Benchmarking of Resource Use and Embodied CO_2 in Buildings

Report on the GLOBE Consensus Workshop
13-14 February 2023, EPFL Lausanne (CH)

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Background

Objectives

The objective of this GLOBE workshop was to build a foundation for global benchmarks on the carbon footprint of buildings, based on a joint methodology for assessing and reporting embodied impacts in an attempt to generate globally harmonized yet location-specific benchmarks. Measuring and benchmarking is a key strategy to reduce the resource use and CO2 footprints of the global building stock. A global standard will support compare and learn from the wide variety global design and construction practices, fostering research and innovation which are crucial to our common climate ambitions.

Context

The work capitalizes on broad geographical representation and expertise in the GLOBE initiative, especially from the Global South, where the majority of urbanization until 2050 is expected to take place. With reduced emissions for building operation and reduced material needs for façades, the main impact from construction would come from the building structure. The group will work to develop streamlined documentation requirements for the impact assessment and benchmarking process that could be linked to existing structural design and building information modelling (BIM) software solutions.

Focus

The focus is benchmarking embodied impacts (material use, embodied energy and carbon) of buildings, which are little known and growing in importance as the in-use energy efficiency increases. The goal is to create a generic yet robust methodology that complements existing methodologies and supports global implementation.

Main aspects

Three main aspects were to be targeted at this GLOBE Consensus Workshop

a) *Design a strategy to deploy a global protocol* to facilitate global benchmarking of structures and buildings, including the identification of existing global initiatives, standards and tools, main stakeholders to be engaged, necessary actions, and next steps.

b) *Propose minimum data requirements* for a global embodied impact assessment and reporting methodology to allow for consistent benchmarking of the environmental performance of building structures.

c) *Discuss the automation of data processing and exchange,* including machine-readable data protocols and integration with existing architectural and structural modelling tools.

Workshop

Inputs

The GLOBE workshop started off with several input presentations (slides available online):

- Vanderley M John (USP, BR)
  "Benchmarking of Resource Use and Embodied CO2 in Buildings"
- Martin Röck (KU Leuven, BE)
  "Benchmarking Embodied Carbon of European Buildings - Research Perspective on Data Collection and Benchmark Analysis"
- Michael Haist (Hannover University, DE)
  "Construction Product Manufacturers Perspective on Data Provision, EPDs"
- Will Arnold (IstructE, UK)
  "Structural Design Professionals Perspective, Building Design Process Integration, Legislative Initiatives (UK)"
- Ricardo Franca (USP, Brazil)
  "Structural Design Professional Perspective, Design Optimization Potentials and Parameters"
- Cyrille Dunant (University of Cambridge)
  "Halving the embodied carbon of projects in the first afternoon: generating design spaces and collaborative design"
- Patrick Cunningham (UC Davis, USA)
  "The IFC - World Bank Edge tool for CO2 footprint of buildings"

The input presentations were followed by ad-hoc Q&A and concluded by general discussions in the large group on benchmarking of resource use and embodied CO_2 in buildings and building structures.

Discussions

Groups

The workshop participants continued discussion in break-out groups. The three groups aimed to each address one of the following stakeholder perspectives in more detail:

- A: Structural design and building design professionals
- B: Construction product manufacturers and construction companies
- C: Science to policy, regulatory frameworks for decarbonization

The break-out groups then fed back their insights and discussion points into the large group.

Objectives

The break-out group discussions with emphasis on different stakeholder perspectives fed back into the large group and jointly informed the definition of the following objectives for this initiative:

A. Establish baseline data to help us understand status-quo to move towards decarbonization
B. Develop detailed reference values for global benchmarking effort (resource use, emb. CO_2)
C. Enable understanding of how much/little existing decarbonization potentials are utilized
    a. Show range of existing building/structures performance (resource use, emb. CO_2)
    b. Support optimization of new projects through comparison with baseline benchmarks
D. Incentivize data sharing by industry and researchers, accelerate innovation uptake
    a. Industry platform for open data sharing, to certify buildings against benchmarks
    b. Research platform to share data on emerging practice, repository for publications
E. Explore use of benchmark data with AI/machine learning to complete DB, predict MI/EC

