Global benchmarking? Taking a critical look at eco-architectures resource usage

T. Spiegelhalter, R. A. Architect & T. Planner
Florida International University, College of Architecture and the Arts, USA

Abstract

"Eco-architecture, eco-society…this is the gentle hell of the Roman Empire in its decline" Jean Baudrillard, America, Verso, 1988. Human life has always depended on variables such as population, resources, and environment. Today, however, we are perhaps the first generation to face the simultaneous worldwide impact of expanding populations, depletion of resources, massive military built-ups for resource wars and homeland security, environmental degradation, and climate change. The causes and consequences are global and collective action is critical in driving an effective and equitable response on the scale required. All of this is common knowledge, endlessly discussed, widely published, and yet industrial and urban expansion carries on regardless. Eco-Architecture in its infrastructural context of a city's resource use only survives because of human, material, and communication networks with their hinterlands or bioregions, by placing them into a broader geographic context. The author examines how Eco-Architecture should be measured with resource foot printing on a common metric scale, which can only be realistically applied and globally benchmarked when interrelated life cycles of systems (GEMIS, Life-Cycle-Software: Global Emission Model for Integrated Systems Version 4.5, Oeko Institute Freiburg, Germany, http://www.oeko.de/service/gemis/en/), materials, and land-use planning in this wider geophysical perspective are considered. The author investigates the differences in measuring and certifying Sustainable Architecture (or Eco-Architecture) between the U.S. and Europe against international benchmarking.
Keywords: eco-architecture, sustainability, eco-systems, life-cycle-systems, benchmarking, energy performance measuring, climate change.

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1 Global resource use and eco-architecture benchmarking

Urban planners, architects, and engineers contribute through their designs, planning, and realizations approximately 50% of all man-made greenhouse gases. The long term solution for this environmental felony lies in the way our planned eco-architectures and cities actually measure, perform, consume resources, and generate pollution on a global scale. For decades, resource assessments for international performative benchmarking of countries, cities, and buildings have been monitored under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC). The UN Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to scientifically assess socio-economic information concerning climate change, its potential effects, options for adaptation, mitigation, and the development of public policies. UNEP facilitates the transition to low-carbon societies, biodiversity protection, and climate-proofing efforts. It improves understanding of climate change science, raises public awareness about this global challenge, and develops guidelines for calculating GHG Emissions for benchmarking countries, cities, businesses, and non-commercial institutions [2]. These organizations are also international clearing houses for data collaboration and coordinators for international building energy efficiency, carbon metric measuring, and resource use indicators, including sustainability rating systems such as The International Standards Organization (ISO 15392:2008), The Sustainability in Building Construction and General Principles of ISO (14040/44:2006) on Life Cycle Assessment, UK BREEAM, DNGB in Germany, CSTB in France, CASBEE in Japan, Green Star in Australia, Green Building Council South Africa, EEWH in Taiwan, UEA in Dubai, and Energy Star or LEED in the US, some of which are also united under the umbrella of the World-GBC [3].

The common metrics are usually the Energy Intensity = kWh/m2/year (kilo Watt hours per square meter per year), or Carbon Intensity = kgCO2e/m2/year or kgCO2e/o/year (kilograms of carbon dioxide equivalent per square meter or per occupant per year). In several countries, such as Germany and Switzerland, the metric is even more detailed in primary, secondary, and tertiary Energy Intensity. In general, the Energy Performance and Carbon Metric tools are applied to the specific inventory of the buildings under post-occupancy study. Such an inventory can be developed from a top-down or bottom-up approach, depending on the scope and goal of the investigation. Monitoring carbon mitigation measures on a regional or national scale would require a top-down approach, while assessing individual building projects would require a bottom-up approach.

1.1 Bottom-up approach

Each country obtains MRV data on GHG emissions for statistically representative samples of building types. These data may be readily accessible through utility and/or fuel providers. A building inventory requires that buildings be cataloged by location (country, region, and municipality) and identified by street address. The inventory can be correlated with a climate region by the number of heating and cooling degree days of its location. Building stock is to be quantified by type: 1) Residential (a) single-family and (b) multi-family dwellings, and 2) non-residential which includes mixed use and excludes industrial buildings. The stock shall additionally be characterized by age (year built), gross floor area, and occupancy (if available). Average or generic data can be used if it is representative of the subject building type, technologies, and construction techniques and of systems common to the reporting region. The latter is recommended only when measurable statistical sampling is not possible or feasible. Representative sample data can be scaled up or aggregated to the portfolio at the local, regional, or even national level using relevant statistics of the building stock to verify accuracy of the top-down approach.

