

# Life-Cycle Thinking and Personal Carbon Footprint

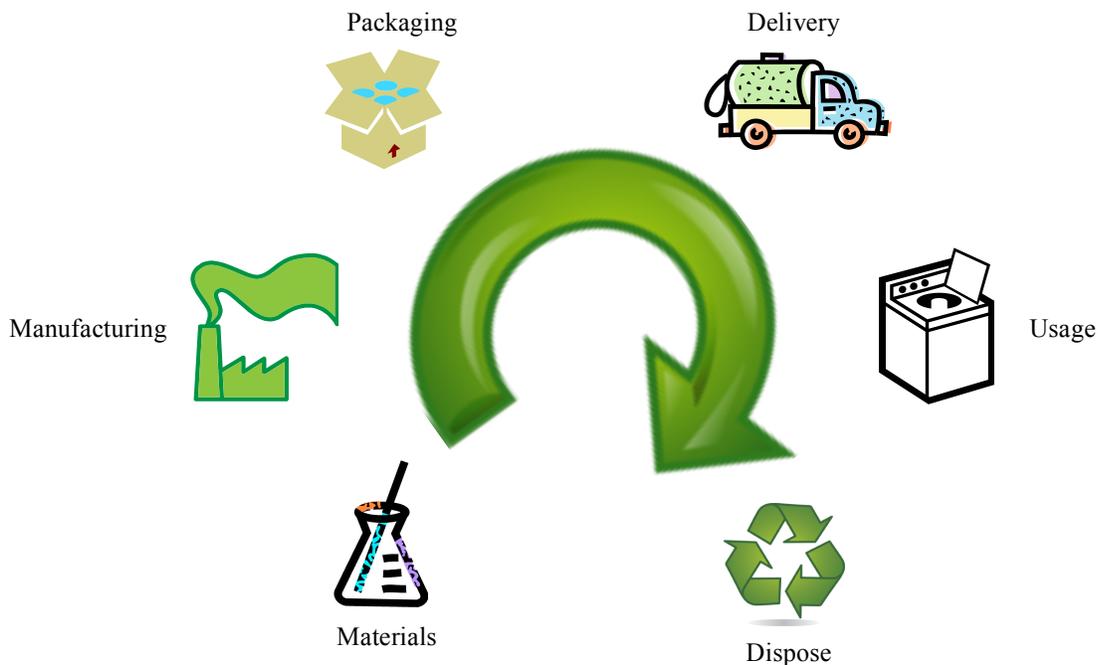
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## Background

A life cycle assessment – or an LCA – is used to determine the potential environmental impact of a particular product or process. A life cycle assessment accomplishes this by compiling material and energy inputs and outputs, evaluating the impact that these inputs and outputs will make, and interpreting the results such that consumers can make informed decisions. (United States Environmental Protection Agency).

There are four basic steps needed to conduct a life cycle assessment. The first is **goal and scope definition**. This step defines why the life cycle assessment is being done, and what inputs and outputs will be considered. The information, accuracy, and interpretation needed to enhance the decision making are determined at this point. (EPA Chapter 2). The second stage is **inventory analysis**, or life cycle inventory. This step collects all of the relevant data needed to complete the overall life cycle assessment, including inputs (e.g., energy and raw materials) and outputs (e.g., atmospheric emissions and solid wastes). In addition to benefits stemming from the LCA, life cycle inventories can also help compare products and determine policy recommendations (EPA Chapter 3). The third stage of conducting a life cycle assessment is the **impact assessment**. This step evaluates how human health and the environment would be affected by the conditions identified in the previous steps. Finally, the fourth step is the **life cycle interpretation**. Here researchers reach conclusions and make recommendations about the product or process at hand. Ultimately, this is the output of the life cycle assessment and should be the information used to make decisions.

Figure 1, below, depicts the six stages of product development that would be analyzed during a complete life cycle assessment: materials, manufacturing, packaging, distribution, usage, and disposal. If the assessment ends at the disposal end, it is said that the life cycle assessment goes cradle to grave. If the product is recycled and the assessment begins from the



starting point again, it is said that the life cycle assessment goes cradle to cradle.

