Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2019
(ICMERE2019) 11 – 13 December, 2019, Chittagong, Bangladesh

ICMERE2019-PI-106

IMPACT OF A 100,000 BARREL PER DAY OIL REFINERY IN THE CONTEXT OF BANGLADESH

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Abstract- *Except for a few very basic condensate fractionation facilities targeting the gasoline market, no crude oil processing refinery has been built in the country in the past 50 years. Consequently, the supply/demand gap for petroleum products – particularly Diesel – has increased drastically, stifling the economic growth of Bangladesh. To address this gap between supply and demand and to unlock the potential for faster growth, it is imperative to start a timely project of a new oil refinery to process crude oil/condensate to produce LPG, Premium quality Gasoline, Jet Fuel, Diesel, Fuel Oil etc. This paper analyzes the impact of a 100,000 barrels per day hydro-skimming refinery added to the fuel supply of Bangladesh by carrying out simulation based on crude oil yield and economic analysis. It is found that, the investment in such a refinery is a profitable one with a payback period of less than 5 years and ROI of around 22.5% and there is enough demand for fuels to consider further investments in such sector.*

Keywords: Crude oil, Refinery, Simulation, Economic analysis, Investment

1. INTRODUCTION

Petroleum is considered as the life blood of an economy. It has great influence, direct and indirect, on all economic sectors. It is a basic requirement of production and constitutes a substantial percentage of production cost in every sector of the economy. Petroleum fuels are used extensively in almost every sector, including transportation, power, agricultural and industrial sectors.

Crude oil is the portion of petroleum that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric conditions of temperature and pressure [1]. It is an exceedingly complex mixture, consisting of countless hydrocarbon compounds ranging from methane, with only one carbon atom, to large compounds containing 300 and more carbon atoms, as well as sulfur, nitrogen and metals, etc. [2] The total proven oil reserve at the end of 2018 was 1729.7 thousand million barrels with a reserve to production ratio of 50. The middle east dominates the oil reserve with a share of 48.3% of the total [3].

Petroleum oil refinery is a well-established industrial sector worldwide. There are around 700 refineries operating globally. Jamnagar refinery in India is the largest with a daily capacity of 1.24 million barrels per day (BPD) [4]. Total oil production in 2018 stood at 94.72 million BPD among which, crude oil and condensate production was 83.16 million BPD [3]. Total global oil consumption is expected to average 99.86 million BPD at the end of 2019 [5]. Current oil demand at the global level is predicted to rise steadily over the medium-term to reach 104.5 million BPD by 2023 [6].

The oil and petroleum industry of Bangladesh is Government regulated. With a view to providing petroleum products to all consumers at equal price irrespective of transportation cost, the government established Bangladesh Petroleum Corporation (BPC) by a presidential Ordinance in 1976. Currently BPC has one refinery, three oil marketing companies, two blending plants and one LPG bottling company working as its subsidiaries.

Eastern Refinery Limited (ERL) is the sole country-owned oil refinery in Bangladesh which started commercial operation back in 1968 [7]. The current capacity of ERL is around 33,000 barrels per day. At present, there are a few public and private condensate based fractionation plants in the country which add little to the fuel supply. Since no crude oil processing facility has been added in the fuel sector for the last 50 years, the gap between supply and demand for petroleum products has widened enormously. Local market analysis leads to the following key findings-

- Currently local petroleum production meets less than 25% of total demand [8]
- Diesel makes up around 65% of total demand; of which approximately 13% comes from local sources [8]
- All Jet Fuel is imported [8]; while local airlines are trying to expand fleet
- The annual demand of various fuels is increasing each year with the average demand increasing at a rate of more than 10% [8].
- Depletion of Natural gas reserve is looming with

almost 60% reserve already exhausted [9]; putting further pressure on energy availability

The petroleum products have wide-ranging applications in our country. Gasoline and diesel are the major source of transportation fuel. Diesel is also extensively used in power sectors and agricultural sectors for irrigation. Furnace oil is used predominantly for electricity generation while LPG and kerosene are widely used as cooking fuel. Some special grades of petroleum oil such as mineral turpentine, jute batching oil etc. have non-fuel uses. Transportation, power and agriculture sectors are the main fuel-demand driver of Bangladesh. The sector wise petroleum fuel consumption in 2017-18 is shown in Fig.1 [8]. At present, BPC supplies almost 80% of the petroleum demand through import from various countries to support the energy need in the above-mentioned sectors [8].

