EBC
Energy in Buildings and Communities Programme

Webinar
2022.06.07

Introduction by Takao Sawachi, Chair of EBC
President, Building Research Institute, Japan

Webinar by
International Energy Agency
Energy in Buildings and Communities (EBC) Programme
"Innovation and Energy Policy for Buildings: International Collaboration to Accelerate Change"

IEA EBC is one of the technological program of IEA.
25 member countries.
87 R&D projects (17 ongoing) and 6 Working Groups

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EBC
Energy in Buildings and Communities Programme

Webinar
2022.06.07

Today's presentations:

1. **Dirk Bessaus (Germany)**
   on Germany energy policy in change
2. **Rolf Frischknecht (Switzerland) and Thomas Lutzkendorf (Germany)**
   on embodied energy and carbon
3. **Karsten Voss (Germany) and Sergio Vega (Spain)**
   on building competition and living lab platform
4. **Liam O'Brien (Canada) and Andreas Wagner (Germany)**
   on occupant-centric design and operation

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THE GERMAN ENERGY POLICY IN CHANGE: RENEWABLES, FOSSIL FUELS, ENERGY EFFICIENCY AND THE INNOVATION PIPELINE

IEA EBC-Webinar 07.06.2022

Dr. Dirk Bessau, Project Management Juelich (Projekttraeger Juelich), division manager „energy and climate“

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AGENDA

- Introduction Project Management Juelich and Dirk Bessau
- The orientation in the German Energy policy
- „Thinking from the end“ – the steps toward the energy system of the future
- The „innovation pipeline“ in Energy Research, Development and Innovation support
- Summary

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OUR SERVICES

IDENTIFYING TRENDS

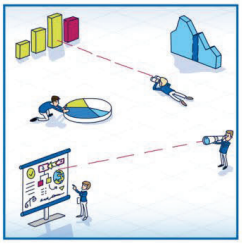
- Innovation and technology analyses
- Identification of new funding approaches
- Advice on funding strategy
- Development of funding programmes

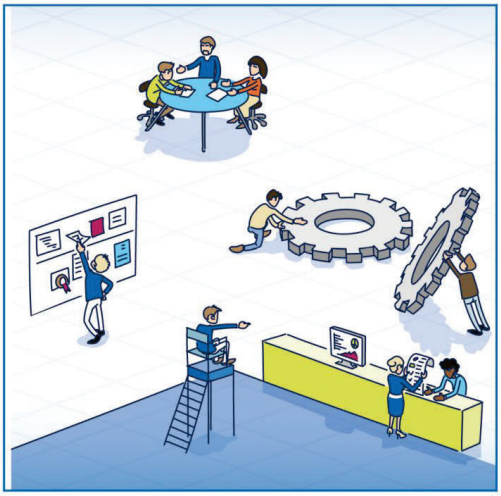
SUPPORTING RESEARCH AND INNOVATION

- Advice on national and European funding
- Evaluation of applications
- Management of funding projects
- Audit of the use of funds and exploitation of results

CREATING THE FUTURE

- Impact analyses and evaluation processes
- Transferring knowledge to the specialist community and society
- Committee work developing programmes





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OUR BUSINESS AREAS

ENERGY AND CLIMATE

- Energy efficiency and storage
- Renewable energies
- System integration and sector coupling
- Regulatory sandboxes for the energy transition
- Smart Energy Showcases
- Electric mobility, hydrogen, and fuel cells
- Municipal climate protection
- Rural development
- Systems analysis

SUSTAINABLE DEVELOPMENT AND INNOVATION

- Sustainability and circular economy
- Basic energy and hydrogen research
- Bioeconomy
- Marine, coastal, and polar research
- Geosciences
- Maritime technologies
- Life sciences and health research
- Materials research and chemistry
- Start-up companies and technology transfer
- Regional innovations

RESEARCH AND SOCIETY NRW

- Energy; environmental and climate protection
- Health economy and life sciences
- Digitization
- New media
- Production and materials
- Electric mobility, mobility, and logistics
- Social innovations
- Universities and culture
- Funding start-ups and small and medium-sized enterprises
- Regional development

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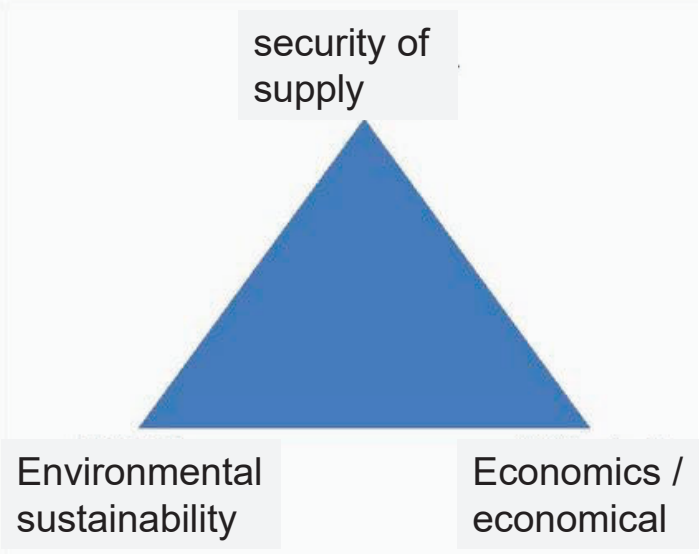
THE „MAGIC“ TRIANGLE



Changes over time, e.g.:
- development of a centralised, hierarchical power system and system of gas supply
- national fossil resources: brown coal
- nuclear research and energy
- first prove of concepts in renewable energy
- energy market liberalisation („big bang“ liberalisation)
- renewable energy act, fast development of renewable energy –> system integration
- discussion on „bridge technologies“
- 100% RE goal in power, „climate neutrality“ 2045
- security of supply / attack on Ukraine: renewable energy expansion

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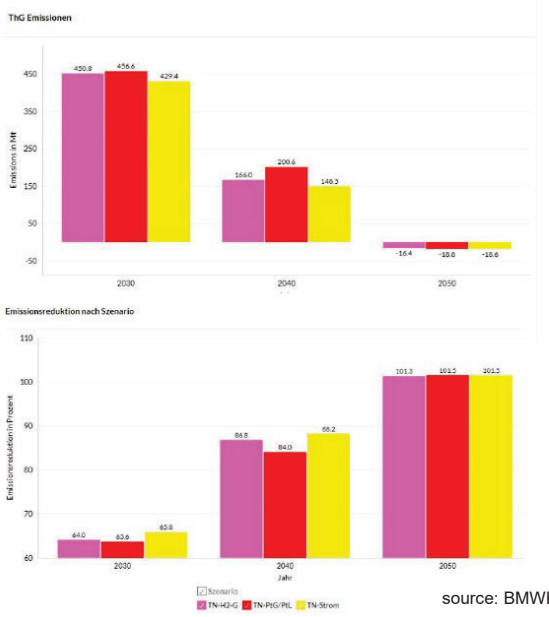
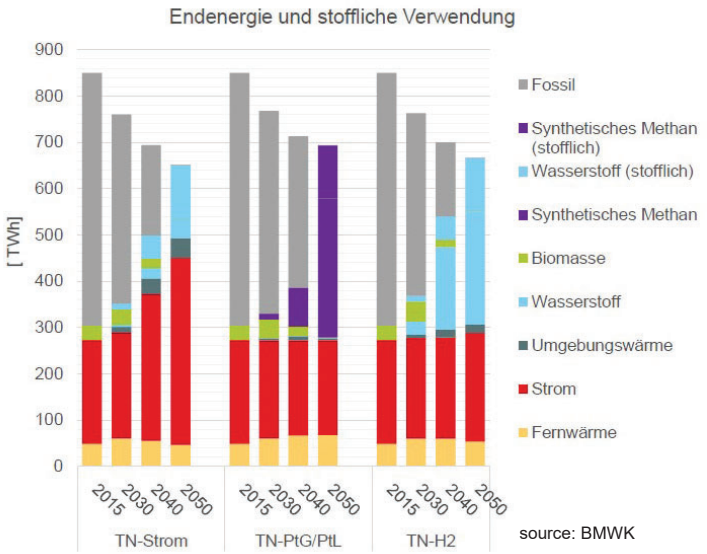
THE LONG TERM AND MID TERM TOPICS

- Year 2040 / 2045
  - to be on track for the 1,5 C – goal
  - 80-95%-GHE reduction
  - „climate neutral“
  - based on renewable energy across the sectors
- Year 2030
  - 63-65% GHE reduction
  - speed up RE growth for power production
  - focus on heat/cooling and mobility



source: BMWK

THE ENERGY INDUSTRY IN CHANGE



source: BMWK

- Different ways for the 1,5C-path are in discussion
- For example: RE power based scenario, PtG/PtL scenario, green H2 scenario
- basically, the change is about to speed up production capacities in wind and power
- and increase energy efficiency.
- There will be solution contributions needed from green H2, e-mobility (cars) and PtL/PtG, especially from 2030 on.
- The war in Ukraine changes the security of supply fundamentally.

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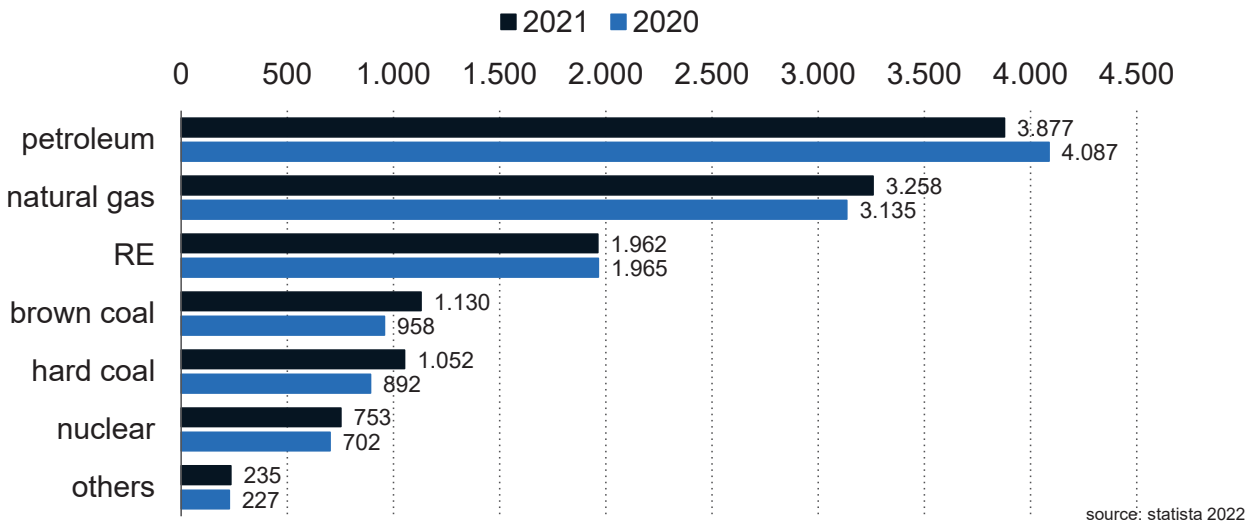
WHERE DO WE ARE? PRIMARY ENERGY CONSUMPTION 2021/2020



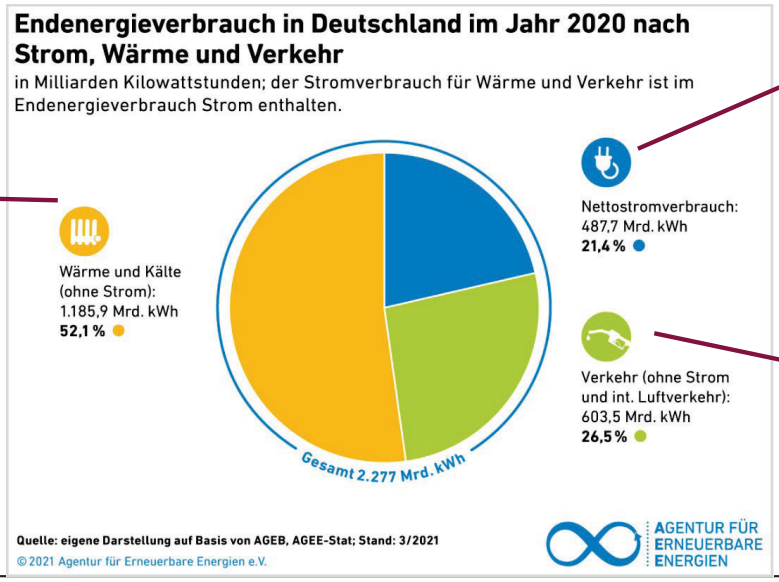
source: statista 2022

WHERE DO WE ARE? ENERGY CONSUMPTION FOR HEATING/COOLING, POWER AND MOBILITY 2020

heating and cooling

power

mobility



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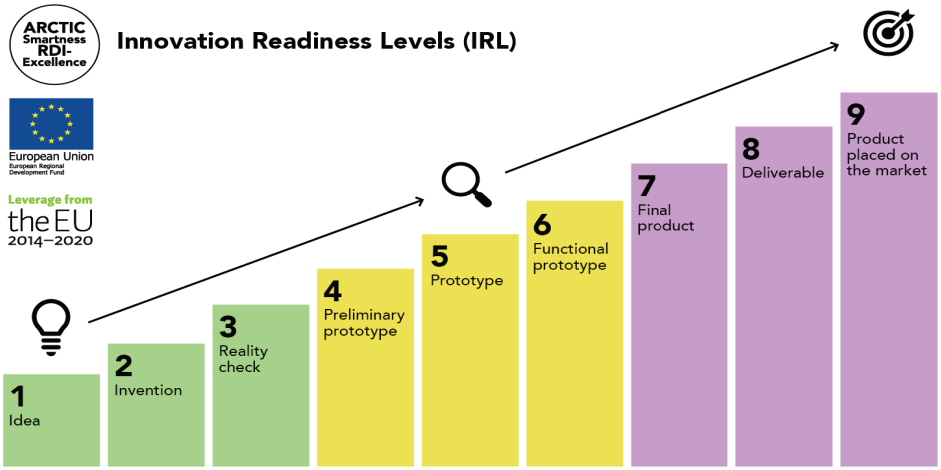
THE INNOVATION PIPELINE AND THE PUPLIC R&D&I-SUPPORT



From idea to product
Developing a service/product/application from an idea to a prototype.

Towards the market
Demo version tested. Production method identified and market research conducted.

Commercialisation
Ready for the market. Production and distribution methods selected, potential customers/clients identified.

Source: arcticsmartness https://arcticsmartness.eu/wp-content/uploads/Arctic_Smartness_Innovation_Readiness_Levels-1.png

ONE STRATETIC ELEMENT IN PUPLIC R&I-SUPPORT IN ENERGY: ENERGY RESEARCH PROGRAMME

- Strategic element of energy policy since 1977
- 2018:
  - launch of current 7th program
  - Common program of BMWi and BMBF
  - > 500 Mio € per year

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7TH RESEARCH PROGRAM „INNOVATIONS FOR THE ENERGY TRANSITION”

- Primary goal of research funding:
  - Support the transition to a climate neutral energy supply
  - Increasing the usability of innovative energy technologies
- Research on technologies and concepts that offer
  - Significant increases in efficiency
  - Integration of renewable energies
  - Ensuring security of supply
  - And a rapid transfer of research results to the application and into the market
- Key ideas
  - Technology-open approach
  - Adoption of new trends: sector coupling or the digitisation of the energy sector
  - Offer opportunities for innovative companies in the national market

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7TH RESEARCH PROGRAM

- Four focus areas
  - Energy in the end use sector (buildings and communities, industry, mobility)
  - Energy supply and electricity generation (wind, PV, bioenergy, geothermal etc.)
  - System integration (power supply system, grids, energy storage and sector coupling)
  - Cross-system research topics (system analysis, “energy transition and society”).
- Digitalisation is a major R&D topic in all of the focus areas
  - digital twins, digital planning, digital concepts for district heating and cooling networks, plant monitoring and asset management,…
  - However: Digitalisation processes are currently more advanced in the area of electricity than in the area of heat supply
- Current development
  - Additional support for climate neutral heat supply

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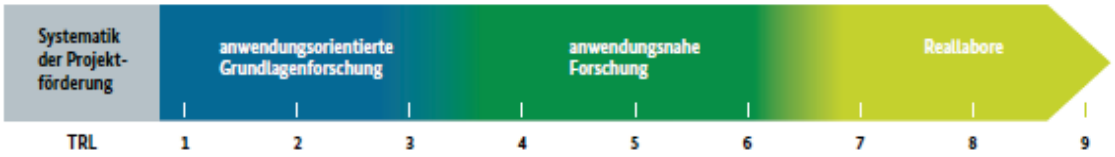
NEW PILLAR 7TH RESEARCH PROGRAM: LIVING LABS

- Focus on the transfer of technologies and innovations into daily life
  - Preparing the market for innovative solutions
- Concentration energy system relevant problems to push forward the energy transition
  - City districts und multi-energy infrastructure, district heating, Hydrogen production and use, Digitalization
- Improved integration of additional funding formats for plant technology and infrastructure



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SUMMARY

- A new orientation in the “magic” energy triangle with the war in the Ukraine: security of supply, environmental sustainability and economics support each other
- As a consequence, for the path for the 2040/2045-goals (“thinking from the end”) we have to speed up the transformation into RE and energy efficiency
- Besides RE from wind and solar, heating/cooling and mobility are on the top of the agenda
- That means, „Wärmewende“ becomes more important
- Especially in the long run, we need an even more filled innovation pipeline

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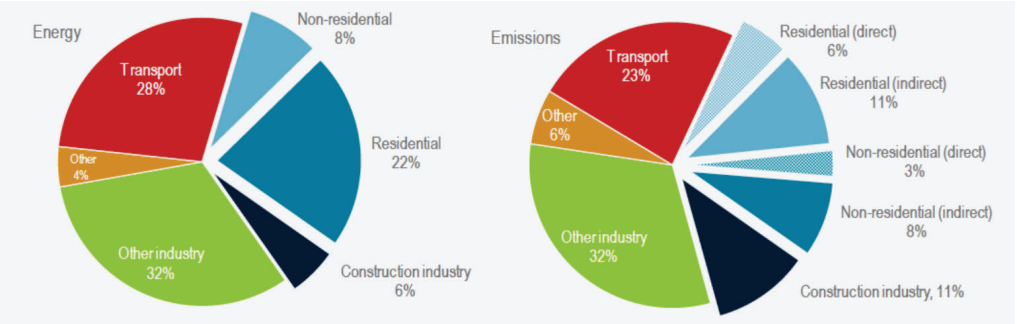
NET ZERO GHG EMISSION BUILDINGS
synopsis and assessment of current concepts and recommendations

Dr. Rolf Frischknecht, Operating agent Annex 72, Switzerland
Dr. Thomas Lützkendorf, Subtask leader (ST 1) Annex 72, Germany

IEA EBC Webinar "Innovation and Energy Policy for Buildings – International Collaboration to Accelerate Change"
7 June 2022

GHG-EMISSIONS IN THE WORLD THE SHARE OF BUILDINGS

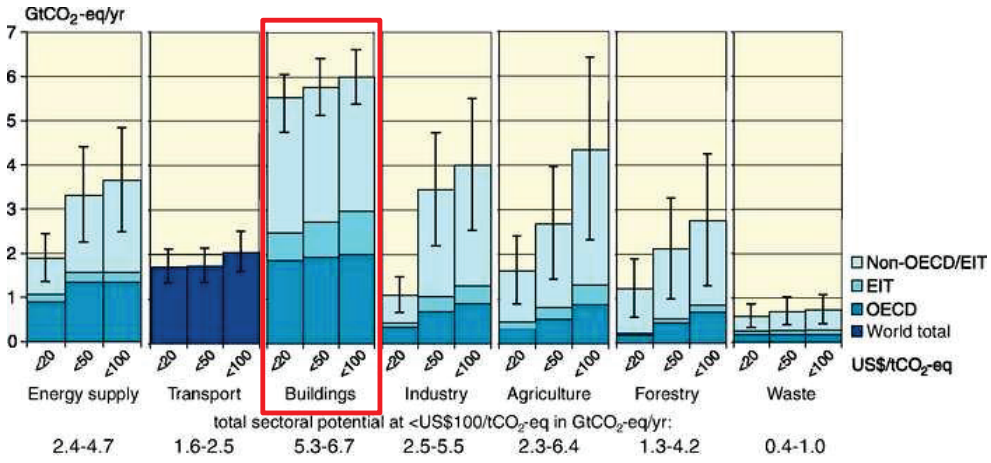
Buildings construction and operations accounted for
36% of global final energy use and
39% of energy-related carbon dioxide (CO2) emissions in 2017



Note: *Construction industry* is an estimate of the portion of the overall industry sector that applies to the manufacture of materials for buildings construction, such as steel, cement and glass.

Sources: Derived from IEA (2018a), *World Energy Statistics and Balances 2018*, www.iea.org/statistics and IEA *Energy Technology Perspectives* buildings model, www.iea.org/buildings.

MITIGATION POTENTIAL OF SECTORS AND AREAS OF ACTION



IPCC projections of CO2 mitigation potential in 2030 (IPCC, 2007) The Intergovernmental Panel on Climate Change (IPCC, 2007) identifies the building and construction sector as the sector with the largest mitigation potential

https://www.researchgate.net/profile/Bruno-Verbist/publication/265290059/figure/fig1/AS:648611159351301@1531652359845/IPCC-projections-of-CO2-mitigation-potential-in-2030-IPCC-2007-The-Intergovernmental.png

Compared to other sectors and fields of action, **buildings** have a comparatively great potential for reducing greenhouse gas emissions. The scope of the reduction is influenced, among other things, by the **level of abatement costs**.

BUILDING AS OBJECT OF ASSESSMENT AND LEVEL TO ACT

There are various levels of action in the construction and real estate industry, including

- National, regional, institutional building stock
- Regional development
- Urban development
- Neighbourhood/district
- **Individual buildings**

All activities in the construction and real estate industries can ultimately be traced back to measures related to

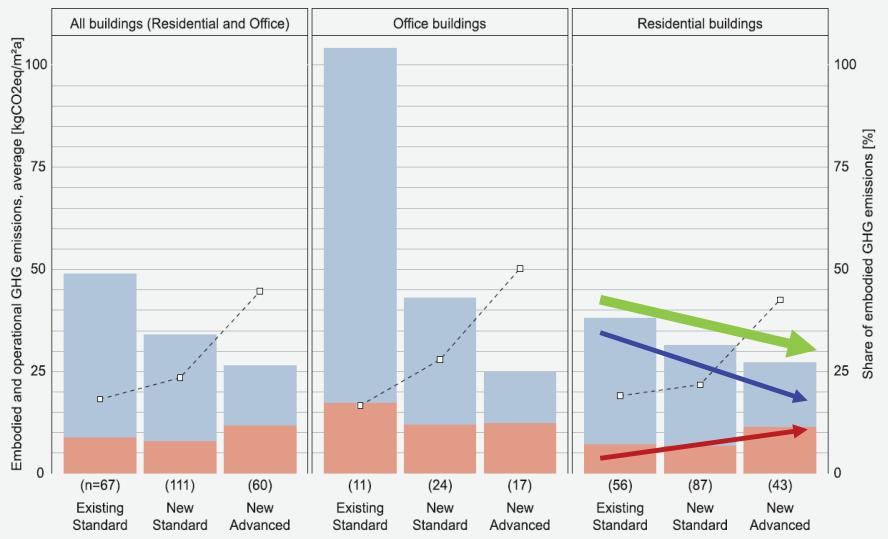
- New construction
- Reconstruction
- Refurbishment

of buildings. These measures can influence the other levels of action.

