Towards a Multidimensional Geometric Metric for Sustainability

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Introduction

Going towards a future of sustainability requires using resources to meet human needs while preserving the environment so both current and future generations' needs can be met. There are three bottom lines to sustainability: environment, economy, and society. Societal aspects of sustainability include ethical, communal and human factors, such as where a product is manufactured in the world. Usually the emphasis of product design is economic – creating the largest profit margin – but recently there has been a demand to focus on environmental factors too.

This project focused on environmental aspect of sustainability. There does exist metrics for environmental factors, such as carbon footprint. There are also metrics such as Eco-Indicators which are aggregate values of multiple factors. Individual factors alone can be too limiting in their scope while aggregate vales can be misleading, weighing different factors seemingly arbitrarily. This project aimed towards creating a metric which included multiple factors not masked behind one aggregate value. There does not yet exist a comprehensive metric for comparing sustainability among products. This project aimed towards creating such a geometric metric.

Objective

•Create a Geometric Metric to compare sustainability aspects among different products with similar purpose. The case study for this research was focused on erasers.

Methods

•Model different erasers (natural rubber, vinyl, synthetic rubber, and electric) using CAD software, applying appropriate material data to each

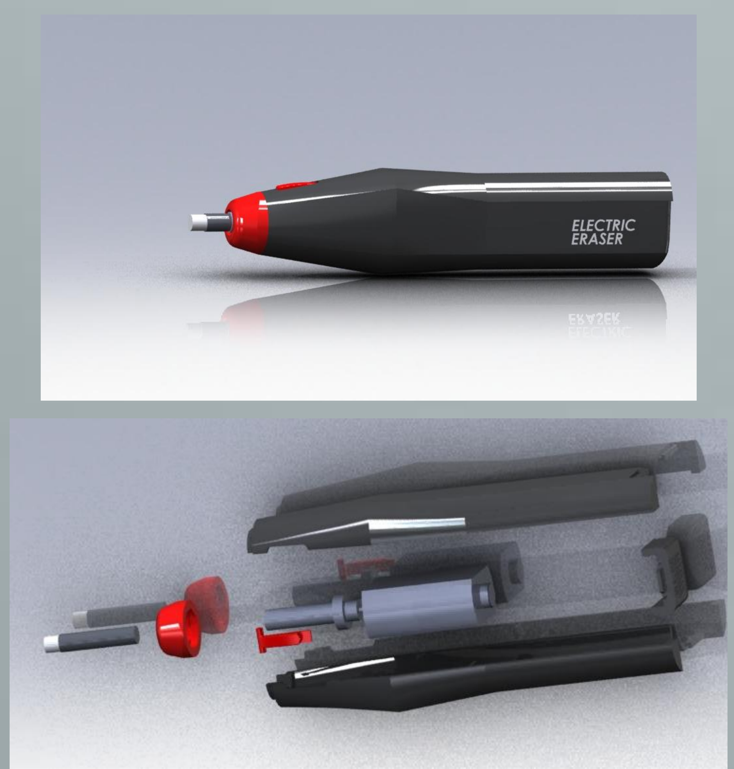
•Obtained Eutrophication, Acidification, Carbon Emission and Energy data from Life Cycle Inventory

•Three aspects of sustainability were chosen to create 3D geometry – Eutrophication, Acidification, and Carbon Emission

•Eutrophication, Acidification and Carbon Emission were independent aspects with readily available data

