

U.S. LCI Database Project – Review Panel Report on the Developmental Guidelines

*Athena™ Sustainable Materials Institute
Merrickville, Ontario, Canada*

*Franklin Associates, Ltd.
Prairie Village, Kansas*

*Sylvatica
North Berwick, Maine*



NREL

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

U.S. LCI Database Project – Review Panel Report on the Developmental Guidelines

*Athena™ Sustainable Materials Institute
Merrickville, Ontario, Canada*

*Franklin Associates, Ltd.
Prairie Village, Kansas*

*Sylvatica
North Berwick, Maine*

NREL Technical Monitor: M. Deru

Prepared under Subcontract No. AAX-1-31445-01



NREL

National Renewable Energy Laboratory

1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at <http://www.osti.gov/bridge>

Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: reports@adonis.osti.gov

Available for sale to the public, in paper, from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: <http://www.ntis.gov/ordering.htm>



Review Panel and Material

The review panel was charged to review a final draft of the *U.S. LCI Database Project¹ Development Guidelines*. This document consists of a 16-page guide and 2 pages of Appendix B. Appendix A (conversion factors) was not included for review and Appendix C will include excerpts from an International Organization for Standardization (ISO) document that was not included and does not need review.

The chairman, Patrick Hofstetter, was charged by the project team to organize and perform an independent peer review of the *U.S. LCI Database Project Development Guidelines*.² He invited experts from the already existing advisory committee and external experts to join the review panel, including Gregory Keoleian, John Sullivan, and Keith Weitz. The review panel was asked to share its expertise without compensation. This report includes the review report from this review panel. Six additional reviews have been submitted by other members of the project's advisory committee, but are not included in this report. Although the review panel took notice of these comments, not all of them are considered in the review report, and the review panel was not charged to respond to these other review comments.

General Comments

The task of the authors of the *Research Guidelines* was enormous. The reviewed guidelines should on the one hand rely as much as possible on ISO 14040ff and on the other hand provide precise and concrete guidance in order to allow for consistency of the planned U.S. LCI Database. Being more precise and concrete than the ISO documents necessarily means that some of the flexibility in reading and interpretation of the ISO documents need to be sacrificed. In general, we believe that the project team was successful in many places in doing so. In a few places, we felt that the research guidelines become unnecessarily prescriptive and in other instances we suggest some even more prescriptive language.

This balancing act between procedural openness and prescriptive language is beyond typical tasks for peer review panels since more than technical expertise is needed to do so. We also recognize that the project team intends to provide both research guidelines and a user's guide to the database. Because we have no access to the guide, we were not able to comment on the relationship between the two.

We think the intent of the project is clear and admirable. There are a number of practical issues that will arise as the data development effort begins because data that is available isn't ideal. A good test of the development guidelines will be the ability to be flexible enough to deal with less than ideal data and yet maintaining its desired high quality. We also recognize that the database project is evolutionary and that the data quality should improve over time.

¹ LCI Database Project information is available at: <http://www.nrel.gov/lci>

² Formerly U.S. LCI Database Project Research Protocol

Detailed Comments

1. Is the goal of the database (and the guidelines) clear?

We find the goal definition is very clear and a strong feature of the development guidelines. The following modifications may be helpful:

1. We recommend the following change to emphasize the importance of maintaining and updating a database once it is established originally. First sentence in 2.1. The basic goal is to establish [add: “and maintain”} LCI modules....
2. We suggest that the environmental impacts to be covered are specified by suggesting which life-cycle impact assessment (LCIA) method(s) will be used as a reference. If no such method is mentioned the goal definition may need to be much more specific on what type of impacts need to be covered and why. (Are noise, radiation, salination, erosion...covered or not, why?)

A useful paragraph that further supports the motivation for developing a U.S. Life-Cycle Inventory Database could be added to the Introduction. It is:

One of the aims of this project is to support the growing trend of taking a systems view when evaluating the environmental performance of products and services. However, because tradeoffs are often encountered in systems analyses, database users, when assessing a particular product system, might actually find it appropriate to choose a subsystem or material that carries higher environmental burdens than its competitors but yet it imparts an overall environmental performance improvement to the product system that it is a component of. Having sufficiently reliable information to assess system performance given tradeoffs is one of the reasons for developing a database.

