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How could Common Carbon Metric be practically usable for international collaboration to reduce greenhouse gas emission from buildings?

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Abstract: Carbon metric is the sum of annual greenhouse gas emissions and removals, expressed as CO2 equivalents, associated with the use stage of the building. ISO/TC59/SC14 is now drafting international standard: Environmental performance of buildings - Carbon metric of a building - Use stage. It aims to set out a globally applicable common method of measuring and reporting of associated GHG emissions attributable to existing buildings, by providing requirements for determining and the reporting of a carbon metric(s) of the building. Carbon metric is just a metric and is not an assessment method for evaluating the overall environmental performance of a building or a building-rating tool, and does not include value-based interpretation. Carbon metric is relevant for snapshot measurement in the operational stage of building. Thus, it is relevant but is different with life cycle assessment (LCA) methodologies. Carbon metric is usable in those countries where experts' services are only limitedly available. Carbon metric provides the basis for global scale carbon trading within building-related sector.

Keywords, carbon metric, carbon intensity, energy use, GHG emission

Introduction

Buildings contribute as much one-third of global greenhouse gas (GHG) emissions (UNEP-SBCI 2009a). With its high share of emissions, the building and construction sector has more potential and opportunity to deliver quick, deep and cost-effective GHG mitigation than any other sectors. In this context, measurement and reporting of GHG emissions from existing buildings is critical for enabling significant and cost-effective GHG mitigation. Currently, there has not been a globally agreed method 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.

UNEP-SBCI proposed the idea of Common Carbon Metric (CCM) of a building in 2009 as a protocol for measuring and reporting GHG emissions from the operational phase of buildings (UNEP-SBCI 2009b). Corresponding to the proposal by UBEP-SBCI, ISO/TC59/SC17/W4

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has launched to document the international standard on carbon metric of a building (ISO 16745 -Environmental performance of buildings - Carbon metric of a building - Use stage). As a convener and the member of ISO/TC59/SC17/W4, the authors have involved in the process of documentation of the international standard. The process has raised the issues that seem to be significantly influential on the effectiveness of CCM as a sustainability indicator of a building. The paper aims to introduce the content of ISO 16745 and tries to identify the way how CCM could be practically usable for international joint initiative to reduce greenhouse gas (GHG) emission from buildings.

What is Common Carbon Metric (CCM)?

The most recent version of the draft of ISO 16745 at the time of writing of this paper (hereafter ISO 16745) defines carbon metric as “sum of annual greenhouse gas emissions and removals, expressed as CO2 equivalents, associated with the use stage of a building." Thus, carbon metric can be measured by kgCO2e/m2/year. ISO 16745 also defines carbon intensity as “carbon metric expressed in relation to a specific reference unit related to the function of the building.” Here, reference units may include per unit area, per person, per kilobyte, per unit output, per GDP. Thus, carbon intensity could be measured by kgCO2e/m2/year, kgCO2e/occupant/year or etc.

If some organization would successfully construct an internationally agreed method of measurement of carbon metric of building, the method would be able to provide Common Carbon Metric (CCM) of the building. In such case, CCM could facilitate the technology sharing across different climate zones and building types. CCM is needed for consistent, measurable, reportable and verifiable GHG emissions reductions from buildings (UNEP-SBCI 2009b). Such metrics can be applied to measure greenhouse gas emissions in individual buildings or groups of buildings. They are also the basis for monitoring emissions mitigation on regional and global scales (UNEP-SBCI 2009b). ISO 19675 aims to set out a globally applicable common method of measuring and reporting of associated GHG emissions attributable to existing buildings, by providing requirements for determining and the reporting of a carbon metric(s) of the building.

Relevance and difference with assessment tools and LCA

ISO 16745 does not include any method of modelling of the operational energy use of the building. Carbon metric is just a metric and is not an assessment method for evaluating the overall environmental performance of a building or a building-rating tool such as LEED, BREAM and CASBEE. ISO 16745 does not include value-based interpretation of the carbon metric(s) through weightings or benchmarking. In principle, accurate and precise reporting can only be achieved if GHG emissions (and removals) from all life cycle stages of buildings are measured and/or quantified as is defined in life cycle assessment (LCA) methodologies. However, not all countries in the world have sufficient capacity or resources to use and apply LCA as is defined in EN15978. Respecting on the necessity for collaboration in a global scale, there exist a need for a metric that is usable not only in countries where the sufficient number of experts and a precise database are available, but also in those countries where

