CREATING AN ENVIRONMENTAL PRODUCT DECLARATION FOR SINGLE-PLY ROOFING

By Martin Grohman and Thomas Gloria

INTRODUCTION

The environmental impact of a product can be modeled and measured using life cycle assessment (LCA). LCA is governed by the International Organization for Standardization (ISO) 14000 environmental management standards (specifically, ISO 14040 and ISO 14044), under which it is defined as "an objective process to evaluate the environmental burdens associated with a product, process, or activity by identifying energy and materials used and wastes released into the environment, and to evaluate and implement opportunities to affect environmental improvements."[1] This method quantifies environmental burden over the entire lifecycle of a product, from the extraction of the raw materials to manufacturing, shipping, installation, use, and eventual disposal or recycling. The intent is to help avoid a narrow outlook on environmental impacts that could result from an overemphasis on one phase of a product's life cycle.

Since a typical LCA explores environmental impact factors in considerable depth, the full report, which is often 70 or 80 pages long, can be somewhat unwieldy in the scope of a large building project, which may involve hundreds of products and potentially hundreds of LCAs. Fortunately, ISO 14025 also defines a standardized summary document called an Environmental Product Declaration (EPD). An EPD condenses the information contained in an LCA into a more easily accessible, two- or four-page summary format.

THE RULES OF THE ROAD

In order to create consistent EPDs within industry sectors or "product categories," the ISO process also calls for the development of a product category rule (PCR). A PCR defines the applicable standards and test methods that will be referenced and the declared unit to be studied (in this case, one square meter of installed roofing), among many other factors. The PCR also provides a list of items required to be included in the EPD. Specific to the building and construction segment, ISO 21930 further dictates that environmental performance is to be measured across a minimum of five standardized impact categories: acidification, eutrophication, global warming potential, smog formation, and ozone depletion. Resource use is also measured across five categories: depletion of nonrenewable energy, depletion of nonrenewable materials, use of renewable resources, use of renewable energy, and consumption of fresh water. (Note: The LCA practice area is full of three-letter acronyms, sometimes humorously called TLAs. This can seem daunting, even to the building envelope professional well accustomed to dealing with large amounts of technical information. But have faith: This is the last significant TLA to be introduced here!)

In short, the development path for a product-specific EPD is well defined and can be summarized as:

1. Select appropriate PCR (or develop one in conjunction with industry members).
2. Complete the LCA.
3. Prepare an EPD in accordance with the chosen PCR.

SCALES OF LIFE CYCLE ASSESSMENT

LCAs can be performed on a variety of scales, from whole buildings to individual products, on subassemblies of products such as an insulated wall, or even on a single raw material. LCAs may also vary in level of quantitative rigor, from streamlined assessments to identifying "hot spots" and supporting internal engineering design choices, to extremely in-depth studies involving extensive details of the supply chain. Ultimately, the type of LCA that is appropriate is dictated by the audience that it serves and the business value that it leverages.

A common (and certainly valuable and valid) approach is to perform an LCA for an entire industry sector. However, the upcoming version of LEED®, called version 4 or v4, includes two credits that call for a product-specific LCA under which an industry-sector LCA would have a lesser impact. GAF's intent was to showcase the environmental performance of thermoplastic olefin (TPO) roofing products, but we wanted to be sure that our work would satisfy the requirements of these credits, so we chose to proceed with a product-specific LCA.

WHOLE-BUILDING LCA

What a product-specific LCA is not intended to be, somewhat surprisingly, is a way to compare the environmental efficiency of one product to another. In fact, the applicable ISO standard specifically prohibits this type of comparison.[2] Instead, the appropriate tool is whole-building LCA. Using whole-building LCA in order to compare two products or subassemblies, the designer would design two buildings containing the products, assemblies, and approaches to be considered and subsequently compare the models for the resulting buildings. In this way, a building designer can balance impact of materials while taking into account their energy efficiency, extraction, supply chain, and eventual end-of-life outcome.

OPPORTUNITY TO LEED

There has been slow but steady growth in the application of the LCA method to building products. By including two related credits in the upcoming LEED® v4, the U.S. Green Building Council (USGBC) is now providing strong incentives for manufacturers and industry associations to develop and publish LCAs and EPDs. They are also providing clarity in the process by only recognizing LCAs and EPDs prepared in accordance with the ISO standard.

