Life Cycle Assessment: TV Remote

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Executive Summary

This project is focus on analysing the TCL company's TV controller which is produced in Shenzhen, China and purchased in Lansing. The TV controller made up of a battery compartment lid, battery springs, a button pad, a LED, a plastic frame back, a plastic frame front and a printed circuit board. By adding all the carbon dioxide emission together, the global warming potential can be determined which is 5.173 kg CO2 eq and the marine eutrophication potential is 4.1244*10-4 kg N eq. The electricity contribute the largest part of greenhouse gases emission, because the coal used to generate electricity releases a large amount of greenhouse gas. After redesign the system, the coal based electricity now is replaced by nuclear, solar and wind power based electricity. Another redesign was reducing the size off the TV controller. By doing so, the cost of aluminum and acrylonitrile can also decrease. The new system result provide evidence to prove this system is more environmentally friendly than before.

Goal of the Study

The first goals of this study was to identify the relative life cycle environmental impacts of a TV Remote to climate change and marine eutrophication. Another goal of the project was to design for X. The project was completed using OpenLCA program. The group decided the chosen environmental impacts would be CO2 emissions and its effects on climate change and marine eutrophication. The intended audience for the project is CE 371 class and Professor Anctil. In this project, the purpose of the Life Cycle Assessment included:

- Comparing inputs and outputs associated with an alternative process
- Finding places within the processes where we can reduce the environmental impact
- Help in navigating the development of improved product to reduce the overall impact on the environment (design for X)

Scope

The scope of the project is to focus on the production, assembly, and shipment of the TV remote. The system boundary is set in China and United States, as the TV Remote was constructed in China and then was shipped and purchased in the United States (Lansing). The stages consider in this report included from raw material, shipping, and to product use. The main life stages to construct the TV remote include transportation, electricity, and injection molding process. (see figure 1 below)

The study included the following parts:

- Plastic Frame Back
- Plastic Frame Front
- Battery Compartment Lid
- LED
- Button Pad
- Battery Springs

The TV remote plastic back frame, front frame, and battery compartment are made of Acrylonitrile Butadiene Styrene . The spring inside the battery is made of aluminum. The rubber pad is made of a silca. The printed circuit board is made of fiberglass, copper foil, and aluminum. Lastly the LED is made of epoxide resin, araldite, and semiconductor.

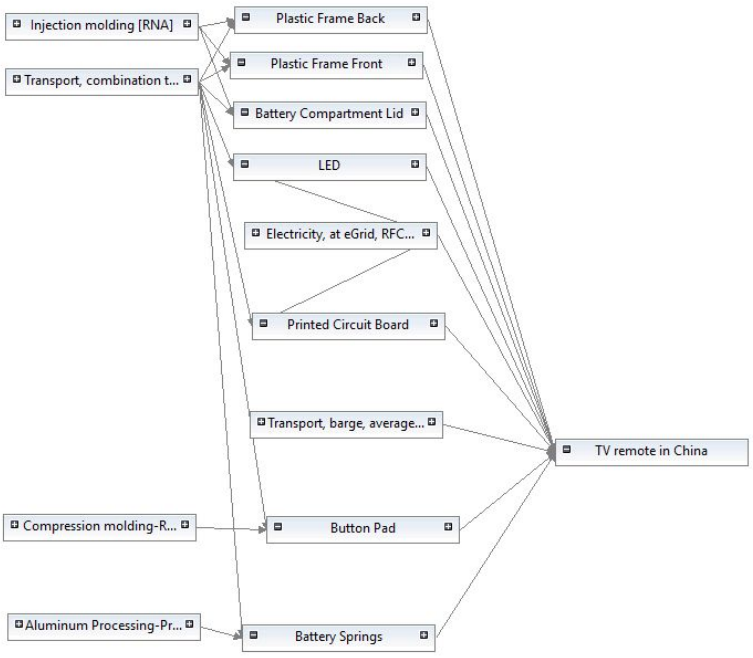


Figure 1: Flow Diagram of Lifecycle processes of TV Remote

The function of the TV remote is to operate a TV remotely. The function unit is the production of one TV Remote and to purchase it here in East Lansing.

By modeling the process of producing one TV Remote, the carbon footprint (C02)and nitrogen (N) footprint will be addressed. From both the carbon and nitrogen footprint we will be able to determine the main causes of global warming and marine eutrophication. The data came from the OpenLCA database and from Professor Anctil.

