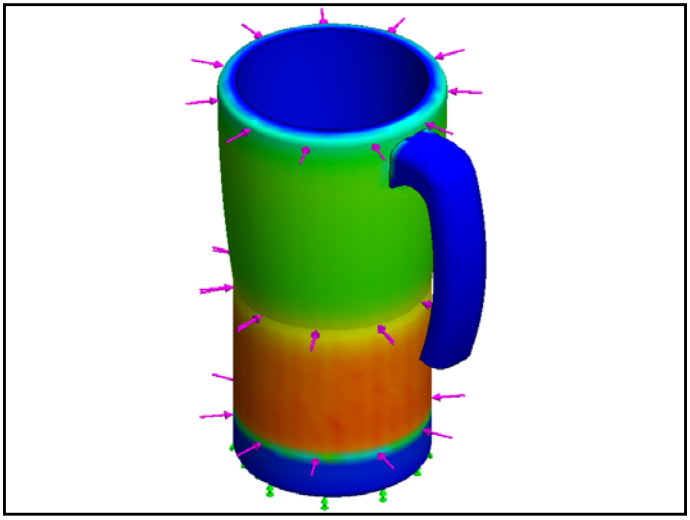
Engineering Design
and Technology Series

SolidWorks® Sustainable Design
An Introduction to Material Choice and Sustainable Redesign



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Lesson 1
Introduction and Material Choice

When you complete this lesson, you will be able to:

- Describe the relationship between Sustainability and SolidWorks;
- Identify the principle components of the Sustainability Add-in;
- Explain significance of Material choice and environmental impacts.

Using This Book

SolidWorks Sustainability An Introduction to Sustainable Design helps you learn the principles of using Sustainability and Sustainability as integral parts of a creative and iterative design process.

For this project, You will "learn by doing" as you complete a structural analysis.

What is SolidWorks Software?

SolidWorks is design automation software. In SolidWorks, you sketch ideas and experiment with different designs to create 3D models using the easy to learn Windows® graphical user interface.
SolidWorks is used by students, designers, engineers and other professionals to produce single and complex parts, assemblies and drawings.

Prerequisites

Before you begin the SolidWorks Sustainability An Introduction to Sustainable Design you should complete the following online tutorials that are integrated in the SolidWorks software:

- Lesson 1 - Parts-Set 1
- Lesson 2 - Assemblies-Set 1
- Designing for Sustainability-Set 2
- Simulation - Static Analysis
- Simulation - Thermal Analysis

You can access the online tutorials by clicking **Help**, **SolidWorks Tutorials, All SolidWorks Tutorials (Set 1)** and Simulation Tutorials by clicking **Help, SolidWorks Simulation, Tutorials**. The online tutorial resizes the SolidWorks window and runs beside it.

As an alternative, you can complete the following lessons from *An Introduction to Engineering Design With SolidWorks*:

- Lesson 1: Using the Interface
- Lesson 2: Basic Functionality
- Lesson 3: The 40-Minute Running Start
- Lesson 4: Assembly Basics
- Lesson 6: Drawing Basics

Conventions Used in This Book

This manual uses the following typographical conventions:

Convention	Meaning
Bold Sans Serif	SolidWorks commands and options appear in this style. For example, **Insert, Boss** means choose the **Boss** option from the **Insert** menu.
`Typewriter`	Feature names and file names appear in this style. For example, `Sketch1`.
17 Do this step.	The steps in the lessons are numbered in sans serif bold.

Sustainability Options

Here we will go through the Sustainability interface and different menus as well as define various terms used within the SolidWorks Add-In. There are four main menus, **Material**, **Manufacturing**, **Transportation and Use**, and **Environmental Impact**.

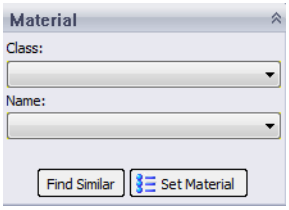
First, we will start SustainabilityXpress.

