How Carbon Metric Standard Could Facilitate Innovation for Reduction of GHG Emission from Buildings?

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ABSTRACT

The authors have collaborated to develop the new international standard on carbon metric (CM) of a building during the use stage (ISO 16745-2015). Carbon metric (CM) is a partial carbon footprint. It implies the sum of annual greenhouse gas emissions and removals, based on the real energy consumption and expressed as CO_2 equivalents. CM is relevant for snapshot measurement in the operational stage of building. It does not require professional knowledge about methods such as overall environmental performance assessment and life cycle assessment (LCA). Carbon metric is usable also in those countries where experts' services are limited.

The paper presents how the standard sets out a globally applicable common method of the calculating, reporting and verification of CM, including an explanation of the different system boundaries and preconditions. It focuses on how the standard simplifies and clarifies the method to make it globally applicable.

The paper discusses on how the standard could facilitate innovation for reduction of GHG emission from buildings. It is applicable in actions and policies for reduction of greenhouse gas (GHG) emission that includes the benchmarking for property management strategy, energy management service contract, post-occupancy evaluation, and education. The standard also provides the basis for cap and trade program. It also enables monetizing for international carbon trading (CDM in building related sectors)

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1. INTRODUCTION

Measurement and reporting of greenhouse gas (GHG) emissions from existing buildings are critical for enabling significant and cost-effective GHG mitigation. Currently, there has not been a globally agreed method established to measure, report, and verify potential reductions of GHG emissions from existing buildings in a consistent and comparable way. If such a method existed, it could be used as a universal tool for measurement and reporting of GHG emissions, providing the foundation for accurate performance baselines of buildings to be drawn, national targets to be set, and carbon trading to occur on a level playing field.

In view of the context above, UNEP-SBC has proposed the idea of Common Carbon Metric of Building as a globally agreed method to measure, report, and verify potential reductions of GHG emissions from existing buildings (UNEP 2009). Following up the initiative by UNEP-SBCI, the authors have collaborated to develop the new international standard on the metric of GHG emission of a building during the use stage (ISO 16745-2015: Environmental performance of buildings — Carbon metric of a building during the use stage). It aims to set out a globally applicable common method of measuring and reporting of associated GHG emissions (and removals) attributable to existing buildings, by providing requirements for the determining and reporting of a carbon metric(s) of a building.

This paper presents how the standard sets out a globally applicable common method of the calculating, reporting of CM, including an explanation of the different system boundaries and preconditions.

2. WHAT IS CARBON METRIC OF BUILDING?

2.1 A measure that focuses on use stage of a building

In principle, accurate and precise reporting can only be achieved if GHG emissions from all life cycle stages of buildings are measured and quantified. However, not all countries in the world have sufficient capacity or resources to use and apply life cycle assessment (LCA) methodologies. Besides, we need to bear in mind that operational energy use in buildings typically accounts for 70 %–80 % of energy use over the building life cycle. Therefore, the operating stage of the building's life cycle could be the focus of measurement and reporting of direct and indirect GHG emissions.

Respecting the need for collaboration on a global scale, the need exists for a metric that is usable not only in countries with a sufficient number of experts and a precise database but also in those countries where experts' services are limited and databases have considerable gaps. The idea of carbon metric has emerged in consideration of 70 %–80 % share of energy use over the building life cycle as well as the need of simple metric that is usable by non-LCA-expert. Carbon metric is a measure that is based on energy use data and related building information for an existing building in operation.

ISO 16745 defines carbon metric (CM) as "sum of annual greenhouse gas (GHG) emissions and removals, expressed as CO_2 equivalents, associated with the use stage of a building". CM is measured by kg CO_2e/ year. CM is, in a sense, a partial carbon footprint. While a product carbon footprint includes all possible GHG emission over the all life stages of a product, CM is based on energy use data and related building information for an existing building in operation.

Associated with carbon metric, the standard defines carbon intensity as "carbon metric expressed in relation to a specific reference unit related to the function of the building." Here reference units include per unit area, per person, per kilobyte, per unit output, and per GDP. Thus, carbon intensity is measured by kg CO_2e/ year/ m^2, or kg CO_2e/ year/ occupants etc.

