Apples to oranges: Comparing building materials data

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ABSTRACT: The building materials sector is composed of a highly distributed network of companies. Ranging in size from boutique companies such as Kirei USA, to architectural divisions within large multi-national conglomerates like Dupont, each manufacturer approaches their communications on building materials' performance and sustainability data differently. The information and terminology are often tailored specifically to the sector and are difficult to decode. As the sector embraces greater transparency, new quantities of data have emerged. However, because no platform attempts to present all performance and sustainability metrics, it is difficult to compare materials side by side. Our paper describes an inclusive model of criteria, with its varied terminology: look and feel; performance criteria; sustainability metrics; ecolabels and LEED points; plus access to MSDS, health product declarations, and environmental product declarations. It also discusses an initial input of seventy materials distributes data across the model.

Initial selection of performance criteria derives from building codes, ASTM standards and government directives, with nomenclature deriving from an analysis of building materials specifications. Sustainability criteria originate in the analysis of eight reputable materials sustainability standards selected across standard types and industries. Because our model is designed to dynamically mirror changes in the sector, initial data entry results in additional criteria for the model.

With over two hundred criteria, our model produces information at the scale of big data. Analysis of the input data is most surprising in the area of sustainability: large voids in information are revealed. Additionally, the visualization of the data indicates significant patterns in the report of information, and where harmonization currently occurs.

KEYWORDS: Materials, Big Data, Sustainability, Performance

INTRODUCTION

Globally, as the world's population increasingly moves to urban environments, it is well documented that there will be a tremendous increase in construction.[i] To accommodate this construction both in the US and globally, the building industry relies on a materials sector with a highly distributed network of companies that are loosely affiliated. Unlike the airline industry, the building materials sector cannot depend upon big manufacturers like Boeing, Lockheed or Airbus for standardization in data. Ranging in size from boutique companies such as Kirei USA, to architectural divisions within large multi-national conglomerates like Dupont, each manufacturer approaches their communications differently, and comparison between products is nearly impossible.

This paper investigates the specific issues that make the comparisons of sustainability and performance metrics problematic. It discusses the isolation of industries with regards to reporting of data, and range of dialects in terminology that result. It then presents the wide landscape of sustainability and performance metrics that exist across the sector, and the distribution of data that is reported by manufacturers on these metrics. As the sector embraces greater transparency, our research uses a base set of seventy building materials to show the quantities of data that have been published by manufacturers. Our analysis reveals a landscape of big data fraught with substantial voids in information. The paper concludes with an analysis of which industries embrace publication of data, and harmonization.

1.0 DATA DIALECTS

The data that manufacturers present on their materials is often tailored specifically to their specific industry, such as the carpet or glass industry. The terminology and distribution of information isolates these industries from users and from each other. Each industry speaks its own dialect, and there is no infrastructure that acts as translator. For example, terminology describing performance characteristics is highly specific, but the words themselves are barely distinguishable. Color fast, fade resistant, lightfastness, and UV resistance relate to degradation of materials by the sun. The carpet industry and the upholstery industry use distinct terminology, because of the specific effects upon their products. But, this vocabulary is nearly homogenous to anyone else. The healthcare industry differentiates between antibacterial, bacteria resistant and bacteriostatic; necessary differentiation, but again confusing to the uninitiated. For fire resistance, materials bear the label Class 1, 2 or Class A, B, C depending on level of flame spread. The numeric system applies to materials like gypsum board, plywood and carpet while the alphabetical system applies to roofs, ceiling tiles, some countertops, and wall-covering.

Sustainability accentuates these dialects. Environmental impacts can be divided into six categories:[ii] resource use, energy use, human health and toxicity, emissions, water use, and social accountability. These impacts occur across the stages of processing, manufacturing, and using materials. Different products use widely different resources. Some require large amounts of raw materials, others are energy intensive, and still others significantly impact water resources. Each environmental impact can be subdivided into subcategories. The terminology within these subcategories is particular; but it is also similar enough that it becomes difficult to distinguish.

