Working Paper No. 1
Review of Research Protocols
and Development Summary

Introduction

This paper presents an overview of selected issues for consideration of participants in the July 24 workshop for the U.S. LCI Database Project. The purpose of the U.S. LCI Database Project is to develop selected product LCI data for use by the public. In the US Database project, unit processes will be developed for segments of production systems, such as mining of coal for steel manufacturing and as a fuel. For these unit processes, the boundaries may well be the same as plant boundaries. In addition, unit processes will be combined into product systems with boundaries at "cradle-to-gate", meaning that the systems will begin with the removal of natural materials from the earth, and end at the basic manufactured material ready for delivery to subsequent processing or fabrication steps, or final product ready for delivery to the user. In addition, data sets will be developed for transformation processes used to convert material into forms in which they are used in final product.

Data on unit processes for post-industrial recovery and recycling of some basic materials will also be included, and for recovery and recycling of some post consumer products, where they are determined relevant to current practices for the products documented by the project. Consumer use and disposal impacts are beyond the scope of this project and will not be included in the cradle-to-gate systems. However, users will have access to the unit processes and can create post consumer recycling scenarios.

The following are notes on various published LCI protocols as well as related selected issue papers. The purpose of summarizing this information was to identify areas of consensus on protocol areas as well as to identify those areas where there is not consensus. It is this latter category which creates items in the greatest need for Workshop discussion prior to developing a protocol for this project. The discussion of essential protocol elements presented here is meant to provide points of departure for the workshop discussions.

The published protocols and other documents summarized here are the following. A comparison matrix is being provided as a separate Excel worksheet.

PROTOCOLS
- Athena/CORRIM
- ISO 14040 (Principles and Framework), and ISO14041 (Goal and Scope Definition and Inventory Analysis)
- American Forest and Paper Association
- Aluminum Industry
- Steel Industry (North America)
- International Iron and Steel Institute
- BRE (Building Research Establishment, LTD, UK)
- Canadian Standard Z760-94
- Canadian Raw Materials Database

SELECTED ISSUE PAPERS

- A Framework For Evaluating Data Uncertainty In Life Cycle Inventories, by Huijbrets, Norris, Bretz, Ciroth, Maurice, Mahasenan, von Bahr and Weidema

- SETAC LCA Workgroup: Data Availability and Data Quality, Energy, Transport and Waste Models, March 9, 2001

- SETAC LCA Workgroup: Data availability and Data Quality, "Recommended List of Exchanges", March 2001

- Eco-efficiency and Materials, by Five Winds for the International Council on Metals and the Environment

- Life-Cycle Assessment: Pilot Study on Inventory Methodology and Data Bases, by Ekvall, Baumann, Svensson, Rydberg, and Tillman

- Framework for Responsible Environmental Decision-Making (FRED): Using Life Cycle Assessment to Evaluate Preferability of Products

- ISO 14048.2 Committee Draft Environmental Management – Life Cycle Assessment – LCA Data Documentation Format

- Technical Report ISO/TR 14049 Environmental Management – Life Cycle Assessment – Examples of Application of ISO 14041 to Goal and Scope Definition and Inventory Analysis

The LCI categories summarized here are as follows. These were identified in the "Database Project Meeting of Interests" on May 21, 2001, and the project team as areas to be examined.

- Unit Process Form of Data
- Substances Reported
- Data Quality/ Uncertainty
- Transparency
- Estimates/Missing Data
- Sensitivity Analysis
- Energy of Material Resource
- System Boundaries
- Exclusion of Small Amounts
- Electricity Grids
- Co-product Allocation
- By-products, Wastes, Recycling

For several of the items discussed below, separate one to two page papers are being provided separately with more detailed discussions.

Protocol Items of Particular Interest

- **Unit Process Form of Data**
  We suggest that the database be developed in a unit process (modular) fashion to the maximum extent allowed by primary data collection and the need to resolve concerns about confidentiality. Although LCI data for "rolled-up" product systems, such as for aluminum sheet manufacturing, will be provided, the unit process components will reveal as much detail of the product systems as possible. In addition, the unit process approach allows a modular approach, whereby processes which are common to more than one product system are only studied once, and the resulting process data are used in each product system for which they are relevant.

See separate paper on transparency, etc. for more detail on unit processes.

- **Substances Reported**
  Provisionally, the project will include all substances reported on data sheets and other submissions (such as data submitted by industries from previous efforts). A list of essential emissions should include the EPA criteria air pollutants (particulates, SOx, NOx, CO, CH4, NMVOC, Pb), global warming gases (CO2 and others). Essential water emissions should include those that result in oxygen depletion and excess nutrients (compounds of nitrogen and phosphorus). Solid wastes should be categorized in at least two categories: industrial or post-consumer. Incineration should be detailed.

See separate paper for more detail.

- **Data Quality/ Uncertainty**
  Including information on data quality and uncertainty is a necessary part of any LCI.

  - Data should be well documented, such as described in the following discussion on transparency.
  - Missing data should not be ignored or omitted. Reasonable estimates should be made in order to avoid errors by omission.
  - Data ranges should be given if possible, and statistical measures should be included if available.
  - Expert review of all data should be undertaken to insure maximum data accuracy.

See separate paper for more detail.

- **Transparency**
  Data sources and methodologies should be well documented and clearly explained. Within the boundaries of confidentiality, an outside researcher should be able to reproduce the database and calculations from the same sources.

