V40

Final

Bangladesh Economic Zones Authority

Feasibility Study of Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata)

Infrastructure Investment Facilitation Company

March 2022

How comments on the draft report have been addressed:

	Comments	Actions
(1)	Please share a detail map in the introduction part including location, influence area, utility connection etc.	Covered as following: Location: Figure 2.1 and Figure 2.2 Influence Area: Figure 5.1 and Section 2.4 Utility Connection: Gas: Section 4.10.2 and Figure 4.21 Power: Section 4.9.2 Road: Figure 4.9
(2)	Change the location map (Figure 2.1)	Changed accordingly.
(3)	Environmental and Social Baseline : Please highlight the social impact for construction of approach road in this chapter including list of affected HHs	Discussed in Section 5.2 regarding land acquisition and resettlement issues.
(4)	Figure 2.5 : Please remove the picture and include a picture without signboard	Removed.
(5)	Please add detail of Moheshkhali Economic Zone in this chapter including investment proposal, BEZA plan and government initiative	Added. Discussed in Section 3.10 and in Section 4.2.
(6)	2.6 Genesis of Economic Zones in Bangladesh : the firm has highlighted the BSMSN Sreehatta, Jamalpur and Sabrang but we are working for construction of 28 EZs all around the country. Please add the overall progress in this chapter.	It is acknowledged and added in the report. But the most notable ones are provided to set the scene of showing that significant progress has been achieved by BEZA. But including progress of all projects loses relevance of the objective of this particular assignment, being not directly related to Moheshkhali EZ.
(7)	Master Plan of Moheshkhali Development: In this chapter you have highlighted the financial express news (you can use as a reference). Why you have incorporated the logo of FE.	FE is a publication, which generally has a news value. However, it has been removed, considering that it may raise controversy of promoting a particular publication.
(8)	Figure 2.6 Development of master Plan : in this map you have mentioned that Sonadia Eco-Tourism Park as Environment Reservation Area. Please delete this word. Pleas highlight the Moheshkhali EZ in this map.	Removed. As writing only eco-tourism park suffices the matter. Highlighted.
(9)	Road : Please share the land information and existing HHs information in this chapter including costing	The existing embankment will be used for the road and shown in Figure 4.9. Land information is provided in Section 5.2. However, identifying affected HHs is excluded from this assignment, being part of RAP. Also refer to clarification to Comment 16.

	Comments	Actions
(10)	Please share a utility map based on finding of feasibility study report (Gas, power, water and road)	Section 3.11 presents of summary of findings. The details of estimation of demand are provided in Annexure A11.
(11)	Please update electricity demand and role of PGCB, REB and BEZA	Updated based on the requirement estimated in Annexure A11. The roles of the PGCB, REB and BEZA are provided in Section 4.9 and Table 4.5.
(12)	Please add the land information in details for gas and approach road	Gas pipeline route has been shown in Figure 4.21. The route of approach road has been shown in Figure 4.9 and discussed that existing embankment will be followed for laying the road. However, land details require a separate LAP and will be part of DPP to be formulated.
(13)	Please remove the primary school from master plan	School removed from the broader picture, but not conceptually discarded for being part of CSR.
(14)	Please incorporate a detail master plan including utility plan	The assignment is to assess the feasibility of infrastructure provisions which excludes internal layout of the EZ. However, an indicative master plan (Figure 4.4) has been provided for the sake of readability of the whole report, with appropriate context only.
(15)	Please try to avoid secondary information for minimizing the negative impact of environment	Avoided.
(16)	Please submit the final report along with the actual acquisition price (mouza, dag no. ,amount of land) of the land information	The estimated acquisition price is provided in Table 5.5. Actual acquisition price, however, is excluded from the scope of this assignment, for being part of LAP, which needs to be carried out separately, after approval of DPP. Therefore, this study kept provision for cost of such LAP under the heading "Preparation of LAP and Updating ESIA," as part of cost estimate in Table 4.8 under Section 4.17. However, as a basis of the estimate of the acquisition price, an indicative list of mouzas and dags (*i.e.* land information) falling on the stretch of land along the alignment of approach road and gas transmission line has been identified in Section 5.2 with details in Annexure A12 and mouza rates for respective mouzas have been considered, so that an average mouza rate on the whole stretch of land can be applied.

Contents

Abbreviations

ADB	Asian Development Bank
BBS	Bangladesh Bureau of Statistics
BCR	Benefit Cost ratio
BMD	Bangladesh Meteorological Department
BOD	Biochemical Oxygen Demand
BSCIC	Bangladesh Small and Cottage Industries Corporation
BTCL	Bangladesh Telecommunications Company Limited
BWDB	Bangladesh Water Development Board
CAD	Computer-aided design
CAPEX	Capital expenditure
CETP	Common effluent treatment plant
COD	Chemical oxygen demand
CPI	Consumer Price Index
DAE	Department of Agriculture Extension
DC	District Commissioner
DLS	Department of Livestock
DO	Dissolved oxygen
DOE	Department of Environment
DoF	Department of Forest
DoF	Department of Fisheries
DPHE	Department of Public Health and Engineering
EBCR	Economic Benefit Cost Ratio
EC	Electrical Conductivity
ECC	Environmental Clearance Certificate
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMMP	Environmental Mitigation and Monitoring Plan
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EPC	Engineering, Procurement, and Construction
EPS	Environmental Performance Standard
EPZ	Export Processing Zone
ER	Emergency Response
EIRR	Economic Internal Rate of Return
ENPV	Economic NPV
ESIA	Environmental and Social Impact Assessment
ETP	Effluent Treatment Plant
EU	European Union
EZ	Economic Zone
FAO	Food and Agriculture organization
FBCR	Financial Benefit Cost Ratio
FGD	Focus Group Discussion
FIRR	Financial Internal Rate of Return
FNPV	Financial NPV
FS	Feasibility Study
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System

GSB	Geological Survey of Bangladesh
GTCL	GAS Transmission Company Limited
HH	Household
HIES	Household Income and Expenditure Survey
ICT	Information and Communications Technology
IESC	Important Environmental and Social Component
IMF	International Monitory Fund
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
IZ	Industrial zone
KII	Key Informant Interview
LDC	Least Developed Countries
LGED	Local Government Engineering Department
LNG	Liquefied natural gas
MNC	Multinational Company
MOU	Memorandum of understanding
NGO	Non-Govt. Organization
NOC	No Objection Certificate
NPV	Net Present Value
NWRD	National Water Resources Database)
O&M	Operation and Maintenance
OECD	Organization for Economic Cooperation and Development
OFC	Optic Fiber Network
OPEX	Operating expense
PBS	Palli Bidyut Samity
PC	Planning Commission
PDM	Public Disclosure Meeting
PGCB	Power Grid Company of Bangladesh Ltd.
PGCL	Pashchimanchal Gas Company Limited
PIA	Project Influenced Area
PM_{10}	Particulate Matter
$PM_{2.5}$	Particulate Matter
PPP	Public-Private Partnership
REB	Rural Electrification Board
RFP	Request for Proposal
RMG	Ready-Made Garment
SCC	Site clearance certificate
SEZ	Special Economic Zone
SIA	Social Impact Assessment
SPM	Suspended Particulate Matter
SRDI	Soil Resource Development Institute
TDS	Total Dissolved Solids
Temp	Temperature
TOR	Terms of Reference
TSS	Total Suspended Solids
UNDP	United Nations Development Programme
UNO	Upazila Nirbahi Officer
WARPO	Water Resources Planning Organization
WB	World Bank
WHO	World Health Organization

Executive Summary

Feasibility Study of Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata)

Scope: This contract covers detailed feasibility study for the Infrastructure Development (Gas, Electricity and Communication) at Moheskhali Economic Zone (Dhalghata). The Kutubdia channel is within the 10 km radius of the project site and Moheshkhali channel is adjacent to the project site. It has been analyzed through assessment of environmental components like air, water, land, noise, soil, etc. and environmental characteristics like physical, biological and socio-economic status of the study area, within the 10 km radial zone of the project site.

Government of Bangladesh has successfully provided serviced land, infrastructure, and a good business environment via the Export Processing Zones (EPZs). Bangladesh Economic Zones Act, 2010 was passed in the Parliament in August 2010, providing an overall framework for establishing EZs throughout Bangladesh.

Digital Island Moheshkhali. BEZA itself has development plans for establishing several economic zones and tourist attractive places. Coal Power Generation Company of Bangladesh Limited (CPGCBL) has an expansion plan of their power plant facility in Moheshkhali. These projects will require about 34,000 acres of land. The plan envisages the island as a massive economic and trade activity center with own power generation, gas transmission, electricity distribution and supply, roads etc. A gas pipeline from Nalbila to Dhalghata is being planned for supply of gas to the proposed economic zone. Power and gas lines are running nearby the site.

Site Visits: Consultation with the stakeholders was used to improve the plan and design of the project rather than merely having project information dissemination sessions.

Main Components of the Project and the Assignment. The proposed infrastructure development (gas, power and communication) at Moheshkhali Economic Zone (Dhalghata) will ensure quality utilities and other common facilities for investors. An admin building was later included.

Technical Design. As the Moheshkhali Economic Zone is situated in Zone 3 of earthquake map of Bangladesh, some special standards and specifications have to be complied with for design. Having location in Zone-III the land buildings and land-based structures for this Project should be designed to withstand maximum lateral load of 28% of gravity load.

Gas. The national gas grid up to Chattogram is the potential source of supplying natural gas to the proposed zone. National Gas Grid system, operated by Gas Transmission Company Limited (GTCL), has been further strengthen by adding a 42 inch gas transmission pipeline from Moheshkhali to Anowara parallel to a 30 inch gas transmission pipeline from Moheshkhali to Anowara.

A gas transmission pipeline from nearest gas transmission pipeline of GTCL and distribution pipelines within the zone are to be constructed. Gas Transmission Company Limited has identified the route of the transmission pipeline from the Nalbila Valve Station up to Moheshkhali Economic Zone. GTCL has proposed a 250 mmscfd gas Town Bordering Station

(TBS) to reduce and process for measurement the gas receives at the TBS and supplies to the proposed EZ inside gas networks to be constructed under this project.

Electricity. For running construction equipment and machinery, approx. 5-10 MW power is estimated to be required. Based on industry assessment, power demand for the proposed EZ during operation will be about 292 MW. Construction may be fed by (1) and (2) and operation by (1), (2), (3) and (4):

(1) 33/11 KV, 2x20/28 MVA Indoor SS: with the intake of power routed through the existing 33 KV power line between 132/33 KV, 2x25/41 MVA grid SS at Matarbari and the indoor SS. The indoor SS, as a base case, is planned to feed partial operation of the EZ. However, it may also be used during construction, if built before construction, to cater the demand in subsequent phases *i.e.* construction and operation.

(2) 11 KV Line**:** from PUL Power to the site to be connected with the live line and thus, HT power in 11 KV will be made available to run BEZA's construction activities.

(3) 230/132/33 KV grid Sub-Station (3x120/140 MVA capacity): to be installed by PGCB as part of 'Matarbari 400/230/132 KV SS and Associated Transmission Line Project' to cater the power demand in the zone during operation. This is to ensure adequate power supply to the zone as per PGCB's objective.

A requisition to PGCB by BEZA, to extend a 230 KV line form Matarbari 400/230/132 kV SS directly to the BEZA site with a grid sub-station of 3x120/140 MVA capacity, is in the pipeline. Few 230/132/33 KV SSs are also to be built in the site with provision of multiple 230/132/33 KV bay breakers.

(4) Power Generation by the Industries Themselves: In case the industries planned in the EZ may have features of extremely power sensitiveness in respect of fluctuations (voltage and frequency) and interruptions, those may go for arranging power through generation by themselves with due concurrence and approval of the concerned authority.

Water Supply. The EZ will draw sweet water from underground sources. It will also pump in saline water for supplying cooling water to the power plants. The pipeline carrying raw water to the project site is proposed to run parallel to road laid as per proposed master plan.

Admin Building: One of the fundamental onsite infrastructures of any economic zone (EZ) is the construction of administrative building. An area of 605 sqm land has been allocated for admin building aimed to support the Moheshkhali Economic Zone during its construction and operational activities by Bangladesh Economic Zones Authority (BEZA).

Prospective Industries. The industries under the sectors identified for the zone to be suitable need relatively large areas of land. The petrochemical complex under implementation in the EZ itself occupies around 500 acres of land. The following table provides the sectors for which the EZ is planned:

(1) Oil Refinery and Petrochemicals
(2) Marine Fish Processing
(3) Ship Building and Repairing
(4) Steel Manufacturing/Rerolling
(5) Logistics Hub/Gas Bottling
(6) Automobile and Heavy Engg.

Cost Estimate. The cost estimate of the infrastructure to be installed as part of the scope of infrastructure design has been carried out. It includes costs for gas and power installations and admin building.

Estimated Cost: ৳ 103,327 lakhs

Financial and Economic Analysis. To demonstrate the financial viability of development of the project the following inputs have been considered: demand forecast, expected utility rates, cost estimates, planning parameters and other information. A financial model has been developed for analysing on options for cost recovery of capital investments and recurrent costs under different demand forecast scenarios. The following table provides the results:

Net Present Value

Discount Rate	FNPV	ENPV
	৳ lakh	৳ lakh
12%	16,200	39,400
14.08%	-	16,700
30%	(48,300)	(48,900)
25%	(41,100)	(39,500)
16%	(12,000)	-

Scenario Analysis

	FIRR	EIRR
Base Case	14.08%	16.09%
Aggressive Case	14.74%	17.09%
Conservative Case	13.49%	15.21%

Review of various reports and activities carried out under this study concludes that development of the economic zone is suitable in the area and is expected to play a key role in improving the industrial and business opportunities in Moheshkhali. It will facilitate organized industrialization in the island, with provisions for the development of backward linkages and an industrial ecosystem with all the required utilities and amenities.

1 Basic Information

(1)	Name of the project	:	Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata)
(2)	(a) Sponsoring Ministry/Division	:	Prime Minister's Office
	(b) Implementing Agency	:	Bangladesh Economic Zones Authority
(3)	Project Objectives	:	Infrastructure Development (Gas, Electricity and Communication) at Moheshkhali Economic Zone (Dhalghata)
(4)	Estimated Project Cost (BDT)	:	৳ 103,327 lakhs
(5)	Sector and Sub-Sector	:	Industry and Energy Division Jute, Textile, BEZA and BEPZA
(6)	Project Category (Based on Environment Conservation Rules 1997)	:	Red
(7)	Project Geographic Location	:	
	Countrywide		Bangladesh
	Division		Chattogram Division
	District		Cox's Bazar
	Upazila		Moheshkhali
	Others (City Corporation/Pourashava)		NA
(8)	Project Duration	:	Tendering Process: 12 mons Construction: 36 mons

2 Introduction

2.1 Project Background

The proposed Moheshkhali Economic Zone is located at Dhalghata union of Moheskhali Upazila at Cox's Bazar District under Chattogram Division as part of a master plan for development of Moheshkhali. Chattogram is the commercial capital of Bangladesh and Chattogram Port is the major gateway for the foreign trade of the country. The Division contributes 19% of overall GDP of the country. Cox's Bazar is the most important tourist spot of Bangladesh with one of the longest sea beaches in the world. Significant development is happening on the northern side of Dhalghata at Matarbari such as a deep sea port and a coal based power plant. The bulk of activities are currently happening with Matarbari at the center.

The land is muddy with loose and unsettled soil. Land filling is being carried out by one[1] of the companies (licensed by BEZA) for petrochemical industries mainly distilling crude oil to refined forms. The land filling is nearing completion. A preliminary jetty structure of the company required around 25 m deep piling which indicates the softness level of the clay in the site.

Currently the main communication of the site with the main land is through Badarkhali at Chakaria of Chattogram district or through Cox's Bazar district through waterways. A semi-pucca and katcha road network is available from Matarbari to Dhalghata across the island alongside the dam of BWDB.

2.2 Objective of the Study

This contract covers detailed feasibility study for the Infrastructure Development (Gas, Electricity and Communication) at Moheskhali Economic Zone (Dhalghata).

2.3 Location of the Project

Proposed EZ is located at Moheshkhali, an island on the western part of Cox's Bazar district at a distance of around 345 km from Dhaka. It can be accessed via Dhaka-Chattogram Highway and RI 72 (2 lane regional highway originating from Dhaka Chattogram Highway). The project is approximately 18.03 km away from Moheshkhali Municipality and 12.10km and 16.85km from the Kutubdia and Sonadia Island. The site is surrounded by the Bay of Bengal towards the south and the west. A deep sea port is also planned at Matarbari, a union adjacent to Dhalghata. Access to sea port is the key enabler towards setting up industries at Moheshkhali. Key location attribute of the project site is its waterfront (Bay of Bengal) access making it suitable for heavy industries requiring waterfront (like shipbuilding, cement, steel, and heavy machineries).

However, the last mile connectivity of the site is through dirt tracks which are unsuitable for movement of commercial vehicles. Currently travel time from Dhaka to the proposed EZ is

[1] TK Group of Companies

around 10-12 hours. A road between Matarbari power plant and the Dhaka-Chattogram Highway is being developed and land acquisition for the project is in progress. It is envisaged to improve the connectivity of the region with Chattogram, thereby increasing its attractiveness as an industrial location. As shown in Figure 2.6, it is situated near Kuhelia River on the west side of Dhalghata union. Additional land is under planning. The surroundings are as follows:

Table 2.1: Surroundings of the Site

		Objects	Coordinates	Distances
(1)	On North	Salt Cultivation	21°48'32.84"N 91°51'23.75"E	Kutubdia Island and Matarbari coal fired power plant are 12.10 km and 3.61 km away respectively from the project site.
(2)	On South	Bay of Bengal	21°25'05.72"N 91°56'04.71"E	Sonadia Island is 16.85 km away from the project site.
(3)	On East	Kuhelia River	21°39'04.97"N 91°47'46.76"E	Adjacent to boundary.
(4)	On West	Bay of Bengal	21°39'01.95"N 91°58'46.24"E	Adjacent from the boundary

Matarbari coal fired power plant is approximately 3.61 km and Deilpara road and Janatabazar-Gorokghata roads are about 12 km and 5.18 km from the project site. The Kutubdia channel is within the 10 km radius of the project site and Moheshkhali channel is adjacent to the project site.

There are no settlements on the land. However, most of the area under demarcation is owned and used for shrimp farming and salt cultivation or remain deserted. This study assumes 1,240 acres as the defined area for the EZ, although additional land is in the pipeline for future development in the next phase (resulting size of the EZ 2,000 acres). Most of the land is khas and therefore, required no major acquisition. In the meantime, BEZA allotted 510 acres to TK Group for establishing a petro-chemical complex in the zone.[2]

[2] mostly for refining crude oil to finer oil commodities

Figure 2.1: Location of the EZ in Moheshkhali

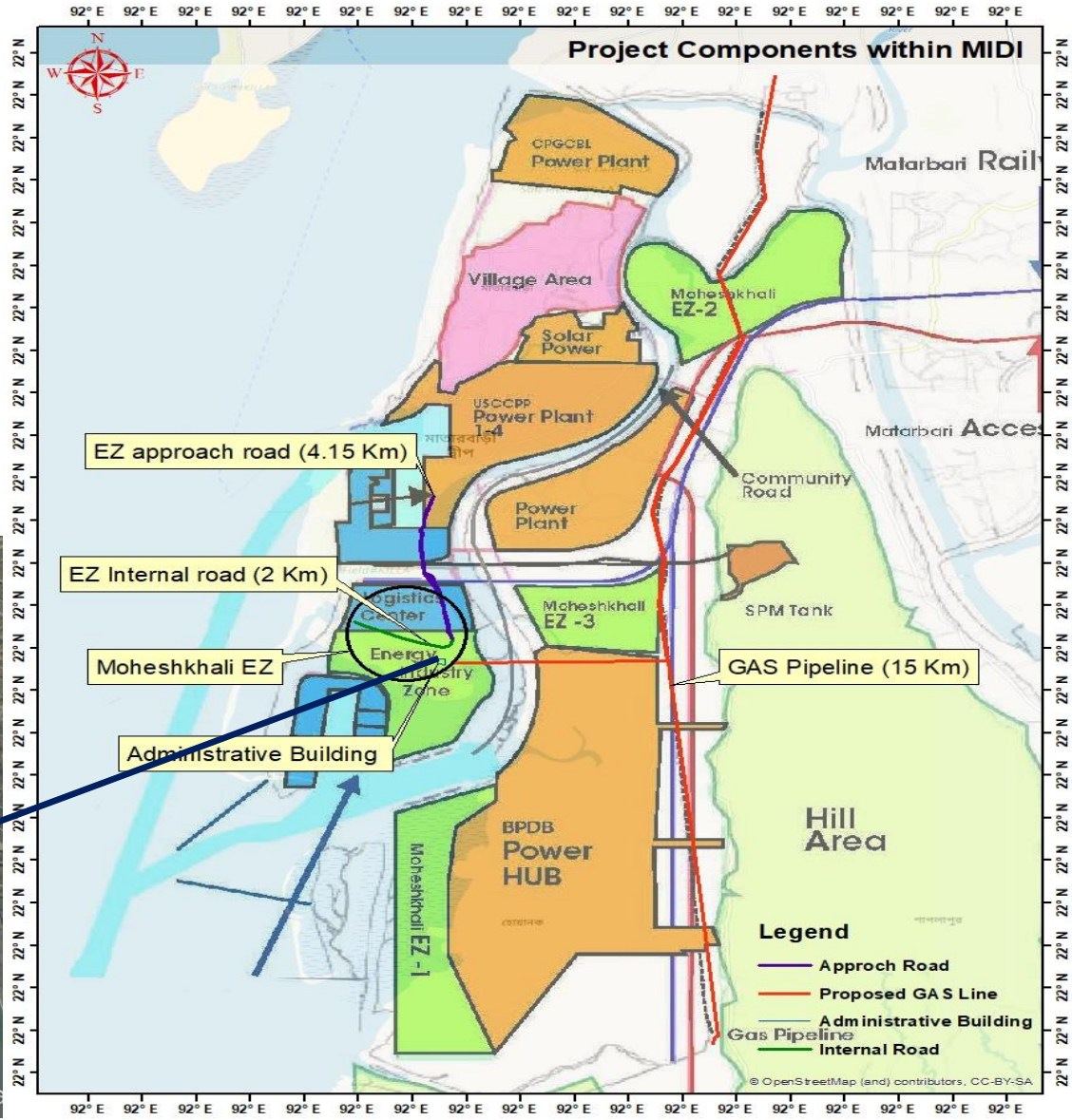


Figure 2.2: Moheshkhali Economic Zone at Dhalghata

Points	Latitude	Longitude
A	21°39'58.00"N	91°52'17.17"E
B	21°39'35.80"N	91°52'57.29"E
C	21°38'36.72"N	91°53'9.20"E
D	21°38'59.49"N	91°52'12.12"E
E	21°39'35.78"N	91°51'13.81"E
F	21°40'30.37"N	91°51'21.95"E

2.4 Environmental and Social Baseline

It has been analyzed through assessment of environmental components like air, water, land, noise, soil, etc. and environmental characteristics like physical, biological and socio-economic status of the study area, within the 10 km radial zone of the project site. Physical environment includes topography, land, soil, meteorology, air, water, noise, etc. and the biological environment includes flora and fauna. Socio-economic environment of the study area includes demography, ethnicity, religion, education and employment opportunity, occupation, income, poverty, social relations, etc.

Baseline environmental conditions are based on the data collected from various related agencies and the secondary documents from published sources and websites. The baseline provides the basis for assessment of impact (potential changes in the baseline conditions) due to the development of proposed zone.

