WISE
Washington Internships for Students of Engineering

The North American Database: Furthering Sustainable Development By Improving Life Cycle Assessment

By

Christine Vehar
University of Dayton

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About the Author

Christine Vehar is from Cleveland, Ohio and is a mechanical engineering student at the University of Dayton in Ohio. Her interest in public policy is related to her experiences in India in May and June of 2000 where she realized a true appreciation for her US citizenship and her desire to be a more active player in US policy.

About the WISE Internship

The Washington Internships for Students of Engineering (WISE) is a program that began in 1980 and each summer selects fourteen to sixteen undergraduate engineering students to come to Washington, D.C. to learn the public policy process. Over ten weeks, the students visit governmental agencies and learn how engineering affects public policy. During this time, each student is also accountable for a policy paper that addresses a technical issue.

Acknowledgements

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Executive Summary

Currently, products and processes can be evaluated by cost and performance; however, it is difficult to evaluate their environmental performance. Life Cycle Assessment (LCA) is a tool that uses an engineering approach to quantitatively assessing environmental impacts of products and processes. This tool analyzes a product's life cycle, which begins at raw material extraction and ends at the product's disposition. To have reliable LCA results, it is important that LCAs are based in quality data that quantifies all of the material and energy inputs and outputs over the life cycle. This process of collecting this data is called Life Cycle Inventory (LCI). The United States, in conjunction with Canada and Mexico, has begun the development of a standard, peer reviewed LCI database called the North American Database.

The underlying goal for both LCA and the database is sustainable development. Sustainable development was defined by the United Nations' Brundtland Commission as "development that meets the needs of the present without compromising the ability of further generations to meet their own needs." Since there is a finite amount of resources on this planet that sustains, or bears the weight of, humanity, it is important that good decisions are made about the use of the Earth's resources. Also, when resources are exploited, economic growth may be achieved, but development may not since society would be in a worse position than before. Therefore, more precautions are being taken that follow the principles of sustainable development.

As mentioned before, LCA is a tool used for sustainable development. Industry, non-profit organizations, consulting firms, academia, and government are using this tool. Internationally, Japan and Europe are both building or have their own LCI databases. Organizations who conduct LCAs value the quantitative, system approach of LCAs; however, they also feel that LCAs are expensive, time consuming, based on inaccurate LCI data, based on too many judgment calls, and are biased. The North American Database project will address these concerns by making LCAs less expensive, less time consuming, based on peer-reviewed data, less based on judgment calls, and harder to bias.

The development of the North American Database has three phases. Currently, the development is in the first phase and is being funded by the Department of Energy (DOE), the General Services Administration (GSA) and soon the US Navy. All users of LCA are represented in the leadership and advisory committee for the North American Database.

For the development of the North American Database to continue, more awareness of LCA, involvement in the database, and funding is needed. Recommendations for government, academia, and the engineering community address these needs.

Sustainable Development Overview

"Sustainable development" was first defined in the1987 report, *Our Common Future,* written by the United Nations (UN) General Assembly-appointed Brundtland Commission to study the nature of the earth and humanity.[1] The Brundtland Commission defined "sustainable development" as "development that meets the needs of the present without compromising the ability of further generations to meet their own needs."[2] According to the U.S. Environmental Protection Agency (EPA), "sustainable development" is "more of a new multifaceted approach to managing our environmental, economic, and social resources for the long term."[3]

The word "sustain" means "to support, hold, or bear up from below; bear the weight of."[4] The Earth is rich in natural resources that support humanity; however, the Earth's resource supply is limited. Therefore, extra precaution is now at the forefront to ensure that the Earth can sustain humanity for generations to come. In the context of "sustainable development", it will also be helpful to understand the definition of "development" as contrasted with the definition of "growth." The words are often used interchangeably; however, in the context of sustainable development, it is important to note the differences in the definitions. John B. Cobb and Herman E. Daly, authors of *For the Common Good, Redirecting the Economy Toward /Community, the Environment and a Sustainable Future,* stated that "growth should refer to quantitative expansion in the scale of the physical dimensions of the economic system, while development should refer to the qualitative change of a physically nongrowing economic system in dynamic equilibrium with the environment."[5] With this in mind, when natural resources are consumed beyond their renewable limit, growth may be achieved, but not development.[6]

Sustainable development has attracted increasing attention from the late 1980s to the present. In 1990, the UN issued a *Declaration on Sustainable Development* through its Commission in Europe. In 1992, the UN Conference on Environment and Development adopted Agenda 21, which is "an action plan for sustainable development for the world in the 21st century."[7] In 1993, President Clinton established the President's Council on Sustainable Development (PCSD) whose vision is "a life sustaining Earth." The PCSD describes a sustainable United States as having:

> a growing economy that provides equitable opportunities for satisfying livelihoods and a safe, healthy, high quality of life for current and future generations. Our nation will protect its

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[1] Aventis Triangle Forum "The Brundtland Commission" July 17, 2001 http://www.aventis-forum.uni-muenchen.de/sustainability/brundt-comm.html

[2] US Environmental Protection Agency "US EPA Region 3, Center for Sustainability" June 28, 2001 http://www.epa.gov/region3/sdwork/about.html

[3] Ibid.

[4] Random House Webster's College Dictionary. New York: Random House, 1995.

[5] US Environmental Protection Agency "US EPA Region 3, Center for Sustainability" June 28, 2001 http://www.epa.gov/region3/sdwork/about.html.

[6] Ibid.

[7] Ireland On-Line (iol) "AGENDA 21 - SUSTAINABLE DEVELOPMENT" July 22, 2001 http://www.iol.ie/~isp/agenda21/intro.htm

> environment, its natural resource base, and the functions and viability of natural systems on which all life depends.[8]

The PCSD released its final report in 1999 making several recommendations including "linking environmental, economic, and social information," "define common metrics for environmental performance," and "involve individuals and communities in improving environmental performance."[9] In 1994, the National Academies of Science and Engineering created a "Global Commons Project" to better understand sustainable development. The NAS created the Board on Sustainable Development to tackle this issue, and its work resulted in the release of *Our Common Journey*. Among many recommendations, the report recommended putting more research into the few sustainability metrics already available to "promote better utilization of existing tools and processes for linking knowledge to action in pursuit of transition to sustainability."[10]

If sustainable development is increasingly viewed as a means of meeting needs without exploitation, then why is sustainable development not a more widely accepted goal? First, sustainable development is a long-term approach to problem solving that does not necessarily yield instant benefits and improvements. Second, there is no consensus as to what "sustainable development" entails. Third, U.S society embraces a "throw away " mentality, i.e., as a nation, our values and habits are inconsistent with sustainable development. Finally, sustainability is difficult and expensive to measure and quantify, and results are not necessarily reliable, as meaningful metrics are directly dependent on the accuracy of the data used in the analysis.

