Plastic Pyrolysis and Waste-to-Energy Potential at The Island School

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Introduction

One million seabirds and 100,000 marine mammals are killed annually from plastic in the ocean (Live Science, 2012). What if plastic waste didn't have to impact the world in this way? Through the more eco-friendly alternative of plastic pyrolysis these effects can be voided and usable fuel is the major byproduct. Here at the Island School, currently there are 4.5 tons of plastic on campus and that number is only growing. Plastic waste has three major options of disposal, landfilling, recycling, and energy recovery from plastic pyrolysis. At the Island School, the first option requires shipping, which is costly and produces harmful emissions. Then after it is transported it's burned in order to reduce volume, which releases carcinogenic fumes and unburnt particles in the air. The second option, recycling, also requires shipping which carries with it all the aforementioned downfalls. In addition, recycling only stalls plastic waste moving into landfills, as it can't be recycled indefinitely. Plastic pyrolysis doesn't require shipping, removes our plastic waste, and produces a usable fuel. Through plastic pyrolysis all of this potential will be harnessed in addition to bringing us closer to becoming a campus with no waste.

Questions

- Is pyrolysis feasible? Is pyrolysis even possible and if it is possible how is going to be feasible to the Island School?
- What are the products of plastic pyrolysis? Can useful oil be created?
- How much plastic waste does the Island School generate? Is it going to be good for the Island School to have a pyrolysis machine on campus?
- What is the waste-to-energy potential for plastic waste at the Island School? Can all of the waste plastic be converted into fuel oil and put in a van that runs on diesel?

Methods

Pyrolysis is thermal decomposition at a high temperature and low oxygen environment. Due to the lack of oxygen in this process, pyrolysis is not the same as burning. Pyrolysis in this case takes the long hydrocarbon chains of plastic and cracks them into much shorter chains in the form of liquids and gases. The process of pyrolysis begins in the air-tight reaction vessel, where the plastic is heated at a temperature of at least 500ºC. 100 gram samples of plastic are tested in each experiment. This high heat and lack of oxygen breaks the bonds of the long hydrocarbon chains, converting the plastic into a gaseous state, which is then fed through copper piping and condensed into a liquid form in a glass of water. All non-condensable gases are released through bubbles in the collection vessel. The condensed product is collected on the surface of the water in the form of fuel. This entire process takes about 45 minutes to complete. Once pyrolysis is complete, the oil is separated from the water and the collected product is measured. The flammability of the collected oil is also tested to determine whether or not it is a fuel product.

Photo 1
Team members with reaction vessel and pyrolyzed oil.

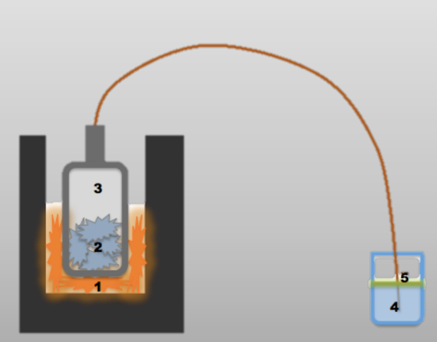

Figure 3
Reaction Vessel Diagram

Results

The average calorific value, a measure of energy content in a fuel, of diesel and fuel derived from waste plastic #2 is given in Table 1. Pyrolyzed waste plastic #2 has the potential to be a substitute for diesel because of the similar energy content of the fuels; waste plastic #2 has only eight percent less energy than diesel.
Plastics type #1, 2, 4, 5 and 6 were pyrolyzed in this study. The volume of pyrolyzed plastic produced is shown in Table 2. Currently there is no data collected for plastics #1 due to the potential oil clogging the piping.
Figure 1 shows the average fuel produced by pyrolyzing each type of plastic. Plastics #5 and #6 appear to have a larger product collection due to these plastics being pyrolyzed later on in the study and modifications being done to the pyrolizer; this is why plastics #2 and #4 have lower product collection. By running three more tests with plastic #2, the average fuel production of plastic #2 is projected to match the average fuel production of plastics #5 and #6.
Figure 2 shows the waste in weight that Island School produces annually by plastic type. Plastics #1 and #2 each account for about one-third of the annually weight, while plastics #6, #5, and #4 account for the other third of the annually weight.

Fuel	Average Calorific Value (MJ/L)
Diesel	36.73 (Khan, 2016)
Pyrolyzed #2 Plastic Oil	33.89 (Gao, 2010)

Table 1
Efficiency of Pyrolyzed #2 Plastic Oil is 92.2%.