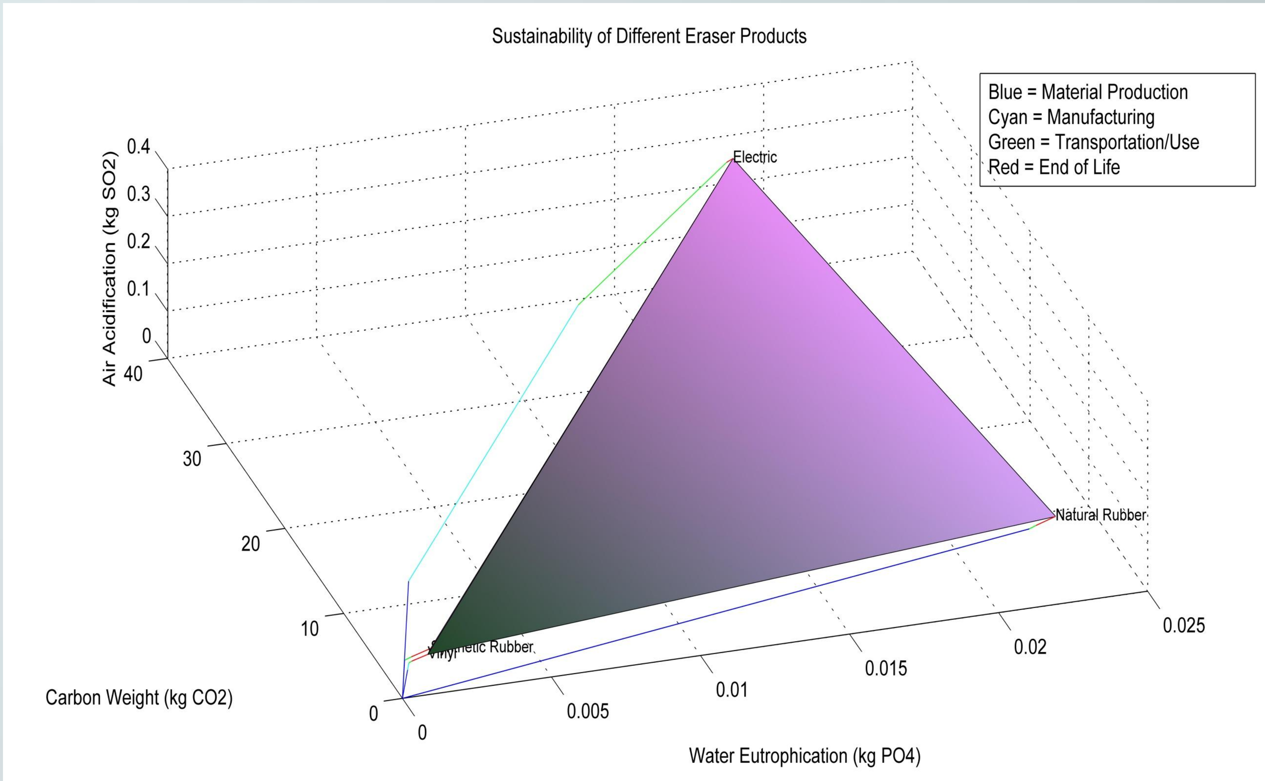
•Created geometry using MATLAB to visually compare sustainability of eraser products

•Included "path" to see how different stages (material production, manufacturing, transportation, end of life) of a product's lifecycle contributed towards ultimate sustainability values



