SolidWorks Education
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Engineering Design and Technology Series

SolidWorks® Sustainability An Introduction to Sustainable Design

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Table of Contents

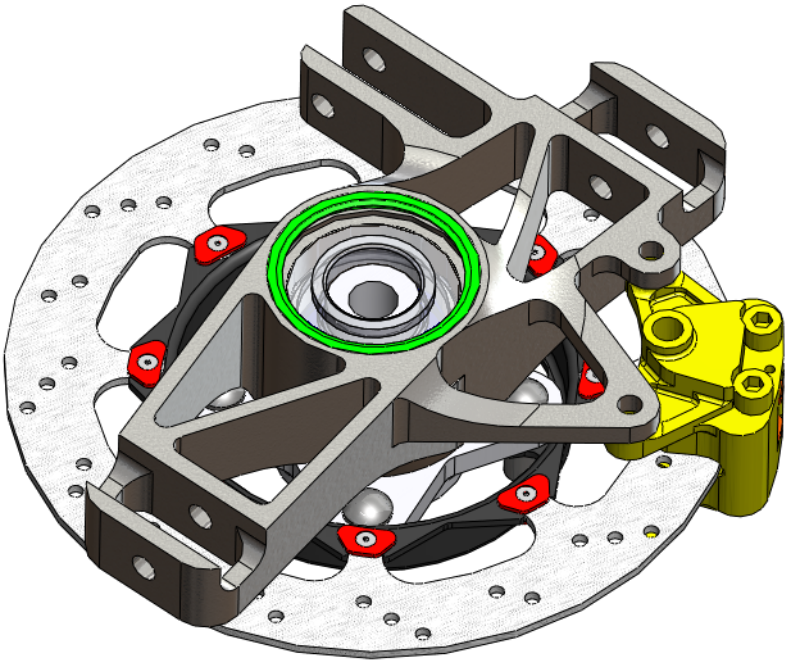
Lesson 1
SustainabilityXpress

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

- Download SustainabilityXpress
- Add-In SustainabilityXpress
- Open a single part from an assembly;
- Navigate SustainabilityXpress
- Generate a Sustainability Report
- Further improve your Sustainable Design.

Using SustainabilityXpress

SustainabilityXpress is a SolidWorks Add-In that gives users the ability to create more sustainable designs depending on material type, manufacturing process, material use, and environmental impacts.

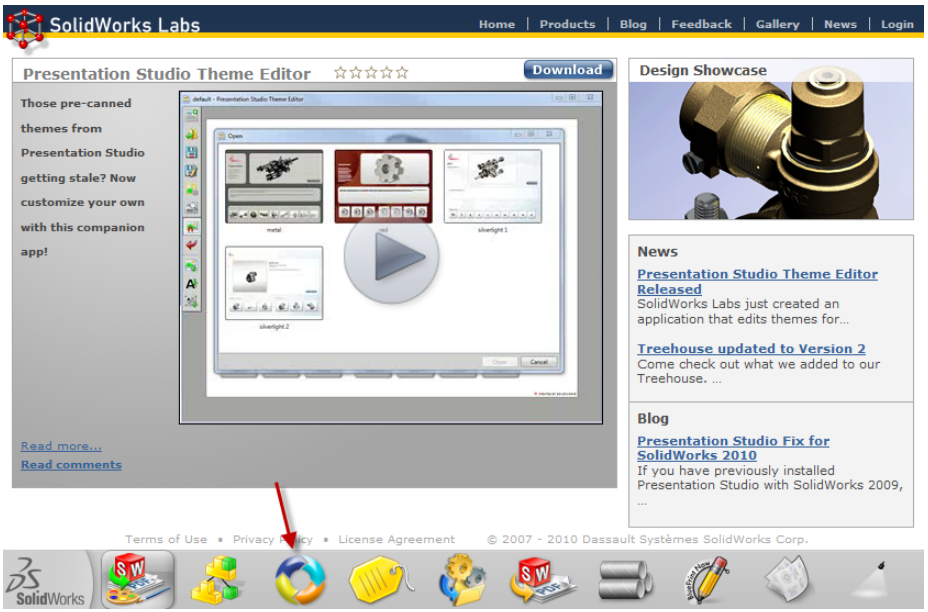


Only for SolidWorks 2009 Users

This section is only for SolidWorks 2009 users. SolidWorks 2010 comes with SustainabilityXpress already loaded.

