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

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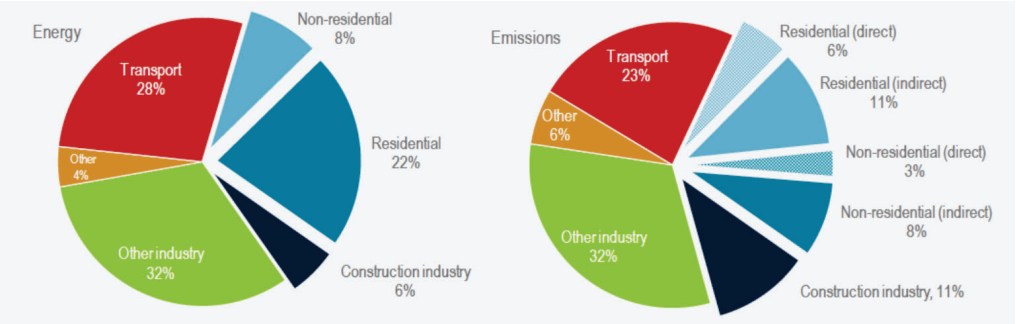
IEA EBC Webinar "Innovation and Energy Policy for Buildings – International Collaboration to Accelerate Change"
7 June 2022



# GHG-EMISSIONS IN THE WORLD THE SHARE OF BUILDINGS

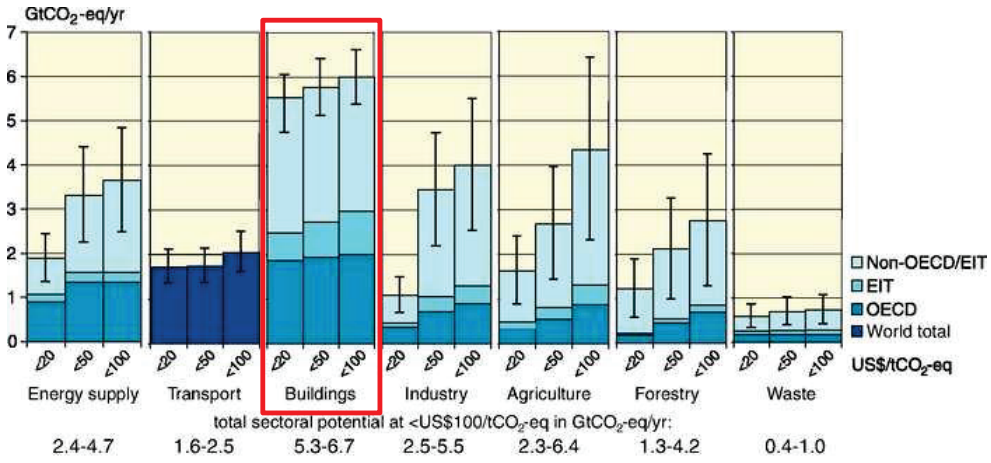
**Buildings construction and operations** accounted for
**36% of global final energy use** and
**39% of energy-related carbon dioxide (CO2) emissions** in 2017




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

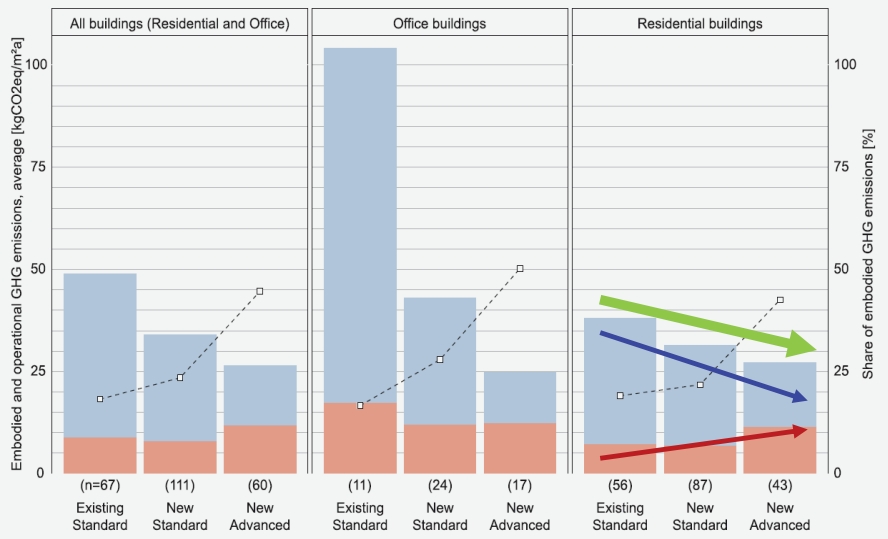
- New construction
- Reconstruction
- Refurbishment