1.2 Top-down approach

Where GHG emissions reports are required at a regional or national level, estimated performance data for subsets or total building stock should be used and coupled with estimates of building stock characterized by age, building type, gross floor area, and occupancy. Where relevant, such aggregated performance data shall be compared with a statistically representative sample set of building performance data (bottom-up) from the same area to verify the accuracy of both data sets. Green Building Councils have an important role in adopting the metrics and offering 3rd party verification of the top-down approach. It is also critical that other established or newly forming national and international data collection efforts adopt the metrics so that data can be compared easily across the world." [4].

2 The building industry has the greatest potential for delivering Greenhouse Gas (GHG) emission cuts

According to UNEP-SBCI (United Nations Environment Programme, and Sustainable Building and Climate Initiative), buildings are responsible for approximately 40% of global energy use and up to 30% of global GHG emission. UNEP-SBCI pledges that countries must support the building industry to meet their existing commitments to Kyoto Protocol from 1997 and to the Bali Roadmap in 2009. The building industry has the greatest potential for delivering greenhouse gas (GHG) emissions cuts using available and mature technologies. This enables market based measures that can support investments in building projects that are energy efficient at a low cost and that reduces GHG emissions, while encouraging governments to conduct inventory and set performance goals for GHG emissions from national building stocks. By 2020, UNEP-SBCI states that measuring baseline GHG emissions to develop and enforce meaningful energy & sustainability codes and standards can achieve 40% improvement in energy efficiency for existing buildings and 40% reduction in GHG emissions for new buildings and the necessary skills and performance standards for those skills. It is required to support the development of GHG emission standards for building types, location and use, and to renovate buildings we occupy so as to reduce direct and indirect GHG emissions. We can then improve climate adaptability, and dedicate research and development to climate neutral, net-zero-fossil-energy buildings, continue to work with governments on policy development and educate our supply chain [5].

The Fourth Climate Change 2007 Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC) was part of a series of reports intended to assess scientific, technical, and socio-economic information concerning climate change, its potential effects, and options for adaptation and mitigation. The report is the largest and most detailed summary of the climate change situation ever undertaken, involving thousands of authors from dozens of countries [6]. The main findings urge country leaders, stakeholders, the building industries and others to move from "climate change is real" to "here is the information you need to make good decisions for your stakeholders." This urgency includes risk management framing, multiple stress framing, and full immediate partnership for adaptation of all the necessary steps to assess and improve the building industry. The IEA (International Energy Agency) in its World Energy Outlook of 2009 estimates that energy efficiency will account for more than 60% of global CO2 emissions reductions to 2030. A significant part of this will need to come from existing and new buildings. [7]

2.1 How will this knowledge be transferred into practice and governance?

Eco-Architecture or Sustainable building means to build intelligently. The focus is on a comprehensive quality concept that serves the building and real estate sectors as well as society and culture in general. Sustainable properties are beneficial to the environment because they conserve resources, and make living more comfortable and healthy for their users while fitting optimally into their socio-cultural surroundings. In the same way, they stand for economic efficiency and long term value retention. Sustainable properties are cost effective due to their lower operation and maintenance costs. The manageable additional planning, commissioning, and construction costs will usually amortize in a few years [8], depending on the political-economic context of the location, size, and scale of the property.

Sustainable building design practice and marketing in the US has changed dramatically in recent years. What started out as a charismatic environmental crusade has matured into an established sector of the US architectural and construction industry. The passion has not diminished, instead it has become more firmly grounded in the realities of the marketplace, and more incentives are given by the new White House Agenda on Energy and the Environment [9]. However, when it comes to the benchmarking of buildings and cities of one of the biggest resource consumers in the world, energy data collection in the US is very parochial. It is hard to get comparable global benchmarks for US cities and buildings. Too often, they are based on theoretical models and not on actual city and building energy performance auditing. According to the U.S. Energy Department, only about 1% of all US buildings have been commissioned to date.

US legislative efforts must be based on actual, yearly, measured building energy performance rather than on modeled assumptions or samples from somewhat exceptional national "demo" buildings. If this approach were to be used, it should be compared against systematic global best practices, rather than only US peer groups of buildings. Doing so would allow pressing questions to emerge about why buildings in Germany or Switzerland use 50 to 70% less energy in similar climate zones than the average US equivalent. There is an urgent need in the US for new, globally comparable, benchmarked building energy performance policies and indicators based on comparable life cycle costs. Disclosure laws for improved energy performance for new and existing buildings to meet short, medium, and long term goals of the 2030 carbon neutral challenge of the AIA are also warranted. These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power, purchasing renewable energy and/or certified renewable energy credits [10].