However, efforts to establish tools for quantifying sustainable development successes are underway. Life cycle assessment (LCA) is one such tool. This tool evaluates the environmental performance of a product (or process) by accounting individual environmental impacts that occur from the beginning of the product's life (raw material extraction) to the end of its life (product disposition). To account for such impacts, amounts of materials inputted and outputted during the life cycle must be quantified. The process of quantifying inputs and outputs is life cycle inventory (LCI). Databases are currently available with LCI data, but there is no standard database from which every LCA is being used. This is creating discrepancies in LCA results. A new initiative, the North American Database Initiative, is in the formative stages. Its goals are to centralize the life cycle inventory (LCI) sources, establish one peer-reviewed database, and make it readily available to the public. By collecting, storing and making available accurate data on which companies and government entities within the U.S. can base LCAs and their associated LCIs, the proponents of the North American Database Initiative hope to advance the going of sustainable development. This paper will focus on the role that this database can play in advancing sustainable development through the wider use of LCA and LCI.

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[8] The President's Council on Sustainable Development. Towards a Sustainable America. Washington: President's Council on Sustainable Development Publications, May 1999.
[9] Ibid.
[10] National Academy Press "Our Common Journey: A Transition Toward Sustainability" July 10, 2001 http://www.nap.edu/catalog/9690.html

Life Cycle Assessment (LCA)

What is Life Cycle Assessment (LCA)?

Life Cycle Assessment is a "cradle to grave" approach for evaluating the environment impacts of industrial systems that considers the full life of product, from the extraction of raw materials from the earth to the product's ultimate disposition.[11]

According to the EPA, "LCA is a technique for assessing all the inputs and outputs of a product, process, or service (Life Cycle Inventory); assessing the associated wastes, human health and ecological burdens (Impact Assessment); and interpreting and communicating the results of the assessment (Life Cycle Interpretation) throughout the life cycle of the products or processes under review."[12] Figure 1 shows the typical stages that are considered in an LCA.

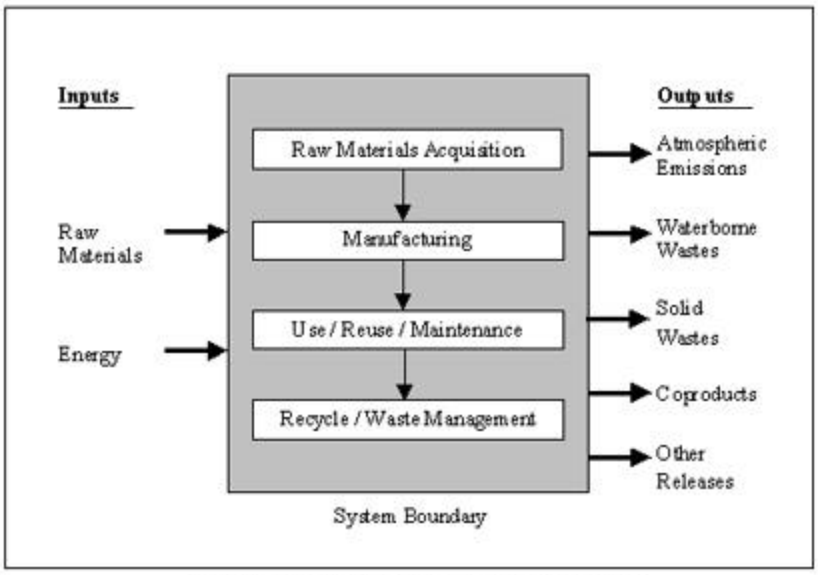

Exhibit 1-1. Life Cycle Stages (Source: EPA, 1993)

Figure 1 - Life Cycle Stages[13]

The Life Cycle

To fully understand the life cycle of a product or process, four life cycle stages must be considered: raw materials acquisition, manufacturing, use/reuse/maintenance, recycle/waste management.[14] Each life cycle stage is defined as follows:

[11] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/
[12] Ibid.
[13] Ibid.
[14] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001

Raw Materials Acquisition includes the removal of the raw materials from the earth and the transportation of the materials to the place in which they will be processed.

Manufacturing includes materials manufacture, product fabrication, and filling/packing/distribution. Materials manufacture entails processing the raw materials into a form that can be used in the finished product. This manufactured material is then made into the product through product fabrication. And finally, the finished product is prepared for shipment and transported through filling/packing/distribution.

Use/Reuse/Maintenance is the stage that includes all of the activities of the product's life that are related to the use of the product. This may entail energy consumption, environmental wastes, reconditioning, repairing, etc.

Recycle/Waste Management is the final stage and includes the energy necessary and environmental wastes that are related to the disposition of the product. [15]

Why LCA?

In order to truly understand the environmental impacts of product or process, it is important to note all of the stages of its life cycle. For example, recycling is beneficial if it reduces the rate of solid waste disposal. However, individual processes in recycling also have environmental trade-offs. The costs and consequences of transportation to waste facilities, energy consumption during material breakdown, and the increased amount of wastewater from the cleaning process are examples where recycling entails environmental impacts other than solid waste disposal. [16] By using LCA, a company or government entity can determine whether or not recycling will truly minimize the environmental impacts of its products and/or processes.

It is important to note that LCA does not entail any economic analysis; however, by combining LCA with cost-benefit analysis or another economic tool, companies and industries can better understand the economical impacts that are related to the environmental and health impacts determined in the LCA.

Conducting an LCA

The EPA has adopted the methodology specified by the International Standards Organization (ISO) in ISO 14000 on Environmental Management. [17] This methodology contains four parts: Goal Definition and Scoping; Inventory Analysis; Impact Assessment; and, Interpretation. [18]

- Goal definition and scoping includes defining the purpose for conducting the LCA and establishing the guidelines needed to obtain the desired results. The primary goal is to

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[15] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[16] Schmidheiny, Stephan. Changing Course. Cambridge, Massachusetts: The MIT Press, 1992.

[17] Mary Ann Curran, Life Cycle Inventory Team Leader of US EPA. Telephone Interview. June 28, 2001.

[18] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

determine which product or process has the fewest environmental impacts. However, there can also be secondary goals, such as determining whether or not a certain product is more environmentally friendly than another. During this phase, it is also important to take note of what information will be needed for the LCA and how the information will be organized and displayed in the final results, as well as deciding how accurate the data being used need to be. Also, the quality assurance procedures must be established. One option would be to require a formal review process at the completion of the LCA. Finally, to prevent misinterpretations, all assumptions and methodologies should be required to be documented in the final report of the LCA. [19]

- In the inventory analysis phase, the amount of harmful pollutants and energy used are accounted for quantitatively through a process called life cycle inventory (LCI). LCI quantifies all emissions, raw materials, solid wastes, etc., to produce a quantitative list showing all the pollutants released and the amount of energy and materials consumed during the life cycle of a product or process. According to the EPA, "without an LCI, no basis exists to evaluate comparative environmental impacts or potential improvements. The level of accuracy and detail of the data collected is reflected through the remainder of the LCA process."[20]

To conduct an LCI, a flow diagram mapping all of the system's inputs and outputs is required. The accuracy of the result will depend on the complexity of the flow diagram. Figure 2 illustrates a generic flow diagram.