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

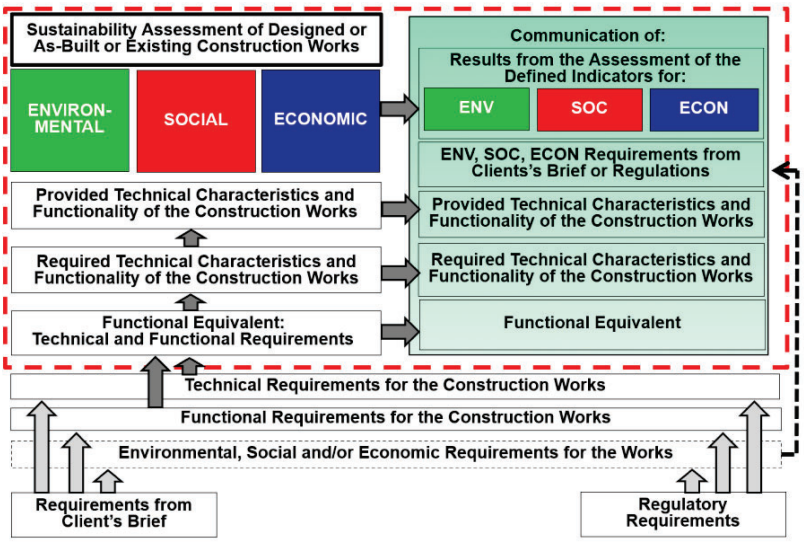



Martin Röck, Marcella Ruschi Mendes Saade, Maria Balouktsi, Freja Nygaard Rasmussen, Harpa Birgisdottir, Rolf Frischknecht, Guillaume Habert, Thomas Lützkendorf, Alexander Passer, 2019

- 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

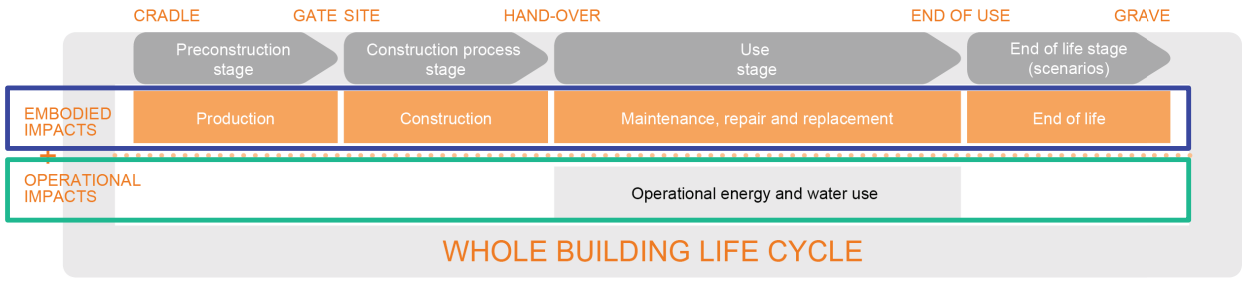
- How can buildings and their life cycle be **modeled** ?
- How can the **life cycle assessment (LCA)** method be applied in a practical manner?
- How can the required data on construction products and processes be determined and made available in **databases** ?
- How can LCA be integrated into the **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