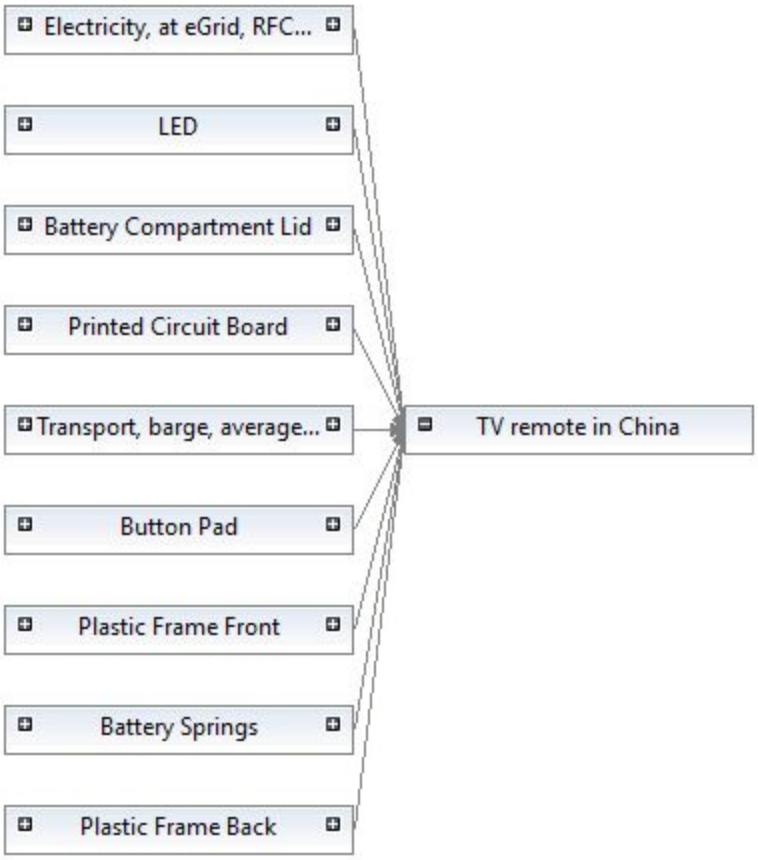
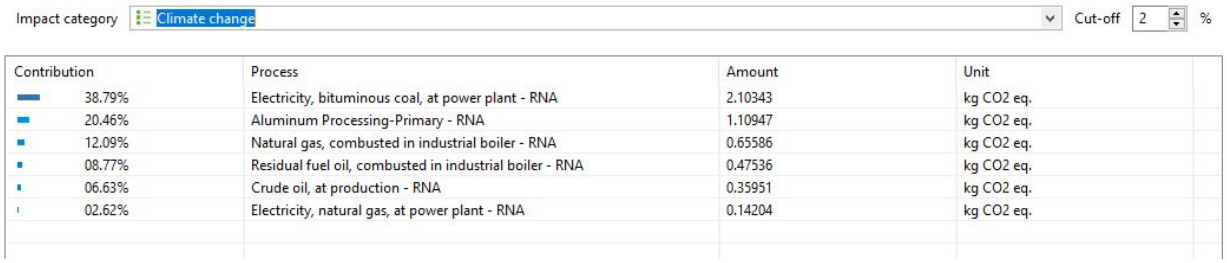


Figure 2: Flow Diagram

Inventory & Impact Assessments

Table 1: Weight of different materials of the TV Remote

Inventory		
Part	Material	Weight
Battery Compartment Lid	Acrylonitrile Butadiene Styrene (ABS)	3.25 g
Plastic Frame- Back	ABS	24.15 g
Plastic Frame- Front	ABS	14.49 g
Battery Spring	Aluminum	0.25 g
Button Pad	Rubber	15.23 g
Printed Circuit Board	Fiberglass, copper foil, aluminum	16.1 g
LED	Epoxide resin, semiconductor	0.25 g
	Total Weight:	73.72 g



Contribution	Process	Amount	Unit
38.79%	Electricity, bituminous coal, at power plant - RNA	2.10343	kg CO2 eq.
20.46%	Aluminum Processing-Primary - RNA	1.10947	kg CO2 eq.
12.09%	Natural gas, combusted in industrial boiler - RNA	0.65586	kg CO2 eq.
08.77%	Residual fuel oil, combusted in industrial boiler - RNA	0.47536	kg CO2 eq.
06.63%	Crude oil, at production - RNA	0.35951	kg CO2 eq.
02.62%	Electricity, natural gas, at power plant - RNA	0.14204	kg CO2 eq.