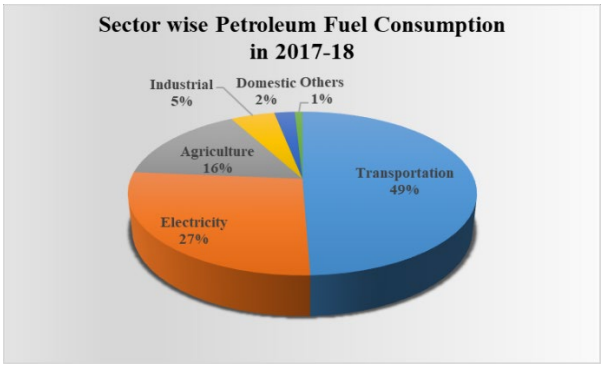

Fig.1: Sector wise petroleum fuel consumption in Bangladesh

This paper analyzes the impact of a 100,000 barrels per day hydro-skimming refinery to process crude oil/condensate to produce LPG, premium quality gasoline, jet fuel, diesel, fuel oil for power plants and marine vessels. The proposed refinery is assumed to run to produce diesel as the major fraction to meet its high demand. The proposed plant is assumed to be designed with flexibility to process light to heavy crude oils from Middle East, Russia, South America, Far-East Asia – blended with condensate, as appropriate.

2. METHODOLOGY

To analyze the impact of a new crude oil processing refinery in Bangladesh, a basic hydro-skimming refinery configuration is chosen as shown in Fig. 2.

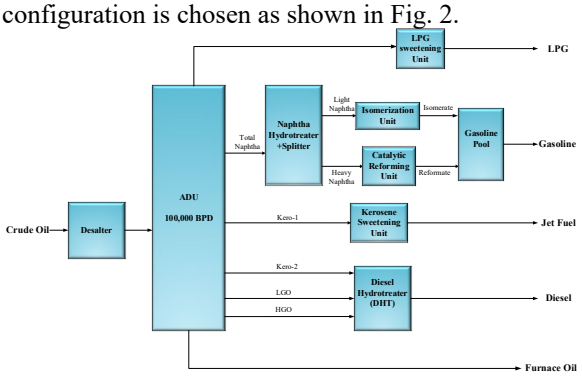

Fig.2: Simplified Process Block Diagram of 100,000 BPD crude oil refinery

A wide variety of crude oils can be processed in a refinery. Crude oil in its natural state has no value to consumers and must be transformed into products that can be used in the marketplace [10]. A crude oil assay is basically the chemical evaluation of crude oil feedstocks by petroleum testing laboratories. No crude oil type is identical and there are crucial differences in crude oil quality. They differ in their chemical composition, physical properties like density, viscosity etc. and types of impurities like sulfur, metals etc. Some of the typical properties of crude oils [11,12] are shown in Table 1.

Table 1: Typical properties and yield pattern of crude oils

Crude oils	Iran Light	Arabian Light	Sokol	Murban
Origin	Iran	Saudi Arab	Russia	UAE
ºAPI	33.8	33.40	34.8	40.50
Sulfur (wt.%)	1.33	1.77	0.29	0.74
Sp. gravity	0.856	0.858	0.851	0.823
Yield (%)				
LPG	1.5	1.9	3.2	1.0
Naphtha	17.1	14.6	10.3	22.2
Kerosene	8.0	8.3	11.3	12.5
Diesel	25.5	27.2	47.4	30.3
Furnace oil	47.9	48.0	27.7	34.0

The production pattern and processing method varies with the choice of crude oil. The sensitivity of product pattern with crude variation is shown in Fig. 3.