Figure 2.3: Environmental Baseline

(1)	Site Elevation	Average 4-5m from MSL
(2)	Land Type	Medium high land
(3)	Nearest Airport	Cox's Bazar International Airport is about 25.81 km away from the site
(4)	Nearest Railway Station	Chattogram Railway Station is about 70.73 km away from the site
(5)	Nearest Port	Chattogram Sea Port is about 70.34 km and Payra Sea Port is about 167.30 km away from the site

(6)	Climatic conditions	Temperature: The annual average temperature varies maximum 34.8°C to minimum 16.1°C. Humidity: Average humidity is around 75.5% throughout the year. Rainfall: The average annual rainfall is recorded approximately 4285 mm.
(7)	Seismic Zone	Zone II (Seismic co-efficient is 0.05g)
(8)	Forests / National Parks	None within 10 km.
(9)	Archaeological Site	The Adinath temple is nearest and the most famous historical place of this Island.
(10)	Water Bodies	Matamuhuri, Bakkhali, Reju Khal, Naf, Uzantia, Kuhelia, Masgona, Moheshkhali channel and Kutubdia channel are main rivers and channels of this district.
(11)	Climate	Project is situated at south-eastern climatic sub region of Bangladesh. Annual average temperature and rainfall varies from maximum 34.8°C to minimum 16.1°C. The annual average rainfall is 4285 mm. The district having been a coastal region often fall victim to sea storm, tidal bore, hurricane and cyclone.
(12)	Ecologically Critical Area	No ecologically critical areas were found within the study area. Kutubdia island is around 12.70 km and Sonadia island is 17.89 km away from the project site.
(13)	Reserve/Protected Forests	No reserve or protected forests were found within the study area.
(14)	Predominant Geological Formations	Project area falls under Chattogram coastal plain. The geological formation of this area is alluvium, stream deposits, delta plain deposits, flood plain deposits.
(15)	Topography	The topography of the project area is predominantly medium high land.
(16)	Major Physiographic Units	The proposed EZ is located in Chattogram coastal Plain.
(17)	Major Soil Type	The project survey area falls in the soil tract group 3, 10, 17a and 17b which are acid Sulphate soil; Grey Piedmont Soils; Mainly Deep, Brown (some red), Soils on low hills and Deep and Shallow Brown soils on very steep, high hill ranges respectively.
(18)	Major crops	Paddy, potato, pulse, onion, garlic, ginger, betel leaf, betel nut, wheat, sugarcane, ground nut, tobacco, rubber and vegetables are main crops of the district.
(19)	Flooding	The proposed project area falls under coastal tidal flood porn area.
(20)	Seismicity	The project area falls in the earthquake Zone-II of the seismic map of Bangladesh. This zone refers comparatively medium intensity of seismic effects.
(21)	Environment and Social Hotspots	Sea, River, Canals, Homestead forests and vegetation, School, College, Madrasa, Mosjid, Mandir, Monasteries etc.
(22)	Major Settlement	Residential area, Commercial area, Industrial Area, Bus terminals, Institutional structures, etc.

(23)	Major Industries/ Business Entrepreneurs	Manufacturing industries of the district are rice mill, salt mill, ice factory, flour mill, fish processing industry, fish feed mill, saw mill, printing press.

2.5 Current Economic Activities at Moheshkhali

The construction of Matarbari coal based power plant has impacted significantly on the social and economic fabric of the society living in Moheshkhali. The reason behind is the huge employment opportunity with significant increase in level of income, created by the project. In fact construction of this power plant is currently one of the main economic activities in the island.

Figure 2.4: Matarbari 1200 MW Coal Based Power Plant Site under Construction

However, this has been relatively recent phenomenon. Traditionally, the principal businesses of local inhabitants are fishing, shrimp and crab farming and salt cultivation. There are many pond-like small and large water reservoirs all over Moheshkhali. These are used for aquaculture during wet season and salt cultivation during dry periods.

Figure 2.5: Catch of Large Sea Fish from around Moheshkhali

2.6 Genesis of Economic Zones in Bangladesh

The sustained growth in Bangladesh's labor force (nearly 2_{mn} a year) is an asset that increased the country's competitiveness in the world market. Creating productive employment will largely depend on creating an environment conducive to private sector investment, particularly within the labor-intensive manufacturing and service sectors. Government of Bangladesh has successfully provided serviced land, infrastructure, and a good business environment via the Export Processing Zones (EPZs). However, Bangladesh's current EPZ model has had its limits, both in terms of cumulative impacts and spillovers into the domestic economy for its concentration around two major cities. The GoB's objective is therefore to maximize the potential direct and indirect impacts through a more modern regime of Economic Zones (EZs) in new areas. Therefore, the government launched a new EZ paradigm in Bangladesh with a vision of developing 100 EZs drawing on numerous successful examples from around the world, as well as Bangladesh's own positive experience with the EPZ model.

In addition, government is expecting additional spillover effects to local firms stemming from new foreign direct investment and from more investment within value chains. This will in turn stimulate the procurement of more local products and produce better linkages of local businesses with exports. A faster adaption to international environmental and social practices is also being encouraged through the EZ regime. It provides for a new approach both in management and investment.

Bangladesh Economic Zones Act, 2010 was passed in the Parliament in August 2010, providing an overall framework for establishing EZs throughout Bangladesh. Under this Act, the Bangladesh Economic Zones Authority (BEZA) was established under the Prime Minister's Office (PMO) to be governed by a Board chaired by the Prime Minister. The law provides the legal coverage for attracting and leveraging private investment in the development of zones as zone developers or operators, and in the provision of providing infrastructure services, such as power, effluent treatment, wastewater treatment etc. The law also allows for development of EZs and support infrastructure through a Public-Private Partnership (PPP) mechanism. BEZA has achieved a remarkable track record of earmarking and developing a number of EZs through government funding as well as licensing many private and PPP EZs. Currently BEZA is working for construction of 28 EZs. Most notable ones are:

(1) Bangabandhu Sheikh Mujib Shilpanagar
(2) Mongla Economic Zone
(3) Sreehatta Economic Zone
(4) Feni Economic Zone
(5) Dhaka Economic Zone (Keraniganj)
(6) Moheshkhali Economic Zone
(7) Sabrang Tourism SEZ

2.6.1 Bangabandhu Sheikh Mujib Shilpanagar

BEZA is undergoing a massive program of developing Bangabandhu Sheikh Mujib Shilpanagar which is located at Mirsharai and Sitakundu of Chattogram district and Sonagazi of Feni district. It is planned on 30,000 acres of land on the mouth of Feni River, covering 25 km of coast lines alongside Sandwip channel of the Bay of Bengal. A number of projects are

being undertaken for making the shilpanagar a fully functional industrial city.[3] Mirsarai[4] Economic Zone (1st Phase), a part of the shilpanagar is being developed encompassing an area of 550 acres. A private developer is on-board for the development. Plots have already been started being allotted in Mirsarai Economic Zone 2nd Phase.[5] Contractor has been engaged for development of the 3rd Phase. The following large allotments have been made:

(1)	BEPZA Economic Zone- Mirsharai	1,150 acres
(2)	BGMEA Garments Park	500 acres
(3)	Bashundhara Industrial Economic Zone	500 acres
(4)	Land allotted to Ananta group	250 acres
(5)	Land allotted to Kunming Iron and Steel Holding Company	

2.6.2 Sreehatta Economic Zone

Sreehatta Economic Zone is located on 352 acres of land in Sherpur Sadar upazila, east of Sylhet, west of Habiganj, Sunamganj on the north and Moulavibazar district on the south. Ground work started in February 2016. Jalalabad Gas Distribution Company Limited has started the construction of a pipeline for providing gas connections to the Sreehatta Economic Zone and BREB is constructing a 33/11 KVA power sub-station for electricity supply. Land development, electricity supply lines and lake development work has already been started by BEZA. In March 2017, investment proposals were invited for Sreehatta Economic Zone and in the meantime, six entities were allotted 231 acres of land.

2.6.3 Jamalpur Economic Zone

This is located in Jamalpur District bordering with the Indian state of Meghalaya. The zone is planned to occupy more than 245 acres of land. The boundaries have been earmarked. The necessary facilities like power station, grid lines and administrative building are operational. Land development work is already undergoing.

2.6.4 Sabrang Tourism SEZ

This SEZ is under implementation in Sabrang in Teknaf Upazila under Cox's Bazar District with an area of 882.26 acres land owned by BEZA. It is the first exclusive tourism park in the Cox's Bazar district, the tourism hub of Bangladesh.

---

[3] (1) Mirsarai Economic Zone -Flood Control, Road Cum Embankment Protection and Drainage Project in Chittagong District
(2) Construction of motorable pavement-18.488 km
(3) Construction of Sluice – 9 nos.
(4) Re-excavation of khal 30.000 km
(5) Construction of super dyke (Embankment) – 18 km
(6) Slope Protection of Embankment -17.872 km
(7) BR Powergen 150 MW Power Plant
(8) Gas Pipeline for Mirsarai Economic Zone and KGDCL, Gas Distribution Network Up-gradation Project from 350 MMSCFD to 500 MMSCFD
(9) Access Road - 10 km
(10) 230/33 KV GIS grid substation - 2×120/180 MVA
(11) 400 KV double circuit transmission line - 7 km

[4] A different spelling of Mirsharai

[5] Plots in the zone have been allotted to Kiswan, Integra Apparels, Reza Fashion, Naf Apparels, Green health, Juhana Textile, Orchid Energy, Gas-1, Fawn International, Great wall Ceramics etc.

2.7 Master Plan of Moheshkhali Development

The government has taken a master plan for development in Matarbari and Moheshkhali Islands through different implementing agencies, with finance from JICA under the project "Moheshkhali-Matarbari Integrated Infrastructure Development Initiative" (MIDI). The master plan is presented in Figure 2.6. Envisaging the effective implementation of this plan, the government of Bangladesh has formed 14 member Moheshkhali-Matarbari Integrated Infrastructure Development Initiative (MIDI) coordination committee headed by the Principal Coordinator (SDG) under the Prime Minister's Office for overall coordination, monitoring and implementation of the projects under implementation, and the future projects in this area.

To develop the connectivity between the mainland of Bangladesh, upgradation of transportation infrastructure development activities such as road and railway network in Matarbari and Moheshkhali Islands is currently going on to facilitate the development projects including the economic zones, tourism parks, power generation plant, etc. On the other hand, to build connectivity with overseas, construction of a deep seaport is also in pipeline. Large scale development activities are going on based on the Moheshkhali-Matarbari Development Plan. A number of establishments are envisaged as part of the plan. They include[6] as follows:

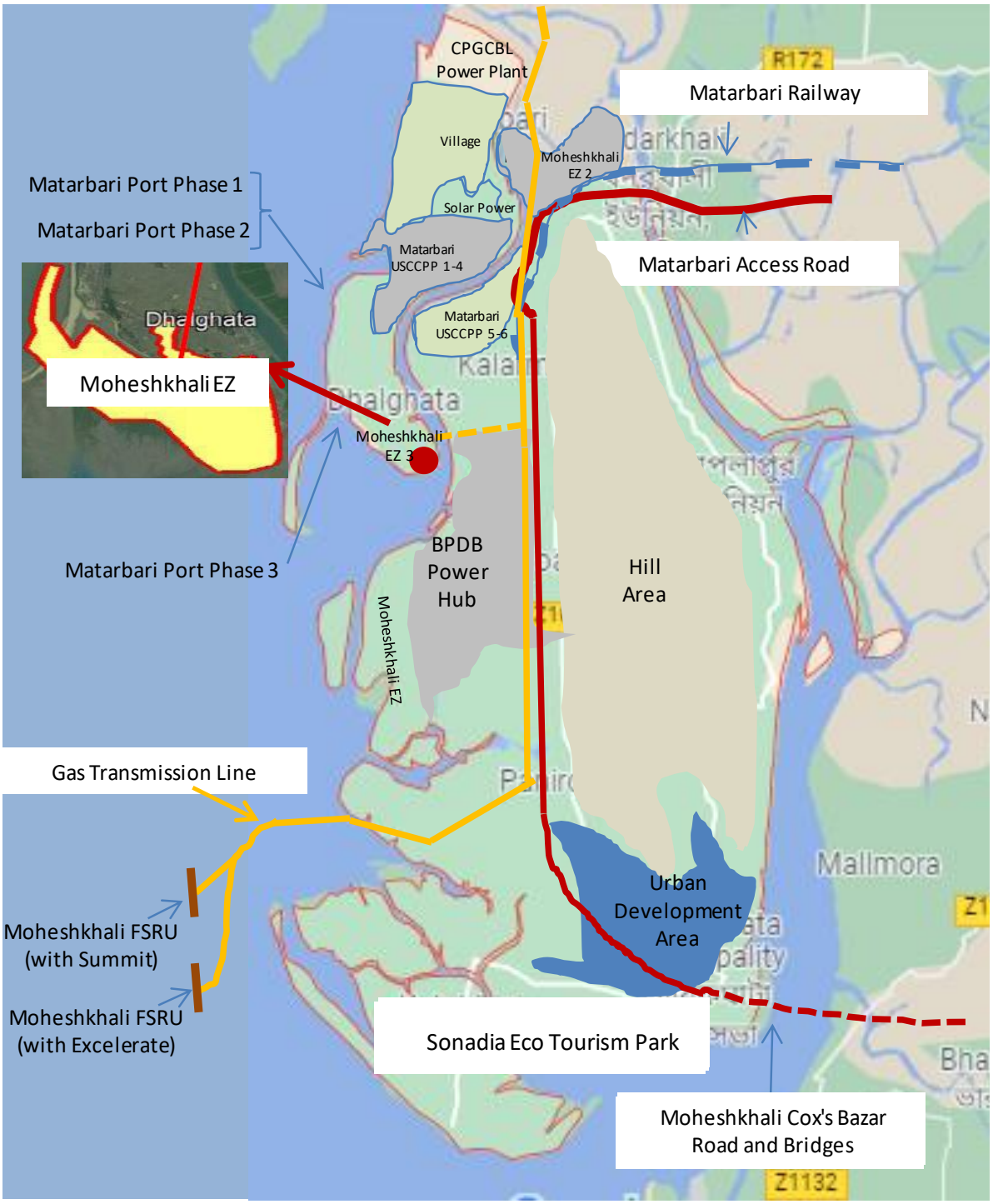
(1) Bangladesh-Singapore 700 MW Coal-based Power Plant: 1,197.88 Acre
(2) Kuhelia 700 MW Coal Power Plant: 360 Acre
(3) LNG and Coal-based Thermal Power Plants: 4,961.95 Acre
(4) Matarbari (600 X 2) 1,200 MW USC Coal Power Plant: 1,414.05 Acre
(5) Installation of SPM with Double Pipeline Project: 32.40 Acre
(6) Moheshkhali - Anowara 79 km parallel Gas Pipeline (Diameter: 42 Inch): 26.56 Acre
(7) Moheshkhali - Anowara 91 km Gas Pipeline (Diameter: 30 Inch)
(8) Moheshkhali Zero Point - Moheshkhali CTM 7 km Gas Pipeline (Diameter: 42 Inch)
(9) Sonadia LNG Terminal-1: 500.00 Acre
(10) LNG Terminal-2: 700 Acre
(11) Kuhelia Economic Zone (Dhalghata): 1,000.00 Acre
(12) Moheshkhali Economic Zone-1 (proposed): 826.00 Acre
(13) Moheshkhali Economic Zone-2 (proposed):670.00 Acre
(14) Moheshkhali Economic Zone (BEZA): 11,471.27 Acre
(15) Moheshkhali Economic Zone-3 (Dhalghata): 3,055.46 Acre
(16) Sonadia Eco-tourism Park under BEZA: 8,045.78 Acre
(17) Road, Bridge and Approach Road to connect Matarbari Coal Power Plant: 62.26 Acre
(18) Digital Island Moheshkhali.

BEZA itself has development plans for establishing several economic zones and tourist attractive places. Coal Power Generation Company of Bangladesh Limited (CPGCBL) has an expansion plan of their power plant facility in Moheshkhali. These projects will require about 34,000 acres of land. The following news provides a glimpse of the national importance that has been provided by the government for the development of Moheshkhali. In fact, government is also planning an authority (*i.e.* Moheshkhali Development Authority) to

[6] Source: Bangladesh Working Group on External Debt

expedite the development of the island. The plan envisages the island as a massive economic and trade activity center with own power generation, gas transmission, electricity distribution and supply, roads etc.

Figure 2.6: Development Master Plan of Moheshkhali



As shown in Figure 2.6, Matarbari deep sea port is planned to operate as an LNG transportation hub for mainland as well as for gas supply in the island. A gas pipeline from Nalbila to Dhalghata is being planned for supply of gas to the proposed economic zone. A two lane road (with provision of 4 lanes) between Moheshkhali and Cox's Bazar with a long

connecting bridge is also under planning. Power and gas lines are running nearby the site. Electricity is supplied to the settlements from nearby Matarbari substation with a single circuit line. However, new electricity supply line alongside the existing one needs to be established for covering the desired load at the proposed EZ. Therefore, there is a gas transmission pipeline to off take gas from LNG jetties at Sonadia. Figure 2.6 depicts the alignment of the same. The nearest power source is the substation at Matarbari connected with main grid in the mainland, being used for construction of Matarbari coal based power plant.

It is understood that ground water would be the easiest source of fresh water. With regard to surface water sources, there is a river named Kuhelia passes nearby the site and Bay of Bengal is on the other side of the site. However, the water is saline and need desalination before human use.

2.8 Railway Development Project

Implementation of the development plan of the Dohazari-Cox's Bazar dual gauge Railway Line is underway. In addition, the government has also plan of extending this line to Matarbari and Moheshkhali to facilitate the Matarbari Seaport and the economic zones in Moheshkhali and Matarbari.

2.9 Matarbari Ultra Super Coal Fired Plant

Construction of an ultra-supercritical coal-fired power plant is underway. The objective of the project is to meet the current demand and the rising demand in future resulting from the implementation of the economic zones and other linked projects. It is expected that construction of the first ultra-supercritical coal-fired power plant (capable of producing 1,200 megawatts of power), will help mitigating greenhouse gas emissions in Bangladesh, thereby contributing to nationwide economic development and climate change alleviation.

2.10 SPM Pipeline Project

Bangladesh Petroleum Corporation (BPC) has undertaken the construction of a single point mooring (SPM) in Bangladesh. The project involves the construction of a single point mooring with a capacity to handle 120,000 tons of oil per month in the Sonadia area at deep sea and will associate with the large oil tankers. It includes the construction of two pipelines comprising a large 36-inch pipeline to pump the oil to a storage plant 32km away from Matarbari to the Eastern Refinery at Patenga, another 188 km long 18 inch pipeline. One pipeline will pump crude oil and the other diesel.

Figure 2.7: SPM Pipeline Project

Eastern Refinery Ltd (ERL) a wholly owned subsidiary of BPC has been appointed as Developer. An estimated 70% work on the overall SPM project has already been completed[7], and is expected to be operational by the end of 2022.

2.11 Moheshkhali Floating LNG Terminal

Moheshkhali Floating LNG (MLNG) is located offshore in the Bay of Bengal. Since beginning of operations in 2018, it delivered over 310 billion cubic feet of liquefied natural gas (LNG) to the region.

Figure 2.8: Moheshkhali Floating LNG Terminal

Importance of the Terminal: Bangladesh is heavily dependent on natural gas for its energy requirements due to limited hydro and wind resources, as well as a lack of available land for the development of solar projects. The country has been experiencing severe shortage of energy resources for many years, with demand exceeding 5 billion m3 a year.

[7] Source: Financial Express, 20 September 2021

These shortages are having a noticeable effect on its energy, water and transport sectors. Additionally, the existing natural gas reserves estimated at 15 trillion cubic feet are forecasted to exhaust by 2031[8]. Envisaging the shortage of natural gas and future demand of it, the government has constructed a floating LNG Terminal at Moheshkhali through which Liquefied Natural Gas is being imported to meet the rising demand.

2.12 Approach and Methodology

2.12.1 Approach

The team worked closely with relevant government ministries/departments and also other stakeholders to understand issues. This helped in developing a clear and realistic understanding of the need, location, dimensions and possible alignment of the infrastructure under the scope of this assignment as laid out in Section 2.12.5.

(1) To have knowledge of preliminary budgets and options, if the project is within budget;

(2) Making plan so that the project may minimize disruptions to surroundings;

(3) Intelligent and economic spending of the public funds for growth and encouragement to promote the development of infrastructure.

The FS provides conceptual design of infrastructure with associated facilities and service activities keeping sufficient provision for growth:

(1) Admin building height, floor height and all other elements like parking was designed as per guidelines of BEZA. The design considered the Floor Area Ratio (FAR) and Set Back as per the guidelines of BEZA;

(2) Proposed gas distribution pipeline alignment considered the source of gas and demand of the gas in the zone.

(3) Proposed approach road considered the existing alignment of the embankment.

(4) Provision of the 33/11 KVA power sub-station was prepared considering the demand of the power at the zone.

2.12.2 Methodology of the Study

2.12.2.1 Desk Review

Feasibility report and other related associated documents were collected at the time of secondary data collection from BEZA. Multiple checklists were developed for collecting data from site considering off-site and on-site objects. Most of the data were gathered by consultation with the stakeholders.

2.12.2.2 Secondary Data Collection

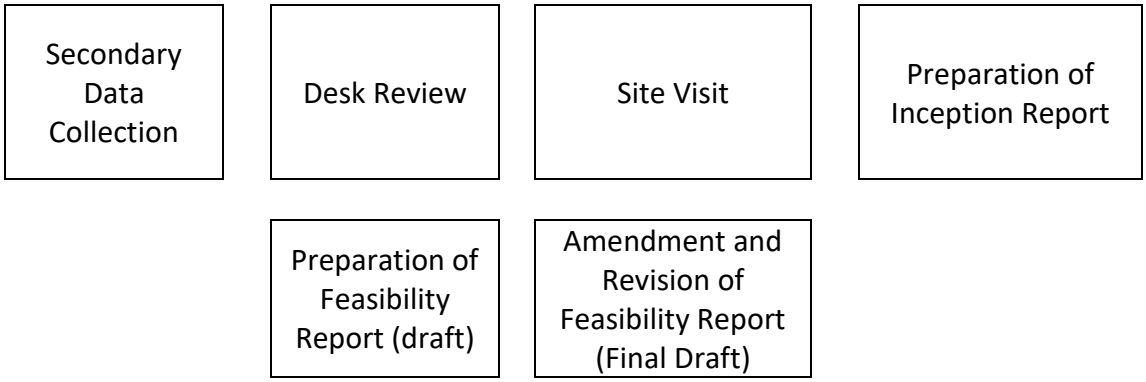
IIFC identified and reviewed all existing reports and documents relevant to the development and operation of the proposed economic zone and any earlier diagnostics undertaken for the zone and identified the key parameters for well functioning economic zone.

IIFC team reviewed laws, regulations, policies and institutional framework of BEZA. In addition, the consultant collected and examined background information/data, relevant

[8] Source: Offshore Technology Newsletter

laws, policies, decrees, mouza maps of the study area, existing studies, documents and reports (Feasibility Study Report) previously undertaken to understand the key development issues for the proposed EZ site.

Figure 2.9: Methodology of the Assignment



2.12.2.3 Site Visits

A physical visit to the proposed EZ was carried out to have an understanding of the following aspects:

(1) project site
(2) shape and size of land
(3) type of land
(4) surroundings
(5) existing roads
(6) drainage, any water body present inside or near the site
(7) location of power source
(8) connectivity of site
(9) health and safety measures.

2.12.3 Stakeholder Meetings

Consultation with the stakeholders was used to improve the plan and design of the project rather than merely having project information dissemination sessions. IIFCs carried out consultations with experts, concerned Government Agencies and other stakeholders to:

(1) collect baseline information;
(2) obtain a better understanding of the potential impacts;
(3) appreciate the perspectives/concerns of the stakeholders; and
(4) secure their active involvement during subsequent stages of the project.

Consultations were preceded by a stakeholder analysis, which was to:

(1) identify the individual or stakeholder groups relevant to the project and to environmental issues;
(2) include expert opinion and inputs;
(3) determine the nature and scope of consultation with each type of stakeholders; and
(4) determine the tools to be used in contacting and consulting each type of stakeholder group.