See separate paper for more detail

- **Exclusion of Small Amounts**

A methodology is needed to set boundaries to exclude small amounts of materials. The following example is consistent with the protocols reviewed.

For each process in a system, a listing of material inputs will be made. At least 98% of the cumulative mass will be included. In addition, 98% of the cumulative energy will be included. Excluded materials will be checked to make sure they contribute no more than 15% to any non-essential substance category, and no more than 2% to energy or any essential substance category. Decisions may be necessary as to whether inclusions of some very small contributors is necessary. This process may be iterative, requiring a preliminary LCI calculation to evaluate some small amounts of materials.

- **Estimates/Missing Data**

Missing data should be replaced by a method that is appropriate for the circumstance. Methods and sources used for estimation and replacement of missing data should be documented.

See separate paper on uncertainty for more detail.

- **Sensitivity Analysis**

If significant exceptions to the methodology employed exist, sensitivity analyses should be used to illustrate the effect of alternate methodologies. Possible examples include the following.

- Co-product allocation
- Recycling scenarios including use or exclusion of upstream burdens
- Major data with large ranges

Sensitivity analysis is also helpful to illustrate importance of various processes and sub-processes, as well as an indicator of the importance of data quality.

Guidelines for the US Database project should be determined by the workgroup.

- **Energy of Material Resource**

Materials that are considered energy resources used as materials (such as natural gas made into a plastic) should be included in a separate energy category, using the combustion value of all fuels extracted for the material purpose. Wood is excluded as it is not generally a fuel resource in North America (although the energy produced and used from burning wood and wood constituents as a fuel is documented in LCI).

- **System Boundaries**

As described in the introduction, this project will collect unit process data which can be aggregated into cradle-to-gate analyses of selected materials and products, ending with materials ready for fabrication into finished products, or products ready for use. A set of

example transformation processes will also be provided which include fabrication processes. Installation, use and disposal of specific products are not included in this project.

Because recovery and reuse is impossible to forecast many years from now, accurate assessment of recycling for products is not possible for products with very long lives. However, potential recyclability of products may be an important consideration. In order to address this, modules will be developed for current post consumer recycling practices so that users will have an option to investigate the implications of post consumer recycling for products with long lives by using current conditions as an optional estimate. Optional generic landfilling and incineration modules will also be included as end-of-life scenarios to be used in conjunction with the post consumer recycling modules.

Because of the complexity of many products, decisions will have to be made as to what products will be studied, and where best to locate the point of termination. Complex assembly operations, such as for automobiles and appliances, will not be included in the database, but LCI data for fuels and energy use (electricity, natural gas, etc.) will be provided so that users can model their own assembly processes.

Exclusions from the boundaries include: capital equipment used in manufacturing, processing and transportation; and personnel-related impacts. Heating and cooling of manufacturing facilities are often comparatively small but will be excluded only when investigation confirms they are sufficiently small. Imported materials, fuels, products, etc. will be assigned North American data unless the actual data is readily available.

- **Electricity Grids**

  In general, regional or local grids will be used to the extent possible. If a product is manufactured throughout the country, and specific electricity data is not available, then a national grid should be used. It is also customary for special cases such as electro-process industries where electricity is a major issue, that specific industry data is used. Self-generated electricity is generally not included as a separate item because the fuels used are part of the process energy.

- **Carbon Cycle**

  In order to assess global warming effects, biomass carbon cycles need to be carefully analyzed. For example, growing trees remove carbon from the atmosphere. If this wood is eventually sequestered in long term products or in landfills, the carbon is removed from the environment and a global warming credit will be applied. Combustion of wood releases CO_2 to the air, but is not an anthropogenic contribution to global warming. It is part of the natural carbon cycle.

  One issue that will need to be resolved is to specify how long sequestration needs to last to be able to apply a credit. The common time frame used by most practitioners of global warming calculations is 100 years, but a shorter time, such as 60 years may be used for the life of construction products. If wood is discarded to landfill after 60 years, there may be methane emissions from degradation that will need to be considered, even though generally end-of-life of products is beyond the scope of this project.

- **Co-product Allocation**

    Co-product allocation should be avoided when possible. If employed, physical units should be used as the basis in most cases. Mass is the most common basis, but energy and moles of material are two other bases that may be appropriate.

- **By-products, Wastes, Recycling**

    This will be one of the most difficult issues because there is no widely accepted analytical methodology. A major issue is whether recovered materials will have upstream burdens or not. Consensus of the nine protocols evaluated are that post consumer materials carry no material production burdens, i.e., all burdens of material manufacture are allocated to the initial product system in which the material is used, although burdens for recovery and reprocessing of the post consumer material are charged to the system using the post consumer material. However, if open-loop recycling is employed, burdens of material manufacture are allocated among the multiple product systems in which the material is used.

    In the protocols analyzed, post-industrial scrap may or may not be burdened. If it arises and is used within a process, it is simply a part of the process and no ambiguities exist. If it arises outside of the process being considered, it is treated it as a co-product of the virgin process and has an allocated share of burdens from that system.

    Specific examples should be presented in the protocol to show the effects of various decisions. Paper and metals may be involved in either open or closed loop systems, and post consumer materials can be evaluated different ways. Examples showing 0% and 20% recycling could form the basis of educational examples. Sensitivity analyses will illustrate the effects of decisions. Sensitivity analyses will also be recommended to users of the data base.