FEASIBILITY STUDY

ROOIKAT RECYCLING PLASTIC TREATMENT FACILITY

Plastic processing in the Garden Route is limited and the local landfill sites are becoming overfilled. There is an opportunity to process domestic discarded plastic, which is 80%+ plastic, to produce fuels that can be widely used. In addition, tyres can also be processed to produce fuels.

Rooikat Recycling Plastic treatment facility

1. Introduction

Plastic has formed such a massive part of our everyday life and it is hard to evade. The Garden Route is developing at a rapid pace and with the increased number of households being established, there is also an increase in the amount of discarded plastic.

Plastic separation and recycling projects have been successful in the Eden district to some extent, but only a small fraction of the plastic collected is actually reprocessed into other plastic goods – the majority still ends up in landfill sites. This is because the recycling of plastics is not as easy as melting everything together and making useful items. Not all plastics are created equal and the contaminants in plastics make the processing of it challenging.

Although used tyres are being collected for intended recycling, most of the tyres are simply stored in bulk. These cannot be landfilled and there is a need to find alternative uses and means of processing/recycling of these tyres.

Currently, most of the refuse generated in the Garden Route is transported to the Mossel Bay landfill site. Landfill sites are fast becoming overfilled with the large amount of refuse generated by households and businesses and it is believed by Rooikat Recycling (RR) that there has to be a more efficient way to treat this.

The aim of this feasibility study is to evaluate the available technologies for waste processing and to identify a viable processing method for the Garden Route.

2. Solution requirement/Scope

2.1 Plastic problem – the proof is in the numbers

In 2015 the Eden Municipality (Mossel Bay) started a waste characterization study of the area to add to the Mossel Bay Municipality's Integrated waste Management Plan (Eden Distric Municipality, 2016).

This comprehensive study indicated that 42% (mass) of the waste sampled from black bags were recyclable. In total 16% (mass) were plastics. On a volume basis a staggering 39% of the contents sampled were plastics (Eden Distric Municipality, 2016).

This indicated that although there are recycling initiatives in the area, a large fraction of the plastic still ends up in the landfill sites. This is problematic since the plastic takes many years to decompose and it poses a risk to the environment.

The study indicated that the recyclable portion of the total waste landfilled on a monthly basis is an astounding 986 tons and 6420m^3. Of that, 157 ton is plastic. This equates to 2504m^3 of plastic to landfill per month.

2.2 Capacity required

Based on the study done (Eden Distric Municipality, 2016), it is thus required to process 10 to 20 tons of plastic per day to effectively reduce the amount of plastic to the environment.

3. Background and processing options

As stated earlier, the recycling of plastic is not as simple as merely melting everything together and manufacturing plastic goods. The products typically produced are specialized, expensive and difficult to place. To better understand the possibilities of plastic, it is good to have an understanding of where exactly most plastics come from.

3.1 Where does plastic come from?

A plastic bottle started its life as crude oil or if you live in South Africa, most likely as coal. Coal and oil are the pinnacle of carbon sequestration because they sit deep underground, and have been there for thousands of years. People then found ways to use it and started harvesting it out of the ground.

Let us use crude oil as the example, because it has wider application. To get our hands on oil we first need to explore for oil, then we need to drill for it and then we need to build facilities with which to extract and store oil. We will often flare large amounts of gas just to get our hands on the oil. All these activities produce large carbon footprints.

Once we have the oil, we generally need to transport it to a crude refinery and then refine the oil. The refined product is then transported to a factory, and further processed to produce plastic (typically in the form of granules). The plastic in raw form is transported to the next facility and then further processed into a final product i.e. the plastic bottle we are talking about.

As you can see in the Figure below, it is quite a myriad of steps.