A systematic consultation plan with attendant schedules was prepared for subsequent stages of project preparation as well as implementation and operation, as required.

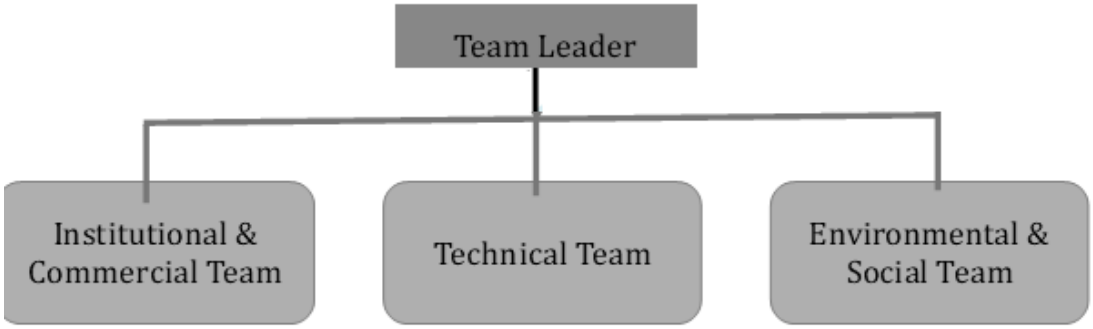
IIFC met key BEZA staff, relevant Ministries and Government Agencies and utility providers, as well as, all other interested stakeholders (private/public sectors and civil society) to discuss the project. The purpose is to understand stakeholder concerns and interests.

2.12.4 Organization of the Feasibility Study

The assignment consists of the following three broad disciplines:

(1) Commercial, transactional and institutional aspects
(2) Technical aspects
(3) Environmental and social aspects

Figure 2.10: Schematic Organogram of the Assignment



IIFC was associated with two other local consulting companies for smooth and timely completion of the assignment. The figure shows a simple structure of the tasks of the assignment.

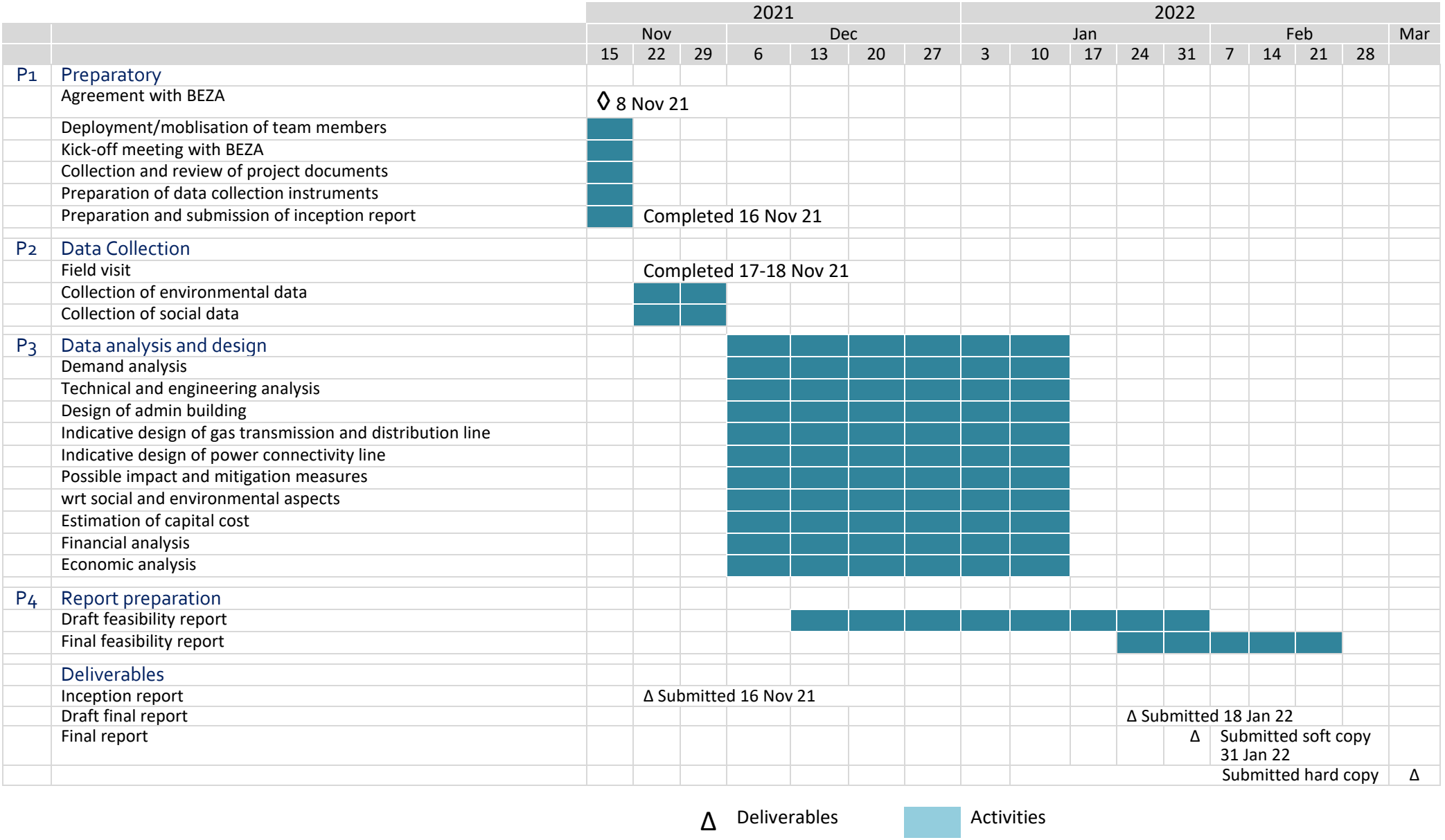
A team of multi-disciplinary experts worked for the assignment and had their inputs for different time schedules. In addition to these key experts, a number of non-key experts worked in the project for various periods. The list of key experts and key support are given in the following table.

Table 2.2: List of Key Experts

	Position	Name of the Expert
(1)	Team Leader	Muhammad Shamsur Rahman
(2)	Infrastructure Expert (Civil Engineer)	Md. Shamim Kabir Sarker
(3)	Architect	Nasrin Akter
(4)	Infrastructure Expert (Gas pipeline engineer - Distribution)	Md. Mukhlesur Rahman
(5)	Infrastructure Expert (Gas pipeline engineer - Transmission)	Manjur Morshed Talukder
(6)	Infrastructure Expert (Electrical)	Md. Abdul Matin
(7)	Infrastructure Expert (Road)	Md. Selim Uddin
(8)	Financial Expert	Md. Amzad Hossain
(9)	Industry Sector Expert	Md. Shariful Islam
(10)	Social Expert	Md. Badrul Islam
(11)	Environmental Expert	Muhammad Abul Foysal
(12)	Economic Expert	Shyamal Chandra Nath Talukder

The time frame for the consultancy assignment was 3 months. The contract was signed with the Client on 8 November 2021. According to contract, completion was scheduled for January 2022. The following figure provides the timeline:

Figure 2.11: Work Schedule



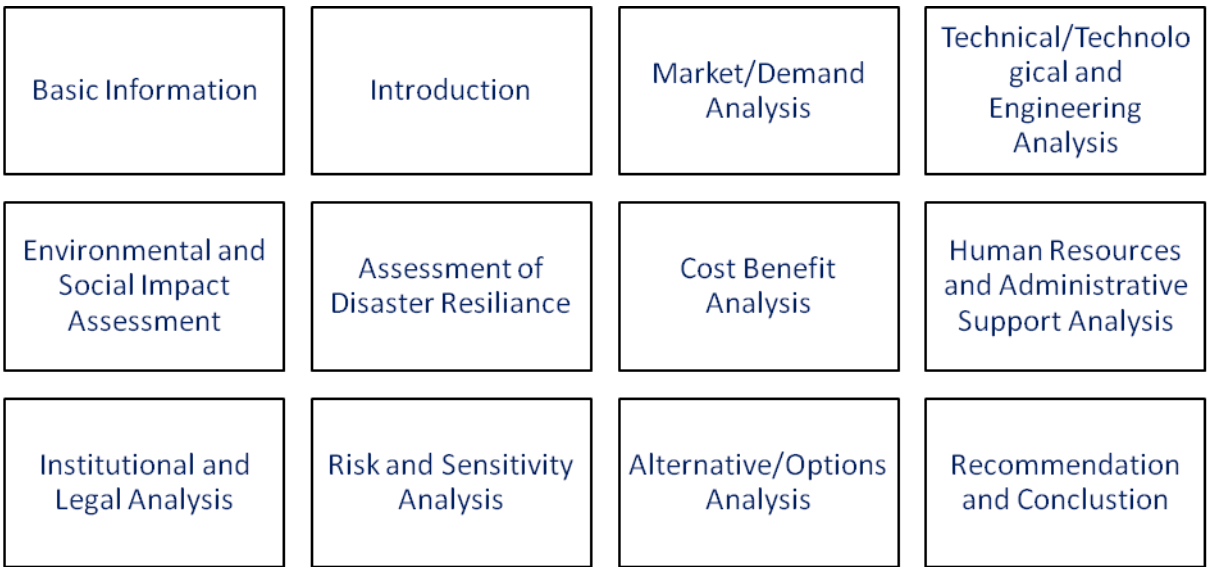
2.12.5 Main Components of the Project and the Assignment

The proposed infrastructure development (gas, power and communication) will ensure quality utilities and other common facilities for investors. The main components of the project are as follows:

(1) Construction of admin building
(2) Internal road[9]
(3) Construction of 15 km gas pipeline
(4) Construction of 33/1 I KVA power sub-station

Planning Commission has prescribed a format for preparing feasibility studies. Accordingly the feasibility study contains the following sections:

Figure 2.12: Sections of Feasibility Study as per PC Format



[9] Later provision of approach road was added

3 Demand Analysis

3.1 Defining the Problem: Scope of Work of the Project

BEZA as the owner of the EZ, needs to connect utilities with the zone, for attracting investment and allotting land to the private sector. In other words, providing land in an EZ without utilities, is the same as private sector purchasing private land and set up industries. However, EZ concept has to be fundamentally concerned with land and at the same time, connectivity with utilities. The zone having been located in an island the challenges for providing such connectivities has been more demanding than those in a normal EZ located in the main land. Therefore, BEZA has taken up the project and assigned consultants to prepare feasibility study for the same, which will be a reference document for subsequent Development Project Proposal (DPP). The following facilities need to be conceptually designed and feasibility study for providing those facilities has to be prepared under this assignment:

(1) Admin building
(2) Internal road
(3) 15 km gas pipeline
(4) 33/11 KVA power sub-station

Later after reviewing the site conditions, it was observed that an approach road also needs to be added with the above scope of work.

3.2 Relevance of the Project

While Bangladesh has done well in some sectors and acquired global recognition in RMG, attracting industries for accelerating domestic growth also requires certain critical enablers including access to market, presence of supporting infrastructure (power, water supply, connectivity etc.) and supportive policies and enabling environment. Economic zone is the modern era mechanism for industrial development.

Following are the few core rationales for the EZ regime:

(1) Meeting investment requirement: Bangladesh's GDP has been increasing at a consistent rate of 7-8% over the past few years, except in 2020 when it witnessed a decline in growth due to COVID 19. However, it is important to note that the current level of investment is significantly below the economy's potential. GoB recognizes the requirement for private investment in its infrastructure development.

(2) Through focused intervention on infrastructure availability, removal of bottlenecks and suitable policy support, economic zones has great potential to attract new investment in Bangladesh.

(3) Maintenance of Assets: EZ contracts can be structured in a way to ensure regular maintenance of developed asset. Specifying "Performance Indicators", as part of performance management and measurement, and linking those to asset quality is a way government authority may not only ensure service delivery but would also ensure that

EZs deliver value for money to the government. Intervention by the private sector can support in meeting the challenges faced by the sector.

(4) They provide cluster benefits for the local and international industries and helps in coordinated development for the manufacturing sector and small and medium enterprises of Bangladesh;

(5) The expected increase in private investment because of development of economic zones shall boost exports from Bangladesh and generate educated employment in the country;

(6) The economic zones help in concerted and planned development of commercial, residential and other social infrastructure in the region;

(7) It has the potential to develop the underdeveloped region, which is a prime objective of the GoB;

(8) The economic zones can help in diverting some of the existing or migrating population to this new region and hence decongest the city. This is a significant benefit to the nation, which will save the much talked about national idle time and resources lost due to congestion.

The above discussion reveals the reasons why this study has became relevant. It means that BEZA being authority of EZs has taken as part of its responsibilities, the provision of connectivities (including gas, power, and road) to Moheshkhali zone.

The EZ is one of the projects approved by the honourable PM and it is part of BEZA plan to develop 100 EZs. Bangladesh Economic Zones Act, 2010 was passed in the Parliament in August 2010, providing an overall framework for establishing EZs throughout Bangladesh. Under this Act, the Bangladesh Economic Zones Authority (BEZA) was established under the Prime Minister's Office (PMO) to be governed by a Board chaired by the Prime Minister. The law provides the legal coverage for attracting and leveraging private investment in the development of zones as zone developers or operators, and in the provision of providing infrastructure services, such as power, effluent treatment, wastewater treatment etc. The law also allows for development of EZs and support infrastructure through a Public-Private Partnership (PPP) mechanism.

In addition, government is expecting additional spillover effects to local firms stemming from new foreign direct investment and from more investment within value chains. This will in turn stimulate the procurement of more local products and produce better linkages of local businesses with exports. A faster adaption to international environmental and social practices is also being encouraged through the EZ regime. It provides for a new approach both in management and investment.

3.3 Proposed Project Interventions

BEZA has undertaken this project for providing the facilities mentioned in Section 3.1.These facilities are extremely necessary for the development of EZ as those are common user facilities and therefore, a single investor cannot solely take the responsibility for developing them.

Earlier there was no significant initiative of the government to develop the designated area, being in a remote place and government initiatives being prioritised for the development of mainland over that for island. However, a large scale 1200 MW coal based power plant is close to completion at Matarbari situated in the same island (*i.e.* Moheshkhali), with funding

from JICA being implemented by Coal Power Generation Company of Bangladesh. The power from the plant will be delivered to the national grid through Power Development Board (PDB) of Bangladesh. In fact all the development activities of Moheshkhali have been centered at the construction of the power plant.

A deep sea port is also planned at Matarbari. There are two LNG jetties at Sonadia for unloading LNG for the mainland.

3.4 Stakeholders: Synergy between Matarbari Power Plant and Moheshkhali EZ

Both the projects have institutional as well as general stakeholders. As stated earlier the coal based power plant is being implemented by Coal Power Generation Company Ltd and development of Moheshkhali EZ is being guided and regulated by BEZA. Both the projects carry significant national interest in terms of employment generation, power production for economic activities, and contribution to the social well being in the surrounding especially in Moheshkhali, which remained underdeveloped since independence. In a sense the two projects, though not directly interlinked, will have a strong synergistic effects on the local population.

This is due to the fact that a significant section of them is now engaged in the construction of the power plant. Once the construction of the project is over, many of them will be laid off, which may have a negative impact on the society. In other words, a new social and economic fabric, that has been created during a long period of construction of the power plant, will be disrupted on completion of the project.

Moheshkhali EZ is expected to create a buffer during this transition period by providing employment to skilled personnel generated during construction of the power plant.

Apart from institutional and general stakeholders, an investor community will be forthcoming in the proposed EZ. A private investor has already anchored in the EZ on 510 acres of land for 50 years.[10] They will be a strong part of the stakeholders in the proposed development. In summary, the following are stakeholders of the proposed development:

(1) Bangladesh Economic Zones Authority
(2) Bangladesh Coal Power Generation Company
(3) Power Development Board
(4) Local inhabitants of Moheshkhali
(5) Investor Community

3.5 Current Demand for Industrial Land

The sustained growth in Bangladesh's labor force (nearly 2_{mn} a year) is an asset that increased the country's competitiveness in the world market. However, this needs growing sectors with employment potentials. Creating productive employment largely depends upon creating an environment conducive to private sector investment, particularly within the labor-intensive manufacturing and service sectors.

[10] Source: TK Group of Companies

Existing high demand for fully serviced industrial plots: Around 93% of the plots under the existing eight export processing zones have already been sold out. The industrial estates in Dhaka and Chattogram demonstrate a near 100% occupancy level. The EZs already taken up have received significant response from the investors. This demonstrates a high industrial/export potential, necessitating provision of additional land for industrial activity. The current demand for industrial land is significantly growing due to increased competitiveness with enhanced quality of Bangladeshi products in the export market. Apart from achieved competitiveness the following reasons are also contributing towards increasing demand for industrial land.

Access to private sector funding: The private sector has continued to be a key driver for infrastructure investments and in future most of the investments are expected to come from private developers and operators for EZs. Even if government pays to acquire private land, it can recoup the cost from private investors later, given the demand for suitably developed industrial land.

Low training costs: Availability of skilled labor is a key driver attracting industries to set up facilities.

Conducive policy environment: The promulgation of Economic Zones Act of 2010, the establishment of BEZA under the PMO, provision of legal coverage for attracting/leveraging private investment and provision of tailored infrastructure services on PPP basis is expected to help drive investments in the EZs.

3.5.1 Reasons behind Businesses Hindered from Large Scale Investment

Despite a matured entrepreneurial base, many investors are being hindered from taking up large scale ventures due to shortage of land. As Bangladesh is a land scarce country and there is need for agricultural land, it is observed that desired large scale investment has been hindered, the land prices being exorbitantly high.

3.5.2 Past Up take Rates of other Industrial Zones

The industrial estates in Dhaka and Chattogram demonstrate a near 100% occupancy level. While understanding the demand, the fact was recognized. It was also recognized that rental and utility services, good governance like one-stop service and other facilities that would be provided in the zone, would trigger more demand.

3.6 Long List of Sectors

A long list of sectors was taken primarily based on classification of the Planning Commission, prospect of the sector in Import and export basket of the country and growth prospect. All the sectors have high growth prospect, although in some of the other criteria, some sector may not fit as “High.” However, the sectors were scored for suitability for setting a priority to determine which sectors will best fit in Moheshkhali EZ, being located in an island rather than in a main land. The long list of sectors is as follows:

Table 3.1: Long List of Sectors

(1)	Oil Refinery and Petrochemicals	(9)	Agro Processing
(2)	Ship Building and Repairing	(10)	Textile and Jute

(3) Steel Manufacturing and Rerolling
(4) Light Engineering
(5) Marine Fish Processing
(6) Logistics Hub/Gas Bottling
(7) Renewable Energy Generation
(8) Automobile and Heavy Engg.
(11) RMG
(12) Plastic
(13) Cement and Ceramics
(14) Leather and Leather Goods
(15) Electrical and Electronics
(16) ICT
(17) Pharmaceuticals/Chemicals

3.7 Short-listing of Sectors for Moheshkhali Economic Zone

A scoring exercise was carried out to prioritise space allocation for each sector based on suitability. The scoring system with respective weights for different parameters was as provided in the following table, based on purely commercial and economic perspectives:

Table 3.2: Format Used for Scoring the Long Listed Sectors

	Parameter	Weightage	Suitability[11] (Insignificant /High/Low/ Medium)	Score	Weighted Score
(1)	Suitability for proximity to Port Facility or Sea	25%	-	-	-
(2)	Labor availability in the region	15%	-	-	-
(3)	Growth Prospect/Export Competitiveness	15%	-	-	-
(4)	Import substitution Prospect	20%	-	-	-
(5)	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	-	-	-
	Total	**100%**			

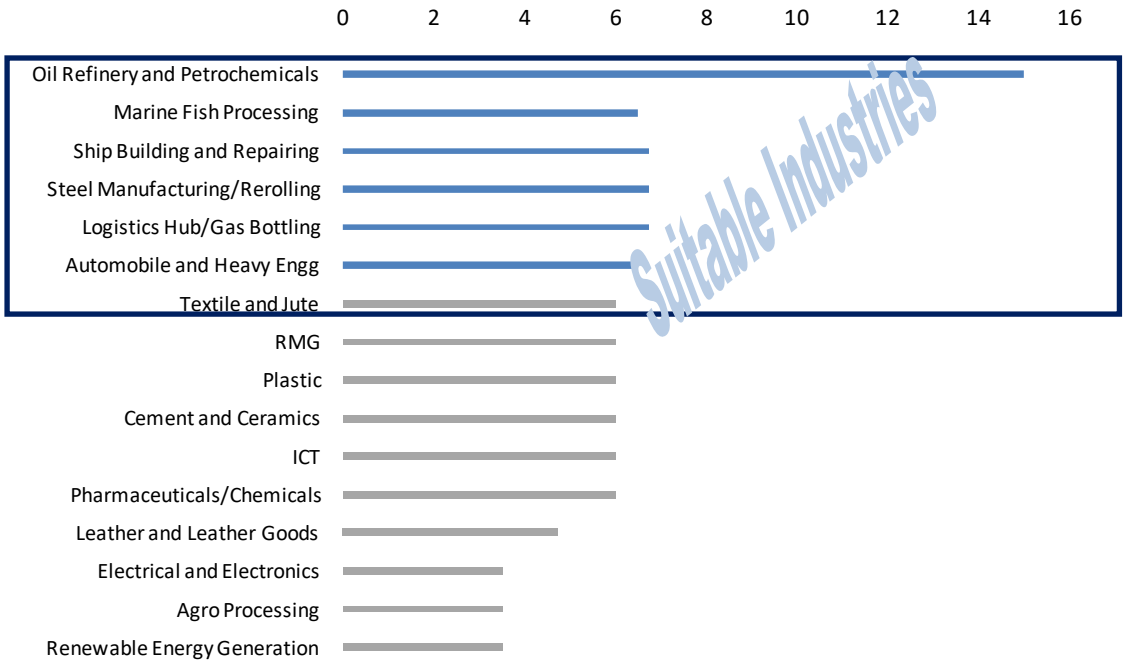
The above box has been filled up for each sector to find the total score and then they were ranked by total scores. Space has been allocated on the basis of total scores so that viable sectors receive highest consideration for potential investment. Applying the above table to different long listed sectors, and ranking the scores based on suitability for the proposed zone is provided in a table presented as Annexure A2. The next section provides the results of the suitability exercise.

3.8 Nature of the Zone with Respect to Suitability of Industries

The above industry analysis assessed suitability of different industries for the zone, as they are scored. The following figure shows a ranking of the sectors based on the scores.

[11] Scores: [4 High score = 15], [2 Low score = 5], [3 Medium score = 10], [1 Insignificant score = 0]

Figure 3.1: Suitability Scores of Industries



3.9 Prospective Demand for Industrial Land in the Proposed EZ

3.9.1 Investment Trends

Much of the demand for space in the proposed EZ is likely to be from large companies with experience of establishing and operating heavy industries. There is remote possibility that new investors will be able to run the businesses in Moheshkhali, given the level of risk in a new environment with large scale capital needs.

3.9.2 Growth Trends

The growth rate of business enterprises changes quite often depending on government policies, particularly with respect to taxation and availability of utilities. Overall the consultation found that there is a great potential for growth in Moheshkhali from investment to be made by large business enterprises, given almost green field nature of the area and higher level of margins in the type of industries that are envisaged in the proposed EZ. The single factor most likely to hamper growth, is the shortage of gas and power. In a positive note, the island itself has LNG jetties and as part of this assignment, provision of a dedicated gas line to the EZ is being kept.