Key Aspects

The workshop participants furthermore discussed key aspects for this initiative, including:

- Scope definition
- Building/structure description
- Material data sources
- Building inventory
- Impact assessment
- Relevant parameters and indicators to report
- Data exchange format

The following aspects were found particularly relevant to consider and leverage during the next steps:

- We have diverse target audiences – Need to further clarify intended use cases
    - Use case depends on stakeholders and design phases
    - Requires context-specific, tailored benchmarks, relevant to, e.g., Regulators; Developers; Designers; Engineers
- We build on previous experience and expertise and will link with relevant initiatives, e.g., for
    - Data collection and benchmark creation processes,
    - Performance comparison and design implementation,
    - Elaboration on benchmark use cases and data requirements
- We aim for a detailed data collection (minimum/standard/advanced data requirements)
    - To enable analysis and benchmark creation of relevant subsets (e.g., building types)
    - To enable analysis of design parameters enabling low carbon construction (e.g., material choice, structural design, number of floors)

Implementation

Conceptual Approach

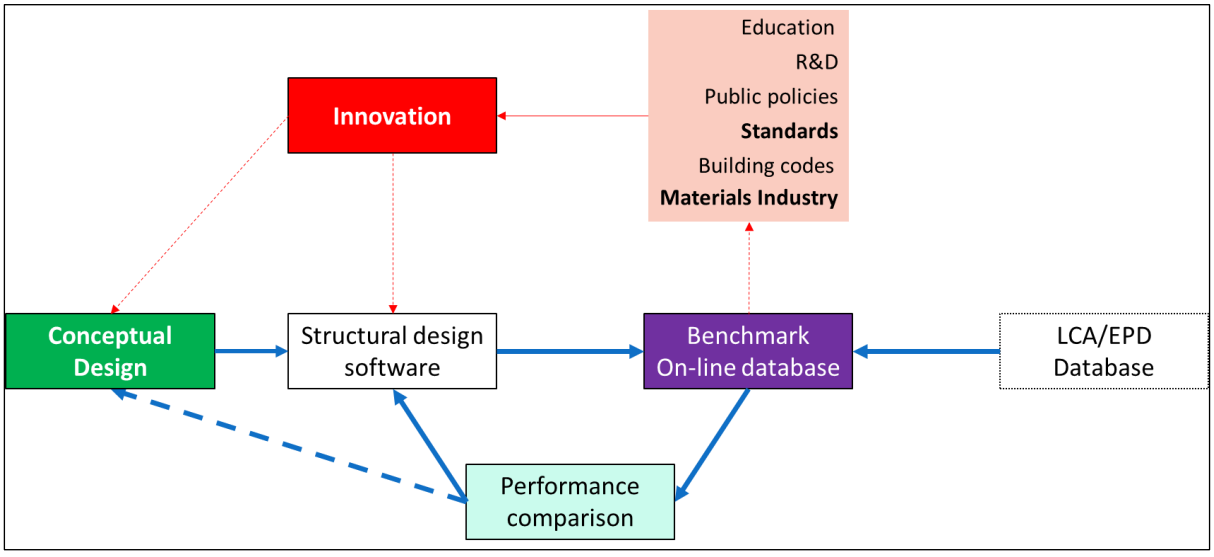

Figure 1: Conceptual framework for implementation and performance assessment to stimulate innovation.

Figure 1 illustrates a draft of the conceptual framework for implementation and performance assessment to stimulate innovation for decarbonization action. The implementation of these phases is envisioned along a conceptual framework that focuses on the role of building design professionals (architects, engineers) and the aim of incorporating performance comparison and optimization of

resource use and embodied CO2 in daily design practice. An online benchmark database is proposed to provide the science-based reference values for such a comparison and optimization through integration with structural design software solutions. The online benchmark database will process information on resource use provided by designers and link it with databases for life cycle assessment (LCA) and environmental product declarations (EPD). For quality assurance and validation of data records, a link with academia and R&D departments of key industry stakeholders is anticipated. The aim is furthermore to stimulate innovation for enhanced and wide decarbonization action by involving a broad set of stakeholders (e.g., education, R&D, policy makers, standardization and buildings code bodies, material industry and construction product manufacturers).