Relevant actors are

- Building permit authorities/legislators
- Building owners/investors
- Financers
- Design professional and consultants
- Construction material industry
- Construction companies

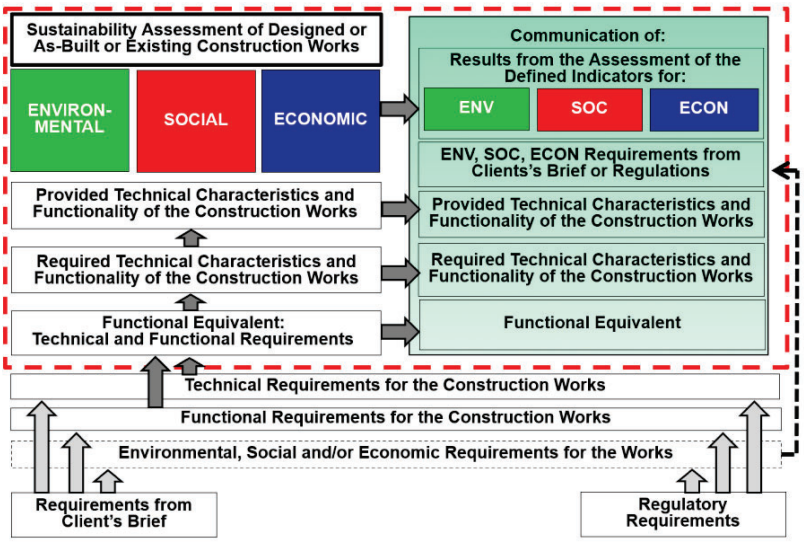
ASSESSING OPERATIONAL AND EMBODIED EMISSIONS – CURRENT TRENDS



Martin Röck, Marcella Ruschi Mendes Saade, Maria Balouktsi, Freja Nygaard Rasmussen, Harpa Birgisdottir, Rolf Frischknecht, Guillaume Habert, Thomas Lützkendorf, Alexander Passer, · 2019·

- There is a downward trend in operational emissions relating to an improved energy performance and increasing use of renewable energy.
- The relative and absolute values of embodied impacts (here embodied GHG emissions) increase.
- The consideration of the entire life cycle, the limitation of the upfront/initial emissions, as well as the development of overall goals and guidance values for operational and embodied GHG emissions are necessary.

BUILDINGS IN THE CONTEXT OF SUSTAINABILITY ASSESSSMENT



NOTE The outer box with the red dotted line represents the area standardized by CEN/TC 350.

FprEN 15643:2021 (E)

There are design goals as well as assessment criteria on topics such as

- Resource conservation
- **Greenhouse gas (GHG) emissions** (contributing to climate change)

In the near future, a "**budget**" of GHG-emissions in the life cycle of a building will become part of a **clients brief and/or legal requirement** – expressed as part of **environmental requirements**.

BUILDINGS IN THE CONTEXT OF SUSTAINABILITY ASSESSSMENT

EBC

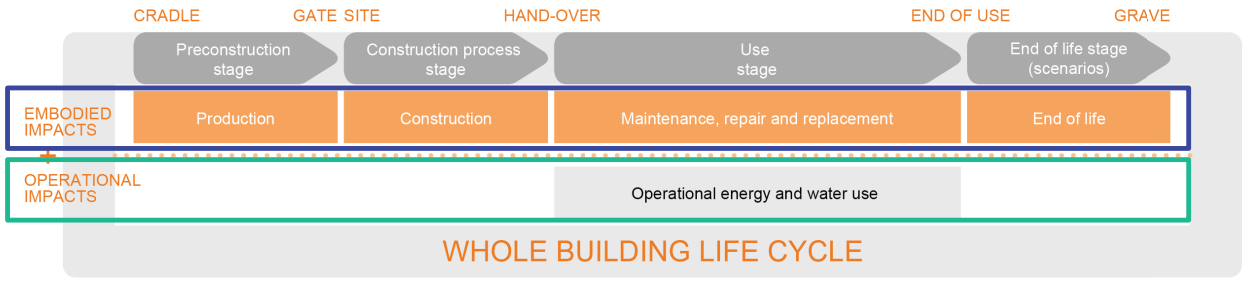
- How can buildings and their life cycle be **modeled** ?
- How can the **life cycle assessment (LCA)** method be applied in a practical manner?
- How can the required data on construction products and processes be determined and made available in **databases** ?
- How can LCA be integrated into the **design**, which **tools** are suitable ?
- Which **benchmarks and design targets** result in relation to the limitation of primary energy consumption and greenhouse gas emissions in the life cycle of buildings ?
- Which **terms** need to be defined and which **system boundaries** to be considered ?

In connection with the content and goals of this contribution, the questions shown on this slide arise. In particular, the topic of the development and application of benchmarks should be dealt with.

PROVIDING ANSWERS BASED ON JOINT RESEARCH ACTIVITIES AROUND THE WORLD

EBC

IEA EBC Annex 72 - Assessing Life Cycle Related Environmental Impacts Caused by Buildings



Net Zero

IEA EBC ANNEX 72: Subtasks

Subtask 1: Context-specific **methodology** guidelines:

- developing and extending the methodology guidelines

Subtask 2: Building assessment **workflows and tools**:

- description and development of national or regional building assessment tools, in particular embedding of life cycle assessment approach into BIM (Building Information Modelling)

Subtask 3: **Case studies**:

- analyzing building case studies using the methodology agreed in Subtask 1

Subtask 4: Building sector **LCA databases**:

- development and supply of life cycle assessment databases targeted to the building sector

Subtask 5: **Dissemination**:

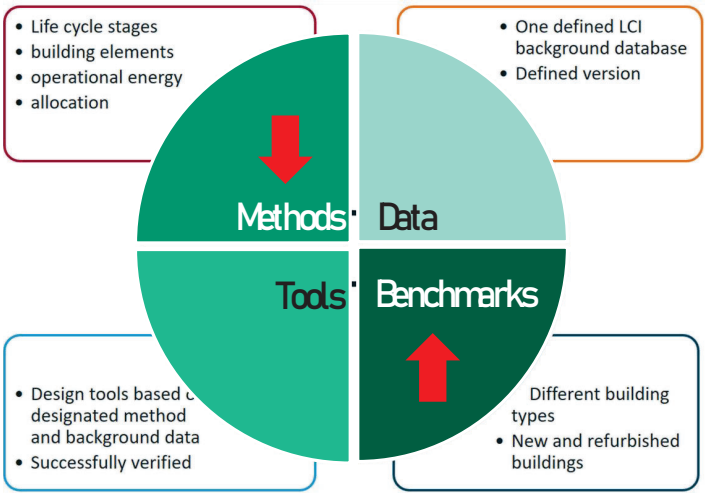
- communication and dissemination of the results

EXPLAINING THE "PACKGAGE"

To support the design and decision-making process in the direction of resource efficient and climate friendly buildings one needs:

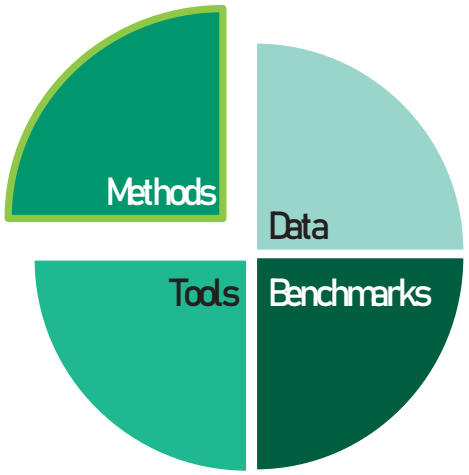
a) **Assessment methods (terms, definitions, system boundaries)**
b) **LCA-data for construction products and processes**
c) **Design & assessment tools**
d) **Bechmarks and target values**

a) to d) form a system.



METHODOLOGICAL BASICS

- Modelling a **building & its life cycle** and check of completeness
- Rules for **calculation, assessment and compensation**
- Dealing with
  - **uncertainty and range** of input parameters
  - building integrated / site related **generation of energy**
  - **imported and exported energy**
  - **decarbonisation** of grid and production processes

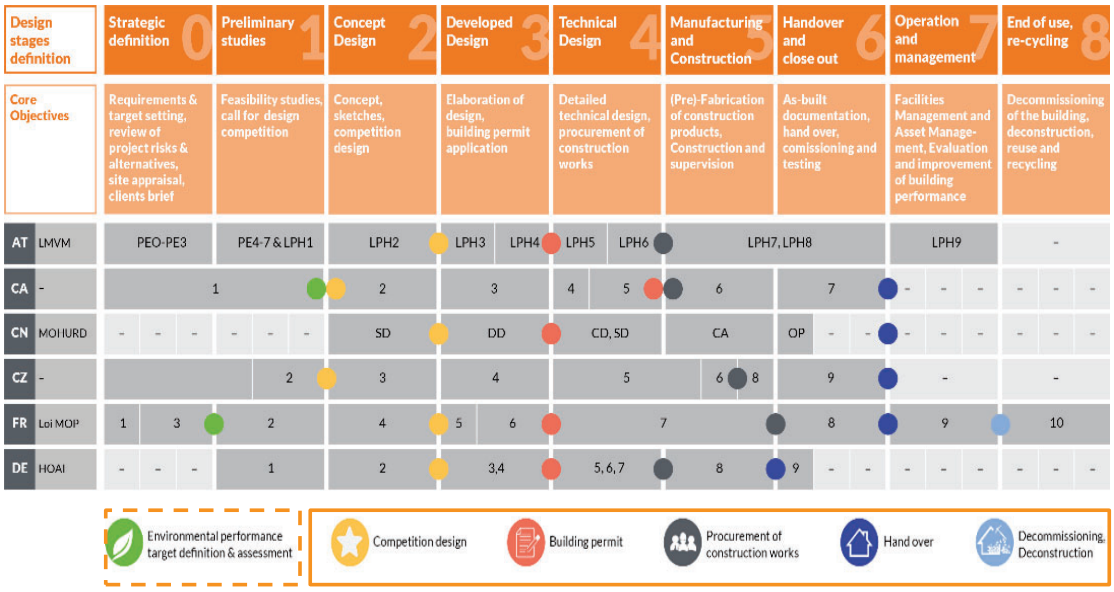


➢ **RULES AND RECOMMENDATIONS FOR (further development of) ASSESSMENT METHODS**

TERMS AND DEFINITIONS

- Carbon positive building
- Climate neutral building
- Carbon neutral building
- Carbon free construction
- (Net-)zero carbon building
- (Net-)zero emission building
- (Net-)zero GHG emission building
- Paris building
- Low carbon building
- *… others ?*

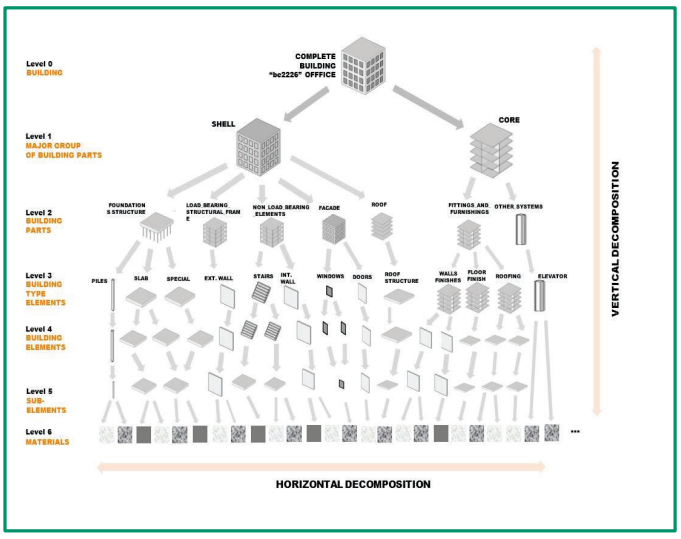
INTEGRATION INTO DESIGN AND DECISION MAKING PROCESS – THE STEPS

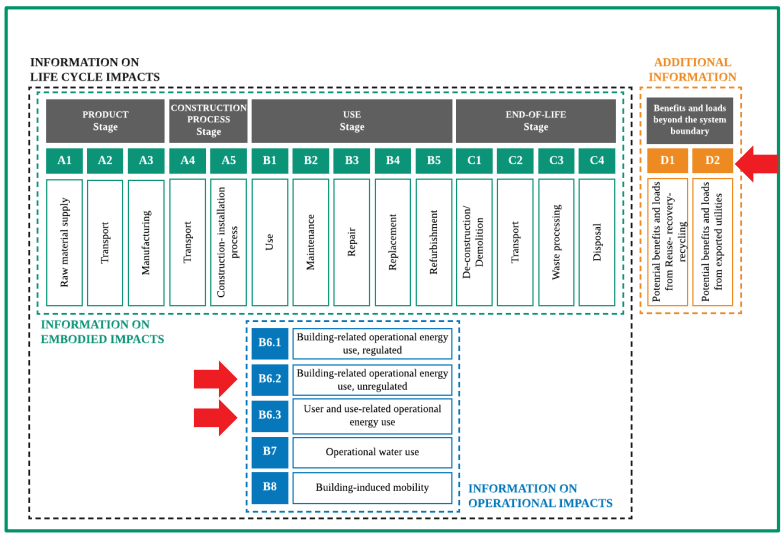


- Target setting in clients brief
- Early design
- Building permit
- “As built”
- Monitoring

Taking into account available information, data and related uncertainty = consequences for assessment

MODELLING OF THE BUILDING AND ITS LIFE CYCLE



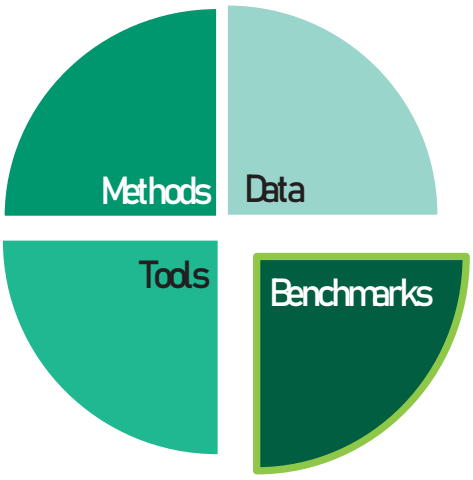


LINKS TO OTHER ANNEXE's (Examples only)

… can and will help us to simulate the energy demand and to assess operational GHG-emissions …

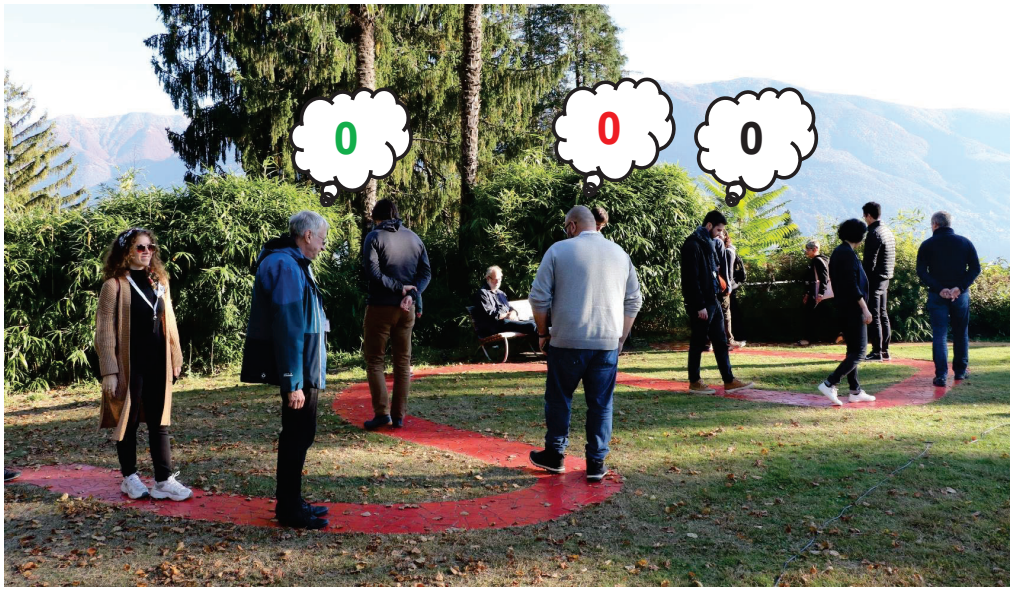
CREATION, APPLICATION AND INTERPRETATION OF BENCHMARKS

- System of **performance levels**
- (net)zero as **top down** target based on **planetary boundaries**
- **Legally binding benchmarks** & design targets / guiding values
- **Reference unit** for benchmarks
- Examples and **case studies**



➢ **RULES AND RECOMMENDATIONS FOR CREATION AND INTERPRETATION OF BENCHMARKS AND TARGET VALUES**

WHAT IS MEANT BY "ZERO"?



- (net) zero operational?
- **(net) zero life cycle**

- Zero carbon?
- Zero $GWP_{100?}$
- **Zero GHG-emissions**

OPTIONS TO DEFINE AND ACHIEVE (NET) ZERO GHG-EMISSION BUILDINGS

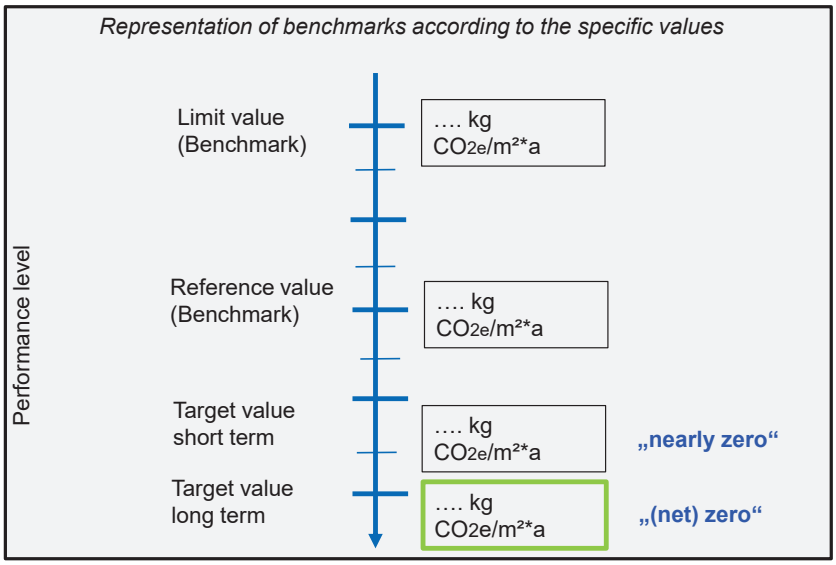
Net Zero emission approaches				Zero emission a.
Net balance	**Net balance**	**Economic compensation**	**Technical Reduction**	**Absolute Zero**
potentially avoided emissions	**allocation**			
Accounting for the potential benefits caused by exported energy produced on-site	Attributes the pro rata share of GHG emissions caused by on-site energy production to the exported energy	Purchase of CO_2 certificates based on potentially avoided or reduced GHG emissions	Investment in technical-reduction measures to compensate for life-cycle-based GHG emissions caused by the building	Use of construction materials/operational energy with zero GHG emissions (including supply chain emissions)

Lützkendorf, T. and Frischknecht, R., 2020. (Net-) zero-emission buildings: a typology of terms and definitions. *Buildings and Cities*, 1(1), pp.662–675. DOI: http://doi.org/10.5334/bc.66

\- Level of ambition +

Lützkendorf & Frischknecht (2020)

PERFORMANCE LEVEL & BOUNDARIES

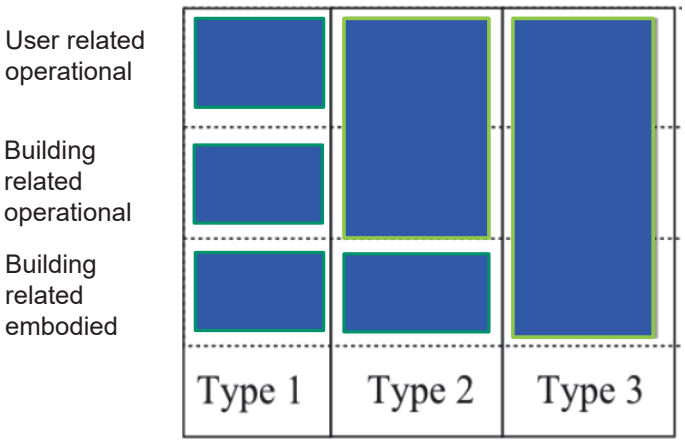


Possible types of application
Selected examples only

	A	B	C	D
Building related operational GHG-emissions	●	●	●	●
User related operational GHG-emissions		●	●	●
Upfront/initial embodied GHG-emissions			●	●
GHG-emissions from replacement, deconstruction				●

GRANULARITY OF BENCHMARKS

Job sharing between mandatory target values and informal guiding values to support the design process



SIA 2040: guide and target values residential buildings

Residential	Primary energy, non-renewable kWh/m²		Greenhouse gas emissions kg/m²	
	New building	Conver-sion	New building	Conver-sion
Guide value construction	30	20	9,0	5,0
Guide value operation	60	70	**3,0**	5,0
Guide value mobility	30	30	**4,0**	**4,0**
Target value	120		16,0	**14,0**
Additional requirement construction + operation	90		**12,0**	10,0

Technical bulletin SIA 2040 (2017) SIA Energy Efficiency Path

APLLICATION IN GERMANY

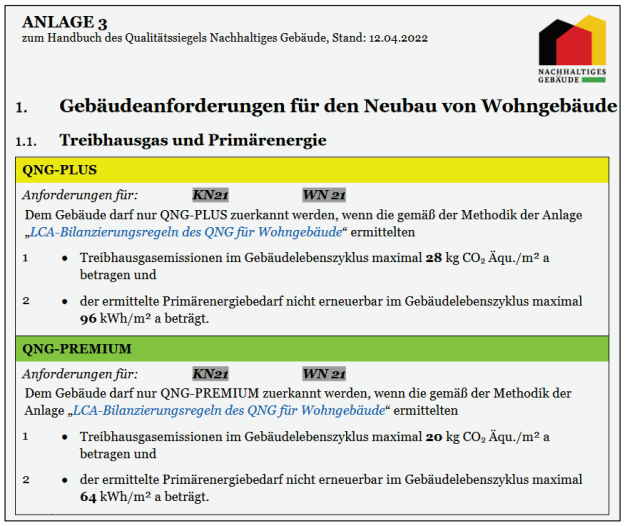
Requirements for residential buildings (all kind)

+ embodied GHG-emissions (A1-A3, B4, C3-C4)*
+ operational GHG-emissions (B6.1, **B6.3**)

= life cycle based GHG-emissions (RSP = 50 years)

	Primary Energy, non renewable kWh/m²a	GHG Emissions kg CO_2-Äqu./m²a
Level I (PLUS)	**96**	**28**
Level II (PREMIUM)	**64**	**20**

** Including HVAC-systems, and BIPV (partial allocation to the buildig)*



ANLAGE 3
zum Handbuch des Qualitätssiegels Nachhaltiges Gebäude, Stand: 12.04.2022

NACHHALTIGES GEBÄUDE

1. Gebäudeanforderungen für den Neubau von Wohngebäude

1.1. Treibhausgas und Primärenergie

QNG-PLUS

Anforderungen für: *KN21* *WN 21*

Dem Gebäude darf nur QNG-PLUS zuerkannt werden, wenn die gemäß der Methodik der Anlage *„LCA-Bilanzierungsregeln des QNG für Wohngebäude"* ermittelten

1 • Treibhausgasemissionen im Gebäudelebenszyklus maximal **28** kg CO_2 Äqu./m² a betragen und

2 • der ermittelte Primärenergiebedarf nicht erneuerbar im Gebäudelebenszyklus maximal **96** kWh/m² a beträgt.

