

# International Energy Agency

## Building Competitions as an Incentive for Research, Education and Communication

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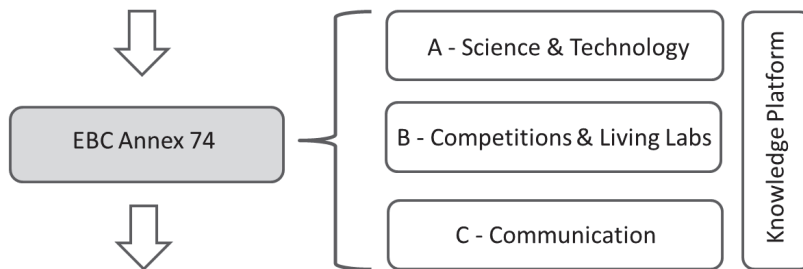
<https://annex74.iea-ebc.org/>

Competition & Living Lab Platform – Annex 74

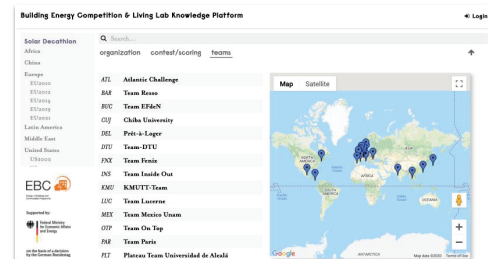


### Resources

- EC project: Solar Decathlon Europe – Analysis of Results
- Impact from building related IEA Annexes / Tasks
- International Solar Decathlon Community



## Annex 74, 1/2018 – 6/2021: Competition & Living Lab Platform



### Improving & Stimulating Events

- Science & Technology Report (A)
- Impact & Performance Report (B1)
- After Competition & Living Labs Scenario Report (B2)
- Linking Competition & Science
- Living Labs Networking

### Audience

- Educational Institutions
- Public Bodies
- Industry & Professionals
- Scientific Community
- Energy Policy Makers

### Participating Countries

(Belgium), China, **Germany**, The Netherlands, **Spain**, Switzerland, United States

