EPD-ENVIRONMENTAL

PRODUCT DECLARATIONS FOR WOOD PRODUCTS—AN APPLICATION OF LIFE CYCLE INFORMATION ABOUT FOREST PRODUCTS

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ABSTRACT

Transparent and credible environmental labeling of products is vital for a sustainable future. Ecolabeling shows information on the environmental performance of products, processes, and services. This article focuses on one type of ecolabeling referred to as environmental product declarations (EPDs) that provide environmental impact information based on life cycle assessment (LCA) data. Businesses and consumers who are not familiar with life cycle analysis can use LCA-based EPDs for comparison between competing products, much like using nutritional labels. In addition, this article describes the process of developing EPDs from LCA data in conjunction with product category rules and the status and future needs of EPDs in the U.S. forest products industry.

INTRODUCTION

Environmental product declaration (EPD) is the term that is used to describe a summary of the environmental impacts associated with producing and using a product or service. An EPD is based on a life cycle assessment (LCA) and can be used to compare products on an equal basis. EPDs are meant to communicate standardized LCA information in a way that is meaningful to people who may not be familiar with LCA.

EPDs are a recent development and are being promoted as a way to improve the quality, credibility, and transparency of environmental impact information available to consumers and businesses. Several countries are today considering requiring EPD documentation in

international trade. Should one or more key trading partners move to require EPDs for products sold within their borders, developing and maintaining the mechanisms for writing EPDs, and the supporting LCA data, could become important for maintaining access to global markets.

This article briefly describes the purpose and history of EPDs and outlines the EPD development process with a focus on wood products. The need for a consistent and concerted effort to develop EPD processes and data is highlighted.

LCA AND EPDs

Life cycle assessment is a growing area of research and is of increasing interest to policy makers and consumers. LCA can be done on products, processes, and services and can be used for various purposes such as identifying "hot spots" of environmental impacts within a manufacturing process or product life cycle. LCAs provide life cycle inventory data (such as emissions of CO, CO_2, and CH_4) and life cycle impact assessment data (such as global warming potential) on a per unit product basis through the life cycle of a product or process. Although LCAs provide the foundation for assessing the environmental performance of products and processes, LCAs are poorly suited for communicating the results to consumers or businesses that are not experienced in life cycle analysis (Schmincke and Grahl 2007).

The Consortium for Research on Renewable Industrial Materials (CORRIM), based in North America, has produced considerable LCA data on wood products, including comparisons of wood products with non-wood alternatives (Lippke et al. 2004, Puettmann and Wilson 2005, Puettmann et al. 2010). People familiar with wood research, including readers of this journal, may be well acquainted with these studies; however, the general public is not. EPDs provide one way for non-specialists to become informed about the life cycle environmental impacts (and advantages) of wood products.

Because EPDs are based on LCA, they have some of the same weaknesses of that methodology. These include the static (snapshot in time) nature of the evaluation, the burden of data collection and analysis and the potentially large importance of underlying assumptions such as product geographical source and the allocation of environmental burdens to co-products. However, the LCA and EPD development processes are transparent, so these potential weaknesses should be readily apparent, and the significant data demands reflect the effort to base the evaluation on objective measurements.

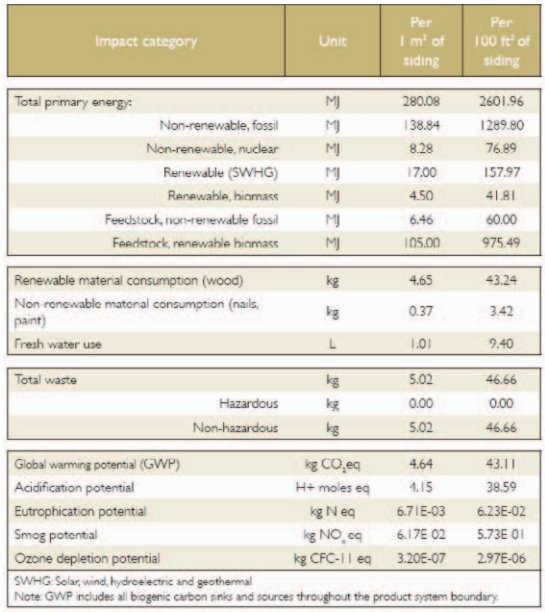
EPDs ARE ECO-LABELS

Ecolabels help consumers take a product's environmental impacts into account when shopping. The International Organization for Standardization (ISO) defines three types of ecolabel (Table 1; ISO 14020) (ISO 2000). Type I