6 Downloading SustainabilityXpress for SolidWorks 2009

Go to http://labs.solidworks.com and click on the **Sustainable** icon at the bottom of the page.



7 Download.

At the top of the SustainabilityXpress page click **Download** Download. This brings you to another web page.

8 Select option.

At the bottom of the page there are three links, **Download 32bit**, **Download 64bit**, and **Download Tutorial**. If you do not know whether your computer is 32 or 64 bit, follow these directions.

1. Click **Start Menu** and **All Programs, Accessories, System Tools, System Information**.
2. Double-click on System and click on Properties.
3. In **System Summary**, there is a list of information. Under **System Type** it will tell you whether your computer is x86-based (32-bit) or x64-based (64-bit).

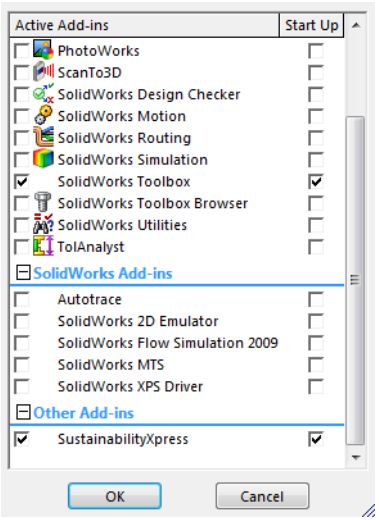
9 Run.
Once you have figured this out, go back to the download site and click on the proper **Download** according to your system type.

On the download screen, click **Save File**. Once your browser is done downloading the .exe file, open the .exe file and Click **Run**.

10 Self-extractor.
A self-extractor window will appear. Click **Unzip** and then Click **OK**.

Another Download window will appear. Continue clicking **Next** and then click **Finish**.SustainabilityXpress will load the files. Once it is done, click **Close** to exit the download wizard.

11 Activating the Add-In.
Click **Tools, Add-Ins**. Click both check marks of SustainabilityXpress as shown.



Note: If you are Activating SustainabilityXpress after downloading it for 2009 it will appear in **Other Add-Ins** as shown. Otherwise it will appear in **Active Add-Ins**.

Working with Parts and Assemblies

In this section we will open a part from an assembly and show two different types of viewing methods for an assembly.

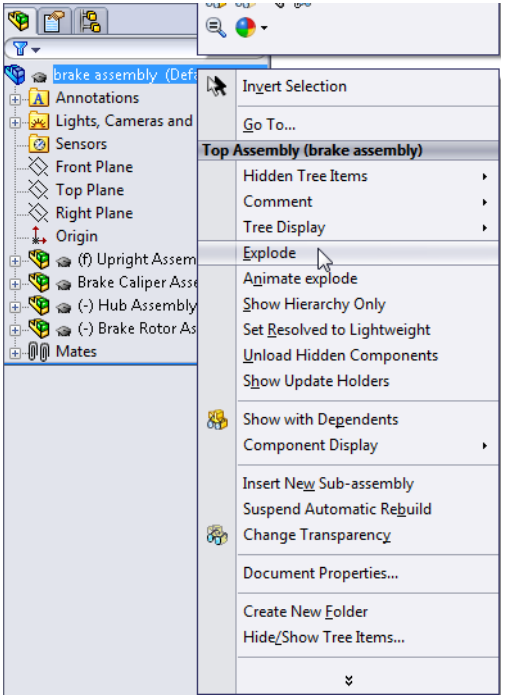
Note: There is an existing exploded view in this assembly. We will be showing you how to access this exploded view without creating the exploded view.

1 Open Assembly.
Open the assembly `Brake Assembly` from the `Brake Assembly` folder.

Exploded View

First we will show you how to access an exploded view of an assembly. An exploded view is a representation of an assembly with spacing between each individual part. It looks like someone had taken a picture mid-explosion of the assembly.

