Preliminary Design Review

The bus frame needs to be lightweight from aluminum to allow for greater fuel efficiency and cost reductions to run the buses. When redesigning the CATA bus, we want to make sure that aluminum is incorporated into the design to increase the effectiveness of CATA buses around Penn State's campus and the State College area. All of our redesigns will include aluminum in some facet to lower the bus cost and potentially increase the number of buses running. Our redesigns will focus on these specific criteria:

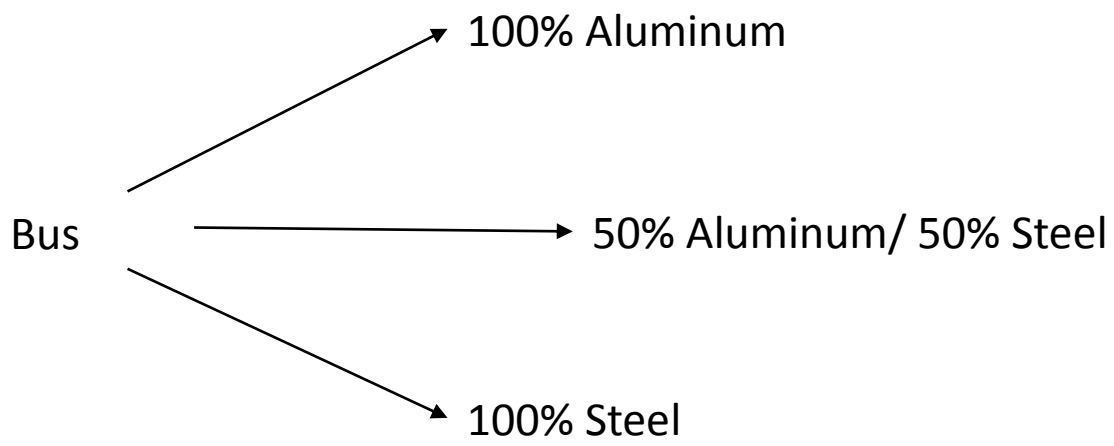
Need less crowded buses
Need more buses per route
Need green buses
Need more timely buses
Need longer stops
Need bigger buses
Need cheaper buses
Need accurate bus stop information
Need quicker buses
Need comfortable seats
Need friendly bus drivers

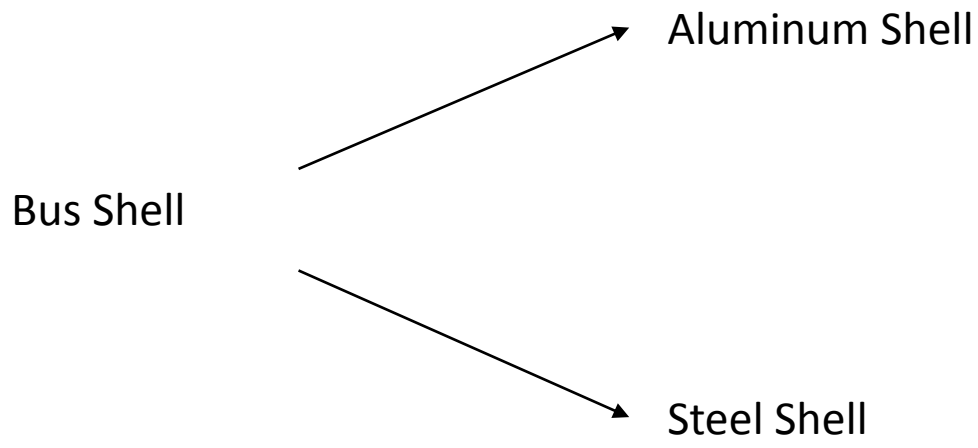
Customer needs	Weight	Overall importance
Need less crowded buses	4	2
Need more buses per route	5	1
Need green buses	4	3
Need bigger buses	3	6
Need cheaper buses	4	4
Need longer stops	3	7
Need accurate bus stop information	2	8
Need quicker buses	3	5
Need comfortable seats	2	9
Need friendly bus drivers	1	10