**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

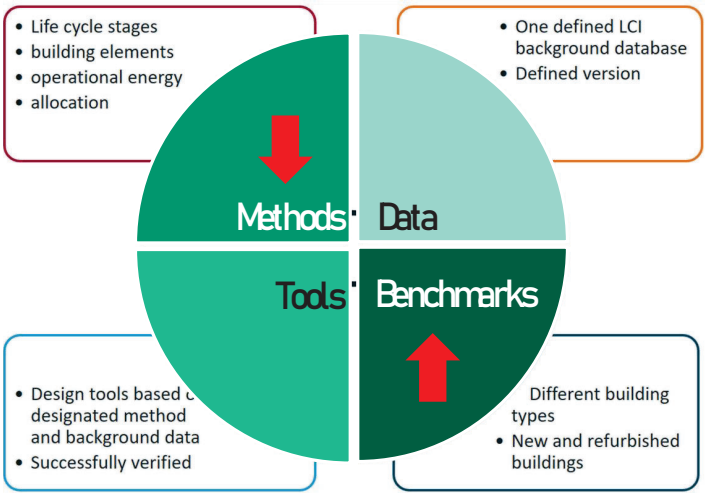


# EXPLAINING THE "PACKGAGE"

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

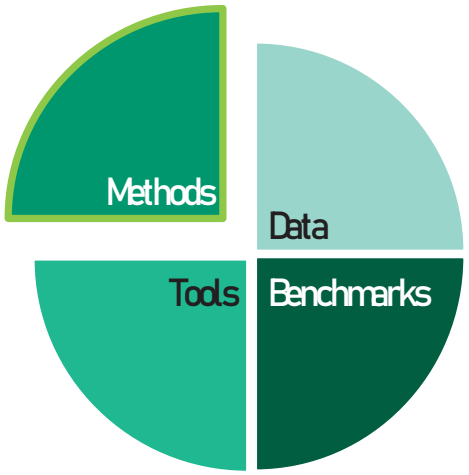
a) **Assessment methods (terms, definitions, system boundaries)**
b) **LCA-data for construction products and processes**
c) **Design & assessment tools**
d) **Bechmarks and target values**

