Subcontractor Report

U.S. LCI Database Project

1st Quarterly Report and Development Plan Update, December 2002

Athena™ Sustainable Materials Institute
Merrickville, Ontario, Canada

NREL

National Renewable Energy Laboratory

U.S. LCI Database Project

1st Quarterly Report and Development Plan Update, December 2002

Athena™ Sustainable Materials Institute
Merrickville, Ontario, Canada

NREL Technical Monitor: M. Deru

NREL

National Renewable Energy Laboratory

Acknowledgments

Table of Contents

U.S. LCI Database Project

1st Quarterly Report and Development
Plan Update: December 2002

1 Introduction

This development plan represents the first scheduled Phase II deliverable for the U.S. LCI Database Project.

The original intent was to supplement the preliminary Work Program for Phase II recommendations from the *U.S. LCI Database Project Phase I Final Report* with a more detailed Phase II implementation plan, including data to be collected, sources, identification of subcontractors, timelines, and cash flow projections. This document generally meets these objectives, but stops short of identifying specific data sources and subcontractors beyond the core project team (i.e., the Athena Institute, Franklin Associates and Sylvatica). As discussed later in the document, the data development focus over the next several months will be on the high priority fuels, energy, and transport databases; on the conversion of existing Athena Institute data for specific materials; and on the acquisition of recently developed data such as that available from the CORRIM project, or Consortium for Research on Renewable Industrial Materials project. The potential sources and related subcontractors for other data will have to be identified as the work progresses, and it would be premature to speculate on those aspects this early in the project.

As discussed with the National Renewable Energy Laboratory (NREL) Technical Monitor, it is preferable for a project of this nature to visualize the development plan as a 'work in progress,' rather than as a rigidly defined program. The plan will therefore be adjusted and updated as required, with changes submitted as part of the quarterly reporting process.

In the next section, we present a brief overview of progress since October 22, 2002, the official start date. The basic program elements are then identified and discussed in Section 3.

2 Summary of Progress to December 30, 2002

2.1 Task 1: Development plan, reporting, and project management

1. A project initiation and planning meeting involving the full consulting team was held to discuss outstanding issues from the Phase I research protocol (*U.S. LCI Database Project Data Development Guidelines*) and report, determine appropriate approaches in Phase II, and set corresponding team assignments (October 22-23, 2002).

2. Procedures have been developed, discussed, and implemented for project management and control, including setting and approving work priorities, subcontractor invoicing, and monthly/quarterly reporting.

3. Forty unit processes needed for a complete fuels and energy database were identified, and the Franklin Associates, Ltd. FAL fuels and energy database was then reviewed for completeness, currency, and usefulness for Phase II. The conclusions of this work were as follows:

   a. The database was developed with a valid methodology and is essentially ISO compliant;

   b. Several unit processes related to fuels production, combustion, and transportation should be updated and/or expanded to reflect new or changed technologies, to improve modeling accuracy using the greater level of detail now available in public data sources, and to provide necessary data quality documentation.

4. A work plan was developed for updating unit-process data in each fuels and energy database category, with the priority on those data modules that require the least work and that can therefore contribute sooner to the public database.

5. Data sources that will be needed to update and expand the FAL database have subsequently been identified and acquired.

6. The U.S. Environmental Protection Agency (EPA) E-GRID, or *E*missions and *G*eneration *R*esource *I*ntegrated *D*atabase program for electricity generation was reviewed to evaluate its usefulness for Phase II. The main conclusions were as follows:

   a. The E-GRID program can be used to develop grid profiles for the US and selected NERC regions, including percentages of each generating fuel, as well as emissions of CO_2, SO_2, NO_x and mercury.

   b. E-GRID spreadsheets can be used to develop profiles for generation by fuel type and boiler type, which can be linked to the fuel combustion data sets and the grid fuel percentages to develop data on emissions that are not included in E-GRID.

7. Detailed discussions were initiated with the EPA's National Risk Management Research Laboratory and its contractor to coordinate planned EPA work on LCI data for electricity and to ensure the most cost-effective combined approach. Detailed documentation was subsequently exchanged between the EPA contractor and the project team as a basis for further discussion.