One useful application of the life cycle assessment is to determine the carbon footprint of a product or process. A carbon footprint is the total amount of greenhouse gases produced as the result of a given process (Time for change). By finding the carbon footprint at each step in a life cycle assessment, it can be determined which step has the greatest potential impact on the environment (Empreinte Carbone Quebec).

### **Objective**

Students will be able to:

- Identify the seven main life-cycle stages of a product.
- Define a personal carbon footprint.
- Rank the carbon footprint of personal transportation, air travel, home energy usage, food consumption, and all other activities.

### **Materials Needed**

- Toaster
- Worksheet
- Calculators
- Computer
- Projector
- Protective eye wear

### **Safety Concerns**

- Students should wear protective eye wear when taking apart the toaster.

### **Vocabulary**

- Carbon footprint: the amount of greenhouse gases caused by an individual, product, or event.
- Life cycle analysis (LCA): a method used to determine the environmental impact of a particular product.
- Outflows: what is left over, or what leaves, from a process or the creation of a product; anything that flows out from a particular process.

### **Procedure**

<b>Time</b>	<b>Activity</b>	<b>Description</b>	<b>Supplies</b>
10	1. Introduction	Discuss LCA with students per the background above. Introduce two examples:  Orange Juice Example 1. Brainstorm all the inputs required to make a glass of orange juice - everyone adds one step	

		<p>2. Ask students to put production steps in chronological order.</p> <p>Toaster Example</p> <ol style="list-style-type: none"> <li>1. Have students take apart a toaster,</li> <li>2. Weigh its components</li> <li>3. Show a 2 minute clip from how it's made. What did the students miss?</li> </ol> <p>Link:  <a href="http://www.youtube.com/watch?v=WYcw_DcZsak">http://www.youtube.com/watch?v=WYcw_DcZsak</a></p>  <p>Note: Other household items can be used for the second example as well.</p> <ol style="list-style-type: none"> <li>1. Hair dryer: <a href="http://www.youtube.com/watch?v=LeRa7WfMETU">http://www.youtube.com/watch?v=LeRa7WfMETU</a></li> <li>2. Remote control (video is poor quality, but is an example): <a href="http://www.youtube.com/watch?v=cSaGifj9sF0">http://www.youtube.com/watch?v=cSaGifj9sF0</a></li> <li>3. Book: <a href="http://www.youtube.com/watch?v=mfcEFEaxaLs">http://www.youtube.com/watch?v=mfcEFEaxaLs</a></li> <li>4. Kindle: <a href="http://www.youtube.com/storyofstuffproject#p/u/3/sW_7i6T_H78">http://www.youtube.com/storyofstuffproject#p/u/3/sW_7i6T_H78</a></li> </ol>	
5	2. Summarize seven main life-cycle stages.	<p>List on board the seven steps:</p> <ol style="list-style-type: none"> <li>1. Raw Materials extraction</li> <li>2. Component Transportation</li> <li>3. Product Manufacturing</li> <li>4. Product Distribution</li> </ol>	