Figure 3. Impact assessment result of Global Warming

Contribution	Process	Amount	Unit
50.44%	Electricity, bituminous coal, at power plant - RNA	0.00221	kg N eq.
12.81%	Crude oil, in refinery - RNA	0.00056	kg N eq.
09.07%	Residual fuel oil, combusted in industrial boiler - RNA	0.00040	kg N eq.
07.74%	Transport, train, diesel powered - RNA	0.00034	kg N eq.
04.73%	Natural gas, combusted in industrial boiler - RNA	0.00021	kg N eq.
04.07%	Crude oil, at production - RNA	0.00018	kg N eq.
02.46%	Transport, barge, residual fuel oil powered - RNA	0.00011	kg N eq.

Figure 4. Impact assessment result of eutrophication

Inventory Analysis

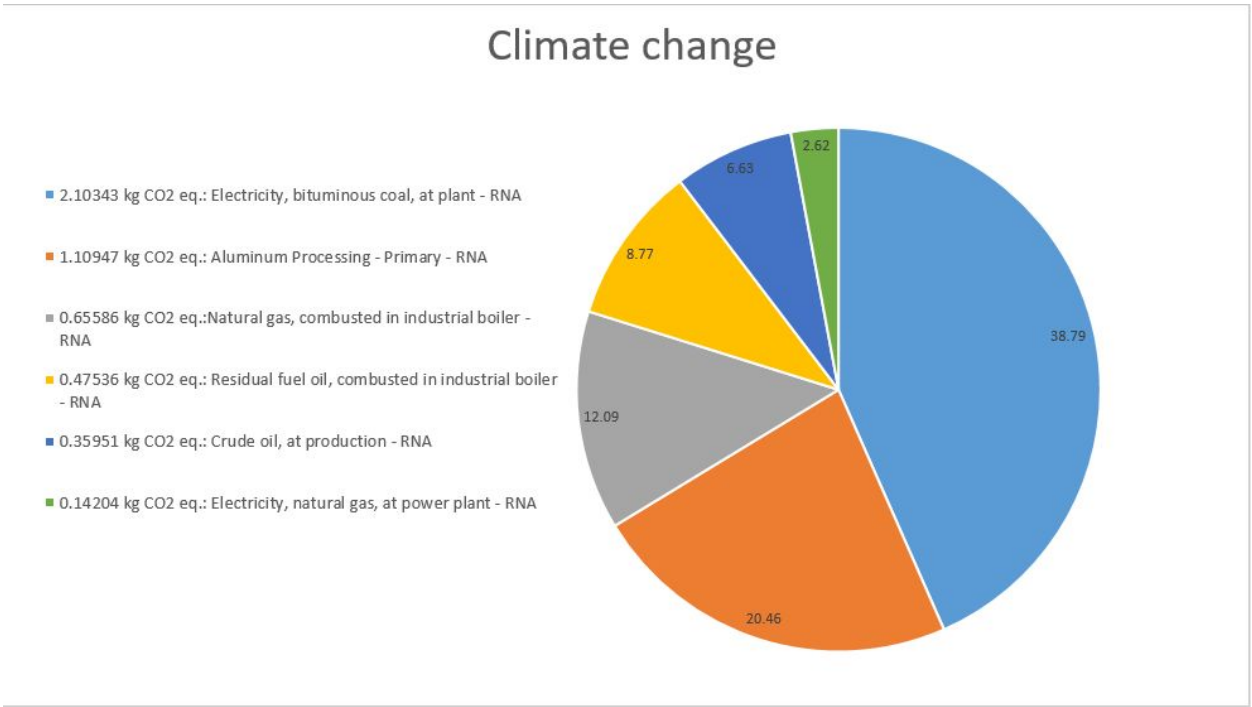
This TV remote is composed of a few main materials. The outer shell or frame of the remote is made of acrylonitrile butadiene styrene (ABS). ABS is a plastic that responds to heat by melting, but without degradation of the material. This allows it to be both molded into the proper shape, as well as easily recycled. The frame was designed in a way that allowed the plastic to clip together without the need for any screws. Inside the shell are the other main components. There is a button pad that allows the user to press any buttons on the remote. The pad is made out of rubber silica gel that is found in most remotes. Beneath the button pad is the printed circuit board. This is the electronic piece that allows the signal to be sent from the remote to the TV. We could not separate the components of the printed circuit board, so the assumption was made that it was just a typical printed circuit board made of fiberglass and copper foil. Attached to the circuit board were an LED and an aluminum spring. The aluminum spring acted as half of the spring for the battery compartment, while a separate aluminum spring makes up the other half. We were also unable to take apart the LED, so we made an assumption that it was a typical LED made of a semiconductor surrounded by an epoxy resin. The process of making the plastic components comes from a process called injection moulding. In which plastic pellets are melted, and shot into a mold in which is cooled and released.

