University of Washington
College of Built Environments
Department of Architecture

MOTIVATING LOW-CARBON CONSTRUCTION:
Opportunities and Challenges

A road map for rapid and significant impact

Carbon Leadership Forum White Paper

Kathrina Simonen
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APPENDIX/ISSUE SUMMARY

Proposing a road map for action/impact:

CHALLENGE

In order to motivate, evaluate and reduce carbon impact of the built environment we must:

-Create a demand for the data-motivate users to ask for it.

-Provide mechanism for data collection and dissemination-enable manufactures to provide it.

-Develop 'product category rules' (pcr's)-ensuring results that are fair, complete and effective.

-Develop ambitious yet realistic targets-motivate and reward industry innovation.

STRATEGY

1. **First motivate environmental declarations, then target improvement:** Substantial demand is needed to motivate baseline LCAs and development of standards and benchmarks.
2. **Establish appropriate Product Category Rules:** Establish 'rules' for creating LCA's structured to motivate substantive innovation in manufacturing processes and efficiency.
3. **Strategic Start with Limited Scope:** Identify a 'short list' of products/materials to address first. Provide background research to support relative importance (impact + volume).
4. **Develop Robust and Replicable Method:** Lead standards development. Use Hybrid I/O + supply chain process data. Provide both prescriptive and performance based methods.
5. **Link to Established Data and Resources:** Use WRI/ISO as guide for LCA/PCR standards, comply with intent of ASTM standards under development and support their finalization.
6. **Establish Framework for Expansion/Development:** Recognize that this is an emerging discipline and that effectiveness will require a strategy that is flexible and continually refined.

TIMELINE

2011

- Publicize Environmental Product Declarations (EPDs)& Product Carbon Footprint potential.
- Integrate with emerging product category rule 'operator' framework.
- Propose two carbon specific product category rules and targets.
- Analyze opportunities and challenges and present results

2012

- Develop industry benchmarks.
- Issue additional PCRs and carbon targets.
- Analyze opportunities and impacts within design and construction practice

2013+

- Annual review and revision of targets and PCR's
- Critically evaluate impact of PCR's and EPDs.

RESPONSIBILITIES

Advocacy	Motivation of industry, driving demand.
Management:	Responsible for managing and moving the PCR process forward.
Research:	Compiling and creating background LCA research necessary for PCR creation.
Implementation:	Providing resources for industry to adopt and comply with recommendations.

SITUATION

The rapid adoption of low carbon construction materials and methods is necessary in order to reduce greenhouse gas emissions as reducing energy efficiency alone will not be sufficient to meet international carbon reduction targets. The development of tools and processes that enable the building industry to integrate available scientific methods and knowledge to enable this reduction is thus critical and timely.

National and international standards bodies such as ASTM, ISO and WRI/WBC are currently undertaking efforts to create standards appropriate for use in creating Environmental Product Declarations, 'ECOlables' and product carbon footprints. However, all these standards are still quite general and many unique 'product category rules' (pcr) will need to be developed to capture the unique conditions of the many diverse building products (such as concrete, windows, carpet etc).

While some countries (e.g. Sweden, France, Korea, Japan) are providing top-down leadership and support for the development of national databases and standards, the U.S. government is not funding or centralizing leadership in this area. Given the existing gaps in knowledge, understanding and ability there is need for strong leadership in order to motivate industry and government to close the gaps and advance our ability to predict and reduce the environmental impacts of manufacturing, construction and use of the built environment.

CHALLENGES and ACTIONS

In order to address these challenges,	We must:
As building energy efficiency increases, the embodied impact becomes more significant-how to motivate innovation/change here?	Incentivize the development of low carbon building products and processes.
Designers and builders are missing key information about products and construction methods that they need to reduce carbon in building construction.	Create mechanisms to communicate complex information in simple terms with replicable methods.
Manufacturers see low demand for environmental product declarations and without clear standards, these can not be used to compare products.	Motivate specifiers to request LCA/carbon footprints and create appropriate product category rules
The US government is not providing the funding or leadership to develop national standards and comprehensive life cycle inventory databases.	Articulate the economic and environmental value in open source, transparent and comprehensive data.
We cannot afford to wait for the refinement of international standards to act and reduce carbon in construction today.	Build a bottom up methodology that prioritizes efforts towards greatest immediate return and is adaptable to emerging standardization.