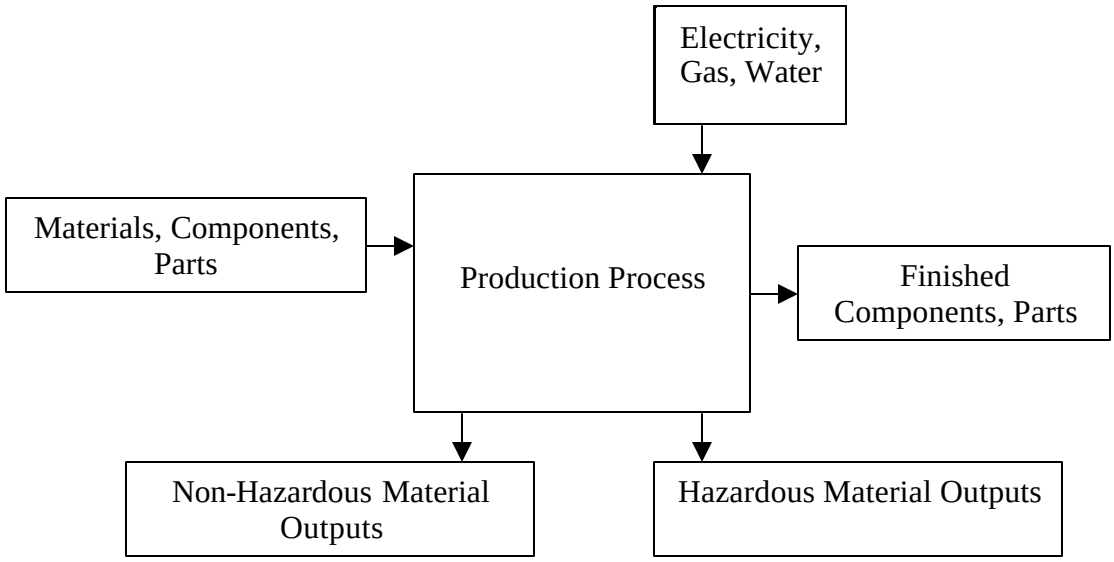

Figure 2 - Life Cycle Inventory Flow Diagram[21]

[19] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/
[20] Ibid.
[21] Ibid.

Once the flow diagram is constructed for the product or process, an LCI data collection plan must be established. Typical LCI data will provide specific amounts of emissions and energy consumptions for a specific process. For example, for the process of copper extrusion, LCI data may provide the typical amount of carbon dioxide releases per number of pounds of copper extruded. Obtaining this information requires determining which data sources are going to be used to obtain the information needed. Sources may include meter readings from equipment, reference books, industry data reports, laboratory test results, etc. The type of data should also be determined. This requires determining whether the data should be measured, modeled, from vendors, non-site specific, etc.[22]

Criteria must also be established for specific decision areas in a data collection worksheet and checklist. Examples of specific decision areas include, but are not limited to: purpose of the inventory; system boundaries; data collection procedures; and, data quality measures. [23]

Once the data sources and criteria are established, appropriate data must be collected. These are numerical data used to fill in the flow diagram and worksheet. This part of the LCA process can be difficult, expensive and time consuming.[24]

Under current LCA practice, data are gathered through research, visits to sites, and direct contact with LCA experts with generated LCI databases. However, when time and resources are limited, non-site specific inventory data can be used. Several organizations and industries have developed databases with LCI information. This information is usually available through software, websites, or individual resources. In cases where this helpful information is proprietary, the holders of the information are sometimes willing to act as consultants in LCI information. Once the data are collected, they must be evaluated, verified, and documented.[25]

- In the impact assessment phase, a life cycle impact assessment (LCIA) is conducted, taking the results of the life cycle inventory and evaluating the potential environmental and human health impacts. For example, an LCIA may address "what are the impacts of 9,000 tons of carbon dioxide or 5,000 tons of methane emissions released into the atmosphere? Which is worse? What are their potential impacts on smog? On global warming?"[26] To answer these questions, the LCIA process uses the concept of stressors,

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[22] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[23] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[24] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[25] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[26] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

e.g., "a set of conditions that may lead to an impact." [27] By following the LCIA procedure, stressors become quantifiable and comparable based on their impacts.[28]

- The final phase in LCA is interpretation or life cycle interpretation where the significant issues from the results of the impact assessment phase are identified. The LCA is also looked at as a whole to evaluate completeness and consistency. And finally, appropriate conclusions and recommendations are made. The preferred product or process is chosen with an understanding of the LCA's overall accuracy and assumptions made throughout the assessment.[29]

[27] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[28] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[29] EPA's Life Cycle Assessment web site "LCA 101" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

Current Status of LCA Implementation

Background

The concept of life cycle assessments was first considered in the US in the late 1960s and early 1970s. However, the term life cycle assessment (LCA) was not coined until 1990 when it was an outcome of a workshop held by the Society of Environmental Toxicology and Chemistry (SETAC), which is "an independent, nonprofit professional society that provides a forum for individuals and institutions engaged" in a broad range of environmental issues, including LCA.[30] Prior to 1990, life cycle studies were referred to as resource and environmental profile analyses (REPA).[31]

The Coca-Cola Company initiated the first REPA ever conducted in 1969 to determine whether or not the company should self-manufacture their beverages cans. The analysis examined the packaging materials available at the time and focused on the comparison of refillable bottles as opposed to disposable bottles. Coca-Cola's study also took into account energy issues related to specific materials.[32]

Since this type of analysis was new and complex, Coca-Cola retained the Midwest Research Institute (MRI) to conduct the REPA which recommended that the Coca-Cola Company manufacture disposable bottles. While the final report was not published, a summary was released to the Office of Technology Assessment of the US Congress in 1976 and appeared in an article in an issue of *Science* Magazine.[33]

The second major REPA study was initiated by the Mobil Chemical Company, which manufactured polystyrene foam trays for meat packaging. The company's competitors were asserting that the foam trays were environmentally harmful. The REPA revealed that Mobil's material compared favorably to the competing molded pulp trays giving the company more environmental confidence in its product.[34]

Throughout the early 1970s, the REPA concept continued to evolve: the first REPA computer program was developed; publications focusing on life cycle studies were released; and, the U.S. government began to take interest in REPA. MRI was commissioned by the President's Council on Environmental Quality to conduct REPAs on the recycling of various materials, the results of which were used to provide policy analysis to the Office of the President.[35]

The EPA also conducted studies to determine whether or not disposable materials contained in refillable bottles were harmful to the environment. Based on those studies, the Agency, in 1974, issued a final, public report entitled "Resource and Environmental Profile Analysis on Nine Beverage Container Alternatives," which included the REPA database and methodology used.