2.2 Principles in determining the carbon metric

To ensure that GHG-related information represents a true and fair measure, ISO16745 indicates the following principles in the determination of carbon metric.

- Completeness: Include all relevant GHG emissions that provide a significant contribution to the carbon metric.
- Consistency: Apply assumptions, methods, and data in the same way throughout the carbon metric determination to arrive at conclusions by the needs of the intended user and intended use.
- Relevance: Select the GHG sources, GHG sinks, GHG reservoirs, data, and methodologies appropriate to the needs of the intended user and the intended use.
- Coherence: Select the methodologies, standards, and guidance documents already recognized and adopted for energy measurement and consumption to enhance comparability between carbon metrics calculated by different system boundary definition (See 2.3).
- Accuracy: Ensure that the carbon metric quantification and communication are accurate, verifiable, relevant, and not misleading and that bias is avoided and uncertainties are minimized.
- Transparency: Address and document all relevant issues in an open, comprehensive, and understandable presentation of information.
- Avoidance of Double Counting: Avoid counting of greenhouse gas emissions that have already been allocated within other carbon metrics.

2.3 System boundaries of a carbon metric

A consistent definition of system boundary is essential to satisfy the principles shown in 2.2. ISO 16745 indicates the following three types of carbon metrics of a building:

- Carbon metric 1 (CM1) is the sum of annual GHG emissions, expressed as CO_2 equivalents, from building-related energy use;

- Carbon metric 2 (CM2) is the sum of annual GHG emissions, expressed as CO_2 equivalents, from building- and user-related energy use;
- Carbon metric 3 (CM3) is the sum of annual GHG emissions and removals, expressed as CO_2 equivalents, from building- and user-related energy use, plus other building-related sources of GHG emissions and removals.

The system boundary for the CM1 and CM2 of a building is shown in Figure 1. It consists of the equipment to operate the building fulfilling the demand as energy end use and the technical building system(s) to deliver, convert, and generate energy for the energy end use. All building-related energy end use (as indicated by the pale gray boxes in Figure 1) shall be taken into account for the carbon metric (CM1).

User-related energy use (as indicated by the dotted box in Figure 1) shall be included in the CM2, including energy for supplementary lighting installed by building users. It is NOT necessary to separately measure the amount of energy generated, converted, or consumed within the system boundary by each system, piece of equipment, or machine. Exported energy is outside the system boundary but may be reported as additional information where appropriate.