Impact Assessment

Production of any good has negative effects on the environment and TV remotes are not an exception. Negative effects to the environment usually come in two categories production and transportation. Production effects are those created by the production of a good whether it be by bi-products, the use of energy to create said product, or actual impacts the final good and its components have on the environment. Secondly negative effects can come from the transportation of said good to its final location. Transportation impacts usually come from the burning of fossil fuels but also can come from environmental destruction along the way to its destination.

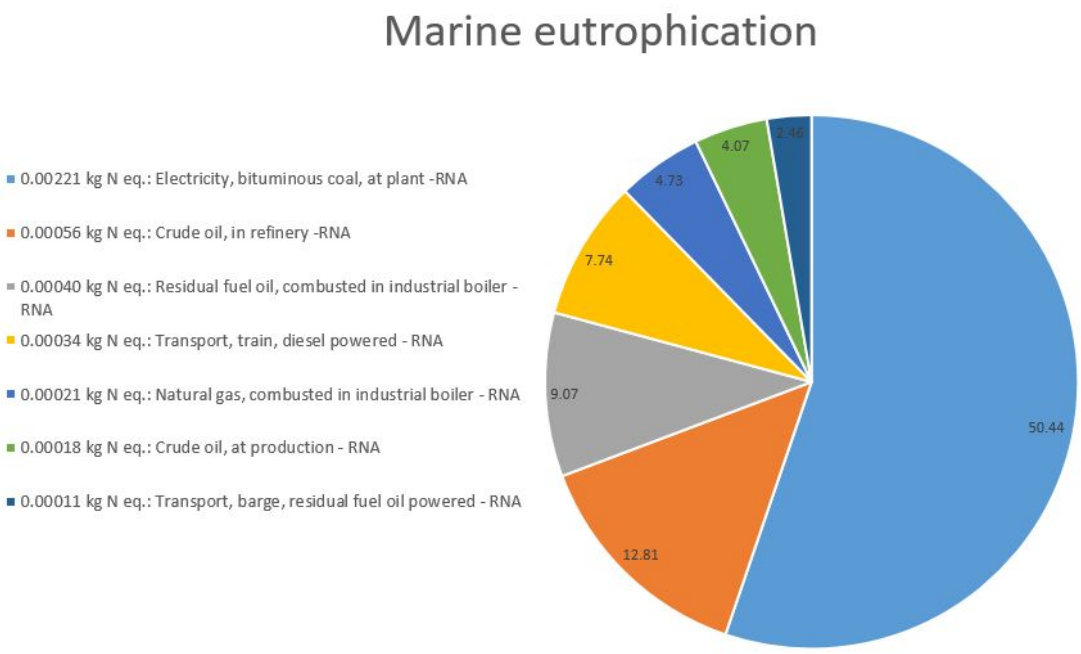
For this LCA we focused on two categories of environmental impact; climate change and marine eutrophication. The method used to perform the LCA analysis calculations was ILCD 2011, midpoint. By choosing the midpoint (rather than endpoint), we were able to see the what the production of our TV remote directly affected in terms of emissions or resource depletion. Endpoint would have been more focused on what's caused by those midpoint items, such as an increase in global temperatures. Climate change is primarily driven by the greenhouse effect, the warming of our atmosphere due to high energy storing molecules dispersed throughout it. Because of this the driving factor behind climate change is the introduction of these gaseous molecules into the atmosphere like CO_2. The production of TV remotes in china is a contributor to climate change. The production of the electricity used in the production of the remote accounts for most of the CO_2 sent into the atmosphere as shown by the graph below. However, it

is not the only cause, production of CO_2 is also caused by the aluminum processing involved in production and the combustion of industrial broilers. Transportation via barges, trains and shipping trucks also accounts for a small amount of the CO_2 released into the atmosphere.



The second Impact category we focused on was marine eutrophication. Eutrophication is the process of enriching water, often with nitrogen, and its effect on the ecosystem. This enriched water spurs large algae blooms which eventually die. When the dead algae starts to sink to the bottom local decomposers go to work and reproduce to fit the large food source. Its then that these decomposers consume large amounts of dissolved oxygen and create what is know as a dead zone. Examples of dead zones exist in places like Lake Erie but also in places like the Gulf of Mexico.

Although rarely talked about disturbances to the nitrogen cycle can be just as impactful as disturbances to the carbon cycle and are a major concern for sustainability. We found that many of the processes used in the production and transportation of TV remotes contribute to increasing nitrogen levels that eventually lead to eutrophication. Again electricity seemed to contribute the most to eutrophication as shown by the graph below.