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experts' services are limited, and precise databases are not available. With the potential for global scale carbon trading within building-related sectors, a method that is consistently usable in both the well-developed and developing world is needed. CCM aims to respond to such needs. 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 is the focus of measurement and reporting of direct and indirect GHG emissions. This is the reason why ISO 16745 focuses on operational stage of building

System boundary of carbon metric of building

ISO 16745 defines the three types of carbon metrics of a building as follows:

- Carbon metric 1 (CM1) is the sum of annual GHG emissions from building-related energy use;
- Carbon metric 2 (CM2) is the sum of annual GHG emissions from building- and user-related energy use;
- Carbon metric 3 (CM3) is the sum of annual GHG emissions and removals 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 Table 1 and 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. CM1 and CM2 of a building are determined based on the following:

a) delivered energy for the building and for other energy use within the building's site (curtilage),
b) total on-site energy generated and used in the building and for other energy use within the building's site (curtilage).

Table 1 List of energy end use included in the carbon metric for CM1 and CM2 (DIS 16745)

CM1 only includes Building-related energy use while CM2 includes both Building-related energy use and User-related energy use

	Energy consumption related service
CM1 & CM2 Building-related energy use	• Space heating
	• Space cooling
	• Air movement
	• Domestic hot water
	• Lighting for basic building function (fixed lighting etc.)
	• Auxiliary energy (e. g. for heat pumps)
	• Indoor transportation
	• Building auxiliary devices
CM2 User-related energy use (Examples)	• Plug-in supplementary lighting
	• Household/office appliances
	• Refrigerator
	• Devices in Data Centre
	• Other specific functional devices

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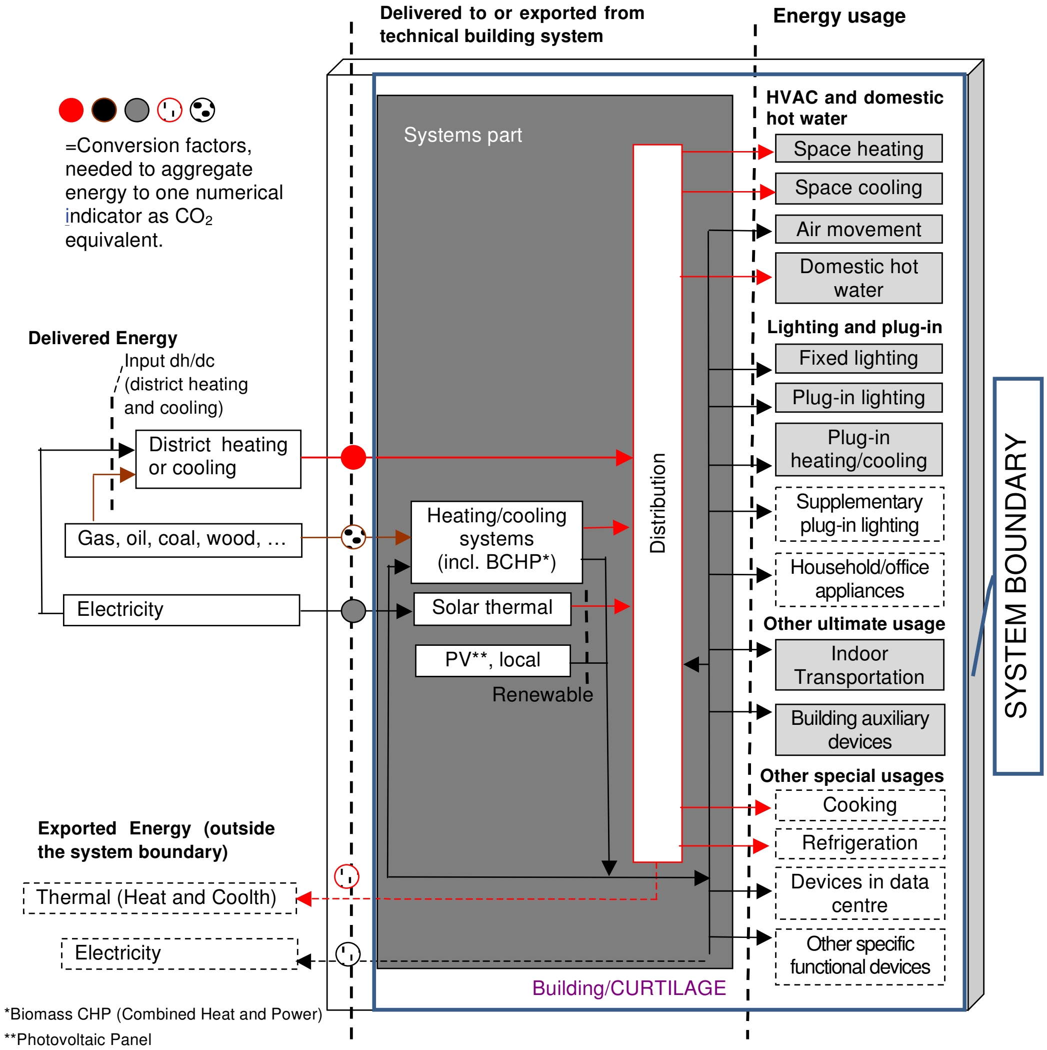