QNG-PREMIUM

Anforderungen für: *KN21* *WN 21*

Dem Gebäude darf nur QNG-PREMIUM zuerkannt werden, wenn die gemäß der Methodik der Anlage *„LCA-Bilanzierungsregeln des QNG für Wohngebäude"* ermittelten

1 • Treibhausgasemissionen im Gebäudelebenszyklus maximal **20** kg CO_2 Äqu./m² a betragen und

2 • der ermittelte Primärenergiebedarf nicht erneuerbar im Gebäudelebenszyklus maximal **64** kWh/m² a beträgt.

SYNTHESIS

- Embodied environmental impacts gain importance and need (more) attention
- Paris Agreement and its 1.5° C target calls for high ambition "net zero emission" buildings
- Growing demand for life cycle based GHG-emission results in the context of EPBD, LEVEL(s), TAXONOMY, BWR/CPR
- **Guidelines, data, tools and expertise are ready for application in many countries**: time for life cycle based policy measures like legal binding requirements to limit GHG-emissions in the life cycle of buildings

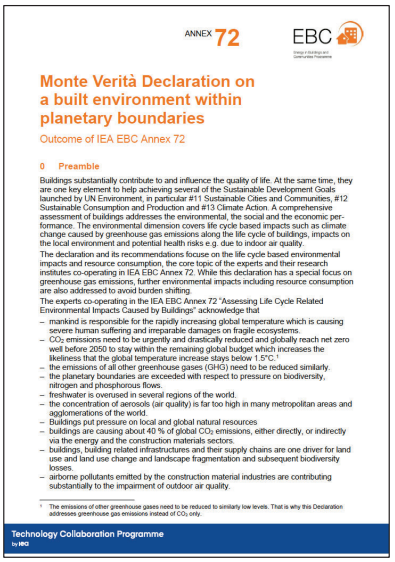
THE Monte Verità DECLARATION

On a built environment within planetary boundaries

Introduce legally binding maximum target values for GHG-emissions of new constructions and of refurbishments by 2025 latest **with a roadmap to net zero** by 2035.

10 Signatures

Nr.	Title	Name, Surname	Affiliation	Signature
1	Dr.	Rolf Frischknecht	treeze Ltd.	
2	Dr	Thomas Lützkendorf	KIT (Germany)	
3	D.	ALEXANDER PASSER	TU GRAZ	
4	Dr	Freja Rasmussen	Aalborg University	
5	Dr	Guillaume Habert	ETH Zurich	
6		Lina Reinsch	treeze Ltd.	
7	Dr	Maria Balouktsi	Empa (EPFL)	
8		Nicolas Francart	KTH (Stockholm)	
9	Dr	Endrit HOXHA	TU GRAZ	
10	Dr	Lasvaux Sébastien	HES-SO	
11	Dr	Rolf A Bohne	NTNU	
12		Roberta Di Bari	~~Fraunhofer IBP~~ University of Stuttgart	



ANNEX 72 EBC

Monte Verità Declaration on a built environment within planetary boundaries

Outcome of IEA EBC Annex 72

0 Preamble

Buildings substantially contribute to and influence the quality of life. At the same time, they are one key element to help achieving several of the Sustainable Development Goals launched by UN Environment, in particular #11 Sustainable Cities and Communities, #12 Sustainable Consumption and Production and #13 Climate Action. A comprehensive assessment of buildings addresses the environmental, the social and the economic performance. The environmental dimension covers life cycle based impacts such as climate change caused by greenhouse gas emissions along the life cycle of buildings, impacts on the local environment and potential health risks e.g. due to indoor air quality.

The declaration and its recommendations focuse on the life cycle based environmental impacts and resource consumption, the core topic of the experts and their research institutes co-operating in IEA EBC Annex 72. While this declaration has a special focus on greenhouse gas emissions, further environmental impacts including resource consumption are also addressed to avoid burden shifting.

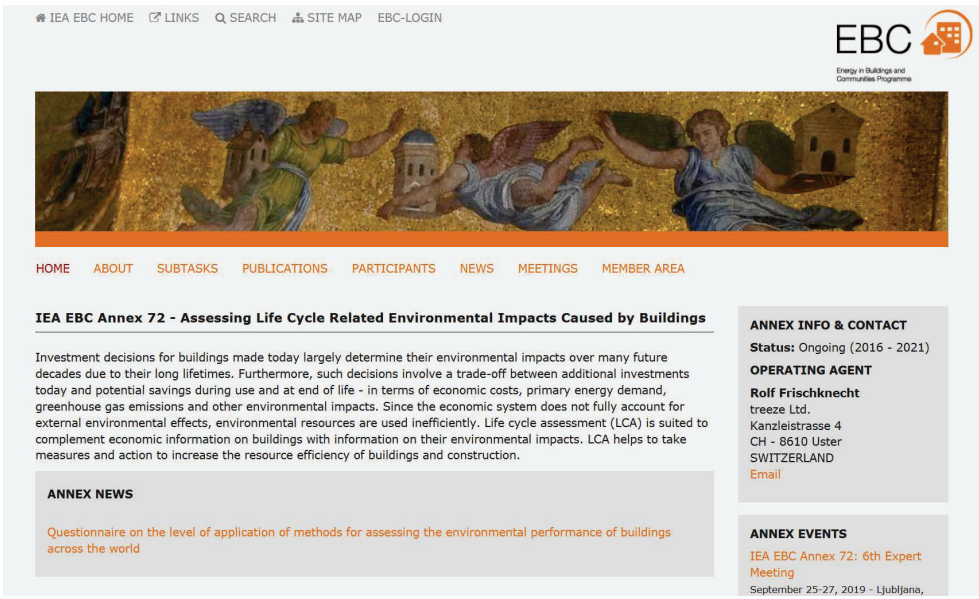
The experts co-operating in the IEA EBC Annex 72 "Assessing Life Cycle Related Environmental Impacts Caused by Buildings" acknowledge that

- mankind is responsible for the rapidly increasing global temperature which is causing severe human suffering and irreparable damages on fragile ecosystems.
- CO_2 emissions need to be urgently and drastically reduced and globally reach net zero well before 2050 to stay within the remaining global budget which increases the likeliness that the global temperature increase stays below 1.5°C.[1]
- the emissions of all other greenhouse gases (GHG) need to be reduced similarly.
- the planetary boundaries are exceeded with respect to pressure on biodiversity, nitrogen and phosphorous flows.
- freshwater is overused in several regions of the world.
- the concentration of aerosols (air quality) is far too high in many metropolitan areas and agglomerations of the world.
- Buildings put pressure on local and global natural resources
- buildings are causing about 40 % of global CO_2 emissions, either directly, or indirectly via the energy and the construction materials sectors.
- buildings, building related infrastructures and their supply chains are one driver for land use and land use change and landscape fragmentation and subsequent biodiversity losses.
- airborne pollutants emitted by the construction material industries are contributing substantially to the impairment of outdoor air quality.

[1] The emissions of other greenhouse gases need to be reduced to similarly low levels. That is why this Declaration addresses greenhouse gas emissions instead of CO_2 only.

Technology Collaboration Programme by IEA

MORE INFORMATION IS AVAILABLE …



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EBC Energy in Buildings and Communities Programme

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IEA EBC Annex 72 - Assessing Life Cycle Related Environmental Impacts Caused by Buildings

Investment decisions for buildings made today largely determine their environmental impacts over many future decades due to their long lifetimes. Furthermore, such decisions involve a trade-off between additional investments today and potential savings during use and at end of life - in terms of economic costs, primary energy demand, greenhouse gas emissions and other environmental impacts. Since the economic system does not fully account for external environmental effects, environmental resources are used inefficiently. Life cycle assessment (LCA) is suited to complement economic information on buildings with information on their environmental impacts. LCA helps to take measures and action to increase the resource efficiency of buildings and construction.

ANNEX NEWS

Questionnaire on the level of application of methods for assessing the environmental performance of buildings across the world

ANNEX INFO & CONTACT

Status: Ongoing (2016 - 2021)

OPERATING AGENT

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treeze Ltd.
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Email

ANNEX EVENTS

IEA EBC Annex 72: 6th Expert Meeting
September 25-27, 2019 - Ljubljana,

https://annex72.iea-ebc.org/

THE TEAM BEHIND THE AUTHORS ….

Contact:
Dr. Rolf Frischknecht,
Operating Agent, treeze Ltd.
http://annex72.iea-ebc.org/
LinkedIn; ResearchGate

International Energy Agency

Building Competitions as an Incentive for Research, Education and Communication

Professor Dr Karsten Voss, University Wuppertal, Faculty of Architecture and Civil Engineering, Germany

Professor Dr Sergio Vega Sánchez, Technical University Madrid, School of Architecture, Spain

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

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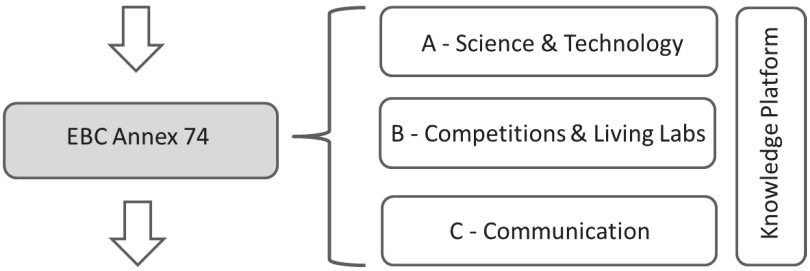
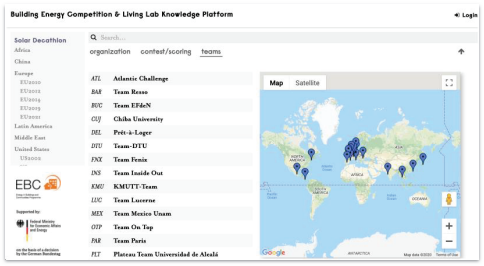
Annex 74, 1/2018 – 6/2021: Competition & Living Lab Platform

Resources

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





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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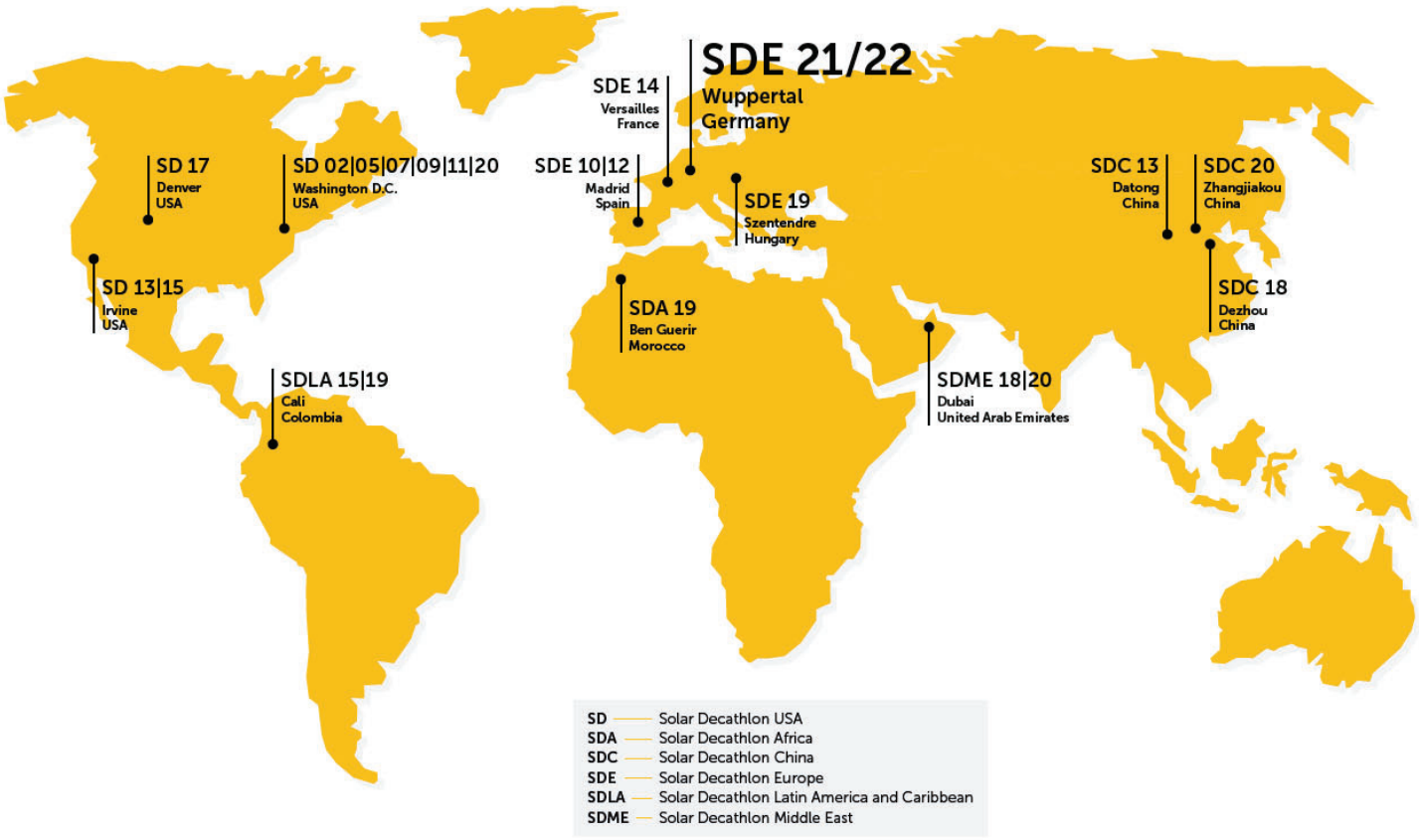
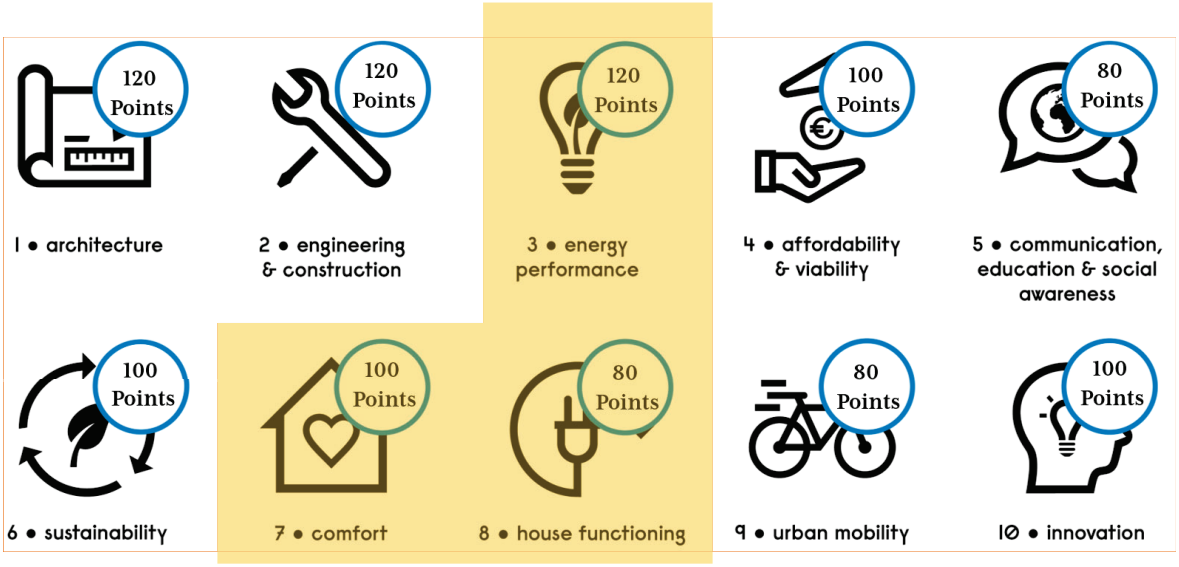
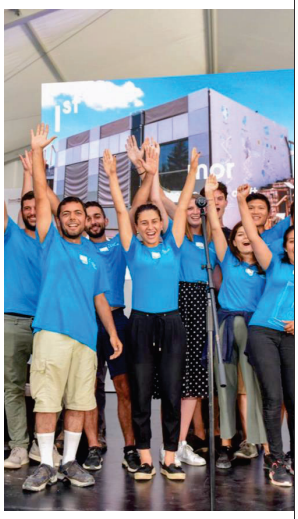
Solar Decathlon Europe 2010, Madrid



Ten Contests Example SDE 21/22





monitored

Competition & Living Lab Platform – Annex 74

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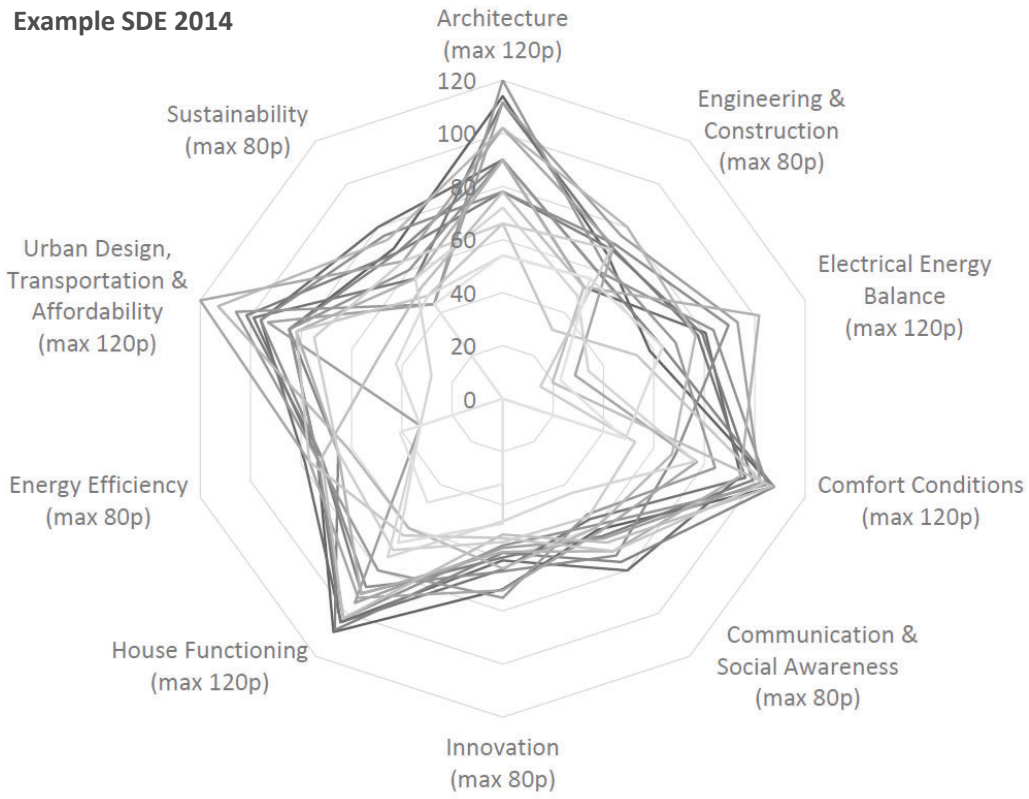
Scoring Example SDE 2014



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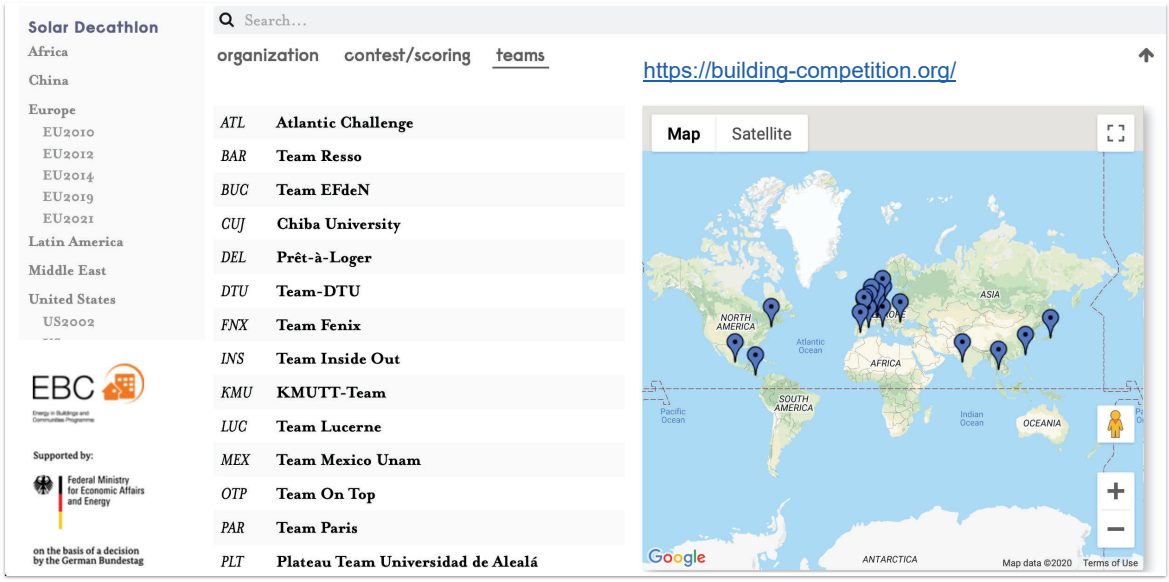
Sharing Results & Experiences

Building Competition & Living Labs Knowledge Platform



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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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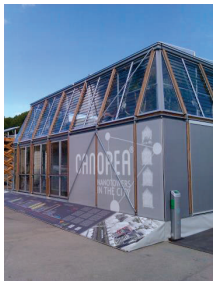
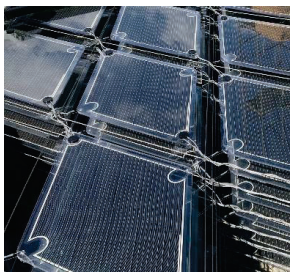
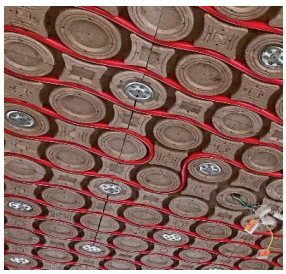
Building Competitions as an Incentive for Research, Education and Communication

Architecture **Construction** **Energy Engineering** HVAC Controls

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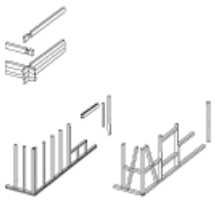
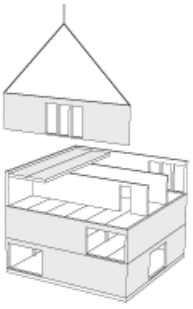
Modular and prefabricated construction – Design, Testing and Inspiring the Market


assembly of single parts


combination of single parts and elements


prefabricated structural elements: walls, ceilings


prefabricated space modules


© Sigurd Steinprinz, Düsseldorf

low **degree of prefabrication** high

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)