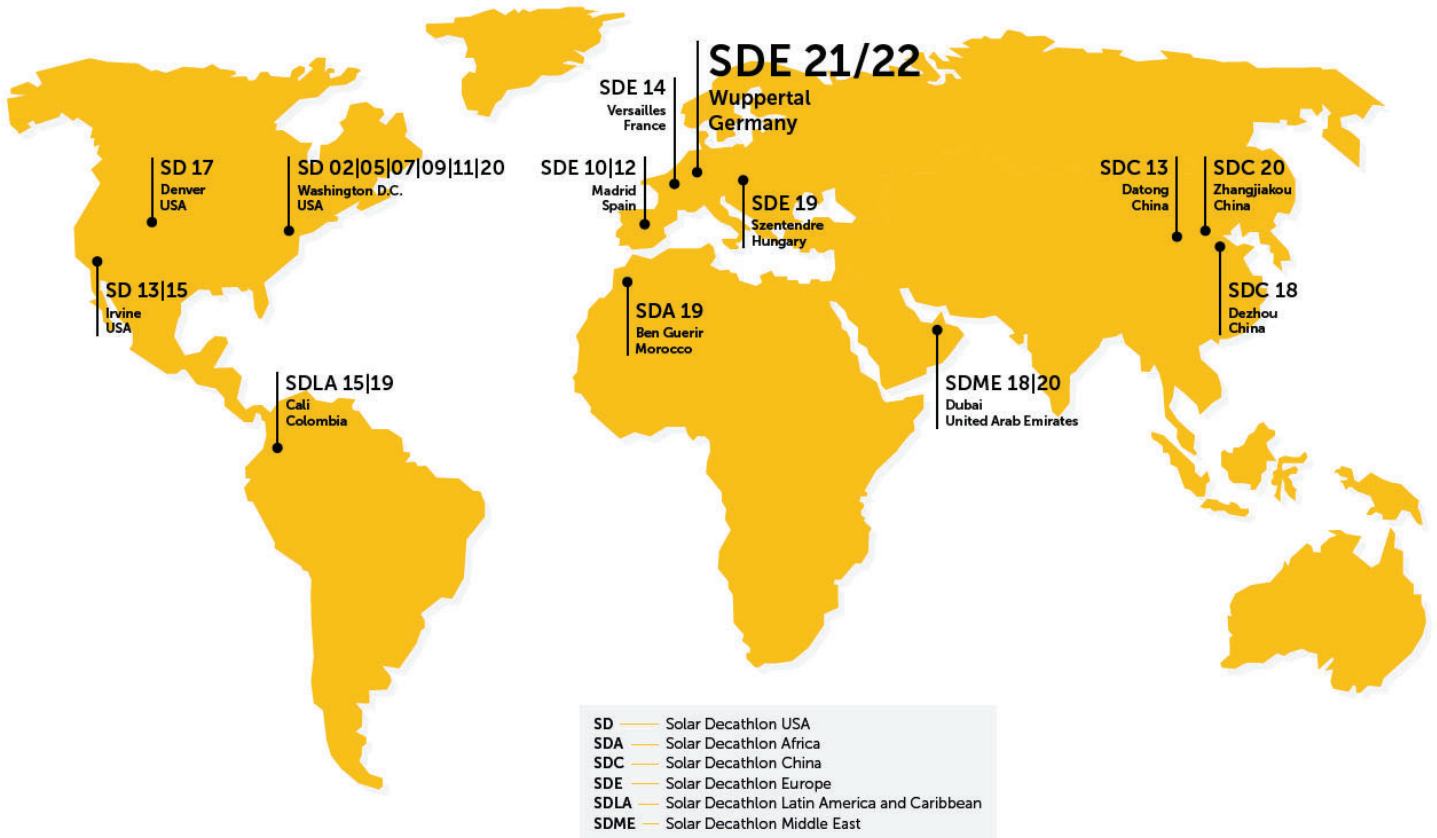
### Observers

Hungary, Morocco, United Arab Emirates, Colombia

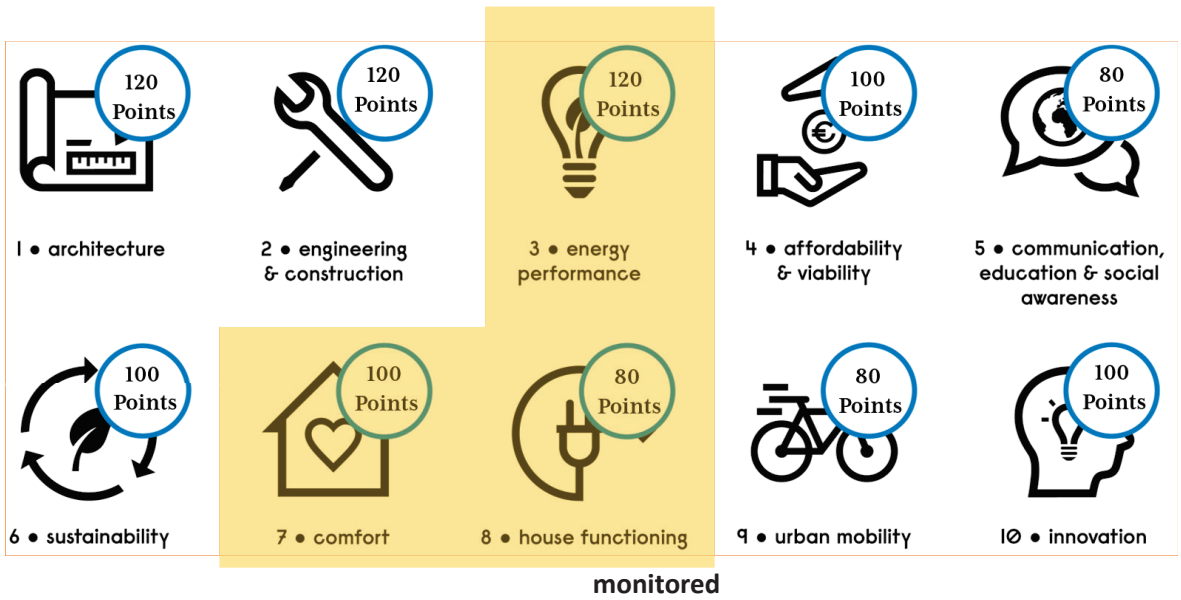
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# Solar Decathlon Europe 2010, Madrid