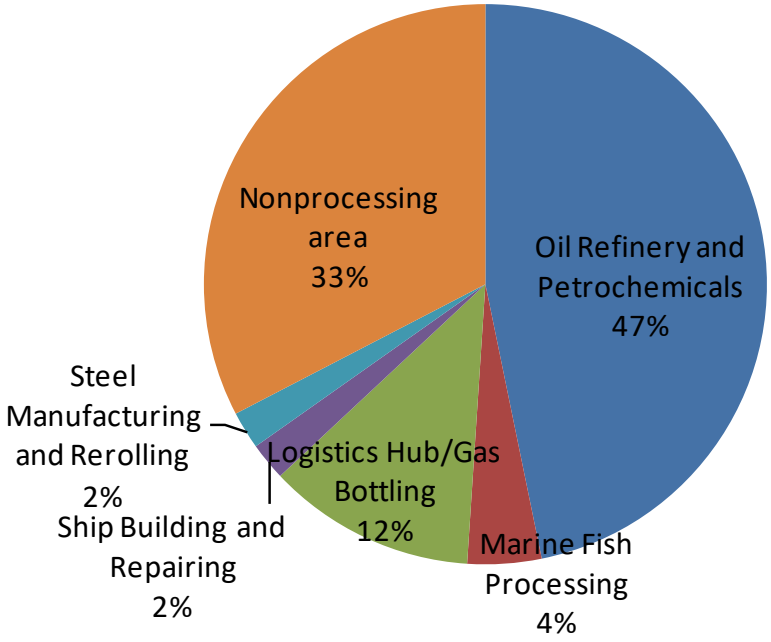
3.9.3 Industries Having Potential Demand to be setup in the Proposed EZ

The above figure shows that there is a significant level of suitability of the zone for establishing the following industries (blue bars in the above figure):

(1) Oil Refinery and Petrochemicals
(2) Marine Fish Processing
(3) Ship Building and Repairing
(4) Steel Manufacturing and Rerolling
(5) Logistics Hub/Gas Bottling and
(6) Automobile and Heavy Engg.

The industries marked in ash colors in the figure have been discarded due to low scores. With the above background and understanding the space allocation for different sectors has been designed for the zone as in the following figure.

Figure 3.2: Proposed[12] Space Allocation for Different Sectors in Moheshkhali EZ based on Selective Suitability Factors



3.9.4 Prospective Demand for Land in the Proposed EZ

The industries under the sectors mentioned above need relatively large areas of land. The petrochemical complex under implementation in the EZ itself occupies around 500 acres of land. The following table provides the need of land by different industries and total land demand that are envisaged.

Figure 3.3: Demand for Land in the Proposed EZ

	Industry	Land of the EZ	EZ Defined Area		EZ Processing Area		
			Sectoral Allocation	Already Allotted	Already Allotted	To be Allotted	
		Acres	%	Acres	%	%	Acres
(1)	Oil Refinery and Petrochemicals	539	43%	410	47%	36%	129
(2)	Marine Fish Processing	48	3.9%			13%	48
(3)	Ship Building and Repairing	25	2.0%			14%	25
(4)	Steel Manufacturing	25	2.0%			14%	25
(4.1)	Steel Rerolling	25					25
(5)	Logistics Hub/Gas Bottling	134	11%	100	12%	9%	34

[12] Indicative

	Industry	Land of the EZ	EZ Defined Area		EZ Processing Area		
			Sectoral Allocation	Already Allotted	Already Allotted	To be Allotted	
		Acres	%	Acres	%	%	Acres
(6)	Automobile and Heavy Engg.	48	4%			13%	48
	EZ Processing Area	**868**	**70%**	**510**	**59%**	**100%**	**334**
(7)	Non-processing area	372	30%				
	EZ Defined Area	1,240	100%				
(8)	Provision for Future Expansion	760					
	Planned Area of the EZ with Provision of Future Expansion	**2,000**					

3.10 Investments Already Made

BEZA has already allotted 510 acres of land in the proposed EZ, as shown in the above table, to SPL Petrochemical Complex and Samuda Gas, ventured under banner of TK Group of Companies. In other words, the proposed EZ has already existing demand for land. The location of the complex is shown in Figure 4.4. As the path of setting up industries in the EZ has already been set new industries are in pipeline with a number of propositions submitted to BEZA.

3.11 Prospective Demand for Utilities in the Proposed EZ

Based on existing usage rates of utilities by different industries, found from secondary research, the requirement of the particular industries that are envisaged in the proposed EZ has been estimated. The details are provided in Annex A11.

Figure 3.4: Demand Per Acre for Utilities in the Proposed EZ

	Sector	Power	Gas	Water
		MW/acre	m3/day/acre	m3/day/acre
(1)	Oil Refinery and Petrochemicals	0.48	4,313.67	
(2)	Marine Fish Processing	0.0194	89.00	154
(3)	Ship Building and Repairing	0.0043	4.17	
(4)	Steel Manufacturing	0.202	2,055.28	
(4.1)	Steel Rerolling	0.196	210.90	
(5)	Logistics Hub/Gas Bottling	0.046	0	
(6)	Automobile and Heavy Engg.	0.097		
(7)	Misc. Industrial Use	0.03		
(9)	Other than Industrial Use	0.00		7.36

Based on the above rates of requirement that following demands have been derived:

Table 3.3: Total Requirement of Utilities

		Sector	Power	Gas	Water
			MW	m3/day	m3/day
(1)	**Industries**				
	1.1	Oil Refinery and Petrochemicals	260.30	2,324,553	-
	1.2	Marine Fish Processing	0.94	4,292	7,427
	1.3	Ship Building and Repairing	0.11	104	-
	1.4	Steel Manufacturing	5.07	51,467	-
	1.4.1	Steel Rerolling	4.91	5,281	-
	1.5	Logistics Hub/Gas Bottling	6.16	-	-
	1.6	Automobile and Heavy Engg.	4.69	-	-
	1.7	Misc. Industrial Use	4	-	-
		Subtotal (Industrial use)	**286**	**2,385,698**	**7,427**
(2)	**Other than Industries**				
	2.1	Domestic or Personal Use	1.56		1,167
	2.2	CETP (Plant Use)	0.28		
	2.3	WTP (Plant Use)	0.07		
	2.4	Street Lighting	2.43		
	2.5	Misc. Domestic Use	1.20		
		Subtotal (non-processing area)	**5.54**	**-**	**1,167**
		Total	**291.7**	**2,385,698**	**8,594**

3.12 Demand Forecast

The demand forecast is the most important element of the feasibility study, and draws upon findings from the industry analysis, stakeholder consultation, and open source data and published studies. The demand forecast identifies: a) the type of industries most likely to locate in the zone, b) the number of tenants proposed, and c) the land and infrastructure requirements of units over a 20 year period. Assumptions were made according to three demand scenarios—Base Case, Aggressive Case and Conservative Case. The result is three demand estimates, one conforming to each of the three sets of assumptions. This will provide public officials, physical planners, and investors with realistic views of interest of the business enterprises in the zone, infrastructure requirements, suggested timeframe of the project, and marketing and promotional recommendations to meet anticipated demand.

3.12.1 Purpose of Demand Forecast

The demand forecast has broad and important applications throughout the feasibility study:

(1) Demand Projection. Estimate the number of companies that will locate in the zone over a period of 20 years.
(2) Financial Analysis. Estimate the costs and revenues associated with developing and operating the zone, and project the internal rate of return (IRR) of developing and operating the project.
(3) Economic Analysis. Suggest effects the zone will have on society, and estimate the economic rate of return (ERR) to the government based on its financial and in-kind contributions to zone development and operation.

3.12.2 Demand Forecast Methodology

Demand estimations for EZs provide calculations of the likely intent on new and existing companies to locate—or relocate—operate in a particularly defined zone. The forecast

represents an approximation based upon several "pillars" that provide evidence to substantiate the demand estimation. This section defines those pillars that constitute the methodology behind the demand forecast, and discusses the evidence each of them provides in detail.

(1) Assumptions. Demand for space in the zone is contingent upon policies and conditions that were assumed at the outset of the study.

(2) Investment Trends. The demand forecast considers new company formation trends and viability of existing business enterprises as a way to establish a baseline upon which the demand estimations are based.

(3) Uptake Rates in Bangladesh. The demand forecast reviewed actual land uptake rates of other EZs in Bangladesh in support of high demand for serviced industrial space.

Utilizing the above facts, data were gathered and analyzed to understand trends, economic pressures, and policies and to determine the likely number of companies that would be located in the zone.

3.12.3 General Assumptions

The following broad assumptions define the parameters against which the demand forecast was made. A change in any of these assumptions could affect the demand estimations in a positive or negative manner.

(1) Business enterprises in the designated sectors will be the target groups to locate in the zone, regardless of their export status. The zone will be open to any in these sectors that desires land and/or building space in the sizes offered. The business enterprises in the zone will be allowed to have sales to the Bangladeshi domestic market as well as export.

(2) The zone will offer a streamlined approval process for establishing business enterprise units at a one-stop office within the zone. This will include services such as business registration, licensing, permitting, environmental clearances, work permits, and others.

(3) Law and order within the EZ will be maintained at the desired level to maintain a peaceful business environment.

(4) A power plant will be constructed in the zone. This will provide a dedicated power supply for tenants in the zone.

(5) Additional utilities such as gas, LPG, water, waste treatment, and telecommunications will be available to zone tenants at market-rate tariffs.

(6) Business enterprises will have the option to lease serviced land.

3.12.4 Growth Trends

The number of new business enterprises created each year ranges between 5 to 8%, based on published data[13]. The growth rate of business enterprises changes quite often depending on government policies, particularly with respect to taxation. Overall the consultation found that there was a great potential for growth. The single factor most likely to hamper growth, according to firm, is the shortage of gas and electrical power. An indirect effect has arisen from the lack of gas supply at the national level. These industries form a major customer-

[13]International Journal of SME Development, Small and Medium Enterprise Foundation, April 2014

base for the zone. Therefore, the gas shortage has negative impact on the growth of industries.

3.13 Demand Forecast Scenarios and Findings

This section of the pre-feasibility study presents the demand forecast calculations under three distinct growth scenarios—Base Case, Conservative, and Aggressive. In addition to calculating the number of tenants likely to locate in the zone, extrapolations of the utility and land requirements, as well as employment generation was carried out.

3.13.1 Base Case

The Base Case Scenario makes the following assumptions with regard to firms actually locating in the proposed EZ.

(1) Interest from business enterprises remains strong, being actually interested and capable of relocating to the zone.
(2) COVID situation shall remain unchanged.
(3) Pressure from international buyer of RMG to establish compliance factory remains strong.
(4) The government of Bangladesh takes action or incentives to encourage industrial enterprises to establish new industries in the zone and relocate/expand away from city. BEZA promises to provide facilitation services such as training, one-stop bureaucratic services, and other amenities inside the zone.
(5) The zone contains a dedicated source of power generation, water, effluent treatment, and solid waste disposal.
(6) New EZs may be built or expanded during the next 20 years.

3.13.2 Aggressive Case

The Aggressive Scenario assumes more positive assumptions about economic and political conditions in the country and streamlined approval process under the new EZ regime. It differs from the Base Case Scenario with respect to the following aspects:

(1) The proposed zone will contain more newly formed firms than in the Base Case Scenario. This will arise due to the greater ease to start and opera tea factory in the proposed EZ.

(2) COVID situation will improve.

(3) All regulatory approvals, especially those for establishing the business enterprises in the zone, will be provided and regulated within the zone itself. This differs from the Base Case, where by all consents must be obtained from BEZA or the central authorities.

(4) The political conditions will remain peaceful, for at least first five years of operation.

(5) The linked projects for off-site infrastructure needed for the zone, will be completed on a fast track basis by the government, while the Base Case assumes that the operation of the zone will continue in parallel with the period while the entire required off-site infrastructure may not be complete. he zone can start operation, with a slim access road first, then widening works may go on while the operation of the EZ is continued. However, it assumes that the power plant will be built on an urgent basis.

(6) The proposed zone will be aggressive in marketing and promotion of the zone to business enterprises.

(7) Raw material land service suppliers will be allowed to locate inside the zone on a first-come, first serve basis.

3.13.3 Conservative Case

The Conservative Scenario differs from the other two scenarios in the following manner.

(1) There are delays in preparing necessary off site infrastructure for the zone.

(2) COVID situation will deteriorate

(3) Business enterprises remaining city as pressures to relocate lessen.

(4) Business enterprise, industry associations are not able to effect en masse re location, and are not able to arrange for the necessary financing for business enterprises.

Table 3.4: Twenty-Year Demand Forecast (land uptake percent)[14]

	Years	2026	2027	2028	2029	2030	2035	2045
Base Case		1	2	3	4	5	10	20
(1)	Oil Refinery and Petrochemicals	20	30	50	70	80	95	95
(2)	Marine Fish Processing	20	25	40	50	70	95	95
(3)	Ship Building and Repairing	10	25	35	50	70	95	95
(4)	Steel Manufacturing	20	25	50	95	95	95	95
(4.1)	Steel Rerolling	20	25	50	95	95	95	95
(5)	Logistics Hub/Gas Bottling	20	25	35	50	75	95	95
(6)	Automobile and Heavy Engg.	20	25	50	75	95	95	95

Aggressive Case

	Years	2026	2027	2028	2029	2030	2035	2045
(1)	Oil Refinery and Petrochemicals	25	35	55	75	85	100	100
(2)	Marine Fish Processing	25	30	45	55	75	100	100
(3)	Ship Building and Repairing	15	30	40	55	75	100	100
(4)	Steel Manufacturing	25	30	55	100	100	100	100
(4.1)	Steel Rerolling	25	30	55	100	100	100	100
(5)	Logistics Hub/Gas Bottling	25	30	40	55	80	100	100
(6)	Automobile and Heavy Engg.	25	30	55	80	100	100	100

Conservative Case

	Years	2026	2027	2028	2029	2030	2035	2045
(1)	Oil Refinery and Petrochemicals	20	25	45	65	75	90	90
(2)	Marine Fish Processing	15	20	35	45	65	90	90
(3)	Ship Building and Repairing	5	20	30	45	65	90	90
(4)	Steel Manufacturing	15	20	45	90	90	90	90
(4.1)	Steel Rerolling	15	20	30	45	70	90	90
(5)	Logistics Hub/Gas Bottling	15	20	30	45	70	90	90
(6)	Automobile and Heavy Engg.	15	20	45	70	90	90	90

[14]Projected occupancy in percentage of processing area to be designated for the particular sector.

Table 3.5: Twenty-Year Demand Forecast (land and utilities)

Years	2026	2027	2028	2029	2030	2035	2040	2045
Land								acres
Base Case	166	238	394	565	676	802	802	802
Aggressive Case	209	280	436	607	718	844	844	844
Conservative Case	151	196	348	511	629	760	760	760
Power								MW
Base Case	57	85	143	202	232	273	273	273
Aggressive Case	72	99	157	217	246	288	288	288
Conservative Case	56	71	127	186	216	259	259	259
Water								m3/day
Base Case	1,709	2,177	3,500	4,473	6,108	8,134	8,134	8,134
Aggressive Case	2,137	2,605	3,928	4,901	6,536	8,562	8,562	8,562
Conservative Case	1,317	1,749	3,067	4,029	5,673	7,706	7,706	7,706
Gas								m3/day
Base Case	477,129	712,652	1,192,404	1,683,297	1,916,631	2,266,414	2,266,414	2,266,414
Aggressive Case	596,414	831,937	1,311,689	1,802,582	2,035,916	2,385,698	2,385,698	2,385,698
Conservative Case	474,072	593,367	1,072,327	1,561,635	1,796,290	2,147,129	2,147,129	2,147,129
CETP								m3/day
Base Case	1,337	1,671	2,674	3,342	4,679	6,350	6,350	6,350
Aggressive Case	1,671	2,005	3,008	3,676	5,013	6,684	6,684	6,684
Conservative Case	1,003	1,337	2,340	3,008	4,345	6,016	6,016	6,016

3.14 Constraints and Means to Meet the Demand

The following constraints and means have been considered against which the above demand is assumed to be created. A change in any of these assumptions could affect the demand estimations in a positive or negative manner.

(1) The zone will offer a streamlined approval process for establishing business enterprise units at a one-stop office within the zone. This will include services such as business registration, licensing, permitting, environmental clearances, work permits, and others.

(2) Law and order within the EZ will be maintained at the desired level to maintain a peaceful business environment.

(3) A power substation will provide a dedicated power supply for tenants in the zone.

(4) Additional utilities such as LNG, water, waste treatment, and telecommunications will be available to zone tenants at market-rate tariffs.

3.15 SWOT Analysis

Strengths, weakness, opportunities and possible threats of the EZ have been identified. They are presented in the following table:

Table 3.6: Strengths, Weaknesses, Opportunities and Threats[15]

	Strengths	Weakness
1.	**Location, Contiguity and Surroundings**	
	1.1. Does not lie in any City Corporation, Municipality, and Cantonment Area as per requirement of sub-section 3 of section 5 of Economic Zone Act, 2010. 1.2. Close proximity to Bay of Bengal; 1.3. Land Availability for future expansion; 1.4. Low land value and no resettlement issue.	1.5. Requirement of construction of sea bank/boundary wall to protect EZ site; 1.6. Scarcity of freshwater sources; 1.7. Less communication facilities and heavily depend on waterways for primary transportation; 1.8. No education, medical and market facilities within 10 km radius of the site.
2.	Accessibility	
	2.1 The site is adjacent proposed Matarbari Deep Sea Port, Matarbari Coal Power Plant and Sonadia Island; 2.2 In waterway the site is 70 km from Chattogram sea port; 2.3 Teknaf Private Land Port is about 106km away from the site; 2.4 Navigation is possible throughout the year in Bay of Bengal and Kuhelia River.	2.5 No highway road connectivity. The nearby national highway is 25 km from the site. 2.6 Currently, there is no access road to reach the site
3.	**Proximity to urban hubs and industrial areas**	
	3.1 Upazila headquarters is at distance of 12 km east; 3.2 Proposed LNG Terminal and deep-sea port is around 12 km from the site.	3.3 No cargo handling facilities by Rail transport; 3.4 No urban facilities like College, University, Hospital; 3.5 Currently there is no recognized industry rather than salt farming and dry fishing.
4.	**Available Infrastructure Facility**	
	4.1 LNG Terminal and Deep-sea port will give extra benefit for the site; 4.2 Matarbari coal fired power plant can mitigate the electricity demand for the Moheshkhali EZ 3; 4.3 Setting up of all infrastructure facilities will induce setting up of new townships and other developments. 4.4 Though there is no telephone network but mobile telecom network is available within the project site.	4.5 Current infrastructure facility is not adequate to cope up the running of a large industrial activities and need to be improved 4.6 Fire service within 12 km of site located at Upazila Headquarter. 4.7 Police station within 12 km of site.

[15]Important Note of Acknowledgement: This table is extracted from Environmental Impact Assessment (EIA) Report on Moheshkhali Economic Zone 3, VIRID Associate in association with Shahidul Consultants, prepared for the Client BEZA. IIFC received access to the document by BEZA, after being supplied by BEZA as part of reference materials.

	Strengths	Weakness
5.	Eco-sensitivity and threat to bio-diversity	
	5.1 The entire area is a salt pan and the local people used it as for salt farming and dry fishing; 5.2 No protected areas within 10 km radius of the site; 5.3 There are some mangrove species within and nearby the project area that would be preserved;	5.4 During pre-construction phase, existing trees would be felled before land filling. 5.5 Industries, if discharge waste/ effluent, it may disturb the aquatic ecosystem of nearby river; 5.6 Extraction of sand for land filling may causes interruption of aquatic ecology; 5.7 Periodic dredging may hamper the benthic organism of the sea and may cause ecological disruption especially for the turtle;
6.	**Quality of life and employment generation**	
	6.1 Creation of about 50,000 of direct jobs for skilled, semi-skilled and un-skilled labor. 6.2 Developments in nearby area after development of EZ. 6.3 Quality of life will boost with the running of EZ	6.4 Unavailability of required skilled labor. 6.5 Adequate environment management plan is to be prepared to prevent damage of environment and the health of the residents in nearby area due to discharge of effluents/gases from EZ site

7.	Opportunities	Threats
	7.1 Government provision of tax holiday 7.2 High provision of incentives 7.3 Duty free import of capital machinery and other support 7.4 People's willingness about the industrial activities 7.5 Enough vacant land for infrastructure development 7.6 LNG Terminal deep sea port make extra advantage for transportation of goods 7.7 No Resettlement Issues 7.8 Matarbari Coal fired power plant and Industrial hub is nearby the Moheshkhali EZ 3	7.9 Poor Road Transportation system 7.10 Competitive market 7.11 High borrowing costs- high interest rates of banks and financial institutions 7.12 Risk of natural disasters 7.13 Risk of environmental pollution and social disruption

4 Technical and Engineering Analysis

4.1 Technical Design

Detailed design and drawings are not included in this assignment. As such, basic design codes, practices are provided. Some basic map and schematic drawings of the infrastructures are provided in this section.

4.1.1 Codes and Practice

The following codes are to be used in structural design of the structures in Moheshkhali EZ:

(1) Bangladesh National Building Code (BNBC 2020)
(2) American Concrete Institute (ACI318 2008)
(3) American Society of Civil Engineers(ASCE7-05)

Guidelines of Bangladesh National Building Code (BNBC, 2020) may be used for analysis. For the reinforced concrete design, American Concrete Institute (ACI 318, 2008) code and for loading criteria ASCE/SE7-05code may be consulted as and when necessary, to complement the BNBC.

4.1.2 Design Programs and Software

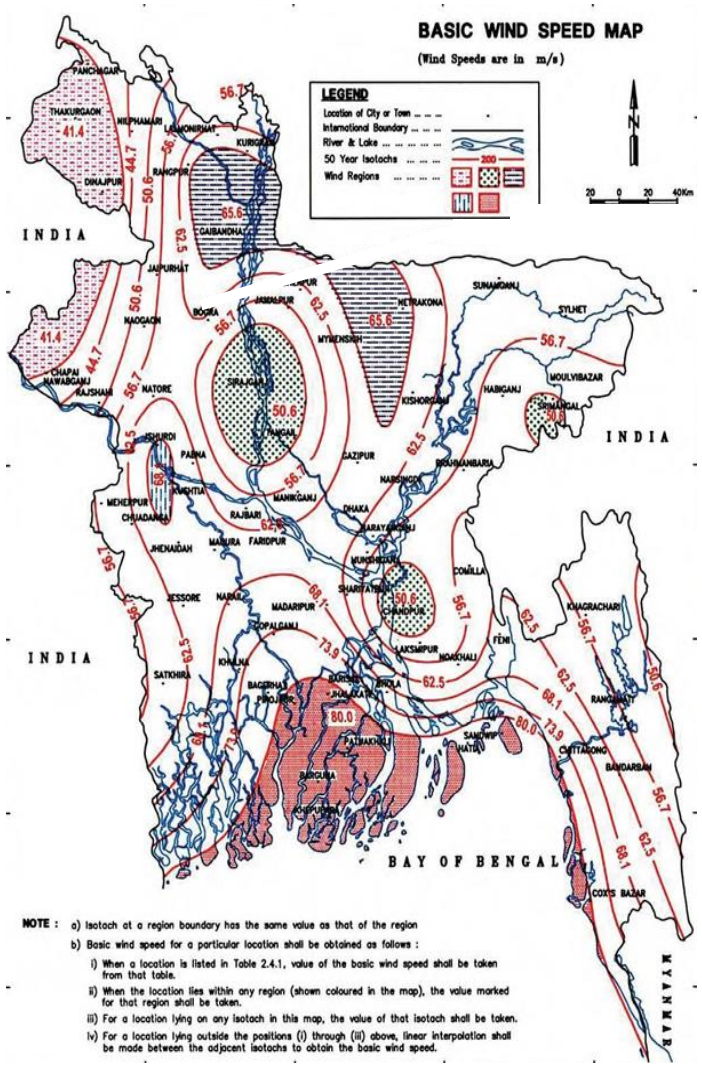
Commercial building design software ETABS, Staad Pro, SAP2000 may be used for buildings. For foundation, Safe, Plaxis 3D may be used. Besides other programs like Microsoft office and project are also used for project management.

4.1.3 Earthquake and Wind Load design

As the Moheshkhali Economic Zone is situated in Zone 3 of earthquake map of Bangladesh, some special standards and specifications have to be complied with for design. Bangladesh is typically a storm prone area where due consideration to the thrust due to storm must be given in the analysis and design of building and structures.