2.2 The U.S. Green Building Council (USGBC) actual building energy use measuring in relation to modeling

In March 2008, a report by Cathy Turner and Mark Frankel of the U.S. based New Buildings Institute (NBI) analyzed measured energy performance compared to initial design and baseline modeling for the voluntary LEED (Leadership in Energy and Environmental Design) New Construction (NC) certified buildings (11). Of 552 LEED-NC version 2 buildings certified through 2006, only 22% or 121 buildings were able to provide the requested information. Measured energy savings for these buildings averaged 28% compared to code baselines, close to the average 25% savings predicted by energy modeling in the LEED submittals. Some buildings performed much better, but as the report notes, "There is wide scatter among the individual results that make up the average savings, and nearly an equal number are doing worse—sometimes much worse." Indeed, roughly a dozen of the LEED-NC certified buildings used more energy than predicted by code baseline modeling. The variability between predicted and measured performance has significant problems for the accuracy of prospective life-cycle cost evaluations for any given building. Much more feedback from actual building performance results is needed.

Nevertheless, a good start in the right direction is ASHRAE's recent release of a new Building Energy Quotient labeling program as a pilot phase at the end of 2009, similar to what was launched in the European Union in 2002. [12]

According to the Institute for Market Transformation (IMT), more good news for the US Green Building Industry is that Building owners in Washington, D.C., will start measuring the energy use of commercial properties on January 1, 2010. This new law aims at reducing energy use and costs for building owners and tenants [13]. Under this new law, the Clean and Affordable Energy Act, passed in 2008, will prompt building owners to publicly disclose energy ratings starting in 2012, which will give prospective tenants and buyers an easy-to-understand way to compare the energy consumption and operating costs of buildings. The benchmarking will be done through a U.S. EPA online tool called the Portfolio Manager. It asks for information about the building and its energy use, rolling them into a rating on a 100-point scale. A building performing better than 60% of the stock would receive a 60. It remains unclear if the metrics can be further compared on a global level or if they only relate to the US EPA's peer buildings rating.

2.3 Energy performance of buildings directive (EPBD)

One of the key driving forces of European energy-efficient design is the European Union's 2002 Energy Performance of Buildings Directive (EPBD), inspired by the Kyoto Protocol of 1997, which commits the EU to reduce CO2 by 8% in 2010. This means a reduction of 5.2% below 1990 levels, using radical energy reduction, resource conservation strategies, and renewable resources wherever possible. Each of the twenty-seven member states of the European Union is responsible for individual implementation of the EPBD through national laws. The focus of European sustainable building design at this time is on reducing energy use directly and carbon emissions indirectly. The yearly certification inspections are publicly displayed when buildings are constructed, sold, or rented out, and the actual energy use certificate must be made available to the prospective buyer or tenant. The display certificate is valid for only one year, which means that the continuing title of sustainable building (or Eco-Architecture) has to be earned, based on city or district wide performance standards and ordinances such as Low-Energy (30-60 kWh/m2), Passive Energy (15-20 kWh/m2), Zero-Net-Fossil or Plus-Energy-Buildings (which can produce more renewable energy than they need, and sell the surplus to the public grid). The display must include the rating from a prior three-year period so that building occupants can see whether resource-saving improvements have been made or not. In summary, the European approach substitutes information for regulation.

2.4 Globally benchmarked, nationwide building energy use and GHG displays for the United States

Actual building energy use and GHG rating displays should be emulated in the United States. Without clear standards for new buildings and major upgrade requirements for existing buildings, the US will never be able to reduce the carbon emissions from residential and commercial buildings. All those procedures required to assess and rate the building's energy use should be nationwide. GHGs emissions and progress against resource and GHGs reduction targets annually on an objective global benchmarking scale should be tied to energy use of the UNFCCC carbon emissions counting and ranking. This is already partly practice in the United States with the Energy Star Portfolio program [14], but it is only a relative national ranking (the top 25%), as opposed to an absolute global benchmarking scale. If the US wants to get serious about reducing energy use in buildings and inducing energy-saving remodels, refurbishments, and renovations, it has to start comparing energy use per unit area per year by reliably linking local practice to global UNFCCC aims.