Table 1. Types of eco-labels

Eco-label	Characteristics	Example
Type I	Products that have been third-party verified to be preferable with regard to a particular attribute or set of attributes (ISO 1999b)	
Type II	Claims are made by the producer but are not independently verified or supported by LCA (ISO 1999a)	

Table 1. Types of eco-labels, cont.

Eco-label	Characteristics	Example
Type III	A standard set of data based on LCA that must be third-party verified if directed to consumers. These labels may or may not include comparisons with other products (e.g. value ranges)	

Impact category	Unit	Per 1 m² of siding	Per 100 ft² of siding
Total primary energy:	MJ	280.08	2601.96
Non-renewable, fossil	MJ	138.84	1289.80
Non-renewable, nuclear	MJ	8.28	76.89
Renewable (SWHG)	MJ	17.00	157.97
Renewable, biomass	MJ	4.50	41.81
Feedstock, non-renewable fossil	MJ	6.46	60.00
Feedstock, renewable biomass	MJ	105.00	975.49
Renewable material consumption (wood)	kg	4.65	43.24
Non-renewable material consumption (nails, paint)	kg	0.37	3.42
Fresh water use	L	1.01	9.40
Total waste	kg	5.02	46.66
Hazardous	kg	0.00	0.00
Non-hazardous	kg	5.02	46.66
Global warming potential (GWP)	kg CO_2 eq	4.64	43.11
Acidification potential	H+ moles eq	4.15	38.59
Eutrophication potential	kg N eq	6.71E-03	6.23E-02
Smog potential	kg NO_x eq	6.17E-02	5.73E-01
Ozone depletion potential	kg CFC-11 eq	3.20E-07	2.97E-06

SWHG: Solar, wind, hydroelectric and geothermal
Note: GWP includes all biogenic carbon sinks and sources throughout the product system boundary.

An excerpt from a BtoC EPD for western redcedar siding (FPInnovations 2011)

declarations identify products that have been third-party verified to be preferable in that they have a certain set of attributes (ISO 14024) (ISO 1999b). Green Seal and the Energy Star are examples of type I declarations. Type II declarations are claims made by the producer that are not independently verified (ISO 14021) (ISO 1999a); the Mobius Loop recycling symbol is a visual example of an environmentally related unsubstantiated claim. Type I and type II declarations do not require LCA data.

An EPD is a type III environmental declaration: it provides a standard set of data (not recommendations) that must be third-party verified if directed to consumers (ISO 14025) (ISO 2006c). The familiar nutrition label is similar to a type III ecolabel in that it contains standardized information that is third-party verified. Where a nutrition label lists calories, fat, and fiber content of food, an EPD might list several environmental impact measures, such as the following:

- *Embodied energy*—Total energy required to make a product, including raw material growth or extraction, through processing and transportation
- *Global warming potential*—A function of all the greenhouse gases produced during the life cycle and their relative potential to contribute to warming
- *Acidification*—Total release of chemicals to the air that can result in acid rain (such as sulfur oxides).

EPDs are intended for public distribution and should provide a transparent and credible basis for product comparison, based on LCA data. EPDs have requirements to facilitate consumer understanding of the data found within the EPD (ISO 2006c). An EPD can be either "business-to-business" (BtoB) or "business-to-consumer" (BtoC), depending on the use. Most EPDs are categorized as BtoB. BtoB EPDs give LCA information on environmental inputs and outputs up to the end of the manufacturing process but the EPD itself does not need to be third-party verified. BtoC EPDs give LCA information on environmental inputs and outputs on manufacturing and through application in end use and to final disposition after use (such as recycling, burning, and landfill). BtoC EPDs must be third-party verified.