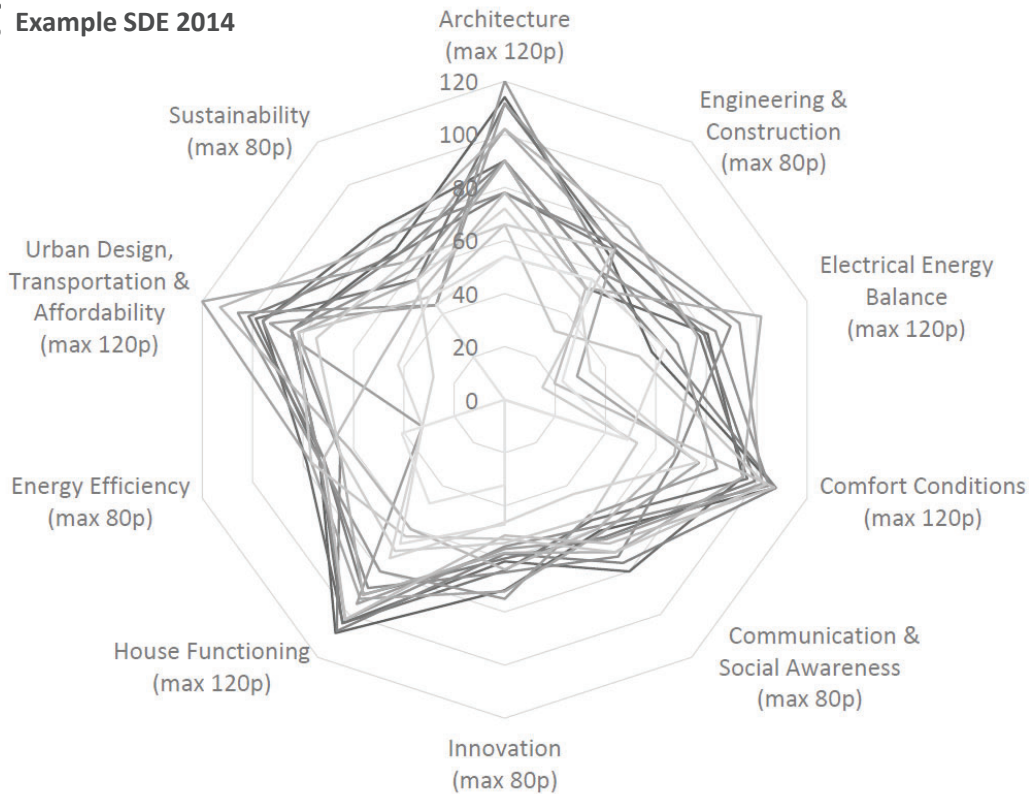
# Ten Contests Example SDE 21/22



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# Scoring Example SDE 2014



# Sharing Results & Experiences

## Building Competition & Living Labs Knowledge Platform

**Solar Decathlon**

Africa

China

Europe

- EU2010
- EU2012
- EU2014
- EU2019
- EU2021

Latin America

Middle East

United States

- US2002

Q Search...

organization contest/scoring teams

<https://building-competition.org/>

ATL	Atlantic Challenge
BAR	Team Resso
BUC	Team EFdeN
CUJ	Chiba University
DEL	Prêt-à-Loger
DTU	Team-DTU
FNX	Team Fenix
INS	Team Inside Out
KMU	KMUTT-Team
LUC	Team Lucerne
MEX	Team Mexico Unam
OTP	Team On Top
PAR	Team Paris
PLT	Plateau Team Universidad de Alealá

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## SDE 21/22 Start 10. June 2022

First edition stimulated by the work Annex 74: advanced monitoring, improved analysis & documentation



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# Building Competitions as an Incentive for Research, Education and Communication

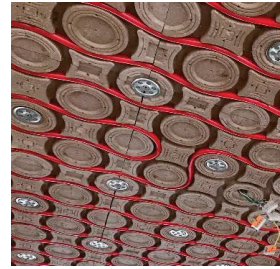
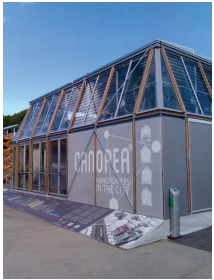
Architecture

Construction

Energy Engineering

HVAC

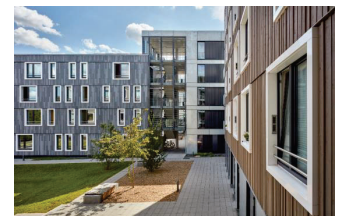
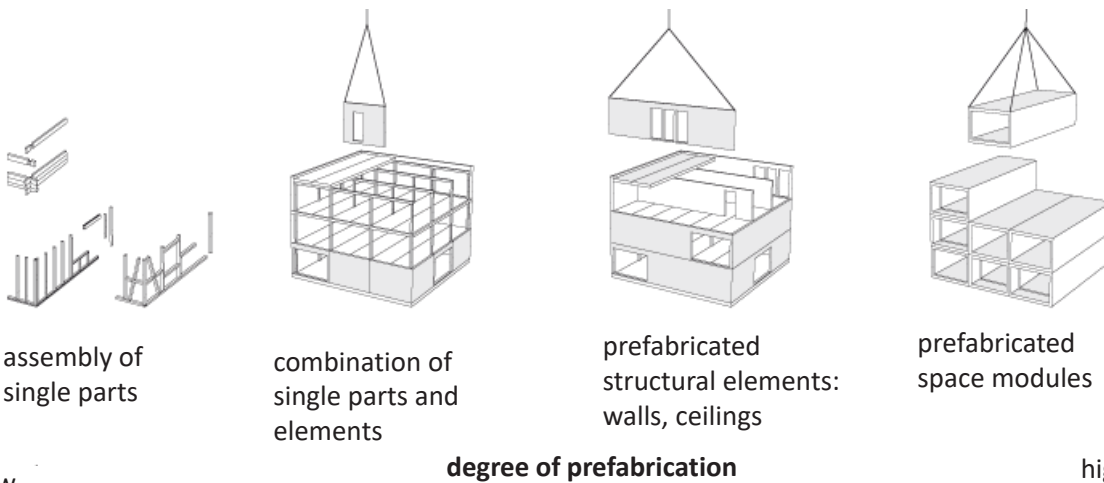
Controls



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## Modular and prefabricated construction – Design, Testing and Inspiring the Market



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The degree of prefabrication differs depending on the chosen construction principle.

