

# Plastic to Petrol Pyrolysis in Nepal: Technology, Environmental Impact, and Future Scope

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**Course:** Research and Study Skills

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**Submission Date:** 7 January 2026

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## Abstract

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Plastic waste is a large problem in Nepal. In many cities in Nepal, increasing amounts of plastic waste are created daily, but there are very limited systems for managing this plastic. Much of the plastic ends up being burned in open air or dumped into nearby rivers, which creates air pollution and negative health impacts for people. Additionally, several countries sell petrol to Nepal, and a large amount of the fuel that is sold to Nepal has a very high price.

The large amount of plastic waste that is generated in Nepal presents an opportunity for the development of a new technology called pyrolysis, which is capable of turning plastic waste into a petrochemical-like product. Pyrolysis works by heating plastic waste in an oxygen-free environment, which causes the plastic to melt down. The end product is a usable fuel that can be used in a generator or a vehicle. This presented an opportunity for me to investigate whether this type of technology has a good chance of working in Nepal.

The information that I used to do my research came from books, reports, and other studies about how the technology works and where things could go wrong. Pyrolysis has the potential to aid in eliminating waste and generating fuel; however, there are several very serious problems with the technology. First, the cost of a machine capable of pyrolysis is enormous. Secondly, the process must be controlled very carefully so that pollution is not generated.

Although pyrolysis could work for Nepal, there will first have to be a lot of planning before the technology can be implemented in the country. For example, it may be possible to build small pyrolysis plants within cities that would convert plastic waste to fuel. This could potentially solve Nepal's waste issues while providing a locally produced source of fuel; however, the implementation of this plan will require a significant government investment and the establishment of regulations governing pyrolysis plants in Nepal. In order to fully realize the benefits of this technology, it will require additional study.

**Keywords:** Plastic waste, Pyrolysis, Fuel from waste, Nepal, Environment, Energy

# 1. Introduction

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Globally, plastic waste has become a significant issue, but it is increasingly on the rise in Nepal with cities such as Kathmandu and Pokhara adding large quantities of plastic waste each year. The prevalence and use of plastic bags, bottles, and other forms of packaging is very common in everyday life, and upon completion of their intended use, the plastic has nowhere to go other than into waterways where it will pollute the surrounding environment or in open-air burning.[1].

Nepal is home to some of the world's most stunning mountain and river landscapes. Unfortunately, plastic waste has wreaked havoc on some of these areas. Plastic is consumed by animals and creates health issues. Water sources are also tainted with plastic contamination. Upon combustion, plastic generates harmful smoke that can create breathing issues for humans. [2].

At the same time, Nepal relies heavily on imported fuels (gasoline and diesel) and spends a lot of foreign currency to do so. The country often faces periods where there are shortages of certain types of fuel; this creates issues with transportation services as well as electricity supply.[3].

Pyrolysis is a technology that can assist in addressing both the plastic waste and the fuel dependency problem. Pyrolysis works by converting plastic waste back into usable sources of energy (gasoline) utilizing heat to break down plastic into basic molecular elements, creating a liquid fuel similar to gasoline. [4].

## 1.1. Problem Statement

Nepal is not managing its solid waste very well. The plastic portion of Nepal's solid waste has caused destruction to the environment. The importation of fuels is draining Nepal's financial resources. There is a need for a solution that combines addressing both of these problems.

## 1.2. Research Aim and Objectives

**Aim:**To investigate the possibility of using the pyrolysis process to transform Nepal's plastic waste into fuels, thereby providing a means for managing the plastic waste while at the same time providing a source of fuels.

### Objectives:

- To gain an understanding of pyrolysis technology and how it functions;
- To study the current condition of the plastic waste in Nepal;
- To examine the potential environmental impacts associated with pyrolysis;
- To investigate the economic viability of utilizing pyrolysis technology in Nepal;
- To recommend possible implementation strategies for utilizing pyrolysis in Nepal;

## 1.3. Research Questions

- Does Pyrolysis assist Nepal in recovering plastic waste?
- What will be the potential benefits and risks to the environment?
- Is Pyrolysis feasible financially within the country of Nepal?

- What must be implemented for Pyrolysis to have success in Nepal?