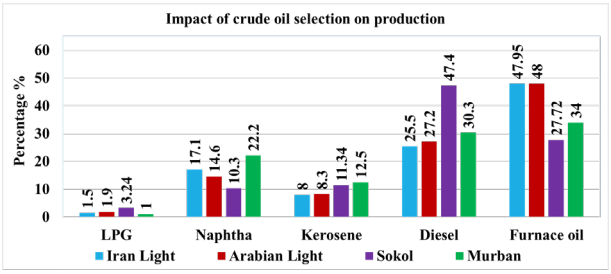

Fig.3: Sensitivity of crude oil on product pattern

2.1 Configuration of the Refinery

Each refinery is unique in its configuration. Refineries vary in size, sophistication, and cost depending on their location, the type of crude they refine, and the products they manufacture [10]. The chosen configuration of the refinery consists of the following main process units-

(i) Atmospheric Distillation Unit:
- Separates the crude oil into several primary semi-finished products to be further processed in downstream units.
- Designed with flexibility to process different combinations of light and heavy feed stocks

(ii) Naphtha hydrotreater:
- Removes impurities from straight run naphtha to meet downstream unit specifications.

(iii) Isomerization unit
- Used to upgrade RON of light naphtha and then blended in the gasoline pool

(iv) Catalytic Reforming unit
- Used to upgrade RON of heavy naphtha and then blended in the gasoline pool

(v) Kerosene sweetening unit
- Removes impurities such as mercaptans and other malodorous & corrosive compounds from straight run light kerosene to meet jet fuel specifications.

(vi) Diesel hydrotreater
- Removes impurities (mainly sulfur) from straight run cuts from ADU to meet environmental specifications.

(vii) LPG sweetening unit
- Removes impurities and converts mercaptans

(viii) Auxiliary units
- Other auxiliary units such as captive power source, boiler, hydrogen and nitrogen production unit, effluent treatment plant etc.

2.2 Selection of Crude Oil

For the proposed refinery configuration, Sokol crude oil is chosen as the feed to the ADU. Country of origin of the selected crude oil is Russia. It has an API gravity of approx. 36 and is rich in middle distillate cuts which are essential for Bangladesh. It also has a low sulfur % making it easier to process compared to other alternatives.

2.3 Plant Material Balance

For the chosen configuration, MS Excel 2016 is used to simulate the process based on typical yield of the selected crude oil and also the yield of various Licensed process units using literature value. The input and output values of the plant are shown in Table 2.

Table 2: Overall Material Balance of the plant

Feed/Products	Values (Ton/Year)	Percentage
Crude Oil	-4,785,374	-100.00
LPG	83,156	1.74
Jet A-1	379,002	7.92
Diesel	2,016,762	42.14
Gasoline	391,061	8.17
Reformate (export)	247,554	5.17
Furnace Oil	1,451,404	30.33
Total product	4,568,939	95.48
Loss + Consumption	-	4.52

2.4 Economic Analysis

After the product slate is obtained, overall economic analysis of the refinery is conducted using current market price of the raw materials and selling price of the products. For the products, both local and international price is used depending on the respective demand in local market and the import potential. For raw materials, factors such as freight, duties and lightering cost has been taken into account for calculation of feedstock landed price as per Eq. (1).

$$FLP = FOB + Fr + D + L \quad (1)$$

Variable costs such as cost of catalysts and chemicals, distribution and marketing costs, processing costs are taken into account to calculate unit cost of production as per Eq. (2).

$$CP_{unit} = FLP + VC \quad (2)$$

Total sales revenue is generated by multiplying the individual product quantity by its selling price and then adding the individual terms. Average selling price is then obtained as per Eq. (3).

$$SP_{avg} = \frac{TSR}{TF} \quad (3)$$

Total profit is calculated from the difference of total sales revenue and total cost incurred and depreciation costs as per Eq. (4). Net refining margin is then calculated by dividing total profit by the total quantities of feed processed as per Eq. (5).

$$TP = TSR - TC - T_{Dep.} \quad (4)$$

$$NRM = \frac{TP}{TF} \quad (5)$$

Finally, for a fixed capital expenditure, the payback period and the return on investment are calculated to assess the profitability of the project as per Eq. (6) and Eq. (7).

$$PB = \frac{FC}{TP} \quad (6)$$

$$ROI = \frac{TP}{FC} \times 100 \quad (7)$$

It is assumed that, the refinery project will start from January, 2020 with a duration of 42 months and come into operation on July, 2023. Finally, the product slate is compared with the forecasted market demand for each major product to analyze the impact on local fuel sector.