2 Exploded view.
Right-click `Brake Assembly` from the FeatureManager Design Tree and select **Explode**.

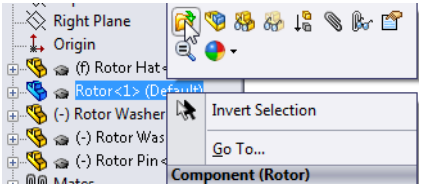


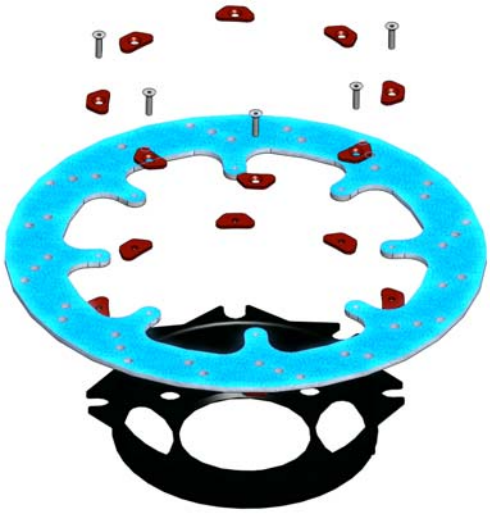
3 Zoom.

Next, we will be using **Zoom to Selection** to focus on the Rotor. In the FeatureManager Design Tree expand the Brake Rotor Assembly component.

Click the Rotor component.

Click **View, Modify, Zoom to Selection**.



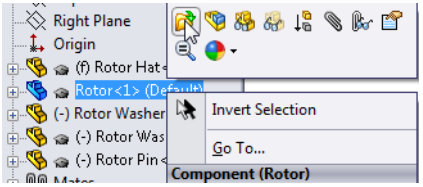


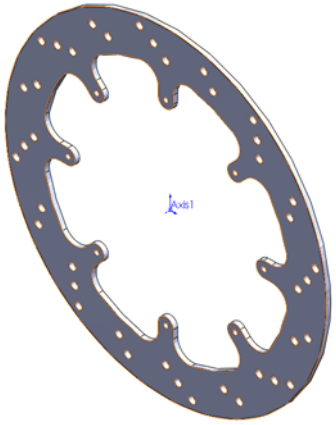
Opening a Part from an Assembly

Now we will open the Rotor component. To individually edit a part of an Assembly you can open the part by itself, edit the part, save and close the part, and then rebuild the assembly.

4 Open part.

In the FeatureManager Design Tree right-click Rotor and select **Open Part** .





Note: **SustainabilityXpress** only works with single parts. The full version, **Sustainability**, works with parts or assemblies.

SustainabilityXpress Options

Here we will go through the SustainabilityXpress 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**.

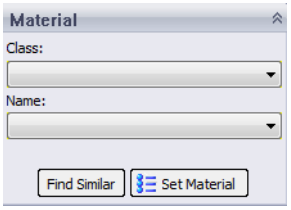
First, we will start SustainabilityXpress.

1 **Start SustainabilityXpress.**
Click **Tools, SustainabilityXpress**.

Note: 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

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

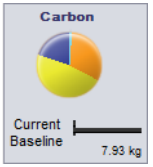
The second world map is used in this menu. Here you are able to chose where your product will be transported to after production. The further the distance between manufacturer and user the less environmentally friendly.

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**.

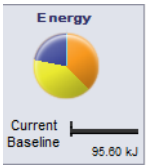
Carbon Footprint

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.



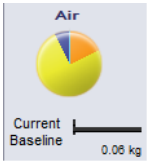
Energy Consumption

A measure of the non-renewable energy sources associated with the part's lifecycle in nits of megajoules (MJ). This impact includes not only the electricity or fuels used during the product's lifecycle, 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.



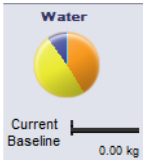
Air Acidification

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

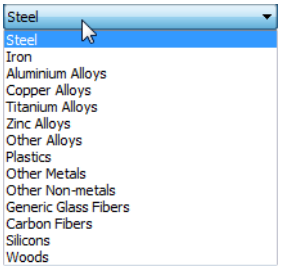
To the right of the report buttons are the **Set Baseline** and **Import Baseline** buttons. By clicking set baseline, SustainabilityXpress automatically takes the most recent material type and sets it as the material that every other material will be compared to. Otherwise, every time the user clicks 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.