1 **Start Sustainability.**
Click **Tools, Add-Ins, Check Sustainability**.

Note: A Part or Assembly needs to be open to view Sustainability. When you first open the Add-In, everything should be black except for the regions.

Materials

In this option you can choose between different materials for the specific part using the drop down menus. You are also able to search for alternative materials using the **Find Similar** option. You can also assign a material of your choice to the part.



Manufacturing (Parts)

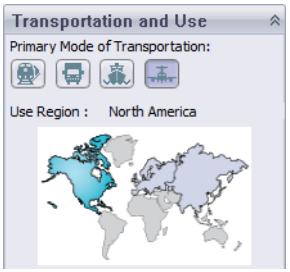
The **Manufacturing** section includes **Process** and **Use** to define world locations.

Process

In this option, there is a drop down menu labeled **Process** where the user can chose between multiple different production techniques to manufacture their part. There is also a world map. The world map is for the user to define where the part is going to be made. There are four different areas to choose from, North America, Europe, Asia, and Japan.

Use

The second world map is used in this menu. Here you are able to chose where your product will be transported to after production. The further the distance between manufacturer and user the less environmentally friendly.



Note: All the regions for Manufacturing and Use are the same.

Manufacturing and Transportation (Assemblies)

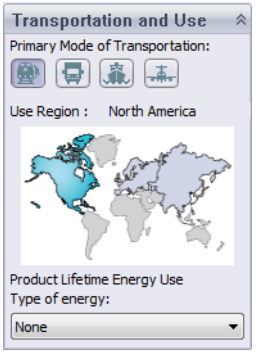
Within Assemblies the Sustainability interface changes slightly.

Manufacturing (Assemblies)

The only difference from the manufacturing menu for a part is that it does not have a process drop down menu instead the user is only able to choose the Manufacturing Region.

Transportation and Use (Assemblies)

With in this menu the user is given the ability to chose the Primary Mode of Transportation (Train, Truck, Boat, or Plane). The user is also able to choose the Type of Energy that will be used throughout the lifetime of the product. Like before in the Use menu for Parts the user is also able to choose the Region the that product will be used.

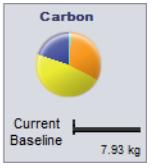


Environmental Impact

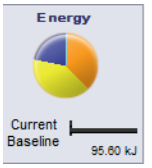
This area includes four quantities: **Carbon Footprint**, **Total Energy**, **Air Acidification**, and **Water Eutrophication**. Each graph shows the user a graphic breakdown of **Material Impact**, **Transportation and Use**, **Manufacturing**, and **End of Life**.

Carbon Footprint

A measure of carbon-dioxide and other greenhouse gas emissions such as methane (in CO2 equivalent units, CO2e) which contribute to an emissions, predominantly caused by burning fossil fuels. Global warming Potential (GWP) is also commonly referred to as a carbon footprint.

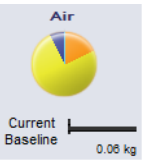


Energy Consumption



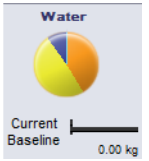
A measure of the non-renewable energy sources associated with the part's life cycle in nits of mega joules (MJ). This impact includes not only the electricity or fuels used during the product's life cycle, but also the upstream energy required to obtain and process these fuels, and the embodied energy of materials which would be released if burned. Energy Consumed is expressed as the net calorific value or energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

Air Acidification



Sulfur dioxide, nitrous oxides other acidic emissions to air cause an increase in the acidity of rain water, which in turn acidifies lakes and soil. These acids can make the land and water toxic for plants and aquatic life. Acid rain can also slowly dissolve man-made building materials such as concrete. This impact is typically measured in nits of either kg sulfur dioxide equivalent (SO2e), or moles H+ equivalent.

Water Eutrophication



When an over abundance of nutrients are added to a water ecosystem, eutrophication occurs. nitrogen and phosphorous from waste water and agricultural fertilizers causes an overabundance of algae to bloom, which then depletes the water of oxygen and results in the death of both plant and animal life. This impact is typically measured in either kg phosphate equivalent (PO4e) or kg nitrogen (N) equivalent.