3. RESULTS AND DISCUSSION

Based on the economic evaluation described under section 2.4, the key financial aspects of the project are outlined in Table 3.

Table 3: Financial aspects of the plant

Item	Approx. Values
Total estimated cost	6,000 crore BDT
Yearly Revenue	1,250 crore BDT
Payback Period	4.5 years
Return on Investment	22.50%
Internal rate of return	21%

3.1 Market scenario for Diesel

Diesel is the most in demand petroleum fuel in our country with a rapid increase in demand each year. The current demand of diesel is around 5 million tons per year

(TPY) majority of which comes from import. Assuming an increase in demand of 5 to 6% per annum, the demand is projected and compared with the production from the proposed refinery by 2023. As shown in Fig. 4, the refinery output supplements the overall demand to an extent but there is still significant gap between supply and demand of around 3.5 million TPY which will increase gradually. In fact, there will be enough market demand to consider additional refining facilities in future.

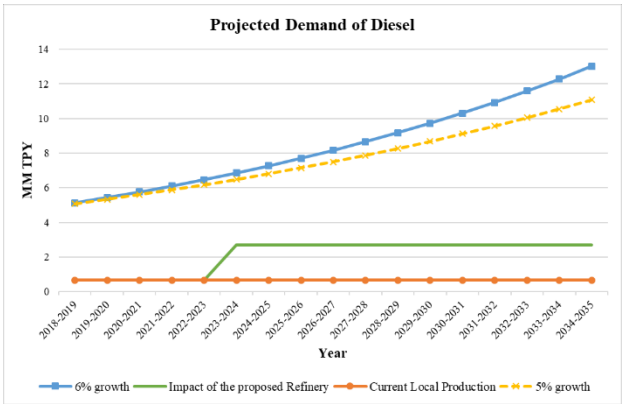

Fig. 4: Impact of the proposed refinery on Diesel market

3.2 Market scenario for Gasoline

Gasoline is the third most in demand petroleum fuel in our country with a gradual increase in demand each year. In local market, there are two grades of gasoline named petrol and octane with a combined demand of around 550 thousand TPY majority of which comes from local source. Assuming an increase in demand of 9 to 10% per annum, the demand is projected and compared with the production from the proposed refinery by 2023. As shown in Fig. 5, the refinery output almost meets the overall demand by 2023, but the gap between supply and demand will increase gradually from then onwards.

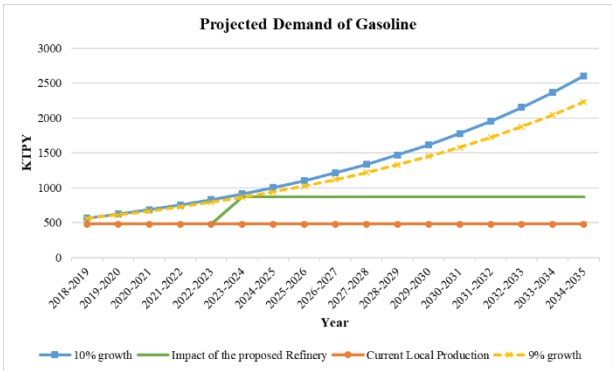

Fig. 5: Impact of the proposed refinery on Gasoline market

3.3 Market scenario for Furnace Oil

Furnace oil (also known as fuel oil) is the second most in demand petroleum fuel in our country after diesel with a gradual increase in demand each year. At present, the demand stands at around 1.6 million TPY majority of which comes from import by govt. and private sources. Assuming an increase in demand of 5 to 6% per annum, the demand is projected and compared with the production from the proposed refinery by 2023. As shown in Fig. 6, the refinery output supplements the overall demand, but the gap between supply and demand will be around 1.0 million TPY which will increase gradually. So, the proposed refinery will not be enough to completely meet the future demand and additional refining facilities may be considered in future.