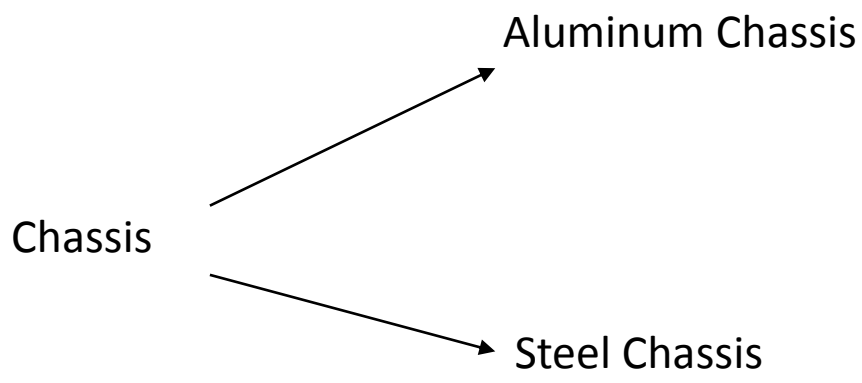
*weight bases on frequency of demand

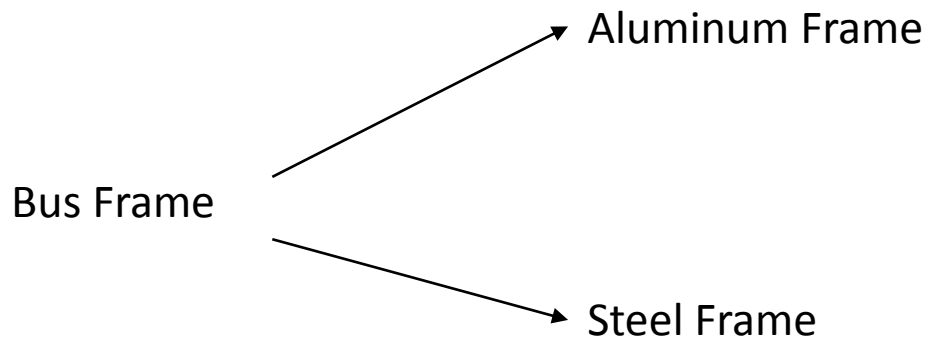
Based on this information, our goal is to create a cheaper and efficient bus line that will allow more buses to be implemented. This will satisfy all the riders who believe there aren't enough buses, the buses take too long, and the riders who would like less crowded buses.

These redesign criteria will help our team to come up with several different concepts for improvements to the CATA bus design. If implemented, CATA buses will become a more efficient feature here at Penn State. To aid with the redesign process, our team focused on parts of the bus that would be easy to replace using aluminum that would not affect the way the bus functioned. The redesigns for the CATA buses were created using concept generation maps.









The concept generation maps that were created helped in the creation of the CATA bus redesigns by focusing on which parts of the bus can be replaced with aluminum to help make a highly sustainable and more efficient bus. After creating a model of the bus in SolidWorks, sustainability tests were run to see which models were the most sustainable to the environment. As a baseline, the bus was made with cast stainless steel and the data was taken in terms of energy consumption and pollution in the environment. For each of the redesigns, aluminum alloy 6063 was incorporated and then new measurements were taken. The first redesign was a bus made completely out of aluminum. The second redesign is a bus made all from steel, but with the frame made from aluminum. The third redesign is an aluminum bus with the frame made out of steel. The fourth redesign is an aluminum chassis with a bus made from steel. The final redesign is an aluminum bus with a chassis made of steel.

Sustainability Report

Model Name: Steel Bus

Weight: 7.30E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

Material:	6.4E+7 kg CO_2e
Manufacturing:	4.1E+6 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	8.9E+5 kg CO_2e
End of Life:	4.0E+5 kg CO_2e

6.9E+7 kg CO_2e

Total Energy Consumed

Material:	6.3E+8 MJ
Manufacturing:	6.0E+7 MJ
Use:	0.00 MJ
Transportation:	1.3E+7 MJ
End of Life:	2.9E+5 MJ

7.0E+8 MJ

Air Acidification

Material:	1.6E+5 kg SO_2e
Manufacturing:	2.8E+4 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	7500 kg SO_2e
End of Life:	200 kg SO_2e

2.0E+5 kg SO_2e

Water Eutrophication

Material:	1.7E+5 kg PO4e
Manufacturing:	1000 kg PO4e
Use:	0.00 kg PO_4e
Transportation:	1200 kg PO_4e
End of Life:	500 kg PO_4e

1.8E+5 kg PO_4e

Sustainability Report

Model Name: Aluminum Bus

Weight: 2.56E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

Material:	3.5E+7 kg CO_2e
Manufacturing:	8.6E+5 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	4.4E+5 kg CO_2e
End of Life:	1.4E+5 kg CO_2e

3.6E+7 kg CO_2e

Total Energy Consumed

Material:	4.4E+8 MJ
Manufacturing:	1.2E+7 MJ
Use:	0.00 MJ
Transportation:	6.6E+6 MJ
End of Life:	1.0E+5 MJ

4.6E+8 MJ

Air Acidification

Material:	2.4E+5 kg SO_2e
Manufacturing:	5800 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	2000 kg SO_2e
End of Life:	72 kg SO_2e

2.5E+5 kg SO_2e

Water Eutrophication

Material:	7500 kg PO_4e
Manufacturing:	210 kg PO_4e
Use:	0.00 kg PO_4e
Transportation:	460 kg PO_4e
End of Life:	180 kg PO_4e

8400 kg PO_4e

Material Financial Impact 5632694.30 USD

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
bus cover	2.7E+6	590	1.8E+4	3.3E+7
Bus chassis	3.7E+5	81	2400	4.5E+6
bus frame base	1.5E+5	34	1000	1.9E+6
frame plate	1.1E+5	24	730	1.3E+6
Bus axle	2.2E+4	4.8	140	2.7E+5
bus frame sweep	1.9E+4	4.1	120	2.3E+5