2.2   Task 2: Database format

1. Discussions have been held with European database developers to explore streamlined approaches to the ISO 14048 data format.

2. Various life-cycle assessment (LCA) tools developers have been contacted to determine their preferred data import or exchange methods and formats.

3. Discussions have been held with the NREL Web site developer to answer questions, discuss issues, and generally coordinate the site and format development tasks.

2.3   Task 3: Additions to research protocol/report on review of protocol & database

1. The research protocol sections dealing with allocation and recycling have been reviewed and rewritten to clarify the meaning and procedures.

2. A first draft of the economic allocation annex to the protocol has been prepared for internal review. The annex deals with the application of economic allocation to multi-product unit processes and systems, including price base years and averaging, pricing points, and a method for imputing missing market price information.

3. A preliminary draft of elementary flow reporting guidelines has been developed taking account of the recommended list of exchanges in the *Code of Life Cycle Inventory Practices* soon to be published by the Society of Environmental Toxicology and Chemistry (SETAC). An approach has been defined to detail an appropriate screening method for future elementary flow reporting.

4. An initial assessment has been made of existing screening tools for small or missing inputs to an LCI, and a corresponding approach to this task has been formulated and discussed internally.

2.4   Task 4: Data collection

1. Specific fuels and energy database work was undertaken, as follows:

   - **Coal.** Based on published data and interviews with industry contacts, separate data sets were developed for the production of anthracite, bituminous, and lignite coal, reflecting the differences in locations and mining techniques. Transportation estimates were developed based on the geographic locations of coal producers and users, interviews with coal industry contacts, and published data. New standards for water quality have been found and work is proceeding on updating data on acid drainage from mines.
   - **Uranium.** Domestic and foreign sources of uranium for electricity generation have been researched and the percentages of uranium extracted by conventional and solution mining determined for producing countries. Data sets have been developed for extraction and processing data and finalization of the module is awaiting enrichment data from the Energy Information Administration. Updated transportation data is based on locations of uranium producers, processors, and users.
   - **Crude oil and natural gas extraction.** Energy and transportation data obtained through new and updated publicly available data sources is being verified. No recent updates of AP-42 emissions data are available for these processes; additional data sources on air

emissions published by the Department of Energy and Argonne National Laboratory have been located and are being utilized.

- **Electricity generation.** Development of generation profiles by fuel and boiler type has been started using the E-GRID spreadsheets.
- **Fuels combustion.** The compatibility between levels of detail available in E-GRID and the most current AP-42 data on combustion emissions by fuel type, boiler type, and control system has been assessed.
- **Transportation.** New data sources and models for combustion emissions for various transportation modes have been identified through an Internet search, including MOBILE6 (motor vehicle emissions software) from U.S. EPA Office of Transportation and Air Quality, and GREET 1.6 (*G*reenhouse gases, *R*egulated *E*missions, and *E*nergy use in *T*ransportation) developed by Argonne National Laboratory under contract to the U.S. Department of Energy Office of Transportation Technologies.

3 Work Program Elements and Schedule

Table 1 details the work program by task elements. The thicker bars indicate periods of relatively more intensive work on specific task elements, while the thinner bars indicate periods of less intensive or uncertain activity. The chart shows the program on a more detailed monthly basis for the next quarter, and on a quarterly basis for the remainder of the project term. The intent is to routinely update the chart as part of the quarterly progress reporting process, with a monthly breakdown for the coming quarter.

The remainder of this section provides a more detailed description of key elements for the main tasks listed in Table 1.

3.1 Task 1

Not shown in Table 1 are the monthly progress reports and more detailed quarterly reports. The latter will include updates to the schedule as indicated above. Cash flow projections will also be updated quarterly. During the last quarter we expect to focus on the completion of documentation as part of the final project report, with the objective of supporting ongoing database maintenance and expansion.

3.2 Task 2

Task 2 is being undertaken in conjunction with NREL, with the project team focusing on the database format and NREL on the related Web site design. We anticipate that task will be essentially complete by the end of January, with ongoing testing and development through the second quarter of 2003.