To create value for a manufacturer's environmentally sustainable efforts, many companies seek certification for their products in order to display an ecolabel seal on marketing materials and product packaging. Evaluating extraction, processing, manufacture, and disposal of building materials, there are dozens of certifications: Cradle 2 Cradle, GreenGuard, Nordic Swan, EU Ecolabel, and FSC are just a few. However, the number and variety of standards creates confusion. In addition, the certifications have non-descriptive and indistinguishable names, insignia and seals, and often those names and graphics are only tangentially related to what is being certified. With the exception of Energy Star and FSC, these certifications bear little name recognition except within their specific sector.[iii] The certifications often are also opaque. Manufacturers choose which criteria they wish to fulfill, and then both certifiers and manufacturers do not reveal this information publicly.

Unlike certifications that focus only on a building product, BREEAM and USGBC LEED are different: they certify an entire building. For example, LEED criteria emphasize how materials, products and systems behave in a building once they are installed, with a small number of criteria focusing upon the sourcing of building materials. Across the 110 criteria Material & Resources environmental product declaration, sourcing

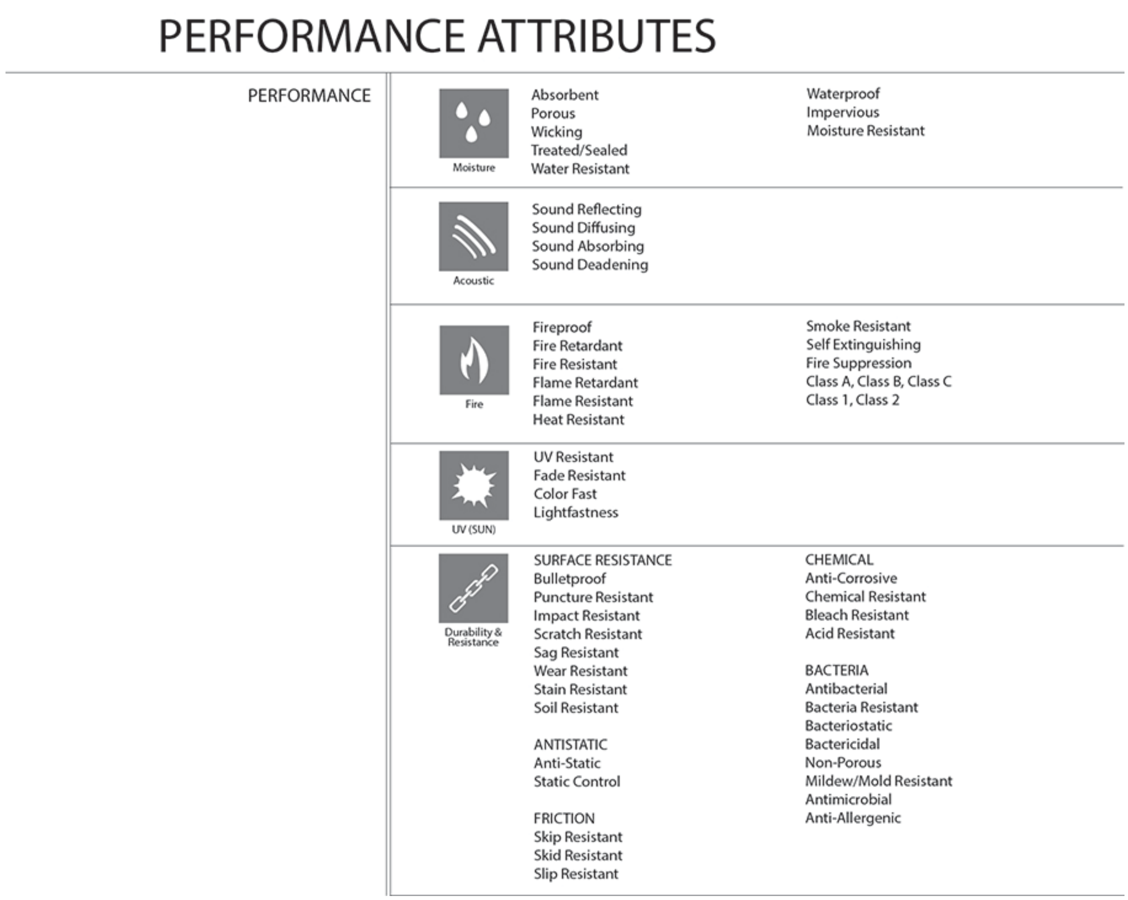

Figure 1: Performance criteria included in the model. Source: (Author 2014)

