Feasibility study of Plastic to Diesel factory at Dhaka in Bangladesh

DEGREE THESIS	
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Degree Programme:	Plastics Technology
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Title:	Feasibility study of Plastic to Diesel factory at Dhaka in Bangladesh.
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Abstract:

Waste plastics can be recycled in many ways. Usually waste plastics recycled to produce new plastic products or resins. It can be recycled to clean distilled fuels. But waste plastic to fuel conversion technology is not familiar to everyone. Recently Company X, Inc. has developed such a technology that can use mixed, unwashed waste plastic and converts it into ultrafine diesel with more efficiency than any other companies.

Waste plastic gradually become a leading problem in Dhaka Metropolitan City Bangladesh. As the city has huge population so it is really difficult to control its numerous uses of plastics and its wastes. Again, Bangladesh has importing huge volume of diesel for the country and paying the highest subsidy for providing diesel to public.

A factory in Dhaka, with a distillation machine and conversion technique from Company X Inc. can convert waste plastics and produces diesel and can be very profitable with the fantastic rate of ROI.

Number of pages:	48
Language:	English
Date of acceptance:	5.11.12

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Objective:

The objectives of the study are:

- Define waste plastics to diesel conversion technology
- Define a small factory
- Use waste plastics as raw material for the factory
- Calculate all the possible expense for the factory
- Calculate ROI of the factory

Methodology:

Qualitative method has followed to analyze this project work. Qualitative research is one kind of scientific research. Data has collected in particular observation, in-depth interview, online information, email communication and so on. This project work has started during July 2012 in Bangladesh. Some field works and companies visit has made during that time to acquired information and experience.

Data collection:

Most of the data related to solid waste and plastic waste has collected from site visits, field works, and several survey reports of Waste Concern Bangladesh and Dhaka City Corporation reports and so on. Some recent data has collected from daily newspaper and journals from Bangladesh also.

The whole project is based on Company X Inc. technology and distillation machine. Information related to machinery, machine´s efficiency, and diesel quality has acquired through email communication with John X, the founder of the company and some other sources of the company.

Interviews over phone have made to collect some unpublicized issues related to business possibility in Dhaka, dealer´s interest, raw material supply, civil work, electricity and some other connections and so on.

Data analysis:

Data analyze based on self-projection and some formulas related to calculation. Civil work and insurance policy has done by the professional but other thing such as layout of the company, production planning, management and so on are established on self-assumption and experience. Mr. Henry Ericson´s lecture has followed to calculate income statement and RIO.

1.0 Plastics to Oil conversion technology:

1.1 Overview of plastic:

Plastic has changed our everyday life. We are involved with plastic or plastic made products in various ways. Plastic plays an important part in our life from morning alarm clock to dinner food table, from coffee cup to desktop PC, from the car you drive to phone you use to talk, from bus to airplane and so on. Plastics are using widely everywhere in our life. Plastic makes our life easier and better. Day by day people are becoming more and more dependent on the use of plastics because of the characteristics of plastic such as inert, durability, flexibility and versatility and so on. Below there are some main criteria of plastics:

- High heat combustion
- Plastics do not absorb much moisture
- Water content of the plastics is far lower than the water content in the biomass.
- Increasing availability in the local community.

Plastic is a general term of any synthetic or semi-synthetic organic polymer consist of repeating long chains of carbon and other chemical elements. For example:

Ethylene (CH2=CH2) is the monomer of polyethylene - (-CH2-CH2-) –

In the polymerization process, monomers bonds break down and then an open bond created in the monomer. So, the monomer can joint with other or same repeating unit and create long chain of the monomer. Such as:

Vinyl chloride (CH2=CHCl) is the monomer of PVC or poly vinyl chloride - [-CH2 - CHCl-] –

Or

- [-CH2-CHCl-]-[-CH2-CHCl-]-[-CH2-CHCl-]-[-CH2-CHCl-]-[-CH2-CHCl-]-[-CH2-CHCl-]-

There are two basic types of plastics.

- Thermoplastic: Thermoplastic made of long side chains. The bond between thermoplastics molecules are weak so they can be soften and harden through heating and cooling process repeatedly. And these changes do not make any kind of changes in their chemical structure. Thermoplastic can be recycled after used. Most of the plastics products are made from thermoplastics.

- Thermoset: Thermoset plastics formed a cross-linked structure during processing so they cannot be reshaped or recycled. The bond between the molecules is very strong.

How we get plastic from petroleum or crude oil:

Plastics are made from petroleum based organic compounds like natural gas, oil, crude oil and so on. These compounds are consisting of polymers which are made up of shorter carbon containing compound called monomer.

- In the refinery industry crude oil refined into ethane, propane, and other petrochemical products such as diesel, fuel gasoline and so on.
- Appling 760º C temperature ethane and propane are cracked into ethylene and propylene.
- After that, these ethylene and propylene gases are separated from the other hydrocarbons of petroleum products.
- In a polymerization reactor, these hydrocarbons are mixed with catalysts and form long polymer chain.

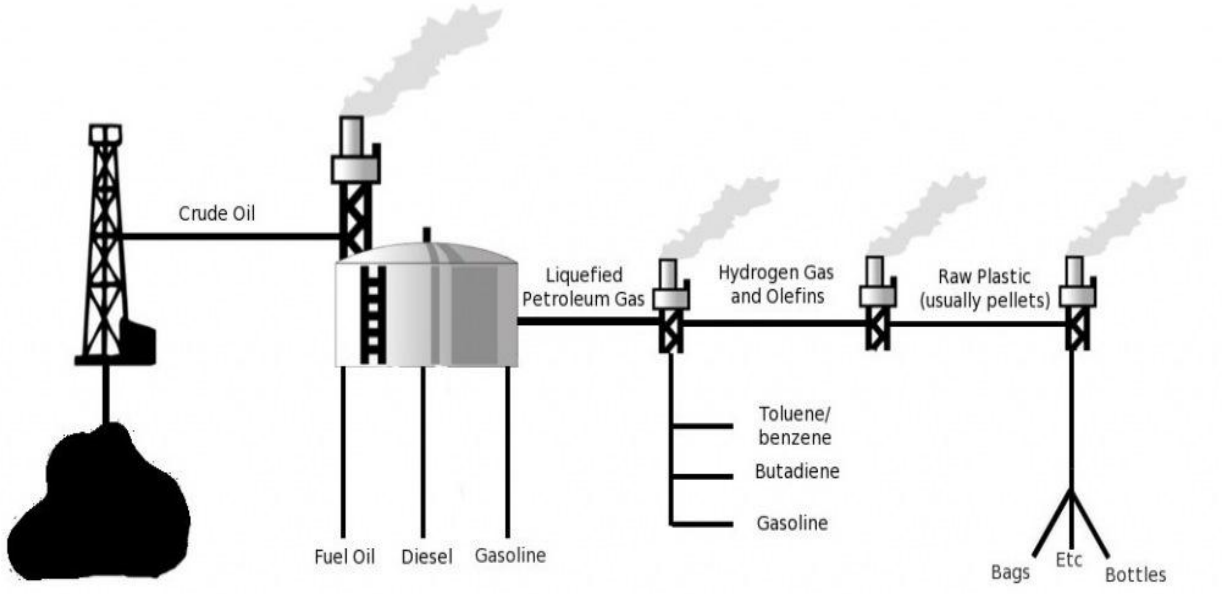

Figure 1: Crude oil to plastic process

Source: http://ecologiquedesign.wordpress.com/2011/03/10/how-plastic-is-made/

How we get oil back from waste plastics:

Plastics are inert. So they usually do not mixed or make bond with other substances. It means that plastics do not decay normally. It takes thousands of years to degrade or to break down in the environment. Some plastics do not degrade at all. They need to through in the landfill or in the ocean. As a result, plastics are making so many harmful problems for mankind, for environment, for animal in the land of even in the oceans. The growth of plastic products and uses are increasing day by day. So it became an important issue to control these problems. Plastic to oil conversion process has been studying since 1990's. Waste plastics first treated in a heater at a certain temperature distance. Then melted plastic passed into a reactor where its carbon chain breaks down into different level depending on different temperature level. Then from the distillation chamber different kinds of gas and fuel can be collected[i]. Later in this report, it has been discussed, how to get diesel from waste plastics.