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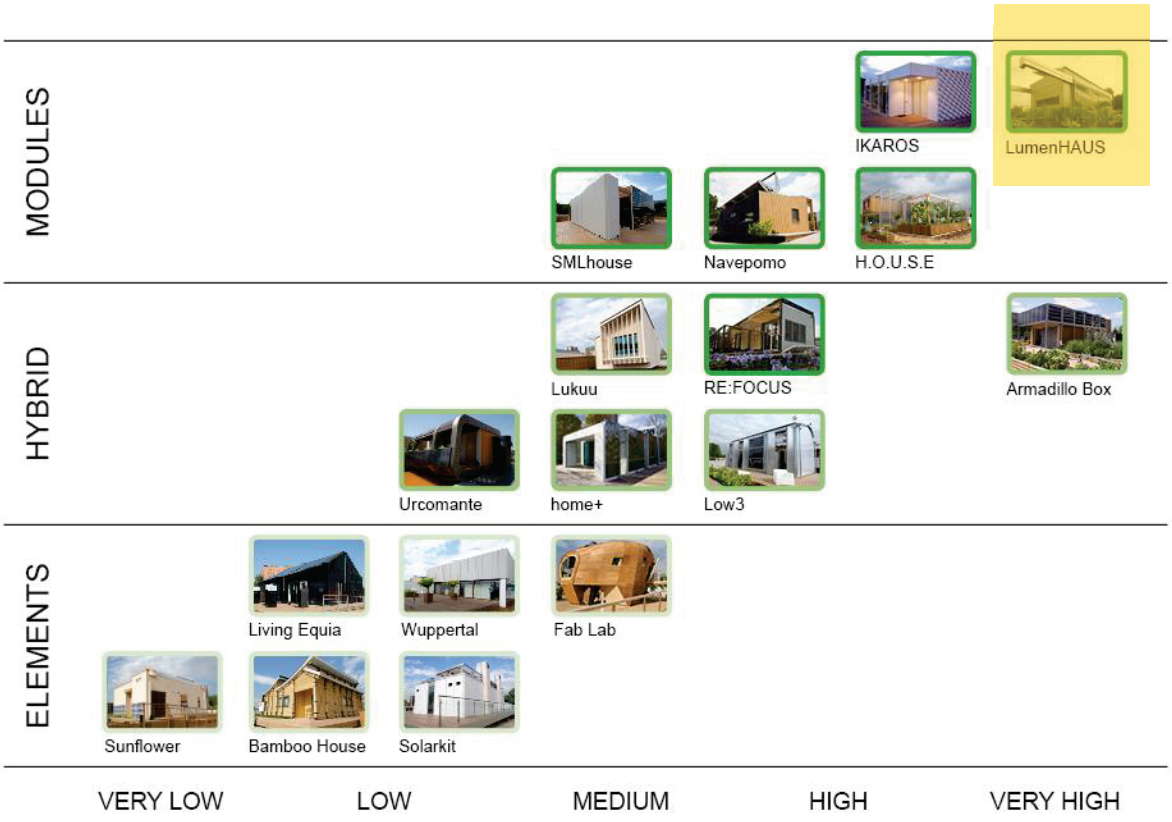

Comparison of the different prefabrication levels of SDE houses in 2010, ascending from low level (left) to high level (right). Source: Frauke Rottschy, University of Wuppertal

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

Source: Virginia Polytechnic Institute and State University, Construction Drawings

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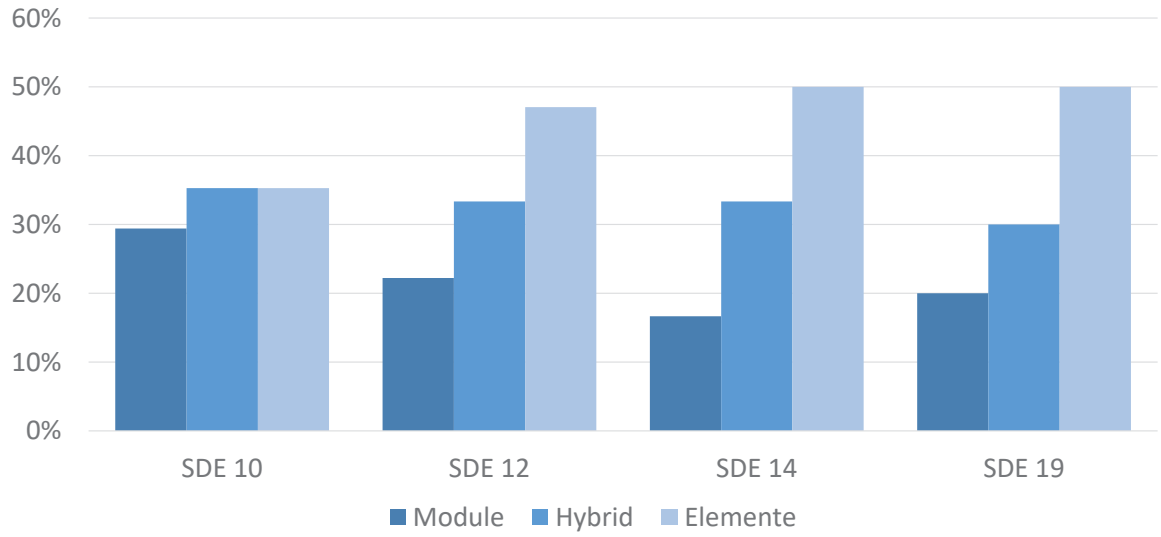
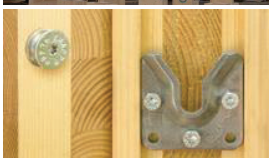
Solar Decathlon Europe – Prefabrication Strategies

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





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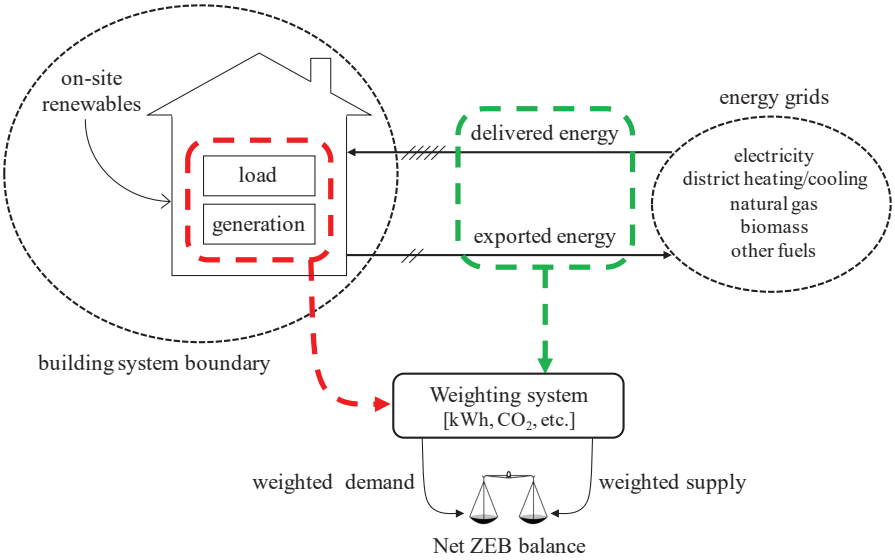
Energy Engineering for (all electric) Net Zero Energy Buildings



Contents lists available at ScienceDirect

Energy & Buildings

journal homepage: www.elsevier.com/locate/enb

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

Karsten Voss, Susanne Hendel, Moritz Stark

ARTICLE INFO

ABSTRACT

1. Introduction

https://www.sciencedirect.com/science/article/pii/S0378778821006204

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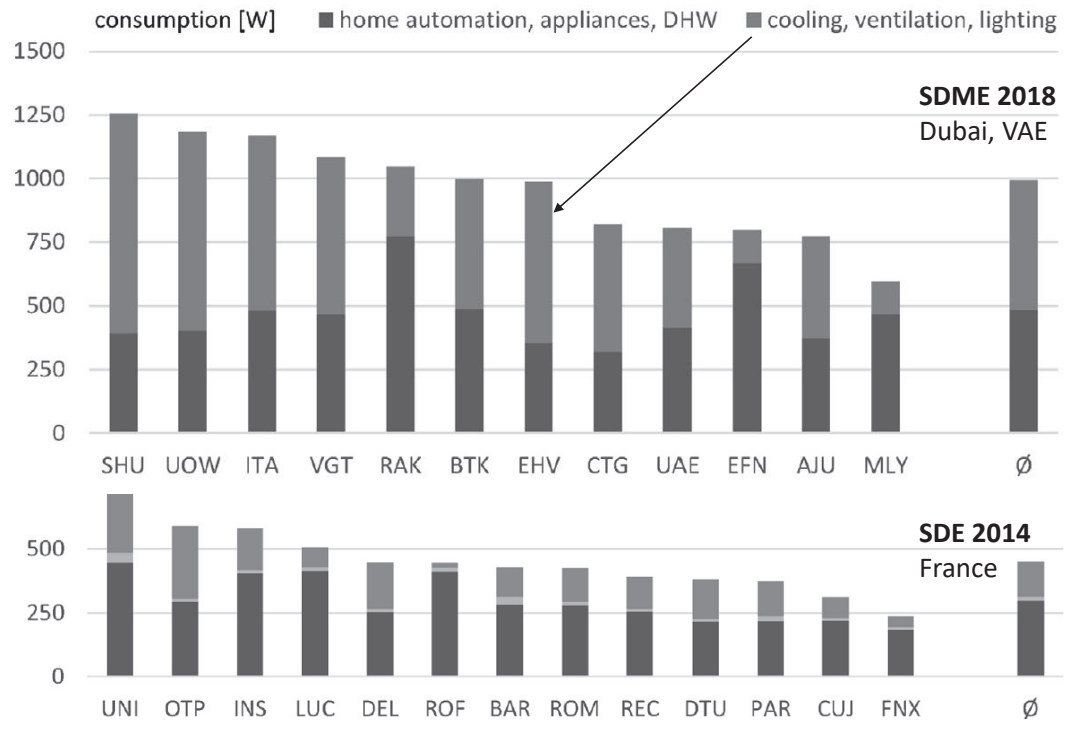

Average power consumption of all houses during the competition period. The climate of the location determines the power consumption of the HVAC equipment.

Energy Use Intensity

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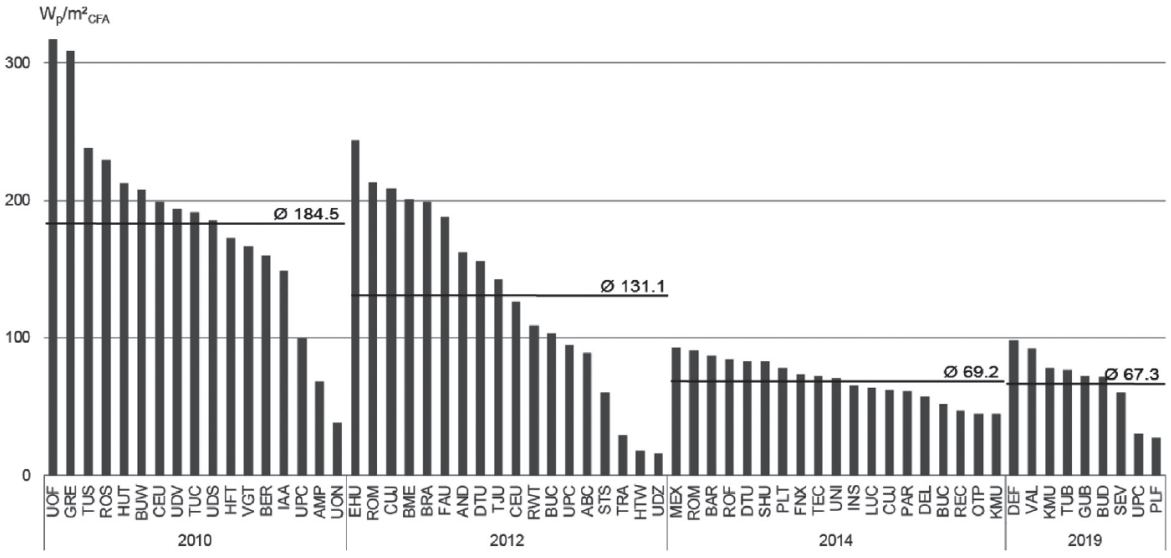
Solar System Sizing - Photovoltaics

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/m²) 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.

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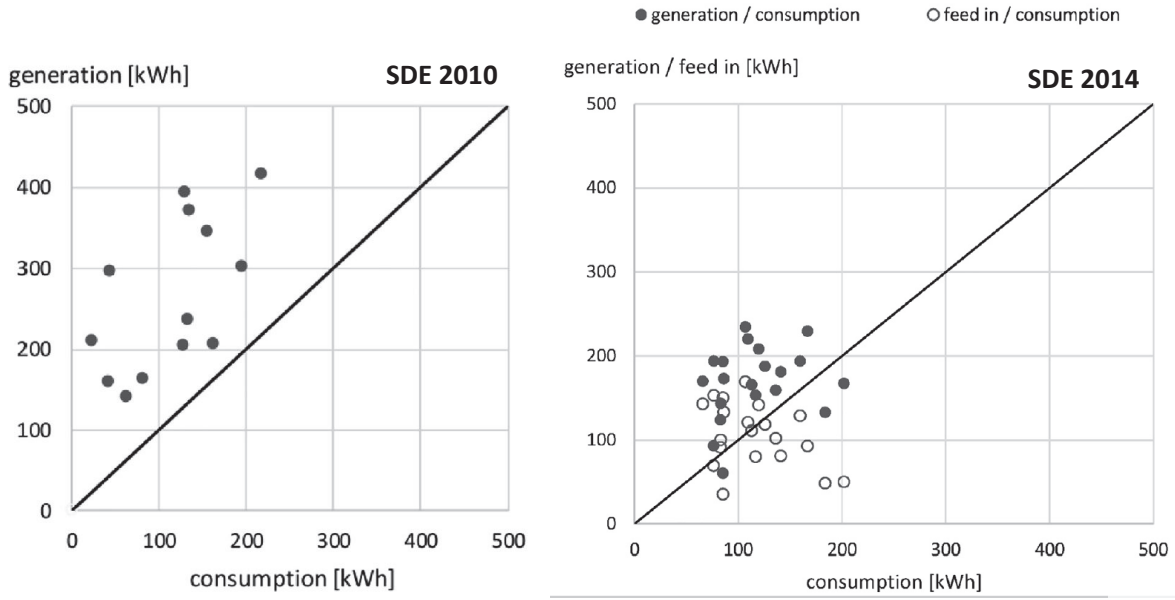
Energy Balance and Self Consumption

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.



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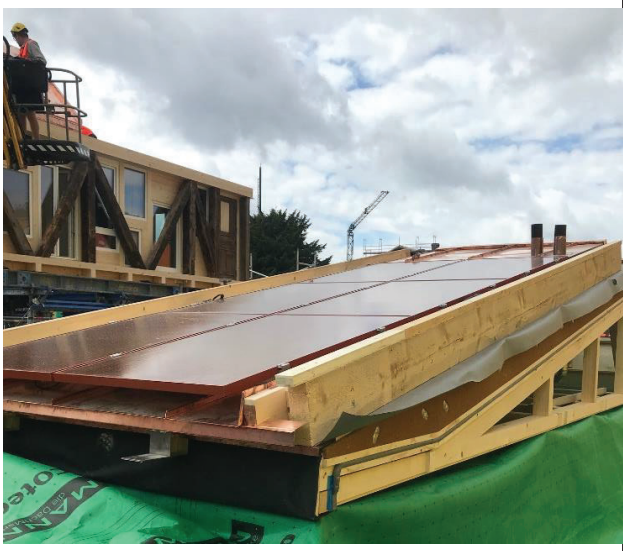
Solar System Integration no system data analysis up to now

Hybrid Solar Systems (PVT)

New Approaches

Design Solutions



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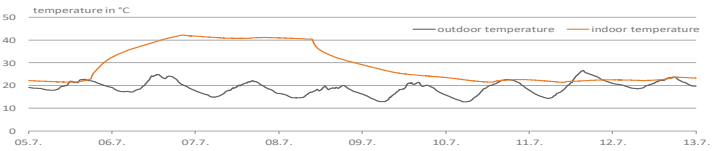
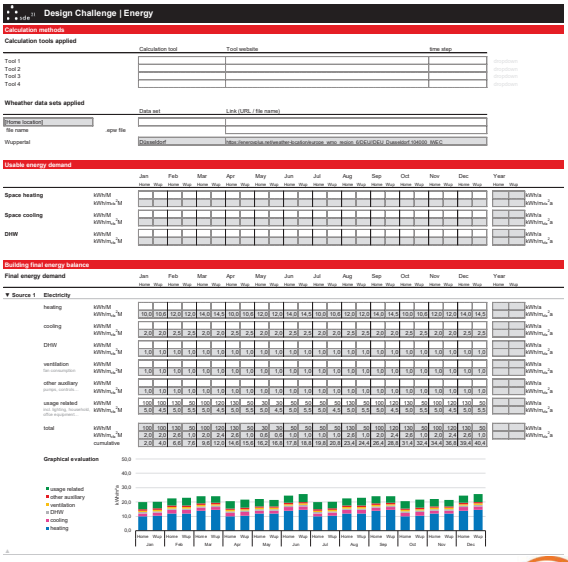
Building Competitions and Research Conclusion and Outlook

- 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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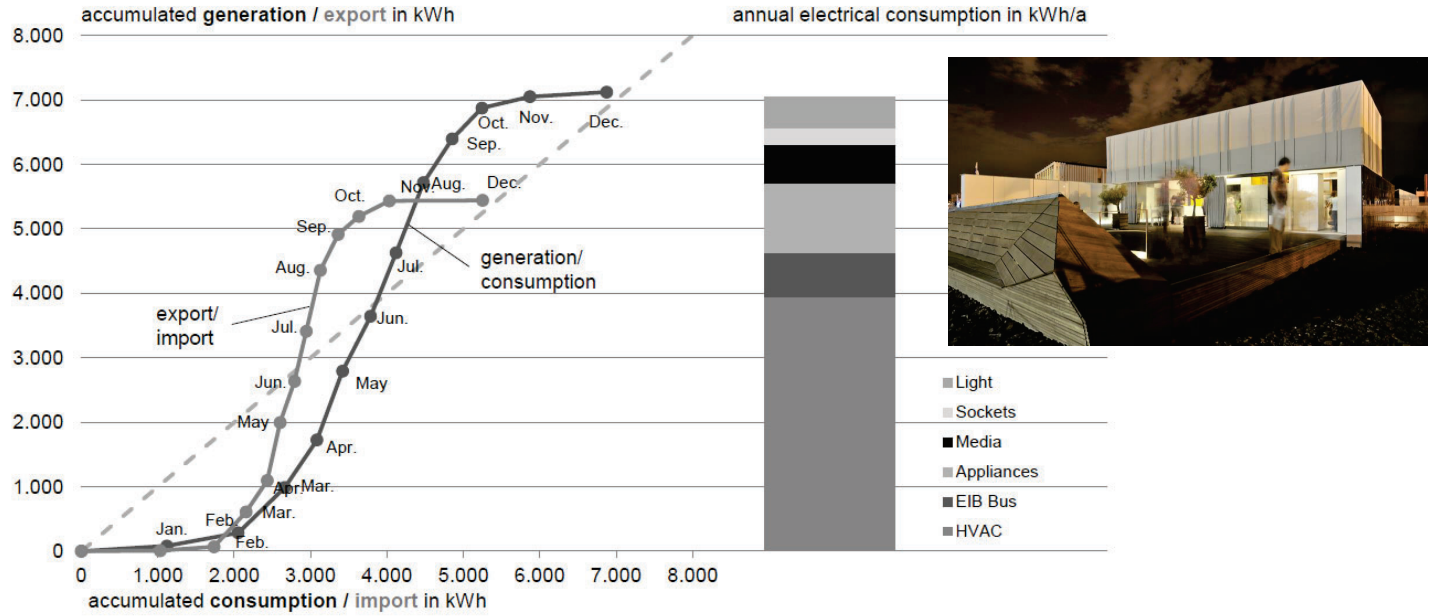
Research following a Competition Participation



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%,

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Living Labs – Educational Platforms

TO (*SDE 2019*)
ETSAV (UPC)

TO at Barcelona, 2020
Source: : https://barcelonatech-upc.es/es/sala-de-prensa/noticias/los-estudiantes-del- equipo-to-consiguen-dos-terceros-premios-en-el-concurso-solar-decathlon-europe-2019
©Andrés Flajszer

Start:	2020
Location:	Barcelona, Spain
Contact:	Martí Cibiels Galí, Project Manager (marti.cibiels@resso.upc.edu)
Main partners / stakeholders:	**Universidad Politécnica de Catalunya (UPC):** Escuela de Arquitectura del Vallès (ETSAV) Escuela de Ingeniería Barcelona Este (EEBE)
Objectives and goals:	• 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
Lab type:	Educational Living Lab
Facilities and tools:	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.
Concept:	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)
Users:	EEBE campus researchers, TO members, general public
Projects / activities:	**EDUCATIONAL** • Guided visits, workshops • House occupation experiment **SOCIAL ACTIVITIES** • Domestic equipment for the EEBE campus researchers
Outcomes:	House occupation experiment with students living in the prototype ongoing.

Source http://www.sde2019.hu/to_en.html ©Andrés Flajszer

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

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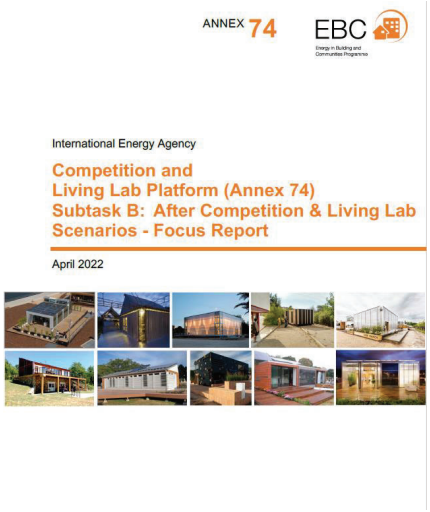
After Competition & Living Lab Scenarios Report

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.



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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

ANNEX 74 EBC Energy in Building and Communities Programme

- 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

EBC Energy in Buildings and Communities Programme

International Energy Agency

Building Competitions as an Incentive for Research, Education and Communication

Professor Dr Karsten Voss, University Wuppertal, Faculty of Architecture and Civil Engineering, Germany

Professor Dr Sergio Vega Sánchez, Technical University Madrid, School of Architecture, Spain

UPM Magic Box, US SD2005

UPM Casa Solar, US SD 2007

UPM Casa Black&White , US SD 2009

Solar Decathlon Europe 2010 - Madrid

Solar Decathlon Europe 2012 - Madrid

Solar Decathlon Europe 2014 - Versailles

OBJECTIVE

The goal of this report B is to gather all the info, analyse SD Competitions & events as a whole, assess its impacts and performance, identify successful key drivers, and take advantage of this knowledge to learn how to improve them, influencing the direction and content of next editions, as well as new competition formats.