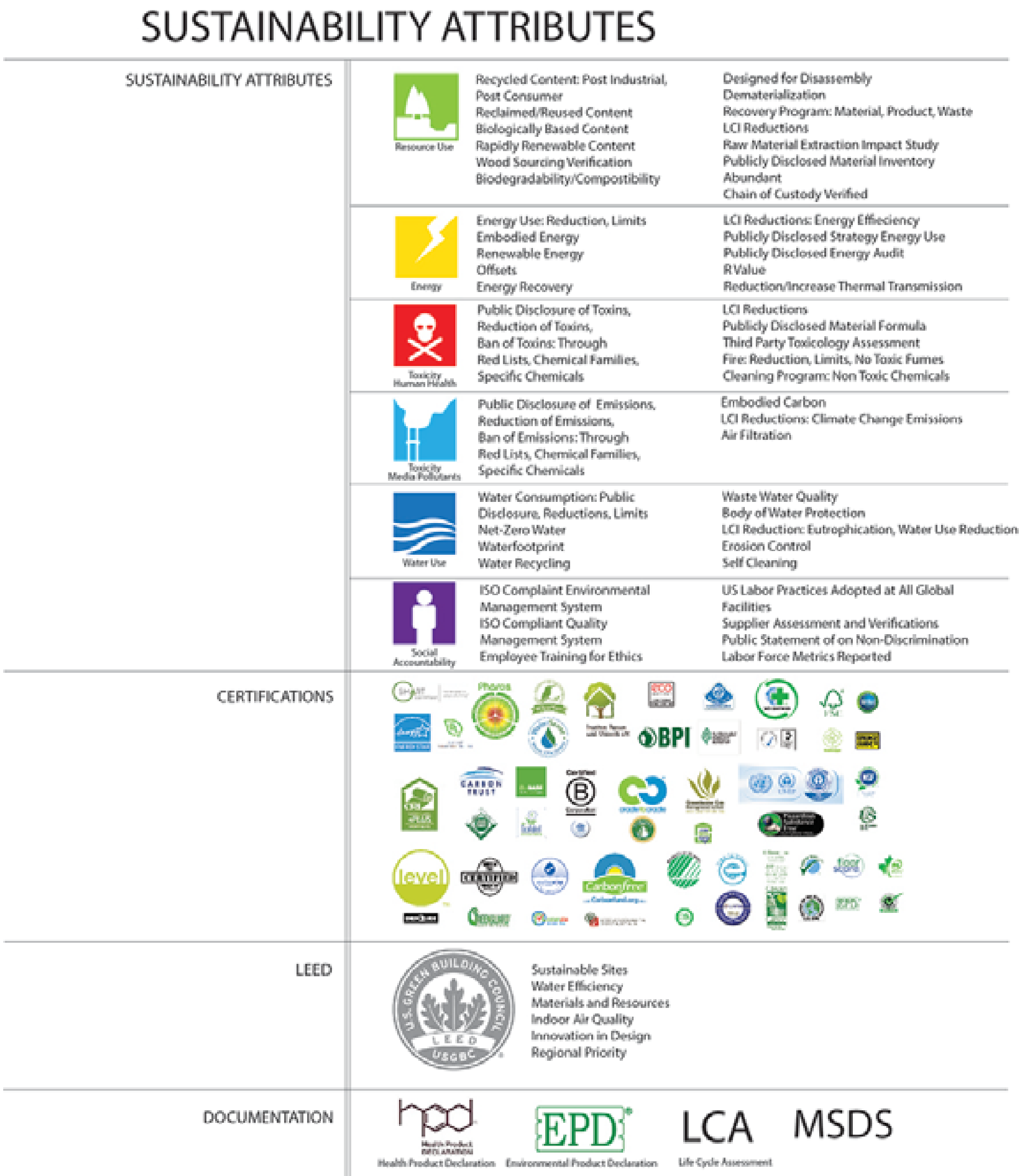

Figure 2: Sustainability criteria included in the model. Source: (Author 2014)

of raw materials, and material ingredients, and Indoor Environmental Quality Credit low emitting materials are the main credits that pertain to materials (USGBC, 2014). This is like trying to define manufacturers' efforts on sustainability through a language of nine words.