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[30] Society of Environmental Toxicology and Chemistry (SETAC) "About SETAC" July 22, 2001 http://www.setac.org/html

[31] Hunt, Robert G. and William E. Franklin. "LCA – How it Came About." International Journal of LCA, 1996.

[32] Ibid.

[33] Ibid.

[34] Ibid.

[35] Ibid.

Many of the impact assessment techniques that were used in those early studies are still being used to conduct present day LCAs.[36]

In 1976, the US Federal Energy Agency, the predecessor of the Department of Energy (DOE), released databases which provided life cycle information regarding beverage containers; however, at about this same time and continuing until the late 1980s, government departments and agencies" began loosing interest in REPA. Then, in 1988, a number of U.S.-based multi-national companies began feeling pressure from international environmental activity in Europe, resulting in a "re-awakening" of environmental concerns in the U.S. As a result, both the public and private sectors "rediscovered" the REPA concept.[37]

In 1990, at an international forum hosted by the Conservation Foundation in Washington, DC, REPA was openly discussed as a possible tool in resource and environmental policy. The Society of Environmental Toxicology and Chemistry (SETAC) became very involved in REPA methodology. At a SETAC workshop, the term "life cycle analysis" was coined to describe REPA concept. As a result, Franklin Associates published the first complete report on LCA methodology in 1992. [38]

It was during this time that EPA once again became involved in life cycle studies. The Agency began developing databases and guidelines that could be used by the public and private sectors. DOE and EPA began to jointly develop LCA tools and databases.[39]

In the 1990s, the International Standards Organization (ISO), a non-governmental standards setting organization based in Switzerland, issued ISO 14000, a series of guidelines or best practices focusing on Environmental Management.[40] Included within ISO 14000 are specific documents on LCA: ISO 14040 and 14041, released in 1998, cover general LCA procedures and LCA inventory procedures, respectively. Currently, ISO 14042 and ISO 14043 are being drafted. These documents will cover LCA impact assessment and interpretation, respectively. The efforts of ISO have increased the awareness of LCA globally, but according to the EPA, "there still remains a need to clarify terms and provide good methodology and data that can be applied to accomplish the goals of each study."[41]

Building on the increased interest in environmental issues and sustainable development, President Clinton in 1998 issued Executive Order 13101 on "Greening the Government through Waste Prevention, Recycling, and Federal Acquisition". The order called for EPA to provide guidelines for government departments and agencies to observe in purchasing environmentally preferable products. The order also encouraged the use of the life cycle approach when developing the guidelines.[42]

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[36] Ibid.
[37] Ibid.
[38] Ibid.
[39] Ibid.
[40] International Organization for Standardization "About ISO" July 22, 2001 http://www.iso.ch/iso/en/ISOOnline.openerpage
[41] EPA's Life Cycle Assessment web site "Why LCA?" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/
[42] EPA's Life Cycle Assessment web site "Why LCA?" July 2, 2001

Over a period of 40 years, LCA has evolved from an abstract concept into a "popular analytical technique". Industry, non-profit organizations, consulting firms, academia, government, as well as U.S. trading partners, have begun to utilize LCA as a tool for achieving sustainability. However, the results have not been reliable or consistent due to the lack of consistency and accuracy of the data used in the analysis.

LCA in Industry

Overview

As mentioned above, while industry has been aware of and utilizing LCA at various levels for several decades, the issuance of ISO 14000 has increased the awareness of LCA, as well as the public imperative for environmentally friendly products and processes. Larger, typically international, companies have been in the forefront of implementing LCAs. These companies utilize LCA as a management and production tool and generally have the in-house resources to conduct their own LCAs. Other larger companies employ consulting firms that specialize in LCA. Either approach requires a great deal of financial capital. Larger companies tend to use LCA as internal checks on performance and identifying opportunities for environmental improvement in their products and/or processes. Because of the nature of LCAs, and the product sensitive information they produce, some companies prefer to categorize LCA results as proprietary information. Smaller companies, typically having more limited human and financial resources, devote the majority of their existing resources to comply with existing environmental regulatory requirements. Since LCAs are currently not mandated by statute, it is the exceptional small company that is investing in this management and production tool.[43]

While some larger companies are experiencing benefits from their investments in LCAs, there is a feeling among some in the industrial sector that LCA, although helpful, is not currently "definitive, simple, relatively inexpensive and timely".[44] The industrial sector views the loose approach to LCA as potentially undermining the effectiveness of the tool, i.e., that companies make their own assumptions, establish their own boundaries, and choose the LCI data to be included in an LCA. There is a concern that some companies may be misusing LCA in order to produce deceivingly impressive environmental results.[45]

Case Histories

Toyota

According to Kevin Webber, Manager of Corporate Planning & External Affairs at Toyota, his company uses LCA "to improve the overall environmental performance of [its] processes and

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http://www.epa.gov/ORD/NRMRL/lcaccess/

[43] EPA's Life Cycle Assessment web site "Why LCA?" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[44] EPA's Life Cycle Assessment web site "Why LCA?" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[45] Dr. Elisa Cobas-Flores, Research Professor at Instituto Tecnologico y de Estudios Superiores de Monterrey. Electronic Mail Interview. July 4, 2001.

products." He says that the LCA is beneficial because it is a "holistic approach", uses more detailed data as opposed to assumptions, and "provides a new way to view one's processes and products." Webber identifies several shortcomings to the LCA tool, including: cost; time; lack of data reliability**;** and, not including other business-related parameters, such as cost.[46]

Proctor & Gamble

Proctor & Gamble, a large consumer products company, used LCA to cut back on the solid wastes generated by their products. For example, Downy fabric softener refills are now being sold on the market. The refill is in concentrated and packaged in cartons made of a new triple-strength fabric conditioner. LCA was used to prove to that refill containers are better for the environment then producing additional recyclable polyethylene bottles. Proctor & Gamble's use of LCA has resulted in economic benefits. Overall, with the help of the slogan "Same Downy Softness and Freshness - And Less Packaging to Throw Away," the refills accounted for nearly 40 percent of total Downy sales across the US in less than a year. [47]

Dofasco

Dofasco is a Canadian company that produces steel and distributes to customers all over North America. Ian Shaw of Dofasco, says that the company uses LCA as "a product support tool", a way "to understand [Dofasco's] ecological impact," a way to gather "information to prioritize and improve environmental performance," and "a customer support tool."[48]

In Dofasco's experience, LCA has both benefits and shortcomings. LCA can be beneficial because "LCA makes a step toward providing a more inclusive understanding of the true value of products." However, this benefit is offset by a number of shortcomings, including: "the link between inventory and environmental impact is complicated; "it is difficult to compare two product profiles and determine a superior product because of the inability to equate different impacts;" and, " even within the bounds of ISO it is still possible to bias an LCA."[49]

LCA in Non-Profit Organizations

Overview

Some non-profit organizations have seen the value of life cycle analysis and are working to promote more use and education of LCA among industry and the government.