2. Are the guidelines compatible and consistent with this goal?

Section 3

Section 1 and 2 suggest that the database should be of value for many different applications and users. However, Section 3.1 suggests that the structure of the product system consists primarily of sequential unit processes and has a cradle-to-gate character. In order to make this statement, one needs to have in mind one modeling approach and a lot of insights about systems. If one does not have such preconceptions about the system, it seems more consistent with the ISO framework that those processes that significantly contribute to the environmental burden related to a service (be it attributed or caused as a consequence) are included per definition.

Or in other words, because this section deals with the type of unit processes to be included, a concrete description would need to differentiate the different modeling approaches. Otherwise, Section 3 will not be consistent with all applications mentioned in Sections 1 and 2. (See remarks under point 5.)

3. Where do the guidelines deviate from ISO 14040ff? Are arguments provided? And are the arguments in line with the stated goal?

The guidelines are almost fully consistent with ISO 14040ff. A few exceptions include the following:

- The points raised under point 5 that are related to system boundaries (Section 3.2), and substance list (Section 6 and Appendix B), and
- The pragmatic view on how to deal with non-domestic production (Section 3.3).

The first bullet will be criticized in point 5; the second bullet seems a pragmatic departure that is supported by the review panel.

Since ISO 14040ff was written without a clear view on attributional versus consequential life-cycle assessment (LCA), some recommendations apply only for one or the other view. Therefore, ISO itself is not sufficiently consistent with the goal of the U.S. LCI Database Project and needs some extensions as indicated below in point 6.

4. Do the guideline cover all aspects that will be important for the database project?

The guidelines may profit from discussing the scope of the database in more detail. Is the database effort seeking industry average data for materials and energy modules or state-of-the-art technology for these modules, or both? The issue of attributional and consequential life-cycle inventory (LCI) could be addressed in more detail to make the consequences of this choice more transparent to the analysts.

More attention in the proposal should be directed toward issues of maintaining the database. The process for updating modules should be discussed in more depth.

5. Are there places where the guidelines are too prescriptive, e.g., presenting lists rather than procedures?

Section 3.2

This section provides a prescriptive list of the system boundaries. While the list of processes that is included is not controversial because it is a “may” list, the processes excluded are more difficult to understand. The two criteria mentioned are “practical” and “appropriate.” It is assumed that Section 7 takes care of a third criterion “relevant.” “Transportation of people to work,” can be excluded by using the criterion “appropriate” arguing that in most cases a company has limited influence whether or not its employees commute (although this is actually part of many EMS). Work in remote areas, like underground mines, space, or oil platforms may require very special transportation to work and should be analyzed where relevant. We do not understand what is meant by other “social costs.” Is this the complement to what Section 6 defines? If yes, then there is no need to mention it, otherwise it should be specified what it means.

All other processes that are mentioned for exclusion are probably considered impractical to analyze. Although this may be true, their exclusion would often violate rules of Section 6 and ISO. Excluding lighting and heating would be in many cases impractical because electricity and heat consumption for these purposes are already included in the process energy needs. We suggest that the guidelines provide here clear definitions on where the responsibility of the worker starts *versus* where the company is responsible for the burdens (e.g., cafeteria, commute) and that all other exclusions from the system boundaries are solely based on Section 6.

Section 6

The criteria used for the selection of elementary flows (the guidelines may state somewhere the ISO term and the synonyms used in the guidelines) in Section 6 and its Appendix B are not stated nor backed by the goal definition. The review panel sees no other reasonable possibility in defining a list of substances by applying the principles mentioned in Section 7. Therefore, the goal and scope definition needs to be explicit about what LCIA method will be taken as reference method to define what are environmental problems and their relative potencies (e.g., TRACI release date xx.xx.2002). The provided list appears arbitrary, extremely comprehensive but also overlapping and imprecise. The research guidelines should be explicit on what substance names shall be used, how the different metals shall be reported (just the metals as total, or the salts, or all different compositions?). For resources, mistakes often happen because it is not clear whether the actual element weight, the pure ore weight, or the raw ore weight are reported. Finally, the list has to clarify how it deals with sum-parameters (like aldehydes), and when it is acceptable to report sum-parameters rather than the individual substances.