Three Phases

Implementation of the GLOBE initiative for benchmarking of resource use and embodied CO_2 in buildings is planned along three distinct phases:

I. Data collection to analyze reference values and build benchmarks

II. Benchmark creation process (reference values, A/B/C/D) for relevant subsets

III. Design implementation and reporting of performance against benchmarks

Several relevant steps are required to implement these three phases. Further details will be elaborated in the business plan that is currently being developed. Thus far the workshop identified the following points:

Phase I: Ask detailed information on material inventory in different parts.

- Define minimum data requirements (MDR), focusing on relevance for detailed analysis
- Encourage comprehensive scope, but use what is available (adaptive analysis)

Phase II: Create benchmarks from initial data collection.

- Use detailed data for sorting/subset definition as needed for different stakeholders
- Create reference values (material kg/m²; $kgCO_2e/m^2$) and benchmarks (e.g., A/B/C/D)
- Understand what data might be missing? – Feedback loop to documentation requirements

Phase III: Design implementation and reporting of performance against benchmarks.

- Encourage to report design performance via specific values on MDR fields
- Encourage detailed reporting for additional analysis and insights
- For empty fields use average values, impute with industry averages or proxy data

Feedback loop: Phases I-III shall be monitored and evaluated to inform continuous improvement of relevant aspects in data collection, benchmark creation and design implementation, respectively.

Methodological Aspects

As a basis for consistent and structured data collection and analysis the initiative aims to develop a standardized protocol for data creation and reporting. The discussion with participating experts revealed several methodological aspects relevant for further consideration. Aspects include: a description of the object of assessment, including general attributes describing the building's context as well as key design parameters; the scope the study and related reporting (e.g., regarding buildings parts), including detailed classification systems applied for collecting data on building structures at a high level of detail. Some considerations discussed during the workshop are presented in the following.

A comprehensive set of attributes, including the distinction of minimum, standard and advanced data requirements, will be established building on relevant existing benchmarking initiatives and embodied CO2 data collection and analysis efforts[1].

Object of assessment

The description of the object of assessment, the building and structure, will have to include, e.g.:

- Building use type
- Floor area (gross, net, used)
- Project stage (concept, scheme, tender, execution, as-built)
- Design load case
- Compressive strength
- Concrete classes, steel grades, etc
- Mechanical properties (optional, encouraged?)
- Minimum: Focus on material quantity/inventory
- Encouraged: Material emission intensity used

Scope of building parts

Minimum documentation requirements will be specified regarding the scope of building parts included in the study, focusing on elements of the structural system while emphasizing a comprehensive scope, including the envelope, internal elements, technical services.

A detailed classification of structural elements will be developed based on the alignment with existing initiatives and relevant structural design tools[2].

1) Structural system
    a) Foundation
    b) Frame (different elements)
2) Envelope
    a) Facades
    b) Enclosure
3) Internal
    a) Partitions
    b) Finishings
4) Services
    a) Heating, Cooling, Ventilation

A more detailed classification of structural elements is proposed to enable in-depth analysis of carbon hotspots and promising reduction strategies. Structural components can be furth distinguished, for example considering:

a. Columns
b. Panels/Walls
c. Slabs
d. Stairs
e. Balconies
f. Foundation
g. (Underground)

[1] For example, informed by the 300+ attributes of the 'CarbEnMats-Buildings-DB, an Open Database on Whole Life Carbon, Energy and Material Intensity of Buildings' (Röck M et al., 2023 (forthcoming)).

[2] For example, informed by the classification logic of 'PANDA: a tool for lowering carbon in structural design' (Durant C)

Partnerships

The following organisations/initiatives have thus far been identified as relevant partners to inform, support, or fund the further development of this initiative.