Case Histories

Market Transformation to Sustainability (MTS)

[46] Kevin Webber, Manager in Corporate Planning & External Affairs at Toyota Technical Center. Electronic Mail Interview. July 9, 2001.
[47] Schmidheiny, Stephan. Changing Course. Cambridge, Massachusetts: The MIT Press, 1992.
[48] Ian Shaw, Dofasco Steel. Electronic Mail Interview. July 9, 2001.
[49] Ian Shaw, Dofasco Steel. Electronic Mail Interview. July 9, 2001.

The mission of Market Transformation to Sustainability (MTS) is to "foster and accelerate the global free market to sustainability." MTS began in 1999 and achieves its mission by providing training sessions to purchasers, developing standards, and posting advertisements that increase the awareness of the benefits and make-up of sustainable products. Training sessions educate purchasers about sustainable products so that there is a larger pull and demand for products that are more compatible with the environment and economy.[50] The Ford Motor Company, the City of Portland, Oregon, and Forbo Linoleum are a few of the financial supporters of MTS.[51]

Greenseal

As consumer environmental consciousness is increasing, environmental labeling has become a part of some companies' marketing strategies. Greenseal is one of approximately 40 eco-labels that can be assigned to products. The Greenseal label is unique because it uses a form of LCA to develop its standards for products. Greenseal believes that the use of LCA eliminates "greenwash," i.e., the practice of claiming that a product or process is environmentally friendly when in fact it is not. For example, some companies may flaunt their use of recycled materials, without factoring in and addressing the environmental effects of recycling the materials.[52]

LCA in Consulting Firms

Overview

Consulting firms have seen the bottom line business value of conducting LCAs for clients, notwithstanding the elaborate process involved in the conducting of LCAs. Consulting firms generally have their own LCA resources and tools and may specialize in servicing specific industry sectors. Franklin Associates Limited, Sylvatica, and Sustainable Products Corporation are two representative consulting firms. Although very helpful to industries, the cost of having a consulting firm run an LCA can be extremely expensive.

LCA in Academia

Overview

Over recent years, LCA has received more attention in academia; however, like any new concept, its integration into curricula is gradual. Some universities that offer education on the life cycle approach are Carnegie Mellon University, North Carolina State University, University of Dayton, and Georgia Institute of Technology.

Professor Michael Overcash of the Department of Chemical Engineering at North Carolina State University, claims that the department's "emphasis is on life cycle inventory and evaluating these for large numbers of chemical manufacturing facilities. We use a design-based approach.

[50] Mike Italiano, CEO of Sustainable Products Corporation. Personal Interview. July 11, 2001
[51] Market Transformation to Sustainability Brochure. http://MTS.sustainableproducts.com June 29, 2001.
[52] Mark Petruzzi. Certification Division of Greenseal. Telephone Interview. July 7, 2001.

In addition, we are involved in life cycle of materials used in buildings and furnishing."[53]

LCA in Government

Overview

Executive Order 13101 is the only comprehensive attempt to address LCA within the federal government. Some agencies, Environmental Protection Agency and Department of Energy are among the leaders, are attempting to address LCA in a more limited, agency-specific fashion. The very structure of the federal government (departmentalized and fractured), coupled with the short-term view of the Congress (what will promote re-election prospects in the next election cycle), has made it difficult to make LCA (cross-disciplinary and long term by definition), a priority of the US government.[54] Congress, as well as the general public, tends to care more about the short-term, up-front costs than the long-term benefits that LCAs can provide.[55]

Case Histories

Positions on LCA by Department of Energy (DOE), the General Services Administration (GSA), and the Department of the Navy (Navy) will be discussed later in the paper.

EPA

The EPA has been taking the lead on LCA for slightly more than a decade. The Agency has established a website, LCAccess at www.epa.gov/ORD/NRMRL/lcaccess/ that provides helpful information regarding LCA, including what LCA is, why LCA is used, and links to other LCI databases and LCA tools.[56]

Mary Ann Curran, one of the two full-time EPA employees focusing on LCA, says that the Agency wants to promote a better understanding of how LCA can be used to the benefit of both users of LCAs and the environment. Curran has concerns about the lack of awareness of the life cycle concept among small companies and the general public. She fears that LCA results might not always be accurate or accurately interpreted, as well as the subjective aspect of where information is included or not based upon non-scientific and objective criteria.[57]

LCA Internationally

Asia

[53] Professor Michael Overcash, Professor in the Department of Chemical Engineering. Electronic Mail Interview. July 13, 2001.
[54] Mary Legatski. Government Relations Representative of the Policy Development Office of American Society of Mechanical Engineers. Personal Interview. June 13, 2001.
[55] Hank Hatch, P.E., Lieutenant General, U.S. Army, Retired. Telephone Interview. June 16, 2001.
[56] Mary Ann Curran, Life Cycle Inventory Team Leader of US EPA. Telephone Interview. June 28, 2001.
[57] Mary Ann Curran, Life Cycle Inventory Team Leader of US EPA. Telephone Interview. June 28, 2001.

Many Asian countries including Japan, China, Korea, Taiwan, Thailand and Vietnam have taken special interest in LCA. Activities range from LCA research, to adopting ISO 14000 as the national standard, to initiating a five-year LCA development project. Further information on Asian countries' investment in LCA may be found at http://www.aist.go.jp/NIRE/~lca/GroupReport.html [58]

Japan

In 1998, Japan initiated a five-year LCA development project called "Development of Assessment Technology of Life Cycle Environment Impacts of Products and so forth". Over $1.5 million were allocated to the project in its first fiscal year. The Ministry of International Trade and Industry (MITI) manages the project, which includes establishing a national LCA method, developing a LCA database for all of Japan, and creating a LCA user-friendly network system. Additional information on Japan's investment in LCA may be found at http://www.jemai.or.jp/english/e-lca/e3-1lca-project.html.[59]

Europe

For the most part, European countries have implemented the LCA process more rapidly than has the U.S. LCA software is available in Germany, the Netherlands, Austria, Switzerland, Sweden, and Belgium.[60] Italy has developed its own life cycle inventory (LCI) database.[61] The United Kingdom also established an LCI database.[62]

Overall, the European Commission is interested in using more LCA for its Integrated Product Policy (IPP),

> an approach that begins by asking how the environmental performance of products can be improved most cost-effectively. It is founded on the consideration of the impacts of products throughout their life cycle, from the natural resources from which they come , through their use and marketing, to their eventual disposal as waste. It is also a relatively new approach to environmental policy [in Europe].[63]

On February 7, 2001, the European Commission released a Green Paper on IPP to initiate debate on involving IPP activities at the European Union level. It and other IPP information may be viewed at http://europa.eu.int/comm/environment/ipp/home.htm.