Figure 4.1: Seismic Map of Bangladesh as per BNBC 2020

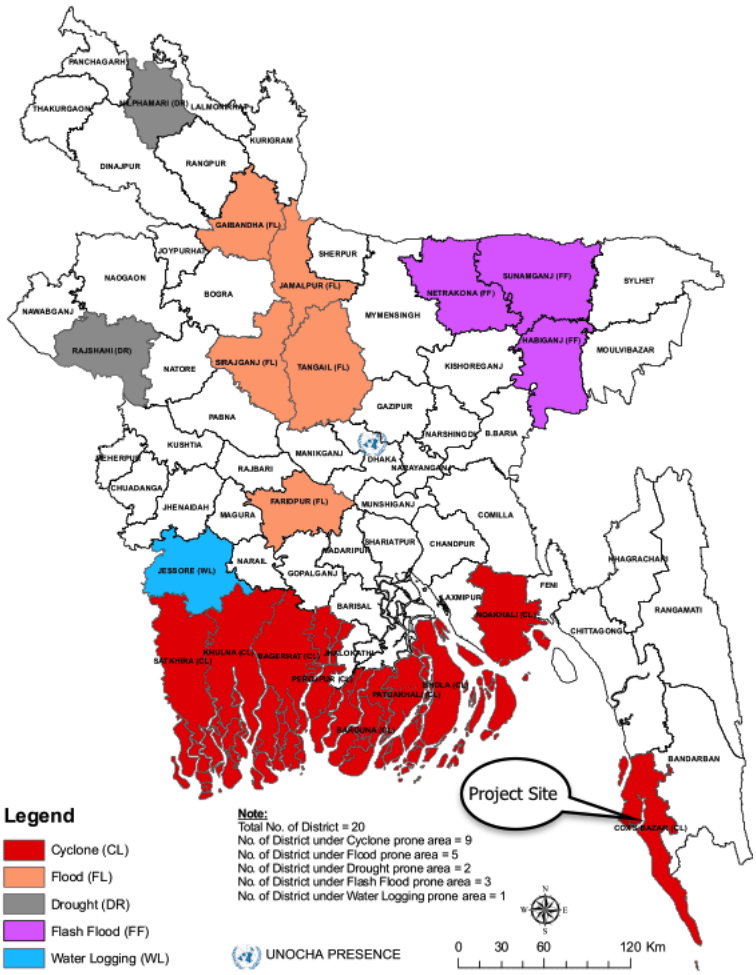
Figure 4.2: Basic Wind Load Map of Bangladesh



Seismic structural strength assessment of existing buildings, strengthening of existing proposed foundation system and superstructures of critical structures, incorporation of liquefaction potential criteria in the structural design process for structures are few of the considerations to be in mind. A preventive measure can be coordinated by ensuring anti-seismic design (end bearing pile foundation including bored or driven piles and use reinforced concrete raft for shallow foundation), quality control (selection of adequate material and appropriate workmanship) under expert supervision. According to BNBC, 2020, project site lies in the Seismic Zone 3 which is also called moderate intensity seismic zone with basic seismic co-efficient of 0.28g. Having location in Zone-III the land buildings and land-based structures for this Project should be designed to withstand maximum lateral load of 28% of gravity load.

The cyclonic map of Bangladesh shows that the proposed project area falls under high cyclonic risk area with surge height above 1 m and subsequently tidal flood occurs in the project area. The proposed EZ has no possibility of erosion/river bank erosion according to the morphological history of Kuhelia River despite the river along the EZ has possibility of erosion. However, the proponent will construct retaining wall along the river bank in order to get protected from erosion.

Figure 4.3: Cyclone Proneness



4.2 Output Plan and BEZA's Vision with Moheshkhali EZ

BEZA has a vision to develop and expand the Moheshkhali EZ as a flagship island based project. Although initially 1,240 acres has been defined for the zone, the plan is to expand it to 2000 acres. More land is already in the pipeline to be demarcated as part of the zone. Figure 4.4 shows the direction of extension of the zone. Improving the livelihood of the inhabitants of the island and creating employment is part of the overall plan of the government with regard to Moheshkhali Island. In fact, the proposed EZ is part of the overall development of Moheshkhali (*i.e.* Moheshkhali Integrated Development Initiative). Already a number of investment propositions are on the table and therefore, the plan is to expand the zone as much as environmentally and social sustainable.

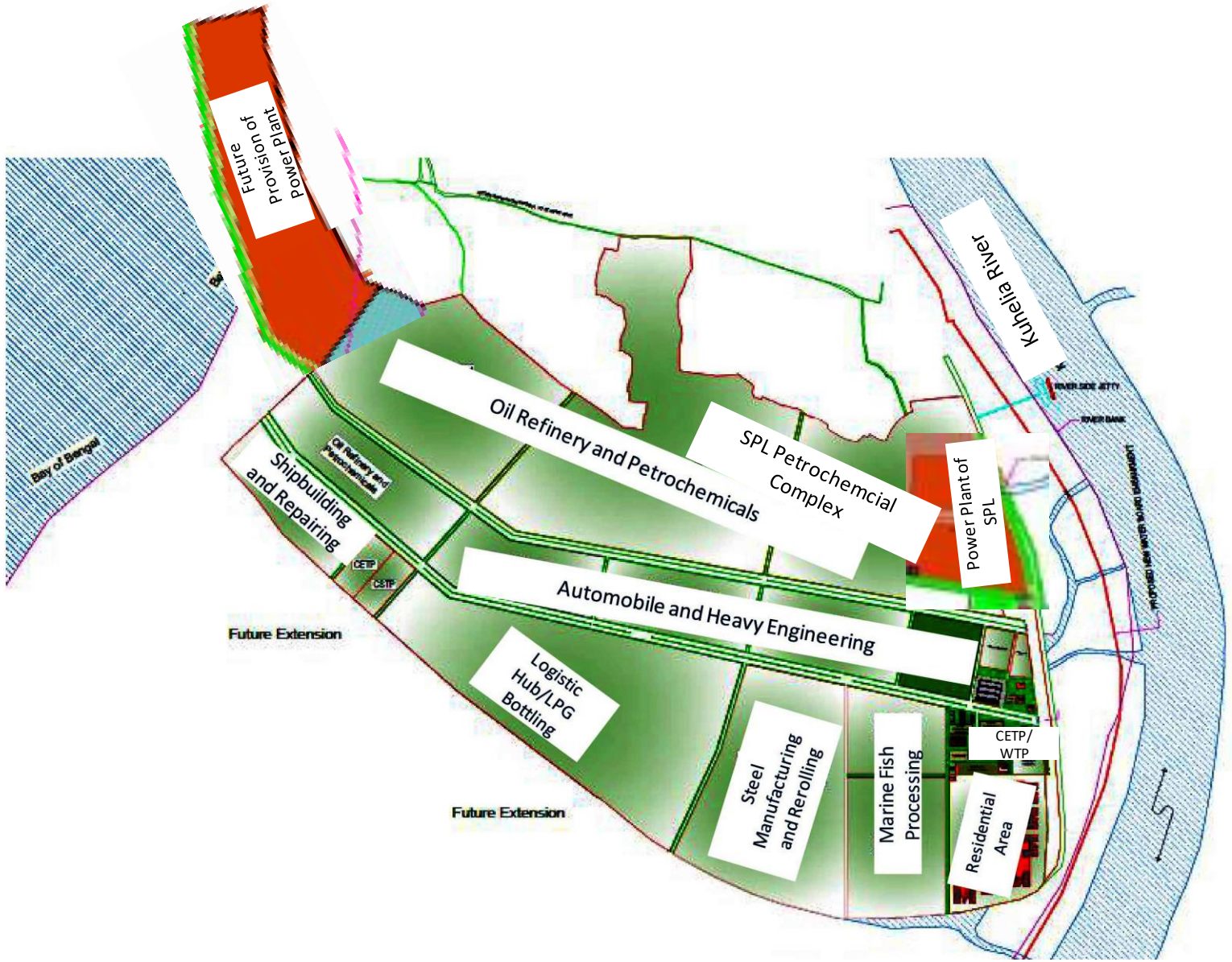
The zone will be broadly divided into 2 subzones *e.g.* i) Processing Area and ii) Non-Processing Area. The structures of non-processing area will be developed by BEZA. Out of 1,240 acres EZ defined area, processing area is around 744 acres (60%) and non-processing 496 acres (40%). The processing area is meant for industrial units.

Table 4.1: Planned Economic Zone Components

	Component		Features
(1)	Processing Area		1.1 Oil Refinery and Petrochemicals 1.2 Marine Fish Processing 1.3 Ship Building and Repairing 1.4 Steel Manufacturing and Rerolling 1.5 Logistics Hub/Gas Bottling 1.6 Automobile and Heavy Engg.
(2)	Non-processing area		
	2.1	Residential Area	• Accommodation With civic amenities • A guest house with modern facilities, which is a complete five-star quality, sufficient for the hospitality of foreigner guests • Officer's buildings • Staff quarter • Staff dormitory • primary school and • a mosque.
	2.2	Administrative Area	A completely independent administrative building and security department are planned to be set up to manage and oversee the economic zone. This building has a one-stop service as well as a daycare center for working mothers to keep their children during the working hours and to work without any worries.
	2.3	Commercial Area	This section contains some important infrastructure. A training center where workers and officers can build capabilities has been provided. As a result, skilled manpower will be created. In addition, banks, Insurance, ATMs, medical centers and medicine shops have been considered as international standard hotel and restaurants for the convenience of the visitors.
	2.4	Utilities/ Mixed-	• Parking big vehicles • Resting place of drivers.

Component			Features
		Commercial Area	• Storage area to load and unload the vehicles
	2.5	Common Facilities	• Boundary wall • Gate house with security arrangements • Security watch tower to keep the surroundings. • Green area and green patch are there for fresh air. Water body is created for adequate water for general use and for emergency use. There are street lights for safety and clear vision during night time.

Figure 4.4: Indicative Master Plan of the EZ

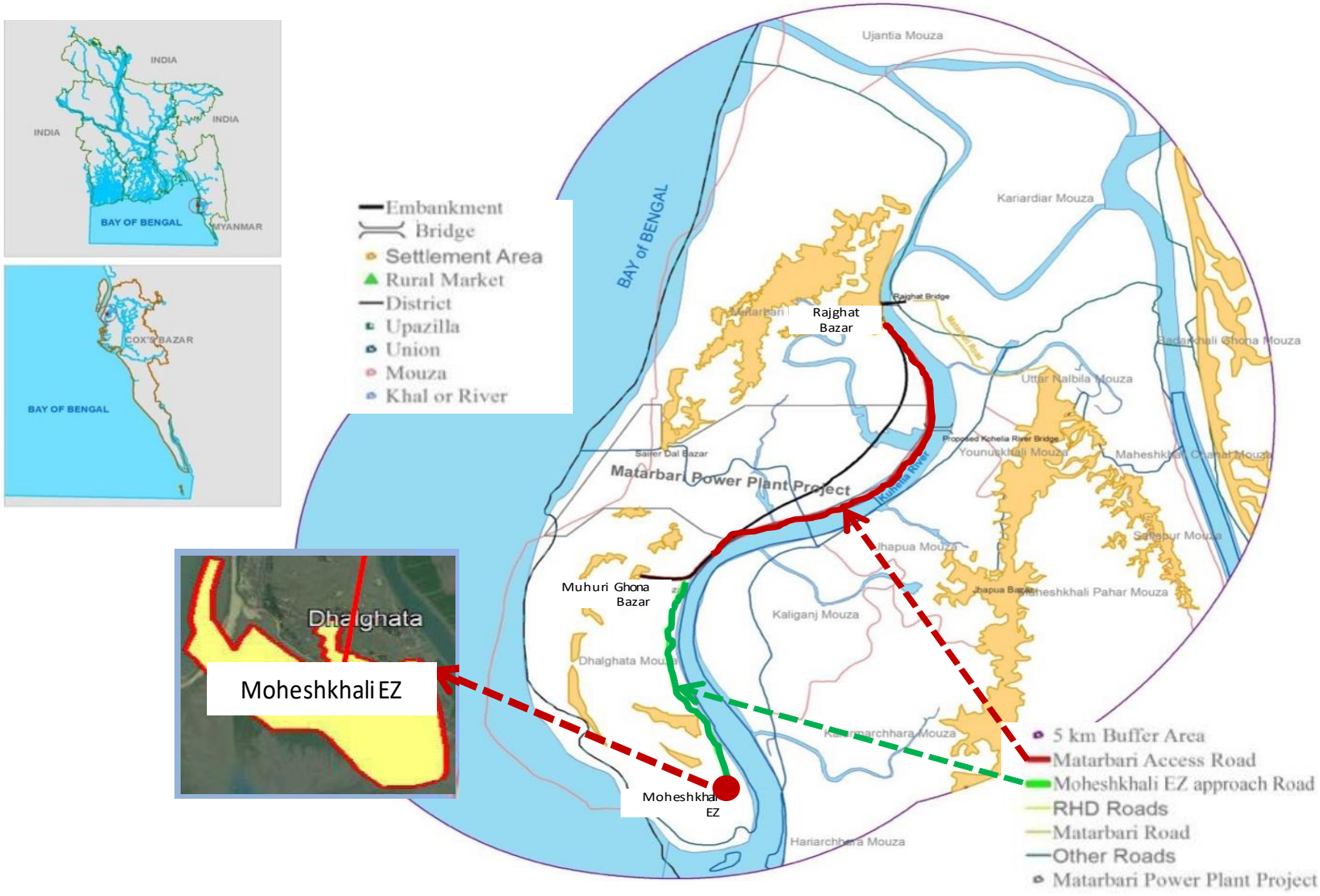


The structures at the processing area will be developed by private sector who takes the land on lease. The non-processing area is used for offices, commercial buildings and common facilities like internal roads and other utilities *e.g.* water, power, gas, etc.

4.3 Approach Road cum Embankment

An approach road of 4.15 km from Mohori Guna to the EZ site along the Kuhelia River is desired for road connectivity to the site. It is planned on an existing embankment of BWDB. The requirement of land acquisition for the road is discussed in Section 5.2.1. The following figure shows the road already exists (red) and that to be newly constructed (green).

Figure 4.5: Road Network



4.3.1 Design and Construction Concept

The design shall be in compliance with the relevant regulations of Bangladesh, American/European Road Standards (AASHTO/TRRL) and Japanese Road Structure Ordinance. In Bangladesh about the design of road structure like culvert, bridge, etc., AASHTO LRDF latest version is followed in every department RHD, LGED, RAJUK, etc. Specifically, the design Standard of RHD shall be adopted in this project as a basic criterion. Design and construction concept are shown in Table 4.2, and the typical cross-section of approach road and internal road is shown in Figure 4.5.

The total land area of the 4.15 km approach road cum embankment proposed for development from Mohori Guna (E 383950.7526N 2398709.8540) to Panditer Dail (E 384229.6941N 2395632.0081) under Dhalghata mouza of Dhalghata Union under approach road construction component of Moheshkhali EZ is about 47 acres. Internal road would be started from Panditer Dail *i.e.* main gate of the EZ. Internal road shall be designed as per BEZA Building Code, 2017.

Table 4.2: Design Dimensions of Approach Road

		Item		Description
(1)		Road Design		
	1.1	Design Type		5
	1.2	Design Speed		65 km/h
	1.3	Sight Distance	SSD	90 m
			ISD	180 m
			OSD	
(2)		Crest Width		9.80 m
(3)		Carriage Way Width		5.50 m
(4)		Minimum Horizontal Curve		250 m
(5)		Minimum Vertical Curve (k value)		18 m
(6)		Passenger Car Unit (PCU) Value		3.0 (truck)
	6.1	Minimum Super Elevation Requirement	250	3
	6.2		500	5
	6.3		1000	Nil
(7)		Minimum Design Transition Length (Lc)		25
	7.1	Extra Carriageway Width on Curves	201-350	0.6
	7.2		351-600	0.6
	7.3		601-1000	Nil
(8)		Minimum Length of Vertical Curve		40
(9)		Maximum Gradients		3%
	9.1	Embankment Slope	River Side	3:1
	9.2		Country Side	2:1
(10)		Shoulder	2.15 (Hard: 1.20 m, Soft: 0.95 m) x 2	
(11)		Crest Level of road on embankment		9.8 m
(12)		Maximum Vehicle	Medium Truck (Category 2 in RHD Guideline)	

4.3.2 Major Structures

Relative major structures are considered as follows.
Regulator – 8 (eight) sluice gates will be re-constructed for flood control in the embankment.

4.3.3 River Training and Bank Protection Works

The purpose of river training is to stabilize the channel along a certain alignment with certain cross section for one or more of the following objectives:

(1) Safe and expeditious passage of flood flow
(2) Efficient transportation of suspended and bed load
(3) Stable river course with minimum bank erosion
(4) Sufficient depth and good course for navigation
(5) Direction of flow through a certain defined stretch of the river

Type of river training works: Type of works to be done for the purpose of training a river is dependent on the objectives and engineering principle chosen to be adopted in the river training programme. The usually adopted types of river training works are:

(1) Bank revetment
(2) Groynes
(3) Guide bundh
(4) Artificial loop cut
(5) Pallasiding
(6) Percupine

Bank revetment: This type of river training works involves a protective cover of suitable hard material applied on the slope and toe of the river bank so that the bank soil is protected from the actions of erosive forces of flowing water and dynamic actions of waves. The protective work can be divided into two main parts *i.e.*, protection of bank itself and protection of the toe of the bank. The protection of the bank is done by revetment using selected materials and the protection of toe is done by launching apron.

The following general criteria should be considered during design of protection works:

(1) the revetment does not slide under frequently occurring hydraulic loads
(2) the revetment including filter layers and subsoil must be in equilibrium as a whole
(3) the component of the weight of the revetment normal to its face should be greater than the uplift pressure caused by water
(4) the surface particle of the revetment should have enough resistance against wave and current attack
(5) the toe of revetment shall be stable against probable maximum scour in the river bed

The structural elements of the protection work need to be selected to fulfill the above criteria are as follows:

(1) size and thickness of revetment materials
(2) thickness and gradation of riprap
(3) thickness and gradation of granular filter
(4) type of fiber filter
(5) dimension of launching apron
(6) depth of pile used as toe protection

Hydraulic factors: For design of bank protection work or any other river type of river training work the following hydraulic factors shall be established:

(1) Flood level
(2) Lowest water level during dry season

(3) Discharge
(4) Velocity
(5) Wave characteristics

Slope Protection: Slope protection consists of a cover layer and a filter layer over a developed slope along the reach of bank to be protected from erosion. The cover layer must be able to resist hydraulic impacts (current and waves) while the filter layer in between cover layer and core materials is responsible to prevent migration of subsoil particles out of the bank slope (retention criteria) and at the same time to allow movement of water through the filter (permeability criteria). The slope normally developed for bank revetment is 1V: 2H. The revetment must have the following qualities and characteristics:

(1) the surface of individual elements of the cover layer should be sufficiently resistant against abrasion by wave and current attack,
(2) sufficient weight and permeability to keep the subsoil stable against uplift forces
(3) filter layer to prevent migration of soil
(4) stability to withstand against sliding due to frequent hydraulic loads

Toe Protection: Lack of protection of toe of the revetment against undermining is a frequent cause of failure of revetment. Therefore, protection of the toe of revetment by suitable method is a must. The toe protection of revetments may be provided by following methods:

Extension to maximum scour depth: lower extremity of revetment placed below expected scour depth or founded on non-erodible bed materials. This is preferred method, but it is difficult to execute when under water excavation is required and at the same time expensive, that is why not usually practiced in Bangladesh.

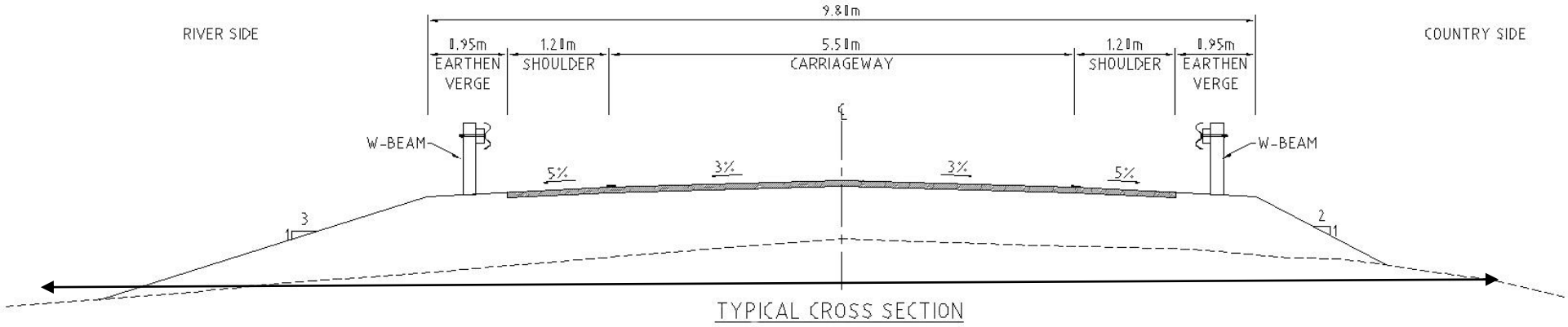
Placing launching stone: Launching stone is defined as stone that is placed along the expected erosion areas at an elevation above the zone of attack. At the estimated scour depth, the launching apron is assumed to cover and stabilize the bank side river profile reducing further erosion of the bank. This method has been considered to be most economical and common method of toe protection of revetment.

Dimension of Launching Apron: Adequate quantity of stone shall be required for ensuring complete protection of the whole of the scoured face. This quantity will obviously depend on the apron thickness, depth of scour, and slope of launching apron.

Thickness of Launching Apron: A thickness of apron at junction of toe and apron should be 1.5 times and that at the river end of apron shall be 2.25 times the thickness of riprap in slope (according to T.N. Rao, 1946) while according to Spring (1903) a minimum thickness of apron equal to 1.25 times the thickness of stone riprap of the slope revetment shall be provided at junction of toe and apron which shall be increased in the shape of wedge towards the river end. The face slope of launching apron may take as 2(H): 1(V) for loose stone as suggested by Spring (1903) and Gales (1938).

Length of Launching Apron: The length of launching apron depends on the anticipated scour depth. The length of launching apron generally adopted as 1.5 times the scour depth (L= 1.5D). For proper dimensioning and estimating the quantity of materials in launching apron it is most necessary to estimate the expected scout depth as follows.

Figure 4.6: Cross Section of Proposed Approach Road[16]



Right-of-Way (RoW): Approx. 45m

[16] 4.15 km

4.3.4 Materials to be used for Construction

The construction of the project will require considerable quantities of construction materials of various types and quantities.

Embankment Fills: The proposed embankment cum road requires significant amount of filling materials to make it a reasonable height. The GoB has adopted a policy to encourage construction of roadway embankments with river sand rather than clayey agricultural soil. River sand is a good fill material with higher CBR value. It is quite abundant in the various river beds in the project area. Sand is easily compactable to a high degree of compaction but will require protection against erosion by cladding with a layer of cohesive soil.

Concrete Aggregate: Stone aggregates are commonly used for the manufacture of normal and high strength concrete and it is proposed to be used for these roads as well. The major concreting operation for Jamuna Bridge was undertaken using stone aggregate.

Cement and Steel Reinforcement: Bangladesh produces different classes of EN and ASTM standard cement and high strength deformed bar of 40, 60 and 75 grades. These materials are readily available in the project area.

Bitumen: Bitumen will be imported. Commonly used bitumen in the road construction industry in Bangladesh is 60-70 and 80-100 penetration grade bitumen. For Bangladesh, temperatures 60-70 grade is better suited but the supply of this grade is limited.

Figure 4.7: Existing Condition of the Embankment

4.4 Internal Roads and Walkways

Internal roads would be constructed after the land development work of the EZ.