We did not understand why solid waste is listed here since the guidelines state clearly that downstream processes shall be included.

The justifications for excluding ozone-depleting substances is not supported by the goal definition, and if no such emissions are emitted anymore, then they need no analysis anyway. Many of the ozone-depleting substances (and also many metals) are also covered in the Toxics Release Inventory (TRI). The given justification about the decrease of emissions and the elimination by most industries would hold true for many other substances as well. However, if we argue impact oriented then every additional release that causes additional impacts should be reported, if relevant.

Section 8

The review panel does not understand why this section was added. This section states nothing more than what was already stated in Section 4 and 7. We suggest to skip this section and to supply—if necessary—an example in the guide that illustrates why negative CO₂ emission may occur in a cradle-to-gate analysis to make sure that end-of-life emissions are considered independent of the source of the C. Further, it is important that the growing process of biomass is always part of the ‘cradle.’

Section 9

Whether energy use is considered an impact category or not, it needs to be defined in the goal definition. Those impact assessment methods that do consider ‘energy use’ an impact category will then calculate the primary energy demand based on the use of energy resources. Some methods will include fossil sources only, while others include all non-sustainable harvested energy resources. Again, others consider energy inputs from all resources used. However, for all cases it is sufficient to follow the exact same procedure as suggested for all other resources and materials. Section 9 would complicate the analysis and would certainly add inconsistency because the analyst would not only need to report the amount of energy materials consumed but also its energy content. The review panel suggests to drop this Section 9 and to provide instead a list of higher heating values for all energy resources that may be used within the project in Appendix A. Such a list is needed in order to apply the rules of Section 7, and it needs to be an open list that will be updated as the project runs.

6. Are there places where the guidelines should be more prescriptive to improve the consistency?

Section 8

With respect to carbon releases from end-of-life processes, how will time frame issues be handled? For example, carbon releases from waste combustion are instantaneous whereas carbon and methane emissions from landfills occur over a long period of time. We typically use a 100-year time frame for estimating landfill emissions. This question refers to all elementary flows.

Section 10

This section basically deals with the problem that different analysts will work on different processes that ultimately need to fit together. This “fitting together” is difficult because there are more different transportation vehicles, furnaces, and power plants than the project can possibly cover and because the data should be useful for both attributional and consequential analysis. However, as stated earlier in the guidelines, the same requirements also hold for many other materials that are generally used in several products. Therefore, we suggest that this section will provide a procedure on how consistency is assured. This includes a guide on how process names need to be defined (output based, service based, or input based?) and what aspects (technology, capacity, region, time) need to show up in the name. Further, it needs a proposal on how the communication between the analysts will be organized (e.g., Web page with existing process models, intended process models, and needed process models).

Because of differences in transportation losses, electricity use needs not only to specify the region but also mention the voltage level. Putting up a list of intended process models using the needed level of dis-aggregation is probably the most effective way to reach consistency.

One issue that will likely come up is that data available for some materials will have been developed with energy and transport data from other LCA consultants and cannot be separated cleanly from the data set. Examples of this are the Association of Plastics Manufacturers (APME) data for plastics or the American Iron and Steel Institute (AISI) data for steel. The

guidelines may want to give guidance as to whether such data is acceptable at all, and if it is, how it should be adjusted.

Section 14

The described procedure does a good job in reflecting ISO and being slightly more precise than ISO. Although the procedure works for both, attributional and consequential LCA modeling, the used language of “causality” reflects more the consequential LCA. If allocation can not be avoided by splitting up processes and if there is no direct physical causality (this is common if the output shares are fixed) then expanding the system or using monetary flows as the most plausible causal relationship may become the standard procedures in consequential and attributional LCA, respectively. Therefore, it seems important to provide more guidance for those two procedures. In the case of system expansion, the guidelines may need to address how the displaced system can be identified and how to deal with co-production within the displaced system. In the case of using economic relationships, the guidelines need to be specific whether the economic value (ISO) or revenue (guidelines) shall be used (and why) and how to calculate those (considering before/after tax issues, averaging over time, publicly available sources for such data, reference year and currency, etc.). Being precise and specific about those issues is essential for the consistency of the database. If co-product allocation becomes an issue within the US Database Project because more than unit process data is provided, then it may be helpful if the research guidelines provide two different procedures for attributional and consequential LCA modeling, respectively. This would then help to increase the consistency of the database.