Environmental Impact Comparison

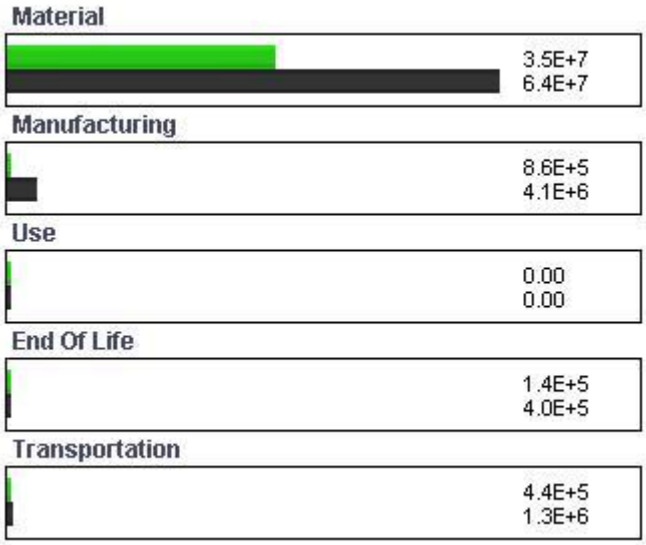
New Design: Better, Worse

Original Design: Baseline

Carbon Footprint - Comparison

Total : 3.6E+7 kg CO_2e

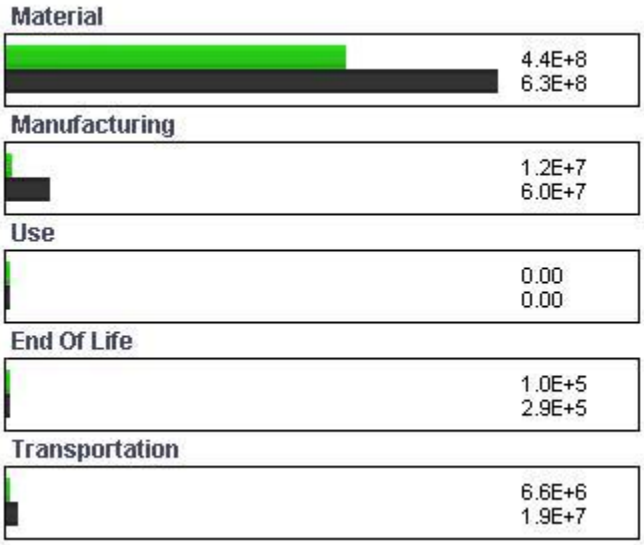
: 6.9E+7 kg CO_2e



Total Energy Consumed - Comparison

Total : 4.6E+8 MJ

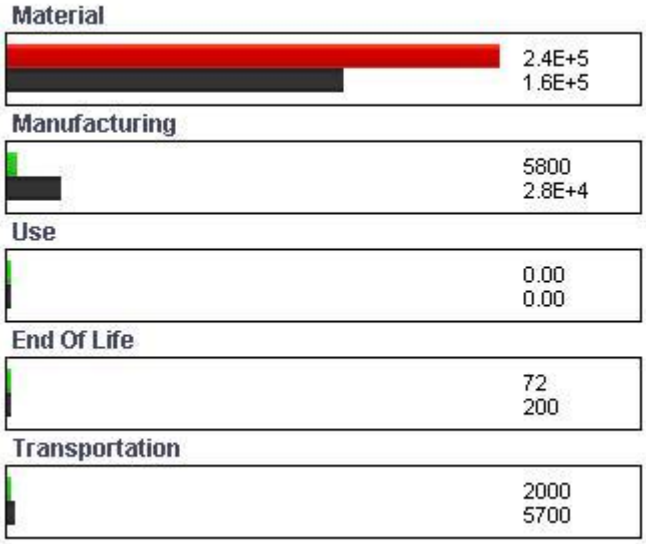
: 6.9E+8 MJ



Air Acidification - Comparison

Total : 2.5E+5 kg SO_2e

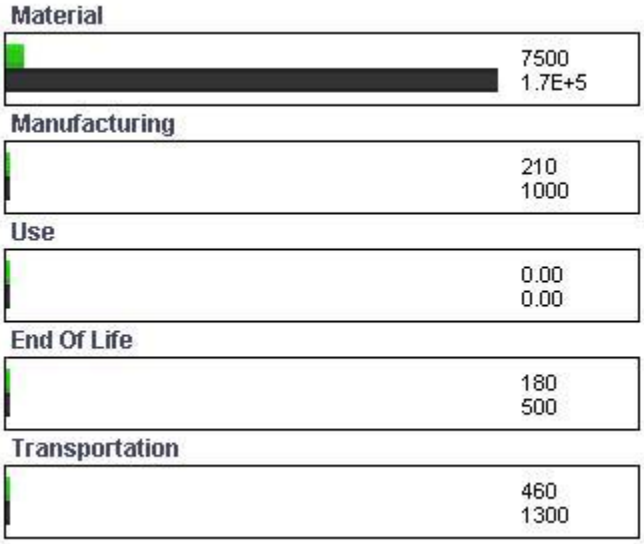
: 1.9E+5 kg SO_2e



Water Eutrophication - Comparison

Total : 8400 kg PO_4e

: 1.7E+5 kg PO_4e



Sustainability Report

Model Name: Steel Bus Aluminum Frame

Weight: 6.51E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

6.4E+7 kg CO_2e

Material:	5.9E+7 kg CO_2e
Manufacturing:	3.6E+6 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	1.1E+6 kg CO_2e
End of Life:	3.6E+5 kg CO_2e

Total Energy Consumed

6.6E+8 MJ

Material:	5.9E+8 MJ
Manufacturing:	5.2E+7 MJ
Use:	0.00 MJ
Transportation:	1.6E+7 MJ
End of Life:	2.6E+5 MJ

Air Acidification

2.0E+5 kg SO_2e

Material:	1.8E+5 kg SO_2e
Manufacturing:	2.4E+4 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	4800 kg SO_2e
End of Life:	180 kg SO_2e

Water Eutrophication

1.5E+5 kg PO_4e

Material:	1.5E+5 kg PO_4e
Manufacturing:	890 kg PO_4e
Use:	0.00 kg PO_4e
Transportation:	1100 kg PO_4e
End of Life:	450 kg PO_4e

Material Financial Impact 931370.50 USD

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
bus cover	5.4E+6	1.3E+4	1.6E+4	5.5E+7
Bus chassis	7.4E+5	1800	2200	7.6E+6
bus frame base	1.5E+5	34	1000	1.9E+6
frame plate	1.1E+5	24	730	1.3E+6
Bus axle	4.4E+4	100	130	4.5E+5
bus frame sweep	1.9E+4	4.1	120	2.3E+5