		<ol style="list-style-type: none"> <li>5. Consumer Purchase &amp; retail</li> <li>6. Consumer User</li> <li>7. Disposal</li> </ol>	
5	3. Brainstorm environmental impacts of the seven life-cycle stages	<p>Have students brainstorm. Discuss key outflows, including:</p> <ul style="list-style-type: none"> <li>• Greenhouse gases</li> <li>• Waste water</li> <li>• Air/water/soil Pollutants (Particulates, NOx, and Sox, N)</li> <li>• Toxic Emissions (chemicals, heavy metals)</li> <li>• Solid Waste</li> </ul>	
10	4. Why LCA? Better decision-making as consumers, business and government leaders.	<p>Lead group discussion. Discuss:</p> <ul style="list-style-type: none"> <li>• Environmental labels</li> <li>• Choosing between gasoline or electric or biofuel cars</li> <li>• Other policies</li> <li>• Levi’s example of businesses using product life-cycle</li> </ul> <p>Introduce personal carbon footprint concept: e.g. paper vs. plastic for grocery bags</p> <ul style="list-style-type: none"> <li>• Ground in actual examples...</li> <li>• Give a bunch of pairs of products. <ul style="list-style-type: none"> <li>○ LED vs fluorescent light bulbs</li> <li>○ Hybrid vs non-hybrid cars</li> <li>○ Tap water vs bottled water</li> </ul> </li> </ul>	
10	5. Calculate your own carbon footprint	<p>In partners, complete:</p> <ol style="list-style-type: none"> <li>1. Carbon Footprint, By Hand Worksheet</li> <li>2. Carbon Footprint, Online Worksheet</li> </ol>	<p>Calculator, “Carbon Footprint, By Hand Worksheet”, “Carbon Footprint, Online Worksheet”</p>
10	6. Group discussion	<ol style="list-style-type: none"> <li>1. Debrief the students’ carbon footprint.</li> <li>2. Enter results into spreadsheet.</li> <li>3. Display results (Mean and distribution of carbon footprints), compare with national average (from primary source Weber and Matthews)</li> <li>4. Discuss: <ul style="list-style-type: none"> <li>• Calculation <ul style="list-style-type: none"> <li>• What was difficult?</li> <li>• What assumptions did we have to make?</li> <li>• Do you think these values include the entire life cycle analysis?</li> <li>• What causes the differences between the by hand and online tool?</li> </ul> </li> <li>• Lifestyle choices <ul style="list-style-type: none"> <li>• How do you and your classmates compare to the rest of the US? Europe? The world?</li> <li>• What choices result in the largest carbon footprint?</li> <li>• What is the role of diet: food-miles, relative impact of red meat, other meat, dairy, and all</li> </ul> </li> </ul> </li> </ol>	<p>Computer, projector</p>

		<p>other foods?</p> <ul style="list-style-type: none"> <li>• Which portions of the carbon footprint do students personally control, vs. their parents, vs. broader society.</li> <li>• What can students change?</li> </ul>	
11	7. Quiz	Give Carbon Footprint Quiz.	“Carbon Footprint Quiz”, “Carbon Footprint Quiz Solutions”

**Additional Resources**

**Reputable:**

**EPA Life Cycle Analysis Chapters**

"Life Cycle Assessment (LCA)." *US Environmental Protection Agency*. United States Environmental Protection Agency, 15 Aug 2012. Web. 6 Jun 2013. <<http://www.epa.gov/nrmrl/std/lca/lca.html>>.

This EPA page gives a bit of a background description of what a life cycle assessment is, and then outlines a 70 page PDF dedicated to learning more about life cycle assessments. Any teacher looking to get a very detailed introduction to the topic – or anyone who wants a comprehensive read on LCAs – should look here.

**NREL Life Cycle Assessment Harmonization**

"NREL: Energy Analysis - Life Cycle Assessment Harmonization." *National Renewable Energy Laboratory*. National Renewable Energy Laboratory, 24 Jan 2013. Web. 7 Jun 2013. <[http://www.nrel.gov/analysis/sustain\\_lcah.html](http://www.nrel.gov/analysis/sustain_lcah.html)>.

The NREL page on Life Cycle Assessment Harmonization provides information on what harmonization is (reducing uncertainty and variability in a range of published results), what it does, and specifically its relation to types of renewable energy. Teachers looking for an alternative use of the life cycle assessment and perhaps a relation back to energy and the environment could look here for results.

**MSU Life Cycle Analysis Powerpoint**

Selke, Susan E. “Life Cycle Analysis.” Microsoft Powerpoint.

Dr. Susan Selke’s powerpoint goes through each aspect of the life cycle analysis in a succinct, slide by slide format. A teacher looking to present the information visually – especially by using diagrams for each concept – could start here to get an outline of what to present.

**University of Michigan LCA**

Svoda, Susan. "Note on Life Cycle Analysis." *Pollution Prevention in Corporate Strategy*. University of Michigan, n.d. Web. 12 Jun 2013. <<http://www.umich.edu/~nppcpub/resources/compendia/CORPpdfs/CORPlca.pdf>>.