NEED FOR EPDs

Organizations may develop EPDs to provide consumers with science-based disclosures of their product's environmental performance and to counter green-washing (TEM 2009, 2010)—the act of incorrectly stating environmental impact information when selling a product or service. Terrachoice Environmental Marketing found that false or misleading environmental impact information is the norm, with 95% of consumer products in 2010 violating one of their seven "sins" of green-washing (TEM 2010). An example is the "Sin of No Proof" for papermaking, when companies claim a certain percentage of post-consumer recycled content without providing evidence that is easily substantiated or that has third-party verification.

Another reason to develop EPDs is to maintain market access (Schenck 2009, Bowyer et al. 2011). The United States exports wood products to countries, such as France, that are starting to require EPDs or a sub-set of EPDs for products sold in their countries.[1] The Federal Trade Commission has developed *Guides for the Use of Environmental Marketing Claims*, known as "Green Guides," to assist manufacturers when they make claims about the environmental impact of their products (FTC 2010). However, the Green Guides are focused on domestic law and do not address potential requirements by, for example, the European Union. Also, unlike EPDs, the Green Guides do not require third-party verification, and this weakens their potential international influence. For these reasons, there is increasing demand to develop a framework for producing EPDs in the United States that will satisfy growing domestic and international demands for credible environmental impact information about wood and other products.

LCA studies consistently show that wood products are better than alternative materials in terms of environmental impacts (e.g. Puettmann and Wilson 2005). However, this information is not well understood by the public, nor is it well reflected in some "green building" efforts. EPDs could provide a way to communicate the environmental benefits of wood to consumers. EPDs could relatively easily be incorporated into purchasing preference programs and green building rating systems. For example, if EPDs for cedar and vinyl siding were available, the smaller global warming potential of the wood siding product would be readily apparent to a potential specifier or building impact evaluator.

DEVELOPMENT PROCESS FOR EPDs

Underlying an EPD is a life cycle assessment that follows ISO standards 14040 and 14044 (ISO 2006a,b; Schmincke and Grahl 2007). The general guidelines for all environmental labels and declarations are found in ISO standard 14020 (ISO 2000). The relevant standards for developing EPDs are ISO 14025 (ISO 2006c) and ISO 21930 (ISO 2007). ISO 21930 was prepared specifically for the construction industry. Figure 1 details the basic steps in developing an EPD.

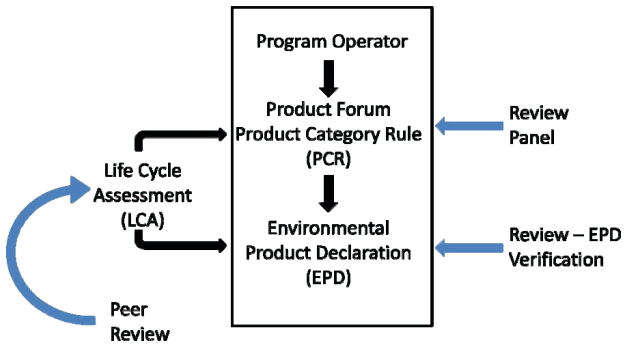


Figure 1. The basic steps in developing an EPD. Peer review of the LCA is required for a business-to-consumer EPD and is recommended for a business-to-business EPDs.

The EPD process starts with the establishment of a program operator. A program operator is the individual or organization that develops the product category rules (PCRs) or procedures that govern development of an EPD (Bolon and Fujihira 2006, ISO 14025). Program operators

[1]France has pushed back their original 2011 implementation time frame for requiring EPDs for commodity products sold within their borders. Personal communication with Annie Prigge, National Resources Canada, February 15, 2011

are normally an interested party that can, but may not necessarily, develop the EPD itself. An example of a program operator concerned with wood products is FPInnovations, a large wood research institute in Canada that is funded by industry and government. The program operator designation for FPInnovations was established in January 2011. Other examples include the German Institute for Construction and the Environment (IBU) (established in 2007), Norwegian EPD Foundation (established in 2002), and the Korean Environmental Declaration program (EDP, Environmental Declaration of Products) (established in 2001).