Source: proHolz Austria, Zuschnitt 50 - Journal about wood as a material and works in wood (proHolz Austria, 2013)





# Virginia Tec SDE 2010: 1 Module Home 10,2 x 3,2 x 3 m

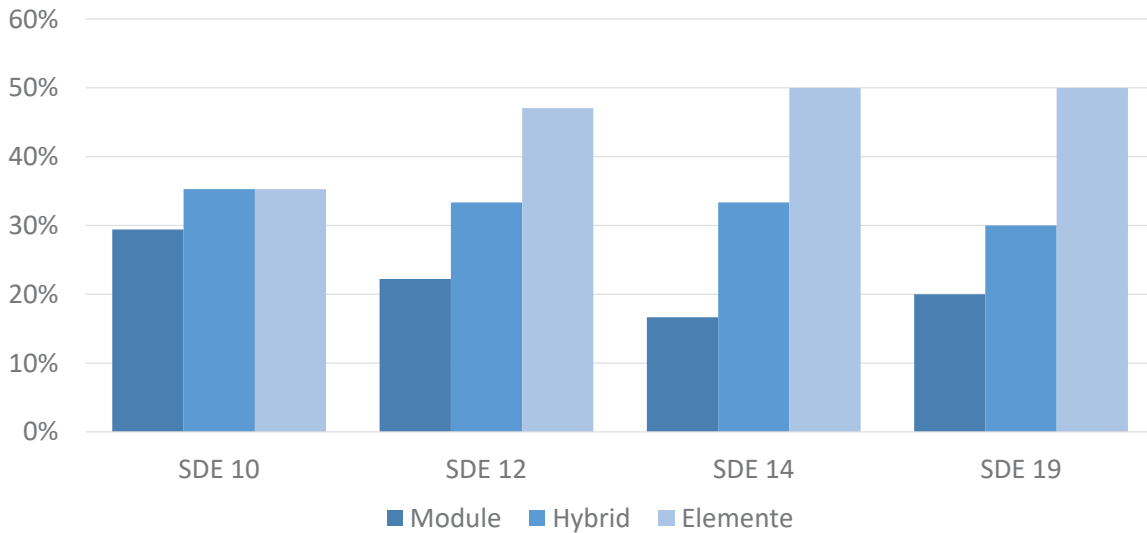


Source: Virginia Polytechnic Institute and State University, Construction Drawings



# Solar Decathlon Europe – Prefabrication Strategies

Modular constructions do not dominate so far, mainly due to limitations in design.



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# Energy Engineering for (all electric) Net Zero Energy Buildings



## Solar Decathlon Europe – A review on the energy engineering of experimental solar powered houses

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 Building grid integration

### ABSTRACT

The Solar Decathlon is a competition for universities from all over the world to design, build and operate small experimental solar powered houses. Its first edition took place in the US in 2002. Since 2010 it is in practice in Europe with four competitions and 65 net zero or net energy plus houses build and tested in 10 disciplines (decathlon). This paper provides an overview and analysis on the European edition of the competition. The work was carried out within the framework of Annex 74 'Competition and Living Lab Platform' of the International Energy Agency and an EC funded project named 'Solar Decathlon Europe – Analysis of the Results'. The analysis was based on the development of a web based knowledge platform, providing a large set of information and monitored data from past competitions. Based on the availability of information and data, the comparative evaluation is centered on the building energy supply system and their performance. Starting with very large PV systems, the latest competitions rules trigger the teams to apply systems sized comparable to small buildings in net zero energy building practice. As a result not all houses succeed in a positive energy balance. Due to the wider introduction of batteries the self-consumption of the solar yield and the degree of self-sufficiency increases. New developments of the competition rules stimulate the energy flexibility in operation with the power grid. Modifications for the rules and the monitoring procedure for the next edition intend to further link the competition to building science.

