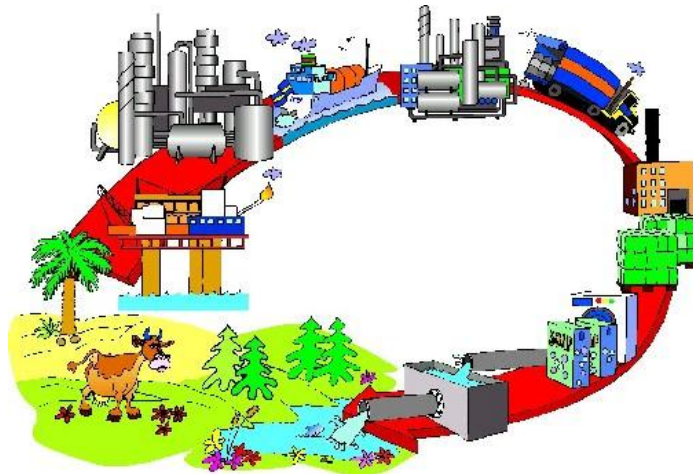


Environmental Life Cycle Assessment

PSE 476/WPS 576/WPS 595-005

Lecture 7: Life Cycle Inventory: LCA Stages: Raw Materials and Energy



Fall 2012

Richard A. Venditti
Forest Biomaterials
North Carolina State University
Raleigh, NC 27695-8005

Richard_Venditti@ncsu.edu
Go.ncsu.edu/venditti

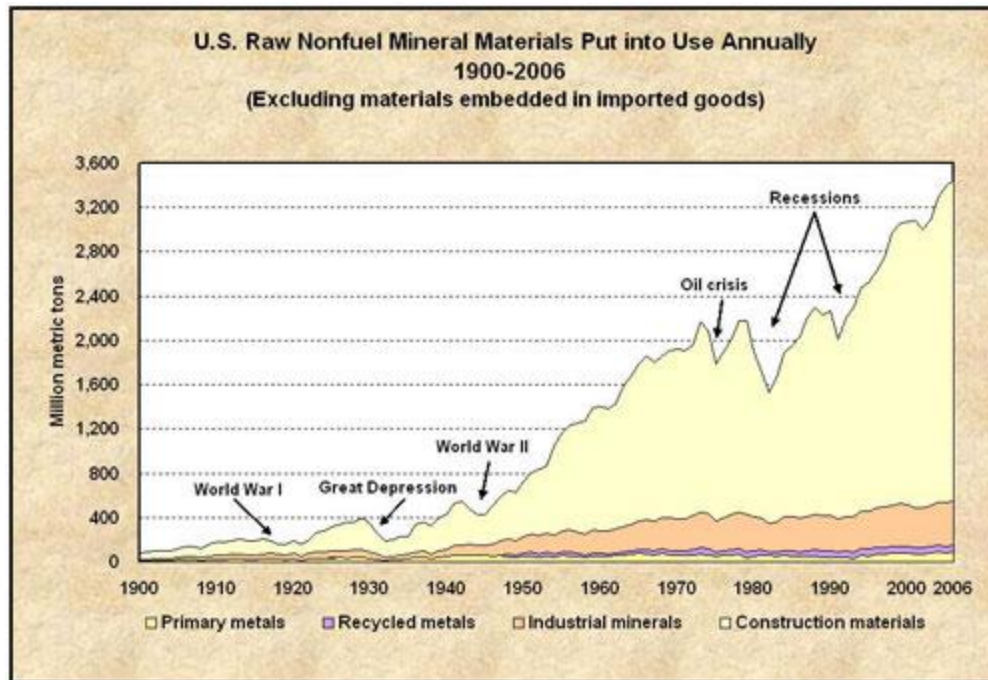
Raw Materials:

- Primary materials: materials that have not been recycled/reused
- Secondary materials: materials have been recycled/reused
- Secondary materials are of especial importance since they can:
 - Reduce the requirements of primary materials
 - Have significantly different acquisition processes relative to primary materials: with different environmental impacts
 - Different transportation modes
 - Different collection baskets
 - Different quality and purity
 - Reduce waste

Renewable vs Non-renewable Materials:

- A **nonrenewable resource** is a natural resource which cannot be reproduced, grown, generated, or used on a scale which can sustain its consumption rate, once depleted there is no more available for future needs.
- A **renewable resource** is a natural resource with the ability to reproduce through biological or natural processes and replenished with the passage of time.