LEED® v4 has been published, is now in use, and will become the only registration option for new LEED® projects as of July 1, 2015. It is the authors' understanding that a relatively small percentage of projects to date are pursuing the whole-building LCA credit. While the calculations involved may sound daunting, it could actually be argued that the whole-building LCA-related credits are among the easiest to pursue, since they require only data collection and analysis, as opposed to expensive and unfamiliar changes in construction methods or difficult compromises in product selection. As an additional plus, project teams will be able to attain credits by using permanently installed products for which third-party certified LCAs and EPDs, such as those described here, have been completed.

GREEN BUILDING PROGRAMS IN NORTH AMERICA RECOGNIZE THE VALUE OF LCA IN SUSTAINABLE DESIGN

Four green building programs in North America have incentives for designers to use LCA to guide measurable environmental improvements in new construction. The programs are all similar—designers earn compliance by showing that the final building design (core and shell) has lower LCA impacts than a reference building; typically, this would be an earlier design iteration. Conducting LCA during the design process creates an initial performance benchmark to beat, helping inform decisions as they evolve from conceptual design through design development.

- **LEED®:** Three points are available for LCA in the version 4 new-construction Materials and Resources credit, "Building Life-Cycle Impact Reduction" (option 4). The same requirements are also found in LEED® pilot credit 63.
- **Green Globes:** See New Construction (June 2013 release) – Materials and Resources Section 3.5.1.1, Path A. This is an LCA performance path option for building core and shell worth 33 points (versus 20 points for the prescriptive path).
- **IgCC:** The 2012 International Green Construction Code, Section 303, offers an LCA performance path alternative to prescriptive material requirements.
- **CALGreen:** The 2010 California Green Building Standard Code (with 2012 supplement), Section A5.409.2 has a performance path alternative to prescriptive material requirements.

Courtesy of Athena Sustainable Materials Institute.

In summary, although the process of applying for the credits may seem complex, LCA-related credits in LEED®, Green Globes®, the International Green Construction Code (IgCC), and the California Green Building Standards Code (CALGreen) are easier to attain than they look and provide a fairly clear path to success. The Athena Sustainable Materials Institute's Impact Estimator whole-building LCA tool is one way to complete this process.

ADDRESSING DATA GAPS

While LCA has been in fairly widespread use in the building products marketplace, to the authors' knowledge, no product-specific EPDs have previously been published within the single-ply roofing sector. Plus, according to Athena Sustainable Materials Institute President and CEO Jamie Meil, the Impact Estimator database did not contain any reliable primary data for TPO prior to this study. This is a notable gap that creates problems when modeling the life cycle performance of buildings.

Additionally, completing LCAs on its single-ply products allows GAF to build on its commitment to developing practical knowledge of life cycle environmental impacts in the roofing industry and improving the sustainability of its products and operations. As an additional incentive, since a comprehensive LCA is a thorough look at energy, water, and materials (even considering items down to the level of extruder gearbox oils) it may serve (although this is not its stated intent) as a review of manufacturing, procurement, and recycling processes. This provides the kind of valuable lens to identify areas for improvement that any leading manufacturer is looking for.

And, of course, completion of the LCAs enable publication of the associated EPDs, the construction industry equivalent of