Structural engineering organisations:

- FIB - The International Federation for Structural Concrete
- ECCS - European Convention for Constructional Steelwork
- WCTE - World Conference on Timber Engineering
- GCCA - Global Cement and Concrete Alliance

Potential data partners:

- US: SE2050, Carbon Leadership Forum (CLF)
- PCI/PTI buildings
- ISO 23/94 group

Potential funding partners:

- ClimateWorks
- Laudes Foundation
- VW Stiftung
- ARUP foundation
- Public (EU, National)

Group Picture

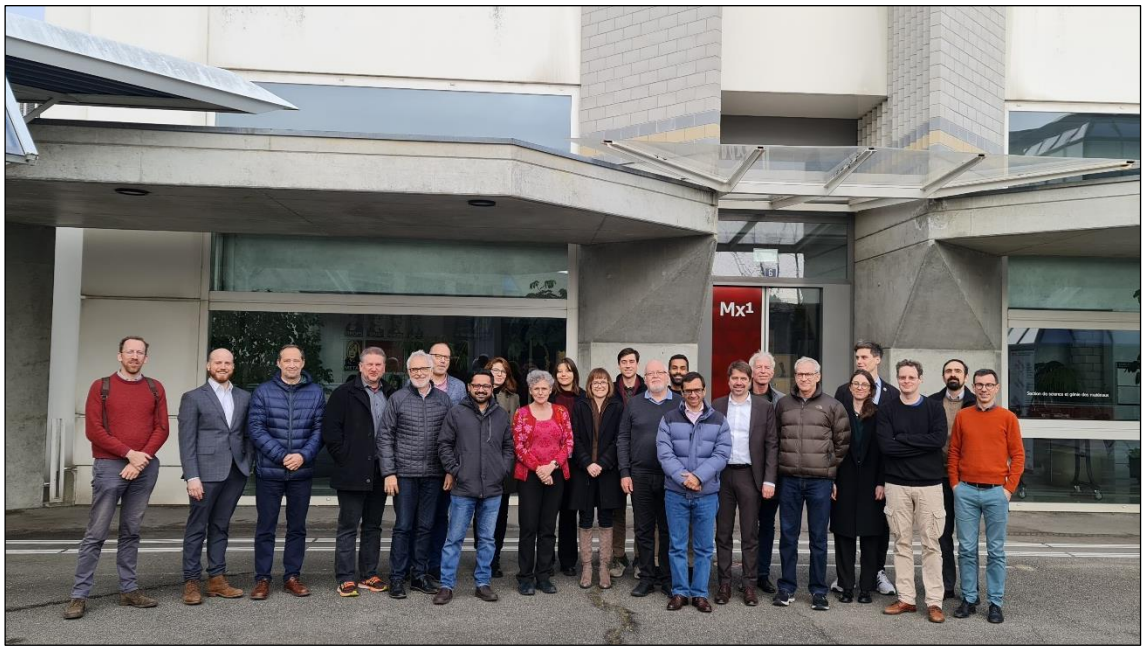

Figure 2: Group picture of the participants of the GLOBE Consensus workshop on 13-14 February 2023, EPFL Lausanne (CH)

Outlook

Workshop

Timing for a next workshop (large group) is yet to be determined. The following options are currently considered as occasions to continue cocreation and advance the benchmarking initiative:

- **FIB meeting, Istanbul, June 5-7 2023**
- WCTE, Oslo (NO), 19-22 June 2023
- IALCCE, Milan (IT), July 2-6, 2023
- **ACI, Boston (US), Oct 29-03 Nov 2023**
- WSBE, Montreal (CA), Spring/April 2024

Taskforce

The participants decided to build a taskforce for carrying forward the initiative for “Benchmarking of Resource Use and Embodied CO2 in Buildings” which includes:

- Taskforce: Martin Röck; Michael Haist; Guillaume Habert; Cyrille Durant; Vanderley John; Abram Belk; Michael Havbro Faber; Karen Scrivener
- Advisors: DFO - David Fernández-Ordóñez; DA - Domenico Asprone

Next Steps

- Workshop report (this document)
- Business plan development
- Partnerships and funding
- Community engagement