Non-renewable Materials: Minerals



Every American born in 2008 is estimated to use the following amounts of nonfuel mineral commodities in their lifetime for their necessities, lifestyles, and health.

Mineral commodity	Amount required over a lifetime
Aluminum (bauxite)	5,677 pounds
Cement	65,480 pounds
Clays	19,245 pounds
Copper	1,309 pounds
Gold	1,576 ounces
Iron ore	29,608 pounds
Lead	928 pounds
Phosphate rock	19,815 pounds
Stone, sand, and gravel	1.61 million pounds
Zinc	671 pounds

Data from U.S. Geological Survey and U.S. Energy Information Administration; statistical analysis by National Mining Association. Source of information: <http://www.mii.org/pdfs/CalculationsfmiiBaby.pdf>.

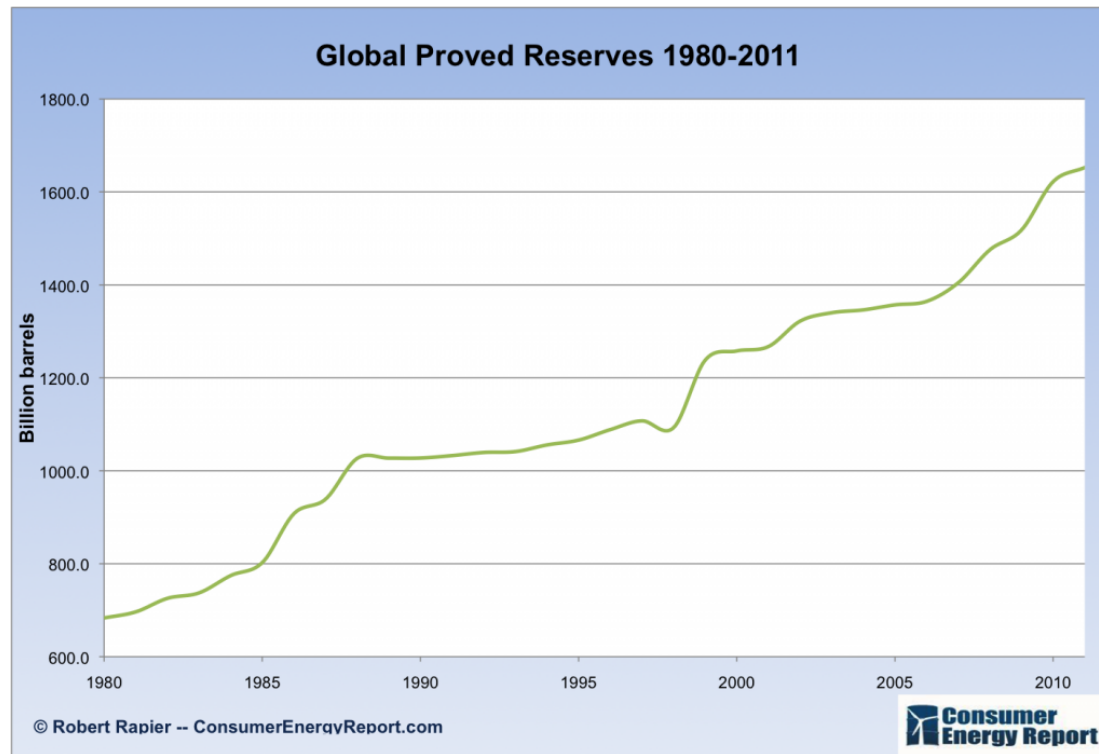
<http://minerals.usgs.gov/granted.html>

How much copper ore do we have left?