RECOMMENDATION: Motivate Expanded Carbon Footprint Accounting (CFe)

1. **Strategic Start with Limited Scope:** Identify a 'short list' of building materials/products with either a very high-embodied impact, significant application volume and/or a relatively short life time such that their relative impact on the built environment is significant. The final selection of the 'short list' would require some additional research to identify the highest impact products and to create a refined position statement. Initial suggestions include: Concrete, gypsum wallboard, flooring, cabinetry and roofing.
2. **Develop Robust and Replicable Method:** Develop product category rules (pcr)[i] to create an Expanded Carbon Footprint (CFe, a LCA based analysis that quantifies carbon impact plus other critical environmental factors) specific for each of these applications/industries. The steps for this include:
    a. Establish foundation LCA Research: The creation/assembly of comprehensive LCAs of typical manufacturing variations and impacts. This would identify product or system 'hot spots' essential for inclusion in carbon footprint comparisons and potential 'secondary' significant impacts (such as water use, toxicity etc) that should be included to 'expand' the carbon footprint to capture complexities of environmental impact.
    b. Create unique pcr's: The development of prescriptive recommendations for, 'product category rules' that follow the intent and methodology of evolving ISO/WRI standards while clearly articulating where divergence occurs. As national and international standards are refined, the intent would be to 'harmonize' the pcr's to conform to the standards. Limit time applicability of standard to 3-5years.
    c. Set performance targets: Define industry averages and set goals to improve. Given unique conditions of industry, these targets may not be consistent across sectors.
    d. Establish framework for evaluation and improvement: Recognize that this is a rapidly evolving field and thus a system should be in place to re-evaluate and update pcr's, targets and processes within a regular timeframe. Additionally, resources will be needed to develop and maintain connections with evolving standards bodies.
3. **Motivate Demand for Data, Expertise and Standards Development:** Motivate designers, specifiers and builders to commit to mandating CFe (at a minimum for the 'short list' of building products) within their specifications. Provide resources to encourage specification of 'low carbon certified' materials. Develop structure to ensure that information is shared with national databases to promote a more transparent and comprehensive resource.
4. **Develop Strategies for Efficient Expansion of the 'Short List':** Build upon expertise developed in stage 2 to enable creation of pcr's to encompass the wide diversity of building products and systems.
5. **Link to Existing/Emerging Data and Standards Efforts:** Utilize existing national resources to manage and disseminate data. Engage with emerging standards bodies to help advance valuable and applicable standards.

NATIONAL DATABASES NEED DATA

The two major national LCA databases appropriate for use in understanding the environmental impact of construction are the LCI inventory supported by NREL and the BEES database supported by NIST. Both of these resources provide free and relatively transparent data enabling user to look beyond a single number to understand the complexities of the analysis. Both databases are sparsely populated and currently do not have adequate data to effectively use in practice. Athena is a proprietary non-profit assessment tool that has developed a more comprehensive dataset for building products and systems.

NREL/LCI Database: The NREL database provides disaggregated source data of varying completeness and complexity. The completeness of the wood products dataset is a direct result of research by an inter-university research collaboration, Consortium for Research on Renewable Industrial Materials (CORRIM) currently directed by Elaine Oneil at the University of Washington. Similar research consortia could be formed to develop and advance data resources for other building materials and processes. NREL provides a place to hold the data but is not providing a comprehensive review of the data quality or completeness.

NIST/BEES: The NIST database provides aggregated data for individual products. The resulting environmental impact is assessed over 12 categories and also includes cost assessment. This data resource is better suited for design professional use however it is still formatted within a framework appropriate for more complex LCA studies. 240 products are included however significant gaps exist (e.g. no structural steel) making the resource unsatisfactory in its current application.

NIST uses primary data supplemented with the LCI database and proprietary LCA data sets to develop LCA's for each of the products. Documentation clearly identifies the scope included in each assessment and the results are presented in a simple manner. Given that data is reviewed by NIST before publishing, the relative numbers presented there are reasonably appropriate for use in comparing different products. The major challenge is that there are not enough products included to make this tool useful and that NIST does not have funding or mandate to expand the database.

Athena/Impact Estimator: the Athena Impact Estimator is created by the Athena Institute that is a non-profit organization with offices in Canada and the United States. The Impact Estimator is designed to be a whole building assessment tool and therefore is structured to enable input of individual components to create a full building model and includes many assumptions about 'standard' building practices. This is valuable when working with incomplete information but not ideally suited to integrate with design and construction practice or analysis when more specific information is already known. A simplified version of the tool, the EcoCalculator, is available for free download. The more comprehensive estimator requires a fee. The results are presented in multiple formats appropriate for both summary and more detailed understanding of the relative impacts of decisions. All data used are industry averages adjusted to regional conditions. The data is aggregated such that it is difficult to understand the detailed underlying assumptions used in creating the dataset.