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[58] National Institute of Advanced Industrial Science and Technology (AIST) "UNEP/APEC/AIST/NEDO Symposium for LCA in the Asia Pacific region" July 7, 2001 http://www.aist.go.jp/NIRE/~lca/GroupReport.html

[59] Japanese Environmental Management Association for Industry "The Activities of the LCA-National Project in Japan" July 7, 2001 http://www.jemai.or.jp/english/e-lca/e3-1lca-project.html

[60] EPA's Life Cycle Assessment web site "LCA Resources" July 2, 2001 http://www.epa.gov/ORD/NRMRL/lcaccess/

[61] Mary Ann Curran, Life Cycle Inventory Team Leader of US EPA. Telephone Interview. June 28, 2001.

[62] Nigel Howard, US Green Building Council. Electronic Mail Interview. July 5, 2001

[63] Europa: The European Union On-line "Integrated Product Policy" July 7, 2001.

North American Life Cycle Inventory Database

Background

The reliability of LCA results is dependent on the quality of life cycle inventory data. Other countries have realized this and have begun to create, or already created, complete, reliable databases.[64] The LCI databases in foreign countries are of little use in North America, since effective databases are specific to a country's economy and ecology.[65]

The U.S. lacks a consistent and comprehensive LCI database. There is, however, a recent initiative to develop a North American life cycle inventory database. This database is generally referred to as the North American Database. A plan to implement the initiative was devised, and an advisory committee formed through the cooperative efforts of the Athena Institute, a non-profit, Canadian consulting group that has already established an LCI database for Canadian construction materials[66]; two US, consulting companies, Sylvatica and Franklin Associates Limited; and, the National Renewable Energy Laboratory (NREL), a Department of Energy laboratory.[67]

Objectives

The main objective of the project is to "produce publicly available LCI databases for commonly used materials, products and processes."[68] Throughout the development of the North American Database project, the focus is to be on identifying the needs of the user, supporting all decision support systems and tools, and creating benchmarks that are regionally specific.[69]

Project Criteria

To meet the objectives of the North American Database project, several criteria must be met, including:

- developmental procedures must be consistent to ensure data that is transparent, representative and peer reviewed;
- data must be regionally analyzed;
- all materials considered for the database should see equal treatment; and,

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[64] Trusty, Wayne. "The US Database Project: A Public/Private Research Partnership" Power Point Presentation presented at the Database Project Meeting of Interests in Dearborn, Michigan on May 21, 2001.
[65] EcoDesign Website "An Innocent Abroad: The Netherlands ***Green*** Buildings & People PART 2 by Ian Theaker" July 7, 2001 http://www.ecodesign.bc.ca/InnocentAbroad/IA4Part2.htm
[66] Wayne Trusty, President of Athena Sustainable Materials Institute. Telephone Interview. July 3, 2001.
[67] Trusty, Wayne. "The US Database Project: A Public/Private Research Partnership" Power Point Presentation presented at the Database Project Meeting of Interests in Dearborn, Michigan on May 21, 2001.
[68] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[69] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.

- data should be available in formats that are accessible to specific users and tools.[70]

Scope

The database will include "materials and products commonly used in manufacturing" processes, such as common processes like "electricity generation, transportation, industrial boilers, energy pre-combustion" and transformation processes like "stamping, processing, painting."[71]

The project will emphasize the data needed for the "cradle to gate" life cycle. This is the part of the cycle begins at raw material extraction and ends when the product is ready for shipment.[72] The rest of the life cycle is dependent on where and how the product is utilized; therefore it is extremely difficult to incorporate into an LCI database. However, companies or government agencies conducting LCAs should be able parallel their products specific end-of-life processes with some common and transformation processes that are included in the North American Database.[73]

Phasing

The project is divided into three phases. To date, only Phase One has been funded with monies provided by DOE and the GSA. The Navy supports the initiative and intends to grant funding.[74]

Phase I

Phase I will be operating on a budget of about $100,000 .[75] An Advisory Committee comprised of approximately 40 persons from industry, government and academia will be established. Advisory Committee members will represent "key potential user groups (e.g. tool developers, architects and product designers, process engineers, environmental authorities or regulators)", manufacturers, data providers, LCA experts, LCA practitioners, and environmental groups.[76] The objective of the Advisory Committee will be to develop the Phase 1 work program by discussing the project's details and issues. Subgroups of the Advisory Committee will undertake work on:

- the development of protocols;

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[70] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[71] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[72] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[73] Trusty, Wayne. "The US Database Project: A Public/Private Research Partnership" Power Point Presentation presented at the Database Project Meeting of Interests in Dearborn, Michigan on May 21, 2001.
[74] Sullivan, John L. of the Ford Research Laboratory. "Invitation Letter to the Database Project Meeting of Interests." 2001.
[75] Wayne Trusty, President of Athena Sustainable Materials Institute. Telephone Interview. July 3, 2001.
[76] Trusty, Wayne. "The US Database Project: A Public/Private Research Partnership" Power Point Presentation presented at the Database Project Meeting of Interests in Dearborn, Michigan on May 21, 2001.

- the establishment of research parameters, including products, processes, data categories, and data quality;
- an assessment of the availability of data and the identification of data gaps;
- a determination of which data, if any, needs to be regionalized;
- defining transparency; and,
- developing a peer review process.[77]

Phase II

The second phase will include the collection of inventory data and building the database. According to information derived from the Canadian and other international experiences, it is anticipated that a minimum of two years will be required to have the LCI database in place.[78] However, Phase II is not yet funded and will also be effected by the outcomes of Phase I.[79] The estimated cost for Phase II is approximately $1,000,000.[80]

Phase III

The third and final phase will consist of long-term database distribution and maintenance. The cost of Phase III has not yet been determined.[81]

Why is the North American Database Being Funded by Government?

As mentioned before, the North American Database is being funded by the DOE and GSA. The Navy supports the initiative and intends to provide grant funding. The subparagraphs below explore each agency's financial contribution, the source of the funding, and why the funding is being provided.