1.2 Target waste plastics:

Conversion of the waste plastics depends on the plastic types and its properties. Not all plastics are suitable for oil conversion. To get effective conversion from the waste plastics it is most important to select non-hazardous, combustible and suitable feedstock. Because some plastics contain undesirable substances such as nitrogen, halogens, sulfur and flame-retardants additives such as bromine antimony compounds.[ii]

Type of plastics	Resin code	Example	As a feedstock of liquid fuel
PET	1	Solid products, plastics bottles, textiles	Not recommended
HDPE	2	Plastic bags, cosmetic bottles, milk jugs	Allowed
PVC	3	Pipe, laminate flooring	Not recommended
LLDPE / LDPE	4	Bags, wire coating, wrap	Allowed
PP	5	Liquid hydrocarbons, bottle caps, computer parts, automotive parts	Allowed
PS	6	Cutlery, cups, food containers, CD cases	Not recommended
Others	7	Mixed plastic products	Depends on the plastics

Table 1: Plastics as a feedstock for fuel conversion

Source: FAQ's Polymer energy. http://www.polymerenergy.com/faq

Bellow there are thermal properties of different kinds of plastic genre.

Resin type	Resin code	Melting point (C°)	Temperature range (C°)	Maximum temperature of decomposition (C°)
PET	1	260	360-410	400
HDPE	2	134	340-500	475
PVC	3	>140	210-350 (I) 350-500 (I)	250-280 (I) 475
PP	5	132	340-460	425
PS	6	110	320-415	355

Table 2: Thermal properties of different plastics

Source: Feedstock recycling and pyrolysis of waste plastics: converting waste plastics into diesel and other fuels. J.Scheirs and W. Kaminsky, 2006 John Wiley & Sons

1.3 Petroleum products from the crude oil:

Plastics are long chain of hydrocarbons. When they heated to melt down, their hydrocarbon bonds break down in to smaller number. Again, petroleum based compounds are depends on the number of hydrocarbons in the chain. Below there are some levels of hydrocarbons and there petroleum products:

Hydrocarbon level	Product
C 1-4	Gas. Boiling temperature below 0.
C 5-7	Very light so easily vaporized. These clear liquid is called naphtha. Used as solvent. Dry cleaning fluids, paint solvent, quick drying products are made from these liquids.
C 7-11	Gasoline. Vaporized below boiling point of water.

C 12-15	Kerosene.
C 16-18	Lubricating oil. Does not vaporize at normal temperature level.
C 18>	Solid.

Table 3: Hydrocarbon level in different products

Source: http://science.howstuffworks.com/environmental/energy/oil-refining1.htm

1.4 Existing conversion technologies for fuel production:

´´Conversion technology of waste plastics to fuel is related to chemical recycling process or depolymerization process. Depolymrization process converts plastic materials into smaller molecules. It can result in a very profitable and sustainable industrial scheme, providing a high product yield and minimum waste.

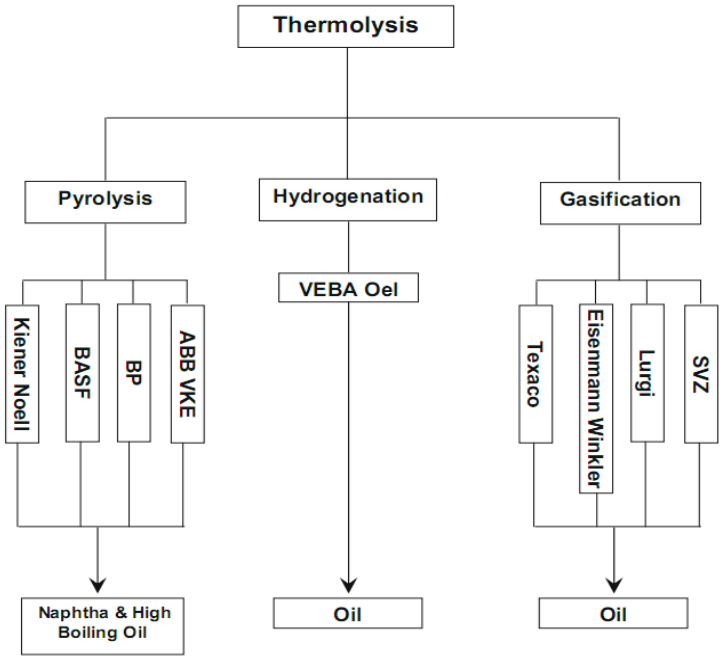

Figure 2: Different thermolysis schemes with reference to the main technologies

Source: S.M Al-Salem et al. /Waste Management, page 2632 (2009)

Thermolysis or non-catalytic method mainly used to produce different kinds of fuel products from depolymerization process. Thermolysis is a method where decomposition depends under controlled temperature. Thermolysis method can be divided into pyrolysis, hydrogenation and gasification process.

Pyrolysis:

Pyrolysis also called as thermolysis (Greek: *pur* = fire; *thermos* = warm; *luo* = loosen)[iii]. This is a process or a treatment that decompose organic materials in the absence of oxygen. It is the most commonly used process to produce clean, high calorific value fuel from waste plastics. In this method hydrocarbon content of the waste plastics converted into fuel or gas with a high calorific value and produce char which has the industrial value as a resource of energy. This technology has the operational advantages, environmental advantages and financial benefits. It is possible to convert around 80-90% of waste plastics into fuel or gas and could be easily marketed. It is the alternative solution for the landfilling problem and reduced CO2 emission in the environment. Pyrolysis technology can be different based on with or without catalyst in the reactor, different kinds of reactor systems, temperature variation, and output product of the process and so on. So it is difficult to find out a common pyrolysis process to describe the whole technology. One of the most selected and significant process could be BP polymer cracking process. The overall operation of the BP polymer cracking process can be described as following way.

- Feedstock: Sorting and size reduction of the waste plastics is required for the feedstock. Input specification of the feedstock has shown in the table 4.
- Pressure at atmospheric. Pyrolysis performs under the absences of oxygen for reason of safety, product quality, yield and so on.
- Reactor: Feedstock of the waste plastics are fed to heated fluidized bed reactor. Operating temperature of the reactor is 500 ºC. Operation temperature and heat rate enhanced bond breaking of the plastic materials into hydrocarbons. Hydrocarbons vaporized and leave the bed with the fluidizing gas.
- PVC produced HCl formation and neutralized.
- 85% weight of the plastic converted into hydrocarbon liquid.

- 15% of the remaining is gas product``[iv].