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### 1. Introduction

The Solar Decathlon (SD) is a competition that the U.S. Department of Energy began organizing in 2000 for universities, which consisted of designing and building a prototype of energy self-sufficient housing, powered solar energy, and equipped with technologies that would allow maximum energy efficiency [26]. The final phase consisted of assembling the houses on a common site where all the prototypes were exhibited and competed, passing through 10 different contests that comprise the competition (Decathlon). Its main objectives were to educate the next generation of architects and engineers as well as the public, making them aware of the efficient use of energy, and promoting the development of building integrated solar energy systems. 2002 was the year of the first competition final. Since then five more competitions followed in the US. With the first SD in Europe held in Madrid 2010, Spain, the competition spreads worldwide, as illustrated in

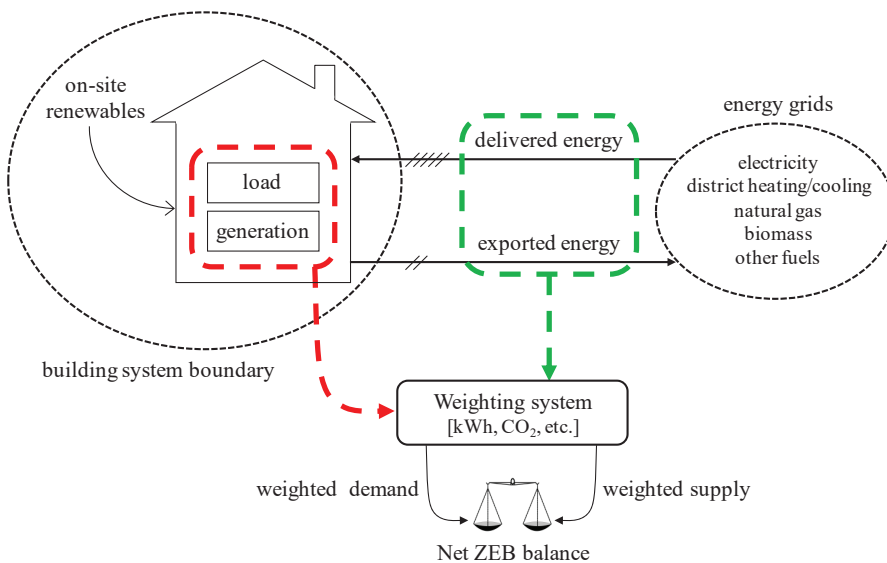
Figs. 1 and 2. For now there are SD editions in the US, Europe, China, Latin America, Middle East and Africa.

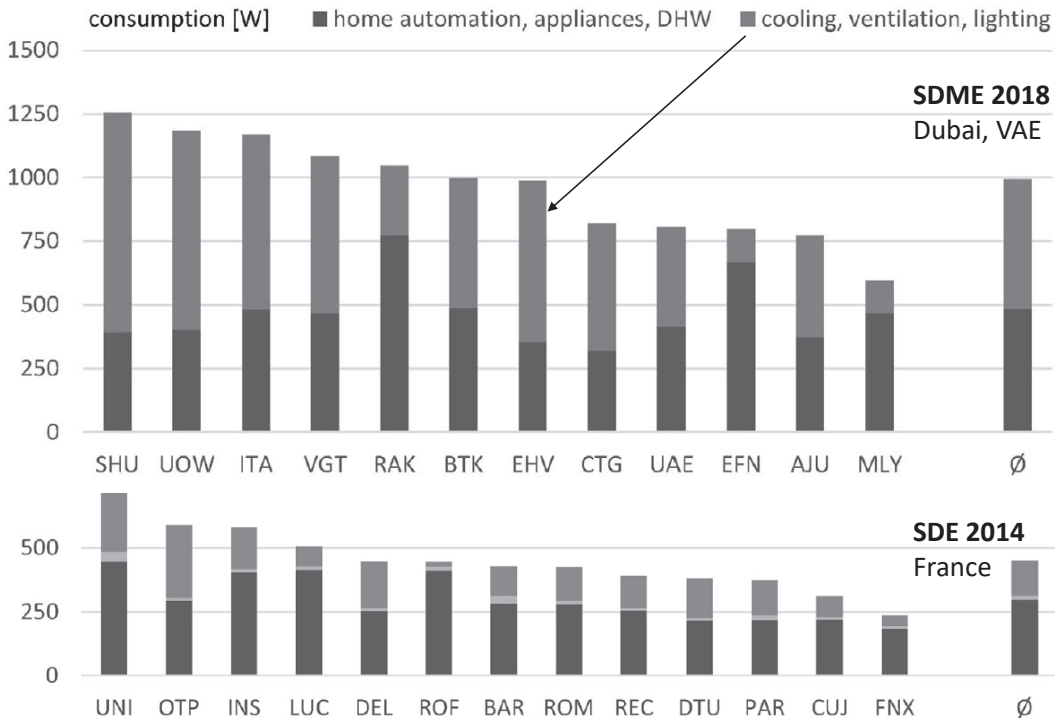
Within the scope of this competition, international student teams design, build and operate experimental houses. To make the assembly, disassembly and transportation process possible, the houses are small, lightweight constructions. A high degree of prefabrication proved to be advantageous as the houses must be built in a short period and able to fully function immediately upon construction without commissioning. Usually, the houses run through the following process:

- pre-construction at the team's home location,
- disassembly,
- transport to the event location,
- simultaneous assembly within two to three weeks,
- testing and demonstration for 10 to 14 days,
- again disassembly and transport back to and assembly either at home or a new location.