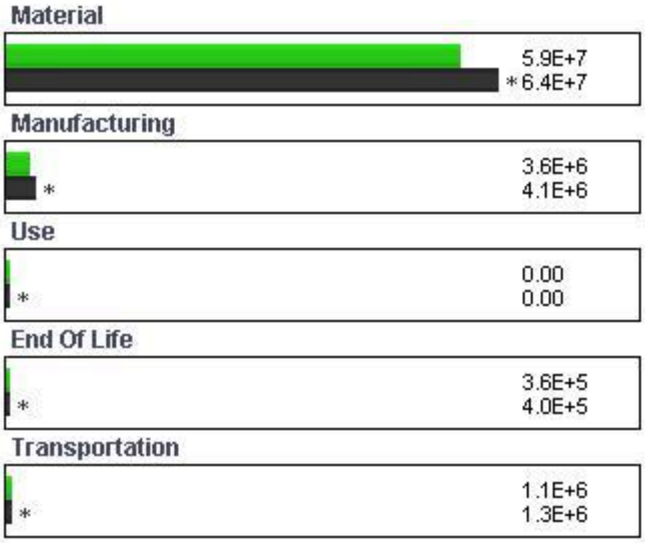
Environmental Impact Comparison

New Design: Better, Worse

Original Design: Baseline

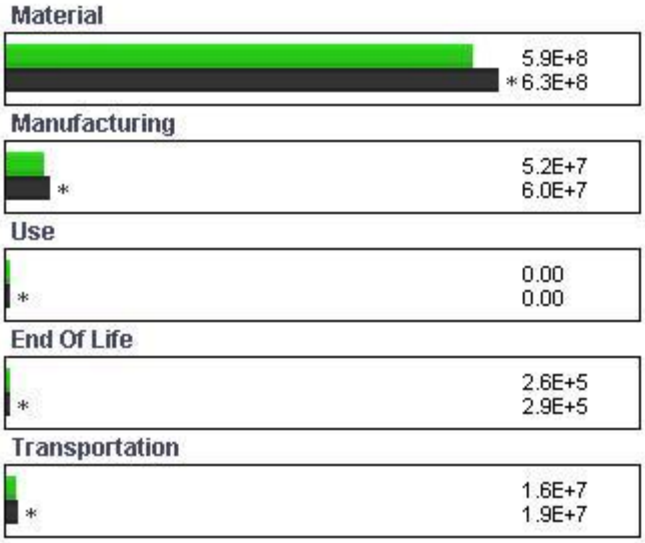
Carbon Footprint - Comparison

Total : 6.4E+7 kg CO_2e
: 6.9E+7 kg CO_2e



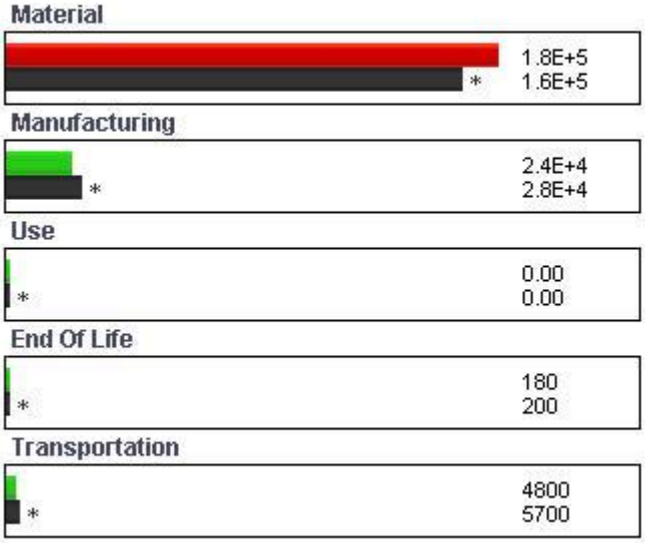
Total Energy Consumed - Comparison

Total : 6.6E+8 MJ
: 6.9E+8 MJ



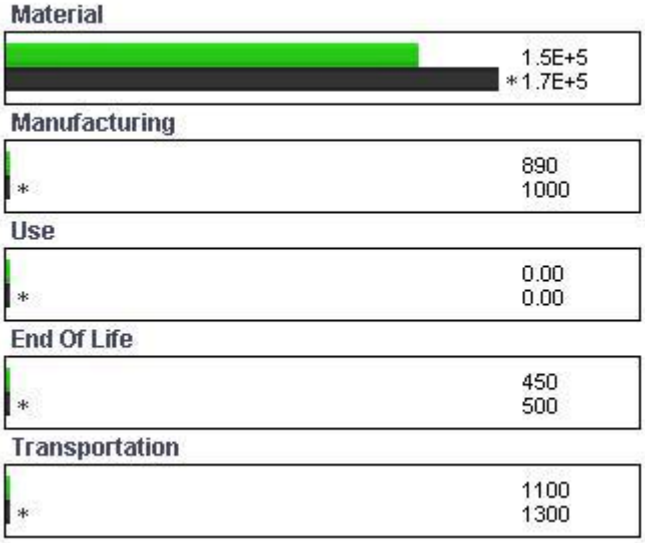
Air Acidification - Comparison

Total : 2.0E+5 kg SO_2e
: 1.9E+5 kg SO_2e



Water Eutrophication - Comparison

Total : 1.5E+5 kg PO_4e
: 1.7E+5 kg PO_4e



Sustainability Report

Model Name: Aluminum Bus Steel Frame

Weight: 3.34E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

4.2E+7 kg CO_2e

Material:	4.0E+7 kg CO_2e
Manufacturing:	1.4E+6 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	6.5E+5 kg CO_2e
End of Life:	1.8E+5 kg CO_2e