*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



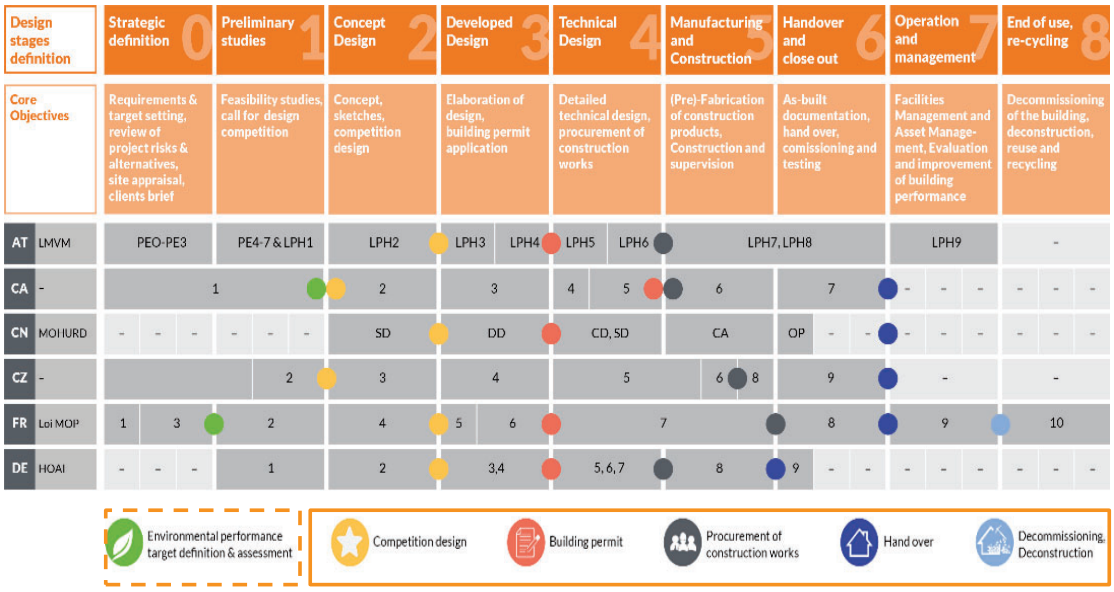

➢ **RULES AND RECOMMENDATIONS FOR (further development of) ASSESSMENT METHODS**



# *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

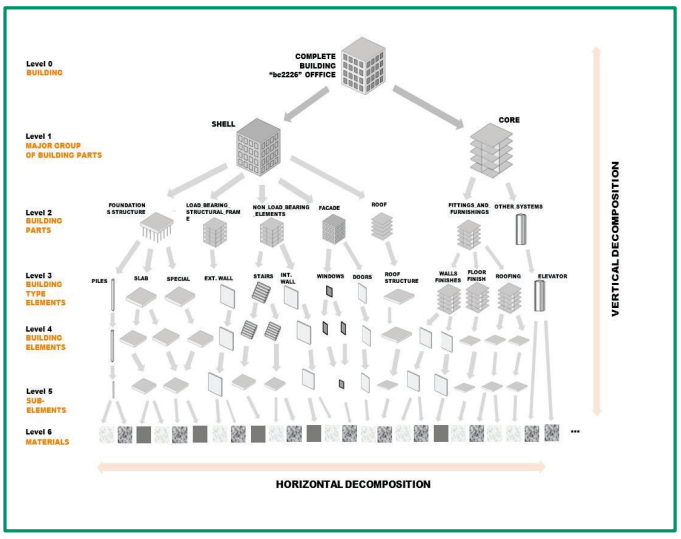


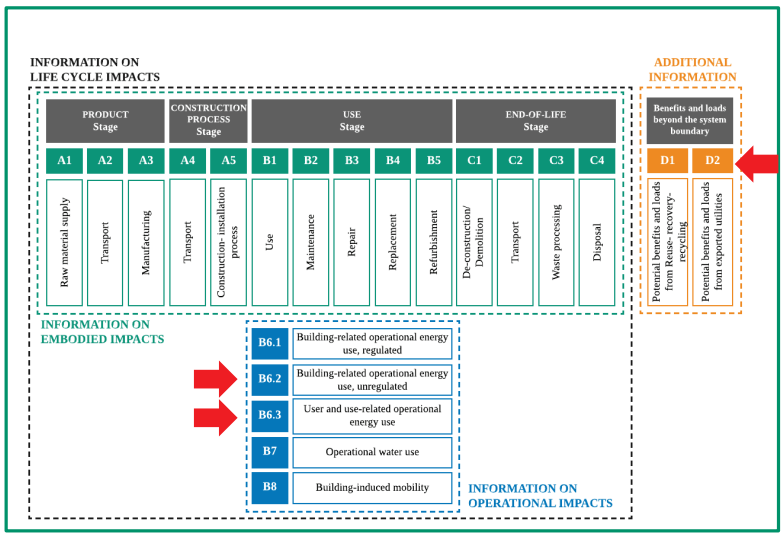

- Target setting in clients brief
- Early design
- Building permit
- “As built”
- Monitoring

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



# MODELLING OF THE BUILDING AND ITS LIFE CYCLE



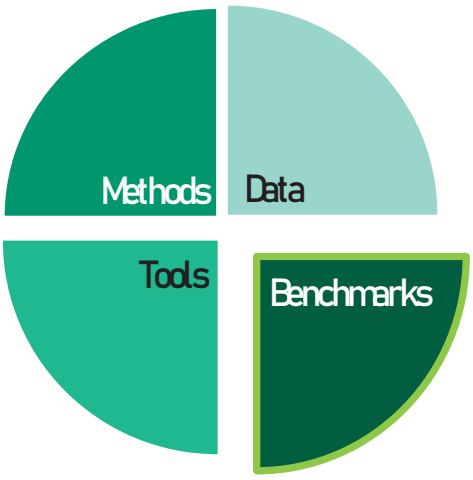
# LINKS TO OTHER ANNEXE's (Examples only)