Materials

In SolidWorks, materials are used to give the model color, texture cross hatching and mechanical properties for such as add-ins as SimulationXpress and SustainabilityXpress.

2 Class.
Click the **Class** drop down menu which has 14 different material categories.

Select **Steel**.



3 Name.
For the **Name** drop down menu, leave it set to the default steel called
1023 Carbon Steel Sheet (SS).

Tip: You may have noticed that the environmental impact menu began to refresh right after you selected steel. This will happen every time we select a new material, process, or region. Every environmental impact should have changed and turned to red.

Set the Baseline

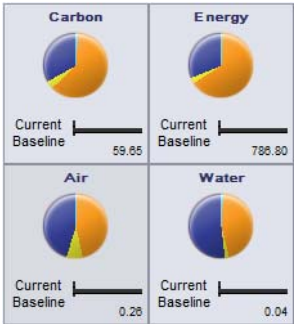
When the you set a material to baseline, SustainabilityXpress will compare every material selected afterwards to that baseline. Normally each material will be compared to the previously chosen material.

In order to show a more relevant comparison between materials, we will set the `Steel 1023 Carbon Steel Sheet (SS)` as our Baseline material.

4 Set Baseline.

Click **Set Baseline** .

Once you have set the baseline, the environmental impacts should once again refresh and look like the image to the right.



Color Coding

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

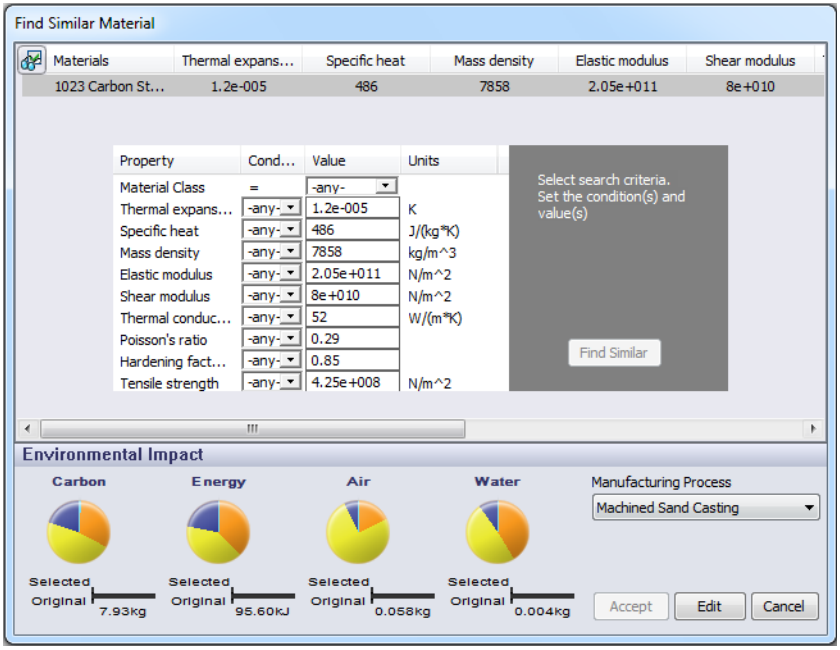
- *Black* represents the baseline material.
- *Green* indicates that the current material is more environmentally friendly than the baseline material.
- *Red* indicates that the current material is less environmentally friendly than the baseline material.

Using Find Similar

Now we will go on a search for alternative materials. This is where you define and search for materials with similar material properties.

5 Find Similar.

In the dialog click **Find Similar**. A new dialog box will appear.



The **Find Similar Material** menu has multiple different options. As you can see, there is a list of multiple material properties starting with Thermal Expansion.

Material Properties

The following are quick the quantities and quick descriptions of each.