CONTENT:

- Methodology
- Solar Decathlon and linked Events
- Impacts in Education, communication and people awareness
- Surveys and key performance indicators
- Key drivers for sucessful SD competitions

PHASE I.A.- IDENTIFY USEFUL INFORMATION TO EMBODY THE KNOWLEDGE PLATFORM

PHASE I

PHASE I.B.- ADAPTATION OF THE KNOWLEDGE PLATFORM TO INCORPORATE ALL INFO

PHASE II

PHASE II.- GATHER AS MUCH INFO AS POSSIBLE

PHASE III.A.- ASSESSMENT METHODOLOGY: SURVEYS, INDICATORS, INTERVIEWS,...

PHASE III

PHASE III.B.- CRITICAL ANALYSIS, DISCUSSION, KEY DRIVERS, AND LESSONS LEARNT

PHASE IV

PHASE IV.- COMPILATION REPORTS WITH CONCLUSIONS AND RECOMMENDATIONS

IDENTIFY USEFUL INFO

SDKP ADAPTATION

GATHERING INFO

ASSESSMENT METHODOLOGY

ANALYSIS & DISCUSSION

REPORTS

Participants

Observers

OBJECTIVES OF THE SOLAR DECATHLON EUROPE

1. TO GENERATE knowledge on the industrialization and sustainability of houses, bringing out suitable scientific benefits as well as the fruitful dissemination of knowledge, and **technology transfer to professionals and industry**

2. TO TAKE ADVENTAGE OF SOCIAL INTEREST AND HIGH MEDIA IMPACT TO MAKE students, professionals, and the general public aware of environmental and sustainability issues, especially in the responsible use of energy and natural resources, promoting the use of the renewable energies, improving energy efficiency, …

Contests US SOLAR DECATHLON

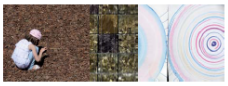
Architecture	100	200
Engineering	100	
Net Metering	100	100
Comfort Zone	100	500
Lighting Design	100	
Hot Water	100	
Appliances	100	
Home Entertainment	100	
Communications	100	200
Market Viability	100	

Contests SOLAR DECATHLON EUROPE

Architecture	Architecture	120	200
	Engineering & Construction	80	
Energy	Energy Efficiency	100	220
	Electrical Energy Balance	120	
Comfort	Comfort Conditions	120	240
	House Functioning	120	
Social Economic	Communication & Social Awareness	80	160
	Industrialization & Market Viability	80	
Strategic	Innovation	80	180
	Sustainability	100	

10ACTION project

The European Project 10ACTION uses the values which boost the SDEurope Competition to raise awareness in European society to achieve the objectives of EU energy policy. These values encourage a responsible use of energy, greater energy efficiency, improvement in sustainability and usage of renewable energies in housing design.



10ACTION consists on a set of activities designed and adapted to five different target groups: children, teenagers, university students, professionals of the building sector and general public.

European partners of 10ACTION

Technical University of Madrid

Equipo de Marketing. Spain

Institute for the Diversification and Energy Saving. Spain

Technische Universität Darmstadt. Germany

Centre for Renewable Energy Sources and Saving. Greece

Portuguese Energy Agency

Austrian Energy Agency

sd europe

Institutional collaborators of SDEurope: Infrastructures Ministry of Spain - Technical University of Madrid - US Solar Decathlon and Department of Energy - European Union - City Council of Madrid - Institute for the Diversification and Energy Saving of Spain. **Sponsors of SDEurope:** Saint Gobain - Schneider Electrics - FCC Citizen Services - Rockwool - Kömerling.

The Solar Decathlon Europe Competition is an international university competition in which each participating university builds a solar & energy sustainable house using market tested technologies. www.sdeurope.org

Actions to Increase Energy Awareness and Sustainable Behaviour in European Citizens

www.10action.eu

FOR A
SUSTAINABLE
FUTURE

ten act10n

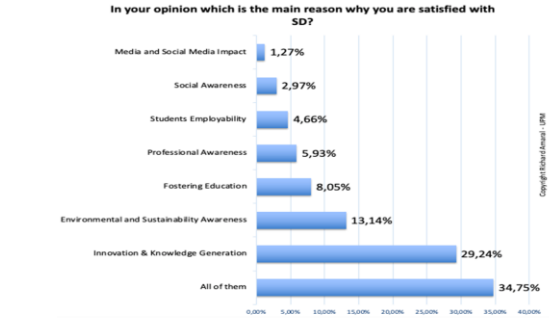
Supported by
INTELLIGENT ENERGY
EUROPE

Competition & Living Lab Platform – Annex 74

Innovation and Energy Policy for Buildings: International Collaboration to Accelerate Change

EBC Energy in Buildings and Communities Programme

34 collaborating countries
60 Universities participating
600 researchers and PhD Students
3.500 Volunteers
25.000 children and teenagers
7.000 university students
25.000 professionals from 12 EU member countries
Scientific output (books, papers, PhDs, patents)
680.000 people participating
Estimated over 700 Million reached


In your opinion which is the main reason why you are satisfied with SD?
Media and Social Media Impact
1,27%
Social Awareness
2,97%
Students Employability
4,66%
Professional Awareness
5,93%
Fostering Education
8,05%
Environmental and Sustainability Awareness
13,14%
Innovation & Knowledge Generation
29,24%
All of them
34,75%
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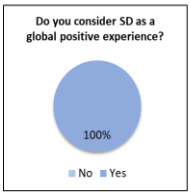
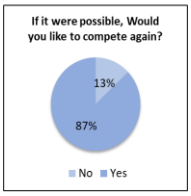
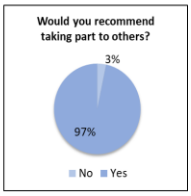
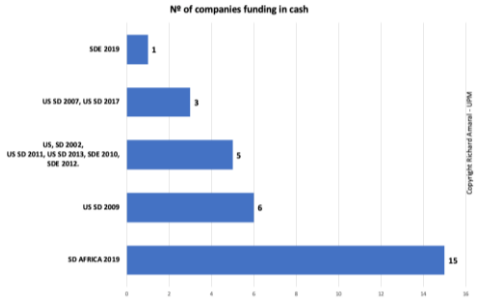

Do you consider SD as a global positive experience?
100%
No
Yes


If it were possible, Would you like to compete again?
13%
87%
No
Yes


Would you recommend taking part to others?
3%
97%
No
Yes


Nº of companies funding in cash
SDE 2019
1
US SD 2007, US SD 2017
3
US, SD 2002, US SD 2011, US SD 2013, SDE 2010, SDE 2012.
5
US SD 2009
6
SD AFRICA 2019
15
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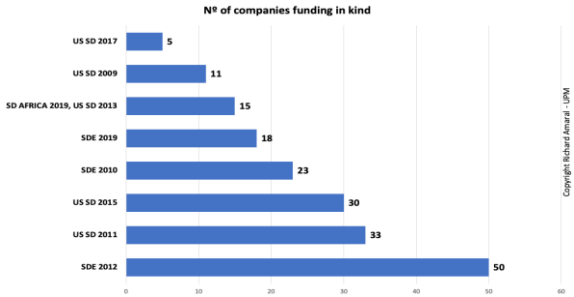
Nº of companies funding in kind
US SD 2017
5
US SD 2009
11
SD AFRICA 2019, US SD 2013
15
SDE 2019
18
SDE 2010
23
US SD 2015
30
US SD 2011
33
SDE 2012
50
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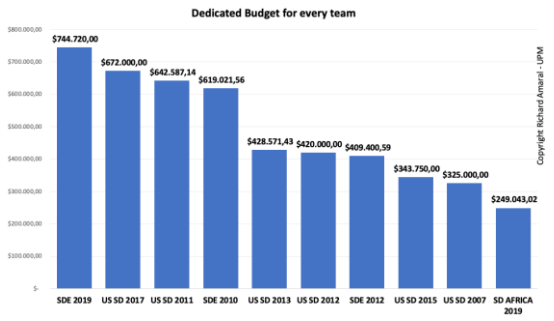
Dedicated Budget for every team
$744.720,00
$672.000,00
$642.587,14
$619.021,56
$428.571,43
$420.000,00
$409.400,59
$343.750,00
$325.000,00
$249.043,02
SDE 2019
US SD 2017
US SD 2011
SDE 2010
US SD 2013
US SD 2012
SDE 2012
US SD 2015
US SD 2007
SD AFRICA 2019
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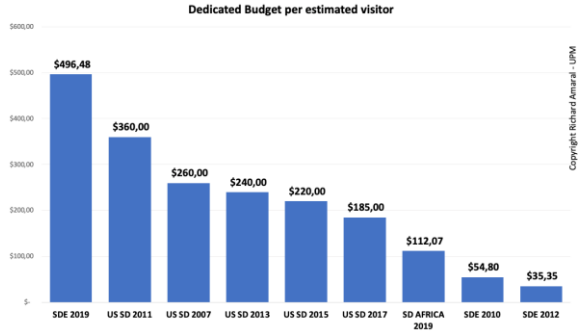
Dedicated Budget per estimated visitor
$496,48
$360,00
$260,00
$240,00
$220,00
$185,00
$112,07
$54,80
$35,35
SDE 2019
US SD 2011
US SD 2007
US SD 2013
US SD 2015
US SD 2017
SD AFRICA 2019
SDE 2010
SDE 2012
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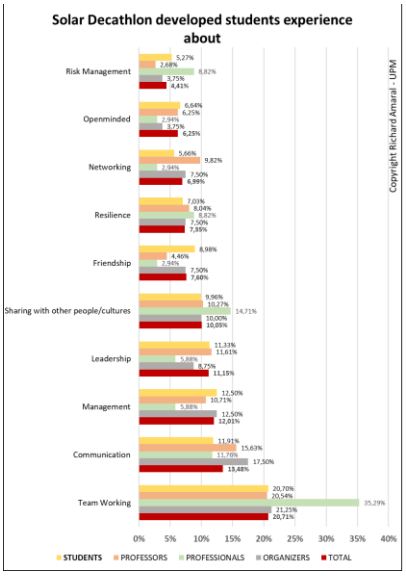
Solar Decathlon developed students experience about
Risk Management
Openminded
Networking
Resilience
Friendship
Sharing with other people/cultures
Leadership
Management
Communication
Team Working
STUDENTS
PROFESSORS
PROFESSIONALS
ORGANIZERS
TOTAL
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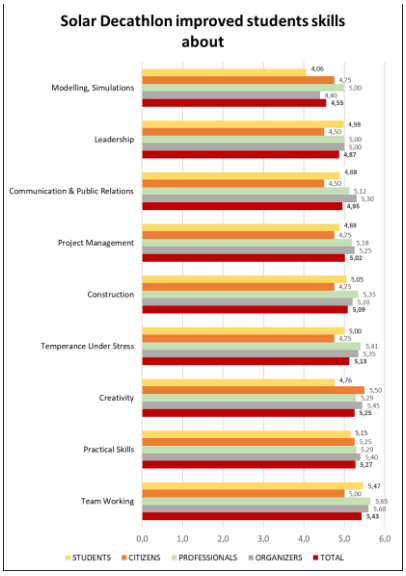
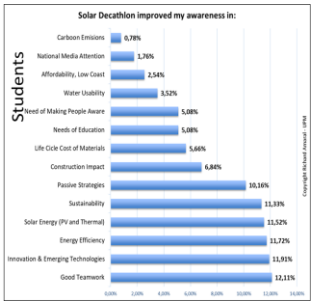

Solar Decathlon improved students skills about
Modelling, Simulations
Leadership
Communication & Public Relations
Project Management
Construction
Temperance Under Stress
Creativity
Practical Skills
Team Working
STUDENTS
CITIZENS
PROFESSIONALS
ORGANIZERS
TOTAL


Solar Decathlon improved my awareness in:
Students
Carboon Emisions 0,78%
National Media Attention 1,76%
Affordability, Low Coast 2,54%
Water Usability 3,52%
Need of Making People Aware 5,08%
Needs of Education 5,08%
Life Cicle Cost of Materials 5,66%
Construction Impact 6,84%
Passive Strategies 10,16%
Sustainability 11,33%
Solar Energy (PV and Thermal) 11,52%
Energy Efficiency 11,72%
Innovation & Emerging Technologies 11,91%
Good Teamwork 12,11%
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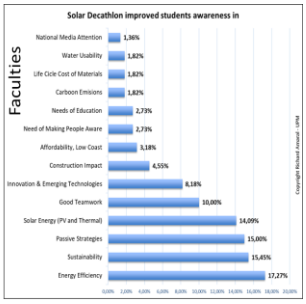
Solar Decathlon improved students awareness in
Faculties
National Media Attention 1,36%
Water Usability 1,82%
Life Cicle Cost of Materials 1,82%
Carboon Emisions 1,82%
Needs of Education 2,73%
Need of Making People Aware 2,73%
Affordability, Low Coast 3,18%
Construction Impact 4,55%
Innovation & Emerging Technologies 8,18%
Good Teamwork 10,00%
Solar Energy (PV and Thermal) 14,09%
Passive Strategies 15,00%
Sustainability 15,45%
Energy Efficiency 17,27%
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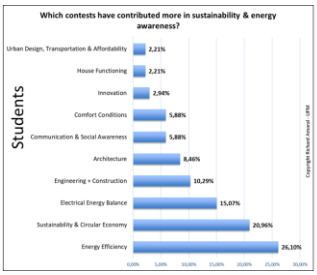
Which contests have contributed more in sustainability & energy awareness?
Students
Urban Design, Transportation & Affordability 2,21%
House Functioning 2,21%
Innovation 2,94%
Comfort Conditions 5,88%
Communication & Social Awareness 5,88%
Architecture 8,46%
Engineering + Construction 10,29%
Electrical Energy Balance 15,07%
Sustainability & Circular Economy 20,96%
Energy Efficiency 26,10%
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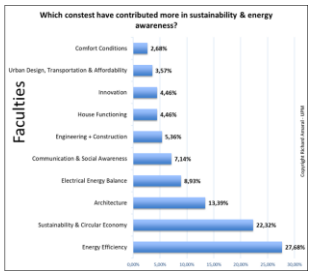
Which constest have contributed more in sustainability & energy awareness?
Faculties
Comfort Conditions 2,68%
Urban Design, Transportation & Affordability 3,57%
Innovation 4,46%
House Functioning 4,46%
Engineering + Construction 5,36%
Communication & Social Awareness 7,14%
Electrical Energy Balance 8,93%
Architecture 13,39%
Sustainability & Circular Economy 22,32%
Energy Efficiency 27,68%
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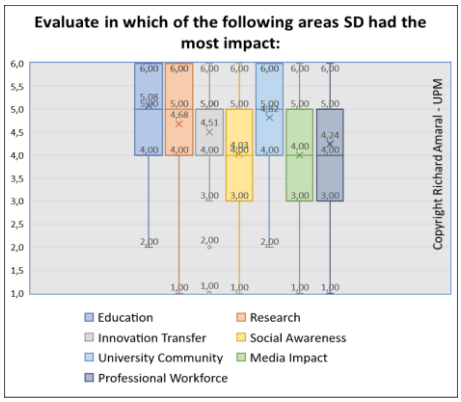
Evaluate in which of the following areas SD had the most impact:
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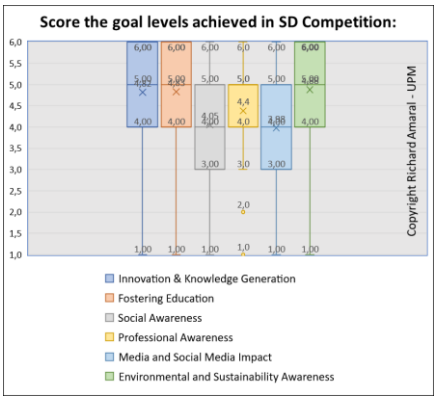
Education
Research
Innovation Transfer
Social Awareness
University Community
Media Impact
Professional Workforce


Score the goal levels achieved in SD Competition:
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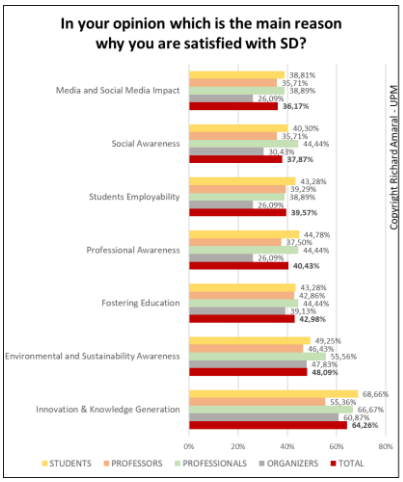
Innovation & Knowledge Generation
Fostering Education
Social Awareness
Professional Awareness
Media and Social Media Impact
Environmental and Sustainability Awareness


In your opinion which is the main reason why you are satisfied with SD?
Media and Social Media Impact
38,81%
35,71%
38,89%
26,09%
36,17%
Social Awareness
40,30%
35,71%
44,44%
30,43%
37,87%
Students Employability
43,28%
39,29%
38,89%
26,09%
39,57%
Professional Awareness
44,78%
37,50%
44,44%
25,09%
40,43%
Fostering Education
43,28%
42,86%
44,44%
19,13%
42,98%
Environmental and Sustainability Awareness
49,25%
46,43%
55,56%
47,83%
48,09%
Innovation & Knowledge Generation
68,66%
55,36%
66,67%
60,87%
64,26%
0%
20%
40%
60%
80%
STUDENTS
PROFESSORS
PROFESSIONALS
ORGANIZERS
TOTAL
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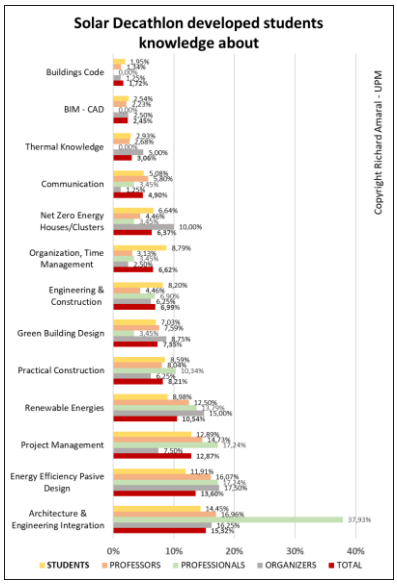
Solar Decathlon developed students knowledge about
Buildings Code
1,95%
1,54%
1,72%
BIM - CAD
2,54%
2,23%
2,45%
Thermal Knowledge
2,93%
2,68%
3,06%
Communication
5,98%
4,80%
4,90%
Net Zero Energy Houses/Clusters
6,64%
4,46%
10,00%
6,37%
Organization, Time Management
8,79%
6,62%
Engineering & Construction
8,20%
4,46%
6,99%
Green Building Design
7,03%
7,59%
7,83%
Practical Construction
8,59%
8,04%
10,34%
8,31%
Renewable Energies
8,98%
12,50%
15,00%
10,34%
Project Management
12,88%
17,24%
12,87%
Energy Efficiency Pasive Design
11,91%
16,07%
17,50%
13,60%
Architecture & Engineering Integration
14,45%
16,96%
37,93%
15,32%
0%
10%
20%
30%
40%
STUDENTS
PROFESSORS
PROFESSIONALS
ORGANIZERS
TOTAL
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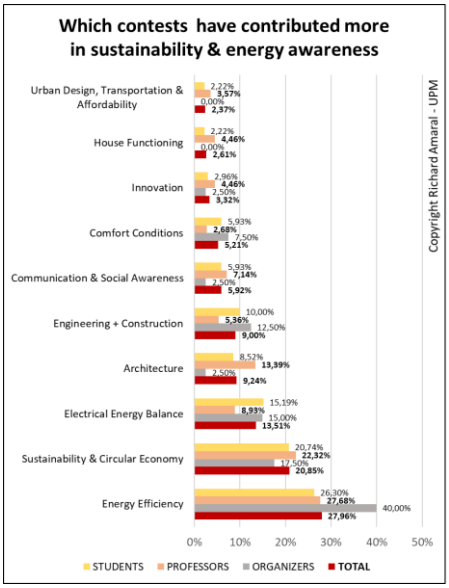
Which contests have contributed more in sustainability & energy awareness
Urban Design, Transportation & Affordability
2,22%
3,57%
0,00%
2,37%
House Functioning
2,22%
4,46%
0,00%
2,61%
Innovation
2,96%
4,46%
2,50%
3,32%
Comfort Conditions
5,93%
2,68%
7,50%
5,21%
Communication & Social Awareness
5,93%
7,14%
7,50%
5,92%
Engineering + Construction
10,00%
5,36%
12,50%
9,00%
Architecture
8,52%
13,39%
7,50%
9,24%
Electrical Energy Balance
15,19%
8,93%
15,00%
13,51%
Sustainability & Circular Economy
20,74%
22,32%
17,50%
20,85%
Energy Efficiency
26,30%
27,68%
40,00%
27,96%
0%
10%
20%
30%
40%
50%
STUDENTS
PROFESSORS
ORGANIZERS
TOTAL
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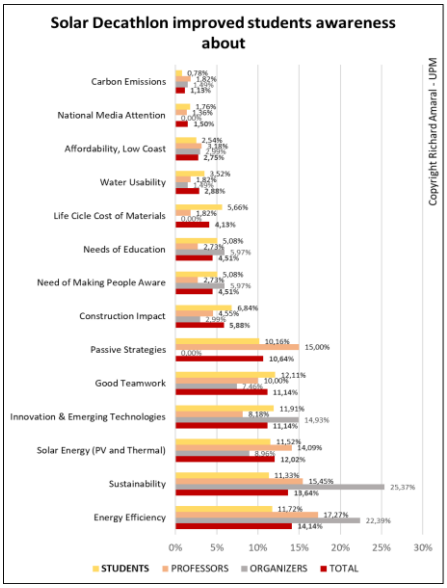
Solar Decathlon improved students awareness about
Carbon Emissions
0,78%
1,82%
1,13%
National Media Attention
1,70%
1,56%
0,00%
1,30%
Affordability, Low Coast
2,54%
3,18%
2,99%
2,75%
Water Usability
3,52%
1,82%
4,79%
2,88%
Life Cicle Cost of Materials
5,66%
1,82%
0,00%
4,13%
Needs of Education
5,08%
2,73%
5,97%
4,51%
Need of Making People Aware
5,08%
2,73%
5,97%
4,51%
Construction Impact
6,84%
4,55%
2,99%
5,88%
Passive Strategies
10,16%
15,00%
0,00%
10,64%
Good Teamwork
12,11%
10,00%
11,14%
Innovation & Emerging Technologies
11,91%
8,18%
14,93%
11,14%
Solar Energy (PV and Thermal)
11,52%
14,09%
9,85%
12,02%
Sustainability
11,33%
15,45%
25,37%
13,64%
Energy Efficiency
11,72%
17,27%
22,39%
14,14%
0%
5%
10%
15%
20%
25%
30%
STUDENTS
PROFESSORS
ORGANIZERS
TOTAL
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SHARE!
SMART SHARING – OUR VISION IS YOUR+

Occupant-centric Building Design and Operation in a Post-pandemic World (EBC Annex 79)

Liam O'Brien, Ph.D., P.Eng.