Based on the experience of European tool and database developers, the most practical streamlined version of the ISO 14048 format appears to be "EcoSPOLD". EcoSPOLD was developed for the Swiss EcoInvent database project and is now going to be implemented by LCA software tools such as SimaPro. In fact, the evidence suggests that this new 14048-based format may become the "de facto" standard. The immediate work program for this task will therefore include the following components:

- Production of a summary document explaining how EcoSPOLD differs from, and complies with, ISO 14048;

- Further communication with database developers worldwide concerning the pros and cons of using the EcoSPOLD format relative to other options, including an assessment of where the worldwide LCA community is headed in terms of database formats for exchange and documentation; and

- Continued coordination with NREL as needed to convey this information, gather new information, and resolve any remaining formatting issues.

An example data module from the Athena Institute databases will be provided in early January to facilitate the format and Web site development task. The test module will also be used to examine the treatment of energy combustion versus process emissions, as well as other issues related to module interrelationships, especially as they might affect or be affected by the format.

Table 1: Work Program Elements and Schedule

	2002		2003						2004			
	Nov	Dec	Jan	Feb	Mar	2nd Quarter	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Task 1 - Planning, reporting												
Prioritize Fuels and Energy data modules	■											
Review/prioitize other data for material modules	■											
Develop/up-date work program		■			■	■	■	■	■	■	■	
Develop/up-date cash flow projections		■			■	■	■	■	■	■	■	
Final project report												■ X
Task 2 - Database/web formats												
Review of recent format developments		■										
Survey of tool developers	■	■										
Initial web format development (with NREL)		■	■									
Provision of test data to NREL			■									
Ongoing development/testing (with NREL)				■	■	■						
Task 3 - Protocol revisions/annexes												
Develop input screening tool		■	■	■								
Standardize substance nomenclature			■									
Develop elementary flow reporting guidelines	■		■	■								
Develop economic allocation annex		■	■	■								
Review and revise protocol as required			■				■	■				
Task 4 — Data collection & analysis												
Fuels, Energy, Transport — High Priority	■	■	■	■	■	■	■					
Fuels, Energy, Transport — Lower Priority								■	■	■		
Other materials			■	■	■	■	■	■	■	■	■	
Transformation Processes	■	■	■	■	■	■	■	■	■	■	■	
End of Life									■	■	■	
Task 5 — Database User's Guide												
Preparation of initial version			■	■								
Revision and up-dating as necessary						■	■	■	■	■	■	

Legend:
- ■ More intensive work program
- ▬ Less intensive or uncertain program
- (shaded) Outside funding -- does not affect NREL budget

3.3   Task 3

With the exception of ongoing review and revision, this task will be completed during the next quarter. Progress has already been made on all of the elements as described in Section 2.

3.3.1 Input-screening tool

The input-screening tool is intended to help analysts screen for missing inputs to a product class, to identify the relevance or potential environmental significance of small inputs to a unit process, and to test for the potential influence of missing flows.

A Missing Inventory Estimation Tool (MEIT) has been developed by CML, the Centre for Environmental Studies, at Leiden University in the Netherlands, to test for missing flows using input-output (I/O) techniques and U.S. I/O and environmental data. While this tool has been previously restricted to fewer than 100 sectors, which is a high level of aggregation for such a screening tool, CML reports an update to 500 sectors is planned for early 2003.   Our approach will be to directly use the CML data and tool as feasible, augmenting it with Sylvatica's OpenLC software where necessary and where the benefits are significant.

In support of this approach, there is a general consensus emerging among LCA practitioners worldwide that process-oriented LCA and LCA based on national I/O data compliment each other. Furthermore, many recent papers and practical applications have highlighted the potential for a hybrid of these two approaches to provide more accurate results than either in isolation. Practitioners use process-based data where available, and fill in the data gaps inherent in such process-based systems using I/O data where necessary. By merging or combining these two data sources, it should be possible to achieve more accurate final results than by using either source in isolation.