Property	Description	Units
Thermal Expansion	The change in length per unit length per one degree change in temperature (change in normal strain per unit temperature).	K
Specific Heat	The quantity of heat needed to raise the temperature of a unit mass of the material by one degree of temperature.	J/kg K
Density	Mass per unit volume.	kg/m3
Elastic Modulus	The ratio between the stress and the associated strain in a specified direction.	N/m2
Shear Modulus	The ratio between the shearing stress in a plane divided by the associated shearing strain	N/m2
Thermal Conductivity	The rate of heat transfer through a unit thickness of the material per unit temperature difference.	W/m K
Poisson's Ratio	The ratio between the contraction (traverse strain), normal to the applied load to the extension (axial strain), in the direction of the applied load. Poisson's ratio is a dimensionless quantity.	---
Tensile Strength	The maximum amount of tensile stress that a material can be subjected to before failure.	N/m2
Yield Strength	The Stress at which the material becomes permanently deformed.	N/m2

Note: The types of material properties are not the same for each material. The types of properties vary depending on the material. For example steel possesses a thermal expansion property and wood does not.

Setting Search Conditions

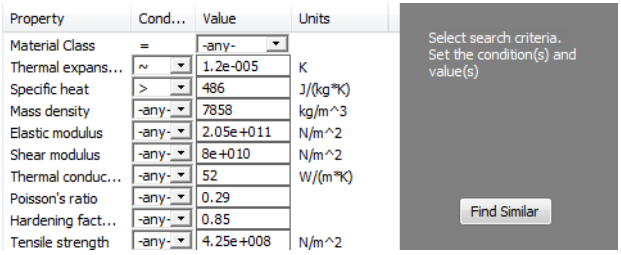
The dialog contains two columns, **Condition** and **Value**, that show default material data. You may have noticed that these columns have the ability of being changed. The first row is labeled **Material Class** and it has no value option. With in the option you can choose whether you want to search for a material within a specific **Class** or within all the materials.

The others, starting with **Thermal Expansion**, notice have a drop down menu under the **Condition** column. Click the downwards arrow and four different options will be presented to you. The four options that appear are **Any**, **>**, **<**, and **~**. These mean that you want the new material you are searching for to be either any value, greater than, less than, or similar to the set value.

6 Set Conditions.

Set **Material Class** to **Any**.

Click **~** to set **Thermal Expansion** to about equal to the default value of **1.2e-005 K**. Also, select **>** for the **Specific Heat** of **486 J(kg*K)**.



7 Search.

Click **Find Similar**.

SustainabilityXpress takes the property conditions and values that we have set and finds all the material that have similar attributes to the Steel 1023 Carbon Steel Sheet (SS) with the added changes. Five different materials will appear. These materials fit the criteria that we specified.

8 Test Material.

Click on the name **Cast Carbon Steel**.

Materials	Thermal expans...	Specific heat	Mass density	Elastic modulus	Shear modulus
1023 Carbon St...	1.2e-005	486	7858	2.05e+011	8e+010
Cast Carbon Steel	1.2e-005	500	7800	2e+011	7.6e+010
Cast Carbon St...	1.2e-005	500	7800	2e+011	7.6e+010
Gray Cast Iron	1.2e-005	510	7200	6.61781e+010	5e+010
Gray Cast Iron ...	1.2e-005	510	7200	6.61781e+010	5e+010
Malleable Cast I...	1.2e-005	510	7300	1.9e+011	8.6e+010

Note: At the bottom of this screen there is also an environmental impact display. When we clicked the **Cast Carbon Steel**, the display dynamically recalculated our environmental impacts compared to the baseline we had set.

Looking at the four impacts we notice that this material is slightly more environmentally friendly in some ways, worse in others. Considering that there are many materials to choose from we may be able narrow the material down even more.

9 Edit Search.

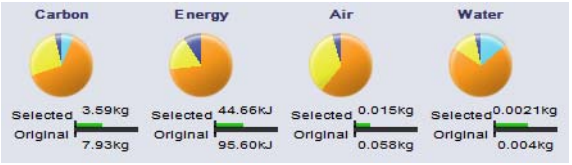
Click **Edit**. This brings us back to the previous screen with the settings we already choose for the conditions and values. Once back at this screen, we will change the requirements for the **Tensile Strength**.

Click the **Condition** drop down menu and select **<** for **Tensile Strength**. Also in the corresponding **Value** column, change the value to **4e+008 N/M^2**.