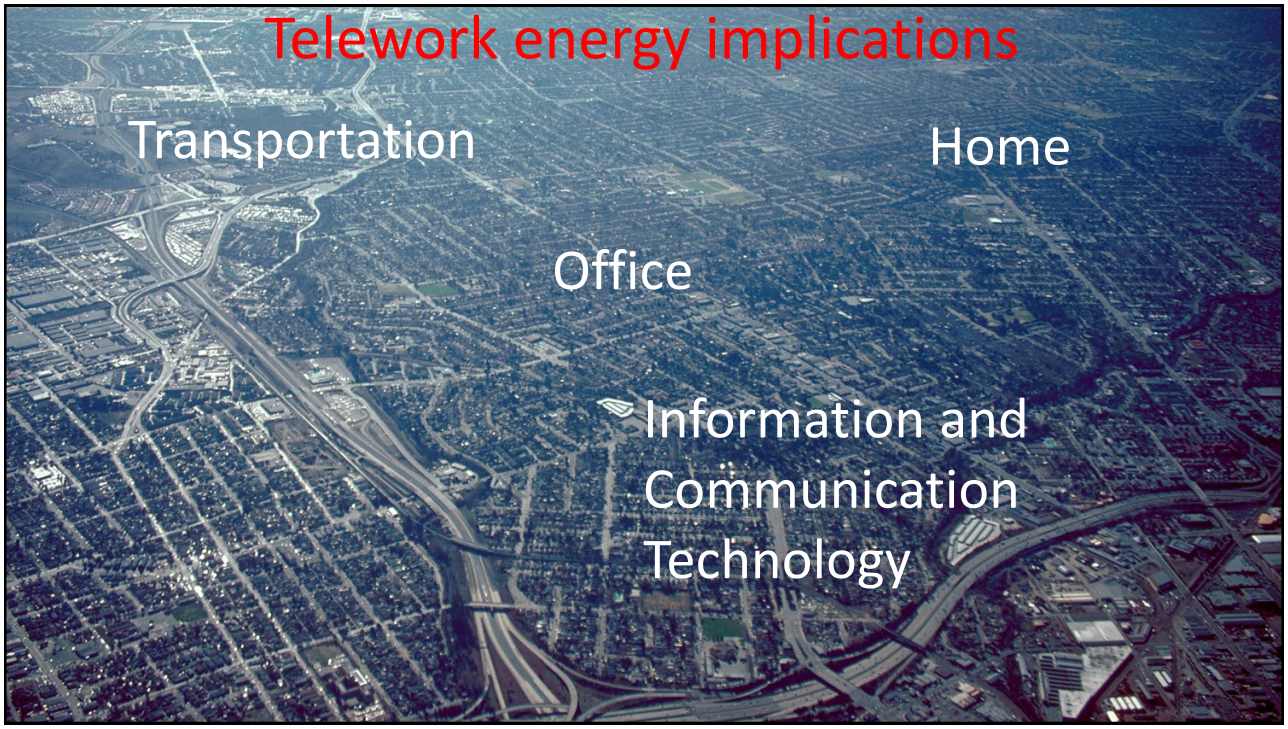
Professor

Civil and Environmental Engineering

Carleton University, Ottawa, Canada

Wednesday, June 8, 2022

1



2

Does teleworking save energy?

IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, VOL. SMC-6, NO. 2, FEBRUARY 1976 77

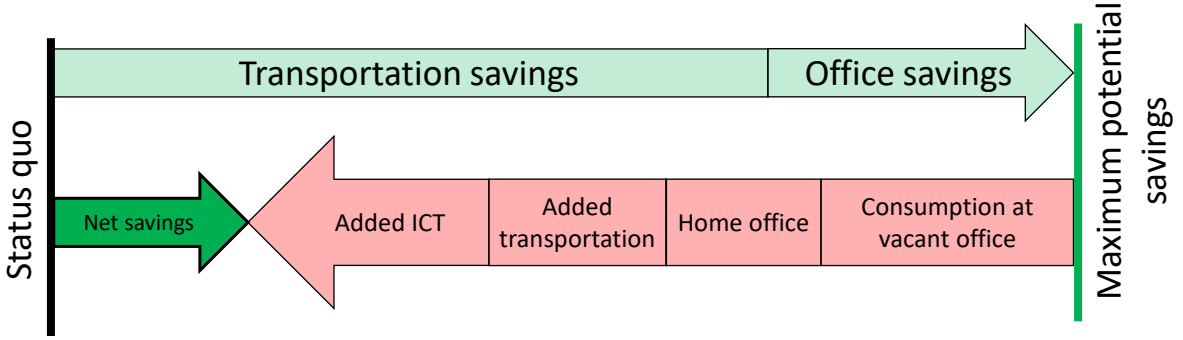
Telecommuting—An Alternative to Urban Transportation Congestion

JACK M. NILLES, FREDERIC R. CARLSON, MEMBER, IEEE, PAUL GRAY, AND GERHARD HANNEMAN

ELSEVIER
Energy and Buildings
Volume 225, 15 October 2020, 110298

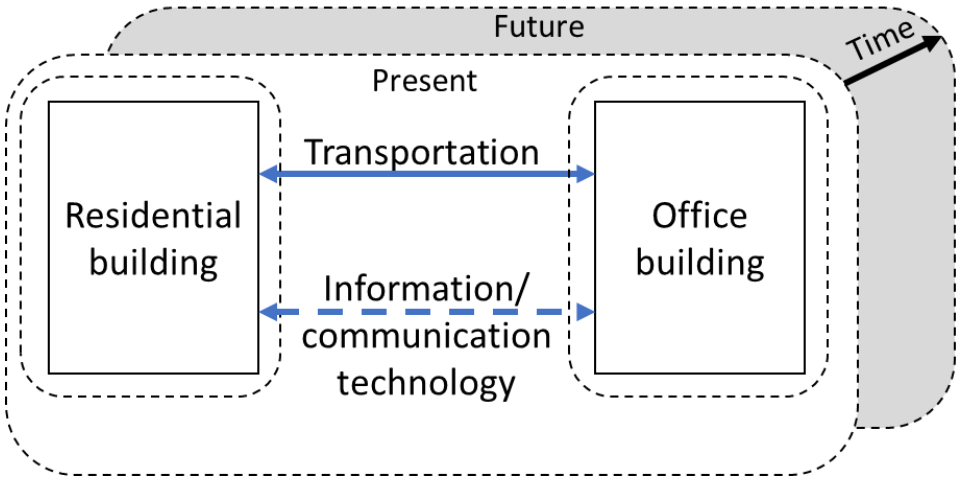
Does telecommuting save energy? A critical review of quantitative studies and their research methods

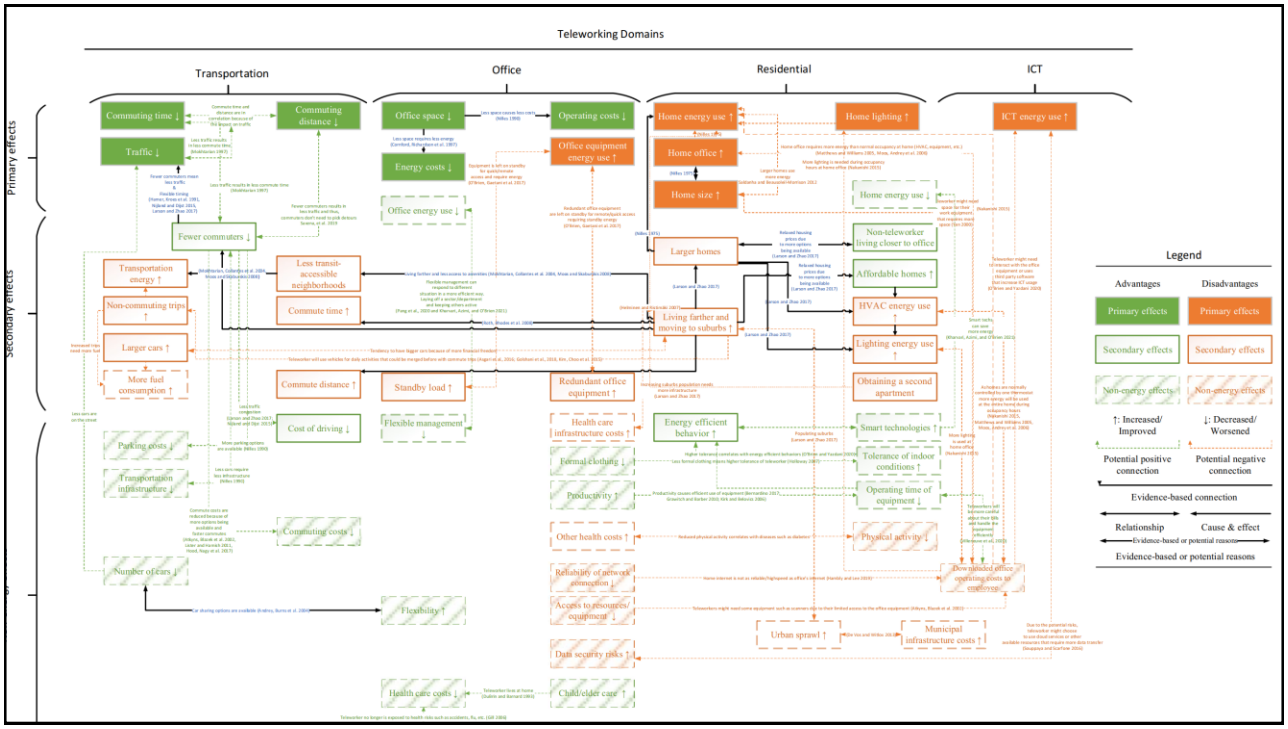
William O'Brien [a], Fereshteh Yazdani Aliabadi [b]



24 studies have looked at one or more domains; none have captured all.

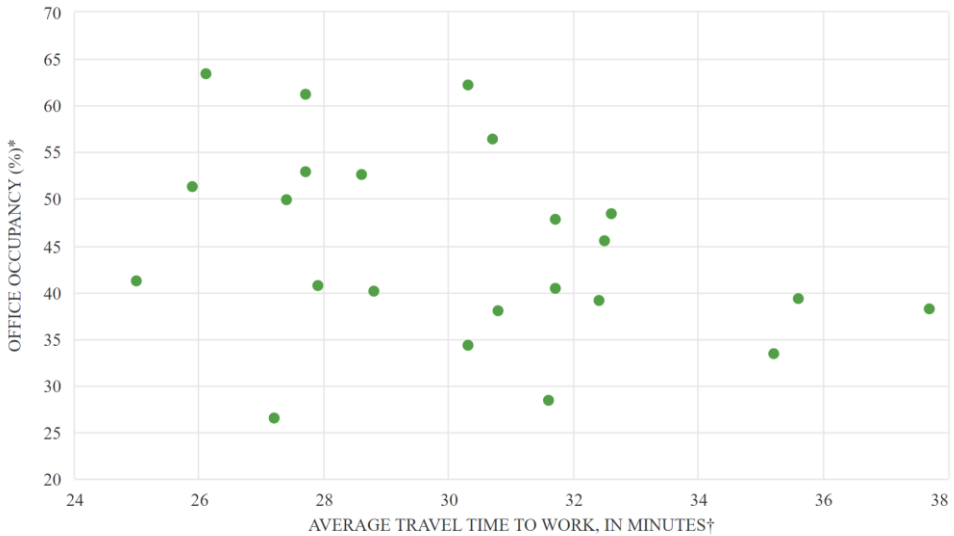
Spatial and temporal boundaries





5

Office occupancy vs. commute time for US cities



*As of 5/18/2022 †As of 2019

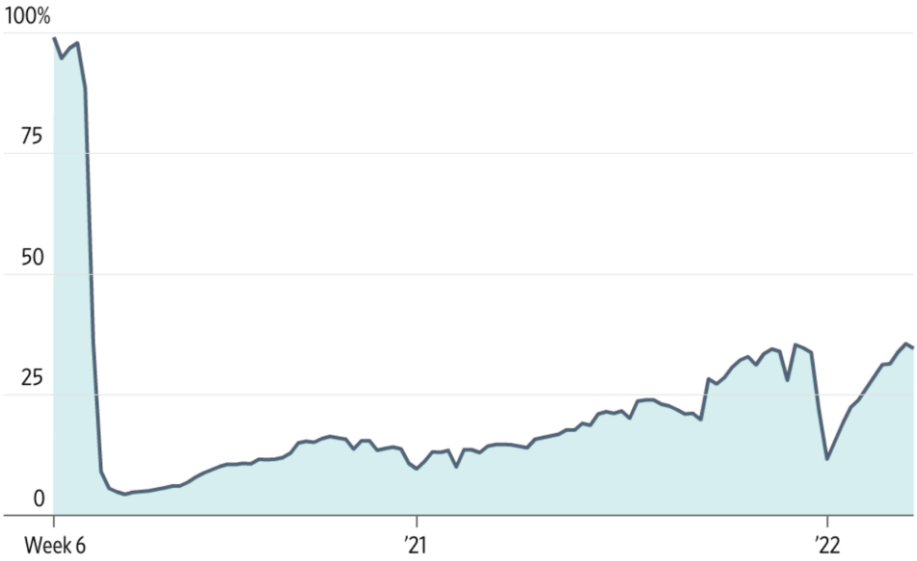
Source: U.S. Census Bureau 2019 American Community Survey, Kastle Systems

Source: WSJ

6

6

Midtown (Manhattan) office occupancy

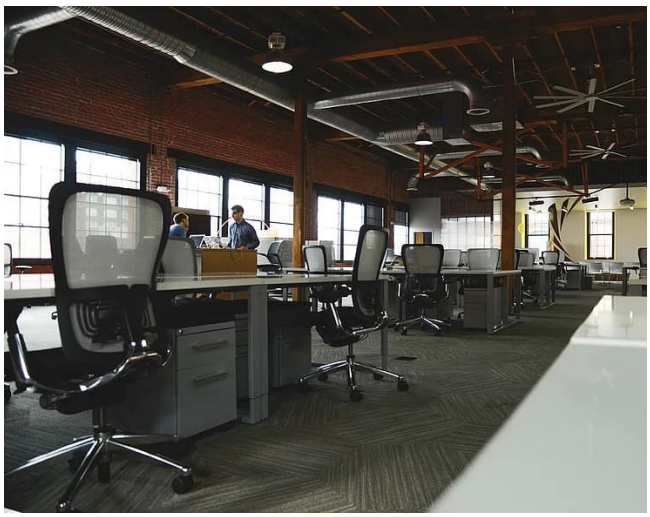


Source: Kastle Systems

Source: WSJ

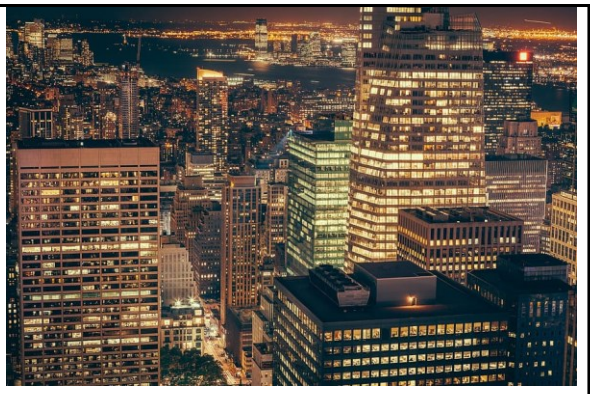
Office buildings

- Minor positive energy benefit
- Highly dependent on adaptability:
  - Hotelling/hot-desking
  - Demand-controlled ventilation (DCV)
  - Occupancy-based setpoint and lighting control
  - Sleep mode on electronics



Office buildings

Why Empty Office Buildings Still Consume Lots of Power During a Global Pandemic



Commercial Building Electricity Reduction

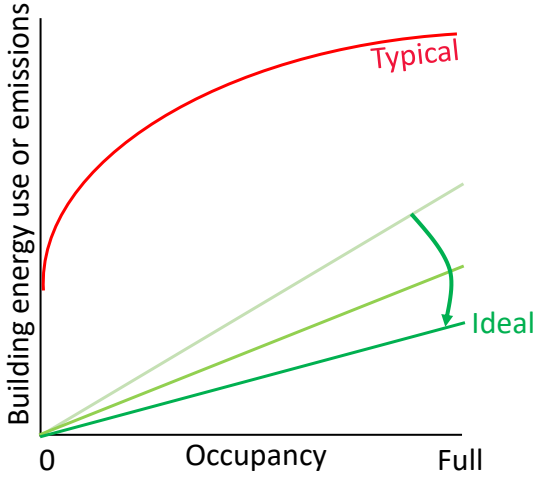
As Compared to Week of March 1st

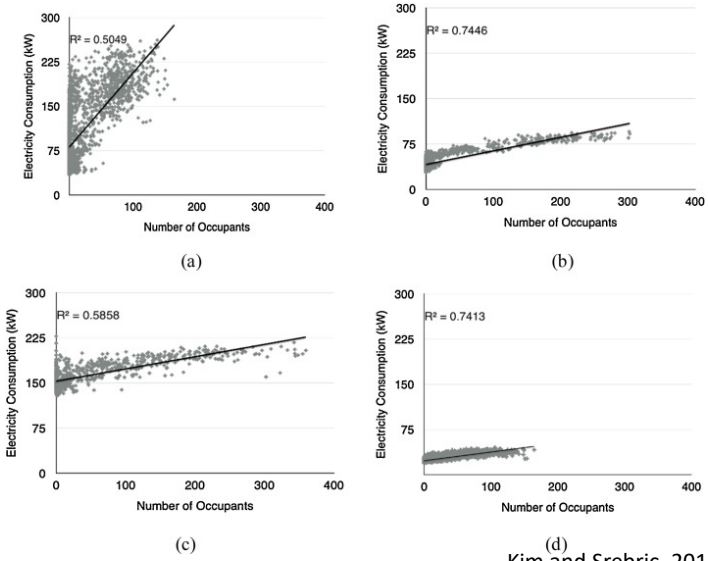
	March 8 - March 14	March 15 - March 21	March 22 - March 28	March 29 - April 4	April 5 - April 11
US Total	5%	12%	18%	22%	25%
Northeast	7%	16%	21%	23%	26%
Midwest	4%	3%	11%	19%	25%
South	5%	10%	16%	22%	24%
West	4%	14%	21%	22%	27%