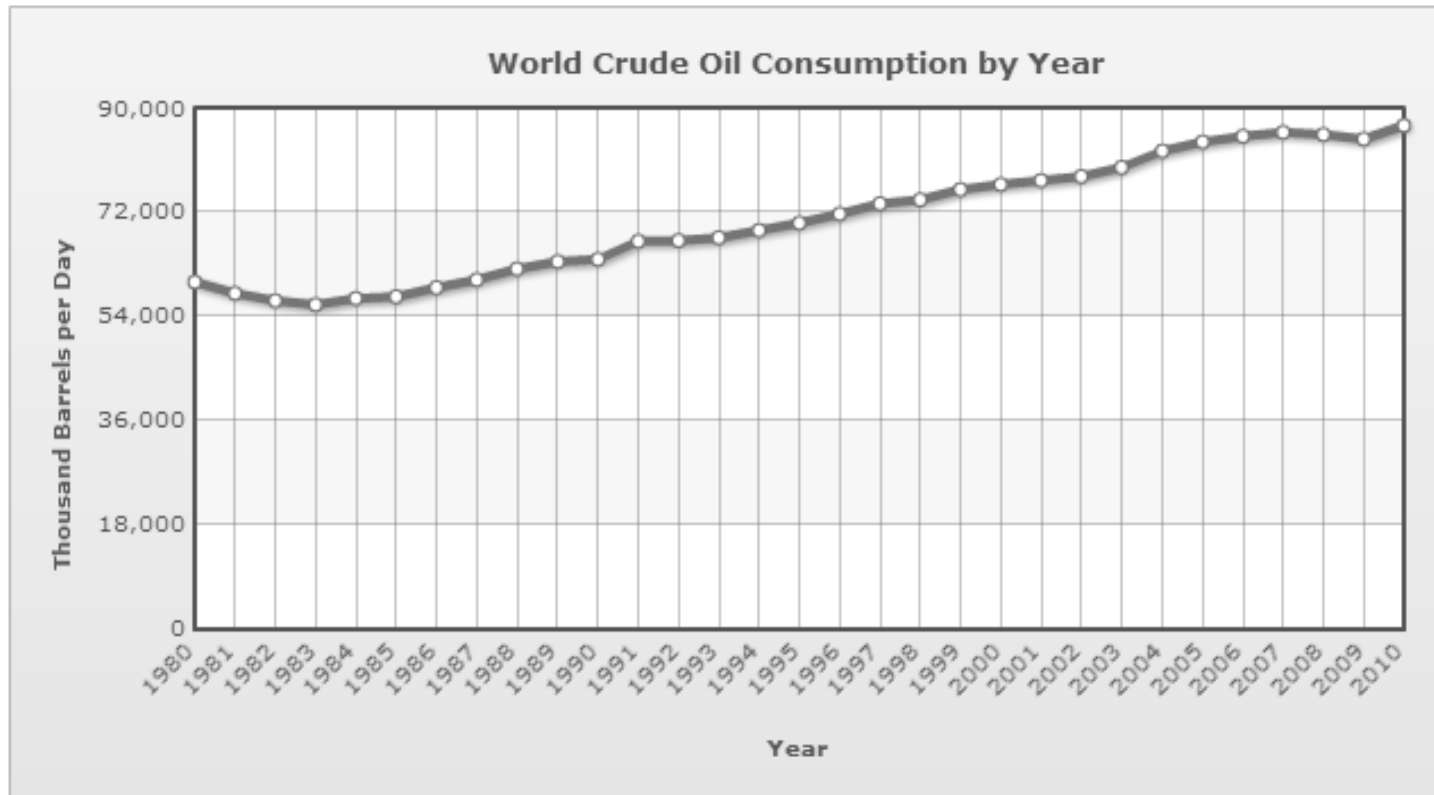
- It is not possible to know exactly.
 - known deposits are being worked and new methods of copper extraction are being developed e.g. using bacteria to 'eat' the copper out of low grade ore
 - some deposits do not contain enough copper to make them economic to extract
 - there are many copper deposits that have not yet been found
 - deposits are still being built up on the seabed

Non-renewable Materials: Crude Oil

Crude Oil Definition: A mixture of hydrocarbons that exists in liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.



Non-renewable Materials: Crude Oil



Source: [United States Energy Information Administration](#)

Non-renewable Materials: Crude Oil

At present consumption, when would proved reserves of crude oil run out?