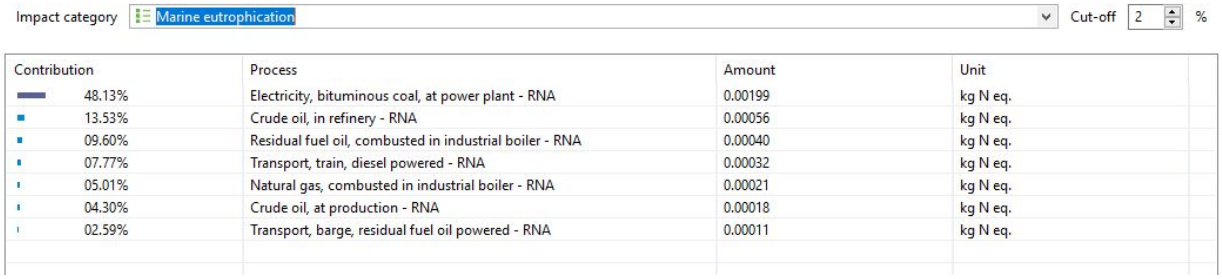
Design for X

By the analysis of the product, it clearly shows impacts of life cycle phase and present the overall environmental impacts of the product. In the life cycle of a TV remote made in China, electricity has the highest impacts in climate changing potential, especially the emission of greenhouse gases which cause the global warming (proportion of energy shown in Figure 3). Furthermore, the electricity is the also the most impactful element in the life cycle for the eutrophication (proportion of energy shown in Figure 4). To maintain a sustainable environment, the most important improvement of the proportion of energy may put in effect. In order to implement the improvement, one way is to reduce the impact on global warming by decreasing the electricity consumed in the producing process. In order to reduce the CO2 emission at producing process, the electricity generate by using of bituminous coal can be replace by clean energy such as solar energy and wind power. And also, in the Figure 7 below, it shows the amount of each kind of energy that been been used to generate electricity in China. It shows the different energy requirement for 1 kWh of electricity. On the other hand, another solution of reducing the impact of electricity on both global warming and eutrophication is to shrink the size of the TV remote control which can significantly reduce the amount of resource needed. By combining two method the new proportion of energy, the new proportion of energy been created and shown in Figure 5 & 6 below.

Impact category: Climate change Cut-off: 2 %

Contribution	Process	Amount	Unit
36.50%	Electricity, bituminous coal, at power plant - RNA	1.88848	kg CO2 eq.
21.44%	Aluminum Processing-Primary - RNA	1.10947	kg CO2 eq.
12.65%	Natural gas, combusted in industrial boiler - RNA	0.65446	kg CO2 eq.
09.15%	Residual fuel oil, combusted in industrial boiler - RNA	0.47322	kg CO2 eq.
06.90%	Crude oil, at production - RNA	0.35721	kg CO2 eq.
02.52%	Electricity, natural gas, at power plant - RNA	0.13043	kg CO2 eq.

Figure 5. New Impact assessment result of global warming



Impact category: Marine eutrophication Cut-off: 2 %

Contribution	Process	Amount	Unit
48.13%	Electricity, bituminous coal, at power plant - RNA	0.00199	kg N eq.
13.53%	Crude oil, in refinery - RNA	0.00056	kg N eq.
09.60%	Residual fuel oil, combusted in industrial boiler - RNA	0.00040	kg N eq.
07.77%	Transport, train, diesel powered - RNA	0.00032	kg N eq.
05.01%	Natural gas, combusted in industrial boiler - RNA	0.00021	kg N eq.
04.30%	Crude oil, at production - RNA	0.00018	kg N eq.
02.59%	Transport, barge, residual fuel oil powered - RNA	0.00011	kg N eq.

Figure 6. New Impact assessment result of eutrophication

Finally, another method that entirely reduce the impacts is to make the hardware remote service as a software. For example, using an APP on phone instead of a material object. Thus, it will consider electricity as the only impactful element in the life cycle. And also, in the Figure 7 below, it shows the amount of each kind of energy that been been used to generate electricity in China.

Flow	Category	Flow property	Unit	Amount	Uncertainty
Electricity, nuclear, at power plant - R...		Energy	kWh	0.0225	none
Dummy_Electricity, solar, unspecified...		Energy	kWh	0.0076	none
Electricity, residual fuel oil, at power ...		Energy	kWh	0.014093	none
Electricity, natural gas, at power plant...		Energy	kWh	0.012617	none
Electricity, bituminous coal, at power...		Energy	kWh	0.72529	none
Dummy_Electricity, at wind power pl...		Energy	kWh	0.2179	none

Figure 7. Input energies for the electricity generation in China.

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