hatchdata

Source: www.hatchdata.com

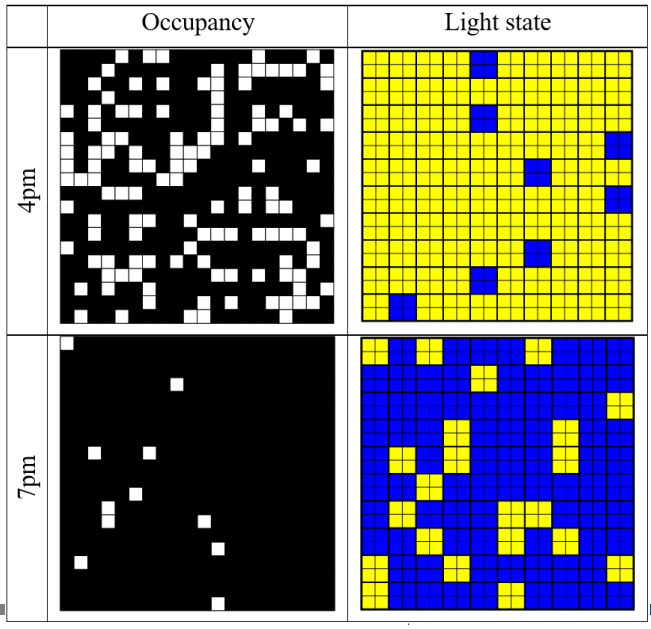
Office buildings





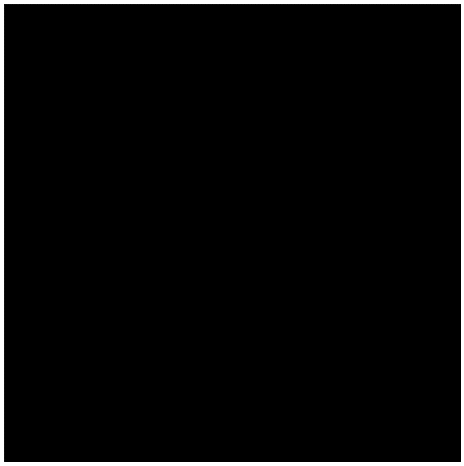
Kim and Srebric, 2017

Occupancy and lighting controls

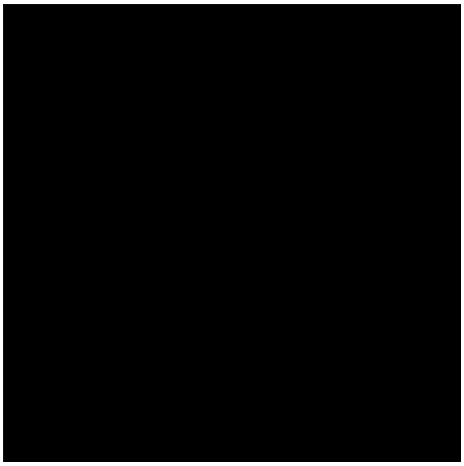


4 cubicles/lighting control zone

Occupancy



Lighting

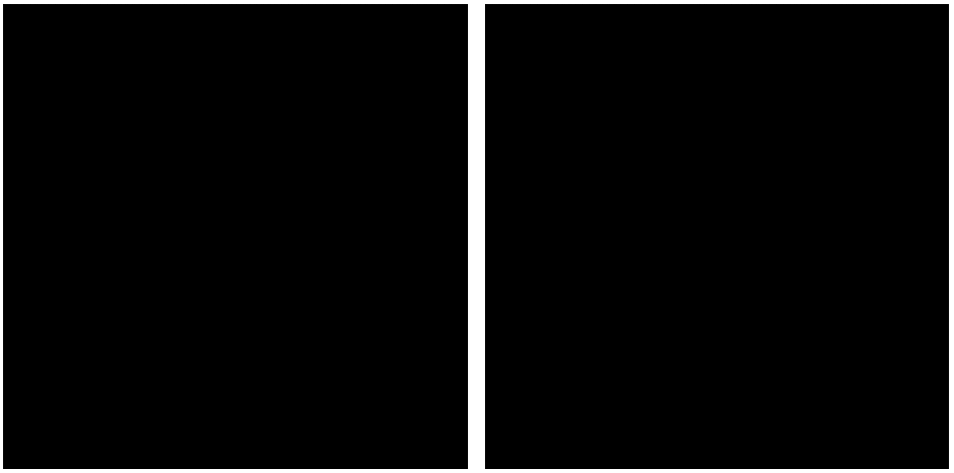


12

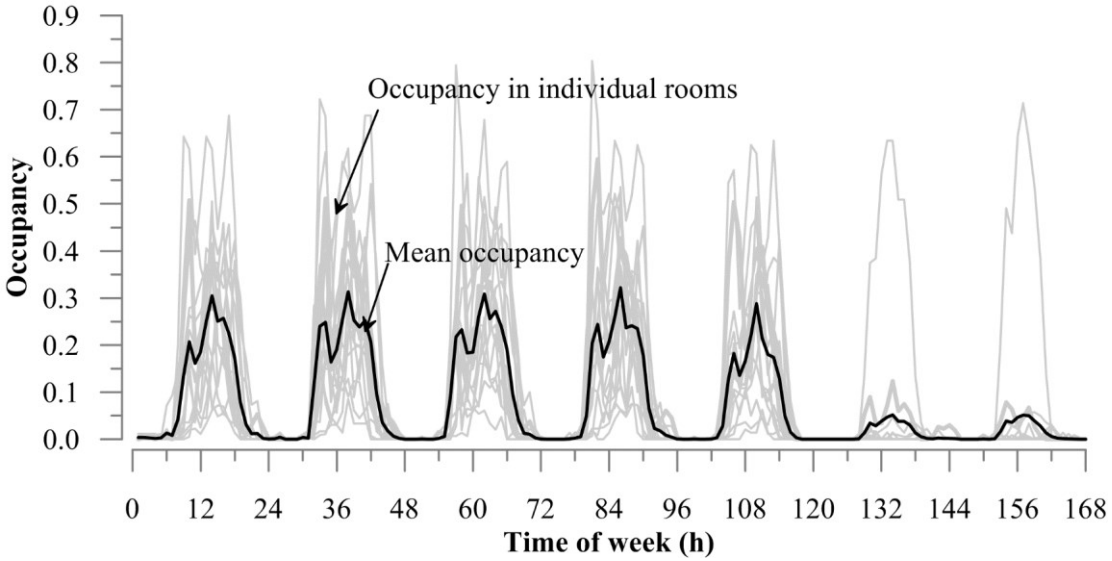
25 cubicles/lighting control zone

Occupancy

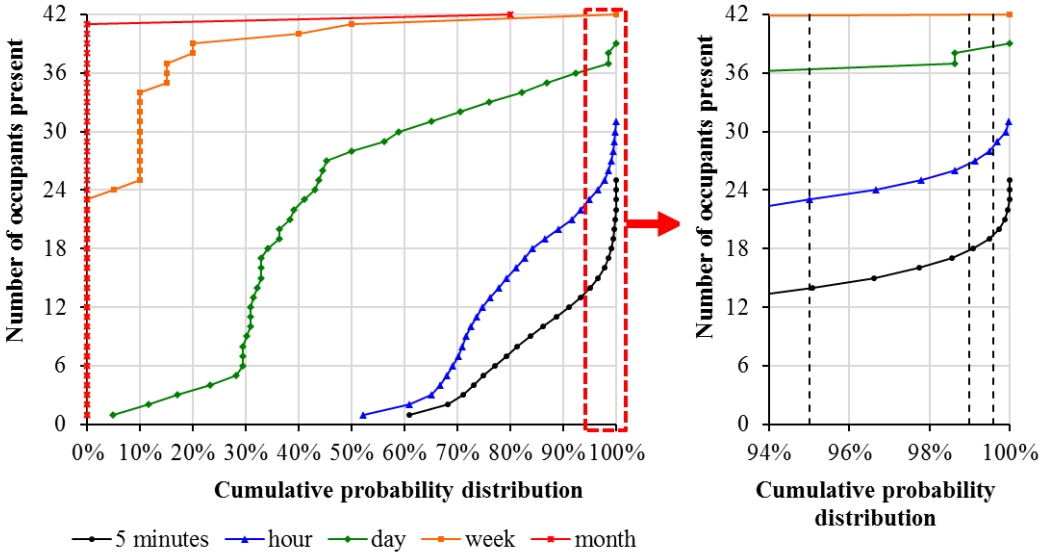
Lighting



Office hotelling potential/probabilistic occupancy



Office hotelling potential/probabilistic occupancy



15

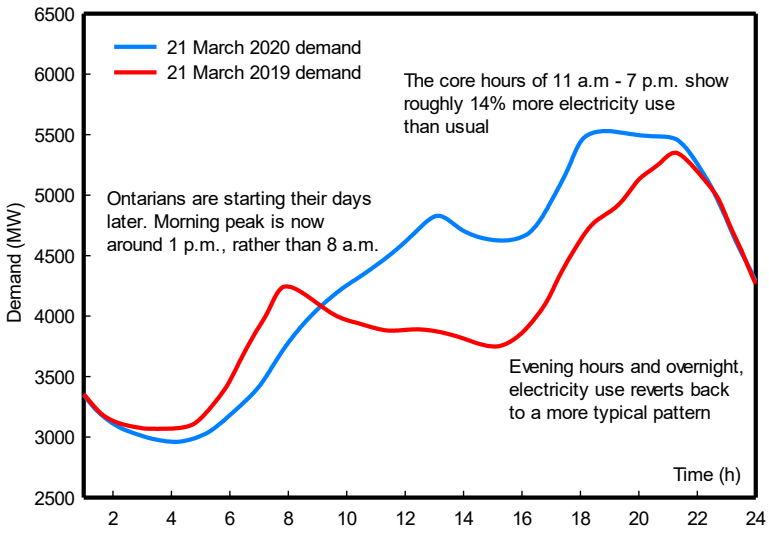
Home

- Net negative effect
  - Previous estimates range from 0.1 to 20 kWh/teleworked day
- Highly dependent on operations
  - Zoned heating/cooling/lighting
  - Optimally-scheduled setpoints with vacancy setback
  - Laundry, baking, etc. shift peak loads
- Bigger home to accommodate office?
  - 4% larger (Nilles, 1990)

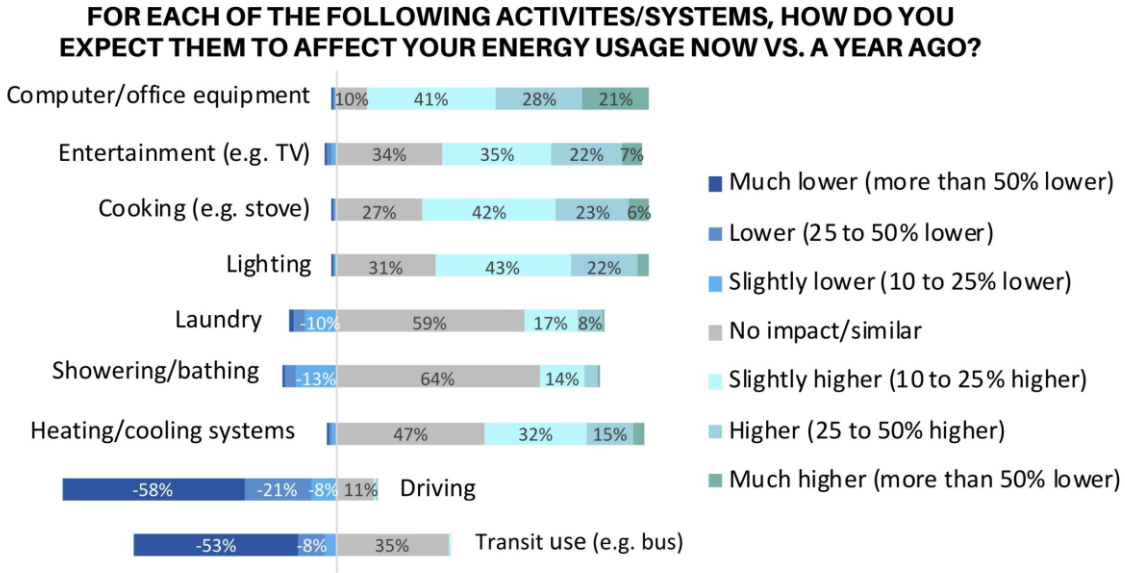
16

Ottawa residential electricity use

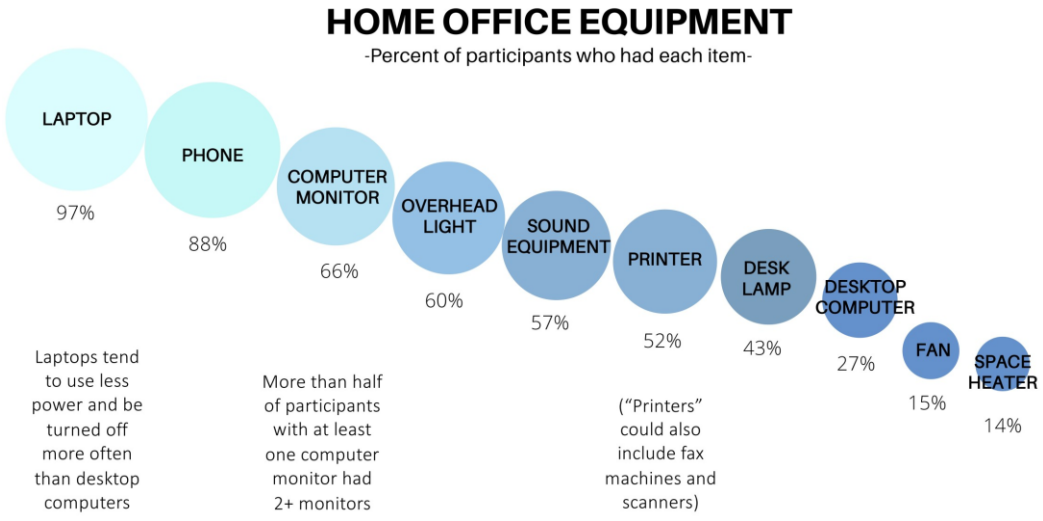
- Average daily home electricity use up from 19.7 kWh to 22.1 kWh (12.1% increase)
- Peak loads are up 15 to 20% over pre-COVID



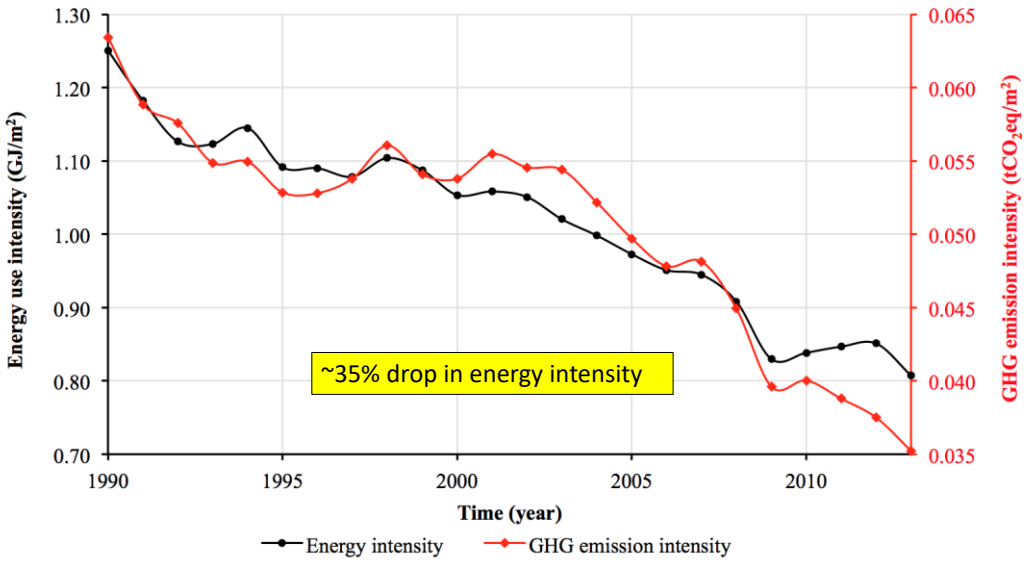
Energy usage in the home (survey of 300 Canadians)



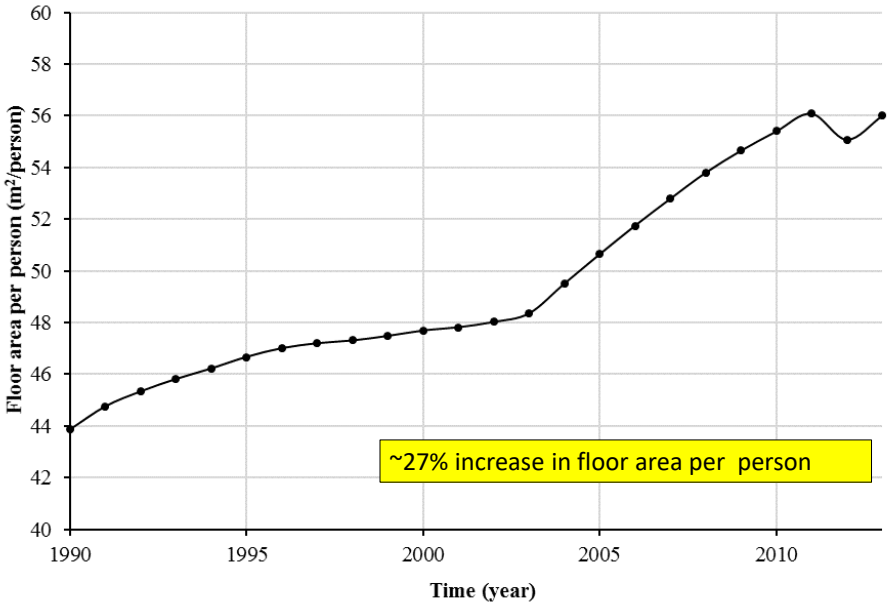
Energy usage in the home (survey of 300 Canadians)



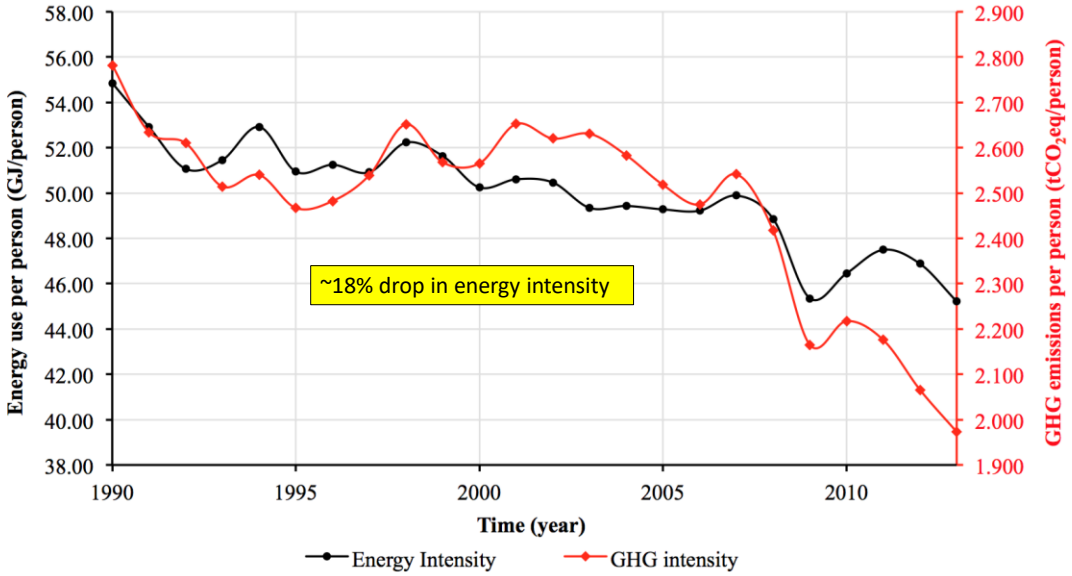
Floor area normalization: Canadian housing stock



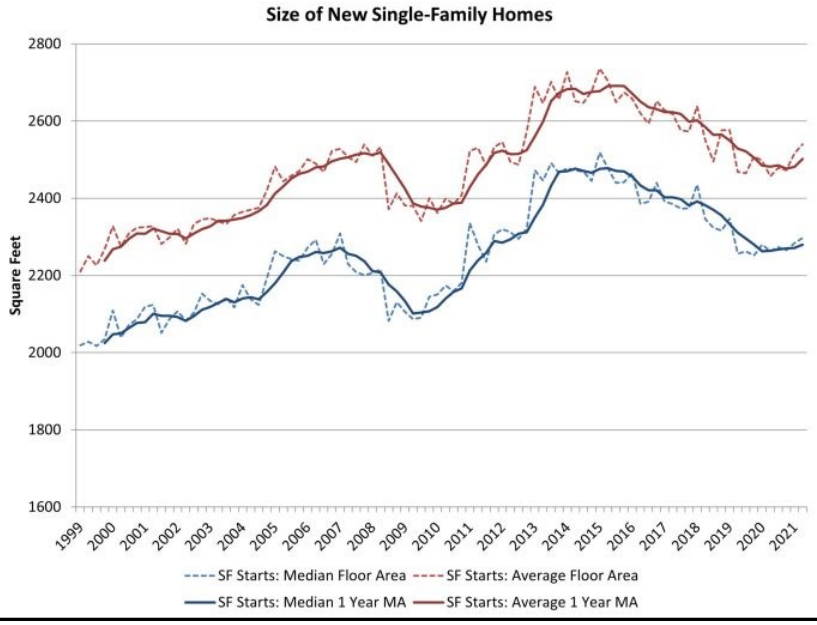
Canadian housing stock: Floor area



Floor area normalization

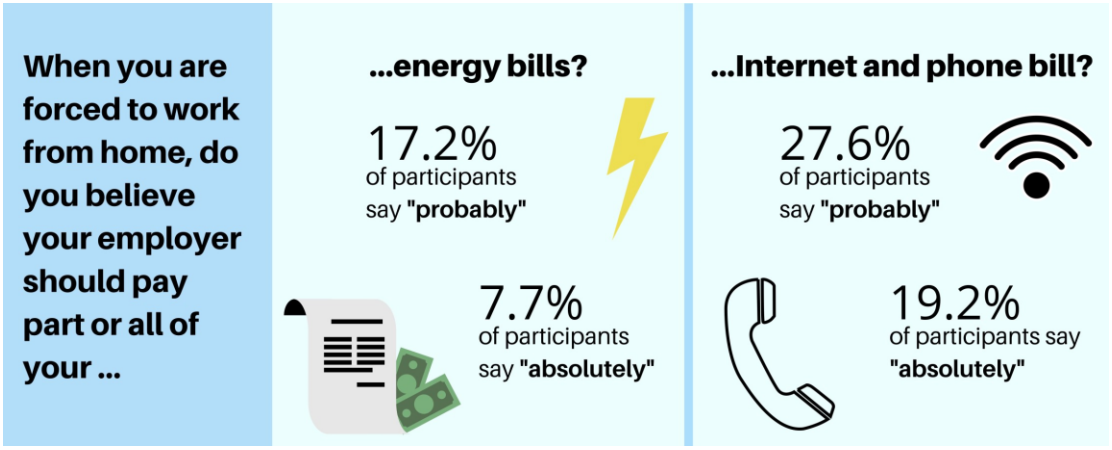


Midtown (Manhattan) office occupancy



Source: National Association of Home Builders (US)

Attitudes towards teleworking

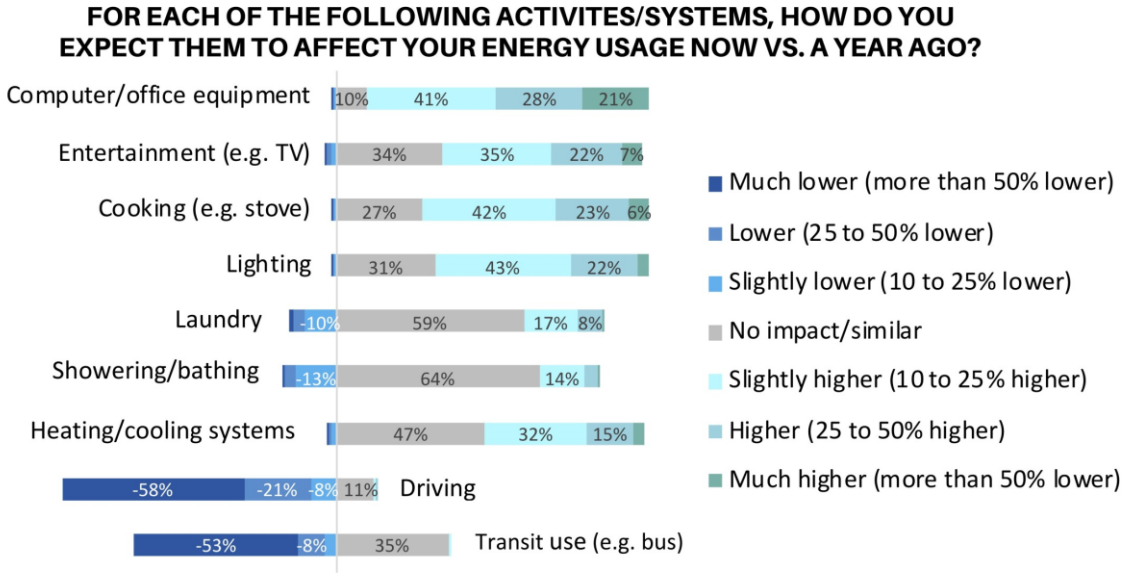


- 67% of participants wanted to work from home more than before based on this teleworking experience

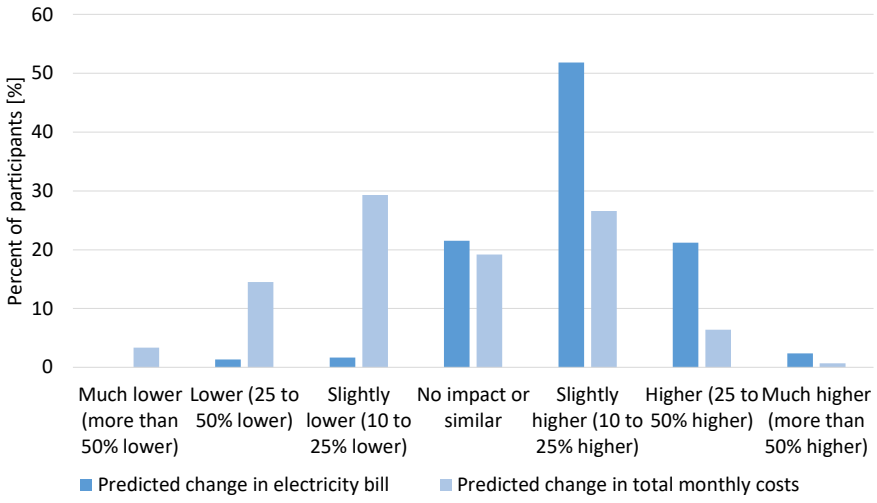
Energy usage in the home

- To improve the functionality of their home working environment…
  - 52.9% of participants had to **start using** more electronic devices/appliances
  - 32.3% of participants had to **buy** new electronic devices/appliances
- Teleworkers need equipment, which is associated with energy use

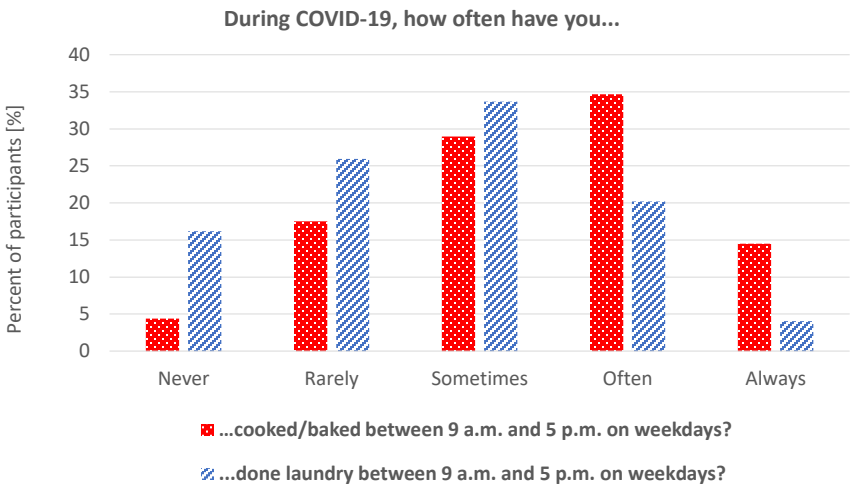
Energy usage in the home



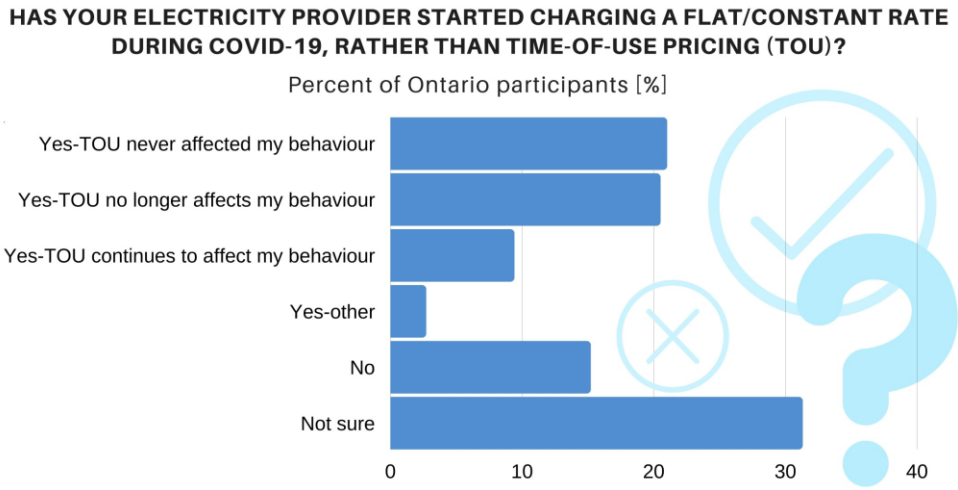
Energy usage in the home



Energy attitudes & behaviours



Energy attitudes & behaviours



Attitudes towards teleworking

When you are forced to work from home, do you believe your employer should pay part or all of your ...