Report

On the very bottom of SustainabilityXpress, there are the **Generate Report** and **Email Report** buttons. By clicking generate report, SolidWorks automatically creates a Word document about the current analysis. This analysis can be on an individual material type and environmental impacts or it can be on a comparison of two different material types. The email report opens Microsoft Outlook for the user to send the word document to an email address.

Baseline

To the right of the report buttons are the **Set Baseline** and **Import Baseline** buttons. By clicking set baseline, SustainabilityXpress automatically takes the most recent material type and sets it as the material that every other material will be compared to. Otherwise, every time the user clicks on another material, SustainabilityXpress will automatically compare them and dynamically recalculate the Environmental Impacts. Also, if there is no difference between the current and previous settings and materials then all of the Environmental Impacts will automatically turn green. Then, by clicking import baseline, the user can import a saved SustainabilityXpress baseline from another part.

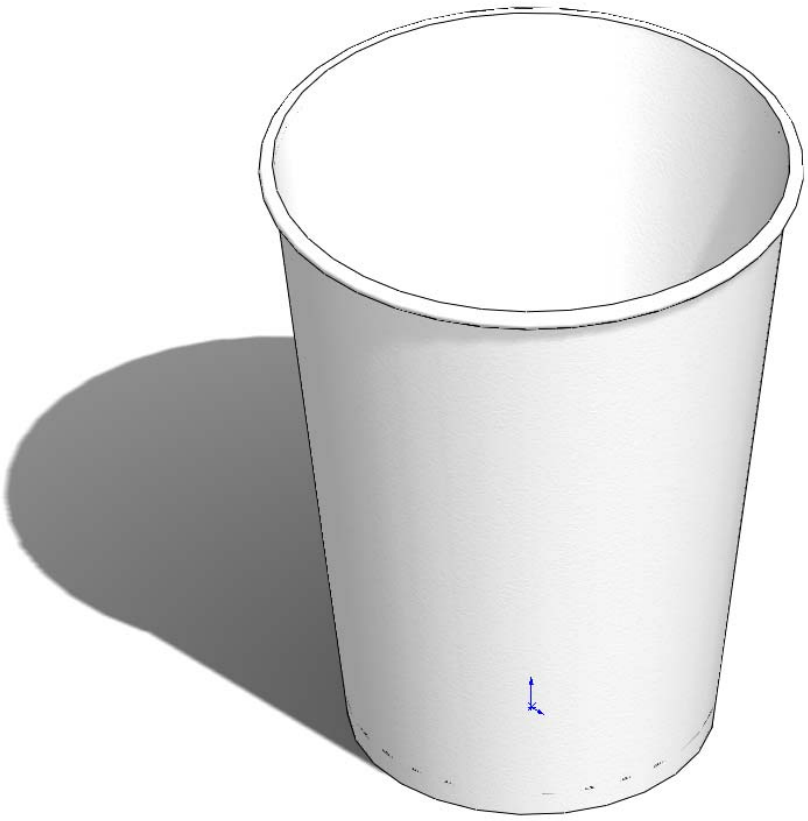
Color Coding

When Baseline is clicked, the environmental impacts turn colors to represent different states.

- *Black* represents the baseline material.
- *Green* indicates that the current material is more environmentally friendly than the baseline material.
- *Red* indicates that the current material is less environmentally friendly than the baseline material.

Material Choice in Sustainable Design

Here we will decide which material is the correct material to use depending of the materials environmental impacts over its lifetime. In this example, imagine the analysis of a cup.