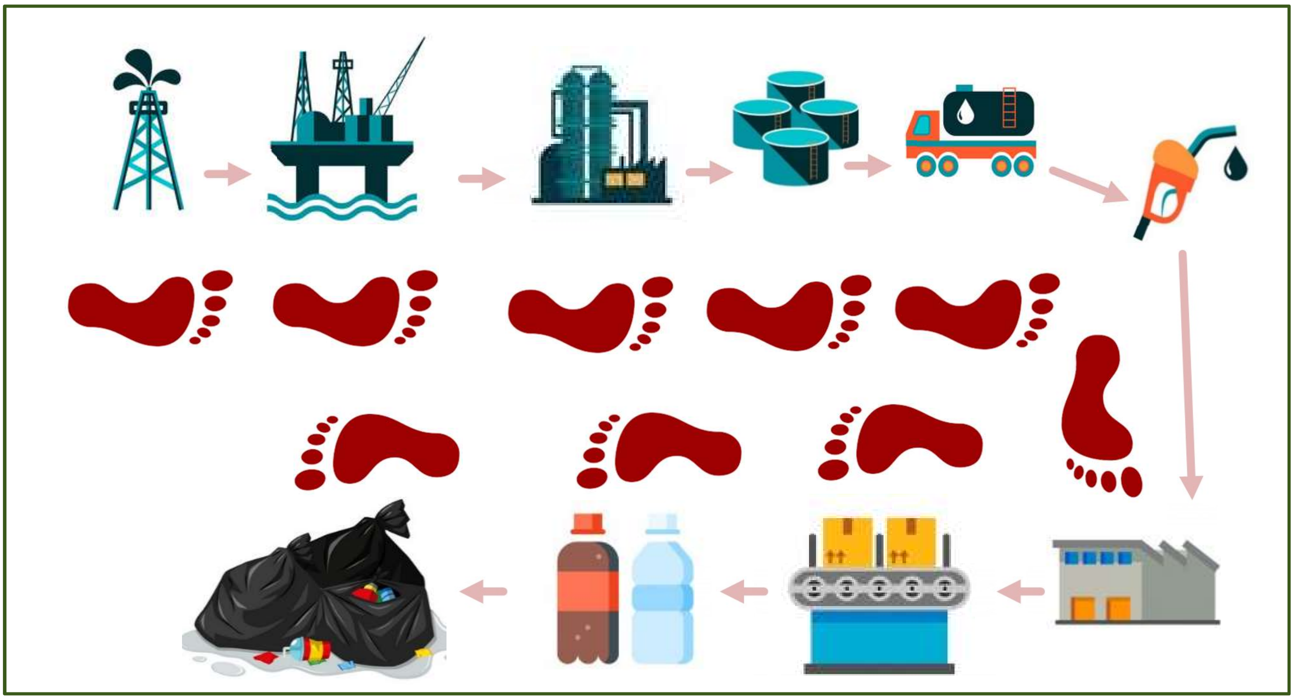


Figure 1: The Footprints in the journey of a plastic bottle

Once we enjoy the contents of the bottle, our experience with the bottle ends and we typically discard the bottle as waste. That is however still not the end of the bottle's journey. Unfortunately, the bottle is a going to be around a lot longer than you or me, and so it will leave footprints long after we have left this life.

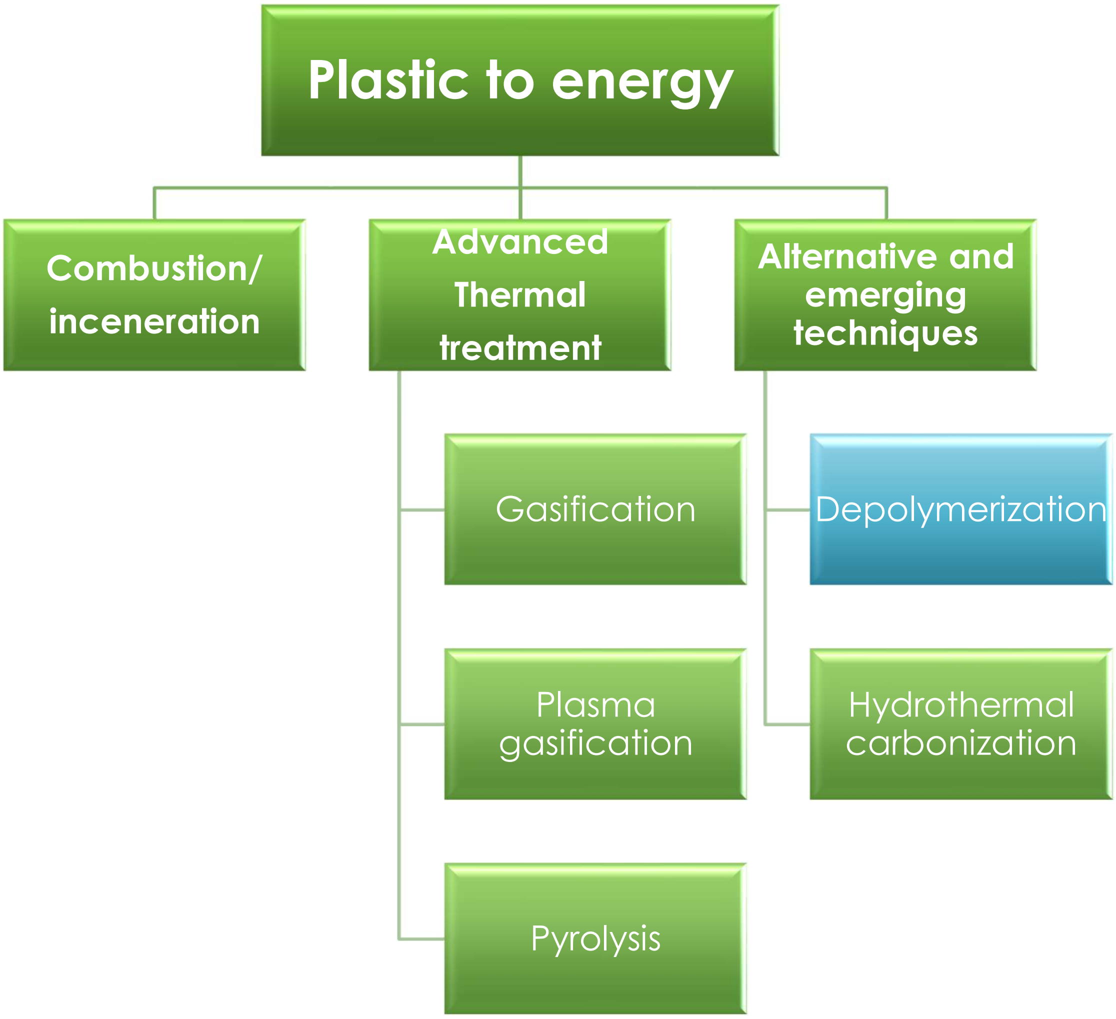
Plastic essentially is a by-product of the oil /fuel industry. There is thus still a lot of potential/energy in used plastic. Plastic consists of long polymer chains that used to be monomers.