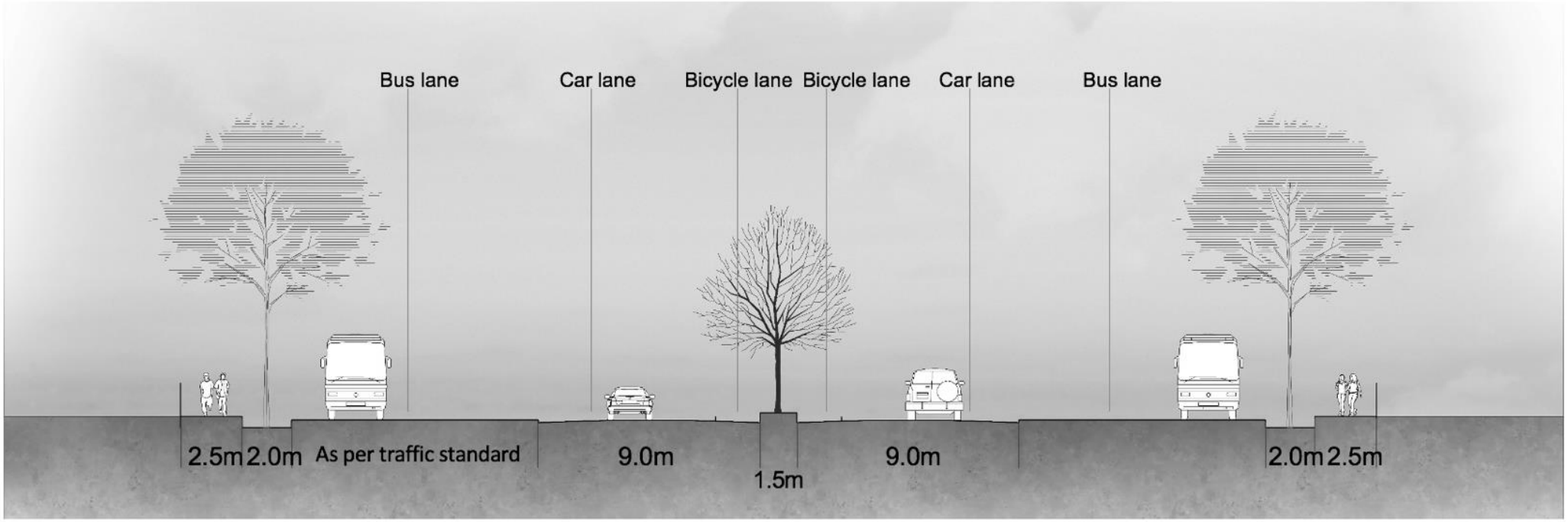
Arterial, primary and secondary roads are planned to give access to the industries within EZ apart from catering to residential and commercial zones and shall be looped with inter connecting roads. In order to minimize land taken by major and minor roads, a proper hierarchy of roads is proposed to ensure smooth traffic movement inside EZ. A bituminous surface road is proposed in the master plan for the internal road in the EZ in terms of its flexibility. The main road is planned from the entrance crossing through factory plots in the EZ. A separate diagram of internal road network has been prepared showing different widths of the road network. Land acquisition and resettlement as well as land filling for the construction of internal road are discussed at the end of Section 2.3.

Aesthetically designed walkways are designed along with green environment on either side of the roads. Pedestrian walkways are to be provided on all categories of roads. All services for drains, sewers, water, power, energy and telecom are maintained within the road right of way. Necessary signage, street name boards, zone guiding maps and visitor's guidance map etc. are planned to be positioned at necessary locations, such as intersections and at various Strategic locations in each zone. No access is planned to be allowed near the road junctions and it is recommended that ingress / egress points will be with a set back from the road junction.

4.5 Utility Corridor

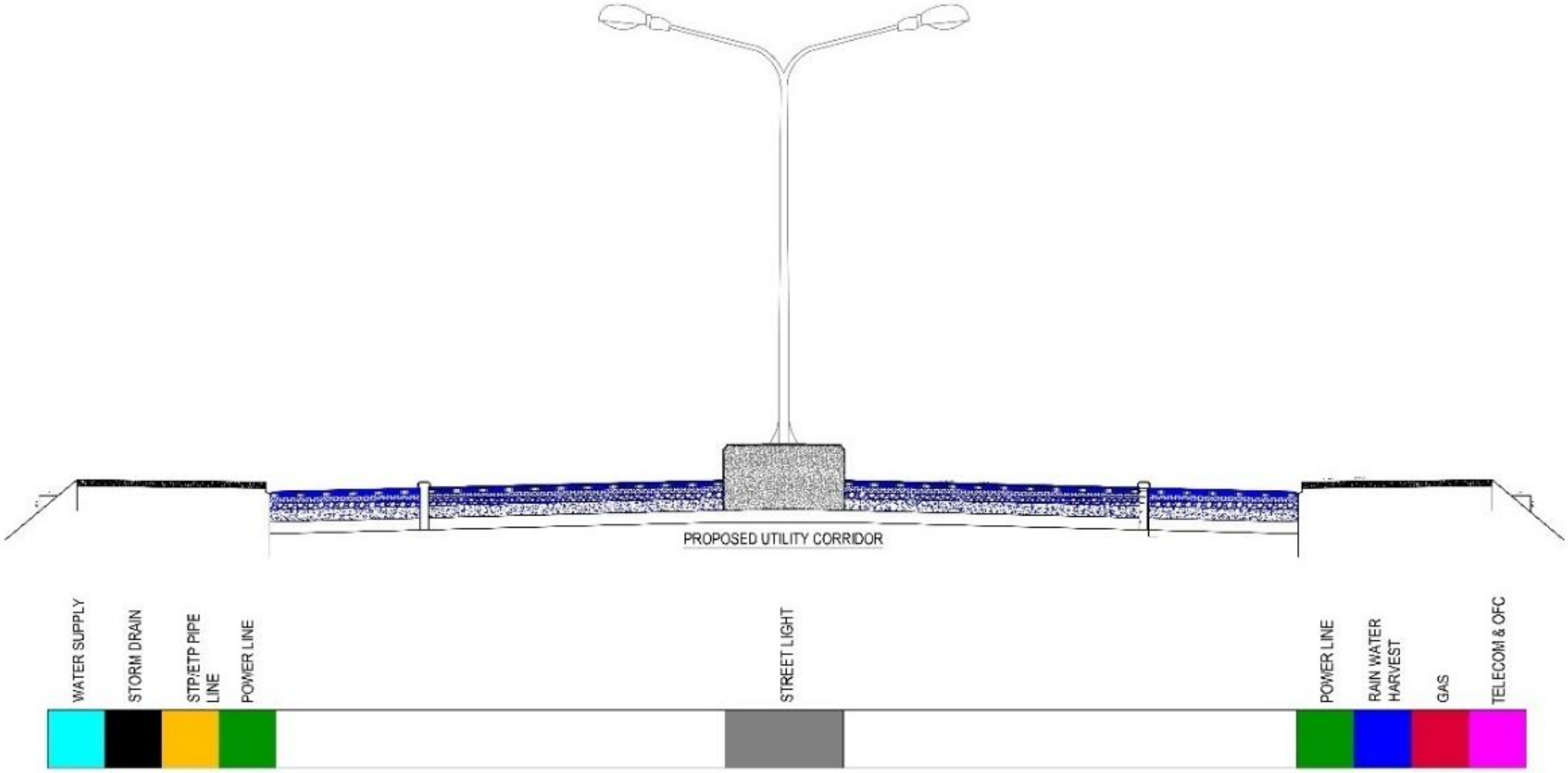
An underground utility corridor has been proposed, under foot-path, beside roads, which will carry different utility pipe lines. Figure 4.9 shows an indicative cross section.

Figure 4.8 Internal Road Cross Section[17]



[17] 2 km

Figure 4.9: Proposed Utility Corridor (Indicative)



4.6 Buildings and Superstructures in Moheshkhali EZ

Table 4.3 provides a list of buildings, utility structures and common facilities. The sizes of the structures given are conceptual. Conceptual drawings of some of the structures are provided in Annexure A10.

Table 4.3: Proposed Buildings and Superstructures in Moheshkhali EZ

Residential Area	Commercial Area	Administrative Area	Mixed-Commercial Area	Utilities Area	Common Facilities	
Guest House	Vocational Training Centre, Environ. Lab and R&D Facilities	BEZA Administrative Offices	Warehouses	Fire Service - Building	Boundary Wall (H-3.05)	Road-side Drainage
Officer's Building	Gymnasium and Health Centre, Canteen, and Public Toilets	One Stop Service	Canteen, Toilet complex	Gas DRS Station	Gate House with security arrangements (15 sqm)	Electrical line and street lightings
Staff Quarters	Workshop	Telecom Office	Trucks Stand and Parking	Electrical Sub-Station	Security Watch Tower	Gas supply network
Staff Dormitory	Banks, Insurance, ATMs	Meeting Rooms		Solid Waste Transfer Station	(4m x 4m, H-3.35 + 2.65m)	Water-supply network
Primary School	,Medical Center and Medicine shop	Day Care Centre		CETP	Green Area and green patch	Fire-hydrant network
Mosque	Commercial offices, Prayer room and Toilets	Customs Office, Security Office		CSTP	Water body/ Pond	CSTP pipe-network
	Investors' Residence and Restaurant			DTW,	Internal Road network	CETP pipe-network
				WTP	Pedestrians foot path	Frontage Road 1,
				OHWT		outside Boundary Wall
				Water reservoir		Frontage Road 2,
				Rain Water Harvesting Units		outside Boundary Wall

Figure 4.10: Residential Zone

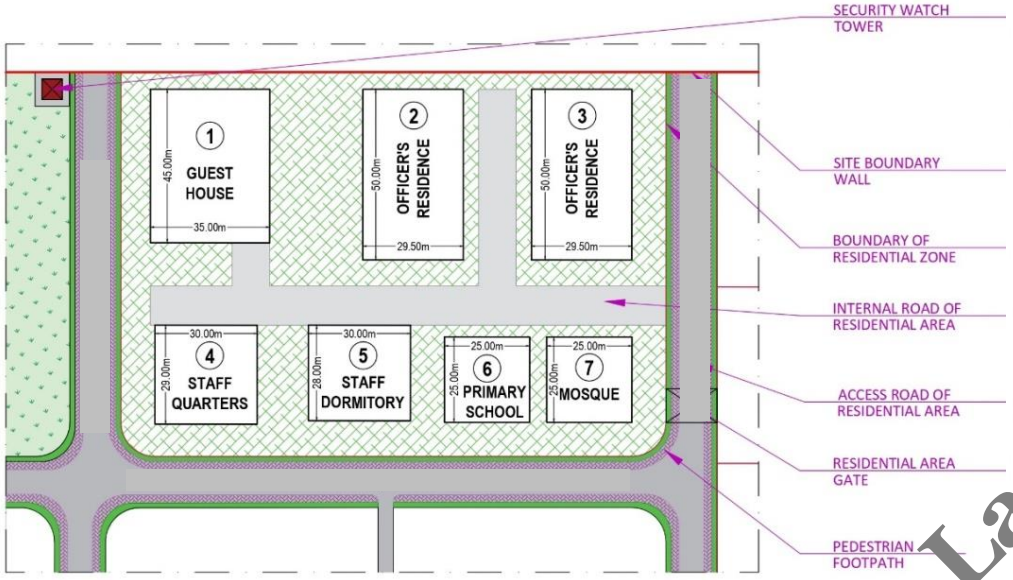


Figure 4.11: Commercial Zone

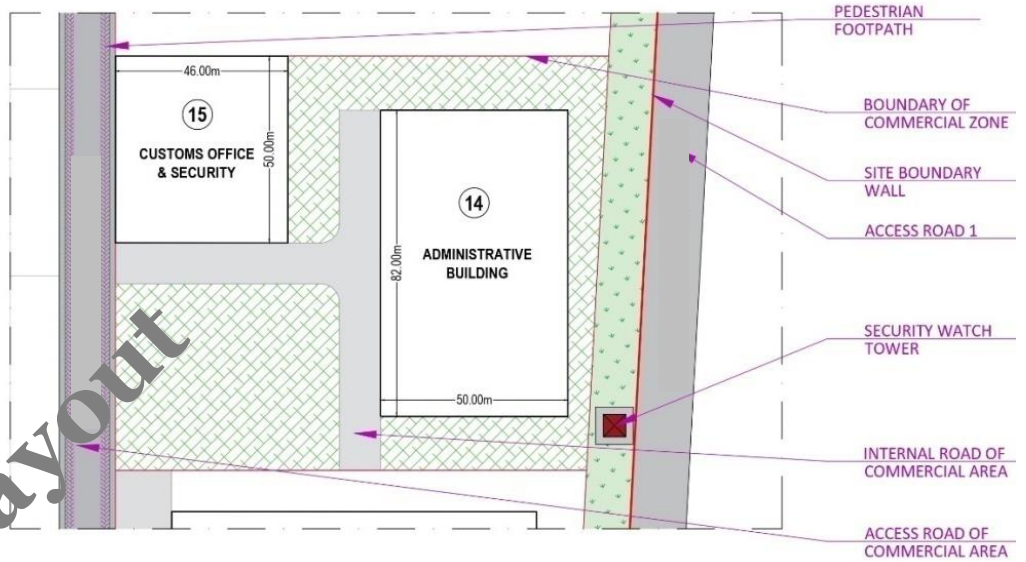


Figure 4.12: Administrative Zone

4.7 Street Lighting

All the road and streets shall be provided with street lighting not only to assist pedestrians and traffic, but also to increase safety and security in the area on both sides of the sidewalk and along the boundary wall. It has been conceived in two different forms.

- Street lights for the road network
- Solar street lighting

It is recommended that all lighting should be by high-pressure sodium lanterns mounted on power poles or on streetlight columns. For major roads the average illumination should be about 20 lux.

4.8 Utilities

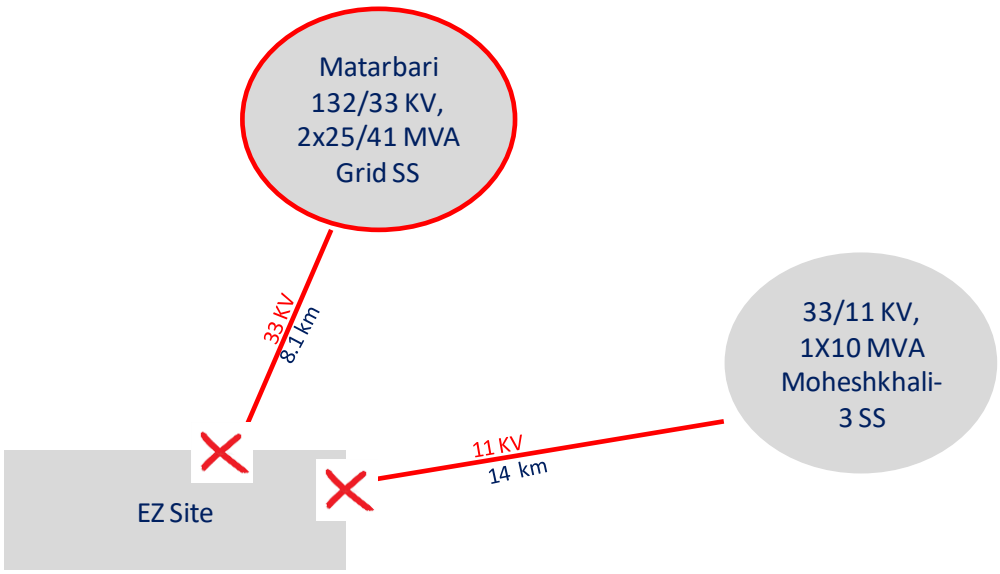
Different industries will have different pattern of consumption of utilities. After a research in length, the requirements have been estimated as provided in Section 3.10.

4.9 Power

4.9.1 Existing Facilities

For catering household electricity demand in the area where the site is located, few LT power lines from nearby REB 11/0.4 KV SS of Cox's Bazar Palli Biddyut Samity exist. A double circuit line (33 KV and 11 KV, on the same series of poles) also runs nearby, which was originally planned for catering the demand of EZ.

Figure 4.13: Existing Power Infrastructure



(1) 33 KV line: linked with Matarbari 132/33 KV, 2x25/41 MVA Grid SS[18] (about 8.1 km from the BEZA site). On the source end of the Matarbari Grid SS, which is in operation and additionally a new 132 KV dedicated power transmission line is under construction for connecting national grid with the SS.

[18] SS = Substation

(2) 11 KV line: linked with 33/11 KV, 1X10 MVA sub-Station (about 14 km from the BEZA site) designated as Moheshkhali 3 SS [(1) and (2) both are installed on the same series of poles.]

Although the above two circuits (1) and (2) were originally planned for feeding operation of the proposed EZ, the capacities of the line are highly limited compared to the need of the EZ. The 33 KV line is not yet energized and not yet connected with any receiving substation. 11KV line up to PUL POWER area is energized to cater household demand in the surrounding area through REB's 11/0.4 KV SS. The other line (11 KV) is disconnected from live line.

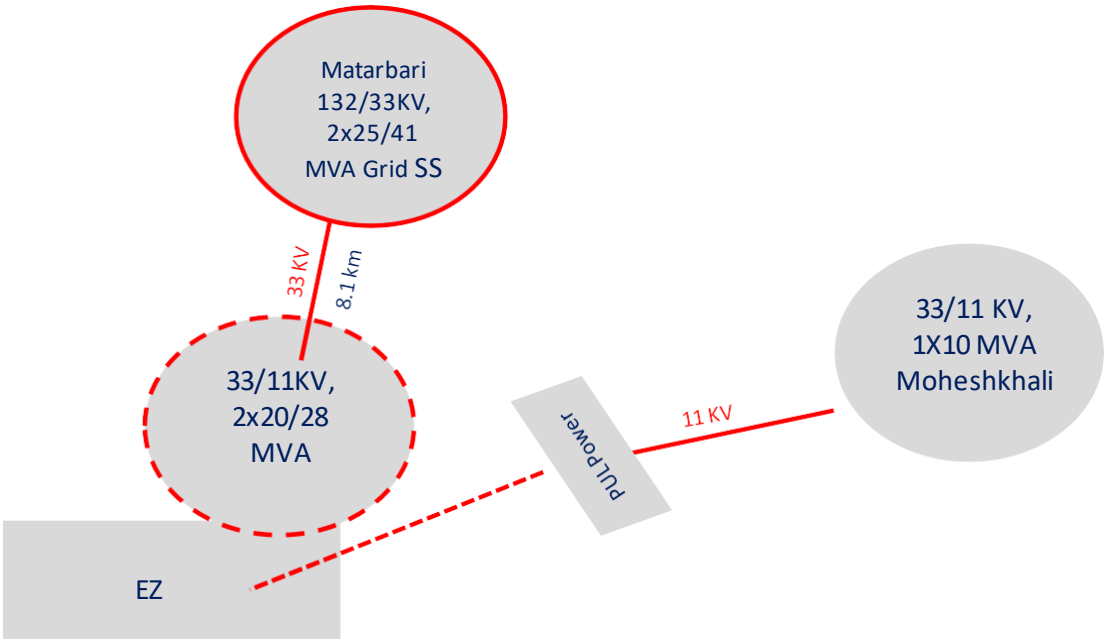
Requirement of power in the EZ site for industrial use will be dealt with in two phases, as mentioned in sections 4.9.2.1 and 4.9.2.2.

4.9.2 New Facilities being proposed

4.9.2.1 For Feeding During Construction of the Site

For running construction equipment and machinery, approx. 5-10 MW power is estimated to be required, which may be obtained from either of the following sources.

Figure 4.14: Proposed Power Supply System during Construction



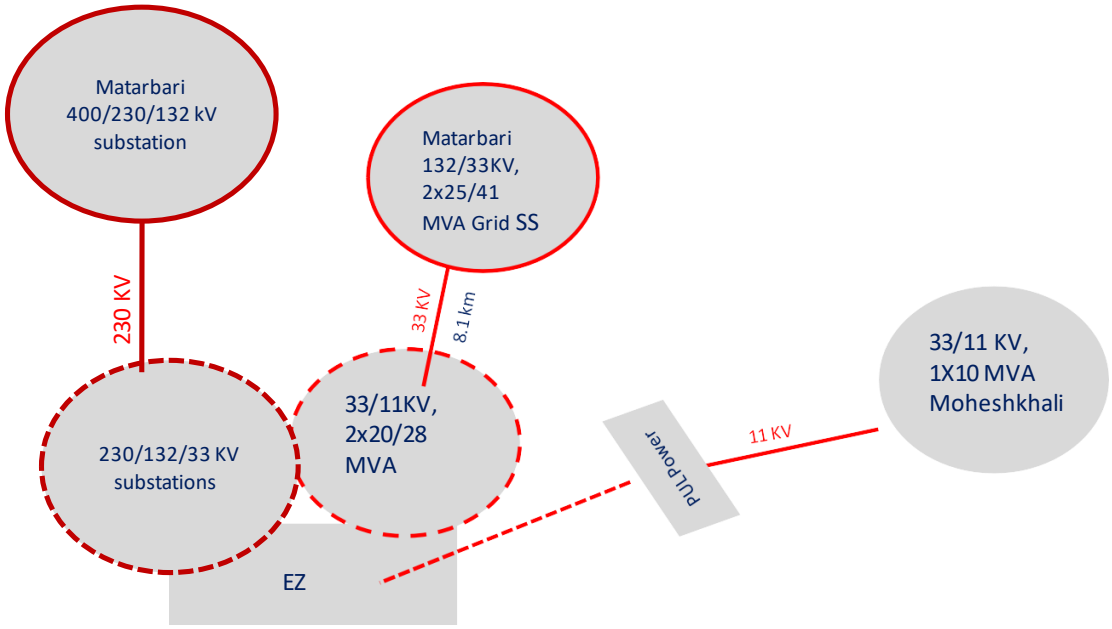
(1) **33/11 KV, 2x20/28 MVA Indoor SS**: with the intake of power routed through the existing 33 KV power line between 132/33 KV, 2x25/41 MVA grid SS at Matarbari and the indoor SS. The indoor SS, as a base case, is planned to feed partial operation of the EZ. However, it may also be used during construction, if built before construction, to cater the demand in subsequent phases *i.e.* construction and operation.

(2) **11 KV Line:** from PUL Power to the site to be connected with the live line and thus, HT power in 11 KV will be made available to run BEZA's construction activities. Afterwards, the same can be used for feeding partial operation of the EZ.

4.9.2.2 For Feeding During Operation of the EZ

The power demand of the EZ upto 2045 has been calculated. Year wise break up is also given. Based on industry assessment, power demand of the proposed EZ during operation will be about 292 MW, which is planned to be fed from a 230/33 KV substation (to be located in the EZ compound). The 230 KV source line of the SS is planned to be drawn from the upcoming grid SS of PGCB at Matarbari (8-10 km). Thus, the power demand during operation is planned to be met from the following sources by order of priority.

Figure 4.15: Proposed Power Supply System during Operation



(1) **230/132/33 KV grid SS (3x120/140 MVA capacity)**: to be installed by PGCB as part of 'Matarbari 400/230/132 KV SS and Associated Transmission Line Project' to cater the power demand in the zone during operation. A requisition to PGCB by BEZA, to extend a 230 KV line from Matarbari 400/230/132 kV SS directly to the BEZA site with a grid SS of 3x120/140 MVA capacity, is under consideration (shown on the left side of the figure). Few 230/132/33 KV SSs are also to be built in the site with provision of multiple 230/132/33 KV bay breakers.

(2) **33/11KV, 2x20/28 MVA Indoor SS** [discussed under 4.9.2.1 (1)]

(3) **11 KV Line** [discussed under 4.9.2.1 (2)]

[Availability of Power in 230 KV, 132 KV, 33 KV and 11 KV:
The industries are planned to be connected in (a) 230 KV (above 140 MW), (b) 132 KV (30 MW ~ 140 MW), (c) 33 KV (5 KW ~ 30 MW) and (d) 11KV (50 KW ~ 5 MW) according to the respective power demand of the industries concerned. For connectivities with (a), (b) and (c), proposed 230/132/33 KV Substations (2x150 MVA capacity) will be used and, for (d), either exiting 11 KV line or the proposed 33/11 KV, 2x20/28 MVA Indoor SS will be sourced.]