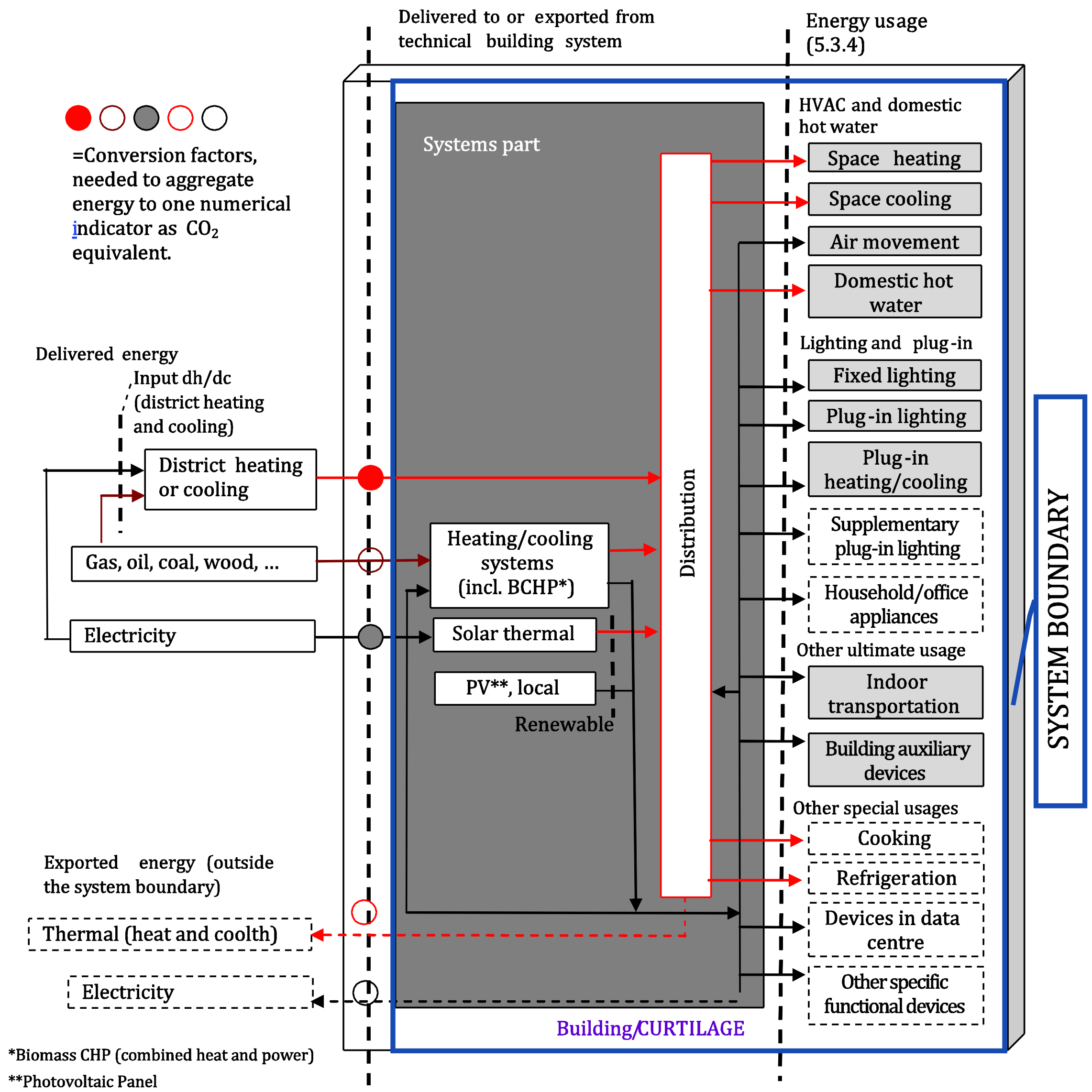

Figure 1: Boundary and energy flows - Main energy flows within and crossing the boundaries for energy use of a building (Source ISO16745)

Figure 2 show examples of the system boundary for CM1. Here only the energy carrier for the delivered energy and energy generated by the PV panels and used within the system boundary are required to be measured for CM1.

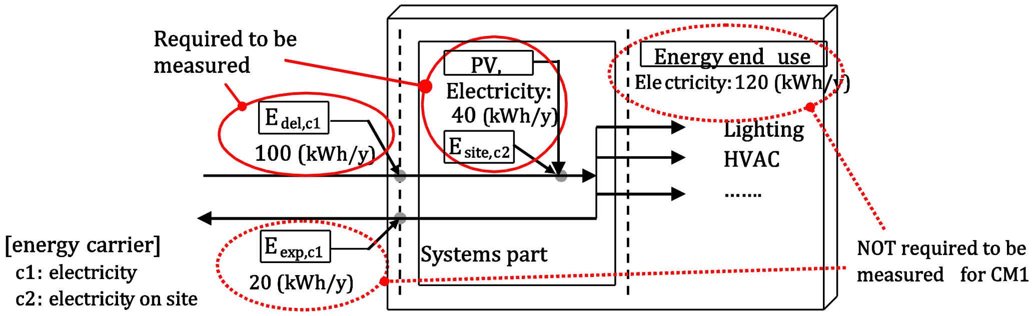

Figure 2: Examples of energy flow measuring by energy carriers

3. CALCULATION OF THE CARBON METRIC

3.1 Equation to calculate the carbon metric

ISO16745 indicates that carbon metric of a building is given by the following equation.

$$m \cdot co_{2eqv} = \sum \{ (E_{del,ci} \times K_{del,ci}) + (E_{site,ci} \times K_{site,ci}) \}$$

Equation 1

Where $m \cdot co_{2eqv}$ is the carbon metric of a building, i.e. the emitted mass of GHG, expressed as kg CO_2 equivalent per kg emission,

$E_{del,ci}$ is the delivered energy for energy carrier del,ci;

$E_{site,ci}$ is the energy produced onsite for the energy carrier site,ci;

$K_{del,ci}$ is the GHG emission coefficient for delivered energy carrier del,ci

$K_{site,ci}$ is the GHG emission coefficient for on-site energy carrier site,ci.