Plastic Number	Product Volume (mL)
1	0
1	0
1	0
2	40
2	47
2	85
4	50
4	50
4	70
5	77
5	70
5	70
6	65
6	72
6	75

Table 2
Fuel Oil Production from Plastic Pyrolysis

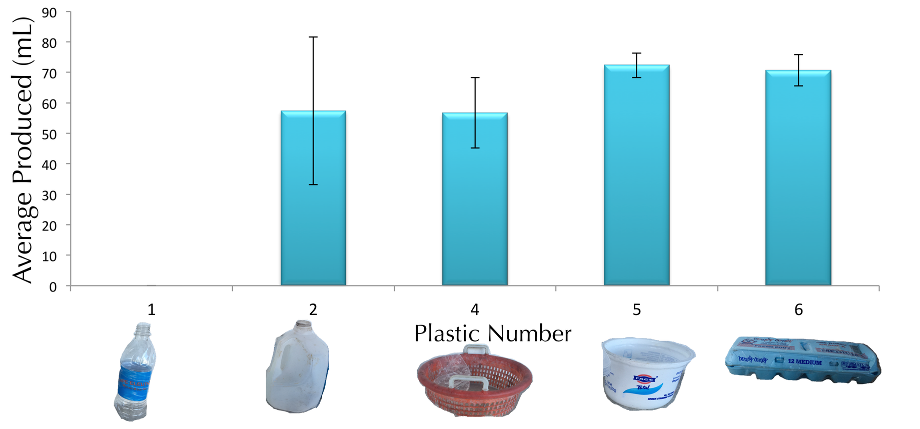

Figure 1
Plastic feedstock type compared to average fuel production.

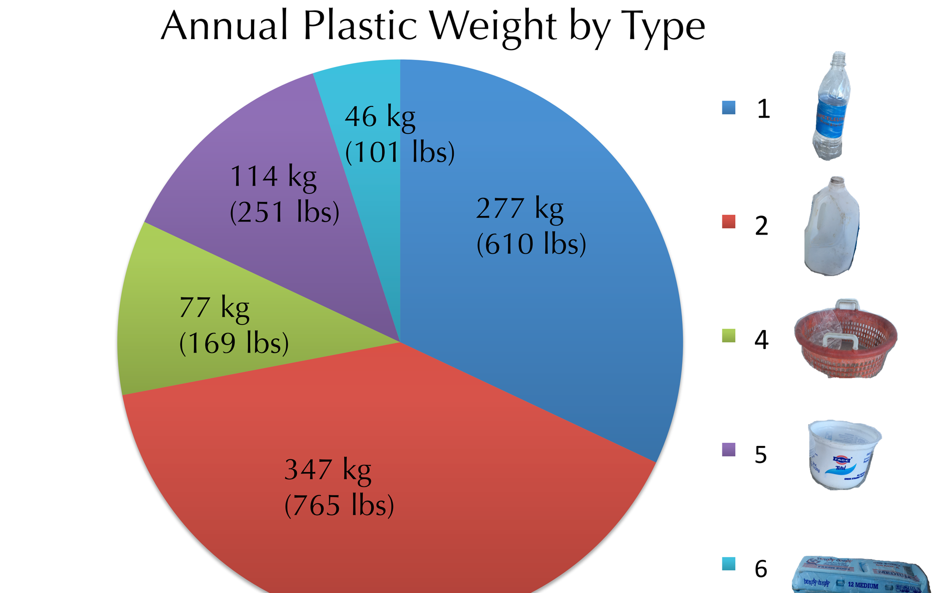

Figure 2
Annual percentages and weights of each type of plastic.

Discussion

Now how can the fuel created in pyrolysis be used? One opportunity for use is to put it in Island School vans. The average van on campus drives around 19,000 miles per year. On pyrolyzed oil alone, that van could drive more than 11,000 miles. That would offset 60% of the fuel used in that van each year.
Another opportunity for use is in energy. On an average November day, around 380 kWh of energy is consumed on campus. Along with that 75 kWh of wind and solar energy is produced. With pyrolysis, 20 kWh could possibly be produced. This would increase renewable energy production each day by 25%.
In the future, the product will be tested to learn more about the makeup and usability. Along with that the financial aspects of a full-scale pyrolyzer will be assessed. Then a full-scale pyrolyzer will be created making The Island School one step closer to a zero waste campus. This would divert plastic from its inevitable journey to a landfill. Through all of this The Island School would become a model to other communities facing similar problems.