Anyone can become a program operator; however, the organization or individual must first develop and publish general program instructions in accordance with international standards. These instructions cover the basic process and procedures, as highlighted in Table 2.

Although the list in Table 2 is lengthy, the actual development is not especially difficult. The final step is to have the program instructions reviewed by a stakeholder group. Stakeholder groups may include representatives from industry, academia, government, and environmental non-governmental organizations (NGOs). Again, this need not be an onerous process, and there is no requirement for consensus.

Table 2. Components of the General Program Instructions, with examples from the FPInnovations EPD Program on Wood Building Materials (www.forintek.ca)

Component	Example
Scope	The program will develop and publish type III environmental declarations for wood products manufactured in North America.
Compliance with standards	EPDs developed under this program will comply with international standards for type III environmental product declarations, namely, ISO 14025 and ISO 21930, and underlying LCA data will comply with the ISO 14040 series.
Objectives	Establish and implement the necessary process(es) for developing credible, comparable, and consistent EPDs.
Audience	The program will develop EPDs for both business-to-business and business-to-consumer applications.
PCR development and review	For each PCR developed, the program will establish a unique and qualified panel. The panel shall ensure PCRs are developed in accordance with ISO standards. Mandatory elements in PCR are listed in the program rules.
LCA information conformance	Ensure LCAs used for EPDs are completed in accordance with the finalized PCRs for the product categories under consideration.
EPD verification	FPInnovations will seek third-party verification of all EPDs even when not mandatory. This includes a review of data accuracy and conformance with the PCR and with ISO standards.
Data confidentiality management	For data other than that published in an EPD, the program operator will maintain data confidentiality when required by EPD clients.
Public access	Post via internet lists and records of PCR documents and EPD.
Disclosure of funding sources & other	Make available upon request.
Use of the EPD and Program logo	Provide written consent from FPInnovations to use information from published EPDs.
Program review	Program rules to be reviewed at least once every three years.

PRODUCT CATEGORY RULES (PCRs)

PCRs are a more detailed and specific set of procedures, defining the product category and including requirements for the LCA that provides the basis for an EPD. As shown in Table 3, the PCR will address considerations such as the following:

Table 3. LCA requirements for the basis of the PCR

PCR components	Description	Examples from wood products
Functional unit	The product, its function, and the quantity that will be referred to regarding environmental inputs and outputs	A cubic meter of installed wood product
System boundaries	Processes that will be considered within the life cycle of the product	Growing trees to product disposal at end-of-life
Cut-off rules	Guidelines for deciding which inputs and outputs can be ignored	Materials that are less than 1.0% of cumulative mass flow
Allocation rules	How environmental burdens are assigned to multiple products from the same process	Burdens assigned to co-products (e.g. sawdust) by mass
Data quality requirements	Which sources of information will be used and how the EPD will be verified	Seconday data (e.g. from CORRIM literature) newer than 10 years
Indicators	Which environmental impacts will be considered and how they will be distilled from the raw data	Fossil carbon emissions

Under international standards, existing PCRs should be used if possible. Once adapted to reflect any product or jurisdiction specifics, a PCR is verified by a small panel, with a chair and two panel members at a minimum. It must also undergo an open consultation process during which interested parties have an opportunity to comment. The review panel then responds to any comments. For example, FPInnovations (Vancouver, BC), the program operator, is in the process of developing PCRs for North American structural and architectural wood products. FPInnovations has based development of North American PCRs on ones developed by the Norwegian EPD Foundation and the IBU.

The LCA–PCR link is critical, with the final LCA on which an EPD is based having to conform to the PCR requirements. Because of this linkage, the ISO standard 14025 for EPD development states that one or more LCAs should serve as the basis for, and be referenced in, a PCR (section 6.7.1, ISO 2006c). This is intended to harmonize the EPD programs being developed around the world.

EPD VERIFICATION

An EPD must be independently verified when it is used for business-to-consumer communication, and a verifier must therefore be identified and

retained. In general, the verifier confirms that the LCA has been done in accordance with the PCR, that all of the required documentation is in place to make the EPD transparent, and that the underlying PCR meets international standards.