Equation 1 implies that carbon metric of a building hall be calculated from the delivered energy for each energy carrier plus the on-site energy, if any, produced without using delivered energy and used in the building and/ or for other energy use within the building's site, multiplied by the respective GHG emission coefficient. In view of ISO 16745 suggests that where the sum of energy produced on-site is estimated to be is less than 2 % of the total energy, $E_{site,ci}$ should be ignored.

3.2 Measurement of energy carrier

ISO16745 requires that measurement of the energy carrier shall take account of all the sources delivered to and generated within the system boundary including electricity, fuels (e.g. gas, oil, wood, and other biomass waste), and imported coolth/ steam/ heat. Data for nominal delivered energy is available from utility provider reports and contracts, electricity bills, invoices for fuel deliveries, gas bills, meter readings, pipeline measurements, energy management software.

3.3 GHG emission coefficients

ISO16745 requires that the choice of the source of the GHG emission coefficient used for calculating a carbon metric shall be appropriate for the intended use of the carbon metric. The standard demands that GHG emission coefficients shall be obtained from, in the following order of priority:

- Nationally agreed data;
- Independently provided information;
- Internationally agreed data.

4. REPORTING OF THE CARBON METRIC

The carbon metric study report is essential to assure fairness, universality, and traceability of measurement of GHG emissions from existing buildings. For that purpose, the report shall include the information on; a) building identification, b) type of the carbon metric (e.g. CM1, CM2, or CM3), c)value of the carbon metric(s), d) value(s) of the carbon intensity(ies) determined, e) purpose of the reporting, f) reporting period, g) whether the CM has been normalized to average annualized conditions such as local climate, h) date of the evaluation, i) name of the organization or individual doing evaluation, j) client of the evaluation, k) description/ illustration of the system boundary, l) list of energy end use included in the CM in relation to the type of CM, m) whether delivered energy end uses are measured or estimated, n) inventory of energy carriers, o) source of GHG emission coefficient (publication, organization, year of the coefficient measured), p) year of construction of building, q) year of latest major renovation affecting energy use, r) year of any (latest) change in use, s) total site area of the building, and t) location.

Table 1 illustrates an example of a table in carbon metric study report to present whether delivered energy end uses are measured or estimated.

	Energy consumption related service		Present in the building (a)	Included in the CM(b)	Separately metered(c)	Measured or Estimated (d)	Energy carrier(e)
1	Building-related energy use	Space heating					
2		Space cooling					
3		Air movement					
4		Domestic hot water					
5		Lighting for basic building function (fixed lighting etc.)					
6		Auxiliary energy (e.g. for heat pumps)					
7		Indoor transportation					
8		Building auxiliary devices					

a Use “P” to indicate if services are present in the building.
b Use “I” to indicate if the energy end use for the service is included in the carbon metric.
c Use “X” to indicate if energy end use for the service is separately metered.
d Use “M” or “E” to indicate if delivered energy end use is based on either measurement or estimation.
e Report may indicate the energy carrier for each energy end use, if known

Table 1: List of energy end use included in the carbon metric for CM1

5. COMMUNICATION OF THE CARBON METRIC

ISO16745 provides two types of communication that may be used to make the carbon metric publicly available.

- A carbon metric declaration
- A carbon metric claim

5.1 Carbon metric declaration

A carbon metric declaration is the communication of a carbon metric that has been verified by an independent third party. Assumptions made to create the declaration shall be included in the documentation of the organization or individual determining the carbon metric, which shall be referenced in the declaration and made available upon request.

5.2 Carbon metric claim

A carbon metric claim is the communication of a carbon metric that has not been verified by an independent third party. When an organization decides to make a carbon metric claim publicly available, the communication of the evaluation of the carbon metric shall be supported by a carbon metric disclosure report Assumptions made to create the claim shall be included in the documentation of the organization or individual determining the carbon metric, which shall be referenced in the claim and made available upon request. ISO 16745 describes the requirement to verify the calculation of carbon metric.