Total Energy Consumed

5.0E+8 MJ

Material:	4.7E+8 MJ
Manufacturing:	2.0E+7 MJ
Use:	0.00 MJ
Transportation:	9.7E+6 MJ
End of Life:	1.3E+5 MJ

Air Acidification

2.4E+5 kg SO_2e

Material:	2.3E+5 kg SO_2e
Manufacturing:	9400 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	2900 kg SO_2e
End of Life:	93 kg SO_2e

Water Eutrophication

3.6E+4 kg PO_4e

Material:	3.5E+4 kg PO_4e
Manufacturing:	350 kg PO_4e
Use:	0.00 kg PO_4e
Transportation:	670 kg PO_4e
End of Life:	230 kg PO_4e

Material Financial Impact 4701323.80 USD

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
bus cover	2.7E+6	590	1.8E+4	3.3E+7
bus frame base	3.1E+5	730	930	3.1E+6
frame plate	2.2E+5	530	670	2.3E+6
Bus chassis	3.7E+5	81	2400	4.5E+6
bus frame sweep	3.8E+4	91	110	3.9E+5
Bus axle	2.2E+4	4.8	140	2.7E+5

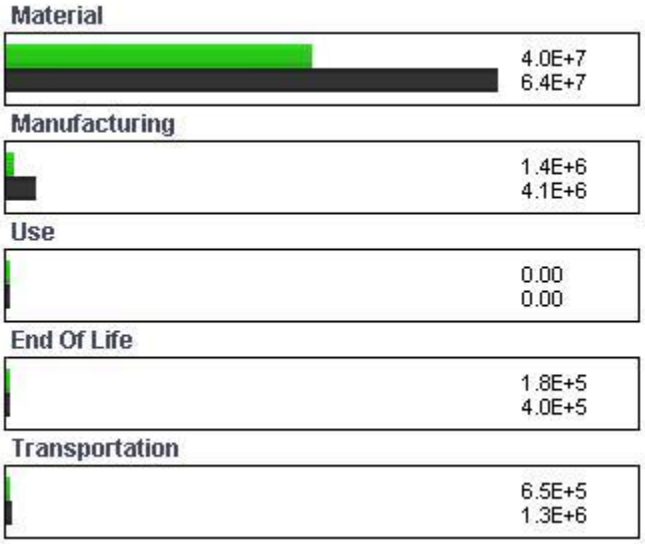
Environmental Impact Comparison

New Design:
Better
Worse

Original Design:
Baseline

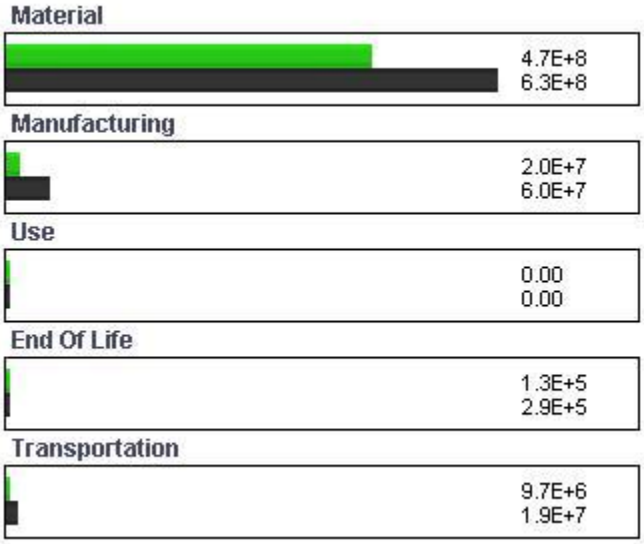
Carbon Footprint - Comparison

Total : 4.2E+7 kg CO_2e
: 6.9E+7 kg CO_2e



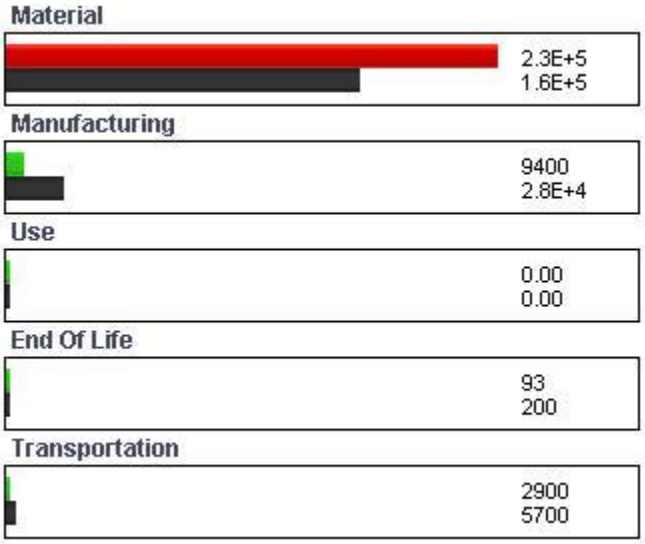
Total Energy Consumed - Comparison

Total : 5.0E+8 MJ
: 6.9E+8 MJ



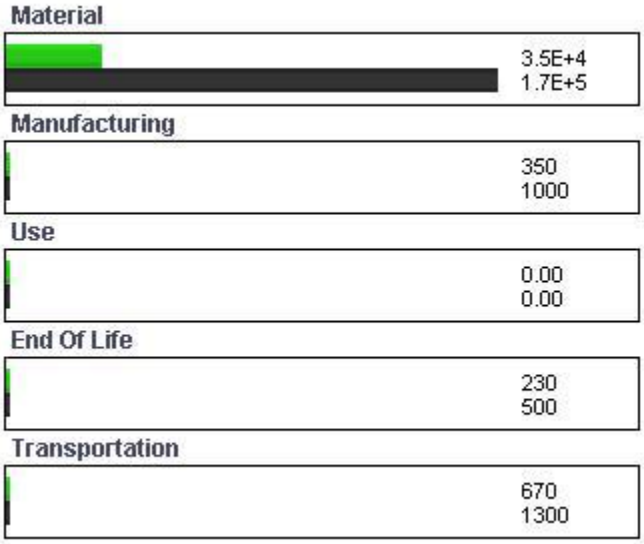
Air Acidification - Comparison