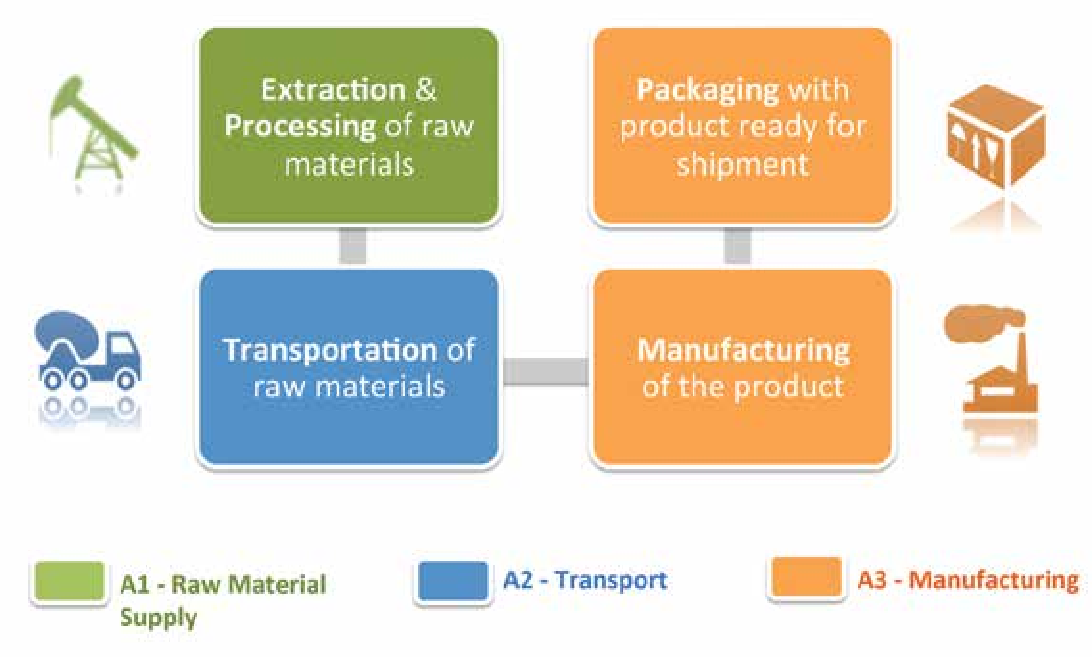

Figure 1 – System boundaries from extraction and processing of raw materials to manufacturing.

"eco-labeling." EPDs help provide verifiable and accurate information on environmental impacts, helping customers assess a product's performance in a whole-building context. Straight from the ISO 21930:

> The overall goal of environmental declarations is to encourage the demand for, and supply of, building products that cause less stress on the environment, through communication of verifiable and accurate information on environmental aspects of those building products that is not misleading, thereby stimulating the potential for market-driven, continuous environmental improvement.

Previous work within the membrane and single-ply roofing category has been instructive and guided our process. Of particular note is an LCA conducted by the EPDM Roofing Association in 2009. However, this work had some fundamental omissions that our work sought to address. It can be said that this LCA was a useful step in the right direction but may be worthy of an update to meet the requirements of the ISO process (and thus create LEED-credit eligibility).

Considering all these factors, GAF undertook to complete an LCA and publish a product-specific EPD for EverGuard and EverGuard Extreme TPO, both single-ply thermoplastic polyolefin roofing products. The LCA should be ISO-conformant and readily integrated into a whole-building assessment tool (e.g., Athena's Impact Estimator or KT Innovations' Tally tool), support a verified EPD by a reputable operator (e.g., ASTM, NSF International, or UL Environment), and satisfy the requirements of LEED® version 4.

We chronicle the process here in hopes of clarifying and explaining it and putting the resulting data into more widespread use.

DEVELOPMENT OF THE PRODUCT CATEGORY RULE

As discussed, the ISO process mandates the development and use of an industry document called a product category rule or PCR. In the case of single-ply roofing, there was no published PCR. In this case, it was possible to complete an LCA, but since the PCR provides the guidelines for the EPD, it would not have been possible to publish an associated EPD.

Industry recognition of this fact led to a call for development of a PCR for single-ply roofing, and the process was undertaken and led by the Single Ply Roofing Institute (SPRI), with ASTM acting as the "program operator." In this role, ASTM provided technical expertise and published the finished PCR for public use.

The industry is to be commended for a collaborative, timely effort. The SPRI PCR team was very capably led by Stan Graveline of Sika-Sarnafil, who was assisted by SPRI Technical Director Mike Ennis along with a committee consisting of a wide cross section of representatives of SPRI membership companies.