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



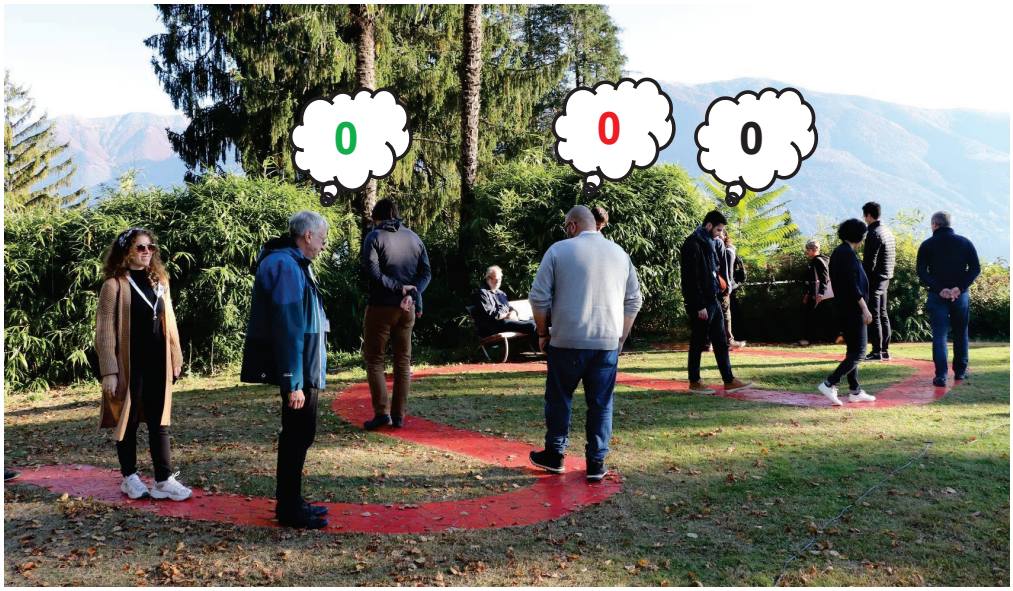

# CREATION, APPLICATION AND INTERPRETATION OF BENCHMARKS

- 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

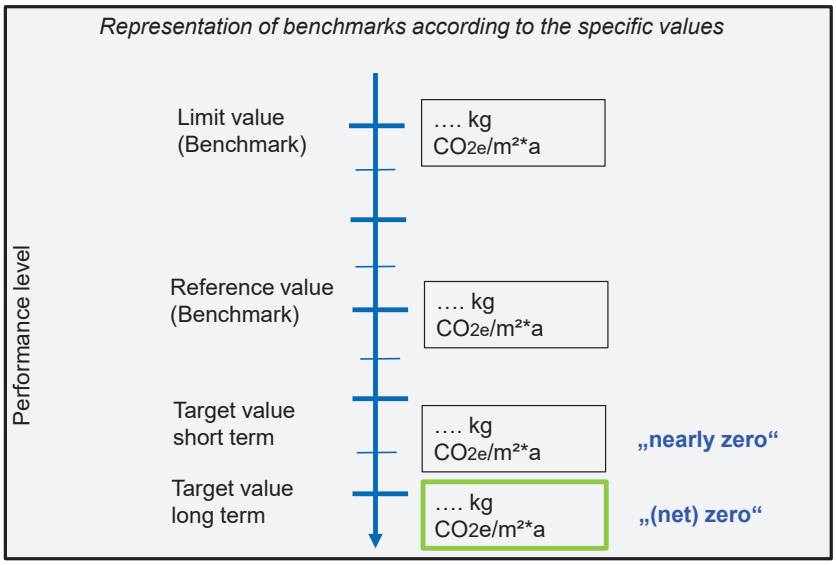
| Net Zero emission approaches | | | | Zero emission a. |
|---|---|---|---|---|
| **Net balance** | **Net balance** | **Economic compensation** | **Technical Reduction** | **Absolute Zero** |
| **potentially avoided emissions** | **allocation** | | | |
| Accounting for the potential benefits caused by 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



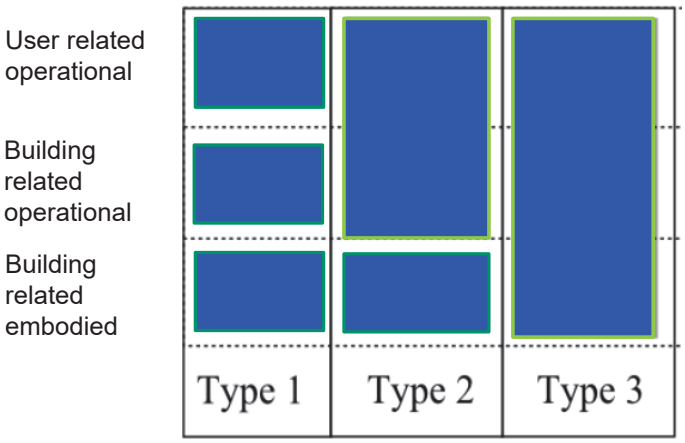

Possible types of application
Selected examples only

| | 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 | Conversion | New building | Conversion |
| 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