3 New studies on efficiency in buildings with global benchmarking

A new study on energy efficiency in buildings indicates that the global building sector needs to cut energy consumption in buildings up to 60% by 2050 to help meet global climate change targets. The World Business Council for Sustainable Development (WBCSD) recommends that worldwide governments, businesses, and individuals must start to aggressively reduce energy use in new and existing buildings in order to reduce the planet's energy-related carbon footprint by 77% or 48 Gigatons (against the 2050 baseline) to stabilize CO2 levels to reach the level called for by the UN Intergovernmental Panel on Climate Change [15]. Much further urgent work is needed to develop a 'common carbon metric' with an integrated resource master plan and diversified renewable energy portfolio for the measurement of the carbon footprint of buildings and cities. This would help to make smart infrastructure and new building choices, and ensure an economically, environmentally self-sufficient fossil-free infrastructure by 2050.

Global large-scale GHG benchmarking means that only systems directly applicable to reliably measure contributions to climate stability are valid. More specifically, these are approaches that embrace a 3.3 ton per annum per person of carbon dioxide by 2050 compared to 1990 levels. This globally benchmarked target is based on a fundamental equity calculation that on a per-capita basis, each person has only an annual 3.3 ton emissions allowance if oceans and forests are to be able to neutralize excessive carbon emissions. In contrast, Australia and the United States approach 20 tons per annum per person, while most developing countries, including India and China, will increase dramatically in the long run. European national governments have been far more willing to accept the conclusions of climate science than American governments and have been willing to develop practical public, socio-cultural, and economic policies for reversing the growth of carbon emissions. This includes subsidies, laws, and regulations to implement sustainability driven policies in order to significantly reduce GHGs as proposed by the UN Intergovernmental Panel on Climate Change (IPCC). To achieve this level of sustainability, it is necessary to develop a common language for carbon metric measuring.

In March 2009, the United Nations Environmental Programme and Sustainable Buildings and Climate Initiative (UNEP SBCI), and the World Green Building Alliance (World GBC), and members of the core groups (BRE Global/BREEAM, USGBC, CSTB, DGNB, FCAV, ITC, NIST, VTT) signed a memorandum of understanding to develop a common carbon metric, that is intended to accelerate the international adoption of Sustainable Building (SB) practices through the promotion of shared metrics of building performance assessment and rating [16].

3.1 Did the global climate summit in Copenhagen help to set a common language for final global benchmarking targets and guidelines?

The United Nations Climate Change Conference took place in Copenhagen, Denmark, between December 7 and 18, 2009. It included the 15th Conference of the Parties (COP 15) to the United Nations Framework Convention on Climate Change and the 5th meeting of the parties (COP/MOP 5) to the Kyoto Protocol.

In order for 9 billion people to live together on one planet in 2040, a circle of trust is required, one that rewards sustainability solutions and discourages the wrong economic activities of the past.

Recently, in Copenhagen an agreement on climate change was reached without any binding obligations. It is referred to as the Copenhagen Accord and aims towards an immediate action on climate change while guiding negotiations on long-term action. It also includes a political agreement to working towards curbing global temperature rise to below 2 degrees Celsius with efforts to reduce or limit emissions, and pledges to mobilize $100 billion a year for developing countries to combat climate change. U.N. Secretary General, Ban Ki-Moon stated, “The leaders were united in purpose, but they were not united in action,” to exhort world leaders to act in concert to ensure that a legally binding treaty is reached in the future. Nonetheless, he said that the talks “represent an essential beginning,” because without nations hammering out a deal in Copenhagen, the financial and technical support for poorer nations agreed upon would not take immediate effect [17].

The COP15 in Copenhagen was a critical and timely step that should have enabled the world to realize the unparalleled, cost-effective carbon mitigation potential of buildings, which account for around 40% of the world's energy use and 33% of global greenhouse gas emissions. However, there are no concrete goals formulated for reducing greenhouse gas emissions for 2020 and 2050 and there is no clearly distributed financing of the promised $100 billion in aid pledged to developing nations to adopt CO2-curbing green technologies to help pay for the damage caused to those countries by climate change. Unfortunately, there is no consistent monitoring of CO2 reductions and of how they are to be achieved. To announce a target of limiting global warming to an increase of 2 degrees Celsius is meaningless as long as there is no limit to the CO2 that humanity allows itself to emit by 2050 and such is close to 750 billion tons, according to the best available science. At the current level that is likely to be emitted by 2020.

It took governments from around the world 17 years of dialogues, countless scientific investigations and negotiations, political-ideological debates, delays and maneuvering, to come together for the Climate Summit in Copenhagen, since the last climate-related Earth Summit meeting in Rio de Janeiro in 1992. Seventeen years of searching for solutions to confront the threats resulting from climate change. The last drafts of the final declaration at COP15 included provisions not only for limiting the rise of global temperatures to 2 degrees Celsius above preindustrial levels by 2050, but also for how this could be achieved. There was mention of reducing greenhouse gas emissions by 80% by 2050 and even the possibility of a mid-term goal by 2020.