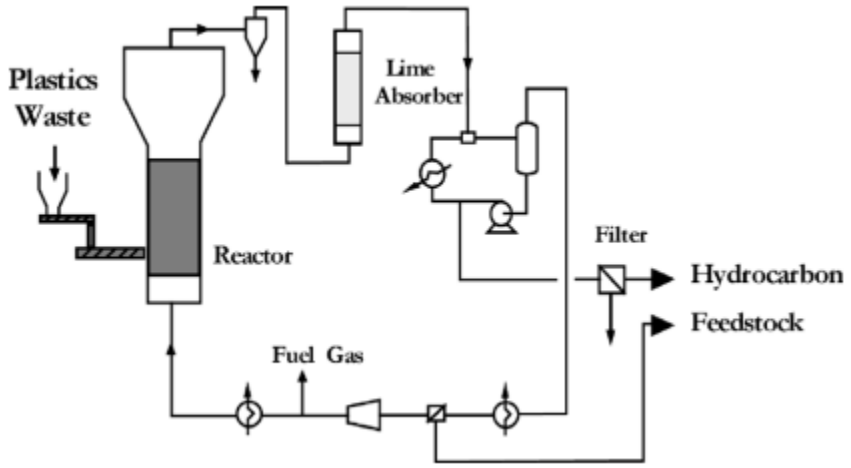

Figure 3: BP polymer cracking process

Source: S.M Al-Salem et al. /Waste Management, page 2633 (2009)

Material	Unit	Normal	Maximum limit
Polyolefin	wt.%	80	Minimum 70
PS	wt.%	15	Maximum 30
PET	wt.%	3	Maximum 5
PVC	wt.%	2	Maximum 4
Total plastic content	wt.%	92	Minimum 90
Ash	wt.%	2	Maximum 5
Moisture	wt.%	0.5	Maximum 1
Metal pieces	wt.%	-	Maximum 1
Bulk density	Kg/m^3	400	300

Table 4: BP polymer cracking process input specification

Source: S.M Al-Salem et al. /Waste Management, page 2634 (2009)

1.5 Conversion technology manufacturers:

Conversion of waste plastics to oil is new invention. Waste plastics can be converted into many products. As plastics are produced from petroleum based materials, so producing waste plastics to oil is one of the main products of this invention. Not many companies have been working on waste plastics to oil technology. During 90's, few companies came out with this idea. Some companies are producing waste plastics to oil commercially. Most of these companies are located in USA, Canada, UK, China, Japan, and Australia and so on. Below there are companies which are commercially producing fuel as an output from waste plastics.

Company name	Location
GEEP	Barrie, Ontario
Nexus fuel	Atlanta, Georgia
Platic2Oil (COMPANY X, Inc.)	Niagara Falls, New York
Cynar Plc	Ireland, facility located in UK
P-Fuel, Ltd.	Australia
Plastic advantage recycling crop.	Illinois, China
T Technology	Poland

Table 5: Companies around the world, using waste plastics as a raw material for fuel production

Source: Conversion technology: A compliment to plastic recycling, 4R sustainability, Inc.

1.6 Company X´s Technology:

Company X has started to develop its business in 2009 under the founder of the company Mr. John X. Next two years Company X worked to establish their company and examined their fuel quality and got all the approval to start their commercial business from the authorities of the Country. In April 2011 Company made its first fuel sell. Since then Company X becoming one of the most familiar name in the global market to produce different kinds of fuel oil from waste plastics. Compare to other conversion technology Company X is better than other because of its

quality of oil, processor´s capability, conversion rate of waste plastics, and use of all kinds of waste plastics as feedstock and so on.

Company´s single distillation processor can accepts unwashed, mixed waste plastics and converts into separated and refined fuel oil. Processor´s footprint is around 111.5 m², height is 4.8 m and operating space is 279 m². Processor runs continuously and does not need to monitor all the time. Its processor is free from susceptible pinhole leaks and works at atmospheric pressure. Electricity consumption is 67 kWh for motors and pumps of the processor. Processor´s conversion rate is 86% of clean fuel with 10-12% of off gas and 2-4% of residue. Company X is permitted to use its off gas as fuel to run the processor. Emission is less than a natural gas furnace and 15.97% of oxygen back into the air[v].

Company X´s advantages compare to other companies with the same pyrolysis technology are following below:

Company name	Conversion rate/yield rate	Feedstock: resin code	Capacity: ton/per year	ROI
Company X	86%	No 1-7	7000 T	One year or less
GEEP	75%	No 1-7	6000 T	2 years
Cyner Plc	75% diesel, 20% gasoline	No 1-7	12000 T	-
Nexus fuel	75-91%	No 1-7	-	-
Polyflow	67-72%	No 3-7	150,000	3-4 years

Table 6: Comparison with other companies

Source: Conversion technology: A compliment to plastic recycling. 4R sustainability, Inc.

1.7 Operation:[vi]

- To most efficiently load the processor, the feedstock is passed through a shredder and granulator.
- The hopper is loaded with approximately 800 kg of waste plastic using a forklift.

- The plastic is loaded into the processor by a continuous conveyor between the hopper and reactor.
- The plastic is then passed into the processor chamber where it is heated at a certain temperature using its own previously made off-gas.
- Hydrocarbon bonds break down in the pyrolysis sector and passed to the distillation chamber.
- During this process inline additive such as lubricant and antioxidant has to add.
- Finally at certain temperature level diesel is collection from the distillation chamber.

Figure 4: Feedstock running procedure

Source: Plastic2Oil. http://www.plastic2oil.com/site/plastic-feedstock

1.8 **Diesel product specification**:

Property	Diesel
Gravity	34-39
Flash point, F˚	130-145
Sulphur, ppm	0.17
Cloud	14-20

Pour	10-14

Table 7: Company X´s diesel specification

Source: John X, founder of Company X Inc. Personal communication

Bangladesh Petroleum Corporation accepts less than 0.20 ppm of sulphur in diesel fuel. And Company X produced better version of diesel with less than 0.17 ppm of sulphur. The less ppm of sulphur means that better diesel quality. Diesel fuel does not need any blending but must need to add lubricate and anti-oxidant additives for further use. 30-40 ppm of doses for both lubricate and anti-oxidant into the diesel.

2.0 Market analysis:

Country profile[vii]:-

Country name: The people´s republic of Bangladesh

Capital: Dhaka

Location: North-east south Asia

Area: 143,988 square km.

Climate: Tropical

Time zone: GMT +6

Population: 161 million

Religion: Islam, Hindu, Buddhist, Christian and others

Language: 95% Bangla, English is widely spoken.

Political situation: Democratic

GDP: 1700 dollar

Labor force: 75.42 million

Currency: Taka. 106, 53 Taka ~ 1 Euro

2.1 Plastic's background in Bangladesh:

In recent times the number of plastic industry increasing as a mushroom growth in Bangladesh. Most of the plastic industries are in the capital city Dhaka. Now there are 2997 plastic industries in Bangladesh[viii]. Among them 1965 companies are small, 980 are medium companies and

around 52 companies are big that deals internationally. Most of the industries are located in the Dhaka metropolitan city, which is 65%. 20% companies are located in the port city Chittagong.