Plastic can thus be seen as fuel in a solid form. It is <u>not a waste</u> it is a feedstock that is currently being discarded and not used to its full potential. We went through all the effort to extract the oil from deep from the ground, leaving large carbon footprints along its way, it would be inefficient to send a portion of the fossil fuel (now plastic) back to the ground. There is thus a great opportunity if one could extract the last bit of available energy from the plastic.

The energy from the plastic can be extracted in different forms. It can either be used to generate heat and electricity or it can be converted into different types of fuels.

3.2 Plastic to Energy processing options

Plastic can be used as a feedstock in many different processes to ultimately produce energy:



3.2.1 **Combustion/Incineration** is where the plastic is reacted in excess oxygen to produce heat that in turn can be used for electricity generation. The combustion process can handle a large variety of different feedstock and ratio's, but it requires sophisticated and expensive gas cleaning, monitoring and control to ensure the emissions are within the governmental specifications.

3.2.2 **The advanced thermal treatment (ATT)** of plastic is a range of processes that includes gasification, plasma gasification and pyrolysis.

- **Gasification** is used under stringent process conditions (specific reaction temperature & pressure, steam and oxygen feed rate) to produce syngas and carbon black from plastic. Syngas is formed during the total decomposition of the feed into carbon monoxide, carbon dioxide, hydrogen, water and methane. Due to the nature of the process tars are also formed which needs to be removed from the syngas as a waste stream. The produced syngas then needs to be processed in multiple steps to finally produce fuels. This is capital intensive, fastidious and complex process which is sensitive to the feedstock and feedstock composition.

- **Plasma gasification** is the decomposition of plastic into gasses and carbon black in an oxygen deprived environment using electricity as a power source. This technology uses electrons, ions and excited molecules together with the high energy radiation to decompose chemicals.
- **Pyrolysis** is a generic term, used to describe thermal degradation in the absence of oxygen. The absence of oxygen means that combustion does not occur and that the feed is devolatilized and decomposed to produce gas, liquid and carbon black. The produced gas is used typically used for internal heating and the liquid and carbon black can be sold as fuels.

3.2.3 **Alternative and emerging techniques** are new and developing methods used to convert plastic to fuels. This for example includes the thermal depolymerization and hydrothermal carbonization among other methods.

- **Thermal depolymerization** is the breakdown of polymers into smaller molecules. Thermal depolymerization processes may utilize steam, catalyst, high temperatures and elevated pressures to achieve the objective. Depending on the application, depolymerization can break down molecules into the monomers (smallest polymer building blocks). In the proposed application the size of the final molecule is controlled to yield molecules within the diesel and fuel oil boiling point ranges.
- **Hydrothermal carbonization** replicates the production of coal by converting material into hydro char under high pressures and temperatures.