Renewable Materials:

- Agricultural products
- Forest biomass
- Fish and animals
- Water
- However, note that any of these materials can be non-renewable in specific situations/locations under specific conditions (non-sustainable consumption practices)

Non-Renewable and Renewable Energy Resources:

- Non-renewable
 - Fossil fuels (coal and oil)
 - Natural Gas
 - Nuclear Power
- Are there examples of renewables for the above list?
- Renewable
 - Solar energy
 - Geo thermal
 - Wind
 - Hydropower
 - Biomass
- What are the issues with renewables?

Primary Raw Materials:

- Cultivation, harvesting, replenishing
 - Farm products
 - Forest products
 - Wildlife
- Mined/Collected
 - Fossil fuels
 - Ores
 - Water
 - Air

Inputs for Basic Raw Materials:

- Energy Utilization
 - Electrical energy in kWh
 - Other energy sources in appropriate units, gallons of fuel, cubic feet of gas
 - Renewable energy
 - Non-renewable energy
- Materials Consumed
 - Pesticides, fertilizers, water, ...
- Harvesting/Processing/Transportation
- Infrastructures required
 - Roads, buildings, drilling rigs,
 - Equipment to explore, mine, extract, harvest materials

Outputs for Basic Raw Materials:

- Air emissions
- Waterborne emissions
- Solid waste
- Other environmental releases
- Habitat changes
- Land use changes
- Aesthetic changes
- Raw material consumption

LCA Information for Basic Raw Materials:

- US Life Cycle Inventory Database, www.nrel.gov/lci/



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U.S. Life Cycle Inventory Database

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NREL's Buildings research supports the U.S. Department of Energy's [Building Technologies Program](#).




U.S. Life Cycle Inventory Database

NREL and its partners created the U.S. Life Cycle Inventory (LCI) Database to help life cycle assessment (LCA) practitioners answer questions about environmental impact. This [database](#) provides individual gate-to-gate, cradle-to-gate and cradle-to-grave accounting of the energy and material flows into and out of the environment that are associated with producing a material, component, or assembly in the U.S.

The goals of the U.S. LCI Database project are:

- Maintain data quality and transparency
- Cover commonly used materials, products, and processes in the United States with up-to-date, critically reviewed LCI data
- Support the expanded use of LCA as an environmental decision-making tool
- Maintain compatibility with international LCI databases
- Provide exceptional data accessibility
- Be fully and sustainably supported
- Support U.S. industry competitiveness.

Read the plan to achieve the goals of the LCI Database Project in the [U.S. Life Cycle Inventory Database Roadmap](#) .

EVENTS

Energy Efficiency in Homes & Buildings, By Paul Kreischer, Lightly Treading Energy and Design

October 9, 2012, 6:00 - 8:00
MDT
Golden, CO

Northeast Sustainable Energy Association (NESEA) - Green Buildings Open House ▶

October 13, 2012
Maine to Pennsylvania

▶ More Events

U.S. Life Cycle Inventory Database Roadmap



U.S. Life Cycle Inventory Database Dataset Additions



LCA Information for Basic Raw Materials:

- Ecoinvent, European LCI database

The screenshot shows the Ecoinvent Centre portal. The header includes the Ecoinvent Centre logo (a red circle with 'ecoinvent Centre' text) and the text 'Swiss Centre for Life Cycle Inventories'. To the right, it says 'a Competence Centre of' followed by logos for ART, PSI, EPFL, ETH, and EMPA. Below the header, there is a 'Direct access to database' section with a login form (Username, Password, Login button, and a 'Forgot your password?' link). A navigation bar contains buttons for 'Organisation', 'Database', 'Documentation', 'News', and 'ecoinvent v3'. The main content area is divided into two columns. The left column, titled 'Latest News', contains three news items: 'ecoinvent v3 further postponed ...' (dated 09.10.2012), 'ecoinvent v3 – release date shifts to September 2012!' (dated 24.07.2012), and 'DF LCA 48 "ecoinvent v3" - presentations online available' (dated 18.06.2012). The right column features a section titled 'Welcome to the ecoinvent Centre portal' with a paragraph describing the centre as a world-leading supplier of LCI data. Below this, there is a section titled 'ecoinvent data v2.2 ...' which lists three bullet points: 1) contains international industrial life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services; 2) is used by around 4'500 users in more than 40 countries worldwide and is included in the leading LCA software tools as well as in various eco-design tools for building and construction, waste management or product design; 3) is our solution for your data needs in Integrated Product Policy (IPP), Environmental Product Declaration (EPD), Life Cycle Assessment (LCA), Life Cycle Management (LCM), Design for Environment (DfE).