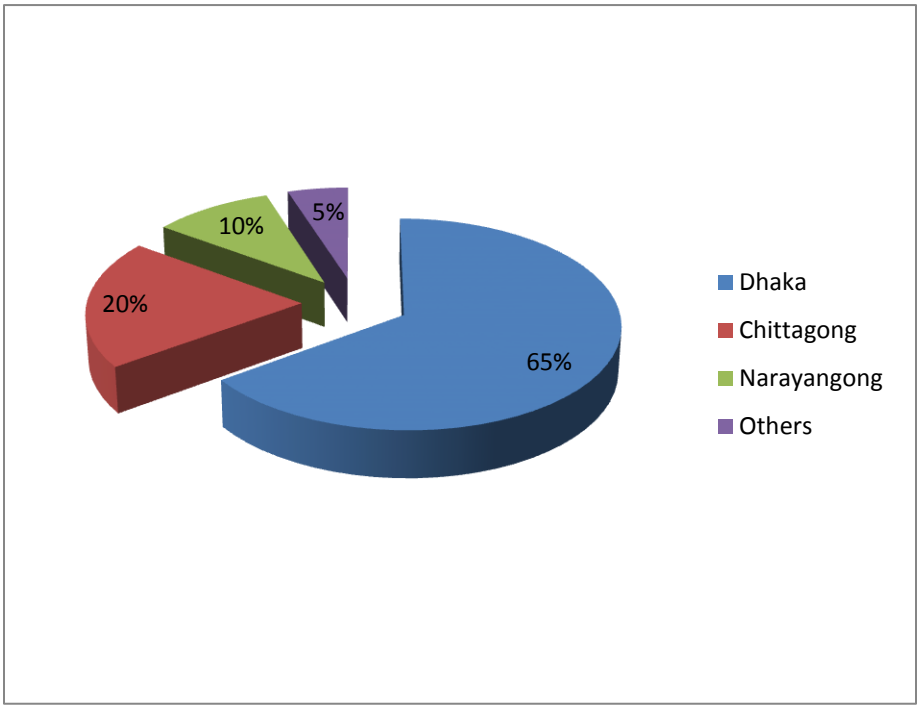

Figure 5: Plastic Industries in Bangladesh

2.2 Plastic consumption rate in Dhaka City Corporation:

Income group	Per capita (kg/year)	Population of the Dhaka city in %	Average rate
Low	5.235	55%	10.66%
Middle	12.73	40%	
High	14.03	5%	

Table 8: Plastic consumption rate in DCC

Source: Plastic waste recycling and its opportunities in Bangladesh. Waste concern consultants

Total demand of plastic for Dhaka city is around 50,213 tons per year of which 33,140 tons (66%) recycled per year. Plastics are non-biodegradable polymers of carbon, hydrogen, chlorine, nitrogen and some other elements. As plastics are non-biodegradable so the waste of plastics are

big headache for waste management. It needs big landfill to dispose and takes hundreds of years to degrade. There are not so many ways to recycle it. So, part of this waste is recycled under some selection. Rest goes to here and there.

2.3 Estimated volume of recycled plastic wastes in DMC

Plastic for recycle	50,213 tons/year	138 tons/day
Recycled	33,140 tons/year	90.8 tons/day
Unsoiled	15,566 tons/year	42.65 tons/day
Soiled	34,646 tons/year	95 tons/day

Table 9: Estimated volume of recycled plastic wastes in DMC

Source: Waste data base of Bangladesh. Waste concern consultants

Unsoiled waste plastic recycle rate more than unsoiled waste plastic. Study found that, every year 14,965 tons of unsoiled plastic recycled which is more than 96% of unsoiled waste plastic, while 17,574 tons of soiled waste plastic recycled with the rate of 50.7% per year.

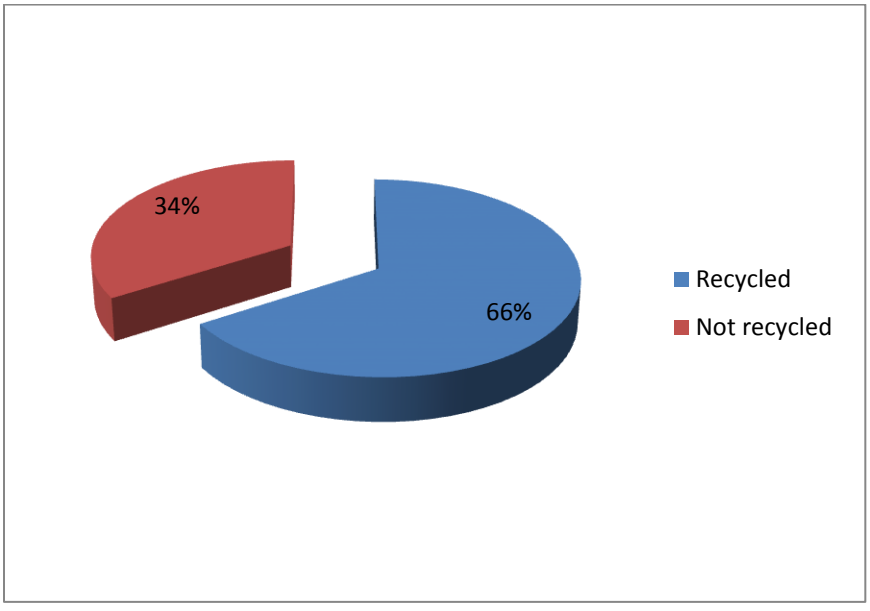

Figure 6: Recycling rate of waste plastic in Dhaka metropolitan city

Above graphs are showing that the consumption rate of plastics are increasing day by day. On the other hand, recycling rate of waste plastics are not increasing that way. These plastic wastes

can be converted in to oil in various ways. Some of the processes are cost effective and some are not effective as a fuel oil product. Company X is such a company that introduced a revolutionary process to convert plastic waste to clean and low sulfur fuel oil. In this process 90% of the waste plastic converted into fuel oil.

2.4 Oil in Bangladesh:

Production	5,724 bbl./day = 911,146.32 liter
Consumption	98,000 bbl./day = 15,599,640 liter
Export	2,770 bbl./day = 440,9286.6 liter
Import	77,340 bbl./day = 12,310,981.2 liter
Proved reserved	28 million bbl. = 4 billion liter

Table 10: Recent oil situation in Bangladesh

Source: CIA – The World fact book. https://www.cia.gov/library/publications/the-world-factbook/geos/bg.html. Access date 15th October 2011

[1 barrel or 1 bbl. is = 42 gallons = 159.18 liter]

Local selling price of the petroleum related products according to the last effective date 30th December 2011 are following below:

No	Product name	Local selling price (tk./liter)
1	Diesel	61
2	Kerosene	61
3	Octane	94
4	Petrol	91

Table 11: Fuel price in Bangladesh

Source: Petroleum local price, Bangladesh Petroleum Corporation. http://www.bpc.gov.bd/contactus.php?id=39. Accessed date 25th February 2012

From the table 10 we can see that diesel price is 61.00 taka. This is equivalent to 0.74 dollar. And in the international market per liter crude oil is 0.72 Dollar or 59 Taka[ix]. Bangladesh government has been importing crude oil with international price; refine them and then market them to public. It means that government paying compensation or paying subsidy to provide service for the public.

3.0 Project analysis:

It is important to know the prerequisite factors before one start a business in Dhaka, Bangladesh. Recently Dhaka has divided into two city corporations. One part called South Dhaka City Corporation and another is called North Dhaka City Corporation. Both parts have huge population with insufficient land area. It has mentioned before that, most of the plastics companies has situated in greater Dhaka. Opening a successful private limited company in Bangladesh one has to know the target market, location and layout of the company, how to get the fund for the company.

3.1 Target market:

Petrobangla Bangladesh or Bangladesh Petroleum Corporation imports unrefined oils from different countries. Then these oils refined in Eastern Refinery Bangladesh, which is located in port area Chittagong. Petro Bangla distributes refined oils to different marketing companies in Bangladesh. They are Padma oil company LTD, Megna oil company LTD, Jamuna oil company LTD. than marketing companies' sale oil to the agents, customers and dealers and so on. Padma Oil Company is one of the oldest and biggest subsidiary limited company of Bangladesh Petroleum Corporation. Padma Oil Company has interest to buy green diesel and distribute in their market[x]. So it is convenient to sell daily produced green diesel to Padma Oil Company.

3.2 Location and site plant:

It is very difficult to get a suitable place for Green Diesel Company in Dhaka. Its huge population is increasing day by day and the total land area of the city reducing rapidly. It is important to stay closer to the raw material market, selling target market and also to the landfill area.