(4) **Power Generation by the Industries Themselves:** In case the industries planned in the EZ may have features of extremely power sensitiveness in respect of fluctuations (voltage and frequency) and interruptions, those may go for arranging power through generation by themselves with due concurrence and approval of the concerned authorities.

Figure 4.16: Proposed Power Connectivity Route to the Site

Table 4.4: Power Infrastructure

Facility		Status	Connectivity	Line Voltage	Capacity	Comments
				KV	MVA	
(1)	400/230/ 132 KV national gridline	under construction by PGCB	to be back-linked with (2)			Suitable for sourcing power for the EZ during operation. 8.1 km from the site.
(2)	230 KV grid line up to BEZA site	recommended to be newly installed/ constructed by PGCB	To connect 230 / 33 KV grid Substation at BEZA site			
(3)	230 / 33 KV grid Substation	recommended to be newly installed/ constructed by PGCB	Power in 232 KV , and 33KV will be available with the provision for providing 132 KV line from spare bay of 230 KV line	230/33	3X 120/140	
(4)	132/33 KV Matarbari grid SS	existing		132/33	2x25/41	
(5)	33/11 KV Moheshkhali-3 SS		Forward-linked with (7)	33/11	1x10	Presently energized and in operation
(6)	11/0.4 KV SS of Cox's Bazar Palli Biddyut Samity		Connecting with (5)	11/0.4		to cater household power in the surrounding
(7)	0.4 KV power distribution line		from (4) to the site and around for feeding household electricity demand	0.4		
(8)	33 KV power line	existing but not yet energized	from (5 to the area near the site	33		Originally planned for the EZ, but with limited capacity.
(7)	11 KV power line	11KV line up to PUL POWER area is energized. Rest 11KV line to BEZA site is disconnected from live line	from (3) to the area near the site Running on the same series of poles as of (6)	11		11KV line up to PUL POWER area to cater household power in the surrounding area through REB's 11/0.4 KV SS. Rest 11KV line up to BEZA site is disconnected from live line
(8)	33/11 KV indoor SS	recommended to be newly installed/ constructed	for feeding the site during construction and operation	11	2x20/ 28	necessary to start construction of the site
(12)	Distribution line within the EZ	to be newly installed	To be back-linked with (8)	11		necessary for feeding partial operation of the EZ

4.10 Gas

The national gas grid up to Chattogram is the potential source of supplying natural gas to the proposed zone. The government planned and implemented the import of natural gas in the liquid form to supplement the supply of indigenous natural gas from gas fields in the country.

(1) The concept of importation of liquefied natural gas (LNG) in the country has already commenced from August 2018 when a Floating Storage and Regasification Unit (FSRU) was commissioned. The FSRU has been built at Moheshkhali Island in the Bay of Bengal by Excelerate Energy Bangladesh Limited, a US company and being operated by them. At present the FSRU is supplying at the rate of 500 mmscfd gas.

(2) Currently about 20% of the total gas supply in the country is the re-gasified LNG. National Gas Grid system, operated by Gas Transmission Company Limited (GTCL), has been further strengthen by adding a 42 inch gas transmission pipeline from Moheshkhali to Anowara parallel to a 30 inch gas transmission pipeline from Moheshkhali to Anowara.

(3) Additionally, a local conglomerate Summit LNG Terminal Co. Ltd. (SLNG) has also added another FSRU of 500 mmscfd capacities and re-gasified LNG is being supplied from there to the national gas grid. This has eased the very critical situation of Chattogram gas distribution system and feeding more gas to the franchise area of Titas Gas T&D Co. Ltd., from where Pashchimanchal Gas Distribution Company Limited (PGDCL) and Sundarban Gas Distribution Company Limited (SDCL) get gas to meets their gas requirements.

(4) Petrobangla is purchasing LNG from RasGas Company Limited (RasGas) of Qatar for supplying of LNG to Bangladesh for a period of 15 years. Besides, efforts are in progress at Petrobangla for acquiring more LNG from spot market and other countries like Malaysian, Indonesia, Oman, Iraq and Australia etc., for not to be tagged with single sources of supply. Petrobangla has signed MoU with PETRONAS of Malaysia.

Therefore, re-gasified LNG is regarded as an economic and clean fuel options for industrial establishments and process industries in the zone addressing the adverse effect of using coal and liquid petroleum products. The demand for natural gas has been considered for sizing the connecting pipeline from the nearby gas transmission pipeline (owned and operated by GTCL).

These are the nearest gas transmission pipeline to the proposed EZ and at Nalbila a Valve Station have multiple off-takes to construct a gas transmission pipeline up to the proposed EZ. These pipelines including other gas transmission pipelines connecting gas fields in the northeastern region of the country are now feeding re-gasified imported LNG and gas from local gas fields for franchise areas of five major gas distributing companies, which are supplying about 87-89% of total gas consumption in the country.

It is expected that gas to be supplied to the proposed EZ would be primarily imported LNG unless any new gas fields in Chattogram area comes up when it will be a blended gas of RLNG and locally produced natural gas.

The pre-feasibility report conducted by PWC, has also emphasized that setting up of industries would be considered in the proposed zone, when gas and power connection is established to the proposed site. They have stated that non availability of gas in this region is a major challenge towards setting up of industry; however, various infrastructure development projects planned in this region are expected to foster the possibility of gas supply in this region. In the process, Gas Transmission Company Limited has installed few pipelines in Chattogram from the FSRU and on land pipelines have been established to facilitate the supply of the re-gasified LNG to National Gas Grid.

A gas transmission pipeline from nearest gas transmission pipeline of GTCL and distribution pipelines within the zone are to be constructed. GTCL will assist BEZA to construct about 11.2 km gas transmission pipelines from the off-take at Nalbila Valve Station of the 42 inch and 30 inch gas transmission pipelines to carry re-gasified LNG from FSRU in the Bay of Bengal.

4.10.1 Codes and Standards

The gas transmission and distribution pipeline and associated facilities would be constructed with materials complying international specifications and code of practice which are followed in Bangladesh for gas industry. Primarily American codes and standards are followed and a few are among the other codes and standards. However, it is mandatory to be within the provisions of the Bangladesh Natural Gas Safety Rules (Updated in 2003).

Table 4.5: Codes and Standards

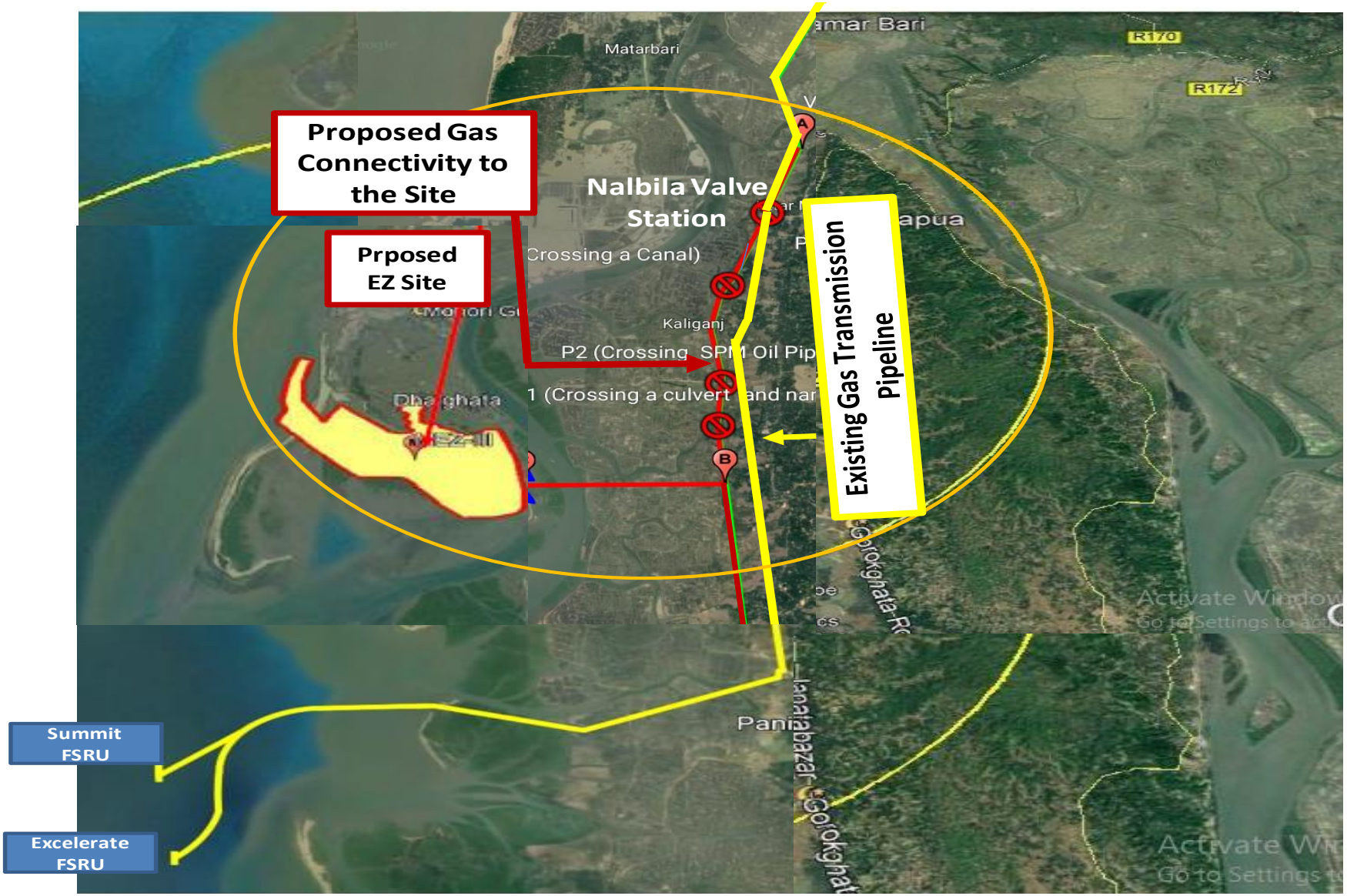
	Codes		
(1)	ASME B 31.8	:	Gas Transmission and Distribution Piping Systems
(2)	ASME	:	ASME Boiler and Pressure Vessel Code (BPVC), Section VIII – Pressure Vessels
(3)	ASME	:	ASME's Boiler and Pressure Vessel Code (BPVC), Section IX – Welding and Brazing Qualifications
(4)	API Spec.5L	:	Specification for Line Pipe
(5)	API Spec.6D	:	Specification for Pipeline Valves (Steel Gate, Plug, Ball and Check Valves)
(6)	API Spec 6FA	:	Specification for Fire Test for Valves
(7)	API Std 594	:	Standard for Check Valves: Flanged, Lug, Wafer and Butt-welding
(8)	API Std 598	:	Standard for Valve Inspection and Testing
(9)	API Std 607	:	Standard for Testing of Valves-Fire Type-testing Requirements
(10)	API Std 608	:	Standard for Metal Ball Valves-Flanged, Threaded and Butt-Welding Ends
(11)	API RP 621	:	Recommended Practice for Reconditioning of Metallic Gate, Globe, and Check Valves
(12)	API STD 1104	:	Welding of Pipelines and Related Facilities
(13)	ANSI/ASMEB 36.10M	:	Welded and Seamless Wrought Steel Pipe
(14)	ANSI B16.28	:	Wrought Steel Buttwelding Short Radius Elbows and Returns
(15)	ANSI N278.1	:	Self-Operated and Power-Operated Safety-Related Valves, Functional Specification Standard
(16)	ANSI/ASME B 1.20.1	:	Pipe Threads, General Purpose
(17)	ANSI/ASME B 16.5	:	Pipe Flanges and Flange Fittings
(18)	ANSI B 16.20	:	Ring Joint Gaskets and Grooves for Steel Pipe Flanges
(19)	ANSI B 16.34	:	Valves-Flanged and Butt-Welding Ends
(20)	ASTM A 101	:	Specification for Forged or Rolled Steel Pipe Flanges, Forged

	Codes		
			Fittings and Valves and parts for General Service
(21)	ASTM A 182	:	Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves and parts for High Temperature Service
(22)	ASTM A 105	:	Specification for Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves and parts for High Temperature Service
(23)	ASTM A 106	:	Specification for Seamless Carbon Steel Pipe for High Temperature Service
(24)	ASTM A 194	:	Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service
(25)	ASTM A 516	:	Specification for Carbon Steel Plates for Pressure Vessels for Moderate and Lower Temperature Service
(26)	ASTM A 53	:	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
(27)	ASME B 16.49	:	Specification for Induction Bends
(28)	MSS 25	:	Standard Marking System for Valves, Fittings, Flanges and Unions
(29)	MSS 44	:	Standard Marking System for Steel Pipeline Flanges
(30)	ISO 9001:2015	:	Quality Management Systems - Requirements
(31)	ISO 14001:2015	:	Environmental Management Systems
(32)	ISO 45001:2018	:	Occupational Health and Safety Management Systems
(33)	ISO 31000:2018	:	Risk Management
(34)	Bangladesh Natural Gas Safety Rules, 1991 (as amended in 2003)		
(35)	Public Procurement Acts, 2006 and Public Procurement Rules, 2008, including all Amendments		
(36)	Bangladesh Energy Regulatory Commission Act. 2003		
(37)	Explosive Rules, 2003		
(38)	Noise Pollution Control Rules 2006		
(39)	The Acquisition and Requisition of Immovable Property Act. 2017, including all Amendments		
(40)	Environmental Conservation Act. 1995, including amendments		
(41)	Environmental Conservation Act. 1997, including amendments		

4.10.2 Gas Pipeline Route

The route planning for gas transmission pipeline is for rational and economic use of the route for which preparation of suitable route planning was based on site visits and Google images. Gas Transmission Company Limited has identified the route of the transmission pipeline from the Nalbila Valve Station up to Moheshkhali Economic Zone. The proposed pipeline would be constructed through a new Right-of-Way (RoW) following about 8 km parallel to the existing GTCL 42 inch gas transmission pipeline and then a straight pipeline up to MEZ.

Figure 4.17: Proposed Gas Connectivity Route to the Proposed EZ



The figure shows that the proposed gas connectivity line to the proposed EZ is running parallel to the existing gas transmission network. However, a detailed route survey would be conducted by GTCL.

For feeding the EZ from the gas transmission pipeline, the following additional facilities are to be built up:

(1) Town Bordering Station (TBS) of 250 mmcfd
(2) Distribution Main Pipeline (3 km)

The distribution main pipeline will run across the boundaries of the industries and feed them.

4.10.3 Rationality of Selection of Routes

Subsequent to the site visit, the team discussed along with analytical review of objects and barrier in the Google map and topographical pictures. The shortest possible length of the route has been taken into consideration for physical and financial point of view. After examination of route, the Consultant Team conceded with that of route selected by GTCL.

4.10.4 Operating Pressure

Historically the gas transmission pipelines in Bangladesh have different operating pressures ranging from 960 psig to 1135 psig based on the maximum allowable operating pressure (MAOP) as per ANSI rating. Except 24 inch Bakhrabad to Chattogram gas transmission pipeline, all other pipelines are within the MAOP of ANSI 600 Class rating. Similar to the pipeline other than Bakhrabad to Chattogram gas transmission pipeline, the proposed pipeline for the project area has been considered for maximum pressure of 1,135 psig operation and suggests the construction and testing for such operating pressure.

4.10.5 Pressure and Flow Calculation

The pressure and flow calculations were based on Revised Panhandle Equation. In getting safe gas infrastructures, the application of American Codes and Standards like API, ANSI, ASTM, ASME etc. maintaining the requirements of the Bangladesh Natural Gas Safety Rule 1991 (updated in 2003). GTCL has proposed a 250 mmscfd gas Town Bordering Station (TBS) to reduce and process for measurement the gas receives at the TBS and supplies to the proposed EZ inside gas networks to be constructed under this project.

The outlet pressure of the TBS was considered as 350 psig since for having a pressure differential of 100 psig between the inlet and outlet of TBS is ideally necessary requirement. The outlet of the TBS has been thought for a major consumer TK Group of Industries would require 115 mmscfd gas at pressure 250 psig to run their petroleum refinery being established in the zone. All mathematical calculations were performed while doing the engineering of this project feasibility studies.

The capacity of the TBS of 250 mmscfd considered by GTCL has been taken as the flow through the 20 inch 11 km transmission pipeline, which was tested using mathematical model of the Revised Panhandle Equation. For safe operation, the calculations were performed to find out the pressure required at Nalbila Valve Station of the gas transmission pipeline of GTCL from where 12 km gas transmission pipeline will be generated. The calculated different pressure level for flow of 250 mmscfd at steady state are shown in the following tables:

Table 4.6: Pressure and Flow at Steady State for 20-inch, WT10.3 mm gas Transmission Pipeline

Gas Flow (mmscfd)	Pressure (psig)	
	Required at Inlet of TBS	Required at GTCL Pipeline
250	600	660
	550	615
	500	570
	450	527

The minimum inlet pressure at TBS has been taken as 450 psig for which it is seen that the minimum pressure of 527 psig at Nabila Valve Station of GTCL gas transmission pipeline, from where the 12 km gas transmission pipeline will be constructed, would satisfy the inlet to the TBS maintaining gas flow of 250 mmscfd.

4.10.6 Valve Stations

Since the pipeline length is only 12 km, no intermediate valve station would be required between the Nalbila Valve Station and that at TBS at Moheshkhali Economic Zone.

4.10.7 Period for Constructing Gas Transmission Pipelines

In Bangladesh, project implementation normally extends 3 to 4 years from date of approval of the project document (Development Project Proposal *i.e.* DPP), the authorized guidelines/document for the approval of the government. The land acquisition and requisition, procurement of permanent materials from abroad take substantial time. Moreover, the pipeline construction is totally season bound during dry season (November-May). However, efforts should be taken so that the entire project is completed before 2025 so as to supply gas to TK Group of Industries, a major stakeholder in the zone.

4.10.8 Right of Way (ROW) Constraints

IIFC team has visited the gas transmission pipeline to get clear idea of right of way and did not find significant constraints and barriers. It is mostly used for salt cultivation. Though the salt cultivation is a profitable livelihood option, local people who are engaged in salt cultivation, are also not entirely dependent on salt cultivation as this activity is restricted only for six months in a year. During physical works that will continue a few months, the sharecroppers and lessee farmers (if any) cultivating within the requisitioned area would have to discontinue their practice in the project area once the construction activities start.

4.11 Water Supply

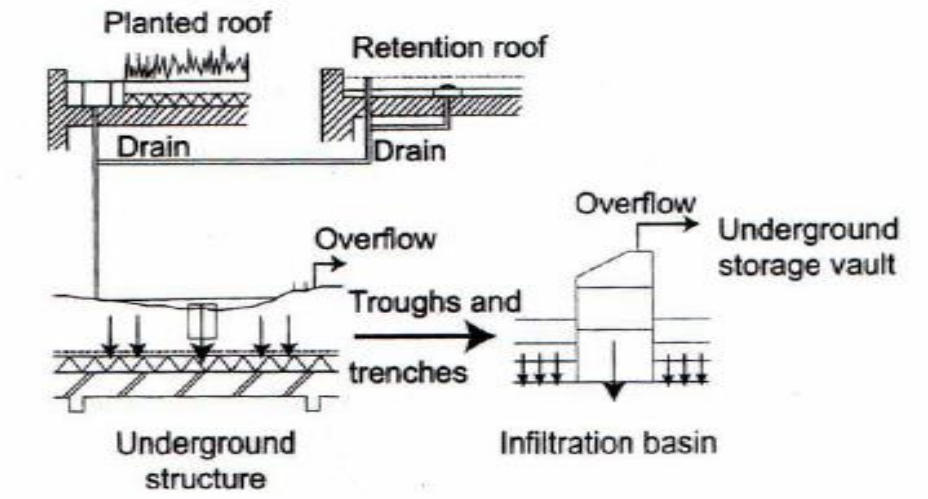
Water will be transmitted from the source to the area of use through a closed conduit, mainly ductile iron pipes with proper protection against corrosion. The pipeline carrying raw water to the project site is proposed to run parallel to line laid as per Master Plan.

4.11.1 Sweet Water

4.11.1.1 Rain Water Harvesting

Rain water harvesting can be a potential source of water. The proposed EZ would set up modern technology to harvest and use rain water during rainy season aim to reduce the pressure on ground water. The water that falls on roof and the ground will be collected into the water reservoir through a system of pipes. The water from the water reservoir will be pumped directly to the industries, as rain water does not need any treatment.

Figure 4.18: Rain Water Harvesting



4.11.1.2 Underground and Surface Water Sources

The area has underground source and canals for sweet water. The water requirement for the construction phase will include water for construction activities such as curing and formation of concrete mixtures and water for domestic consumption. For construction camp housing approx. 500 workers, water will be required @ 60 liters per person per day (lpcd)[1]. Water supply from nearby canal and ground water will be the main source of water during construction phase.

4.11.2 Saline Water

The Kuhelia River passes nearby the site and Bay of Bengal and is on the other side of the site. The water is saline and can be used for cooling machineries that will be installed as part of industries to be set up.

4.12 Telecommunication

Moheshkhali has mobile connectivity from almost all mobile companies. Moreover, there is an established BTCL (Bangladesh Telecom Company Limited) network as fixed Phone Network located almost 12km away from EZ at Gorakghata Municipality. BEZA would develop WIFI zones within the project area.

4.13 Sewage Treatment Plant (STP)

Sewage treatment is the process of removing contaminants from wastewater, comprising of storm runoff, domestic sewage and primary treated effluent. It includes physical, chemical and biological processes to remove various contaminants. Sewage would be managed through soak well and depending on requirement would be developed to full scale plant.

There is a total 0.23 acres of land have been allocated for the establishment of STP in the zone.