ecoinvent Centre
Swiss Centre for Life Cycle Inventories

a Competence Centre of ART PSI EPFL ETH EMPA

Direct access to database

Username:
Password:
[Login](#) [Forgot your password?](#)

[Organisation](#) [Database](#) [Documentation](#) [News](#) [ecoinvent v3](#)

Latest News

ecoinvent v3 further postponed ...
Due to some technical problems, the release of ecoinvent v3 is unfortunately further postponed...
[\[more\]](#) 09.10.2012

ecoinvent v3 – release date shifts to September 2012!
In the last month, the ecoinvent Centre team together with the editorial board worked very hard to...
[\[more\]](#) 24.07.2012

DF LCA 48 "ecoinvent v3" - presentations online available
All presentations from the one-day conference "ecoinvent v3 - an introduction to the new...
[\[more\]](#) 18.06.2012

Welcome to the ecoinvent Centre portal

The ecoinvent Centre - a Competence Centre of ETHZ, EPFL, PSI, Empa and ART - is the world's leading supplier of consistent and transparent life cycle inventory (LCI) data of known quality with the **database ecoinvent data v2.2** and offers science-based, industrial, international life cycle assessment (LCA) and life cycle management (LCM) data and services.

ecoinvent data v2.2 ...

- contains international industrial life cycle inventory data on energy supply, resource extraction, material supply, chemicals, metals, agriculture, waste management services, and transport services.
- is used by around 4'500 users in more than 40 countries worldwide and is included in the leading LCA software tools as well as in various eco-design tools for building and construction, waste management or product design.
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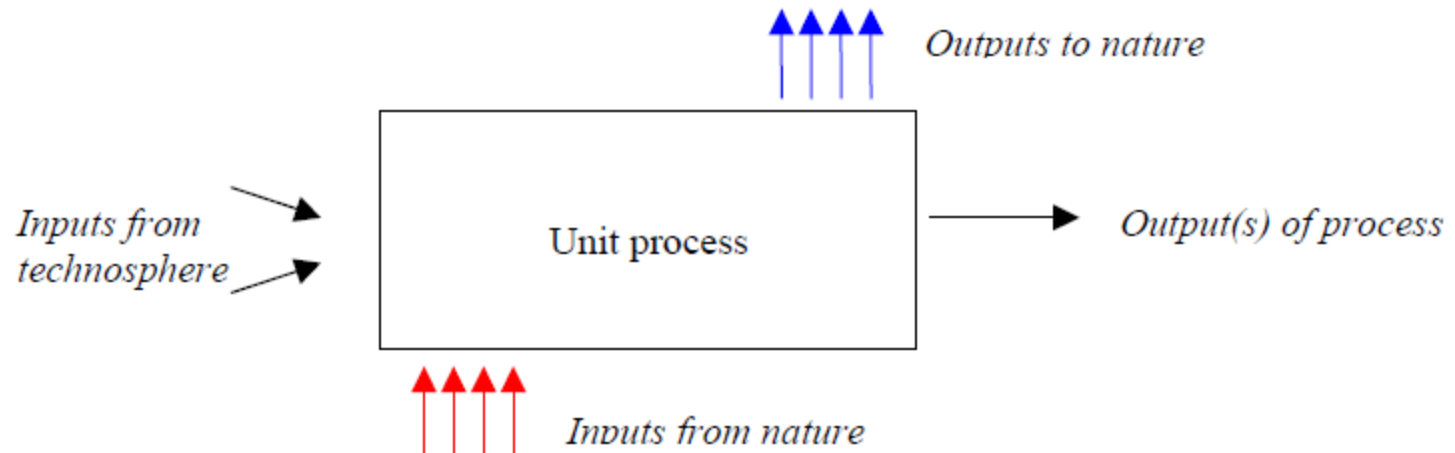
LCA Information for Basic Raw Materials:

US LCI: Overall Theme

- Which has the least impact on the environment, plastic or paper, cellulose insulation or fiberglass insulation, carpet or wood flooring?
- No final answer, each product has advantages and disadvantages when it comes to its environmental impact.
- The science of sustainability is not exact, but we are working on tools to give us better answers to environmental impact questions.
- The U.S. Life-Cycle Inventory (LCI) Database project is providing essential data to support those tools.