Most of the raw material market is in the nearby of tejgaon industrial area of Dhaka South City Corporation. So it is cleaver to stay closer to the raw material market. Again, Green Diesel targets its only dealer Padma Oil Company. At Dhaka metropolitan area there are 3 branches of Padma Oil Company. But all of them are located in the North Dhaka Metropolitan area. The nearby dealer is located at Godenail, Narayanganj, which is the one of the most important western branch of Padma Oil Company. Therefore, Godenail will be the best option for selected dealer market. Again, Dhaka has two landfill areas which are Matuail and Uttora. Matuail is located nearby Dhaka Narayangonj highway and Uttora landfill is situated in the North Dhaka City Corporation area.

So, possible locations for the Green Diesel Ltd could be nearby Dhaka-Narayangonj highway or near Dhaka-Shylhet highway. Dhaka-Narayangonj highway is better option because of the accessibility to communicate with the raw material market and the dealer. Distance from the factory to the raw material market is 12 km, to the dealer is 13.2 km and to the landfill is 3 km. Some other factors for choosing this location:

- Electricity availability
- At least far from the locality
- Environmental issues related to locality
- Near to solid waste landfill
- Less traffic stream
- Has all the communication system

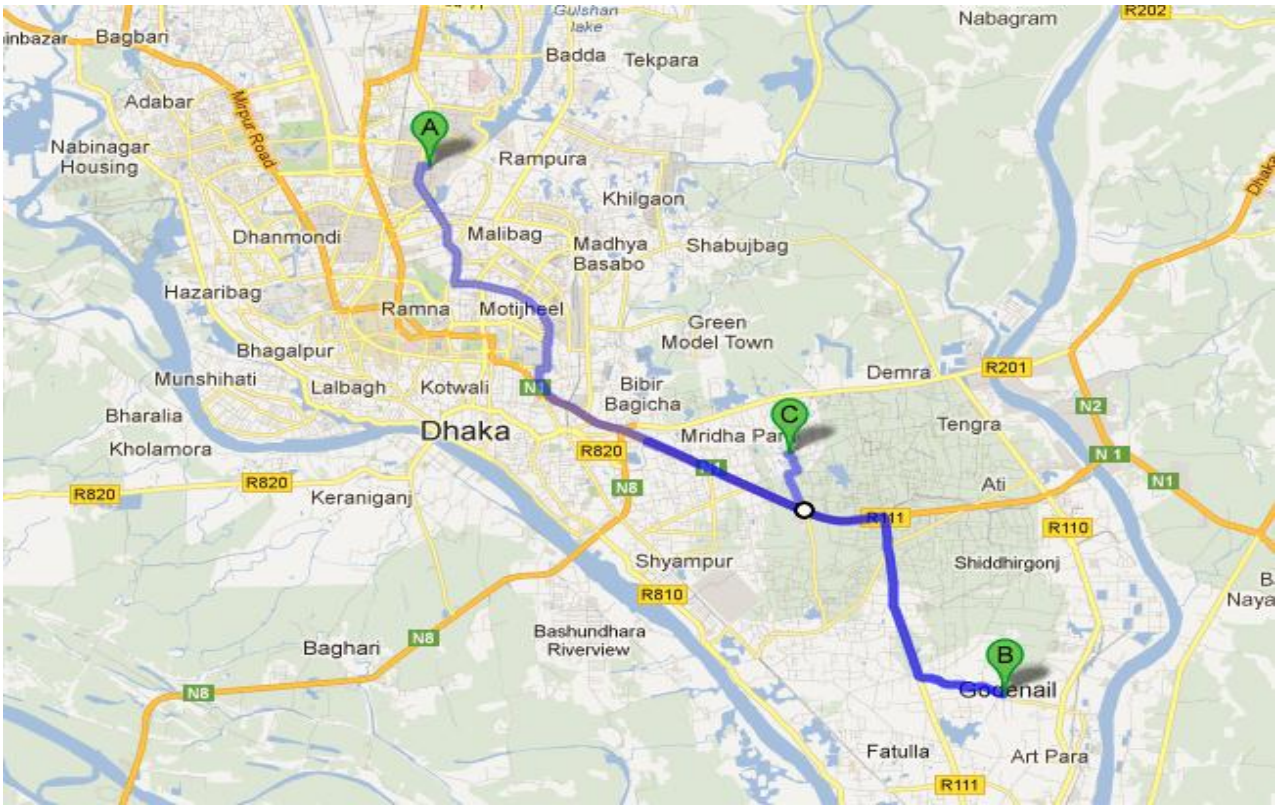

Figure 7: Green Diesel Ltd.'s accessibility to the (A) raw material market tejgaon (B) Godenail, Narayangonj and (C) Matuail landfill.

Source: Google map.

3.3 Layout of the factory[xi]:

- Total footprint of the factory is 12,078 m² (198 m * 61 m)
- Store house area is 231 m² (38.5 m * 6 m) and can be stored for at least 135 metric tons of waste plastics. Store house height is 6.1 m.
- Vertical oil tank capacity is 538,349 liters of diesel. It means that the diesel tank store at least 28 days of production. Height of the tank is 20 m and width is 15 m. Tank´s filled depth 12.2 m.[xii]
- Office rooms are located in the machinery area. Operating area is 279 m² and machine´s footprint is 111.5 m².

- Parking area is in front of the office.