Department of Energy

DOE is granting $50,000 to the development of the North American Database for the Fiscal Year 2001 . The funding comes out of the Department's Commercial Buildings Research Program, which is the single line item within the Interior Appropriations Bill providing the funding for NREL. Overall, DOE's interest in the LCI database focuses on the contribution that such a database could provide in better understanding green and efficient energy, according to Drury Crawley, Operations Research Analyst of the DOE. A credible LCI database will also provide the DOE with information for assessing embodied energy in processes, as opposed to

[77] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[78] Trusty, Wayne. "The US Database Project: A Public/Private Research Partnership" Power Point Presentation presented at the Database Project Meeting of Interests in Dearborn, Michigan on May 21, 2001.
[79] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[80] Wayne Trusty, President of Athena Sustainable Materials Institute. Telephone Interview. July 3, 2001.
[81] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.

energy that can be measured in inputs and outputs. And finally, the DOE is concerned because other international countries are ahead of the US in LCI databases.[82]

General Service Administration

GSA is also granting $50,000 to the development of the North American Database for the Fiscal Year 2001. The funding falls under the Administration's Office of the Chief Architect. Two environmental initiatives within the GSA, Green Buying and Green Building, are the primary reasons for its involvement in this project. Green Buying ensures that governmental purchasing of automobiles and other goods are conducive to environmental concerns. According to David Eakin of the Green Building initiative, the GSA is hoping to find a way to quantify and compare environmental impacts that are incorporated in building design. Although the GSA is not responsible for all federal construction, the GSA currently has around one million governmental employees working in its buildings.[83]

The GSA has found National Institute of Standards and Technology's (NIST) LCA software tool, Building for Environmental and Economic Sustainability (BEES), to be a groundbreaking initiative in the attempt to quantify source-related sustainability data that designers can utilize. However, there is concern that the BEES' LCI database is not peer-reviewed. When considering the intentions of the North American Database to peer-review LCI data from industry, academia, and the public, Eakin feels that its development is a worthy cause.[84]

Department of the Navy

The Navy supports the North American Database and intends to provide financial aid; however, the amount of funding has not yet been determined. The funding would fall under the budget of the Naval Facilities Office. According to Michael Chapman of the Naval Facilities Engineering Command, the Navy is interested in the North American Database, because it views the establishment of the Database as a step closer to achieving sustainability. The Navy is working to gain better environmental information regarding building design. In 1995, the Navy adopted eight building projects that incorporated sustainable designs. The Navy is monitoring the projects to better understand the return on initial sustainability investments. In 1998, the Navy adopted a policy requiring all hired Naval engineers to have an understanding of sustainability principles and all Naval construction to be conducted in accordance to sustainability principles. The Navy is the only branch of the Armed Forces to show financial interest in the North American Database; however, the Army, Air Force, and Navy have all expressed interest in sustainability. The tri-services actually have a work group on sustainability; however, specific information on this work group is limited.[85]

[82] Drury Crawley, Operations Research Analyst of the Department of Energy. Telephone Interview. July 16, 2001.
[83] David Eakin. US General Services Administration. Telephone Interview. July 16, 2001.
[84] David Eakin. US General Services Administration. Telephone Interview. July 16, 2001.
[85] Michael Chapman, Design Policy/ Architecture of the Naval Facilities Engineering Command. Telephone Interview. July 16, 2001.

Current Status

On May 21, 2001, the Ford Motor Company Research Center held the Database Project Meeting of Interests in Dearborn, Michigan. The purpose of the meeting was to explain the North American Database project, identify and discuss concerns, and seek support from relevant groups in the public and private sector. The attendance was made up of thirty-seven persons representing universities (16 percent); consultants (19 percent); government (24 percent); and industry (41 percent).[86] A number of important issues were discussed, including: database maintenance; database scope; data confidentiality/accuracy; funding; and, access to existing databases. Some of the issues were resolved during the meeting, e.g., the scope and maintenance. The maintenance of the database has been accepted by the NREL. Other issues discussed will take longer to completely address, e.g., data confidentiality/accuracy and funding.[87]

On July 24, 2001, the NREL Washington Office held the Advisory Committee Workshop. The purpose of the meeting was to continue discussion about the development of the database. Around forty members of the advisory committee attended. During the meeting, the committee was broken into five work groups to address the issues relevant to the development of the North American Database.

Conclusions of the Advisory Committee

Benefits of Establishing a North American Database

Encourages and Fosters Sustainable Development

"Ford advocates and supports the development of such a database to foster more informed, system-wide, product environmental improvement initiatives, as well as vehicle industrial ecological and sustainability determinations." – John L. Sullivan, Ford Research Laboratory[88]

"We have to create networks among shareholders to move to sustainability and the concept of LCA is a way to Benchmark the products." – Dr. Elisa Cobas-Flores, Research Professor at Instituto Tecnologico y de Estudios Superiores de Monterrey (Tech University in Mexico) [89]

"All recognize that a high quality, public LCI database will be a valuable source of information, one that is needed for assessing future efforts to build a more sustainable world and product systems. And life cycle assessment in general, with its system focus, is the tool of choice." - John L. Sullivan, Ford Research Laboratory[90]

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[86] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[87] Athena Sustainable Materials Institute, Franklin Associates, Ltd, and Sylatica. "Report on Database Project Meeting of Interests (May 21, 2001)" July 2001.
[88] Sullivan, John L. of the Ford Research Laboratory. "Invitation Letter to the Database Project Meeting of Interests." 2001.
[89] Dr. Elisa Cobas-Flores, Research Professor at Instituto Tecnologico y de Estudios Superiores de Monterrey. Electronic Mail Interview. July 4, 2001.
[90] Sullivan, John L. of the Ford Research Laboratory. "Invitation Letter to the Database Project Meeting of Interests." 2001.

The Database Makes LCAs More Accurate

"Our company recognizes the importance of establishing a reliable database in N.A. - it will be important in order for us to conduct accurate LCAs here." – Kevin Webber, Manager in Corporate Planning & External Affairs at Toyota Technical Center[91]

The Database Makes LCA Results More Comparable Across the Playing Field

"A public data base levels the playing field - and puts pressure on non-conforming industries. There is a lot that is imperfect about LCA and how it is practiced. In a way, a common data base will allow the good work to stand out (studies will be easier to compare), and vice versa." - Bruce McKean, Director of Environmental Affairs at the Nickel Development Institute[92]

"Now there are competing LCI databases with different backbone data and so it's hard to compare LCA results across databases. This will make U.S. LCA results comparable." – Bobbie Lippiatt, LCA Software Developer, National Institute of Science and Technology (NIST)[93]

There are not only "green" products and processes, but there are different "shades of green" to be considered. Therefore, it is important to have a means of evaluating "green" products and processes against each other. - Paul Torcellini, National Renewable Energy Laboratory (NREL) of the Department of Energy (DOE)[94]

The Database is a Good Start to Improving the LCA Process

"[The database is] an effort that is attempting to bring consensus in approach is worthwhile." – Ian Shaw, Dofasco Steel[95]

There is no common LCI database for our region. Therefore, we can only do better. - Paul Torcellini, National Renewable Energy Laboratory (NREL) of the Department of Energy (DOE)[96]

"It will be hard to create a database in a detail level. However, it is a good start. The success of this database will be based in who will provide the data and to what level of detail. I hope we can generate the Benchmark of main materials." - Dr. Elisa Cobas-Flores, Research Professor at Instituto Tecnologico y de Estudios Superiores de Monterrey (Tech University in Mexico) [97]