The SD rules have a core of five content namely architecture (visual), comfort, house functioning, energy (monitored) and com-

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Average power consumption of all houses during the competition period. The climate of the location determines the power consumption of the HVAC equipment.

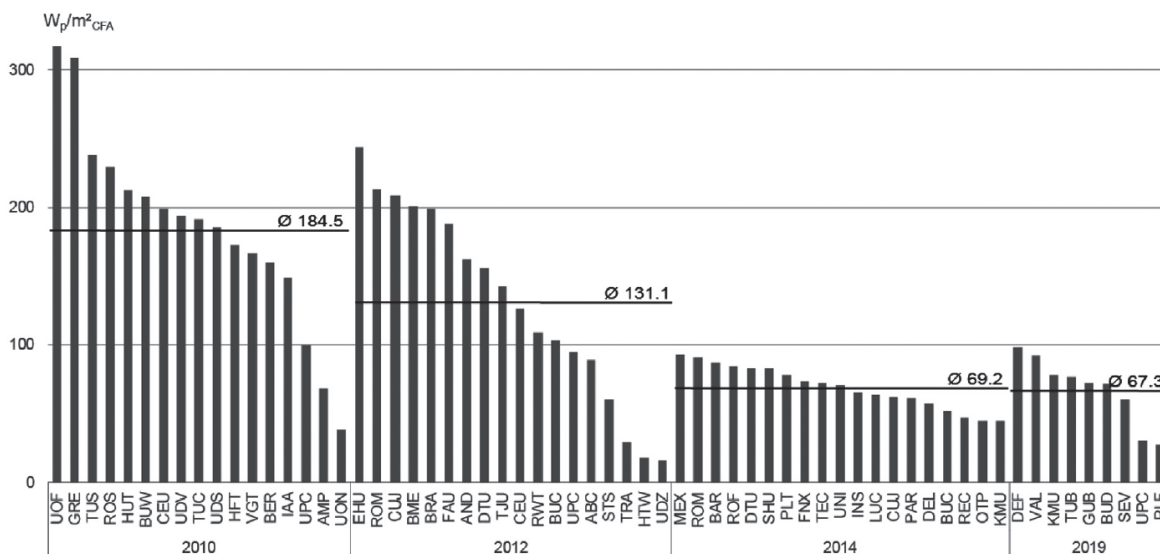
## Energy Use Intensity

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## Solar System Sizing - Photovoltaics

Setting ambitions upper limits for the PV peak power increases the need for energy efficiency to reach a positive energy balance. Limits in SDE 21/22: 3 kW peak power ( 30-40 W/m<sup>2</sup>) 2,5 kWh battery storage capacity



Correlation between the installed peak power of the PV systems and the conditioned net floor area of the houses in the European competitions. The relevant information is not available for all houses.

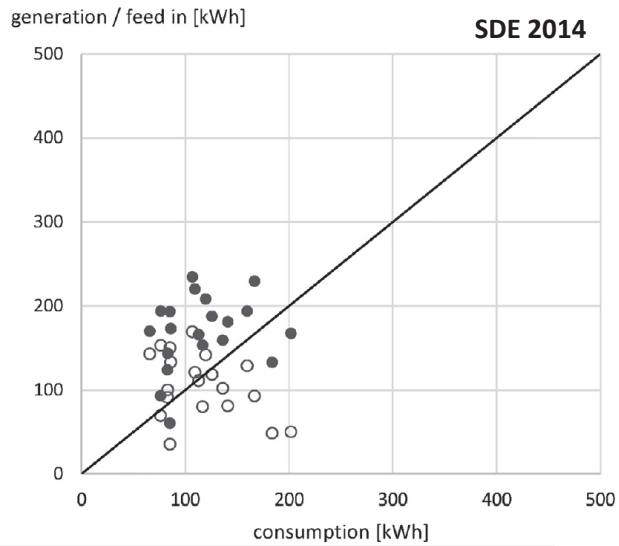
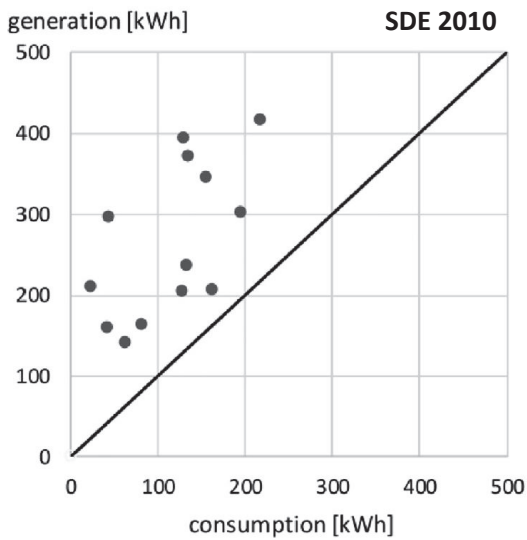




# Energy Balance and Self Consumption

Electrical energy balance of all houses at SDE 2010/2014 based on monitored data during the competition period. Houses with data points above the diagonal are net energy plus homes.