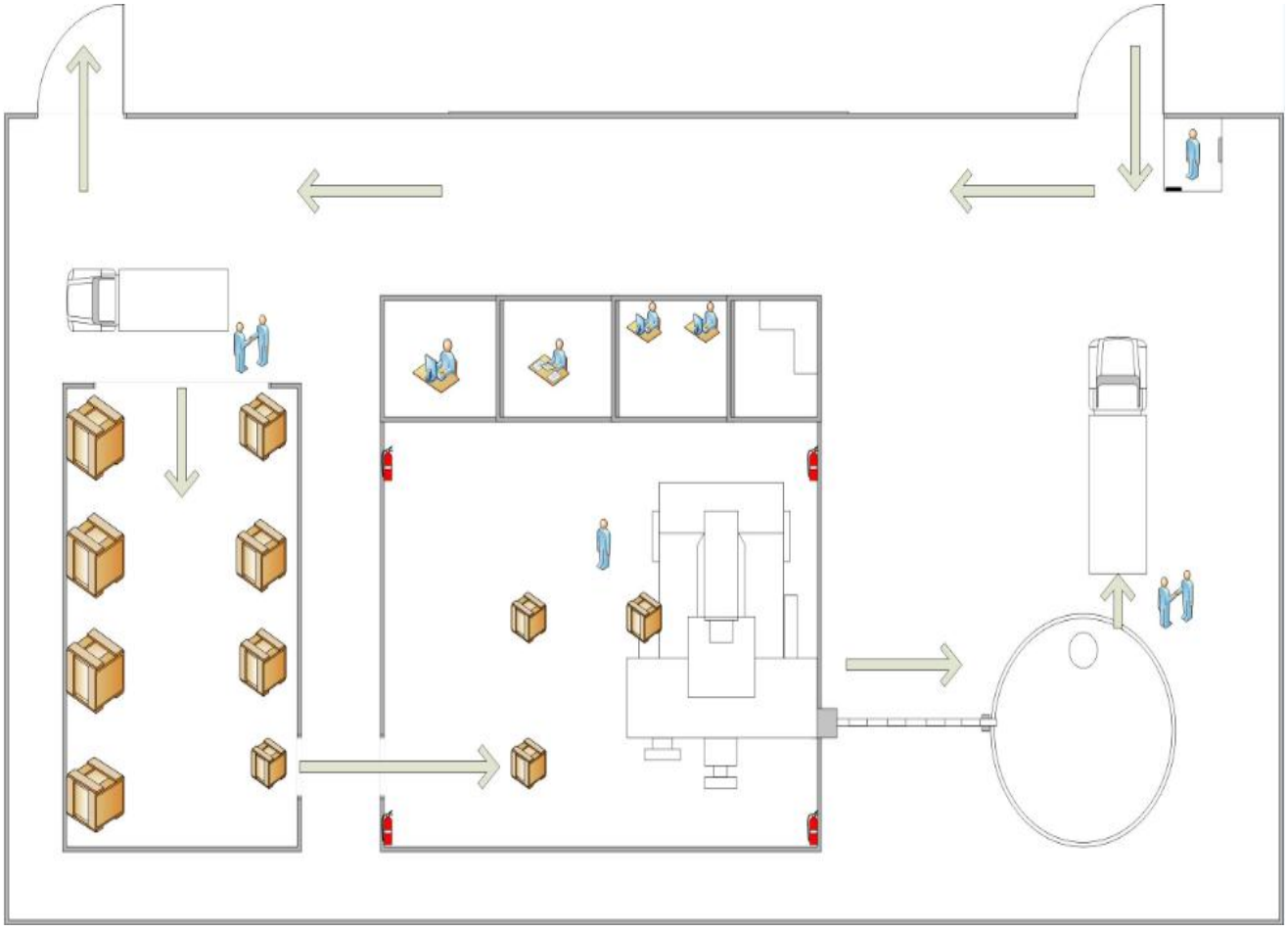

Figure 8: Layout structure of the factory

Source: Self drawn

3.4 Civil work:

- Building structure: Structure of the building included boundary surrounding the factory, storage house, machinery house, office house.
- Electricity connection: Installation of electricity connection through the factory and power house assembly.

- Water supply: Water supply connection through the factory as well as the machinery foot print area.
- Furniture: Furniture to decorate the office rooms, leisure room.
- Oil tank.
- Fuel piping equipment.
- Others: Other works like painting the building, lightening, bathroom and sanitary equipment assembling etc. and so on.

Factory´s building construction investment:

No	Unit	Item description	Unit cost	Cost (local currency)	Total cost
1	1	Machinery house, office house, store house	2,447,000	2,447,000	5,807,000
2	1	Oil tank (capacity 100,000 litters)		2,000,000	
3	1	Boundary & gates	200,000	200,000	
4	1	Electricity connections, security system installation & all other electricity equipment	560,000	560,000	
5	1	Water piping connection	400,000	400,000	
6	1	Furniture & electronics equipment	200,000	200,000	

Table 12: Civil work expense

- Land line and internet connection charge:

Connection charge		2000
Monthly rate	80+ (200 min * 22 days =4400 min *.3 per min)	13280

Internet connection	1M, 12 GB	1000
Total		16280

Table 13: Telephone and internet expense per month

Source: Rate, Bangladesh telecommunication Company Ltd.
http://www.btcl.gov.bd/rate/rate.htm. Accessed date 15th September 2012

3.5 Equipment and vehicle:

Equipment needs for the Green Diesel factory are following below:

- Plastic to Oil distillation machine: machine will be imported from Company X Canada. Their distillation machine can convert 1800 pounds of waste plastics in every hour.
  Operating space of the machine is 1500 square foot and the height of the machine is 16 foot. Price of the machine is 81,780,000 in local tk. currency which is equivalent to 767,671 euro[xiii]
  So we can assume that this distillation machine can fit in a 4 standard 40´ container. Every standard 40´ container weights 26,780 kg.

Distillation machine shipping cost[xiv]:

Ex terminal: Toronto, Canada.

To terminal: Chittagong, Bangladesh. (Delivered cost from Chittagong to Dhaka is excluded)

Ocean freight USD 5135 * 4	Export declaration USD	Handling fee USD	Documentation fee USD	Total cost
20540	50	65	40	20695 USD~ 1,674,010 tk. ~ 15,714 Euro

Table 14: Distillation machine freight price

Taxation for the distillation machine: Taxation is exempted under custom act 1969, (IV of 1969) section 25B. "Permanently imported plant and equipment for power generation by non-government sector for installation of power generation station and machinery and equipment and temporarily imported erection materials under SRO no 73-Ain/97/1700/Shulka, dated 19/03/1997"[xv]. So the C+F price of the distillation machine for the Green Diesel factory:

Distillation machine price	Freight price	Tax 0%	Total price	Total price in Euro
81,780,000	1,674,010	0	83,454,010	783,385

Table 15: Total cost of the distillation machine with freight expense

- Diesel fuel analysis equipment (Molecular analysis equipment and fuel specification equipment).
- 2 Forklifts[xvi].

Item description	Number of items	Unit cost in tk.	Total cost	Total cost in tk.	Total cost in Euro
Forklift	2	1,574,000	3,148,000	6,148,000	371,930
Lab equipment	2	1,500,000	3,000,000		

Table 16: Cost of vehicles and lab equipment

3.6 Raw materials and inputs:

Raw materials are one of the main parts of an industry. Raw materials and their quantity depend on the plant capacity, plant location, technology equipment etc. Raw materials and inputs can be divided into three parts.

1. Raw materials for feedstock
2. Additives

3. Electricity
4. Water

Raw material for feedstock:

Raw materials are coming from Bridgeuness trading Bangldesh to Green Diesel factory. The approximate distance is 12 km. The whole seller is bearing all the transportation cost. All the raw materials are sorted before coming to the factory for use as feedstock. Raw material´s delivery time in the factory is 3:00-5:00 in the morning on Sunday, Tuesday and Thursday. In the inventory house there will at least 7 days stock for the raw materials.

Green Diesel factory will use HDPE, LDPE, LLDPE, and PP etc. mixed waste plastics as its feedstock. All though the distillation machine can handle PVC and produces hydrochloric acid but the factory is going to produce only diesel fuel so PVC will not be taken as raw material. Machine capacity rate is 1800 pounds ~ 816.5 kg (for easy to calculation and safety purpose we use 800 kg). If the machine runs for 24/5 days, then the necessary raw material for machine feedstock will be:

800 kg/hour * 1 day (24 hours) = 19,200 kg/day

19,200 kg/day * 5 days (1 week) = 96,000 kg/week

19,200 kg/day * 22 days (1 month) = 422,400 kg/month

422,400 kg/month * 12 months (1 year) = 5,068,800 kg/year

- Big truck carries 12-13 tons.
- Medium truck carries 7-8 tons.

Waste plastic price depends on the quality of the plastics. Price varies between 20-70 tk. For producing diesel distillation machine doesn´t need clean washed waste plastics. Only thing is to specific plastics waste. For unwashed, mixed but HDPE, LDPE and PE waste plastics, per kg price is 38 tk.

Unit cost tk.	Daily cost tk.	Weekly cost tk.	Monthly cost tk.	Yearly cost tk.
38	729600	3648000	16051200	192614400

Table 17: Raw material cost (communication charge included)[xvii]

Additives:

If one dose is required 40 ppm of lubricate and 30 ppm of anti-oxidant, then total doses for the 19200 liter of diesel for one day will be[xviii]:

40 ppm * 19200 liter = 768000 mg or 0.768 kg of lubricate

30 ppm * 19200 liter = 566000 mg or 0.566 kg of anti-oxidant

Item	Daily amount	Weekly amount	Monthly amount	Yearly amount
Lubricate	0.76 kg	3.84 kg	16.90 kg	202.80 kg
Anti-oxidant	0.56 kg	2.8 kg	12.32 kg	147.84 kg

Table 18: Additives requirement for the diesel

Item	Unit cost	Daily cost	Weekly cost	Monthly cost	Total monthly cost tk.	Total yearly cost
Lubricate	110	84.48	422.4	1858.56	3398,56	40782.72
Anti-oxidant	125	70	350	1540		

Table 19: Costing of Additives

Electricity:

Analysis of electricity for the Green Diesel factory is very essential. As load sheading is very common in Bangladesh so it is necessary to estimate maximum power demand. Power consumption of the Distillation machine and pump is 69kWh. No extra power needed for the machine.