Total : 2.4E+5 kg SO_2e
: 1.9E+5 kg SO_2e



Water Eutrophication - Comparison

Total : 3.6E+4 kg PO_4e
: 1.7E+5 kg PO_4e



Sustainability Report

Model Name: Steel Bus Aluminum Chassis

Weight: 6.77E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

6.6E+7 kg CO_2e

Material:	6.1E+7 kg CO_2e
Manufacturing:	3.8E+6 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	1.1E+6 kg CO_2e
End of Life:	3.7E+5 kg CO_2e

Total Energy Consumed

6.8E+8 MJ

Material:	6.0E+8 MJ
Manufacturing:	5.5E+7 MJ
Use:	0.00 MJ
Transportation:	1.7E+7 MJ
End of Life:	2.7E+5 MJ

Air Acidification

2.0E+5 kg SO_2e

Material:	1.7E+5 kg SO_2e
Manufacturing:	2.5E+4 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	5100 kg SO_2e
End of Life:	190 kg SO_2e

Water Eutrophication

1.6E+5 kg PO_4e

Material:	1.5E+5 kg PO_4e
Manufacturing:	930 kg PO_4e
Use:	0.00 kg PO_4e
Transportation:	1200 kg PO_4e
End of Life:	470 kg PO_4e

Material Financial Impact 627690.40 USD

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
bus cover	5.4E+6	1.3E+4	1.6E+4	5.5E+7
Bus chassis	3.7E+5	81	2400	4.5E+6
bus frame base	3.1E+5	730	930	3.1E+6
frame plate	2.2E+5	530	670	2.3E+6
bus frame sweep	3.8E+4	91	110	3.9E+5
Bus axle	2.2E+4	4.8	140	2.7E+5