LCA Information for Basic Raw Materials: US LCI

- Database is composed of LCI data modules.
 - Inputs from technosphere (The part of the physical environment affected through building or modification by humans.)
 - Inputs from nature
 - Outputs to nature
 - Outputs of process (products)
- Modules can be cradle-to-gate or gate-to-gate or cradle to grave



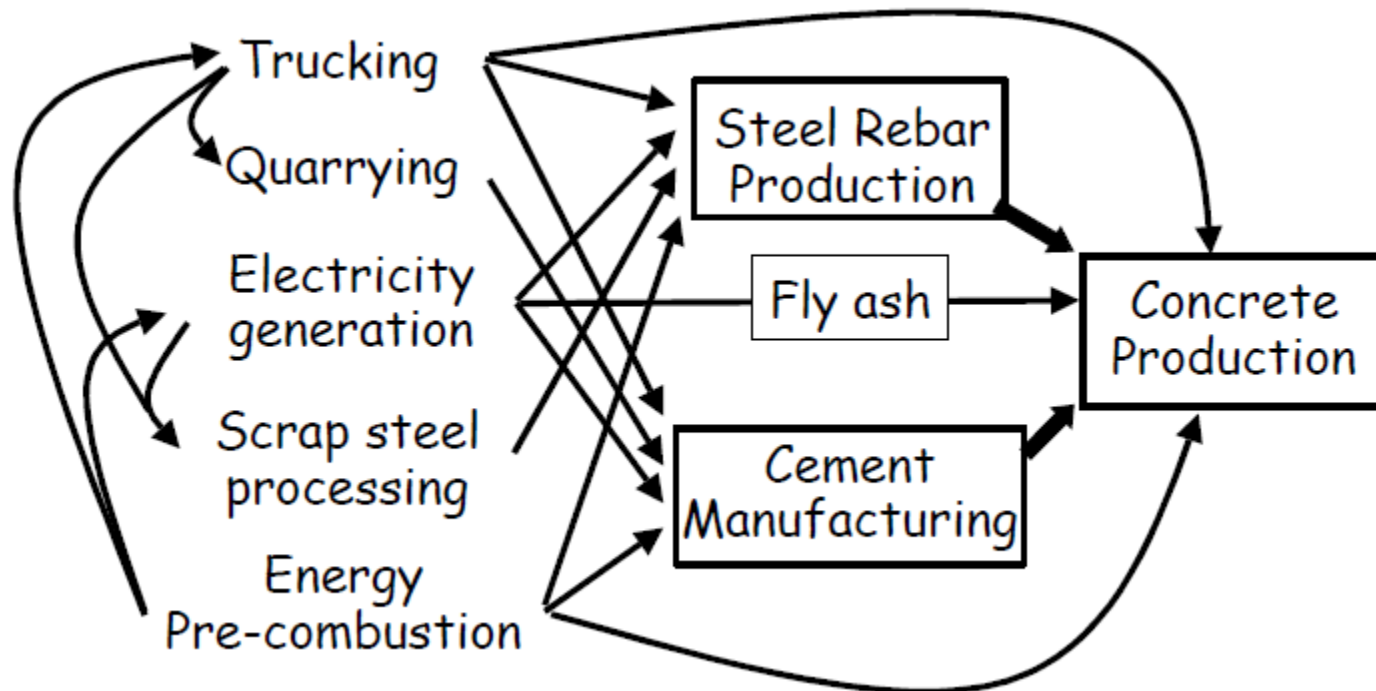
LCA Information for Basic Raw Materials: US LCI

- Note, in some cases, inputs/outputs to nature are qualified

Flow Type	Category	Sub Category
Input from Nature	Resource	Biotic In air In ground In water Land
	Water	Lake Ocean Protected area River River, long-term Unspecified
	Other	Unspecified
Output to Nature	To Air	High population density Low population density Low population density, long-term Protected area Stratosphere Unspecified
	To Water	Fossil Ground Ground, long-term Lake Ocean Protected area River River, long-term Unspecified
	To Waste Management	Building demolition Hazardous waste incineration Inert material landfill Land farming Municipal incineration Recycling Residual material landfill Sanitary landfill Underground deposit Wastewater treatment Others
	Other	Unspecified