Annexes

A. Original workshop agenda

B. List of participants

A. List of participants

* = Remote participation
Bold = Organizers

1.	Domenico Asprone	Italy
2.	Eleanor Batilliet	Germany
3.	Abram Belk	Brazil
4.	Sandra Boivin	Switzerland
5.	Patrick Cunningham	USA
6.	Cyrille Dunant	UK
7.	Michael Faber	Denmark
8.	David Fernández	Spain
9.	Corentin Fivet	Switzerland
10.	Ricardo França	Brazil
11.	Guillaume Habert	Switzerland
12.	**Hisham Hafez**	**Switzerland/Egypt**
13.	Michael Haist	Germany
14.	**Vanderley John**	**Brazil**
15.	Matt Jungclaus	USA
16.	Noushin Khosravi	UK
17.	Célia Küpfer	Switzerland
18.	Carlos Massucato	Brazil
19.	Costantino Menna	Italy
20.	Mehboob Nawaz	Germany
21.	**Martin Röck**	**Belgium**
22.	David Ruggiero	Switzerland
23.	Wolfram Schmidt	Germany
24.	**Karen Scrivener**	**Switzerland**
25.	Ian Smith	Germany
26.	Markus Wüest	Switzerland
27.	Megan Yates	UK / Switzerland
28.	Will Arnold *	UK

B. Original workshop agenda

Day 1 (13th Feb 2023)

Timing	Description	Responsible
08:30	Opening statement on the workshop objectives and dynamics	Vanderley John
08:45	Inputs (10 min presentation + 5 min discussion) ● **Martin Röck (KU Leuven, BE)** Benchmarking Embodied Carbon of European Buildings - Research Perspective on Data Collection and Benchmark Analysis ● **Michael Haist (Hannover University, DE)** Construction Product Manufacturers Perspective on Data Provision, EPDs ● **Will Arnold (IstructE, UK)** Structural Design Professionals Perspective, Building Design Process Integration, Legislative Initiatives (UK) ● **Ricardo Franca (USP, Brazil)** Structural Design Professional Perspective, Design Optimization Potentials and Parameters ● **Cyrille Dunant (University of Cambridge)** Halving the embodied carbon of projects in the first afternoon: generating design spaces and collaborative design ● **Francesco Pomponi (Building Transparency)** Tool Developer's Perspective: Data Provision (EPDs) and Design Integration of Embodied Carbon Assessment	Chair: Karen Scrivener
10:15	Coffee break	-
10:30	Group discussion: **Initial ideas on existing methods, data, tools and benchmarks**	Karen Scrivener
11:00	Parallel sessions: Collect information from the **practical experience of participants**, including useful **references and examples** about the following topics: 1. Scope definition 2. Building/structure description 3. Material data sources 4. Building inventory 5. Impact assessment 6. Relevant parameters and indicators to report 7. Data exchange format Stakeholder perspectives ● A: Structural design and building design professionals ● B: Construction product manufacturers and construction companies ● C: Science to policy, regulatory frameworks for decarbonization	Facilitators: Vanderley John, Guillaume Habert, Martin Röck
12:30	Lunch break	-
13:30	Presentations and discussion of parallel session insights	Groups, All
15:30	Closing remarks	Karen Scrivener
16:00	End of day 1	-

Day 2 (14th Feb 2023)

Timing	Description	Responsible
08:30	Welcome	Vanderlery John
08:45	Group discussion: Reflections on day 1	Karen Scrivener
09:15	Parallel sessions (same leaders as day 1): Develop proposals for minimum, recommended, and ideal requirements for assessing, reporting, and benchmarking the embodied impacts of building structures, including: 1. Scope definition 2. Building/structure description 3. Material data sources 4. Building inventory 5. Impact assessment 6. Relevant parameters and indicators to report 7. Data exchange format	Facilitators: Vanderley John, Guillaume Habert, Martin Röck
10:15	Coffee break	-
10:30	Presentations and discussion of parallel session insights	Groups, All
11:30	Group discussion: Plans for knowledge transfer nodes globally and real case studies	Karen Scrivener
12:30	Lunch break	-
13:30	Group discussion: Plans for the next stage, working sub-group duties, dates for next workshop	Vanderley John
14:30	Concluding remarks	Karen Scrivener
15:00	End of day 2	-

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