This paper prepared at UMich offers a detailed and well cited summary of what a life cycle analysis is, and what steps it consists of. Those looking to get a detailed yet simple summary on the life cycle analysis could start by reading this paper.

#### EPA Life Cycle Assessment Poster

"The Life Cycle of a CD or DVD." *US Environmental Protection Agency*.

United States Environmental Protection Agency, n.d. Web. 6 Jun 2013.  
<<http://www.epa.gov/osw/education/pdfs/finalposter.pdf>>.

This diagram from the EPA shows a colorful example of what a life cycle assessment entails, shares more detail as to what a life cycle assessment actually is, and offers a few interactive games and activities to get readers engaged in topic outside of reading about it. Teachers looking for interesting ways to introduce the topics to young students – as well as teachers looking for an easy graphic to explain the concept behind life cycle assessments – should find what they're looking for here.

#### The Carbon Trust. (2007) Carbon Footprinting

This source was referenced in a Center for Sustainable Systems factsheet about carbon footprints.

#### Quantifying Carbon Footprint

Weber, Christopher L., and H. Scott Matthews. "Quantifying the global and distributional aspects of American household carbon footprint." *Science Direct*. Science Direct, 26 Mar 2007. Web. 26 Jun 2013.  
<<http://www.ce.cmu.edu/~hsm/sust2008/readings/Weber-households-08.pdf>>.

This paper demonstrates how international sources of greenhouse gas affect US household carbon footprints. Teachers looking for national averages and data about carbon footprints could look here.

#### **Opinion / Newspaper:**

##### Carbon Emissions Calculator

"Carbon Emissions Calculator." *Lehigh University*. Lehigh University. Web. 28 Jun 2013.  
<<http://www.ei.lehigh.edu/learners/cc/carboncalc.html>>.

This site offers users the opportunity to calculate their carbon footprint by asking a series of lifestyle questions. Teachers looking for students to calculate their carbon footprint could use this simple website's calculator.

#### Carbon Footprint and LCA

"Carbon Footprint and LCA." *Empreinte Carbone Quebec*. Empreinte Carbone Quebec. Web. 28 Jun 2013.  
<[http://www.empreintecarbonequebec.org/en/empreinte\\_carbone\\_acv.php](http://www.empreintecarbonequebec.org/en/empreinte_carbone_acv.php)>

This site relates carbon footprint to life cycle assessments, and provides a helpful diagram that illustrates each step of the product life cycle. Teachers looking to connect the topics of the carbon footprint and the LCA could look here.

#### The Benefits of Life Cycle Analysis

Comere, Elisabeth. "The Benefits of Life Cycle Analysis." *Environmental Leader*. Environmental Leader, 21 Mar 2012. Web. 12 Jun 2013. <<http://www.environmentalleader.com/2012/03/21/the-benefits-of-life-cycle-analysis/>>.

The article by Elisabeth Comere goes into the positive benefits that her company reaps by their use of the life cycle analysis. If a teacher was looking for an example of using a life cycle analysis positively in the real world, this might be a good place to look.

#### Ecological Footprint Quiz

"Ecological Footprint Quiz." *Center for Sustainable Economy*. Center for Sustainable Economy. Web. 28 Jun 2013. <<http://myfootprint.org/en/>>.

The site shows ecological footprint, not carbon footprint. There are no instructions on how students can't reduce their own footprint.

#### The Earth Day Network Footprint Calculator

"Ecological Footprint Quiz." *Earth Day Network*. Earth Day Network. Web. 28 Jun 2013. <<http://www.earthday.org/footprint-calculator>>.

It has animations, it's pleasant to use, and seems to be fairly complete. Some of the questions are directed to adults, but they can be easily answered or skipped.

#### Kids Carbon Footprint Calculator

"Kids Carbon Footprint Calculator." *Cool the World*. Cool the World. Web. 28 Jun 2013. <<http://www.cooltheworld.com/kidscarboncalculator.php>>.