## 2. Literature Review

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The scientific literature has reflected considerable interest in methods of managing plastic waste. Various countries have employed various methods of managing their plastic waste. While all countries seem to consider recycling as the best solution for managing plastic waste, however, it is evident that not all types of plastic can be recycled. A main concern with many low-income countries is their very low rate of recycling.[5].

### 2.1. Plastic Waste in Nepal

Research indicates that the current condition of the waste collection system in Nepal is not very good; in the cities of Nepal, an estimated 50% of solid waste generated is collected, while all other waste is disposed of indiscriminately. While some informal workers do collect some plastic materials for recycling, the majority of low-value plastic, such as plastic bags, continue to be disposed of indiscriminately.[6].

### 2.2. Pyrolysis Technology

Pyrolysis technology does not come to us recently, but it has been in use for a long time. Different plastics produce different results. Polypropylene and polyethylene have produced good fuel yield, whereas they are also used widely throughout Nepal in bagging and packaging processes[7].

The temperature should be controlled carefully to allow for maximum fuel yield to occur. The optimum range of temperature is between 350 degrees Celsius to 500 degrees Celsius. The quantity of liquid fuel produced is around 70 to 80% of the output, however, gases and solid char can be produced as well [8].

### 2.3. Environmental Aspects

Some studies support that pyrolysis technology is beneficial to the environment, provides fuel for other forms of energy that are non-renewable landfill waste, however, some studies also report the environmental hazards associated with this process. The potential for releasing harmful gases occurs when the process is uncontrolled [9].

The residual char and its components are believed to contain toxic substances, which must be disposed of in a safe manner. Ultimately, the benefits to the environment from pyrolysis technology depend on the control and management of the process [10].

### 2.4. Economic Studies

Pyrolysis Plants are capital-intensive investments, the cost of a small pyrolysis plant is estimated to be approximately \$200,000 with continuous costs of operation, including energy and maintenance. Investments will be recovered through the sale of generated fuel products and receipt of waste management fees[11].

Several Pilot Projects on pyrolysis technology throughout developing nations have reported high rates of failure due to the high costs involved and technical issues associated with the development and operation of pyrolysis facilities, along with lack of support from government entities [12].

### 3. Research Methodology

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In this research, secondary data was used to gather information about pyrolysis technology via other people's studies; no experiments were performed. The information was collected from various sources.

#### ***3.1. Data Sources***

- Academic journals pertaining to pyrolysis technology
- Reports published by the Nepali government regarding waste
- Research done by non-governmental organisations in Nepal
- Nepali government reports relating to energy
- Examples of similar situations in other countries

#### ***3.2. Analysis Method***

After collecting all of this information, I reviewed the materials. I categorised all of the information according to the categories of information that I had established. I then compared the results and documentation from each source to determine what they had in common, and whether any differences existed between them. Following the same procedure, I reached my conclusions regarding the validity or strength of the evidence from each source.

#### ***3.3. Limitations***

The technique I have used has limitations. I was unable to conduct a field study in Nepal. Because I did not collect any original data from the field, I relied only on economic data estimated or projected. Therefore, the actual economic situation in Nepal may differ significantly from the economic data presented in the sections below.