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[91] Kevin Webber, Manager in Corporate Planning & External Affairs at Toyota Technical Center. Electronic Mail Interview. July 9, 2001.
[92] Bruce McKean, Director of Environmental Affairs at the Nickel Development Institute. Electronic Mail Interview. July 4, 2001.
[93] Bobbie Lippiatt, LCA Software Developer, National Institute of Science and Technology (NIST) July 5, 2001.
[94] Paul Torcellini, National Renewable Energy Laboratory (NREL) of the Department of Energy. Telephone Interview. July 5, 2001.
[95] Ian Shaw, Dofasco Steel. Electronic Mail Interview. July 9, 2001.
[96] Paul Torcellini, National Renewable Energy Laboratory (NREL) of the Department of Energy. Telephone Interview. July 5, 2001.
[97] Dr. Elisa Cobas-Flores, Research Professor at Instituto Tecnologico y de Estudios Superiores de Monterrey. Electronic Mail Interview. July 4, 2001.

The Database Enhances the Public Policy Process

"Good corporate decisions and public policy should be based on sound science. Life cycle is a tool to show a more complete picture of the environmental impact of a product. Without using life cycle or comparable methodology, it is easy to over or under estimate environmental impacts." - Ron Liesemer, Vice President, Technology for the American Plastics Council[98]

Concerns Expressed by Advisory Committee

Lack of Human Resources to Staff the Database Project

"Toyota may not be able to participate on a deep level, simply because we don't have the right staff here in the U.S. to contribute to the project." - Kevin Webber, Manager in Corporate Planning & External Affairs at Toyota Technical Center[99]

The Database Does Not Cover Entire Life Cycle

"My biggest concern is the boundary condition that limits data collection from cradle (oil in the ground) to primary fabrication. The "use phase" of durables products often has the biggest environmental impact by far. A study by USCAR [United States Council for Automotive Research] showed the use phase of an automobile (driving 100,000 miles) comprises 80% of the environmental impact. At our first meeting on this project someone from NREL said 90% of the environmental impact of a building is in the use phase, i.e., heating and air conditioning. If the use phase data does not exist, it is likely to be ignored. Those using the database could develop erroneous conclusions, and recommend corporate decisions or public policy based on those erroneous conclusions. That could lead to poor decisions and give the impression that life cycle is not an effective tool." - Ron Liesemer, Vice President of Technology for the American Plastics Council.[100]

[98] Ron Liesemer, Vice President, Technology for the American Plastics Council. Electronic Mail Interview. July 17, 2001.
[99] Kevin Webber, Manager in Corporate Planning & External Affairs at Toyota Technical Center. Electronic Mail Interview. July 9, 2001.
[100] Ron Liesemer, Vice President, Technology for the American Plastics Council. Electronic Mail Interview. July 17, 2001.

Conclusion

The North American Database can enhance the LCA process that is being used by industry, academia, and governmental agencies. LCA is helping these groups meet their needs to measure environmental performances to be better positioned:

- to evaluate and compare the environmental impacts of specific products and/or processes;
- to meet the consumer demand for environmentally friendly products and processes;
- to gain economic benefits; and,
- to stay internationally competitive.

LCA's benefits are its comprehensive analysis due to its life cycle approach and its quantitative results, enabling internal evaluation and comparison. On the other hand, LCA is expensive, time consuming, and difficult to use for external comparisons, i.e., product to competing product. Also, LCA results are not always credible since LCI and LCIA data are not necessarily reliable, LCAs are based partly on judgments and assumptions, and the data can be biased.

The North American Database would address the shortcomings of LCA. With a publicly accessible, peer reviewed database, better access to LCI data would cut costs and time needed to gather LCI data. LCAs could be better compared externally, since all organizations would conduct their LCIs with the same data. LCA results would be more accurate, since the database would be peer-reviewed and based on a larger pool of information. Judgments would be fewer in number, but would still need to be made, and biasing numbers would be less opportunistic with a standard, comprehensive, and easily accessible database.

The North American Database, although not covering the entire life cycle, would offer a good start by making LCA more usable and reliable, which puts the public and private sector in a better position to push sustainable development. The road to sustainable development is one that will take time; however, it is important to take advantage of opportunities that enable society to come closer to the final goal. Therefore, industry, academia, and governmental agencies should take appropriate actions that facilitate sustainable development initiatives, specifically the North American Database.

Recommendations

As stated above, industry, academia, and governmental entities should take action to make sustainable development more attainable, i.e., fostering the development of the North American Database. However, no action will be a "quick fix" since sustainable development is a long-term process. It is recommended that specific initiatives be taken immediately, even though some initiatives will have quicker results than others.

President of the United States

- Issue an Executive Order mandating that all cabinet level agencies, in addition to the GSA and EPA, participate in the North American Database project. This action will give the LCA and the North American Database public visibility and more participation by government.

- Provide funding for Phase II of the North American Database in the Administration's budget requests for Fiscal Years 2003-2005.

Congress

- Appropriations committees approve funding for the North American Database at or above the funding level contained in the President's request.

- Establish a House-Senate Caucus Group on Sustainable Development to promote discussion on sustainable development, LCA, the North American Database, and related topics, and to consider how to incorporate sustainable development mechanisms into appropriate legislation.

ASME International

- Update the 1994 position paper on " Designing for the Environment" to include more recent sustainable development issues, including LCA and the North American Database.

- Educate ASME members on LCA and the specifics on the North American Database through ASME publications and conventions.

- Host a Congressional noontime briefing on sustainable development, LCA, and the North American Database.

Academia

- In conjunction with the Accreditation Board for Engineering and Technology's (ABET's) Engineering Criteria 2000, which requires sustainability principles to be taught in

engineering capstone design courses, continue teaching specifics on LCA in engineering courses, especially design courses.[101]

Engineers' Forum on Sustainable Development[102]

- Take an active role in the development of the North American Database by identifying candidates to serve on the Database's advisory committee.

Potential WISE Interns

- Apply for the WISE internship. The internship not only taught the author about the engineer's role in the public policy process, but it also gave the author opportunities to become more of significant player in the public policy process.

  The author was fortunate to attend the Advisory Committee Workshop held in Washington, D.C. Due to the author's background in engineering and her representation of the next generation, which will use the database, she was asked to join the advisory committee. Therefore, even though the WISE internship ends early August 2001, the author looks forward to continuing her involvement in the public policy process by helping to develop the North American Database.

[101] ABET "Engineering Criteria 2000" June 20, 2001 http://www.abet.org/

[102] Note: The Engineers' Forum on Sustainable Development is a networking group of engineers who meet regularly to discuss issues regarding sustainable development. http://www.aaes.org/content.cfm?L1=4&L2=3