., Serra, J.: Solar Decathlon Europe 2010 - Improving Energy Efficient Buildings, download: http://www.sdeurope.org/wp-content/uploads/downloads/2011/10/SOLAR-DECATHLON-EUROPE-2010.pdf

Vega, S., Serra, J.: Solar Decathlon Europe 2012 - Improving Energy Efficient Buildings, ISBN 978-84-695-8845-1, 2013

Vega, S., Rodriguez-Ubinas, E. (ed.): Science behind and beyond the Solar Decathlon Europe 2012, Energy and Buildings, Special Issue, vol. 83, 2014

Voss, K. et. al.: Solar Decathlon Europe - Dabei sein ist nicht alles, proceedings of the EnOB Symposium, Essen, Germany, 2014

Voss, K., Musall, E.: Net Zero Energy Buildings - International projects of carbon neutrality in buildings, Detail, 2nd edition, ISBN 978-3-920034-80-5, 2012

Web links

link 1: http://www.solardecathlon.gov/, last visited 21.9.2016

link 2: http://www.solardecathlon.eu, last visited 21.9.2016

link 3: http://www.solar-decathlon.fh-rosenheim.de/nachnutzung, last visited 21.9.2016

link 4: http://www.blauelagune.at/r/lisi-haus, last visited 21.9.2016

link 5: IEA EBC Annex 67: www.iea-ebc.org/projects/ongoing-projects/ebc-annex-67/, last visited 21.9.2016

link 6: ec.europa.eu/research/participants/data/ref/h2020/wp/2016_2017/main/h2020-wp1617-energy_en.pdf, last visited 21.9.2016