## 4. Results and Findings

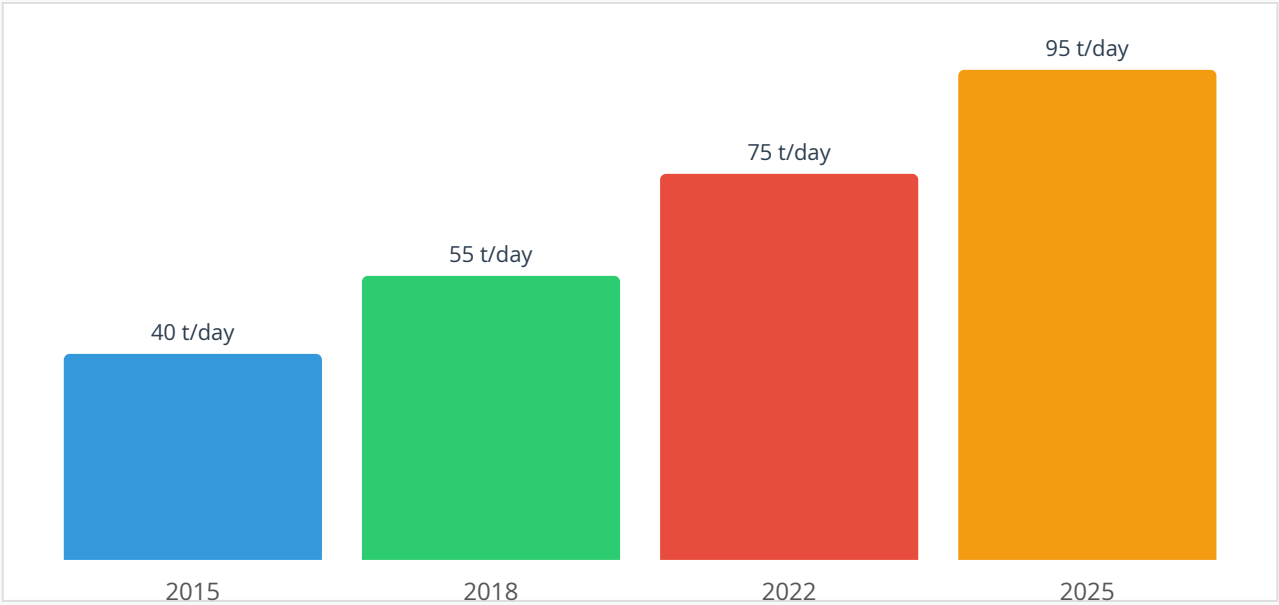
### 4.1. Plastic Waste Types in Nepal

There are five types of Plastics in Nepal that are suitable for pyrolysis. The first two types are the most common and suitable for pyrolysis; however, other types of plastics are good for pyrolysis.

| Plastic Type  | Common Use in Nepal        | Good for Pyrolysis? | Fuel Yield      |
|---------------|----------------------------|---------------------|-----------------|
| PET (Bottles) | Water, drink bottles       | Not good            | Low (20-30%)    |
| HDPE          | Shampoo bottles, pipes     | Good                | High (75-85%)   |
| LDPE (Bags)   | Shopping bags, wrappers    | Very good           | High (70-80%)   |
| PP            | Food containers, caps      | Good                | High (80-85%)   |
| Mixed Plastic | Chip packets, noodles pack | Okay                | Medium (60-70%) |

Based on data from references [6], [8], [17]

Figure 1: Plastic Waste Growth in Kathmandu Valley (Tonnes per Day)



Source: Nepal Ministry of Urban Development, 2023

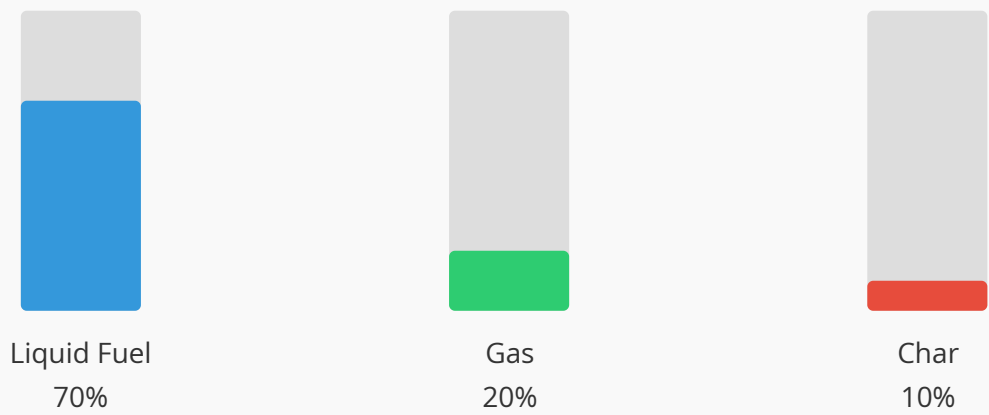
### 4.2. Pyrolysis Outputs

From 1 tonne of plastic waste:

- 650-750 litres of liquid fuel (like diesel)
- 100-200 kg of gas (can run the plant)

- 50-150 kg of solid char (needs disposal)

Figure 2: Output from 1 Tonne of Plastic Waste



Based on laboratory studies [7], [8]