● generation / consumption      ○ feed in / consumption



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# Solar System Integration no system data analysis up to now

Hybrid Solar Systems (PVT)



New Approaches



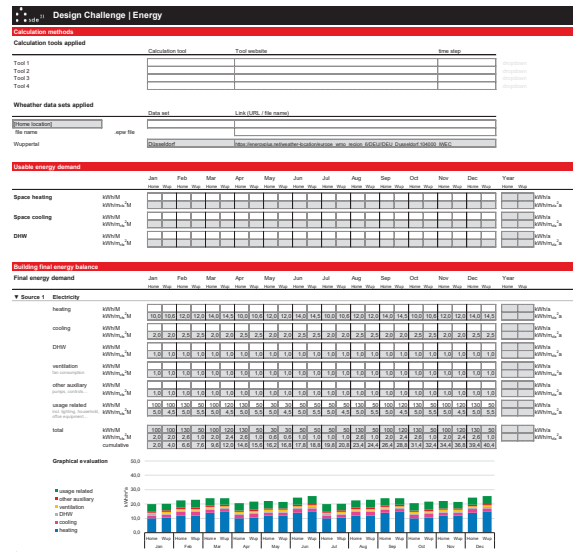
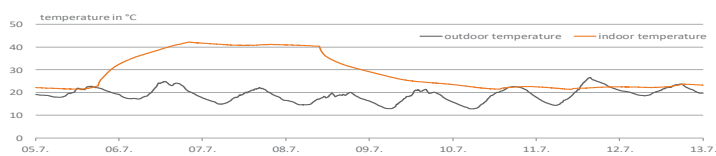
Design Solutions



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# Building Competitions and Research Conclusion and Outlook

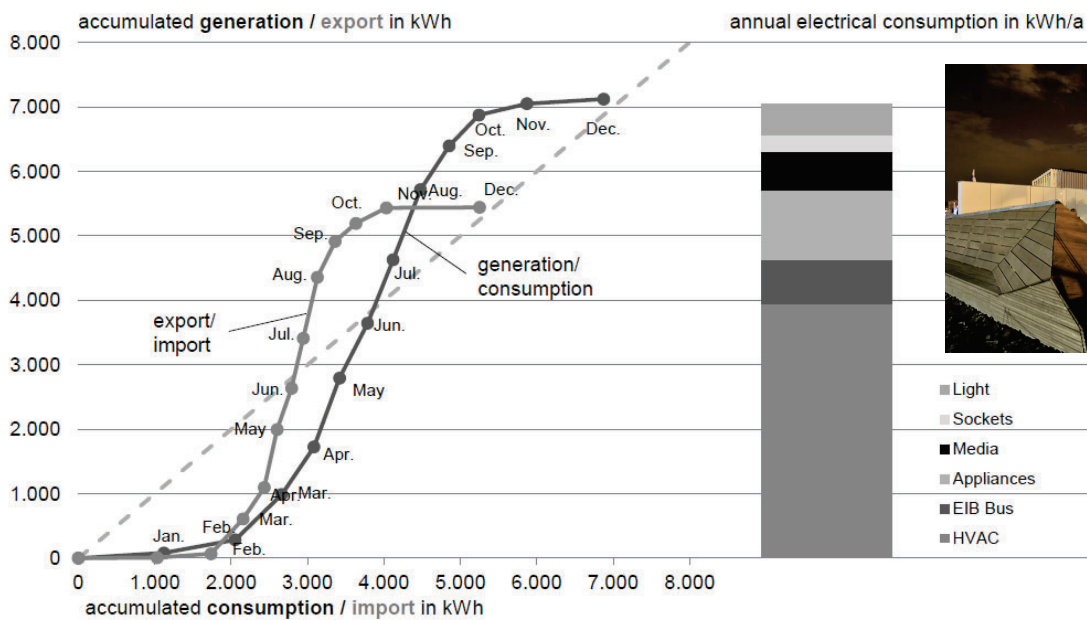
- Research based on competition monitoring data needs a more systematic data and information collection. The Annex introduces suitable platforms.
- SDE 21/22 introduces and tests new contests and test sequences such as co-heating tests, PV system performance rating, grid interaction task, ...
- Systematic modelling and monitoring may allow research on the performance gap of buildings and systems.