EPDs are created by following the requirements dictated by a specific PCR document. For example, an EDP created from a basic PCR module "*Products of wood, cork, straw and plaiting materials*" developed by International EPD® (www.environdec.com) includes the following requirements. Additional information outside a typical LCA may be required.

- Input parameters—Non-renewable resources, renewable resources, water use, electricity consumption
- Potential environmental impacts—Greenhouse gases, ozone-depleting gases, acidification gases, gases contributing to ground-level ozone
- Other indicators—Material subject for recycling, hazardous waste, toxic emissions, substances to water contributing to oxygen depletion

EPD verification is only one of the required reviews that are designed to ensure the transparency of the process and the credibility of the results. As mentioned above, the proposed PCR is reviewed by a panel and opened to stakeholder comment. The life cycle data and analysis used for an EPD are also peer reviewed.

HISTORY OF EPDs

Using the results of LCA to create environmental labels has been under development since about 1990 (Banerjee and Solomon 2003, Salzman 1991). In 1993, Davis prepared a U.S. Environmental Protection Agency (EPA) study on the prevalence of LCA techniques in the creation of independent third-party environmental labeling programs. The study found a number of countries using labeling programs with different methods.

Sweden and Japan have been at the forefront of efforts to bring LCA from research to practical application. In 1999, the first registered EPD in Sweden was published on water taps, and this was followed by EPDs on electrical appliances and other products. The International EPD® system (www.environdec.com) maintains an open-access database that contains many EPDs, including several for wood and paper products.[2] In Japan, the EcoLeaf program (www.jemai.or.jp/english/ecoleaf) was started in 1999 and created its first PCR, the precursor to an EPD, in 2002.

Later in the 2000s, a number of European countries, including Germany and Norway, developed EPDs for construction products (Fet and Skaar 2006). The need to harmonize these efforts led the European Committee for Standardization to establish a Technical Committee (CEN TC 350—Structures) to prepare ISO standards for EPDs, including 14025 (2006c) and 21930 (2007) (Schmincke and Grahl 2007).

UL Environment (www.ulenvironment.com) is a company that provides environmental services to industry and others. They initially began producing type I declarations in fall 2009. As of January 2011, UL Environment became a program operator, intending to provide type III EPDs for building products to help builders, architects and purchasing agents wanting greater transparency on environmental inputs and outputs for products they specify.[3]

CURRENT STATUS OF EPDs

A number of European nations, and France in particular, are developing sustainability initiatives that will encourage or eventually require companies to create EPDs for their products. France announced a target in 2008 to implement EPDs by January 2011 for commodity products sold within their borders, a deadline that has since been pushed back. The French initiative followed actions by the Commission of the European Communities (CEC 2008) to develop an industrial policy action plan with the goal of improving environmental performance of products while

[2] http://www.environdec.com/en/The-EPD-system/
[3] Paul Firth, UL Environment, February 18, 2011

promoting consumer understanding of these improvements. These initiatives encourage environmental labeling as a mechanism for demonstrating compliance.[4] In addition, Germany, through the Institute for Construction and the Environment has become involved in developing building product EPDs (Tobias 2010). Sweden, where the International EPD® system was developed, is a member of the Global Type III Environmental Product Declarations Network (GEDnet). GEDnet's (gednet.org) objective is to support information exchange between type III EPD programs following ISO 14040-series standards. Other GEDnet members include IBU, the Japan Environmental Management Association for Industry, and the Korean EDP and Carbon labeling program.

In the United States, Executive Order 13514 (EO 13514: *Federal Leadership in Environmental, Energy, Economic Performance* (2009) states that federal agencies must improve efforts toward sustainable buildings and set targets for greenhouse gas reduction.

EPD STATUS IN THE UNITED STATES

North America trails Europe and parts of Asia in developing the infrastructure for developing EPDs. Environmental NGOs have been some of the first organizations to become involved with environmental declarations in the United States (Curran 1997). The Earthsure Program, established in 2005 as the first EPD Program in the United States, is a program of the Institute for Environmental Research and Education (IERE). IERE is also developing a PCR for windows, with funding from the National Renewable Energy Laboratory. Another IERE program, the American Center for Life Cycle Assessment (ACLCA), recently formed a National Product Category Rule Repository to collect PCRs for products produced in the United States; to this point, however, the repository remains empty (www.aclca.org).