LOW CARBON IS A CRITICAL-YET NOT SOLITARY- ENVIRONMENTAL IMPACT

Carbon is a compelling environmental impact to focus on both because of the pressing challenge of GHG induced climate change and the growing public understanding of carbon as an environmental performance metric. Reducing the CO2 emissions from buildings by 50% could reduce total US emissions by nearly 25% as outlined in Architecture 2030 (http://architecture2030.org).

When looking to reduce the operational energy impact of the built environment, carbon is a clear and directly applicable metric to motivate increasing energy efficiency and utilizing non-fossil fuel energy sources. Methods to estimate and assess energy use have been well established. Even so, the implementation of the 2030 challenge has necessitated training and innovation within design and engineering teams. The impacts from manufacturing are diverse. The simplicity of only assessing CO2eq, has the risk of both ignoring significant impact, alienating those who prioritize environmental impacts differently and developing solutions that have unintended adverse impacts.

Life Cycle Assessment (LCA) is still an emerging discipline with methodology and standardization currently under lively debate and refinement. The fundamental principles of established methods are transparency, inclusiveness and flexibility. The ISO standards[ii] were developed to enable a focus on internal improvement of processes, not to compare between competing products.

ISO compliant LCA's are ideally developed to include 'all' environmental impacts throughout a life cycle (extraction, manufacture, transport, use, disposal) in order to ensure that changes made to manufacturing to reduce one impact do not cause unintended negative results elsewhere. The complexity of completing and interpreting a comprehensive LCA makes them expensive to perform and difficult to translate to a lay audience. In order to utilize the strategies of LCA to enable product comparison and interpretation my non LCA experts, the creation of specific rules (establishing boundaries, scope and impacts) are needed to ensure that the effort to perform is affordable, the results are replicate able, comparable and comprehendible.

In the development of product category specific rules, there is a unique opportunity to expand a carbon footprint analysis to include additional environmental impacts specific to this product type.

> **Example 1**: There are two different methods of cement production, 'dry' and 'wet', whose water footprint could be significantly different. If in comprehensive LCA analysis it is determined that water use is a significant variable impact in different methods of cement production, it might be appropriate to include water use as part of the product category rule for concrete.
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> **Example 2:** In flooring production, the key expanded issue may be toxicity. Thus the analysis does not need to cover 'everything' but can be constructed to reflect environmental impacts relevant to the product category under study.

Thus we are proposing an 'expanded Carbon Footprint', (CFe) to leverage the relative simplicity of a Carbon Footprint and integrate the more comprehensive review of a LCA. This addresses desires to both drive innovation in low carbon products and processes and advance our industries understanding or and ability to integrate more comprehensive LCA methodology.

BUILDINGS ARE A UNIQUE CLASS OF 'PRODUCTS'

The scale of environmental impact from building construction and the disaggregation of the design, manufacturing and construction processes makes for unique challenges in leveraging the benefits of LCA and in creating applicable product category rules.

LCA optimal for mass-produced products with integrated design/manufacturing: The Life Cycle Assessment standards ISO 14040 and 14044 were specifically created for the purpose of continuing improvement of systems rather than directly comparing products (Jones, Tucker, Tharamaraja, 2009). Given that most buildings are custom, 'one-off' products, the investment and opportunity of a comprehensive full building LCA is radically different than it would be for a conventional product such as car or a paper cup. As designers, builders and building owners rarely have direct control over the manufacturing processes used in creating the products and components used in constructing buildings, the ability to directly compare the environmental impacts of two competing products is necessary if these impacts are to be taken into account in the decision making process.

Buildings are products with complex components and uncertain life. Unlike a ballpoint pen, whose useful life can be defined by something as simple as length of line drawn, a buildings lifespan, use and maintenance are all uncertain. In addition, the construction of a building depends on many diverse products and processes making the tracking of the relationship between embodied and operational impacts a challenging exercise.

Product category rules must capture issues appropriately yet be easy to implement. More generic rules can be simpler to implement yet risk being so general to not accurately capture and motivate substantive change. In order to develop appropriate rule structures a comprehensive understanding of the underlying issues is necessary.