Section 15

This describes the procedure that is consistent with attributional modeling. We suggest that the guidelines offer as well a concrete procedure to be followed for consequential LCA or to make at least the point that this other procedure is not described.

In Section 15.2, the term “from nature” is confusing. Does this mean that the recovered material will be considered a “free good” with no associated burdens for its original production? We are also not sure how to interpret “the system model will then show the balance of input required from virgin material” (see also comment by Alain Dubreuil in the Annex).

Section 17

This section is somewhat ambiguous. Will the data undergo an ISO peer review? It would be useful to have the “agency” develop guidelines for review sooner rather than later.

7. Does the review panel have practicability concerns based on its own experiences?

Section 5

Section 5.1 gives without further arguments preference to primary data sources. We would stress that this may cause unnecessary additional expense without increasing the quality of the data. Therefore, we suggest to say that the mentioned transparency and access to review the data are required and that the most representative data source should be used.

Section 6

Land use is mentioned as something to capture in Section 6 but does not show up other than related to landfilling. Experience in other projects suggests that a very explicit guidelines are needed that defines what area needs to be considered, how to deal with transformation versus occupation, and how to account for pre-occupation of land and land remediation activities. If TRACI is unable to provide hints, the project team may want to consult the special issue in the *Journal of Cleaner Production* on land use or the respective chapter of the Society of Environmental Toxicology and Chemistry (SETAC) Working Group on Life-Cycle Impact Assessment.

Section 7

As suggested by ISO 14041, this section is defining the three criteria exclusion by mass, energy, and environmental relevance. Unfortunately, no reasoning is provided for the chosen percentage numbers. Models and research performed by Dr. G. Norris is probably the major place where the impacts of the set rules could be evaluated. However, experience suggests that the suggested rule may invoke unnecessary high burdens for the analyst. In order to cover 95% of the mass, one may need to include a large number of ancillary materials even if they are neither relevant from an energy nor environmental point of view. On the other hand, the 15% rule of environmental relevance may appear for many practitioners, especially those that perform impact by impact comparisons, to be surprisingly large. Lowering this threshold would not invoke much more work and by far be compensated, if the mass threshold would be set, e.g., to 80%.

The analysis could be further facilitated if the bullet on “extraordinary effects” would be replaced by a short list of stressors that are not covered in, e.g., TRACI, but deserve analysis.

Section 10

The guidelines suggest that transportation services are directly expressed as tonne-kilometers (tonne-km) with allowance for empty backhauls. Our experience shows that this is sometimes a source of mistakes and inconsistencies. For instance, ISO 14041:A2 suggests using a table where the transportation information is collected in a reproducible manner. Based on this table one could add an additional row that calculates the tonne-km. Often, transportation modules would already account for average load factors. If this is the case, the analyst needs clear instruction on how to adjust the calculated trucking service.

Section 11

An additional level of consistency and efficiency could be reached if all analysts (those that are paid by the project and those that contribute voluntarily) would get the same software that includes an electronic data format, includes the maximum list of resource and substance names (copy-paste or roll-down menu), includes an (automatically) updated list of predefined process names, and—if possible—allows for the necessary calculations needed for Section 6. Based on the chosen unit-process approach, it seems that the provided data will not represent trees but matrices. The software should therefore accommodate the necessary matrix calculations.

Experience with the U.S. Automotive Materials Partnership (AMP) LCI of a total vehicle indicated that significant problems can emerge regarding the LCI rules and methods between material industry representatives. Each industry is seeking to protect its own interests, which is

understandable. Consequently, it is important to have an agreed upon mechanism in place to resolve such differences to avoid groups from pulling out of the process. While the stated guidelines are comprehensive, there are always specific cases that emerge that are unanticipated. Establishment of a review council could be beneficial.