CALLING IN THE PROFESSIONALS

LCA work can be complex. There are multiple considerations, including the type of software used for modeling, proper preparation of the data for third-party review, and proper interpretation of the ISO standards. With limited in-house LCA capability and capacity and seeking the credibility of a third-party expert, GAF turned to Meister Consulting Group (with whom we had previously worked on carbon footprint projects), together with its LCA partner, Industrial Ecology Consultants. As one of the first LCA specialists to develop a business in the U.S., Industrial Ecology Consultants has practiced in the area of LCA since 1995. The company specializes in performing LCAs and producing EPDs and was invaluable in guiding the process.

CONDUCTING THE LCA

In order to meet the requirements of the PCR, we needed to cover the following items in the LCA study:

- Extraction and processing of raw materials, including fuels used in product production
- Average or specific transportation of raw materials (including recycled materials) from extraction site or source to manufacturing site (including any recovered materials from source to be recycled in the process) and including empty backhauls
- Manufacturing of the product
- Packaging with product ready for shipment
- Average or specific transportation from manufacturing site to recycling/reuse/landfill for pre-consumer wastes and unutilized byproducts from manufacturing, including empty backhauls
- Recycling/reuse/energy recovery of preconsumer wastes and byproducts from production

In order to make the resulting LCA applicable to the widest possible range of users, we set the LCA boundary as "cradle-to-gate." This means the study included all of the production stage activities, from extraction of raw materials ("cradle") through the manufacture of the products, packaged and ready for shipment (factory "gate"). See *Figure 1*.

SYSTEM BOUNDARY OF THE ASSESSMENT

The next step was to start collecting the data into one central repository, commonly referred to as the life cycle inventory (okay, one more acronym—LCI). The LCI is a catalog of all of the inputs and outputs to make a product, a kind of a summary data table. It's often most useful when compiling formulations with multiple ingredients, such as resins, pigments, and the like. We were fortunate to be able to rely on our talented technical staff to provide the detailed information on material quantities and flows, energy requirements by source (electricity, natural gas, and fuel oil), and process efficiencies (wastes, recyclates, and byproducts generated) needed to prepare the LCI. (Material inputs are tracked at the product level in the form of company confidential formulations and supplier sources, none of which needs to be reported externally in the LCA process under the ISO guidelines, although it is, of course, checked for validity by the third-party reviewers.)

Energy consumption, however, is not typically tracked at the product level, but rather at the plant level. So energy consumption on a per-product basis must be calculated and allocated. Typically, one resolves this issue by normalizing energy consumption based on a physical factor. In this case, using methodology outlined in the PCR, we allocated energy usage based on the weight of the product on a per-unit basis. The last major item—wastes and recyclates generated—was already tracked on a per-product basis as part of the Underwriters Laboratories (UL®) landfill diversion certification held by the manufacturing plants, making this an easy factor to catalogue.

In addition to the direct input materials, to complete the LCA, one needs to identify best representative industry average datasets for the raw materials and their subcomponents (using the LCI data for the raw materials). Fortunately, for this product, the number of ingredients is fairly manageable, consisting of TPO (the main ingredient of the product), fire retardants, UV absorbers, pigments, and, of course, the packaging components—cardboard core, wooden pallets, and stretch wrap (linear low-density polyethylene [LLDPE]). *Figure 2* shows how the packaging breaks downs for each declared unit.

Packaging Material	50 Mil	60 Mil	70 Mil	80 Mil
Cardboard Core	0.068 kg	0.068 kg	0.068 kg	0.068 kg
Wooden Pallet	0.027 kg	0.027 kg	0.022 kg	0.022 kg
LLDPE Film	0.004 kg	0.004 kg	0.004 kg	0.004 kg

Figure 2 – Packaging materials.

LIFE CYCLE IMPACTS

Atmosphere & Water		50 Mil	60 Mil	70 Mil	80 Mil
Climate change	kg CO_2 eq	3.3	3.8	4.4	5.2
Acidification	kg SO_2 eq	0.015	0.017	0.019	0.022
Eutrophication	kg N eq	0.004	0.005	0.005	0.006
Smog	kg O_3 eq	0.16	0.19	0.21	0.24
Ozone depletion	kg CFC-11 eq	6.1×10^{-8}	7.0×10^{-8}	8.2×10^{-8}	9.6×10^{-8}

Declared Unit: 1 m^2

Figure 3 – Life cycle impact assessment results.