2.0 RESEARCH METHOD

In order to fully describe the building materials it was necessary to design a model for the data. We charged ourselves with the task of developing a holistic, consistent, and relevant way to present the full picture of building materials in a single platform single page format: look and feel; performance criteria; sustainability metrics; ecolabels and LEED points; and access to MSDS, health product declarations, and environmental product declarations. Performance criteria originate from building codes, ASTM standards and government directives, with nomenclature presenting itself through an analysis of building materials specifications and data.

To build the sustainability portion of the database, we aggregated the sustainability criteria from eight reputable materials sustainability certifications: Cradle 2 Cradle, SMaRT, EU Flower, Good Environmental Choice Australia, Nordic Swan, NSF/ANSI 140, BIFMA, NSF/ANSI 336. Each criterion for the certification was listed, and grouped into sub categories within the six environmental impacts categories: resource use, energy use, human health and toxicity, emissions, water use, and social accountability.[iv] These certifications were selected to most broadly represent the material sustainability certification landscape, and their criteria focus upon resource extraction, manufacturing, and end of life phases. LEED criteria, and criteria that emphasized sustainability during the performance, such as the energy efficiency measured through R value, were also added. Then as the model was populated, the initial input of materials data provided additional criteria.

To design the database, we developed a traditional, static, hierarchical taxonomy for characteristics such as material makeup, texture, and finish based upon knowledge of the sector. When describing performance and sustainability criteria, however, a heuristic method became necessary. While a selection of specifications and certifications provided the bulk of the criteria, no one source of information provided all the possible terms. Plus, additional terms became apparent as individual materials were entered. If the database was implemented as a static tool, the criteria would be limited to what existed at the time that the database was initially modeled. A dynamic environment was needed, where criteria could be added in real time, and as those criteria were added they could be made available to all the materials that had been entered previously.

We recognized that all performance and sustainable criteria could be described with the same four characteristics: a unique name for each criterion, which is common across all building material entries; whether the criterion was measureable; if it was measureable, one or more numeric (data) entries; and a list of unit(s) associated with the criterion, so that the appropriate unit of measure could be selected by the user. Depending upon the type of criterion, the database presents different subsets from the master unit list. For example, for the criterion Post-Consumer Recycled Content, a % as unit is appropriate. For the criterion Dematerialization a % (of decrease in material) and numeric entry of start date to end date, in years, is appropriate. For the criterion Embodied Energy the unit is energy unit/product unit, so for example btu/ft2.[v] Exceptions from this typical structure are toxicity and emissions. In these cases each named criteria required selection from a drop down menu of: emissions terms, redlist(s), chemical family (or families), or individual chemical(s), with each selection allowing further numeric entry and choice of corresponding unit.

The initial dataset of seventy building materials represented both interior and exterior applications. Building materials were grouped by application, such as exterior cladding or glazing. We felt it was important to represent a range of manufacturers within a given application, thereby presenting groupings of data that are more easily compared across the broader sector. Only one material per manufacturer is represented and only the data represented on the manufactures website in conjunction with environmental product declarations, life cycle analysis and health product declarations is entered into the model. No assumptions about data have been made. For instance, even though silica is locally sourced by the glass industry, regional priority is not mentioned on glass manufacturers' websites and therefore is not included in the data. In an effort to represent the range of data that manufacturers are publishing on sustainability, our selection included a preponderance of manufacturers that are considered leaders in sustainability and approximately 17% of the materials entered carry a health product declaration, environmental product declaration and/or life cycle assessment.

3.0 BIG DATA AND THE GREAT VOID

With over fifty performance criteria, and more than one hundred and fifty criteria focusing upon sustainability, our database represents the breadth of performance and sustainability criteria that exist in the sector today (see Fig. 1 & 2 for reference). With so many possibilities, the model produces information at the scale of big data. An initial input of seventy building materials yields an analysis that is most surprising in the area of sustainability: visualization of the data reveals significant voids in information. For example, even though we include a range of manufacturers who are considered leaders in sustainability in the initial dataset, no individual material presents data on more than 22 sustainability criteria, equivalent to 14% of possible criteria.[vi] The forty-four interior materials from the initial dataset yield a total of 334 data entries and the twenty-six exterior materials yield a total of 156 data entries. We calculated the percentages: for interior materials, sustainability data is published for 4.8% of the total possible criteria; and for the exterior materials that percentage is 3.8%.[vii] (See Fig. 4 & 5)

We believe there are several contributing factors. While manufacturers are releasing more data in efforts of transparency, there is still great hesitancy to reveal information on material makeup and processing. Under the shield of trade secrets, companies shroud toxic materials and processes that they are uninterested in revealing, leaving a large void within the human health and toxicity impact category. Looking across the data, it also seems that manufacturers are predominantly focused upon only what data their direct competitors reveal, and lack a broader understanding of the range of metrics that can be studied. Particularly surprising is the glass industry: the production of glass is an energy intensive process, and so it is understandable that these companies do not publish information on their energy usage. However they are also silent on water use, social accountability, energy recovery, and regional priority for their resources.