8. Is there a good balance between short-term practicability and openness for future improvements and extensions?

The short-term practicality will be dependent upon the way the guidelines will be made more concrete and the available resources. It may well be that further compromises will be necessary. In this case, should the proposed guidelines address the openness for improvements in the database more thoroughly? What is the process for changing the rules/methods that were used in constructing the database as LCI rules/methods evolve over time?

We believe that the attempt to agree on common research guidelines will be one of the key steps in the whole database project and devoted therefore significant effort in commenting on the present draft. We hope that our comments will strengthen the focus of the guidelines and will prove helpful when the data collection is started.

We appreciate the opportunity to provide our comments and advise to such an important undertaking.

Minor and editorial comments

We assume that a technical editing of the guidelines will be done anyway. Therefore, we list here few other minor comments:

- Section 2.1, Project Goal, end of forth paragraph states that “Few, if any, of the modules will represent stand-alone LCIs.” We don’t think that any would represent full LCIs so why include this statement?
- Section 2.1, bullet 1: Adding the comment in brackets introduces terms that may be misleading in the sense that prospective attributional and retrospective consequential LCA are both possible modeling modes. The brackets may instead be used to explain each modeling mode in more detail.
- Section 3.1: Though the reader could conclude it on their own, it does not hurt to explicitly state that some of the modules are cradle-to-gate, while others are gate-to-gate. Indeed, such modules permit a user to build up an LCI for any product system.
- Section 3.2: The use of ‘limits’ instead of boundaries makes this section hard to understand. Especially, “The limits do not include” could be understood in both ways.
- Section 13, first point 2: The used language suggests both, that the system can be presented as a tree and that the most important processes are those that describe cradle-to-gate of a product.

This is misleading in the sense that the cluster of the relevant processes does not necessarily reflect a tree and can much more efficiently be described as matrix and the relevant processes may be very different from what one considers cradle-to-gate.

-Section 13, second point 1 and 2: The wording under 1b) could be more in line with the goal of the guidelines by requiring that the technology used needs to be stated since the database will be technology based. Why do you not require the same information for secondary data as for primary data? The review task described in section 5.1 is only possible if this information is available.

-Section 13, third point 1: You may want to add that the +/-20% estimate should be based on the assumption that this would span a hypothetical 95% confidence interval (or any other number). Since such an assumption will be made anyway when interpreting the data, you can already make this assumption transparent to the analyst who estimates the range.

-Section 15, paragraph 2: Here and in other places the document suggests that the project will also provide cradle-to-gate LCI results. Although this will be necessary for certain sensitivity analyses the guidelines may want to put emphasis on the unit-process data. This is because the calculation of cradle-to-gate LCIs requires at least two calculations, one for attributional and one for consequential modeling. By focusing on unit-process data, the database will also hardly be affected by choices in section 15.

REPORT DOCUMENTATION PAGE

Form Approved
OMB NO. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE August 2003	3. REPORT TYPE AND DATES COVERED Subcontractor report	
4. TITLE AND SUBTITLE U.S. LCI Database Project – Review Panel Report on the Development Guidelines; Period of Performance: May 7, 2001 – December 1, 2001.			5. FUNDING NUMBERS AAX-1-31445-01 WF9V.5501	
6. AUTHOR(S) Athena Institute, Franklin Associates, Ltd., and Sylvatica				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Athena Sustainable Materials Institute Merrickville, Ontario, Canada			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Renewable Energy Laboratory 1617 Cole Blvd. Golden, CO 80401-3393			10. SPONSORING/MONITORING AGENCY REPORT NUMBER NREL/SR-550-34275	
11. SUPPLEMENTARY NOTES NREL Technical Monitor: Michael Deru, Ph.D.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT National Technical Information Service U.S. Department of Commerce 5285 Port Royal Road Springfield, VA 22161			12b. DISTRIBUTION CODE	
13. ABSTRACT (<i>Maximum 200 words</i>) This is a report from the review panel that reviewed the development guidelines of the LCI Database project. The ultimate goal of the project is to develop publicly available LCI Data modules for commonly used materials, products, and processes.				
14. SUBJECT TERMS LCI; LCI Database Project; Review panel; Athena Institute; life-cycle inventory.			15. NUMBER OF PAGES	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102