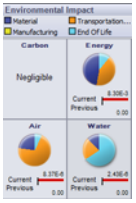
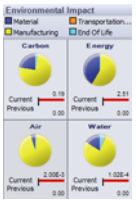
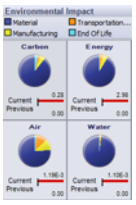
The lifetime of a cup

The material of a product significantly affects its lifetime. For example, a cup could be made from paper, plastic, or metal. Depending on what material we use will decide how many times the cup can be used. For this example we will assume if we made the cup out of paper (we will be using pine because there is no paper material choice within SolidWorks that is linked with Sustainability) it could be used only once, a cup made from plastic can be used 10 times, and a cup made from metal could be used 1000 times.

Environmental Impacts

With the SolidWorks model we have for a simple cup, we have created three different configurations, one for each material type. We activated Sustainability and kept the Manufacturing and Transportation and Use the same continents for all three configurations.

Here are the Environmental Impacts for each material:

Paper (Pine)	
Plastic (ABS)	
Metal (Chrome Stainless Steel)	

From these we will use the Total Energy as a baseline to examine which material is the most Sustainable for its lifetime. The results were as follows:

Paper: 8.30E-3 MJ

Plastic: 2.51 MJ

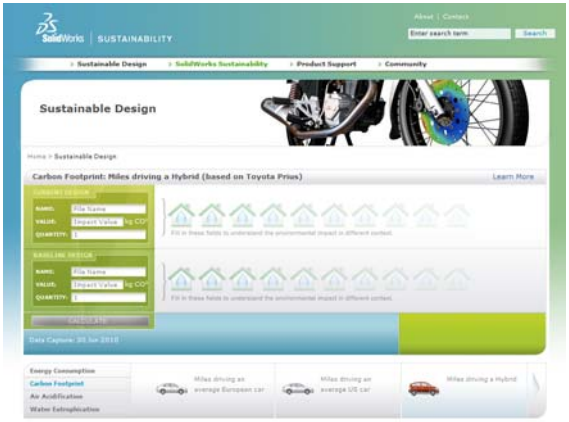
Metal: 2.98 MJ

2 Sustainability Calculator.

Now we need to see which material is the most environmentally friendly based on its lifetime. The **Sustainability Calculator** takes the values that we found for the Environmental Impacts (CO2, MJ, SO2, and PO4) and re calculates it into something that is easier for us to understand (example: miles driven in a car or hours watching tv).

To start, we will open the Sustainability Calculator.

3 Go to www.solidworks.com/sustainability/products/calculator/index.htm.



4 Click Energy Consumption.

5 Click hours of watching TV.

Impact vs. Lifetime

Here we will discuss whether the Lifetime of the material is more important than its Environmental Impacts.

Using the Sustainability Calculator we will use the three Energy values we got from SolidWorks Sustainability and calculate which material is the best for the environment according to its lifetime.

In order to do this we need to use the Lifetime values we discussed earlier. Instead of using the number of times each cup can be used we will use the number of cups that need to be made to equal one Metal cup. This means 1000 paper cups and 10 plastic cups need to be made to equal one Metal cup.

1 Sustainability calculator.
Now, go back to the Sustainability Calculator and find the Current Design box.

2 Enter numbers.
Enter the numbers given for the Values and Quantities and click Calculate.

Note: You are only able to enter one set two sets of values. It would be easier to open three se per ate windows and compare the outcomes.

Name: **Paper**

Value: 8.30E-3

Quantity: 1000

Name: **Plastic**

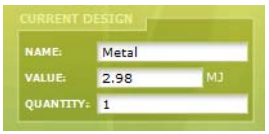
Value: 2.51

Quantity: 10

Name: **Metal**

Value: 2.98

Quantity: 1



The Sustainability Calculator will calculate how many Hours of Watching TV is equivalent to produce these cups. You should get:

Paper: 2 Hours

Plastic: 6 Hours

Metal: 1 Hour

3 Material Decision.
When comparing materials according to their lifetimes and environmental impacts it is wise to chose the material that effects the environment the least compared to how long its lifetime is. In this case, it is wise to chose the Metal Cup. The Metal Cup can be used the longest and when compared to the Paper and Plastic Cups it the least harmful to the Environment based on the cups Energy Consumption.