As mentioned above, FPInnovations recently became a program operator and has developed the first PCR and EPDs for wood products in North America. CORRIM has produced considerable life cycle data that can be the basis for such wood product EPDs. The CORRIM data sets are fully compliant with ISO 14040 and 14044 standards (ISO 2006a,b) and are publically available at the U.S. LCI Database (NREL 2011).

The ATHENA Institute, a North America-based non-profit, currently uses life cycle information from CORRIM and other sources in its databases and analysis tools that help architects, engineers, and other to evaluate the environmental impacts of buildings. The ATHENA Institute is now assisting the ASTM E60 sustainability committee, including sub-committees that are developing U.S. standards for developing EPDs on building products and systems. ASTM International develops and publishes standards, and they are currently working towards a standard practice for the development of PCRs (Work Item 23356), with the intent of adding specificity to the ISO standards. Specifically, ASTM International is working on the international harmonization of the EPD process, which includes definition of functions of the program operators and creation of EPDs from LCA. ASTM is also supporting the need for a U.S. PCR repository.

FUTURE WORK

The global need for credible and transparent environmental product information is likely to increase. LCA-based EPDs can provide this information, whether for business-to-business or for business-to-consumer communication, and are becoming the globally preferred mechanism for providing environmental impact information on products.

CORRIM's data for wood products and FPInnovation's program could provide a solid basis for the development of EPDs for the North American forest products industry. However, the stakeholders in the industry need to create a consistent and inclusive industry-wide

[4] Ann Ngo, U.S. Department of Commerce, March 1, 2011

framework for producing EPDs on a national and international level. Ignoring the development of environmental declarations could result in trade restrictions in the near term.

LCA data provide the background information for producing EPDs. The use of product-specific data is preferable to generic data, as an EPD is only as credible as the LCA data it uses. Therefore, developing, maintaining, and updating LCA data for products and uses every 5 to 10 years will require consistent effort and funding. Without this support, the North American forest products industry may find itself at a disadvantage not only with global forest products industry but also with the steel and concrete industries. By acting as leaders in embracing the EPD movement, the U.S. forest products industry would demonstrate good corporate environmental citizenship. EPDs are cutting edge, fully transparent environmental statements—the first organizations to use them could be seen as sustainability leaders. A side-benefit of having up-to-date LCA data is that the U.S. forest products industry could document the benefits of carbon storage in durable wood products.

One approach to support the development of EPDs for wood is for stakeholders to work together through organizations such as the Green Building Strategy Group (GBSG). Formed in 2010, the GBSG addresses LCA concerns related to the built environment. The stakeholders of the GBSG noted that their highest priority is to update the wood product LCI data developed by CORRIM in order to facilitate the creation of EPDs.

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LITERATURE CITED

Banerjee A. and B. D. Solomon. 2003. Ecolabeling for energy efficiency and sustainability: a meta-evaluation of US programs. *Energy Policy* 31:109–123.

Bolon, K. and K. Fujihira. 2006. Guidelines for the creation of a program for Type III environmental declarations. M.S. thesis. University of Michigan, Ann Arbor. 162 pp.

Bowyer, J., J. Howe, K. Fernholz, S. Bratokovich, and S. Stai. 2011. Environmental product declarations (EPDs) are coming: is your business ready. Dovetail Partners, Inc., Minneapolis, Minnesota. 10 pp. http://www.dovetailinc.org/files/DovetailEPD0111.pdf. Accessed May 5, 2011.

CEC. 2008. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the Sustainable Consumption and Production and Sustainable Industrial Policy action plan. Commission of the European Communities (CEC). 12 pp. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0397:FIN:EN:PDF. Accessed May 5, 2011.

Curran, M. A. 1997. Life-cycle based government policies. *Int. J. LCA*. 2(1):39–43.

Davis, G.A. 1993. The use of life cycle assessment in environmental labeling programs. EPA Project No. X 820663-01-0. Center for Clean Products and Clean Technologies, Knoxville, Tennessee. 60 pp.