Environmental Impact Comparison

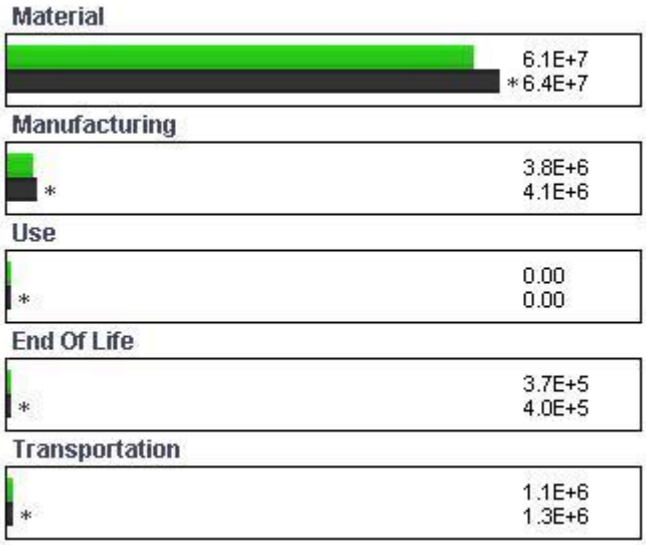
New Design: Better, Worse

Original Design: Baseline

Carbon Footprint - Comparison

Total : 6.6E+7 kg CO_2e

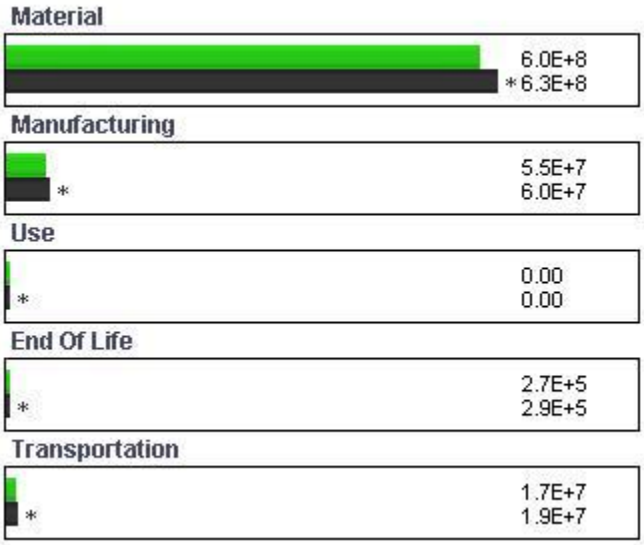
: 6.9E+7 kg CO_2e



Total Energy Consumed - Comparison

Total : 6.8E+8 MJ

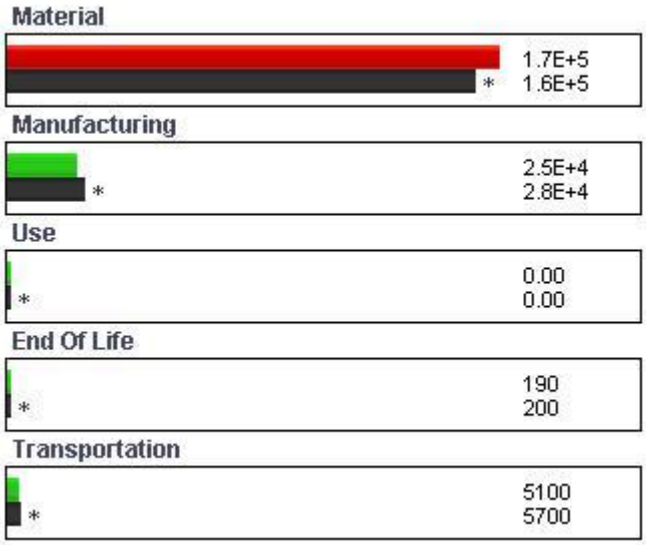
: 6.9E+8 MJ



Air Acidification - Comparison

Total : 2.0E+5 kg SO_2e

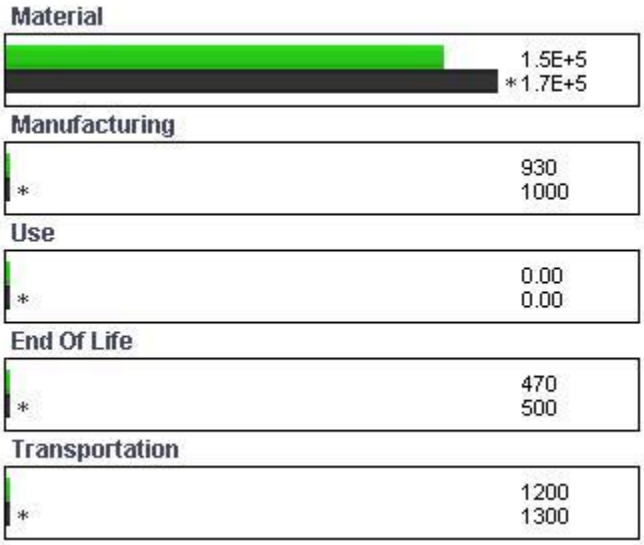
: 1.9E+5 kg SO_2e



Water Eutrophication - Comparison

Total : 1.6E+5 kg PO_4e

: 1.7E+5 kg PO_4e



Sustainability Report

Model Name: Aluminum Bus Steel Chassis

Weight: 3.09E+5 kg
Built to last: 10 year
Duration of use: 10 year

Environmental Impact (calculated using CML impact assessment methodology)

Carbon Footprint

4.0E+7 kg CO_2e

Material:	3.8E+7 kg CO_2e
Manufacturing:	1.2E+6 kg CO_2e
Use:	0.00 kg CO_2e
Transportation:	5.8E+5 kg CO_2e
End of Life:	1.7E+5 kg CO_2e

Total Energy Consumed

4.8E+8 MJ

Material:	4.6E+8 MJ
Manufacturing:	1.8E+7 MJ
Use:	0.00 MJ
Transportation:	8.7E+6 MJ
End of Life:	1.2E+5 MJ

Air Acidification

2.4E+5 kg SO_2e

Material:	2.3E+5 kg SO_2e
Manufacturing:	8200 kg SO_2e
Use:	0.00 kg SO_2e
Transportation:	2600 kg SO_2e
End of Life:	86 kg SO_2e

Water Eutrophication

2.7E+4 kg PO_4e

Material:	2.6E+4 kg PO_4e
Manufacturing:	300 kg PO_4e
Use:	0.00 kg PO_4e
Transportation:	600 kg PO_4e
End of Life:	210 kg PO_4e

Material Financial Impact 5005003.90 USD

Component Environmental Impact

Top Ten Components Contributing Most to the Four Areas of Environmental Impact

Component	Carbon	Water	Air	Energy
bus cover	2.7E+6	590	1.8E+4	3.3E+7
Bus chassis	7.4E+5	1800	2200	7.6E+6
bus frame base	1.5E+5	34	1000	1.9E+6
frame plate	1.1E+5	24	730	1.3E+6
Bus axle	4.4E+4	100	130	4.5E+5
bus frame sweep	1.9E+4	4.1	120	2.3E+5