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# Research following a Competition Participation





Monitored annual electric energy balance of the team Wuppertal house of Solar Decathlon Europe 2010. The house was fully occupied by a two-person household in 2012/13. The annual generation on site balances the consumption. Based on net electricity metering the degree of self-consumption of solar power was 20%, the degree of self-sufficiency was 21%,



# Living Labs – Educational Platforms

<b>TO (SDE 2019)</b> <b>ETSAV (UPC)</b>		
<b>Start:</b>	2020	
<b>Location:</b>	Barcelona, Spain	TO at Barcelona, 2020 Source: <a href="https://barcelonatech-upc.eu/es/sala-de-prueba/hotels/los-estudiantes-del-equipo-10-corruguen-los-terceros-premio-en-el-concurso-solar-decathlon-europe-2019">https://barcelonatech-upc.eu/es/sala-de-prueba/hotels/los-estudiantes-del-equipo-10-corruguen-los-terceros-premio-en-el-concurso-solar-decathlon-europe-2019</a> ©Andrés Flajazar
<b>Contact:</b>	Martí Cobiols Gall, Project Manager (marti.cobiols@resso.upc.edu)	
<b>Main partners / stakeholders:</b>	<b>Universidad Politécnica de Catalunya (UPC):</b> Escuela de Arquitectura del Vallés (ETSAV) Escuela de Ingeniería Barcelona Este (EEBE)	
<b>Objectives and goals:</b>	<ul style="list-style-type: none"> <li>Inculcate that all household activities affect the environment</li> <li>Generate awareness of resources consumption and waste production related to housing</li> <li>Use of house as an educational tool</li> </ul>	
<b>Lab type:</b>	Educational Living Lab	
<b>Facilities and tools:</b>	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.	
<b>Concept:</b>	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. <i>"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."</i> (Project team)	
<b>Users:</b>	EEBE campus researchers, TO members, general public	
<b>Projects / activities:</b>	<b>EDUCATIONAL</b> <ul style="list-style-type: none"> <li>Guided visits, workshops</li> <li>House occupation experiment</li> </ul> <b>SOCIAL ACTIVITIES</b> <ul style="list-style-type: none"> <li>Domestic equipment for the EEBE campus researchers</li> </ul>	
<b>Outcomes:</b>	House occupation experiment with students living in the prototype ongoing.	
		
Source: <a href="http://www.sde2019.hu/ro_en.html">http://www.sde2019.hu/ro_en.html</a> ©Andrés Flajazar		

<b>MOR (SDE 2019)</b> <b>TU DELFT</b>		
<b>Start:</b>	2020	
<b>Location:</b>	Delft, Netherlands	MOR at the Green Village, TU Delft, 2020 Source: <a href="http://mor.tudelft.nl/">http://mor.tudelft.nl/</a> ©TU Delft
<b>Contact:</b>	management-mor@tudelft.nl The Green Village (Educational Research center): info@thegreenvillage.org	
<b>Main partners / stakeholders:</b>	<b>Delft University of Technology</b>	
<b>Objectives and goals:</b>	<ul style="list-style-type: none"> <li>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</li> <li>Research on sustainable technologies</li> </ul>	
<b>Lab type:</b>	Living Lab for Research and Education	
<b>Facilities and tools:</b>	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, soil-based PCM help pre-heat the air in the winter and pre-cool it in the summer.	
<b>Concept:</b>	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.	
<b>Users:</b>	Students and researchers at TU Delft	
<b>Projects / activities:</b>	<b>Education:</b> <ul style="list-style-type: none"> <li>Regular visits of the prototype by Bachelor and Master students</li> </ul> <b>Research:</b> <ul style="list-style-type: none"> <li>Part of the research center "The Green Village" as an ongoing test space for sustainable innovation</li> <li>Monitoring to confirm the viability of the technology's innovation during a Dutch winter</li> </ul>	
<b>Outcomes:</b>	Not documented yet.	
		
Source: <a href="http://www.sde2019.hu/mor_en.html">http://www.sde2019.hu/mor_en.html</a>		

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## After Competition & Living Lab Scenarios Report

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.



International Energy Agency

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

April 2022



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# Building Research Knowledge Pool - Topical Papers

Competitions can make better use of up-to-date knowledge generated and documented in IEA Annexes and Tasks

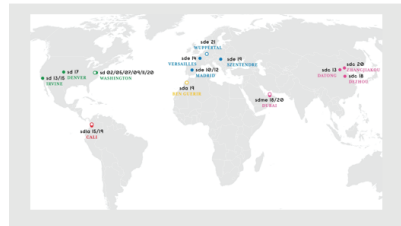
- thermal comfort
  - air tightness
  - modular and prefabricated construction
  - sustainable and recyclable construction
- 
- heat pumps
  - solar thermal systems
  - photovoltaic
  - hybrid solar systems
  - batteries
  - energy flexibility
  - user friendliness



International Energy Agency

**Competition and Living Lab Platform (Annex 74) Science & Technology (Subtask A) Focus Report 2: Topical Paper**

November 2021



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