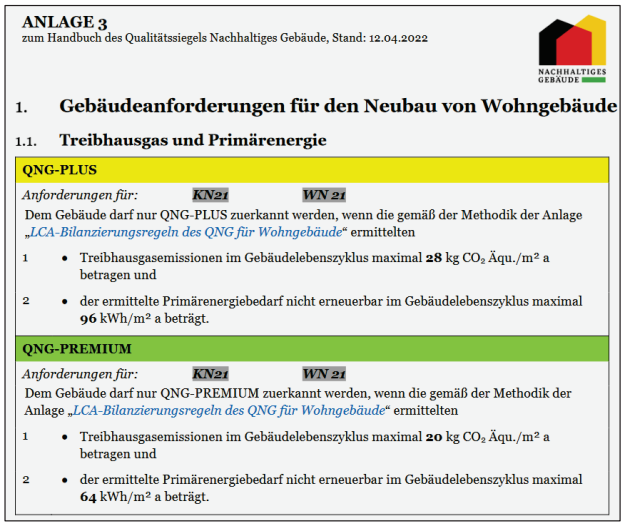
Requirements for residential buildings (all kind)

+ 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

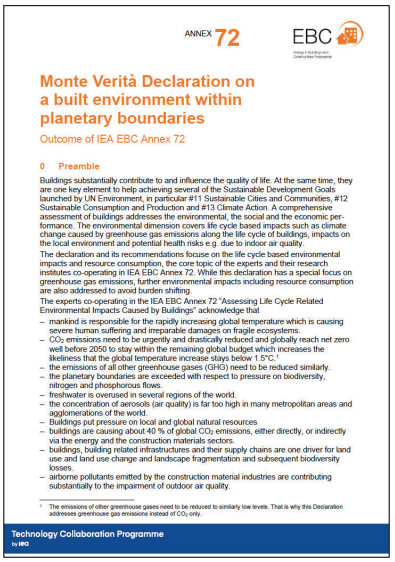
# THE Monte Verità DECLARATION

## 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 Reinscu | treeze Ltd. | |
| 7 | Pr | Maria Balaktsi | [illegible] | |
| 8 | | Nicolas Francart | KTH (Stockholm) | |
| 9 | Dr | Erdem HOXHA | TU GRAZ | |
| 10 | Dr | Lasvaux Sébastien | HES-SO | |
| 11 | Dr | Rolf A Bohne | NTNU | |
| 12 | | Roberto Di Bari | [illegible] 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

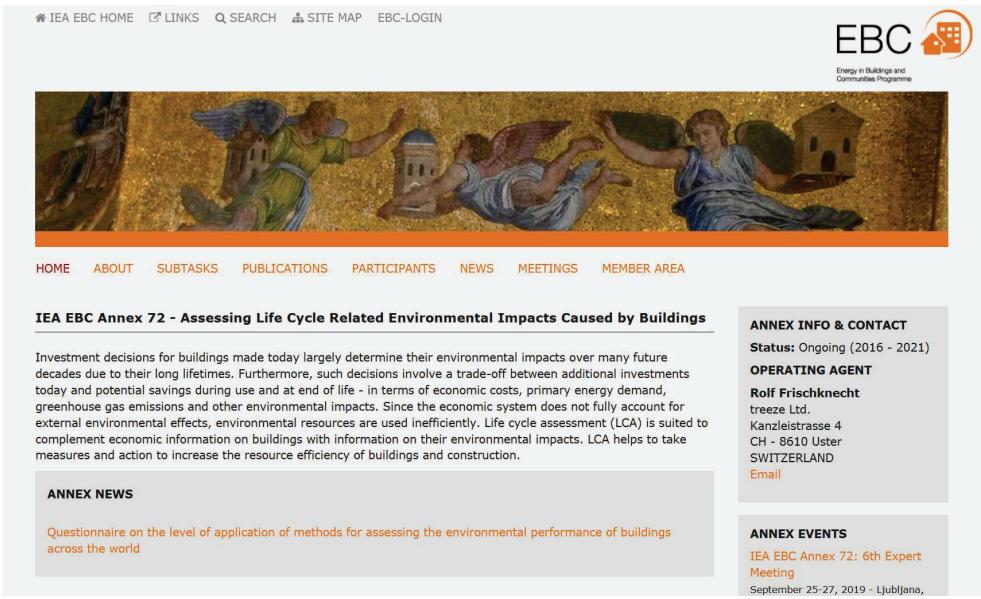
- mankind is responsible for the rapidly increasing global temperature which is causing severe human suffering and irreparable damages on fragile ecosystems.
- $CO_2$ emissions need to be urgently and drastically reduced and globally reach net zero well before 2050 to stay within the remaining global 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)

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**ANNEX EVENTS**

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

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

Technology Collaboration Programme by IEA

# THE TEAM BEHIND THE AUTHORS ….

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