Environmental Impact Comparison

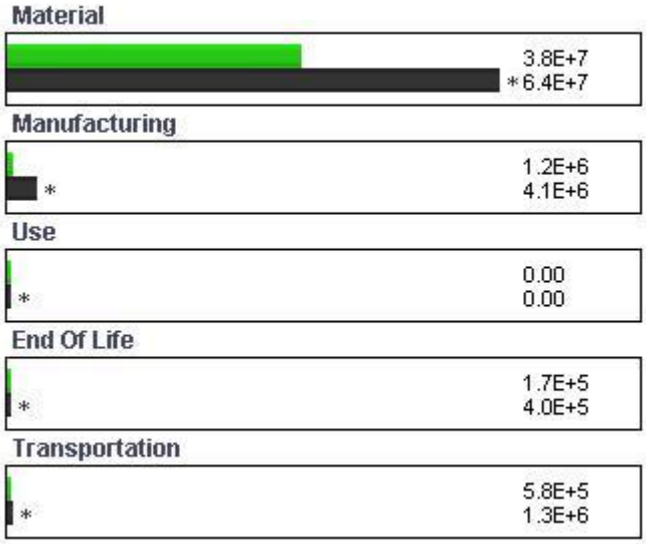
New Design: Better, Worse

Original Design: Baseline

Carbon Footprint - Comparison

Total : 4.0E+7 kg CO_2e

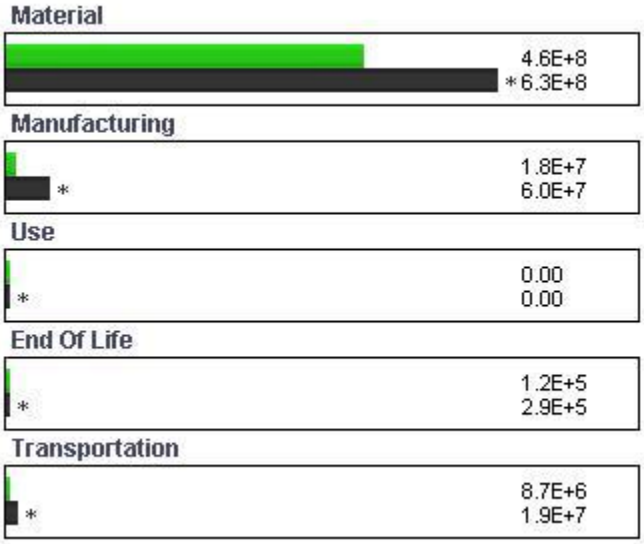
: 6.9E+7 kg CO_2e



Total Energy Consumed - Comparison

Total : 4.8E+8 MJ

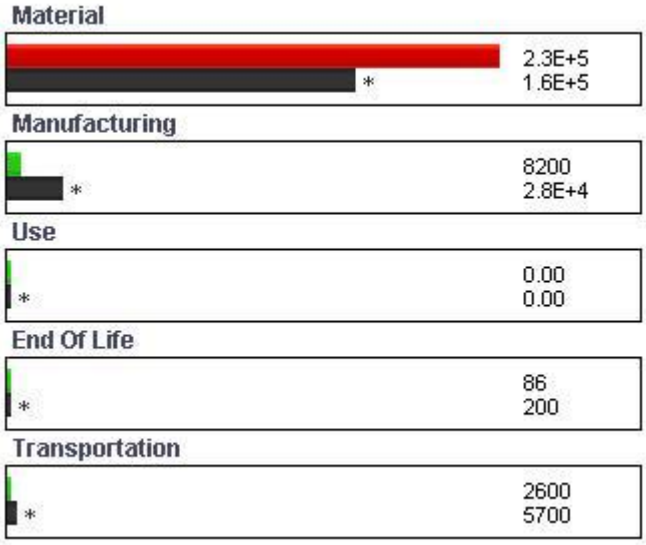
: 6.9E+8 MJ



Air Acidification - Comparison

Total : 2.4E+5 kg SO_2e

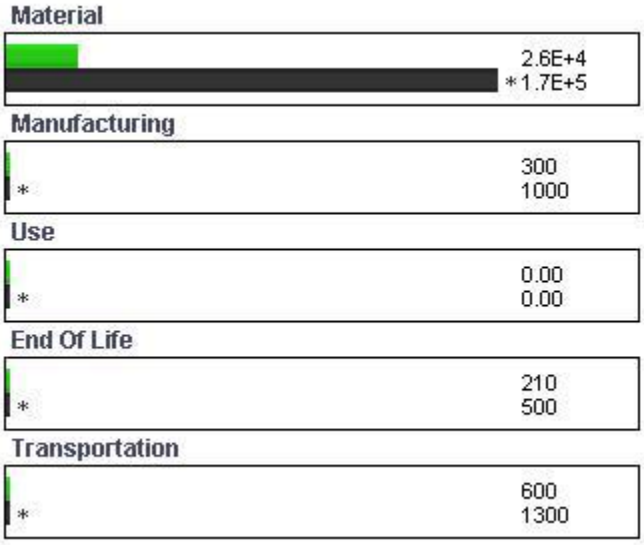
: 1.9E+5 kg SO_2e



Water Eutrophication - Comparison

Total : 2.7E+4 kg PO_4e

: 1.7E+5 kg PO_4e



Concept Design Selection

Concept	Weight	Overall importance
Aluminum Bus	2	1
Aluminum Frame	3	4
Steel Frame	5	3
Aluminum Chassis	2	5
Steel Chassis	4	2

1. A 100% aluminum bus would be revolutionary. A quick, lightweight bus that allows for fast travel and not to mention; if all the buses were made out of aluminum the costs would be much lower. The downside, however, is that an aluminum bus is not as strong as a steel bus and in an accident the aluminum bus might not protect the riders as well as steel.

2. An aluminum bus with a steel chassis would be lightweight and a low amount of materials would be required to make the bus. The steel chassis makes the bus sturdy as well as protects it from bumper collisions, but any damage done to the body of the bus would be dangerous to the passengers riding.

3. The steel frame supporting the bus would be one of the safest models to produce. With low levels of pollution to the environment and moderate cost of production, this efficient bus would allow CATA to manufacture more buses and have a greater number of buses on each route.

4. Manufacturing a bus with an aluminum frame would create a bus that wouldn’t be the safest for the passengers or the driver. It would be one of the cheaper models to produce, but the amount of energy needed to create it and the pollution it would have to the environment makes this an inefficient model.

5. A bus with an aluminum chassis would be the cheapest model to produce, but its lack of safety and stability, as well as the high amounts of energy needed to produce the bus, would make this a questionable option when looking at how to maximize the number of buses.