LCA Information for Basic Raw Materials: US LCI

- Modules as building blocks
- The scrap steel processing module calls for electricity per unit reference flow of product, and obtains inventory data for that electricity from the electricity generation module

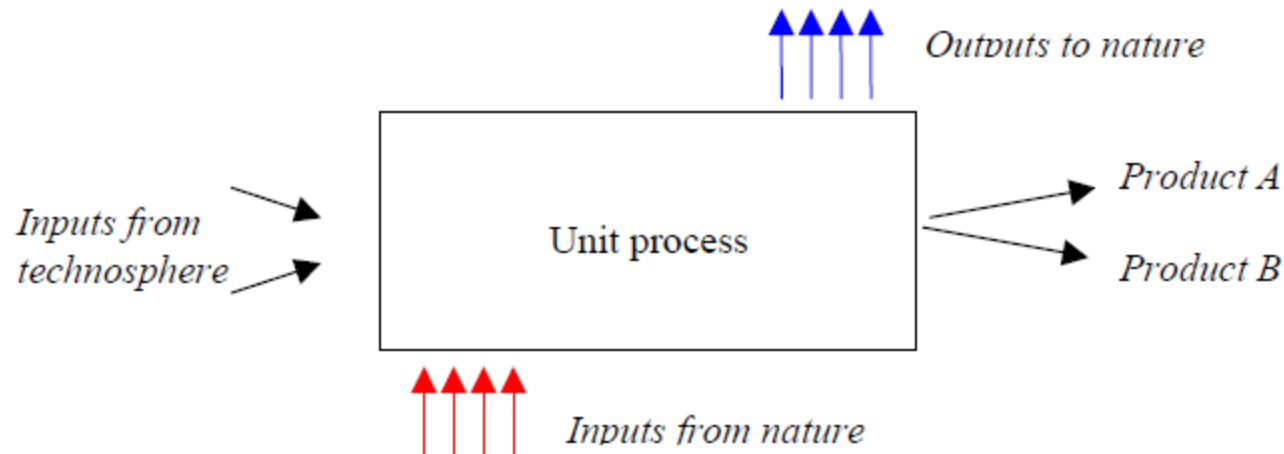


LCA Information for Basic Raw Materials: US LCI

- Aggregate Modules: combined data for several modules into one
 - Convenience
 - Only available at an aggregated level
- Example: kiln dried softwood lumber from the Pac. NW combines
 - Forest resources (forest mgmt and harvesting)
 - Sawing
 - Kiln drying
 - Planning
 - Energy Production
 - Transportation
- Since the individual modules are also available, then a user can pick and choose individual modules to produce a specific “aggregated module” correct for a certain application


LCA Information for Basic Raw Materials: US LCI

- Modules supplied without allocations between co-products
- Allows the users to apply allocation methods as they see fit and to undertake sensitivity analysis on allocation methods



LCA Information for Basic Raw Materials: US LCI

- Database: <https://www.lcacommons.gov/nrel/search>


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DATASET TYPE

☐ Flows (1334)
☐ Process (633)

CATEGORY

☐ Air Transportation (1)
☐ Chemical Manufacturing (84)
☐ Crop Production (34)
☐ Elec. Equip., Appliance, and Comp. Mnf. (2)
☐ Fabricated Metal Product Manufacturing (1)
☐ Forestry and Logging (80)
☐ Mining (except Oil and Gas) (6)
☐ Nonmetallic Mineral Product Mnf. (2)
☐ Oil and Gas Extraction (3)
☐ Paper Manufacturing (1)
☐ Petroleum and Coal Products Mnf. (2)
☐ Primary Metal Manufacturing (23)
☐ Rail Transportation (1)
☐ Transit and Ground Passenger Trans. (46)
☐ Transportation Equipment Manufacturing (5)
☐ Truck Transportation (102)
☐ Utilities (125)
☐ Waste Management and Remediation Service (22)
☐ Water Transportation (6)
☐ Wood Product Manufacturing (60)
☐ biomass (21)