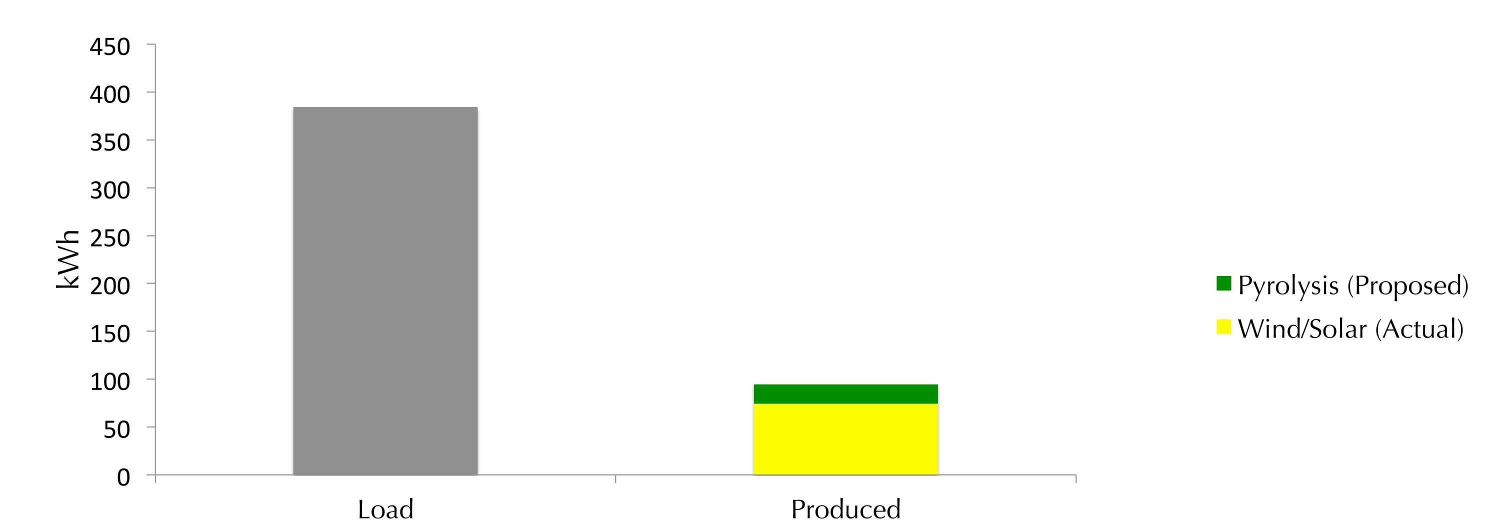

Figure 4
Renewable energy production with pyrolysis compared to consumption.

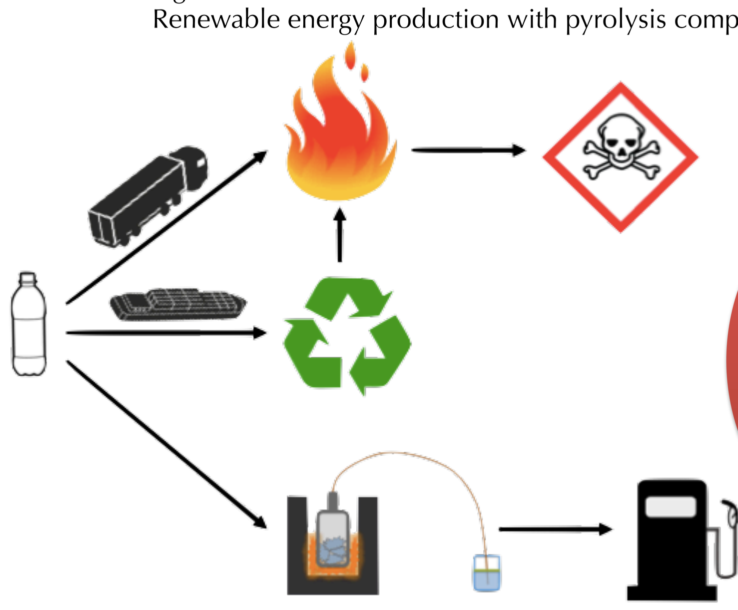

Figure 5
Life-Cycle of plastic

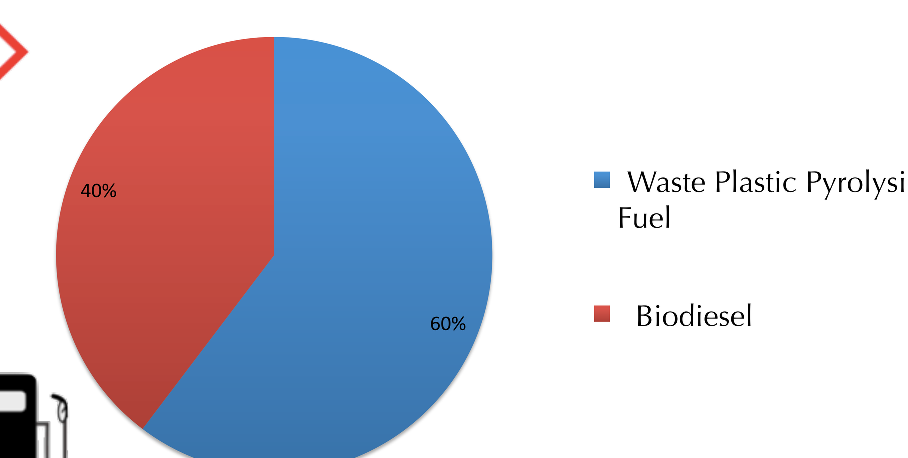

Figure 6
One vans projected fuel offset per year.

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