The largest disclosure of data is in the resource use impact category for interior finishes. This is consistent with the fact that the public is most likely to be involved in material selection. They have the greatest awareness of this impact category; and are therefore most likely to ask for a manufacturer's metrics in this area and respond to marketing on the subject. This impact category is also one of two places that LEED awards points for the selection of building materials. (Reference Fig. 3)

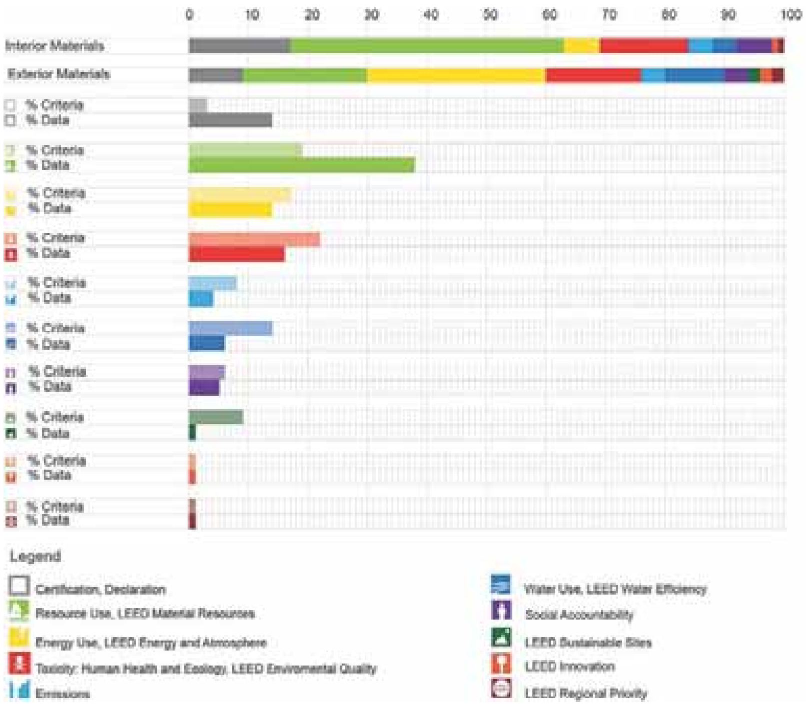

Figure 3: Distribution of both criteria and initial input data in percentages. Source: (Author 2014)

3.1. Environmental impacts

Most companies with significant biologically based makeup focus their sustainability efforts in the resource use impact category; conversely, materials with significant petroleum-based content downplay that content by presenting a broader range of data across impact categories. This seems true of the plastics industry and may partially explain the breadth of data that the carpet industry publishes. With regard to exterior materials, the greatest focus is upon sustainability through energy performance. Human Health and Toxicity presents some of the oldest and most harmonized metrics, many of which were established through legislation. Taking Human Health and Toxicity together with LEED Environmental Quality, 22% of the criteria are dedicated to this impact category – the greatest percentage among impact categories. It is interesting to note Certifications, and Resource Use each hold a smaller percentage of criteria, but our analysis shows a larger percent of data falling into those criteria. This is testament to their popularity. Water is one of the most recently implemented impact categories, and has relatively few criteria. Across the initial dataset, the ceramic tile industry and the carpet industry have the most harmonized response in reporting on water data. Social Accountability holds a relatively small percentage of criteria and data with most of the criteria rooted in applying US legislation abroad. (Reference Fig. 3)