Figure 1 Boundary and energy flows : Main energy flows within and crossing the boundaries for energy use of a building (DIS 16745)

ISO 16734 requires that the system boundary include all the energy consuming and generating systems that are within the building's site (curtilage) and that support operation of the building. All building-related energy end use (as indicated in the pale grey boxes in Figure 1) shall be taken into account for the CM1. Lighting and controls shall be included in the CM1. User-related energy use (as indicated in the dotted box in Figure 1) shall be included in the CM2, including energy for supplementary lighting installed by building users.

Calculation of carbon metric of a building

Carbon metric of buildings, i.e. the emitted mass of GHG expressed as kg CO_2 equivalent per kg emission, is given by the following equation:

$$m \cdot \mathrm{co}_{2\mathrm{eqv}} = \sum\left(\left(E_{\mathrm{del,ci}} \times K_{\mathrm{del,ci}}\right) + \left(E_{\mathrm{site,ci}} \times K_{\mathrm{site,ci}}\right)\right) \quad \text{.................................. (1)}$$

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where

$m \cdot co_{2eqv}$ is the emitted mass of GHG expressed as kg CO2 equivalent per kg emission

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

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

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

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

ISO 16745 recommends to ignore $E_{site,ci}$, in case that the sum of energy produced on-site is estimated to be is less than 2% of the total energy.

Here, energy carrier means substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes. In case that the energy carrier(s) provides energy to support the operation of the building and/or other on-site facilities, the 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. It assumes that data for nominal delivered energy is available from utility provider reports and contracts, or electricity bills, or invoices for fuel deliveries, or gas bills, or meter readings, or pipeline measurements and energy management software. Data for the on-site generated energy shall be based on meter readings or the measured amount of biomass consumed (kg).

Energy usage used in the calculation of carbon metrics

For the calculation of CM1 using the equation (1), ISO 167745 mandatorily demands that building-related energy use to be determined by energy for HVAC and domestic hot water (i.e. energy for space heating and cooling, for air movement and domestic hot water), energy for fixed lighting, energy for plug-in equipment (i.e. plug-in lighting, heating and cooling), and energy for indoor transportation and building auxiliary devices.

For calculation of CM2 using the equation (1), ISO 16745 indicates that user-related energy use to be determined by energy for supplementary lighting installed by building users, energy for household/office appliances and energy for other special usages (i.e. energy for cooking, for refrigeration, for devices in data centres and for other specific functional devices)

GHG emission coefficients used in the calculation of carbon metrics

The GHG emission coefficient(s) used in the equation (1) is based on the delivered energy carrier. Respecting on the fact that there does not exist the exclusively universal table of GHG emission coefficient, ISO 16745 mandatorily demands the following information to be stated regarding the GHG emission coefficient used to determine carbon metric by the equation (1): sources of information (e.g., national, international); greenhouse gasses included in CO2 equivalent (e.g., following Kyoto protocol, Montreal protocol, or other protocols); included elements in supply chain (e.g., on-site, or on-site plus upstream processes); time frame of impacts on environment (100 years); and the year of reference of emission coefficient data.

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ISO 16745 indicates that GHG emission coefficients shall be obtained from, in the following order of priority; nationally agreed data; independently provided information; internationally agreed data.