Tariff of power consumption:

Category C For a small industry	Range	Rate/kWh tk.	Charges demand	Service charge
	Flat	4.02	Above 40KW tk. 35 per month	60 tk. per month
	Peak	5.62		
	Off peak	3.20		

Table 20: Tariff of power and charges for a small factory in tariff category C

Range	Time	Demand power	Total kWh	Rate/kWh	Tk. (Total kWh * Rate/kWh)	Total Tk. For a day	Total tk. for month	Total tk. for a year
Peak	6 hours (17:00-23:00)	69KW*	414	Tk. 5.62	2326.68	6301.8	138623	1663485
Off peak	18 hours (23:00-17:00)	69KW*	1242	Tk. 3.20	3974.4			

Table 21: Power consumption of the distillation machine for a day

Range	Time	Demand power	Total kWh	Rate/kWh	Tk. (Total kWh * Rate/kWh)	Total Tk. For a day	Total tk. for month	Total tk. for a year
Peak	6 hours (17:00-23:00)	11KW*	66	Tk. 5.62	370.92			
Off peak	18 hours (23:00-17:00)	11KW*	198	Tk. 3.20	633.6	1004.52	30135	361627

Table 22: Electricity consumption and costing for the office lightening

Water:

No	Unit	Item description	Unit cost tk.	Cost tk.	Total cost tk.
1	1	Water supply connection fee	22,000	22,000	22,000

Table 23: Water connection fee[xix]

Monthly water bill depends on the use of water consumption. For 1000 liter water from Dhaka WASA, commercial charge is 22.17 taka. [xx]

For the factory, let assume monthly water consumption will be 5000 liter.

Unit price tk.	Total monthly unit	Monthly cost tk.	Yearly cost tk
22.17	5	110.85	1463.22

Table 24: Costing for water

3.7 Production planning:

Production planning is the key part to forecast production rate, sales rate and control production. Effective production planning can utilize resources and minimize wastage of raw materials. Green Diesel factory can get enough raw materials for its production so the most important part is to find out effective planning for the satisfactory outcome.

Factory runs 5 days per week with 24 hours production rate. Each day has 3 shifts with 8 hours per shift.

52 weeks/year = 52 weeks * 5 days = 260 days – 15 public holidays = 245 days/year

Again, 52 weeks/12 months = 4.3 weeks/month * 5 days/week = 21.66 ~ 22 days/month

So, every month normally there are around 22 days.

Capacity of the machine is 1800 pounds or lbs. ~ 816.5 kg in every hour. Instead of 816.5 kg factory will use 800 kg of waste plastics for the machine for every hour. This value has selected only for convenient access. So, for the whole day long, the machine can execute 19,200 kg of waste plastics into clean diesel.

What is liter? Liter is the volume of 1000 g of water at 4˚c = density of water

So, volume of 1000 g of water is ~ 832 g of petroleum diesel[xxi]. If the conversion rate is 86% then, 1000 g of mixed plastic converted into 860 g of diesel, which is the equivalent weight of 1 liter of diesel.

Daily	Monthly production rate (22 days)	Yearly production rate
19,200 liter	422,400 liter	5,068,800 liter/year

Table 25: Factory production rate

- 1 gallon or 3.78 liter of fuel is extracted from 8.3 lbs. or 3.76 kg of plastic.[xxii]

- So, 3.78 liter fuel is extracted from 3.76 kg of waste plastics. Which means that 100 % of the fuel conversion rate.

3.8 Management and personnel:

Green Diesel runs by only one director who control the whole factory, plan production, take the decision and so on. Production engineer will look after all the engineering and lab works. Production engineer will be expert and well trained in related job. Three assistant engineers will perform under his decision. Every shift will has one assistant engineer and three workers. Accountant`s task will be taking care of sales, costing, wages and so on.

Morning shift (08:00-16:00):- Director, Production engineer, Accountant, 1 Assistant Engineers, 3 Workers, Production boy, Cleaner, Security. Evening shift (16:00-24:00) and Night shift (00:00-08:00): - 1 Assistant Engineer, 3 Workers, security.

No	Number of person	Item description	Unit wage tk.	Total Wage tk.	Total monthly wages tk.
1	1	Director	40,000	40,000	256,000
2	1	Production engineer	30,000	30,000	
3	1	Accountant	20,000	20,000	
4	3	Assistant engineer	17,000	51,000	
5	9	Worker	8,000	72,000	
6	4	Security	8,000	32,000	
7	1	Production boy	6000	6000	
8	1	Cleaner	5000	5000	

Table 26: Monthly salary for the employers

3.9 Insurance:

It is important to have insurance policy for the factory house, distillation machine, oil tank and for all the employees of the factory. Reliance Insurance Limited will take care of all the possible insurance for the factory. Insurance will be paid annually. Below there are all the average costing related to insurance of the factory:

No	Item description	Number of the item	Cost tk.	Total monthly cost	Total cost/year tk.
1	Health insurance for the employee	21 person	53613	116124.33	1393492
2	Building, machineries, furniture, electric items		31754		
3	Oil tank	1	158125		
4	Distillation machine	1	1150000		

Table 27: Insurance costing of the whole factory and its employees

3.10 VAT & Income Tax:

Applicable VAT is 15% because the Green Diesel factory has annual turnover more than 2 million.[xxiii] Green Diesel factory will be a private limited company. For a privately owned company applicable income tax is 37.5%[xxiv]. Green Diesel factory will be not going to transfer its shear to the public.

3.11 Pricing of the diesel and marketing:

Price of the product = total product cost * (1+ markup percent). Government VAT is 15%.

Total product cost = raw material cost + additives cost + electricity cost + machine cost + overhead cost

Raw material cost for 1 liter of diesel is 38 tk. Because 1 liter of diesel is getting from 1 kg of raw material and 1 kg of raw material cost is 38 tk.

Additives cost: Daily additives cost is 158.48 tk. So additives cost for 1 liter is 158.48/19200 = 0.008 tk.

Electricity cost for the machine: Daily electricity cost for the machine is 6301.8 tk. So machine´s electricity cost for 1 liter of diesel is 6301.8/19200 = 0.33 tk.

Overhead cost = Salary of all employees, electricity consumption for the office, office expense, water bill, internet bill, telephone bill, insurance for the worker everything are related to the overhead cost.

Item	Total tk. in a month
Salary	256000
Electricity	30135
Office expense or maintaining cost	10000
Water	111
Internet	1000
Telephone	13280
Insurance	116124
total overhead cost	426650

Table 28: Overhead cost

Total employee is 17. Monthly working hour of the employees is 17 * 8 hours per day * 22 working days per month = 2992 hours. Security works (4 persons) = 24 hours * 30 working days per month = 720 hours. Total working hours per month is 3712.

So total overhead cost per hour = 426650.45 / 3712 = 114.94 tk.

Total overhead cost per liter = 114.23/800 liter per hour = 0.14 tk.

Item	Cost tk.
Material cost	38.00
Electricity cost	0.33

Overhead cost	0.14
Additives	0.008
Total production cost	38.48

Table 29: Total product cost per liter

Markup percentage or profit margin is 30 percent.

So, 1 liter diesel selling price = 38.48 * (1+0.30) = 50.02 tk.

If a 15% VAT added than the MRP is 57.53 tk.

Item	Local price tk.	In Euro	Local price with VAT	Price with VAT in Euro
Unit price	50.02	0.47	57.53	0.54
Daily sales	960458	9016	1104527	10368
Monthly sales	21130083	2380184	24299595	228101
Yearly sales	253560991	2618202	291595139	2737211
5^{th} year´s sales	371238647	3484827	426924444	4007551

Table 30: Sales revenue for the factory

Why Green Diesel´s dealer will buy diesel directly from the factory:

As mentioned earlier, Padma Oil Company LTD. is a subsidy oil marketing company of Bangladesh Petroleum Corporation. For selling 1 liter of fuel Padma earns around 1.5-1.75 tk. in local currency.