3.2. Uptake and harmonization

Analysis of the initial dataset indicates significant patterns where harmonization occurs. For example, the carpet industry shows consistency, reporting data across nearly all impact categories. In contrast, wallcovering and upholstery companies deliver almost no information on sustainability initiatives. With regard to size, it seems that large manufacturers, such as Weyerhaeuser and Dupont, have the financial resources to test for a broad range of criteria, producing data across all sustainable impact categories. On the opposite end of the scale, a number of small companies have embraced collecting data on sustainability as a way to differentiate themselves from larger firms. A good example is Forbo and their product Marmoleum. In a few cases the data reveals direct competition between firms that have nearly indistinguishable products. A good comparison is between Metlspan and Kingspan, who have elected to both publish an Environmental Product Declaration, revealing data on nearly the same criteria. (Reference Fig. 4 & 5)

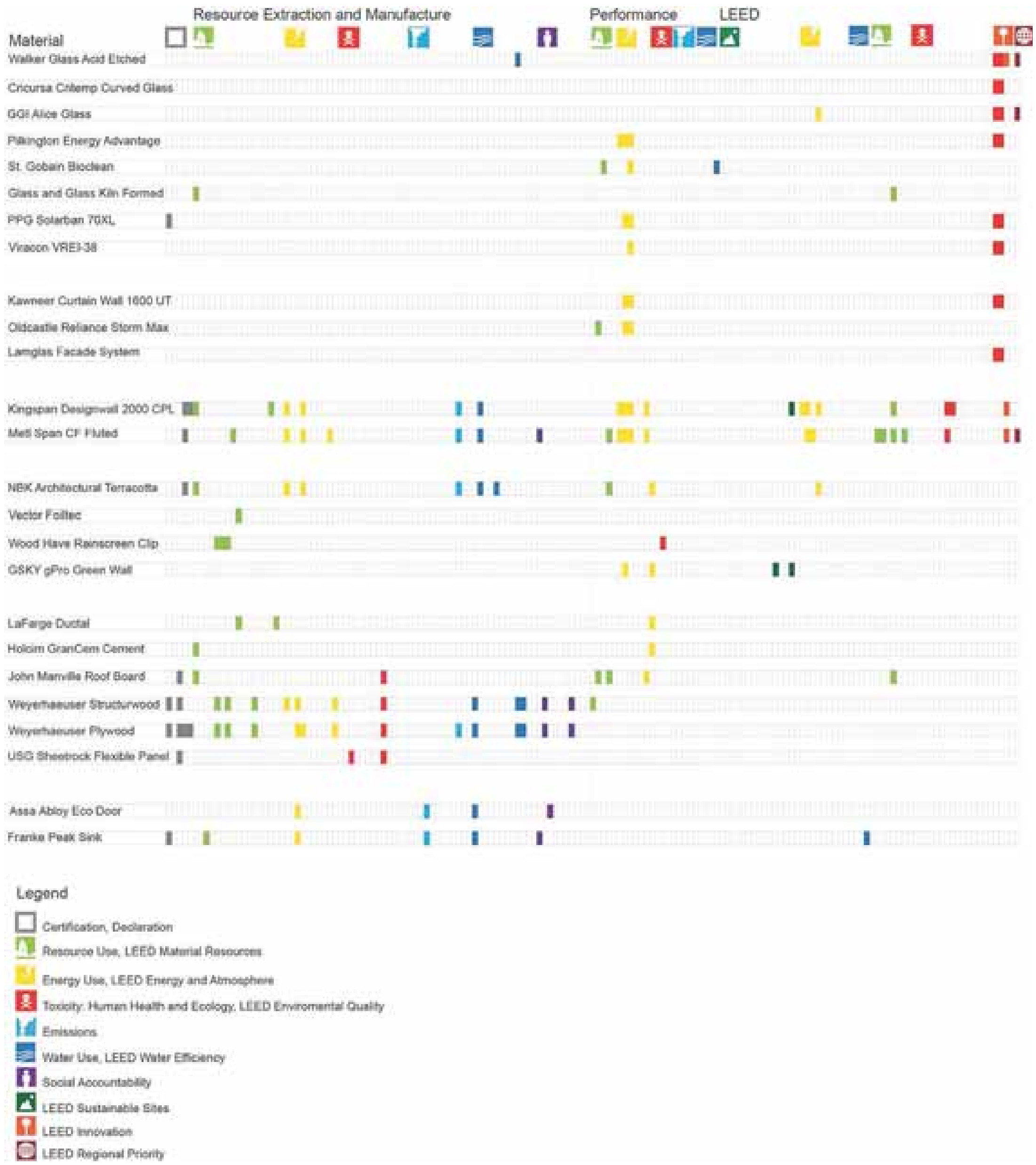

Figure 4: Visualization of the data for seventy initial materials shows every sustainability criterion for each material and whether the criterion's value is null (blank) or whether data has been entered (colored block). Colored blocks are organized as: a certification/ecolabel/declaration; environmental impact category; and/or LEED category. This figure represents analysis of data for twenty six exterior materials. Source: (Author 2014)