The following specific steps are planned:

1.   Use the selected U.S. I/O LCA tool to determine the total upstream environmental burden (e.g., via TRACI, CML method, and Eco-Indicator 99 method) associated with each input to each of 500 sectors in the U.S. I/O model;

2.   Work with test data to determine an algorithm/basis for sorting inputs in terms of their environmental significance (e.g., importance with respect to any of a subset of TRACI impact categories, or other options);

3.   Use uncertainty analysis (Monte Carlo simulation) for the input/output data uncertainties and the emissions coefficient uncertainties to estimate upper and lower bounds for the importance (burdens) of each input to each sector; and

4.   Based on the nature and relevance of the results of step 3, develop screening tool recommendations for further testing and implementation.

3.3.2 Elementary flow reporting guidelines

This research protocol annex will detail reporting guidelines for the selection and reporting of elementary flows, including standard substance nomenclature. In this case, screening will be focused on the problem of ensuring adequate coverage of significant environmental effects without the overwhelming detail encountered in some LCI databases.

A two-step screening process is planned: screening based on direct emissions from each 4-digit Standard Industrial Classification of the U.S. economy (roughly 500 sectors); and screening based on emissions from processes within the SimaPro database for materials of high near-term priority. Screening will be done based on at least three impact assessment methods: TRACI, CML updated method, and EcoIndicator 99.

The two steps have been selected (over screening based on normalization data, or on cradle-to-gate emissions) because these approaches have the highest level of conservativeness and inclusiveness.

Specific planned sub-tasks include the following:

1. *Life-cycle characterization analysis on the direct emissions from each sector, using each of the three life-cycle impact assessment methods listed above*
Inventory flows for this sector-based analysis will include at least the following pollutant data sets: TRI toxic releases to air, water, and land; criteria air pollutants; NTI (additional, and additionally-speciated releases to air); and greenhouse gasses. For each sector, we will rank inventory flows by percentage contribution to each impact category, and determine the subset of flows that contributes total cumulative percentages higher than specified individual percentages of impact, for each impact category. For example, we will examine the flows that must be included to capture at least 99% of the impact in each impact category, or that each account for at least 1% of the total impact in each impact category.

2. *Life cycle characterization analysis for 20-30 different process types (e.g., steel basic oxygen furnace, steel electric arc furnace, etc.) that are found to be of high near-term relevance to the U.S. LCI Database Project*
We will again rank inventory flows by percentage contribution to each impact category. We will also determine the flows that must be included in each supply chain in order to account for at least 99% of the impact in each category.

In addition, during this task we will clarify the flow nomenclature that best serves the impact assessment methods, based on a review and comparison of U.S. reporting nomenclatures (e.g., to U.S. EPA datasets), the nomenclature in each of the impact assessment methods, and the findings and recommendations from the recently completed SETAC Europe working group on data quality and data availability.

3.3.3 Economic allocation annex

This addition to the protocol is an annex to guide the use of economic allocation methods. As noted in Section 2, a draft annex has already been completed. The work program will now focus on further review and evaluation of the recommended procedures, with testing using actual data modules to the extent practical. We plan to complete this annex by mid-February.

3.3.4 Extensive testing and revision of Data Development Guidelines

Once the protocol has been used to guide the first round of data collection, we plan an extensive review and revision as necessary, the results of which will be posted on the NREL website. This work will be completed by the end of 2003.

3.4 Task 4

3.4.1 Fuels, Energy, Transport

This task includes data collection and analysis leading to the database. In Phase I, the highest priority was attached to modules related to fuels and energy, including fuels extraction, processing, and transportation; fuel combustion effects; electricity generation; and transportation fuel use and emissions by mode. The initial Task 1 work described in Section 2.1 led to the following more detailed prioritization of the specific fuels and energy modules.