4 Conclusion

Without waiting any longer for better climate change agreements at the UN-COP16 in Mexico in December 2010, a political contract on the radical improvement of the Energy Performance of Buildings in the European Union was successfully agreed on between the European Parliament, the European Council, and the European Commission on November 17, 2009, to make all new buildings nearly Zero-Fossil-Energy by 2021. As a hopeful global leader in promoting energy efficiency, one key aspect is the requirement that all new sustainable buildings in the EU must be "nearly zero-fossil-energy buildings" and only renewable energy technologies will be accepted to operate buildings on January 2021. In addition, the agreed text does not prevent EU-Member States from setting even more ambitious targets and implementing the provisions of the Directive at an earlier date. In fact, there are many pioneering countries such as Germany, Swiss, and Austria, with leading city governments like Stockholm, Goteborg, Freiburg, or Stuttgart, where the national and regional targets are already more ambitious than the recast European Directive.

However, an area of concern is the fact that the agreed text seems to be under-ambitious in relation to the energy efficiency retrofitting of existing buildings which represents approximately 80% of the building stock in Europe. Despite signs of improvement, Europe's buildings remain a large energy consumer (40% of final energy use), of which too much is wasted in heating and cooling, and a carbon dioxide (CO2) emitter of 36% of EU CO2 emissions. The existing U.S. building stock is facing similar colossal challenges! Energy conservation, efficiency retrofitting of existing buildings, and the radical shift from non-renewable to renewable energy technology economies is the most effective and socio-economical approach to reducing 80% GHG's by 2050 compared to 1990 levels [18]. These changes are imperative for all countries in the world ranging from the most industrialized ones such as the U.S. to the most impoverished ones!

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References

[1] GEMIS, Life-Cycle-Software: Global Emission Model for Integrated Systems (GEMIS) Version 4.5, Oeko Institute Freiburg, Germany, http://www.oeko.de/service/gemis/en/

[2] UNFCCC, United Nations Framework Convention on Climate Change http://unfccc.int/ghg_data/items/3800.php

[3] WorldGBC, World Green Building Council Website, http://www.worldgbc.org/

[4] UNEP-SBCI: The United Nations Environmental Program and Sustainable Buildings and Climate Initiative, COP15, Copenhagen, Dec. 11, 2009. http://www.unep.org/sbci/index.asp
[5] UNEP-SBCI: The United Nations Environmental Program and Sustainable Buildings and Climate Initiative, COP15, Copenhagen, Dec. 11, 2009. http://www.unep.org/sbci/index.asp
[6] Pachauri, R.K. and Reisinger, A. (Eds.). The Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, Geneva, Switzerland. 2007, http://www.ipcc.ch/
[7] IEA (International Energy Agency), World Energy Outlook 2009, http://www.worldenergyoutlook.org/
[8] German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen DGNB) http://www.dgnb.de/
[9] White House Agenda on Energy and the Environment http://www.whitehouse.gov/issues/energy_and_environment/
[10] 2030 Carbon Neutral Challenge of the American Institute of Architects (AIA), http://info.aia.org/toolkit2030/
[11] Cathy Turner, Mark Frankel, Energy Performance of LEED® for New Construction Buildings, FINAL REPORT March 4, 2008 New Buildings Institute (NBI), http://www.newbuildings.org/measuredPerformance.htm
[12] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) New Pilot Phase Building Energy Quotient Labelling http://buildingeq.com/
[13] Market Transformation (IMT): The Clean and Affordable Energy Act of 2008, and signed into law by District of Columbia Mayor Adrian Fenty on Aug. 4, 2008. http://www.imt.org/rating-dc.html
[14] U.S. Energy Star Portfolio and Environmental Protection Agency's (EPA's) Manager Tool, http://www.energystar.gov
[15] The World Business Council for Sustainable Development (WBCSD) http://www.wbcsd.org/templates
[16] UNEP-SBCI: The Common Carbon Metric for measuring energy use and reporting greenhouse gas emissions from building operations was officially launched at COP15 in Copenhagen on 11 December 2009. Website: http://www.unep.org/sbci/news/latestnews.asp
[17] UN-News-Centre Website: UN-Secretary-General Ban Ki-moon, Dec. 30, 2009, http://www.un.org/apps/news/story
[18] Bulletin Quotidian Europe No. 10022 Website, http://register.consilium.europa.eu/pdf/en/09/st17/st17472.en09.pdf