4.3. Economic Analysis

| Cost Item              | Estimate (USD)        | Notes                      |
|------------------------|-----------------------|----------------------------|
| Small plant setup      | \$150,000 - \$300,000 | For 5 tonnes/day capacity  |
| Monthly operating cost | \$8,000 - \$12,000    | Energy, labor, maintenance |
| Fuel production value  | \$15,000 - \$20,000   | From 150 tonnes monthly    |
| Break-even time        | 4-6 years             | If all goes well           |

## 5. Discussion

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Pyrolysis could work in Nepal, but like everything else there is a catch; Pyrolysis does fit with the Plastics waste in Nepal because there is a large amount of Low-Density Polyethylene plastic bags and other packaging types, which give a good fuel yield for Pyrolysis, but there are issues that have to be addressed first.

The first issue will be cleaning the waste before it can go through pyrolysis, as there is a great deal of food and organic waste, thus mixed with the plastic, and sorting facilities would be needed which will add a large cost.

The second issue will be the large capital expense of pyrolysis in Nepal: \$200,000 is a lot of money in Nepal, and banks will likely not provide funding for such a new technology as pyrolysis, but assistance from either the government or donors would assist fulfillment.

When considering environmental impacts, pyrolysis is superior to open burning of waste; however, as with other forms of combustion, emission controls are critical for proper emissions and potential harm to the environment; the absence of emission control would potentially create an area of new pollution.

The economic aspects related to fueling continue to be somewhat unclear, as well as uncertainty of waste supply and fluctuating fuel price; these uncertainties create hesitation for investors.

Considering waste management, all of the above factors will place pyrolysis in a middle ground between recycling and landfilling; recycling is the best, but has limited amounts of material that can be recycled, landfilling is inexpensive, but detrimental to the environment, while pyrolysis affords a balance between these two extremes.

## 6. Limitations of Study

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Several limitations exist in this study's findings.

- Collection of new data was not included, as this research made use of existing data.
- Field observations could not be made by the author in Nepal.
- The economic figures provided are estimates, not actual data. For example, current costs of the technology are unknown as costs change rapidly.
- There were no interviews conducted with stakeholders in Nepal.
- We assumed that waste collection would take place without any issues.
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Based on these limitations, the conclusions made were to be taken as indicative—more investigation would be necessary in order to implement this type of technology.

## 7. Conclusion

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Pyrolysis technology (plastic to petrol) may be the best potential way to solve the problems with waste management and energy shortages in Nepal. This technology is well-established in other countries.

Successful implementation of the pyrolysis system in Nepal depends on many factors, such as the need for adequate waste collection and separation prior to running the pyrolysis process, the installation of emission control equipment, considerable governmental support, and others.

It is likely that starting with small-scale pyrolysis plants located in the three largest cities of Nepal (Kathmandu, Pokhara, and Biratnagar) may be a good way to test this technology in Nepal before considering wider implementation around the country. There is a sufficient amount of waste being generated in Kathmandu, Pokhara, and Biratnagar, and these locations would be the ideal sites to implement pilot projects.

Lastly, while it may be legitimate to say that the pyrolysis process will not provide a 'magic bullet' to resolve the issues of plastic waste in Nepal and provide a solution to the country's energy crisis, the process does have associated costs and risks. Therefore, it will need significant planning and support in order for it to be part of the overall solution to the plastic (waste) issues being faced and to provide for a local fuel source as well.

## 8. Suggestions

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### ***8.1. Government of Nepal***

- Create legislation for WTE projects.
- Provide tax breaks for pyrolytic facilities.
- Establish emission standards for environmental protection.
- Assist with financing of demonstration projects.

### ***8.2. For Implementation***

- Implement a small scale WTE facility (2 - 5 tonnes of waste per day).
- Collaborate with local haulers to collect waste material for pyrolysis.
- Install adequate controls for environmental protection.
- Train technicians in local communities.

### ***8.3. For Future Research***

- Explore the actual composition of solid waste in various cities to better understand the differences in material.
- Conduct laboratory analysis of Nepali plastic mixture to develop a more accurate pyrolytic process.
- Survey local communities to gauge their attitudes regarding proposed WTE facilities.
- Continue to explore ways to integrate the informal waste sector into the formal economy.

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