Supply chain specific data is essential. Designers have flexibility in selecting which products to specify. Industry average data is unsatisfactory when most often decisions are made between similar products. While much effort is being undertaken to differentiate between materials (e.g. steel vs. concrete) the differences between 'average' competing materials can be statistically insignificant where supply chain difference of a single product type may be significant (e.g. locally produced with renewable energy source vs. imported/foreign production with coal power). In order to motivate and reward industry improvement, supply chain specific data is required. Manufactures need clear guidance on how to collect and report data in such a way that is rigorous yet still simple to achieve.

MANY STANDARDS ARE UNDER DEVELOPMENT

While multiple standards are currently under development, it appears that the WRI/WBC scope III carbon foot printing methods are aligning with proposals under development by ISO[iii] See attached white paper (Schenck, 2009) that outlines the state of environmental product declarations (EPD's) both nationally and internationally. ASTM is currently reviewing two proposals: for product category rules for LCA's of building products in general and to define the standard for determining who can create the pcrs, the 'Product Category Rule Operators'.

The strategy of the Carbon Leadership Forum is to develop proposals in general conformance with the intent of both ISO and WRI, to articulate the strengths and limitations of the standards. Supporting and advancing standards processes underway will help enable more rapid adoption.

CRADLE TO GATE ANALYSIS WILL NOT (ALWAYS) BE ADEQUATE

Given the uncertainty in manufacturing and construction locations, it is tempting to develop product ratings simplified to only address the cradle to gate. However, prioritizing manufacturing impacts over transportation, use and disposal phases risks the following significant errors:

> **Example 1:** A heavy energy intensive product produced with clean energy (e.g. stone cut primarily with hydro power) might be prioritized over a local product (e.g. stone cut with coal power). If trucked across the country the environmental impact might be greater than if local option was chosen. (the inverse unintended impact of the LEED 500mile rule)
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> **Example 2:** A high performance window (from an energy use perspective) may be significantly higher in embodied impact than an industry standard window. Product performance must be equivalent to compare cradle to gate impacts. However, for products such as windows, integrating energy performance during use into the overall impact assessment would enable side-by-side comparison between two products with different performance ratings. Current research is underway sponsored by NREL and executed by IERE. The first committee meeting was held in early December with the author in attendance.

Proposed Solution: Deliver product EPD with GPS location of 'gate' to permit analysis of transportation as appropriate. Provide 'gate to site', 'use' and 'end of life' information as a separate line item with assumptions clearly stated.

WHAT IS IN A PRODUCT CATEGORY RULE?

In preparing a LCA many different assumptions must be made. Comparing results from two different LCAs is essentially meaningless unless the assumptions and accounting processes are standardized such that the results would be replicated if performed by two different individuals. An Environmental Product Declaration (EPD) presents the results of an LCA that follows a specific PCR.

Existing PCRs tend to still be quite general.

A Product Category Rule (Capital PCR) is defined by ISO. Generically a pcr is an established method and scope to include in creating an environmental product declaration. Currently there is an active ASTM committee developing standards for both product category rule 'operators' (those who create pcr's) and to create a general pcr for building products.

Ideally each major type of building product would have its own pcr to address issues unique to the manufacturing and use of that product. The pcr's should be organized in a hierarchical fashion such that the details refine from the general to the specific enabling more effective comparisons between products. This is how the International EPD system is organized and is the intent of U.S. practitioners interviewed although not explicitly stated in documentation.

For example:

First tier:	All building products
Second tier:	Flooring
Third tier:	Carpet or Resilient Flooring or VCT
Fourth tier:	Carpet tile vs sheet carpet (as necessary-keep higher level stds as appropriate.

REFERENCES

Jones, D., Tucker, S. & Tharamaraja, A. (2009). Material environmental life cycle analysis. In Newton, P. Hampson, K. & Drogemuller, R. (Ed.), Technology, Design and Process Innovation in the Built Environment (pp. 54-71. Oxon: Taylor & Francis.

Schenck, R. (2009). The Outlook and Opportunity for Type III Environmental Product Declarations in the United States of America: A Policy White Paper. *Institute for Environmental Research and Education.*

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[i] Note: ISO 14025 defines Product Category Rules (PCR) in an explicit manor. Here the term is used in lowercase to define a unique set of rules/procedures appropriate for comparing different products that may or may not correlate exactly with the ISO PCR definition.

[ii] ISO 14040, 14044

[iii] Personal conversation with Jim Fava of Five Winds International and member of the World Resource Institute (WRI)/World Business Council for Sustainable Development (WBCSD) Steering Committee for the Scope 3 and Product GHG Protocol efforts.