Exported Energy

In ISO 16745, exported energy, i.e. energy produced on-site, but not used for the building or other on-site facilities, is not included in the calculation of carbon metric. However, ISO 16745 accept that export energy is reported as additional information. The GHG emissions from the exported energy is calculated by the following equation.

$$m \cdot \mathrm{co}_{2\mathrm{eqv}} = \sum \left(E_{\mathrm{exp,ci}} \times K_{\mathrm{exp,ci}} \right) \quad \text{..... (2)}$$

where

$m \cdot \mathrm{co}_{2\mathrm{eqv}}$ is the GHG emissions from the exported energy

$E_{\mathrm{exp,ci}}$ is the exported energy for energy carrier *ci*,

$K_{\mathrm{exp,ci}}$ is the GHG emission coefficient for delivered energy carrier *ci*

Reporting and communication of the carbon metric

The carbon metric may be used for a variety of purposes, which can include internal or external benchmarking, public information, property evaluation, policy information asset evaluation, etc.. In order to use and apply the carbon metric appropriately, the reporting of the carbon metric shall include information necessary to describe the building, and give sufficient information to allow traceability and transparency of the measurement. ISO 16745 requires that the carbon metric study report shall include the information shown in Table 2.

Table 2 Information imandatorily included in the carbon metric study report (DIS 16745)

a)	building identification; name of building(s), physical address
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, 12 consecutive months, mm/yyyy-mm/yyyy (e.g. 7/2013-6/2014)
g)	whether the carbon metric has been normalised to average annualized conditions such as local climate. If yes, include the method used to normalize the carbon metric for average conditions.
h)	date of the evaluation
i)	name of the organisation or individual doing evaluation (self-measurement or third party)
j)	client of the evaluation
k)	description/illustration of the system boundary
l)	list of energy end use included in the carbon metric in relation to the type of CM
m)	whether delivered energy end uses (eg. heating , lighting, cooling etc.) 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 (for each building of a complex)
q)	year of latest major renovation affecting energy use (eg. change of HVAC, change of building envelope)
r)	year of any (latest) change in use
s)	total site area
t)	location; country and climate

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Possible usage of CCM in building practices and international trading

CCM defined by ISO 16745 is applicable for international collaboration to reduce GHG emission from buildings. CCM offers a common and widely agreed cornerstone for international policy making on climate mitigation in the building sector (UNEP-SBCI 2009b).

CCM is applicable for benchmarking. CCM could be included as one of sustainable building indicators within overall environmental performance assessment method. In such cases, CCM is used for communication among designers, owners, tenants of the building.

CCM is also applicable for baselining in policy targets, taxation and regulations in local, national and global scale. Policy makers and shareholders could be the users for this purpose. CCM provides the basis for the internationally comparable monitoring of the performance of national or regional GHG reduction programs from building sectors. CCM could enable to evaluate internationally consolidated performance of such programs by consistent aggregation of CCM in each nation or region. In addition, CCM is applicable to the consistent definition of zero emission/energy building in regulations.

It is notable that CCM could provide a common basis for monetize the performance of the reduction of GHG emissions from a building. In another word, CCM enables to define monetary scale of rebates and incentives in economic transactions. Investors, financiers, and real-estate professionals could have opportunities to create new types of carbon trading. For example, CCM could monetize the amount of GHG emission reduction by professional services (e.g. operational energy improvement; retrofitting of existing buildings). Even though building sectors have been believed to be the most significant and effective target of GHG emissions (UNEP-SBCI 2009b), clean development mechanism (CDM) initiatives have excluded building sectors probably due to the lack of measurable, reportable, verifiable (MRV) metric. CCM is exactly MRV metric and could enable CDM and carbon trading in building sectors.

Concluding comments

Because of its simplicity and consistency, CCM provided by ISO 19675 is expected to be practically usable for many stakeholders as a reference for decision making in GHG conscious business activities and governmental policies.

Reference

EN 15978:2011 Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method

ISO/DIS 16745 (2013) Environmental performance of buildings — Carbon metric of a building — Use stage

UNEP SBCI (2009a) Buildings and Climate Change Summary for Decision-Makers (http://bit.ly/1nOxfnW retriviewed on 29 July 2014)

UNEP SBCI (2009b) Common Carbon Metric for measuring Energy Use & reporting Greenhouse Gas Emissions from building operations (http://bit.ly/1lMjSyo retriviewed on 26 May 2014)