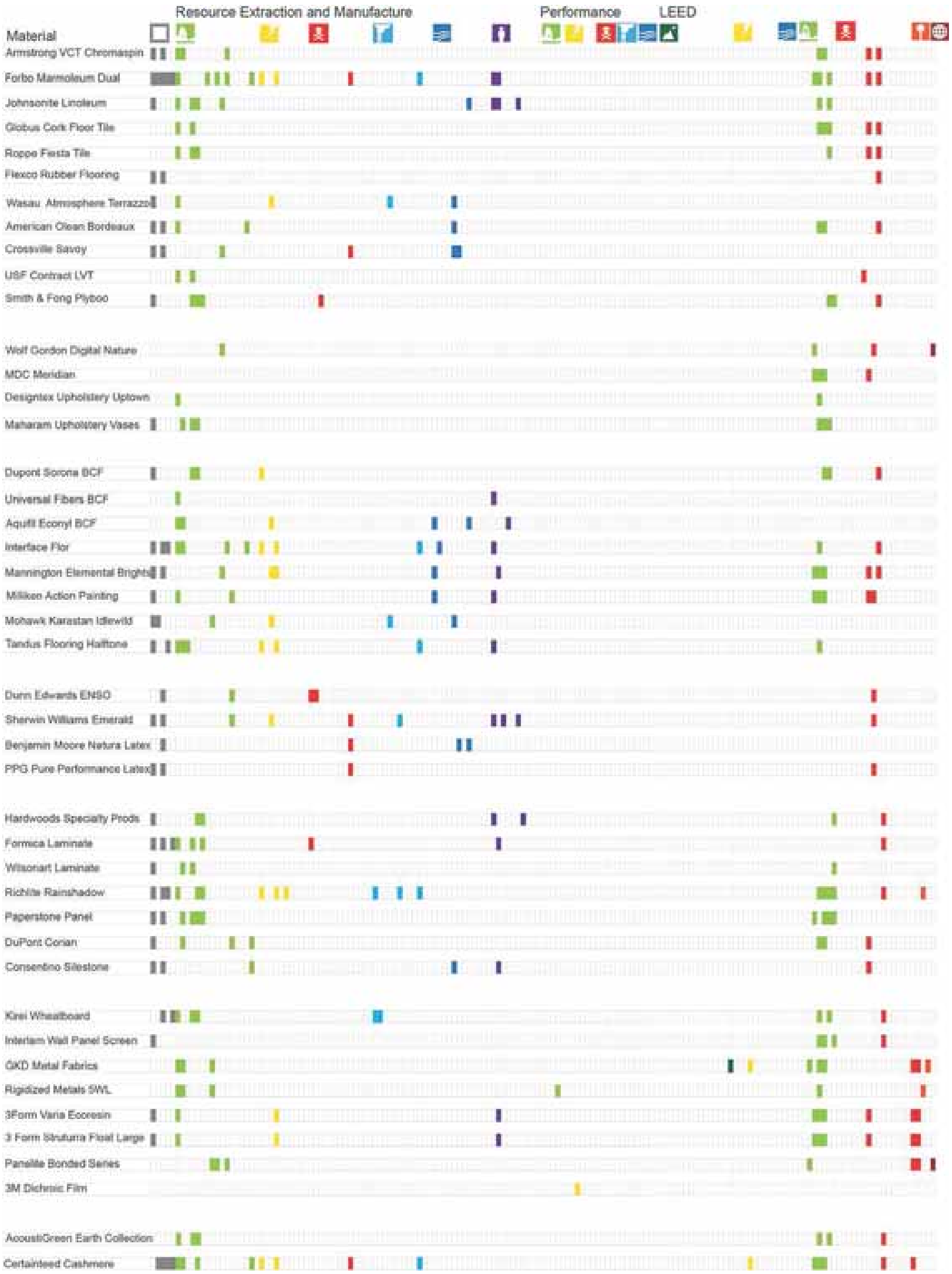

Figure 5: Visualization of input data for forty four interior materials. Source: (Author 2014)