Green Diesel´s diesel is new, ultra clean, don´t need to recycle, cheaper and moreover has the same efficiency as local diesel. Green Diesel´s diesel selling price is 50.02 and after VAT is 57.53 tk. and local diesel price is 61 tk.

If Padma bye Diesel from the Green Diesel factory than they will have possibility to earn around 2.5 tk. in per liter. They may have the continuous diesel flow in the market because the Green Diesel will supply all its production to the Padma. They will have the opportunity to sell a new environment friendly product to the public and earn better from that.

Padma Oil Company LTD. has the interest to buy diesel directly from the factory. In Dhaka nearest local dealer´s office is located 13.2 km far from the factory. Padma will bear all kind of transportation cost to drive diesel from the factory to its own selling office[xxv]. Diesel delivery time is 10:00-13:00 on Monday, Wednesday and Thursday.

3.12 Getting fund and Investment:

Working capital for the factory is for 4 months. So total working capital will be:

4/12 * sales revenue for 1 year = 4/12 * 291595139 = 97198380 tk. = 912404 Euro

Total physical investment for the factory is following below:

Item	Local currency tk.	Euro
Machinery	83454010	783,385
Land	40000000	375,481
Building and other civil work	5807000	54,510
Vehicles and lab equipment	6148000	29,550
Total physical investment	135,409,010	1,271,088

Table 31: Physical investment cost

So, total capital required for the project established is 229.6 million tk. 50 million tk. of this will come from Bangladesh bank with monthly 5% interest rate. Rest will come from shear capital.

Item	Local currency	Euro
Loan from bank with monthly 5 % interest (pay back in 5 years)	50,000,000	469,351
Monthly rate	833,333	7,823
Interest per month	41,667	391
Monthly pay back	875,000	8,214

Table 32: Payback loan to the bank

Total number of share is 20,000 and 1 share is 9130 tk. in local currency.

Item	Local currency	Euro
Total share capital	182,607,390	1,714,141
Price of 1 share	9,130	86

Table 33: Share capital prediction

4.0 Financial projection:

Key assumption:

Item	Assumption
Material cost increase in every year	10%
Additive cost increase in every year	10%
Electricity cost increase in every year	10%
Overhead cost increase in every year	10%
Raw material inventory	7 days
Additives inventory	1 month
Sales increase in every year	10%
Maintain cost decrease in every year	10%

Table 34: Key assumption of the factory

Return on investment (ROI):

RIO:

$$\frac{\text{Total sales revenue for 5 years} - \text{Total production cost for 5 years}}{\text{Total physical investment cost} * 5}$$

Total sales revenue for 5 years

	Local currency	Euro	Total in local currency	Total in Euro
Year 1	253,560,991	2,380,184	1,548,015,206	14,531,261
Year 2	278,917,090	2,618,202		
Year 3	306,808,799	2,880,023		
Year 4	337,489,679	3,168,025		
Year 5	371,238,647	3,484,827		

Table 35: Total sales revenue for 5 years

	Local currency	Euro	Total in local currency	Total in Euro
Year 1	199,779,355	1,875,334	1,218,168,083	11,434,977
Year 2	219,621,117	2,061,589		
Year 3	241,447,055	2,266,470		
Year 4	265,455,586	2,491,839		
Year 5	291,864,971	2,739,744		

Table 36: Total production cost for 5 years

ROI: $$\frac{1,548,015,206-1,218,168,083}{132,409,010 * 5}$$

$$=0.50$$

So, return on investment is 50% in every year.

Income Statement				
Net sales	Year 1	Year 2	Year 3	Year 4	Year 5
Raw material cost	*192614400*	*211875840*	*233063424*	*256369766*	*282006743*
Additives	40783	44861	49347	54282	59710
Electricity cost	*1663485*	*1829834*	*2012817*	*2214099*	*2435509*
Overhead cost	4098949	4508844	4959728	5455701	6001271
Insurance	*1361738*	*1361738*	*1361738*	*1361738*	*1361738*
Cost of product sold	*199779355*	*219621117*	*241447055*	*265455586*	*291864971*
Sales	*253560991*	*278917090*	*306808799*	*337489679*	*371238647*
Gross profit	**53781636**	**59295973**	**65361745**	**72034093**	**79373676**
Operating Expense	253560991				
Bank interest	*500000*	*500000*	*500000*	*500000*	*500000*
Maitaining cost	*10000*	*9000*	*8000*	*7000*	*6000*
Total operation expense	**510000**	**509000**	**508000**	**507000**	**506000**
Income from operation	**53271636**	**58786973**	**64853745**	**71527093**	**78867676**
Tax 37,5 %	*19976864*	*22045115*	*24320154*	*26822660*	*29575378*
Net income	**33294773**	**36741858**	**40533590**	**44704433**	**49292297**
Total net income	**33294773**	**70036631**	**110570221**	**155274654**	**204566952**

5.0 Conclusion:

It is very difficult to find out alternative of plastic. Even plastic´s demand is increasing every day as well as their waste. This project analysis has observed the use of waste plastics, a factory planning and its feasibility in Dhaka Metropolitan City. It is easily assumed that, when the use of waste plastic will increase then the solid waste management will search more ways to find out to collect them.

The implementation of this project can develop so many opportunities in the city. It can be a solution to control waste plastic, develop a new technique or idea, and detect the source of diesel for the country. Bangladesh is such a country where this kind of project could be very promising and effective in the future.

5.1 Required permission from the Bangladesh government:

To establish such a factory in Bangladesh, it is obligatory to get some permission from different ministries and corporations of the Bangladesh.

Environment and forest ministry: It is necessary to provide enough evidence that the factory does not produce excessive CO2.

Dhaka City Corporation: City Corporation approves the entire licenses needed for the factory such as trade license, building permission, waste management permission and so on. Now Dhaka City Corporation has divided into 2 sections, a) Dhaka North City Corporation b) Dhaka South City Corporation. Green Diesel factory and all its market area, dealer´s area and landfill area are located in the Dhaka South City Corporation.

Bangladesh Petroleum Corporation: In order to distribute or sell diesel to the customer or dealer sulfur concentration in the diesel must not exceed 0.20 ppm[xxvi]. The certification must get from Bangladesh Petroleum Corporation. Bangladesh petroleum is the only governmental organization that imports and controls all kinds of fuel in Bangladesh.

5.2 Sensitivity analysis:

This whole analysis based on online surveys, interviews and email communications. When any analysis based on online survey or other electronic communication then this is not obvious that the analysis will be the same on real life experience. So this project analysis also could give same result or different in real life venture.

Green Diesel´s ROI depends on the conversion rate of the diesel from waste plastic. The conversion rate is 86% or 1 liter diesel derives from 1 kg of waste plastics. This analysis is based on Company X´s technology and their machine´s efficiency rate. All the information in this analysis related to conversion process such as distillation machine, diesel quality, conversion process, conversion rate, emission rate etc. and so on are based on email communication and on line surveys. Some other information related to factory planning such as raw material, land, civil work and so on has collected from different sources and based on certain assumptions. All these information could be effective in real life experience or could be not.

If raw materials prices such as waste plastics price go up then there is the possibility of increasing diesel selling price of the factory. All though in recent years in Bangladesh, waste plastic´s price increased few cents in Euro.

If government subsidy dropped down means that government´s diesel price increased in the market then there will be the possibility for the factory to earn more profit from the market by increasing its diesel price. Because government`s diesel price depends on the international fuel market but factory`s diesel price depends on the waste plastics.

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