CAD renderings of Electric Eraser

Results



Geometric results from Sustainability Data

•All aspect values were normalized by their respective masses

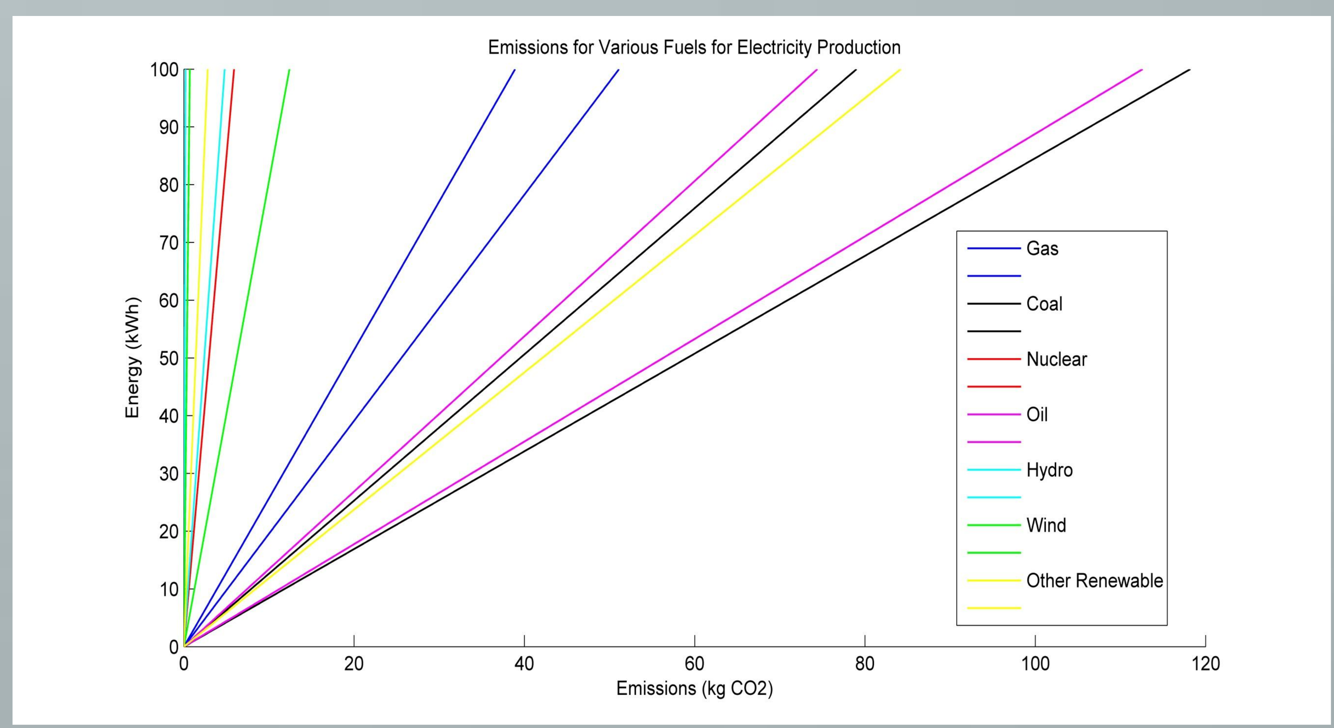
Comparative Ratios for Sustainability Aspects

Column1	Energy	Water Eutrophication	Carbon Weight	Air Acidification
Vinyl	1	1	1	1
Natural Rubber	0.310076201	14.41947136	1.00998846	8.584084893
Synthetic Rubber	1.434101934	1.156368455	1.206991922	0.76365512
Electric Eraser	6.401157187	11.71033771	10.15229386	23.39722536

Chart showing ratio of product to vinyl eraser

•Electric Eraser had higher Carbon Weight, Energy and Air Acidification values that all other products

•Natural Rubber had worst water eutrophication values, 19% greater than the electric eraser



•Different sustainability aspect values change depending on fuel sources for energy production. Designers may choose what fuels are used for different life cycle stages, altering the sustainability of a given product.

Conclusions

•This project provided a comparative geometry for four different eraser products, but future work could greatly improve the concept. Largest limitation of this idea was ultimately using data from one source (PE International's database) since values for life-cycle aspects can greatly vary depending on what assumptions and errors are involved.

•Attempted methods included comparing different aggregate sustainability values, such as Eco-Indicator 95 and 99, but they were not independent from other aspects of sustainability.

Future Work

•Examining only environmental factors of sustainability is too limited – often the more modern product will be the least environmentally sustainable. Including other bottom lines of sustainability (economic and societal) would provide a more comprehensive metric.

•Uncertainties are not evident in the geometric metric, but certainly should be. There are vastly differing values just for carbon emission based on fuel type, so values are difficult to claim as accurate.

•Changing the normalizing factor to how much each erasers degrade for a standard amount of erasing would ensure a fairer comparison between products for this project.

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