...energy bills?

17.2% of participants say **"probably"**

7.7% of participants say **"absolutely"**

...Internet and phone bill?

27.6% of participants say **"probably"**

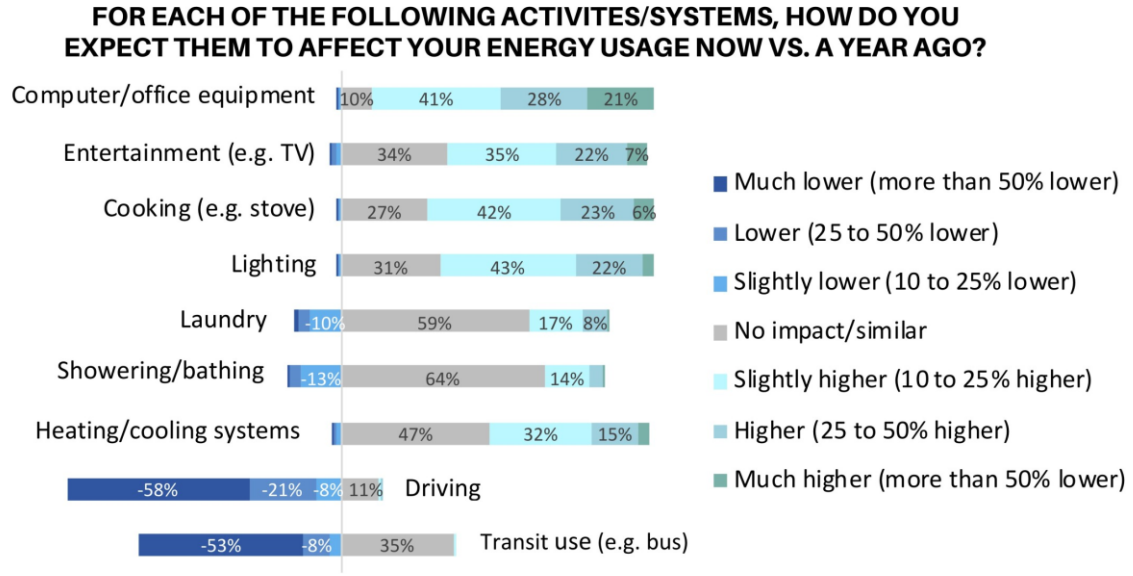
19.2% of participants say **"absolutely"**

- 67% of participants wanted to work from home more than before based on this teleworking experience

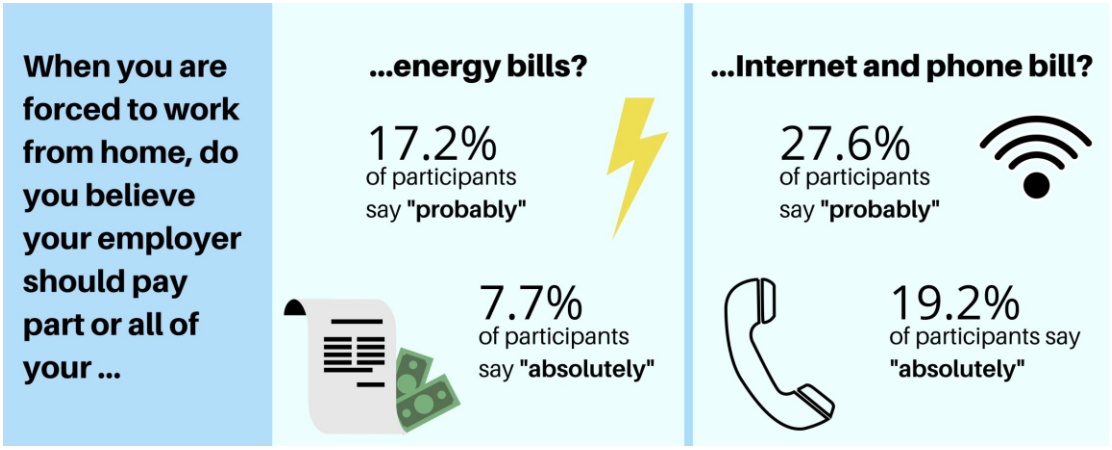
Follow-up survey results

- **"Does your current residence have air-conditioning?"**
  - 77% of the respondents have central A/C
  - 9% do not have any A/C
  - One person said they had both central A/C and a portable/window A/C unit
  - Only one person said they have multiple window/portable A/C units (1 in the room they work in, 1 in their bedroom)
- **"How often are you using air-conditioning compared to last summer?" Of the 51 respondents who had A/C:**
  - 47% of respondents say they are using their A/C more during the day
  - 43% of respondents say they are using their A/C the same amount as last summer

Energy usage in the home



Attitudes towards teleworking

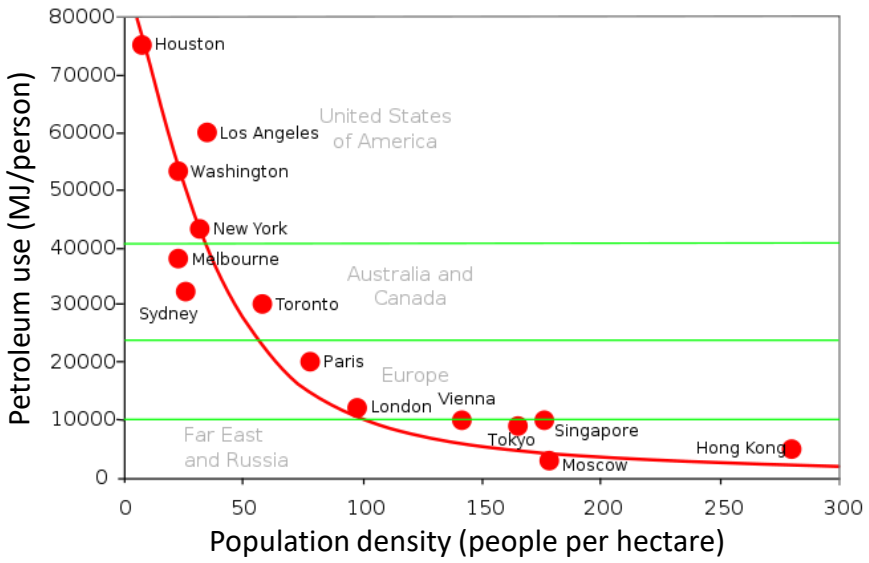


- 67% of participants wanted to work from home more than before based on this teleworking experience

Transportation

- Probably the biggest energy/emissions-saving opportunity
- BUT, 3 of 21 studies reported an increase in transportation use from telework
- Major rebound effects:
  - Poorer trip-chaining
  - Family now has car to use
  - Bigger/more cars
  - Suburban sprawl
  - Less traffic → more driving by others
- Unclear what comes first:
  - Teleworkers move farther
  - Suburbanites start teleworking more

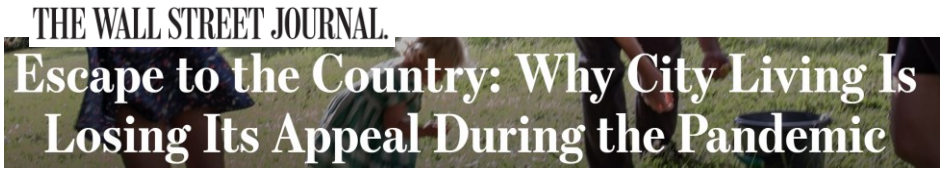
Transportation energy vs. density



Newman and Kenworthy (1989)

The Guardian

Escape to the country: how Covid is driving an exodus from Britain's cities



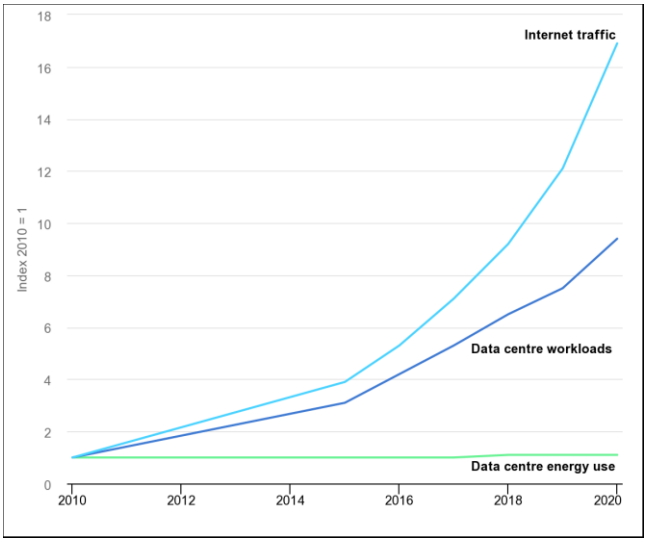
POLITICO

The death of the city

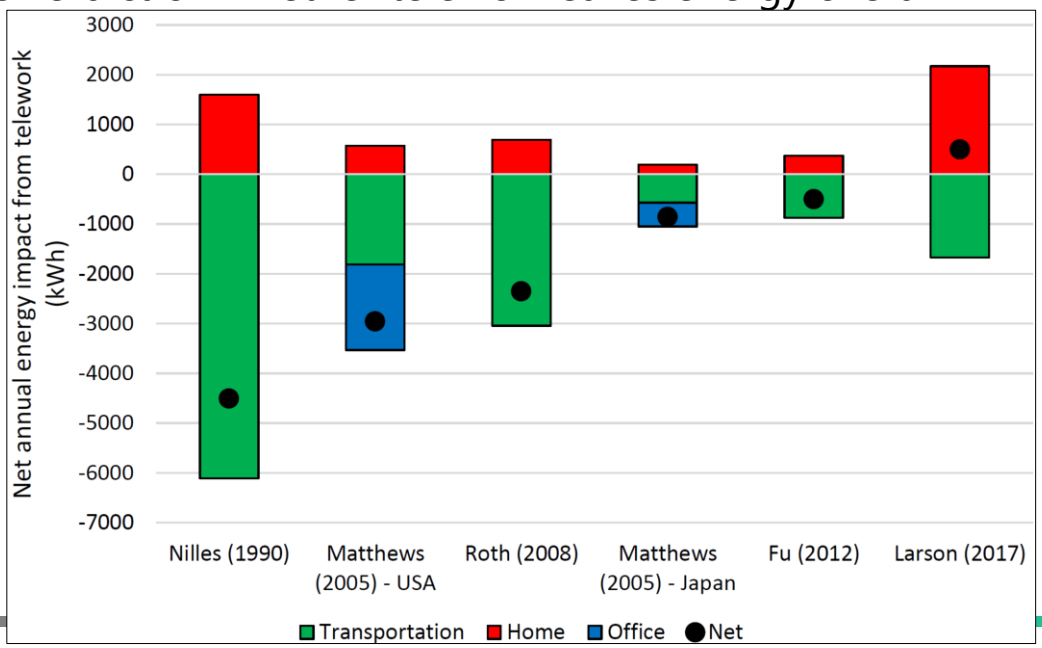
Teleworking, not the coronavirus, is making urban living obsolete.

Information and Communications Technology (ICT)

- Negative effect, but enabler of teleworking
- Global data transmission uses 1.1-1.4% of total electricity use – expected to double in a decade
- Major uncertainty about energy-intensity and data *actually* used for work
- 0.1-1.0 kWh ≈ 1 GB (e.g., 0.5-1 hours of Zoom meetings)



The verdict on whether telework saves energy overall



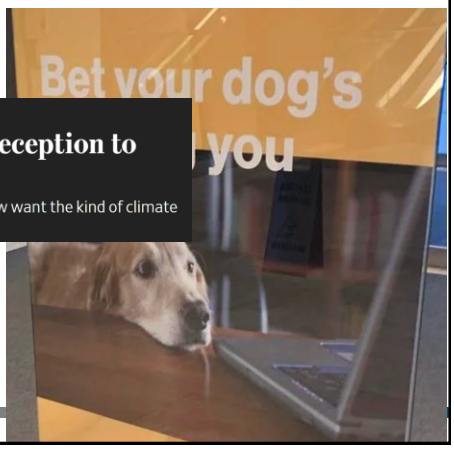
Changing occupant expectations

THE WALL STREET JOURNAL.

A-HED

Brrr! Air-Conditioned Offices Give Chilly Reception to Returning Workers

Employers beware: People who once put up with thermostats set to deep freeze now want the kind of climate control they had working from home



EBC

Energy in Buildings and Communities Programme

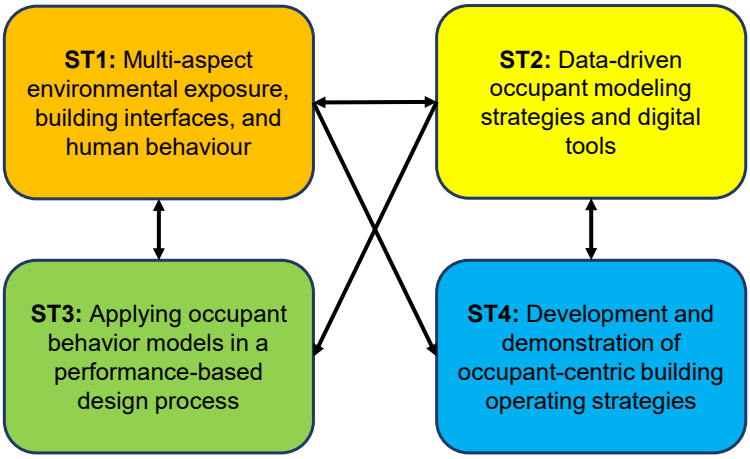
IEA EBC Annex 79

Occupant-centric
building design and operation

2018-2023

Profs. Andreas Wagner (Germany) and Liam O'Brien (Canada)

Organization in four subtasks



44

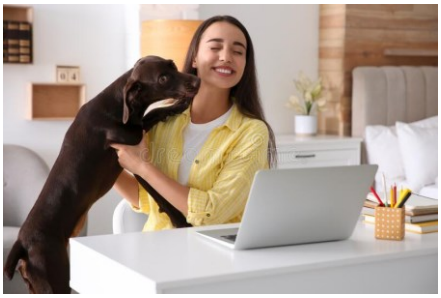
Countries involved

1	Australia
2	Austria
3	Belgium
4	Brazil
5	Canada
6	China
7	Denmark
8	France
9	Germany
10	Italy
11	Netherlands
12	Norway
13	Singapore
14	Sweden
15	Turkey
16	UK
17	USA
18	Switzerland
19	UAE
20	Hungary
21	Poland

Non-member countries/observer status

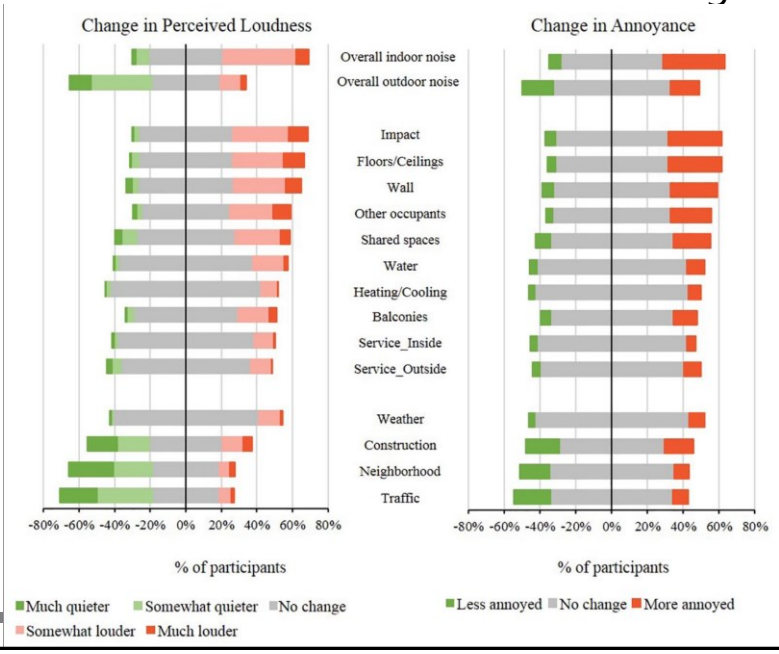
45

Comfort at home and in offices



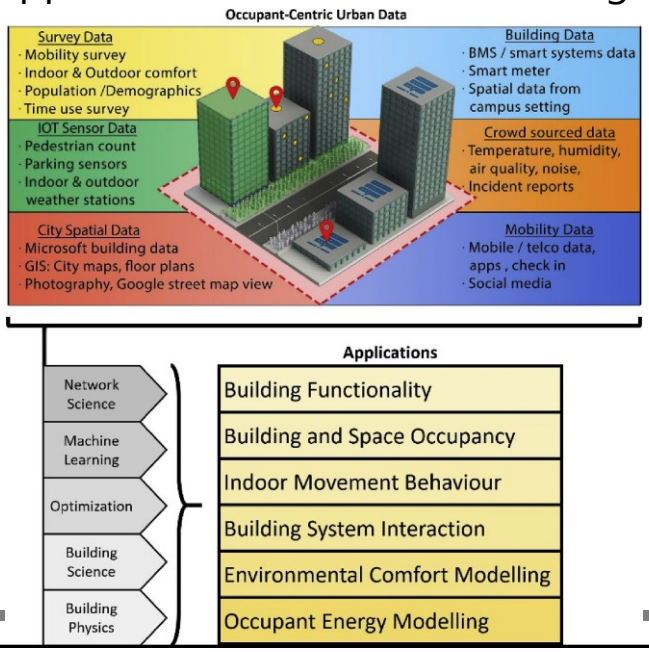
- Office workers have come to expect a high degree of personalized control over their environment
  - We need to provide high IAQ without major energy penalties
- Homes are prone to discomfort with telework and other new uses
- Use of air-conditioning likely to increase at home

Impact of noise in multi-unit residential buildings

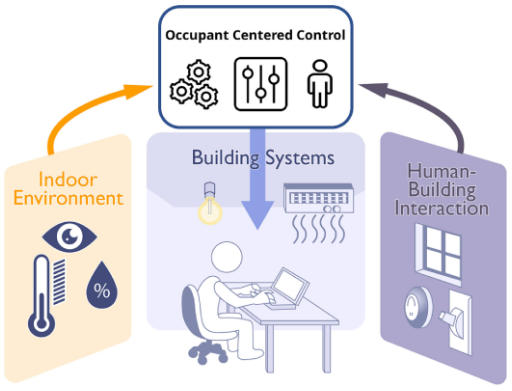


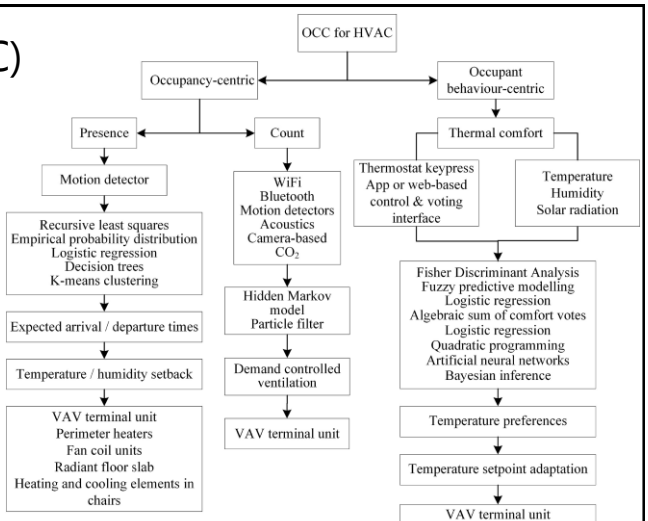
Andargie, Touchie, O'Brien (2021)

Data-centric approaches to research and design

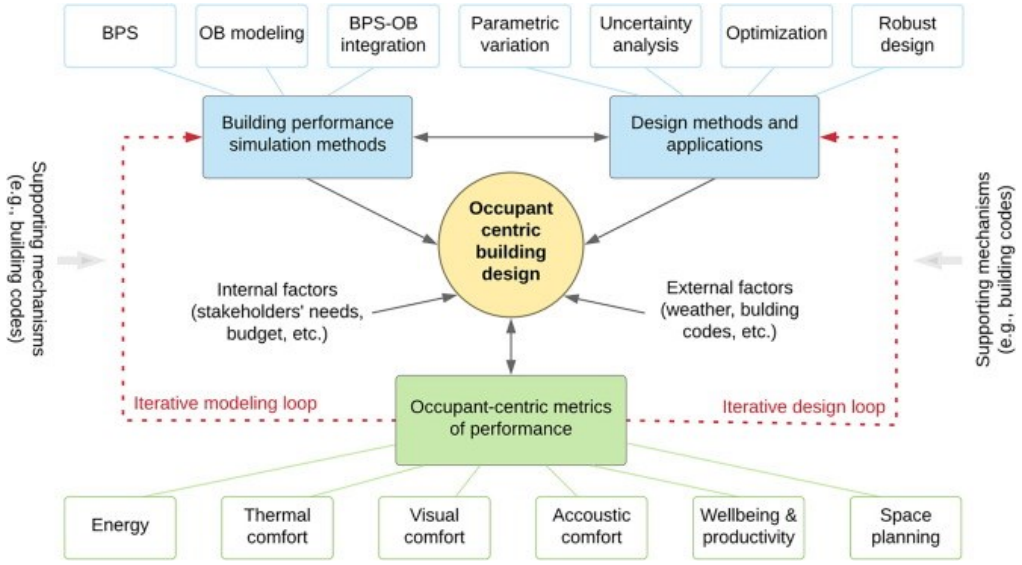


Occupant-centric controls (OCC)





Occupant-centric design



Carleton UNIVERSITY

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