Fet, A. M. and C. Skaar. 2006. Ecolabeling, product category rules and certification procedures based on ISO 14025 requirements. *Int. J. LCA*. 11(1):49–54.

FPInnovations. 2011. Environmental product declaration. Typical western red cedar bevel siding. FPInnovations, Pointe-Claire, Quebec. 10 pp.

FTC. 2010. Proposed revisions to guides for the use of environmental marketing claims. 16 CFR Part 260—Project No. P954501. *In:* Federal Trade Commission (FTC) Green Guides. http://www.ftc.gov/

os/fedreg/2010/october/101006greenguidesfrn.pdf. Accessed May 5, 2011.

ISO. 1999a. Environmental labels and declarations—self-declared environmental claims (Type II environmental labeling). ISO 14021. International Organization for Standardization, Geneva, Switzerland. 23 pp.

ISO. 1999b. Environmental labels and declarations—principles and procedures (Type I environmental labeling). ISO 14024. International Organization for Standardization, Geneva, Switzerland. 12 pp.

ISO. 2000. Environmental labels and declarations—general principles. ISO 14020. International Organization for Standardization, Geneva, Switzerland. 5 pp.

ISO. 2006a. Environmental management—life-cycle assessment—principles and framework. ISO 14040. International Organization for Standardization, Geneva, Switzerland. 20 pp.

ISO. 2006b. Environmental management—life-cycle assessment—requirements and guidelines. ISO 14044. International Organization for Standardization, Geneva, Switzerland. 46 pp.

ISO. 2006c. Environmental labels and declarations—principles and procedure (Type III environmental declarations). ISO 14025. International Organization for Standardization, Geneva, Switzerland. 25 pp.

ISO. 2007. Sustainability in building construction—environmental declaration of building products. ISO 21930. International Organization for Standardization, Geneva, Switzerland. 26 pp.

Lippke, B., J. Wilson, J. Perez-Garcia, J. Bowyer, and J. Meil. 2004. CORRIM: Life-cycle environmental performance of renewable building materials. *Forest Prod. J.* 54:8–19.

NREL. 2011. Life cycle inventory database project. U.S. Department of Energy, National Renewable Energy Laboratory, Golden, Colorado. http://www.nrel.gov/lci. Accessed May 5, 2011.

Puettmann, M. E. and J. B. Wilson. 2005. Life-cycle analysis of wood products: cradle-to-gate LCI of residential wood building materials. *Wood Fiber Sci.* 37:18–29.

Puettmann, M., R. Bergman, S. Hubbard, L. Johnson, B. Lippke, and F. Wagner. 2010. Cradle-to-gate life-cycle inventories of U.S. wood products production—CORRIM Phase I and Phase II products. *Wood Fiber Sci.* 42:15–28.

Salzman, J. 1991. Environmental labelling in OECD countries, OECD Environment Publications. OECD Publications and Information Center, Washington, D.C. 133 pp.

Schenck, R. 2009. The outlook and opportunity for Type III environmental product declarations in the United States of America. Institute for Environmental Research and Education. http://www.lcacenter.org/pdf/Outlook-for-Type-III-Ecolabels-in-the-USA.pdf. Accessed May 5, 2011.

Schmincke, E. and B. Grahl. 2007. The part of LCA in ISO Type III environmental declarations. *Int. J. LCA.* 12(Special Issue 1):38–45.

TEM. 2009. The seven sins of greenwashing. Environmental claims in consumer markets. Summary Report: North America. Terrachoice Environmental Marketing (TEM). 22 pp. http://sinsofgreenwashing.org/?dl_id=2. Accessed May 5, 2011.

TEM. 2010. The sins of greenwashing. Home and family edition. Terrachoice Environmental Marketing (TEM). 22 pp. http://sinsofgreenwashing.org/findings/greenwashing-report-2010. Accessed May 5, 2011.

Tobias, L. 2010. Building the next big thing: international standards for green labels. GreenBiz.com, May 17. http://www.greenbiz.com/blog/2010/05/17/building-next-big-thing-intl-standards-green-labels. Accessed May 5, 2011.