CONCLUSION

The variation in terminology and the lack of comprehensive data across environmental impact categories seems to derive from the fact that individual industries have tailored their efforts on sustainability. This facilitates comparison of products within the same category; however, because the individual industries within the building materials sector are isolated, parallel industries seem to have little knowledge of each other's activities. It remains completely foreign that one source could simultaneously provide data on performance characteristics and sustainable impacts for a perforated metal panel system, a wood louver system, and a terracotta rainscreen.

Existing materials databases are a repository for subsets of the broad range of data available. MaterialConnexxion, material.nl, and the UT Austin materials lab provide data on material look, feel and performance, but are largely silent on sustainability. EcoScorecard offers a database of over 30,000 materials, but limits sustainability information to LEED points. BEES and Pharos go into great detail evaluating the toxicity of materials. None of these search engines produces a complete data picture, or allows for meaningful comparison across materials and industries. We have attempted the first step in that process by creating an environment where data across the sector, across lifecycle, can be compared. Instead of simplifying information, we have created a rich and dynamic network of data that provides a picture of where the sector stands within the ever changing data landscape of performance and sustainability. With over two hundred criteria, our model produces information at the scale of big data. The visualization of the information shows the tremendous breadth in distribution of data, while at the same time revealing substantial absences in data. Additionally, the visualization of the data indicates significant patterns in the report of information, and where harmonization currently occurs across the sector and through individual environmental impact categories.

REFERENCES

USGBC, "LEED for New Construction and Major Renovations (v4)," http://www.usgbc.org/credits/new-construction/v4 Accessed through download scorecard.

ENDNOTES

[i] Joel Cohen, professor of populations at Rockefeller University, states in the Academy of Arts and Sciences Bulletin "From now to 2030, the world will need to accommodate another million urban people in poor and middle-income countries every five days." Cohen, Joel, "Sustainable Cities," *Academy of Arts and Sciences Bulletin* (Summer 2008): p 10.

[ii] See Research Methods Section for method of categorization.

[iii] Partially this has to do with market saturation. Most of the individual sectors are small, and certifying a material is expensive. As of 2011, when our initial analysis was completed, SMaRT had 14 certified materials; NSF 140 had 232 materials; and Cradle2Cradle had a total of 348 certifications. As of 2014 SMaRT has 16 certified materials; NSF 140 had dropped to 61 materials; and while Cradle2Cradle lists over 2000 certified materials, there are 113 certified building supplies and materials, and 119 interior design materials and furniture, making a total of 232 materials related to the building industry.

[iv] Data based on a study completed at Washington University in St. Louis, in 2011. Eight material sustainability standards were analyzed, looking at the criteria required to achieve certification. The author was a member of the research team. Principal Investigator: Charles McManis Washington University in St. Louis, Project Director: Hannah Rae Roth, Washington University in St. Louis. Other Participants included: Dr. Charles Ebinger, Senior Fellow and Director, Brookings Institution, George Contreras Associate Professor, American University, and a team of graduate and undergraduate research assistants. This research was funded by the Brookings Institution.

[v] In the case of this example units include: energy unit/linear dimension, energy unit/area, and energy unit/volume such as btu/linear foot, btu/ft2, btu/ga; and both English and Metric units. By providing an array of units tailored to the specific criterion, data entry is greatly simplified. In addition, a user may select a specific unit type, and the database can automatically recalculate and display within that system (so English to Metric and Metric to English). This facilitates comparison between materials.

[vi] The material is Kingspan Designwall 2000 CPL. There were 159 possible criteria. 22/159=13.8%

[vii] The current dataset includes 44 interior materials. Each material has a total possible number of 159 sustainability criteria. Data is published on 334 sustainability criteria. The calculation is 334 criteria fulfilled/(44 interior materials*159 criteria per material) = 4.8%. The current dataset also includes 26 exterior materials. With 159 possible criteria for each material, we found data published on 156 total criteria. The calculation is 156 criteria fulfilled/(26 exterior materials*159 criteria per materials) = 3.8%.