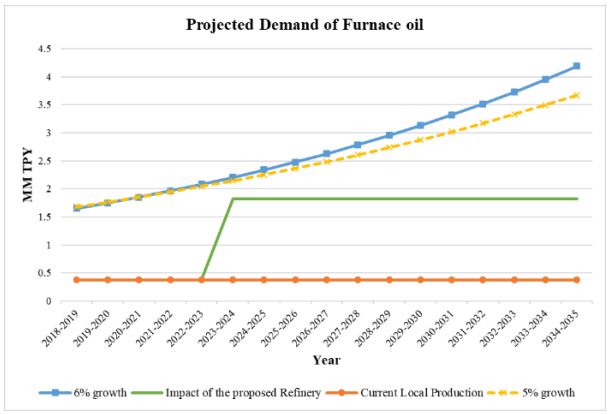

Fig. 6: Impact of the proposed refinery on Furnace oil market

3.4 Market scenario for Jet A-1

Jet fuel is also in high demand in our country and the demand is increasing each year. The current demand of jet fuel is more than 400 thousand TPY almost all of which comes from import. Assuming an increase in demand of 5 to 6% per annum, the demand is projected likewise and compared with the production from the proposed refinery by 2023. As shown in Fig. 7, the refinery output supplements the overall demand by 2023 with a gap of around 200 thousand TPY between supply and demand which will increase gradually from then onwards. So, the proposed refinery will not be enough to completely meet the future demand of jet fuel.

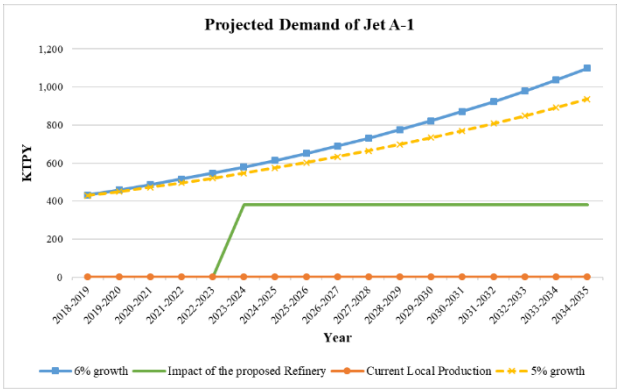

Fig. 7: Impact of the proposed refinery on Jet fuel market

3.5 Foreign Currency Savings

The refinery will help in saving a significant amount of foreign currency through reduction of import of petroleum fuels once it comes into full commercial

operation. Taking into consideration the recent import data from BPC [13], the overall scenario is outlined in Table 4.

Table 4: Foreign Currency Savings by the plant output

Type of Fuel	Approx. Yearly savings (crore BDT)
Diesel	10,000
Gasoline	2,250
Jet fuel	1,950
Furnace oil	4,900
LPG	400
Total	19,500

4. CONCLUSIONS

Petroleum sector is considered one of the most sensitive sectors of economy. Macro-economic indicators are highly sensitive to the price of petroleum products. The present petroleum sector in our country is predominantly import based. Since no refining facilities has been established for the last 50 years, the supply/demand gap has increased manifold over the course of time. As presented in this techno-economic study, the impact of a refinery in the economy of Bangladesh is a positive one. Not only it will supplement the fuel demand in the country but also it will reduce import dependency and create job opportunities both directly and indirectly, thus contributing significantly to the national economy. Investment in such sector will be a profitable one as highlighted by the economic analysis. The study also shows that, there will be significant demand in all the major petroleum fuels so that setting up of additional refineries may be taken into consideration. Among the wide variety of factors that affects the economics of an oil refinery, selection of crude oil and process configuration are important ones. They directly impact the product pattern and profitability of the plant, hence should be chosen carefully to optimize the outcome. The present study can be expanded further by analyzing the various crude oils in the market for profitability and also by changing the configuration of the refinery.

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6. NOMENCLATURE

Symbol	Meaning	Unit
FLP	Feedstock landed price	$/barrel
FOB	Free on board	$/barrel
Fr	Freight	$/barrel
D	Duties	$/barrel
L	Lightering cost	$/barrel
CP_{unit}	Unit production cost	$/barrel
VC	Unit variable cost	$/barrel
SP_{avg}	Average selling price	$/barrel
TSR	Total sales revenue	$/year
TF	Total feed processed	MT/year
TP	Total profit	$/year
TC	Total incurred cost	$/year
T_{dep}	Total depreciation cost	$/year
NRM	Net refining margin	$/barrel
PB	Payback period	year
FC	Fixed cost (lump sum)	$
ROI	Return on investment (per year)	%