PREPARING FOR WHOLE-BUILDING LCA

The Athena Sustainable Materials Institute is the only entity offering a free, accessible, and credible tool to conduct whole-building assessments. As mentioned above, this tool is called Impact Estimator. The software's inherent LCA methodology, cradle-to-grave system boundary, and inventory datasets are compliant with several green program requirements, which means users don't have to fret about using the tool to satisfy whole-building LCA credits. From our vantage point, by producing the entire LCA within its ISO-compliant proprietary database, we were able to pass on the model to Athena with little extra effort. This saved critical time and resources and smoothed the integration process. From Athena's perspective, they were able to update their Impact Estimator tool for single-ply roofing components with verified data in conformance with an industry-accepted method.

As of this writing, EverGuard and EverGuard TPO are the only single-ply roofing products included in the Impact Estimator Whole-Building Life Cycle Assessment tool.

MODELING THE IMPACT RESULTS

Once the main inputs and outputs of the product are identified and quantified, the raw materials assigned to the LCI datasets, and the LCA software and database selected, the initial model is then built by an LCA practitioner (in this case Industrial Ecology Consultants). Once this model is completed and goes through the quality assurance process, the life cycle impact assessment results are produced and tabulated.

The PCR dictates that results need to be indexed to a declared unit—in this case, one square meter of single-ply roofing membrane. We then calculated results for a variety of standard thicknesses (50-, 60-, 70-, and 80-mil) across standardized impact categories as shown in *Figure 3*.

MORE ON DECLARED UNITS

The determination of the declared unit (the unit to be studied in an LCA) as one square meter rather than the more familiar "square" (a 10-ft. x 10-ft. area) was based on the PCR, which calls for SI units to be used. There is some momentum within the LCA industry to use units that are more familiar to the U.S. practitioner, but for now, one can multiply the results by 9.2903 to achieve a 1-square equivalent.

THIRD-PARTY REVIEW

In accordance with the applicable ISO standards (ISO 14040, ISO 14044, ISO 14025, and ISO 21930) and the PCR, independent third-party review of the LCA is required. The purpose of this step is to review the data for completeness and accuracy and verify its suitability for use by industry colleagues and fellow practitioners. Having worked extensively with NSF International as a verifier on previous product certifications and working on a tight deadline, they were a natural choice for this role.

Fortunately, since we had followed the guidelines of the PCR closely, the peer review process was fairly straightforward, and with the exception of the addition of a few items of supporting documentation, the LCA was found to be in conformance with the applicable standards and the PCR. With the completion of this external review step, we were ready to produce the EPDs.

PRODUCING THE EPDs

As mentioned above, what is required in the EPD is detailed in the PCR. Some information not included in the LCA is called for in the EPD, such as product part numbers and a listing of applicable technical standards and proof of conformance. However, beyond a clear listing of required information, there is no standardized format for an EPD, and it can be done either using the third-party reviewer's supplied template or one to the manufacturer's liking. We chose to produce our own format for our EPD for reasons of style; at just two pages long, we wanted to keep the EPD short, to the point, and light on graphic fluff. The published EPDs on EverGuard® and EverGuard Extreme® may be found on NSF's website, nsf.org.

SUMMARY AND CONCLUSIONS

Conducting an LCA can be an arduous task, but the rewards are well worth the effort. As GAF looks to the future of building products, LCA provides a means to develop products that are verifiably better for the environment across a wide range of measures and that do not overemphasize the reduction of one environmental impact category at the expense of another. Additionally, an LCA provides accurate information on the environmental performance of a product in a whole-building context that is third-party verified.

Preparation of the data for use by a whole-building LCA tool is essential to compare one product system to another. Athena's Impact Estimator is one tool that provides this computational context.

LEED® v4 seeks to provide incentives for publishing environmental impact data and does so by including three entirely new paths to obtaining credit points: inclusion of products with published LCAs, published EPDs, and the completion of a whole-building LCA. These credit paths are fundamentally supported by conducting standardized LCAs of a manufacturer's products.

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FOOTNOTES

1. ISO 14040/44
2. ISO 21930 and ISO 21931-1

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