Property	Cond...	Value	Units
Material Class	=	-any-	
Thermal expans...	~	1.2e-005	K
Specific heat	>	486	J/(kg*K)
Mass density	-any-	7858	kg/m^3
Elastic modulus	-any-	2.05e+011	N/m^2
Shear modulus	-any-	8e+010	N/m^2
Thermal conduc...	-any-	52	W/(m*K)
Poisson's ratio	-any-	0.29	
Hardening fact...	-any-	0.85	
Tensile strength	<	4e+008	N/m^2

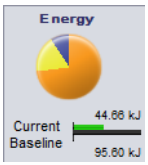
10 New search.

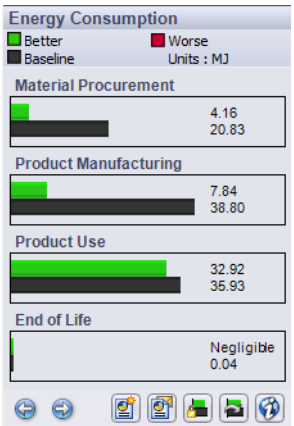
Click **Find Similar**. The search will finish with two materials. Click the first material called **Gray Cast Iron**. Notice, that all of the environmental impact comparisons are green. We successfully found a material that is overall environmentally more friendly than **1023 Carbon Steel Sheet (SS)**.



11 Accept the material.
Click **Accept**. By clicking accept, SustainabilityXpress changes the material to **Gray Cast Iron**.

12 Environmental Impacts.
In the environmental impacts menu, we are able to view the impacts as bar graphs rather than a pie graph. Click the **Energy Consumption** environmental impact. The environmental impact menu will automatically refresh and display only the bar graph breakdown for energy consumption. You can return to the impact original screen with all four impacts by clicking the left arrow .





Tip: This can be done for all four environmental impacts.

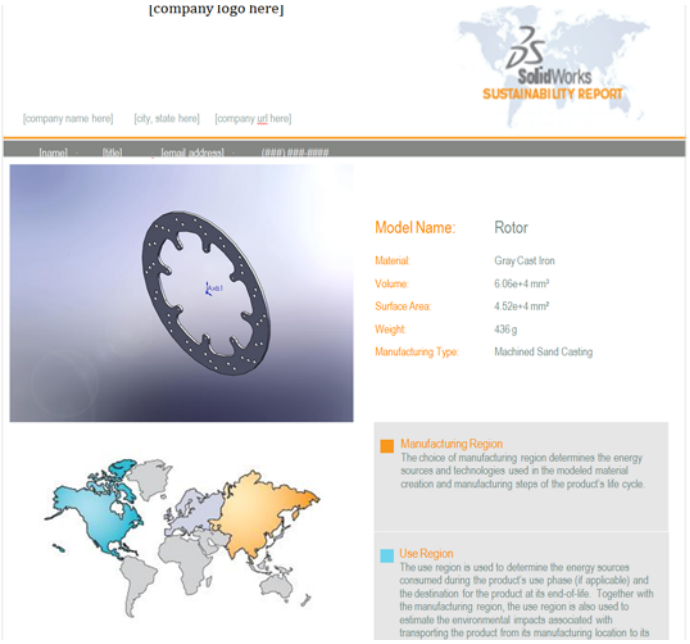
Creating a Report

In this section we will be generating a report in the form of a Microsoft Word document. that compares the materials
1023 Carbon Steel Sheet (SS) to the Gray Cast Iron.

Note: After creating the first report for your part, the **Generate Report** Icon changes to **Update Report**.

13 Generate report.

Click **Generate Report** . The document opens automatically. Take a look!



What is in a Report?

The report is organized in a specialized way. Below is a description of the contents.

Page	Description
1	Attributes of the final material we chose such as Material, Volume, Surface Area, Weight, and Manufacturing Type.
2	Environmental Impacts. It gives a visual graph and numerical breakdown for each Impact's Material type, Manufacturing, Use of material, and End of Life.
3	Same information as the first page but for the Baseline material.
4	A full breakdown of all the impacts with comparing the Gray Cast Iron to the 1023 Carbon Steel Sheet (SS) baseline.
5	
6	Glossary of terms that are in the report.