6. THEN HOW CM FACILITATE INNOVATION FOR REDUCTION OF GHG EMISSION FROM BUILDINGS?

ISO16745 provides globally agreed method to measure, report, and verify reductions of GHG emissions from existing buildings in a consistent and comparable way. Due to its simplicity, the method is usable not only for building profession and LCA expert but also for a wide range of stakeholders who commit in economic transactions, business activities, and governmental policy making. Thus, the metric and its protocol defined by the standard is usable both in the developed world and in developing countries as a reference and as a baseline for benchmarking.

It implies that CM defined by the standard provide the foundation for national targets to be set, a contractual agreement to be prescribed, and carbon financing to occur on a level of varieties of playing fields. Therefore CM could provide the basis to initiate and facilitate social innovation that considerably reduces GHG emission from existing buildings. The following are the possible examples of initiative for such innovation.

6.1 CDM in building sectors

In general, Clean Development Mechanism (CDM) is an effective instrument to globally rationalize investment for GHG reduction by transferring technologies from knowledgeable groups and countries to less capable or less experienced. However, so far, there are very few examples of CDM in building sectors because Certified-Emission Reductions (CER) had not been available due to a lack of globally agreed method of measurement, reporting and verification of GHG reduction from existing building. In principle, burden shifting via CDM should be assessed and verified by LCA basis. However, operational energy use in buildings typically accounts for 70 % to 80 % of energy use over the building life cycle. Therefore, CM and its protocol defined by the standard sufficiently enable to introduce CDM in buildings sectors by providing the basis of CER to the investment for the improvement of energy efficiency of buildings. Therefore CM and its protocol are expected to trigger off the innovation by creating new services and technologies associated with CDM in building including global scale cap-and-trade in buildings.

6.2 Green investment fund for building sector

By the dissemination of socially responsible investment (SRI), green investment fund has been grown globally in the last decade. The current target of the funds is large-scale green infrastructures such as renewable energy generation plant regarding which green performance is measurable, reportable and verifiable. CM and its protocol by the standard open up the possibility that groups of buildings could be the target of a green investment fund. It is notable that building sector has the highest GHG reduction per investment efficiency. It is probable that investment on energy performance improvement of groups of buildings could have considerable better performance than investment on green infrastructures. CM could be the basis such comparative study in investment strategies. If the energy performance of buildings is included in the target list of a green investment fund, it facilitates technology innovation that reduces GHG emission from operations of buildings.

6.3 Green lease

Green leases are contracts between the landlord and the tenant to share the financial benefit of energy savings of a rented building. The practice of green lease requires measurable, reportable and verifiable energy performance which is the basis of mutual contractual obligation. Thus, CM and its protocol defined by ISO16745 could be the essential elements to make the green lease contract feasible. So far most of the precedents of the green lease in Japan aims to replace existing artificial lighting to LED, simply because energy use and GHG reduction are predictable and measurable. In case CM and its protocol are applied, replacing of HVAC and building services could be included in green lease practice because such actions would become measurable, reportable and verifiable. It implies CM and its protocol could broaden the scope of the green lease, thus facilitate social innovation including behavioral changes of stakeholders that have significant impact on GHG reduction.

6.4 Innovative intervention by governments

Any government policies (legal control, intervention to activities in market place and provision of information) for GHG reduction require a fair and comparable reference for benchmarking and baselining. CM and its protocol by ISO16745 satisfy such requirement. Thus CM and its protocol could make the contribution to the innovation that is triggered by benchmarking and baselining policy by the governments.

7. CONCLUDING COMMENTS

The paper summarizes the idea of CM and its protocol that are prescribed in ISO16745 documented by the authors. The protocol assures internationally agreed method of calculation of GHG emission from buildings in operation. CM and its protocol provide the measurable, reportable and verifiable reference for GHG emission based trading, contracts, financing and policies that could be the sources of social and technological innovation in building sectors.

CM and its protocol are, in a sense, a simplistic approach among a set of possible holistic approaches against the complex crisis of global climate we are facing. The authors wish that the appropriate and effective usage of CM and its protocol would be identified and enhanced through "learning by using of CM and its protocol" in trading, contracts, financing and policy-making.

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