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1,967 records found

1 2 3 4 5 6 .. 57 Next

Transport, single unit truck, short-haul, diesel powered, West	General Freight Trucking	
Transport, motorcycle, gasoline powered	Other Transit and Ground Passenger Tran	
Phenol formaldehyde, at plant	Plastics Material and Resin Mnf.	
Soybean oil, crude, degummed, at plant	unspecified	
Palm kernels, at plant	Oilseed (except Soybean) Farming	
Polystyrene, high impact, resin, at plant, CTR	Petrochemical Manufacturing	
Electricity, at eGrid, HIMS, 2008	Utilities	
Forest residue, processed and loaded, at landing system	Logging	
Anode, at plant	Misc. Fabricated Metal Product Mnf.	
Combustion, wet wood residue, AP-42	Other Electric Power Generation	
Dry veneer, at plywood plant, US SE	Softwood Veneer and Plywood Mnf.	
Soybean grains, at field	Soybean Farming	
Delimbing, slide boom delimber	Logging	

LCA Information for Basic Raw Materials: US LCI

- Example: corn stover, ground and stored


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Delimbing, slide boom delimber	Logging	

LCA Information for Basic Raw Materials: US LCI

- Example: corn stover, ground and stored

Showing details for *corn stover, ground and stored*

 [Back to Results](#)

Activity		Modelling	Admin Info	Exchanges
Name	corn stover, ground and stored			
Category	biomass - production			
Description	Taken from Sheehan, Corn Stover Ethanol LCA. (Directly from TEAM). The corn steep liquor production involves the steeping of harvested corn for a period of from 24 to 48 hours in a light sulfurous acid solution. The production of sulfurous acid was assumed to be negligible. The only emissions were SOx from the steeping tanks. Emission factors provided by USA EPA AP-42. All of the production burdens from corn are assumed to be allocated to the production of the steeping liquor.			
Location	RNA			
Geography Comment	North America			
Infrastructure Process	False			
Quantitative Reference	corn stover, ground and stored			

LCA Information for Basic Raw Materials:

- Example:
corn
stover,
ground
and
stored

Activity	Modelling	Admin Info	Exchanges
Inputs			
Flow	Category	Type	Unit Amount Comment
corn stover, carted	root/Flows	ProductFlow	t 1.28e+00 comes in wet
Dummy_agricultural machinery, general, production	root/Flows	ProductFlow	kg 9.00e-01
Dummy_conveyor belt, at plant	root/Flows	ProductFlow	m 3.47e-05 conveyor for storage
Dummy_conveyor belt, at plant	root/Flows	ProductFlow	m 3.47e-05 conveyor for grinder in-feed system
Dummy_dried roughage store, non ventilated	root/Flows	ProductFlow	m3 1.17e-07
Dummy_fodder loading, by self-loading trailer	root/Flows	ProductFlow	m3 2.78e+00 loading to storage
Dummy_loading bales	root/Flows	ProductFlow	p 1.43e+00 loading bales for grinder. Calculation of number of bales comes from 2000 lbs of corn stover divided by weight per bale. Trailer volume is 2511 ft^3 (INL table 4-5), density is 12 lbs/ft^3 dry (=20 wet at 40% moisture).
Dummy_maize drying	root/Flows	ProductFlow	kg 2.38e+02
electricity, at grid, US, 2008	root/Flows	ProductFlow	kWh 5.37e+01 Electricity needed for pelletization.
electricity, at grid, US, 2008	root/Flows	ProductFlow	kWh 3.26e+00 Electricity needed for twine removal
electricity, at grid, US, 2008	root/Flows	ProductFlow	kWh 6.13e+01 Electricity needed for dust collection
grinding	root/Flows	ProductFlow	sh tn 9.31e-01
Outputs			
corn stover, ground and stored	root/Flows	ProductFlow	t 1.00e+00
Water	air/unspecified	ElementaryFlow	kg 2.80e+02 water dried per ton of final moisture corn stover.

Summary terms

- Primary materials
- Secondary materials
- Non-renewable
- Renewable
- Technosphere
- Aggregated model
- US LCI
- ecoinvent