Tip: On the second page at the bottom, there is a link to the SolidWorks web site. Click on this link (or ctrl+click on it to open). This site calculates how much we would save using Gray Cast Iron in terms of miles driven in a hybrid car. You can compare materials or just view the breakdown from our material. There is a tab for each Environmental Impact near the bottom of the page. When we open the page is set on carbon Footprint and tells us that our design would be the equivalent of 20 miles in a hybrid. or if you Click on the Energy Consumption tab it is equal to 11-23 hours of watching TV.

Life Cycle Assessment (LCA)

On the sixth page of the Report there is a LCA Diagram.

What is LCA you may ask. Well LCA enables you to analyze the life cycles of products regarding their ecological and environmental impacts and displaying them in a transparent way. The goal of LCA (also known as 'life cycle analysis', 'ecobalance', and 'cradle-to-grave analysis') is to compare the full range of environmental and social damages assignable to products and services, to be able to choose the most sustainable one.

Some advantages to doing this are:

- You can determine the strategic risks and environment related problem fields of your products at an early stage and can have them identified in form of an “early warning system”.
- Identify the proportionality and relevance of the individual phases within the product life cycle.
- Concretise your ecological need for action and achieve an improved image compared to your competitors.
- Improve the communication with political decision makers and public authorities with the help of Life Cycle Assessement (LCA).
- Contribute to ecological innovations by implementing Life Cycle Assessements (LCA).

You can visit http://www.pe-international.com for more information.

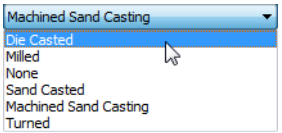
Further Improve Sustainable Design

We will make further changes to the design by altering the **Process** and **Regions**.

Process Change

The **Process** is the manufacturing process. This describes how the part is made and implies environmental impacts.

14 Process.



At the top of the **Manufacturing** menu there is a drop down menu next to the title **Process**. Currently it is set to **Machined Sand Casting**. We want to change this process to see if it is more sustainable.

Instead of **Machined Sand Casting**, Click **Milled.**

There are two ways of changing the process of manufacturing. The first way you can access in the **Find Similar** menu. You may also use this method when conducting a search of similar materials.

The second way which we will be demonstrating is found on the SustainabilityXpress Add-In under the manufacturing menu.

Note: The drop down menu for processes does not always show the same set of selections. The selection varies depending on the type of material.

Notice that the Environmental Impacts have refreshed and that they are all slightly better than before.

Manufacturing and Use Regions Change

Underneath the **Process** drop down there are two world maps as explained before. These maps represent where the part will be made and where it will be transported to. Currently we left it on the default regions of being made in Asia and transported to North America.

Let’s change this and tell SustainabilityXpress we want our part made and transported in the same region so we can save money on transportation.

15 Regions.

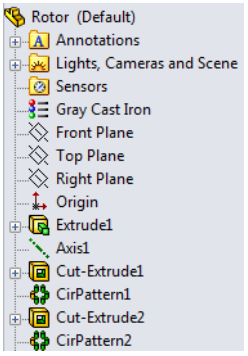
Click on **North America** on the first map.

Once again, this change in regions has further improved our design in terms of being more sustainable. All environmental impacts are still green.

Set the Material in the Part

Last but not least we will be setting the material. We have gone through the entire SustainabilityXpress Add-In and found the material that fits the type of material that is needed for a Rotor in the braking system of a car.

16 Setting Material.
Click the **Set Material** button in the **Materials** menu. This automatically sets the `Rotor` to `Gray Cast Iron` as seen in the FeatureManager Design Tree.



If you want, you can generate another Report to see the differences that the change in Process and Region have made to the Environmental Impacts.

17 Close SustainabilityXpress.
Click the red "**X**" on the SustainabilityXpress menu to close it.

18 Do not save.
In the part, click **File, Close** to close the part. Click **No** at the `Save changes to rotor?` message.

In the assembly, click **File, Close** to close the assembly. Click **Don't Save** in the **Save Modified Documents** dialog.

You have successfully completed the SustainabilityXpress tutorial.