4. Technology selection

As highlighted in the previous section, various means exist to produce fuel from waste. The key to a successful facility is to select technology that is:

- Robust
- Easy to control
- Safe
- Treat varying feed compositions and material (varying types of plastic and tyres in varying ratios)
- Environmentally sustainable
- Low emissions
- Simple engineering
- Easy to maintain
- Reproducible
- Implementable at local municipality level
- Once commissioned , personnel can be easily trained to control the process
- Produce useable products
- Economical

None of the technologies fully covers all the listed considerations. Incineration is not environmentally beneficial due to the associated emissions and inefficiencies. Gasification is too expensive and sensitive to feed variations and requires several more processing steps to yield fuels. Plasma pyrolysis is highly specialized and hydrothermal carbonization is relatively new and requires operation at high pressures. Pyrolysis produces a wide range of molecules which require refining before being sold as products. As a result, these technologies were not selected as the "best" technology.

Rooikat Recycling are developing a robust, fit for purpose thermal depolymerisation technology consisting of depolymerization and separation sections. This technology will allow the treatment of domestic plastic at a large scale to produce a basket of fuels that can be successfully placed in the existing market.

To demonstrate the technology, it is required to construct a pilot plant to demonstrate and refine the technology. A test/pilot facility that can process 10 to 20 tons a day of either plastic or tyres, or both, is required. The data collected during the operation will be used to develop and optimization the technology to process discarded rubber and plastic.

5. Location evaluation

Based on communications with the Mossel Bay Municipality, the ideal location for the plant is an Industrial Zone 3 classified area. The only Industrial Zone 3 area in the greater Mossel Bay area is proposed area in Groot Brak.

An Industrial Zone 2 area was considered as an alternative location, at Mossdustria. The Mossel Bay Municipality indicated that the alternative location may be challenged with respect to air emissions on the basis of complaints in the areas. It was further advised that an application for rezoning has to be lodged for reclassification to a Zone 3. It is unclear if such an application would be successful.

6. Supply and Offtake demand evaluation

Based on the waste classification study cited (Eden Distric Municipality, 2016), there is a steady supply of plastic in the Garden Route area. The "In Principle" supply agreement with a waste collector can be found attached to prove availability of sorted plastic feed. As part of the testing it is planned to supplement the feed with recycled tyres.

Many fuel-consuming industries are based in the Eden district. These include brick factories, a fishmeal factory, a petrochemical factory, and food and beverage factories that all use heavy fuel oil (HFO) and/or coal.

An "In Principle" agreement is currently in progress with a large food and beverage manufacturer to ensure offtake of the produced fuels.

7. Local Employment

A plant to convert plastic to fuel will serve as a catalyst for waste segregation in the area as it will provide an outlet for plastic waste, which is currently not available. Waste segregation will employ between 15 to 30 persons in temporary and permanent positions. The pilot plant will employ between 10 and 20 persons in permanent positions. Additional persons will be employed during construction and in support services. In total at least 35 new permanent jobs will be created during the pilot plant phase. Significantly more job opportunities will be created on completion of the pilot plant phase should the commercial plant be commissioned.

8. Business Plan

The business plan is based on a cost saving to the municipality compared to landfilling. It is hoped that saving to the municipality and/or waste collectors will be passed down to residents in the form of lower levies for refuse collection and disposal. On this basis and the "in principle" supply and offtake agreements, the business plan for the pilot facility is robust and sound.

9. Environmental Footprint

All efforts have been made to reduce the environmental footprint of the facility in the design. The following considerations have been made:

- Feedstock storage will be minimized at the processing site. Feedstock will be stored at the existing licensed collection and segregation sites.
- Waste water recycling. All waste water produced will be recycled as cooling water.
- Air emissions abatement devices. A water scrubber is included in the design to purify flue gas from the combustion process. The device will remove impurities e.g. particulates from the stack.
- Bunded areas. The pilot plant is designed to contain all runoff from potentially oil contaminated areas e.g. concreted plant areas. Runoff will be collected and separated from oil in an oil separator. Oil and water will be recycled.

10. Conclusions

The necessity to process discarded plastic is becoming more and more evident as the impact on the environment is becoming clearer. In the Garden Route, there is an urgent need to reduce the plastic to the landfill sites, as they are already overfull. The increased growth in the economic and permanent residency population in the area is escalating the need to find an alternative solution to expensive landfilling soon.

There is a need to process 10 to 20 tons of discarded plastic (different types) in the Mossel Bay Municipality based on the surveys done by the Mossel Bay Municipality. There is an additional requirement to discard recycled tyres in an environmentally sustainable manner.

Plastic can be converted into different fuels. There are several technologies available to do so. These technologies are limited in their application as they are:

expensive, complicated, sensitive to impurities and produce products which cannot be placed in the local market.

Rooikat recycling will develop and optimize a depolymerization plastic processing process. The process must be economical, simple and robust. A pilot plant facility is to be erected in a municipal Zone 3 classified area.

In short, there is need and a means to address plastic processing in the Garden Route and Rooikat Recycling is best placed to implement this initiative.