HIGHEST PRIORITY	SECOND PRIORITY
Primary Fuel Production	**Primary Fuel Production**
Coal: Bituminous	Residual oil
Coal: Anthracite	Distillate oil
Coal: Lignite	Gasoline
Natural Gas	Propane LPG
Crude Oil	Jet fuel (kerosene)
Uranium	Other-Hydropower
Electricity Generation	Other-Biomass
Primary Fuel Consumption	Other-Wind
Coal in utility boilers	Other-Ethanol
Coal in industrial boilers	Other-Geothermal
Residual oil in utility boilers	
Residual oil in industrial boilers	
Distillate fuel oil in utility boilers	
Distillate fuel oil in industrial boilers	
Natural gas in utility boilers	
Natural gas in industrial boilers	
Natural gas in industrial equipment	
Diesel powered industrial equipment	
Gasoline powered industrial equipment	
LPG in industrial boilers	
Wood in industrial boilers	
Uranium fuel use	
Mobile Sources	
Tractor-trailer (gasoline)	
Tractor-trailer (diesel)	
Single-unit truck (gasoline)	
Single-unit truck (diesel)	
Locomotive (diesel)	
Barge (diesel)	
Barge (residual fuel oil)	
Ocean freighter (diesel)	
Ocean freighter (residual)	
Airplane (kerosene)	

The above priorities are reflected in the Table 1 schedule and, as discussed in Section 2.4, work is already well advanced on several of the highest priority modules using existing Franklin Associates databases as the starting point or foundation. Also discussed in Section 2.1 is the fact that discussions are underway with the EPA to coordinate work on electricity generation.

3.4.2 Other Materials

The initial work on other materials will be based on existing Athena Institute databases. The immediate priority will be to extract a basic steel production data module that can be linked to selected energy production modules (e.g., coal production) for the purpose of developing and testing the data format and Web site (see Section 3.2).

As indicated in Table 1, we plan a period of more intensive activity during the first quarter of 2003 when we will concentrate on the Institute data modules that can most readily be extracted and adjusted to suit the requirements of the project. The realities of cash flows dictate less intensive activity during the second and third quarters in order to maintain the focus on high priority energy and transportation modules. However, we expect to at least initiate activity on several other fronts. For example, data on various wood building products should be available from the CORRIM project and there is publicly available data on basic aluminum production that may be usable with little additional work by the project team. As well, discussions are continuing with other industries (e.g., plastics, lime, other metals) to either acquire or develop appropriate data modules.

3.4.3 Transformation Processes

Table 1 shows work underway and planned in the transformation process category, with the note that the work has outside funding and does not affect the NREL budget. That work is currently being funded by the Vehicle Recycling Partnership (VRP) of the U.S. Car Project (Ford, General Motors, and Daimler Chrysler). It has two aspects: internal data collection and analysis by VRP; and separately funded advisory and data aggregation work by the project team.

The current focus is on different aluminum casting technologies for complex parts like engine blocks. Future VRP work will focus on other transformations of interest to the automobile industry, but the exact details are yet to be determined. As a result, Table 1 shows the transformation process category as less intensive or uncertain after the first quarter of 2003. This is one area where the Table is likely to be updated as part of the next quarterly report.

We should also note that, while the intention is to provide data modules for the database project, there would have to be ultimate approval from senior auto industry management before data will be released for public use.

3.4.4 End-of-Life

The development of end-of-life process modules related to recycling or ultimate disposal of products or materials is shown as an uncertain activity for 2004. No specific starting databases have yet been identified and there is not sufficient funding available, given the other priorities, to initiate primary data collection activities any sooner.

3.5 Database User's Guide

Development of an initial version of the database user's guide will be completed during January and February. The guide will then be reviewed, revised, and updated as a routine ongoing activity throughout the rest of the project period.

REPORT DOCUMENTATION PAGE

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 March 2004	3. REPORT TYPE AND DATES COVERED Subcontract Report December 2002

4. TITLE AND SUBTITLE U.S. LCI Database Project: 1st Quarterly Report and Development Plan Update, December 2003	5. FUNDING NUMBERS LDC-3-32452-01 BEC3.3004
6. AUTHOR(S) Athena Sustainable Materials Institute	

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-550-35623

11. SUPPLEMENTARY NOTES NREL Technical Monitor: M. Deru

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 (Maximum 200 words) Summary of progress on LCI Database project for 2002.

14. SUBJECT TERMS LCI Database Project; 1st Quarterly Report and Development Plan Update; 2002	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