It is concise, summarizes information in a nice way and gives advice on how to reduce the carbon footprint but it seems to have been designed for younger kids. Also, it's UK based, so one of the questions asks whether they go on holiday to Europe or to the US.

#### Quantis Life Cycle Assessment

"Life Cycle Assessment." *Quantis: Sustainability Counts*. Quantis, n.d. Web. 7 Jun 2013. <[http://www.quantis-intl.com/life\\_cycle\\_assessment.php](http://www.quantis-intl.com/life_cycle_assessment.php)>.

The Quantis page provides a very concise list of what an LCA is, what the goals of it are, what it's used for, and what the strengths of the assessment are. It also provides a link to a more comprehensive, technical analysis of life cycle assessments and a few citations. If a teacher is looking to get a quick summary of what they could teach (goals, uses, strengths, etc), this is a good place to start.

#### Wikipedia Life Cycle Assessment

"Life-cycle assessment - Wikipedia." *Wikipedia*. Wikipedia - The Free Encyclopedia, 28 May 2013. Web. 6 Jun 2013. <[http://en.wikipedia.org/wiki/Life-cycle\\_assessment](http://en.wikipedia.org/wiki/Life-cycle_assessment)>.

The Wikipedia page on life-cycle assessments serves as a good introduction to the topic and the many subtopics it encompasses. For example, the different types of life-cycle assessments are introduced, as well as critiques to the method. There are also more than 40 different sources and 20 different resources for further reading, making the site a good place to start with background research about LCAs.

### Life Cycle Analysis of Cotton

"Life Cycle Inventory and Life Cycle Assessment of Cotton Fiber and Fabric." *Cotton Today*. Cotton Natural, n.d. Web. 12 Jun 2013. <<http://cottontoday.cottoninc.com/sustainability-about/LCI-LCA-Cotton-Fiber-Fabric/>>.

A detailed and diagramed four-page analysis of cotton's life cycle assessment – as well as two longer, more technical documents – is presented here. Teachers looking for a sophisticated walkthrough of an example could look here.

### Levis Strauss - Life Cycle Assessment of a Jean

"Life Cycle of a Jean." *Life Cycle of a Jean*. Levi Strauss, n.d. Web. 7 Jun 2013. <<http://www.levistrauss.com/sustainability/product/life-cycle-jean>>.

Levi Strauss shows a diagram of how their particular brand of jeans is produced, transported, and potentially recycled. While the diagram isn't too technical, it's a great example of how the life cycle assessment could be applied to companies, and a relatable example for older students to see how the lesson in LCAs is relevant.

### Carbon footprint definition

"What is a carbon footprint - definition." *Time for change*. Time for change. Web. 28 Jun 2013. <<http://timeforchange.org/what-is-a-carbon-footprint-definition>>.

This site gives a simple definition of a carbon footprint, as well as examples on how to calculate it. Teachers looking for a broad introductory source to carbon footprints could start looking here.

### **Other:**

#### How A Toaster Works Video

"How a Toaster Works." Online video clip. Youtube. Youtube. 29 January 2008. Web. 26 June 2013. [http://www.youtube.com/watch?v=WYcw\\_DcZsak](http://www.youtube.com/watch?v=WYcw_DcZsak)

This sub two minute video shows the process of taking apart a toaster, as well as what each part contributes to the toaster's performance. Teachers looking to show an example of how complicated a production process is may look here.

Video – How a hair dryer is made - <http://www.youtube.com/watch?v=LeRa7WfMETU>

Video – How a remote control is made - <http://www.youtube.com/watch?v=cSaGifj9sF0>

Video – How a book is made - <http://www.youtube.com/watch?v=mfcEFEaxaLs>

Video – How a kindle is made - [http://www.youtube.com/storyofstuffproject#p/u/3/sW\\_7i6T\\_H78](http://www.youtube.com/storyofstuffproject#p/u/3/sW_7i6T_H78)

**Author(s)**

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**Next Generation Science Standards Alignment**

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing and mineral resources based on cost-benefit ratios.

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.