4.14 Effluent Treatment

The industrial effluents will be collected from the industries through an effluent pipe network and will be treated in the CETP. The industries will be responsible to do preliminary treatment for their industrial effluent. Maximum value for some critical wastewater parameters that can be discharged to the central effluent treatment plant will be set up to prevent overloading of the treatment operation. The process involves following stages:

(1) Pre-treatment stage is the first stage of effluent treatment process of CETP, where materials that can be easily collected from the raw wastewater before they damage or clog the machineries will be removed:

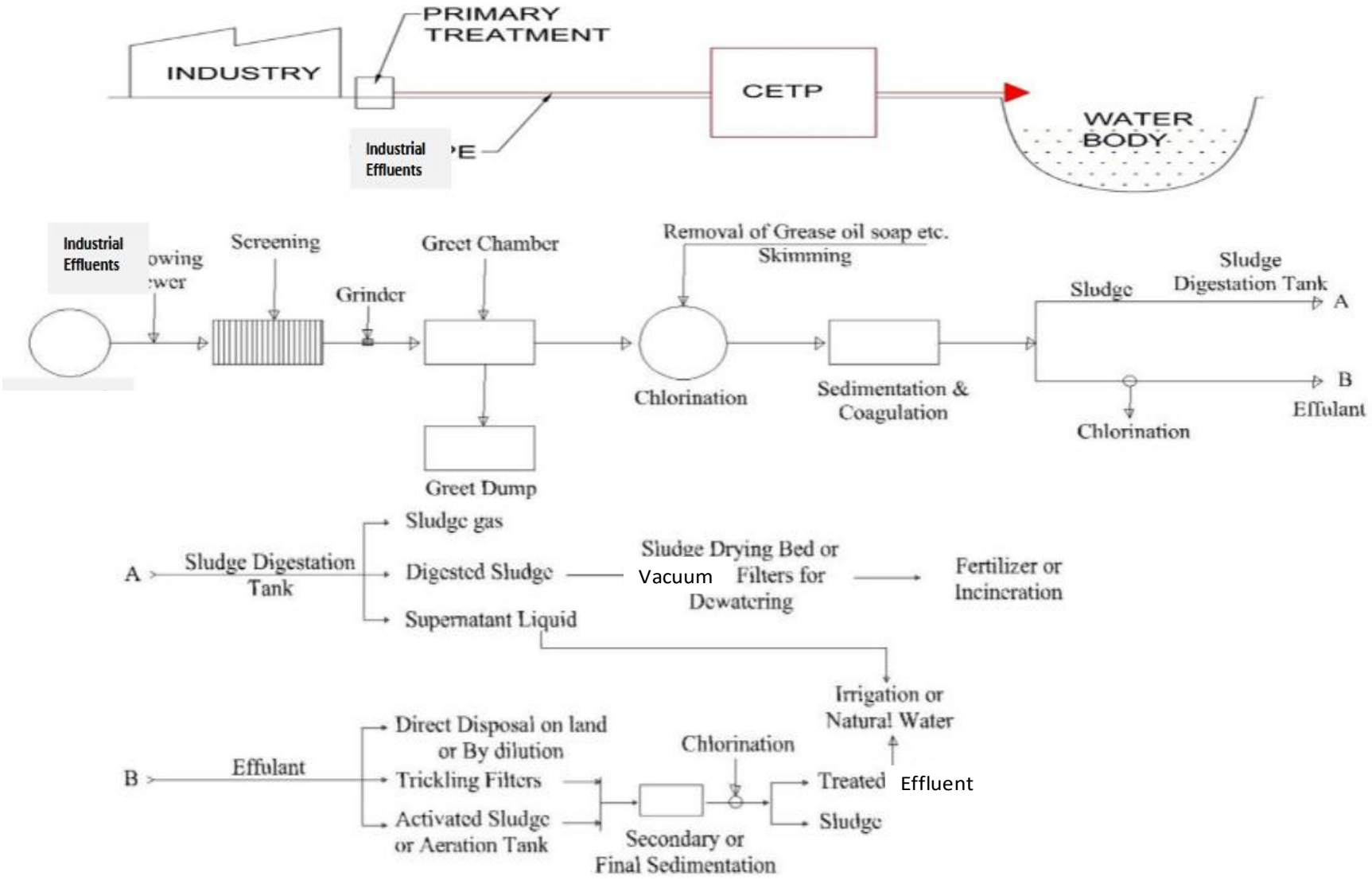
(2) Screening: In screening, large objects or floating solids will be removed from the influent water. This will be done with a bar screen which are cleaned manually. The solids will be collected and later disposed in a landfill or incinerated.

(3) Grit removal: In grit removal, pre treatment may include a sand or grit channel or chamber where the velocity of the incoming wastewater will be carefully controlled to allow sand, grit and stones to settle.

(4) Primary treatment in this stage, the effluent will be converted to a homogeneous liquid capable of being treated biologically. The effluent will be taken to equalization tank through a lift pump for chemical dosing. The chemical dosing is usually done by using alum, ferric chloride, calcium hydroxide or sodium hydroxide. Then the effluent is taken to mixing tank. The pH of the effluent will be corrected here.

(5) The secondary treatment will be done to degrade the biological contents of the effluent. Through aeration secondary treatment will be done. The purpose of secondary treatment is to reduce the organic compounds of the effluent through bacteria formation and help in coagulation of the compounds to create removable solids.

Figure 4.19: Effluent Treatment System



4.15 Drainage

The drainage will be required mainly for discharging rain water. It has been planned to cater for the entire EZ through gravity flow. The rain water/surface water would be dispersed through several points from the EZ. Drains are proposed to be on both sides of the roads. The network would be built using conduit pipe. There would be surface opening via HUM/conduit pipe in specific intervals for intake of surface water.

(1) The drainage system is planned to cater for the entire EZ through gravity flow;

(2) Drains are proposed to be provided on both sides of the roads;

(3) Open trapezoidal drain is considered for the surface runoff collection due to easy maintenance for the primary road. Stone pitching is considered for the side walls and plain cement concrete (PCC) for the base;

(4) Covered rectangular brick masonry drain is considered for the remaining areas for optimization of area under drainage;

(5) Reinforced cement concrete (RCC) box/ pipe culverts of suitable sizes are considered for road crossings;

(6) Rainwater harvesting structures are envisaged all along the drain

For preventing the storm water entering from adjacent areas to the development area, a cut-off drain all along the periphery of the site is considered and connected to existing river / discharge points. The peak runoff and discharge capacities are computed based on the following design parameters and to be computed based on rational formula:

$$Q = C * I * A / 360$$

Where,
Q = Quantity of runoff, m3/s
C = Coefficient of runoff
I = Intensity of rainfall, mm/hr
A = Catchment area, hectare

4.16 Admin Building

One of the fundamental onsite infrastructures of any economic zone (EZ) is the construction of administrative building. An area of 605 sqm land has been allocated for admin building aimed to support the Moheshkhali Economic Zone during its construction and operational activities by Bangladesh Economic Zones Authority (BEZA). The building consists initially of 3-storeyed considering 6-storied foundation for future vertical expansion. However, the capital cost has been estimated considering accordingly.

4.16.1 Planning Consideration

The proposed admin building has been designed based upon the following planning and development objectives:

(1) To provide adequate light, air, and open space for all;
(2) To ensure safety from fire, flood, panic, and other natural and manmade disasters;
(3) Preservation, conservation, and development of areas of natural scenery and landscape;

(4) To ensure that development within the zone does not conflict with any development regulation;
(5) To encourage energy efficient site designs;
(6) Maintenance of highest standards of environmental planning;
(7) Protection of natural resources and environmental assets through land use and development regulations.

4.16.2 Site Development

The proposed site for the construction of admin building is a non-agricultural coastal char land with tidal characteristics. Considering 4m land filling from existing elevation, a total of about 2904 m3 of filling materials have to be compacted to develop the project site.

4.16.3 Space Allocation of admin building

Space allocation of each of the building is given in the table below.

Table 4.7:: Floor Distribution in the Proposed Admin Building

Floors	Descriptions	Area (sqm)	Area (sft)
Ground Floor	Reception and information centre, Parking	558	6,006.26
1st Floor	Office 1 and 2	612.6	6,593.97
2nd Floor	Bank	597	6,426.05
3rd Floor	Accommodation	243	2,615.63
	Total	**2010.6**	**21,641.92**

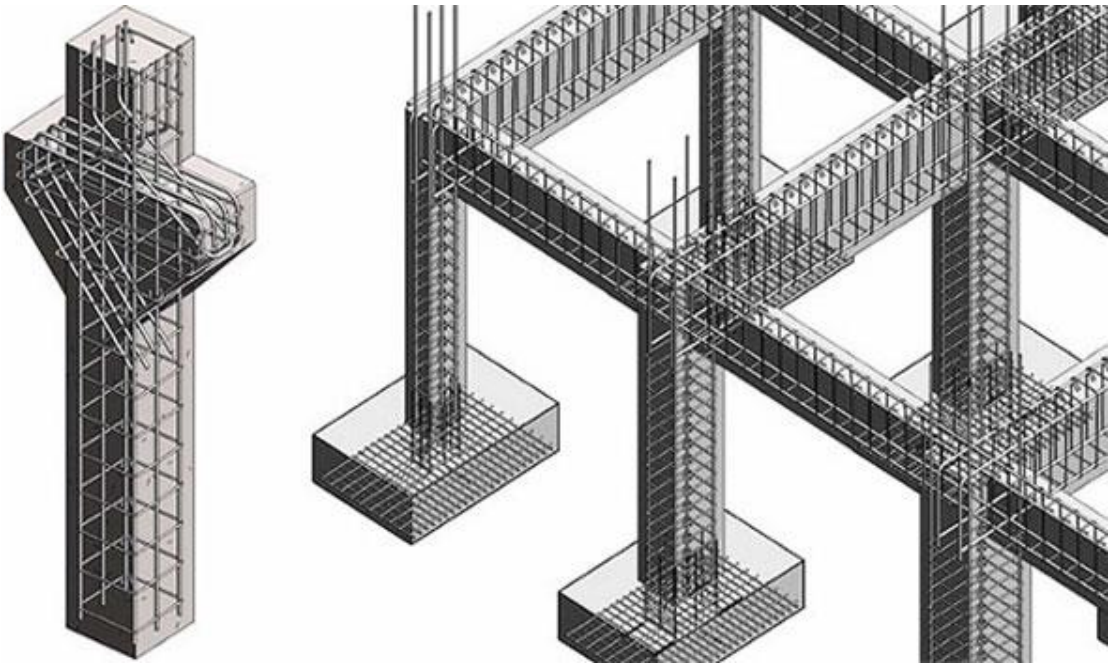
4.16.4 Building Design

The design of the admin building at Moheshkhali EZ is expressed in a building design philosophy. In the building design, the main facilities, *i.e.* the Building is proposed to be designed as a Smart Building with RCC frame structures for quick implementation as well as with brick wall design. The use of the glass will be minimized considering the location and atmosphere of the project area. The design philosophy of the project and the site involved creating an atmosphere of tranquility and a good environment. The soil condition of the site is tested before construction work start and the recommendations of the soil test results are to be used for foundation design.

4.16.5 RCC Structure Building

The admin building of the EZ has been designed as a standard RCC frame structural building *i.e.* the whole building has been built with RCC column and beam frame structure. The floors and roofs will also be made of conventional RCC structure. Pile foundation will be used in the building for distributing the loads in the ground. There will be some shear walls and brick walls for architectural view in the building. Conceptual RCC structure building is shown in the figure below.

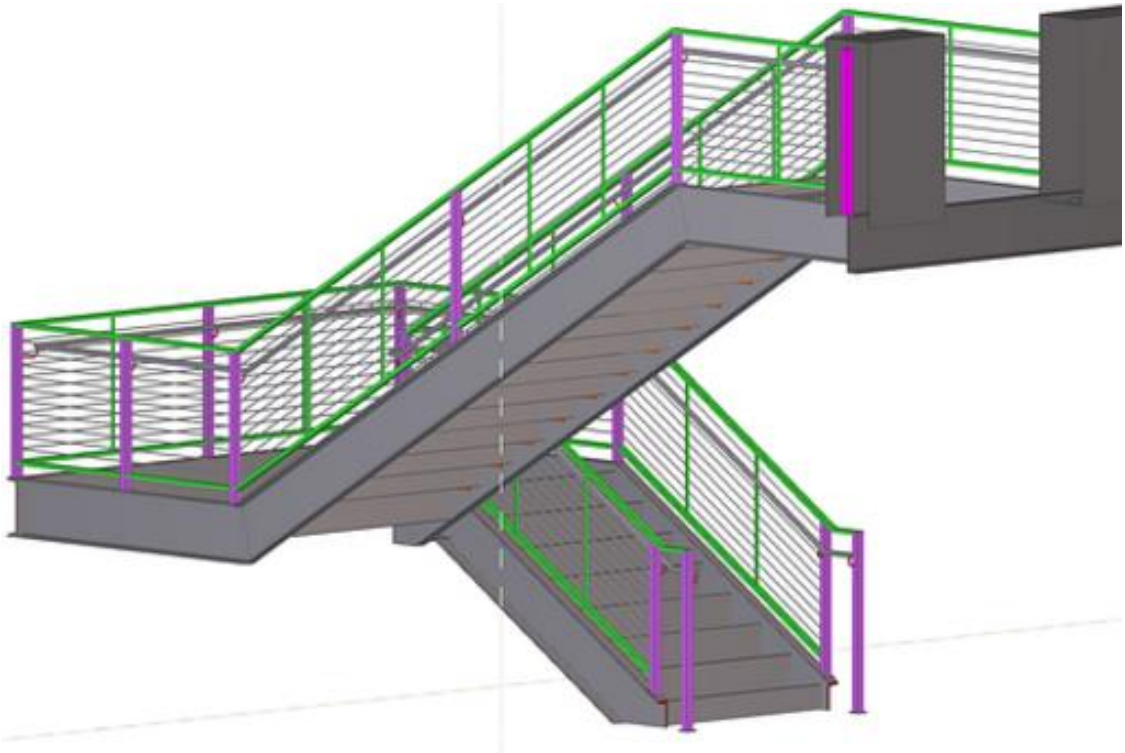
Figure 4.20: Conceptual RCC structure building



4.16.6 RCC Service Core

To give structural stability and particularly against earthquakes, the admin building is designed with an RCC core. Firstly, it has been provided with one RCC stair against the users of the building. Secondly, it has been provided with a fire-rated stair for fire escape provision. Service Core provides two sets of washrooms (male and female) for its users. The service core will provide vertical shafts (Risers) for fire water lines, electrical risers, and bus ways, and fiber optic cables. The conceptual RCC service core is shown in the figure below.

Figure 4.21: Conceptual RCC Service Core



4.16.7 Ceilings and Floors

Supply, fitting, and fixing plain particle board ceiling of 12 mm thick with the best quality and well-seasoned Garjan wood frame of section 75mm×38mm is considered for false ceiling and wall paneling. The ceilings and floors will have provisions for cooling ducts and electrical and power services. The ceilings would be equipped with sprinkler systems for localized fire suppression before it will have the opportunity for spreading. The floors will have an elevated system, capable of carrying all the cables and fiber optics and future requirements of any part of the floors. Conceptual ceilings and floors are shown in the figure below.

4.16.8 External Electrification

HT and LT Switchgear, PFI, Feeder Cable, Pump motor with standby in/c cable and others accessories, 1275 kg.6-stop lift in/c AVR and other accessories, Fire Extinguisher, Fire Detection and Protection System, PABX and intercom system, Security and Guard light, Special type lighting arrestor and Aviation light system, Access control and Car traffic control system, Conference system, Computer networking, etc., Sound system, CCTV Installation, Surge protection Device with Chemical Earthing.

Figure 4.22: Conceptual Ceilings and Floors

4.16.9 Parking

There is no basement considered for the building. However, the ground floor has been used for cars and motorbikes parking. In addition, as there is adequate land available on the project site the cars and motorbikes will also be parked in the on-site parking lots. The cars and motorbikes can enter and exit the parking lots through 6.1m width both ways drive internal roads.

4.16.10 Air Conditioning

Central air conditioning (or central A/C) is a system in which air is cooled at a central location and distributed to and from rooms by one or more fans and ductwork which is not economic and the maintenance will be very difficult because of the location of the project area. For economy and easy maintenance, instead of a centralized cooling system with cooling towers and chilling system, the system proposed is one with a localized split type A/C and cost is considered for split type A/C in cost estimation.

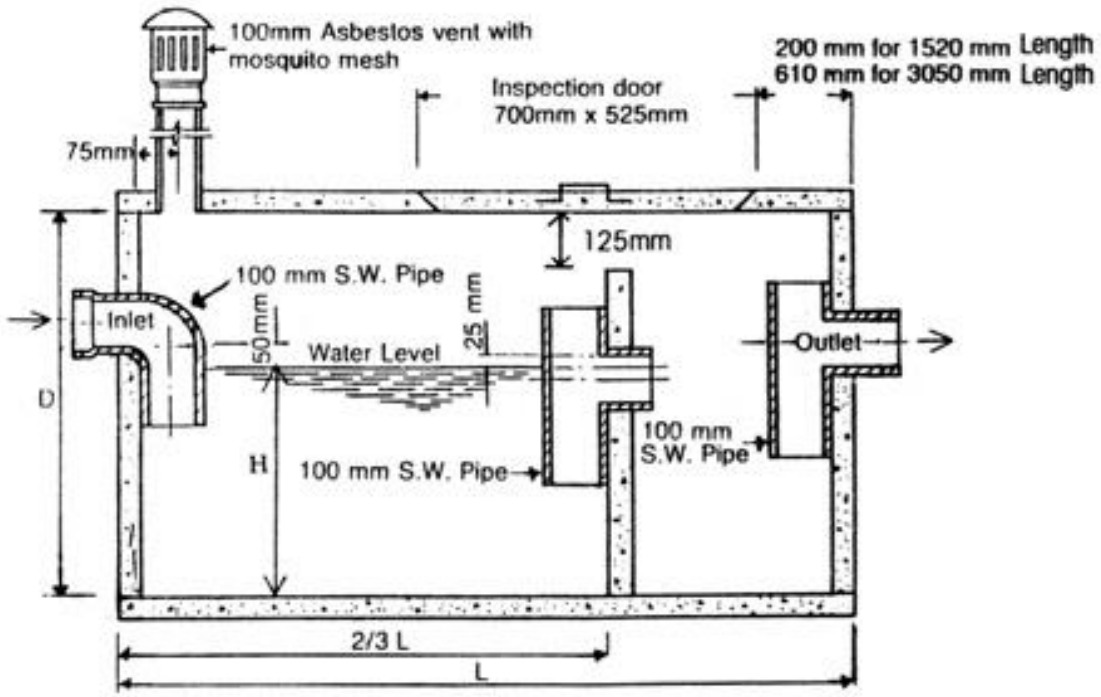
4.16.11 Fire Fighting System

The proposed admin building will be equipped with a fire hydrant and firefighting system. The ceilings would be equipped with sprinkler systems for localized fire suppression. Fire extinguisher, fire detection, and protection system will be equipped within the building for firefighting and in case of emergency.

4.16.12 Septic Tank and Sewage

A soak well septic tank is an underground sedimentation tank used for wastewater treatment through the process of biological decomposition and drainage. Septic tanks allow safe disposal of wastewater. Wastewater generated from toilets is considered as sewage and wastewater generated from bath/ shower, laundry, hand basin, and kitchen are considered as grey water. The sewage generated from the MTB building will be stored in the sock well-based septic tanks. And grey water generated from bath/ shower, laundry, hand basin, and kitchen will be discharged in the nearest sewerage line. The conceptual layout of the septic tank and sewage is shown in Figure 4.23:.

Figure 4.23: Conceptual Layout of Septic Tank and Sewage



4.17 Cost Estimate

An estimated cost has been prepared considering the infrastructure to be provided in the proposed EZ. Total cost of the project is estimated to be ৳ 103,327 lakhs. The estimates have been made by using unit costs, derived from Schedule of Rates of PWD and other government agencies, and updating those to present market rate. A summary of cost estimate is provided in Table 4.8. The details of it are provided in Annexure A13.

Table 4.8: Cost Estimate Summary[19]

			Magnitude	Unit	Unit Rate		Capital Cost	Cost				Capital Cost
					Base Year		Base Year	Escalation	2023	2024	2025	after escalation
					2022		৳ lakh	% per year	Cost Escalation Factors			৳ lakh
(1)	Pre-operating Expenses							1000	15%	1.15	1.32	1.52	1,521
(2)	Preparation of LAP, RAP and Updating ESIA							50	15%	1.15	1.32		62
(3)	Admin Building		2,011	sqm	1,973	৳/sqm		40	15%	1.15	1.32	1.52	53
(4)	Internal Road		275,000	sqm	4,125	৳/sqm		11,344	15%	1.15	1.32	1.52	15,100
	4.1	Footpath	200,000	sqm	2,000	৳/sqm		4,000	15%	1.15	1.32	1.52	5,325
(5)	Approach Road		4.15	km	5,318	৳ lakh/km		22,070	15%	1.15	1.32	1.52	29,378
	5.1	Land Acquisition	89.51	decimal	14,727	৳/decimal	13.18						
	5.2	General & Site Facilities	30	mon	16	৳ lakh/mon	492						
	5.3	Earthwork+	946,000	cum	792	৳/cum	7,489						
	5.4	Pavement Work+	32,800	sqm	7,683	৳/sqm	2,520						
	5.5	Incidentals (slope protection etc.)	101,000	sqm	6,560	৳/sqm	6,626						
	5.6	Sluice Gates	8		48,500,000	৳ each	3,880						
	5.7	Remote Area Allowance				LS	1,050						
(6)	Boundary Wall		9	km	0.75	৳ lakh/m		6,720	15%	1.15	1.32	1.52	8,946
(7)	Drain & Sewage Line		60,000	sqm	3,115	৳/sqm		1,869	15%	1.15	1.32	1.52	2,488
(8)	Water Supply System							500	15%	1.15	1.32	1.52	666
(9)	Power Supply System							3,438	15%	1.15	1.32	1.52	4,576
	9.1	Power Transmission (by PGCB)					-						
	9.2	SS Equipment and Installations					2,225						
	9.3	Land Development for Substation					153						
	9.4	Substation Building	3,000	sqm	1,000	৳/sqm	30						
	9.5	Generator Building	3,000	sqm	1,000	৳/sqm	30						
	9.6	Emergency Generator					1,000						
(10)	Vehicles		3		40	৳ lakh each		120	10%	1.10	1.21	1.33	146
(11)	Security Post, Parking, Loading and Unloading Area		4,500	sqm	1,000	৳/sqm		45	10%	1.10	1.21	1.33	55
(12)	Gate							30	10%	1.10	1.21	1.33	36
(13)	ETP							3,063	10%	1.10	1.21	1.33	3,718

[19]The cost covers the items within the scope of the feasibility study. For example, the cost of land acquisition for the EZ itself, is not part of the estimate.

			Magnitude	Unit	Unit Rate		Capital Cost	Cost				Capital Cost
					Base Year		Base Year	Escalation	2023	2024	2025	after escalation
					2022		৳ lakh	% per year	Cost Escalation Factors			৳ lakh
(14)	Gas Supply System											
14.1	Gas Transmission						16,259	10%	1.10	1.21	1.33	19,734
		Land Acquisition	14.19	acre	27,477	৳/decimal	390					
		Land Requisition	35	acre	18,235	৳/acre	6.31					
		Pipeline with mountings and materials	11	km	992	৳ lakh/km	11,292					
		Other ancillaries					4,130					
14.2	Gas Distribution		3	km	147	৳ lakh/km	442					
(15)	Fire System						50	10%	1.10	1.21	1.33	61
	Capital Cost						**69,548**					**91,862**
	IDC											11,465
	Capital Cost after IDC											**103,327**

4.18 Time Schedule

Tendering Process: 12 months
Construction: 36 months

The following bar chart provides a summary of the implementation time line. The details of time schedule are provided as Annexure A14 of this report.

Figure 4.24: Indicative Project Implementation Schedule

Tasks	mons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
(1)	Preparation Work																																				
(2)	Ground Improvement																																				
(3)	Security fencing, Boundary wall, Gate house & Gates																																				
(4)	Internal Road and Plots/area demarcation works																																				
(5)	Infrastructure & Utility networks																																				
(6)	Construction Group-I (Administrative & Residential Buildings)																																				
(7)	Construction Group-II (Commercial Buildings and Utility structures)																																				
(8)	Water body development and Landscaping																																				
(9)	Project inspection period																																				
(10) 1	Project handover																																				▲

5 Environmental Sustainability, Climate Resilience and Disaster Risk Analysis[20]

BEZA has already conducted an EIA which needs to be updated. This FS recommends a budget as part of DPP for such updating, as it is not part of the present assignment. However, following paragraphs are provided in line with the requirement of the format of the FS

5.1 Environmental, Climate Change and Disaster Risk Analysis

This section discusses the effects/impacts of environmental, disaster and climate change and possible compensations for ecological damages will be covered in the study. Key issues addressed are as following:

(1) likely environmental, disasters and climate change impacts or risks from the project (any impact of project to increase the existing disaster and climate change related risks and/or contribute to create new risks)
(2) Counter measures to be taken to reduce these impacts
(3) Cost for reducing/mitigating the negative impacts
(4) Alternative ways of delivering the required services or goods without incurring these environmental costs
(5) Costs of these alternatives
(6) Assessments required for the project
(7) Any resettlements issues to be addressed

The proposed project appears as one of the key cornerstones of the country's development activities. Similar to other development projects, this project will bring negative consequences for the local environment, landowners and dependent communities; but would be mitigated with proper measures, management plans and monitoring. Thus, groundwater, surface water networks, water body, aquatic and livestock, land losers and dependent population should be given special focus following the measures suggested in this report. Alongside, the project will also bring immense positive impacts for local-regional and national economy and socio-economic benefits for the communities.

Apprehending the project driven impacts on environmental and social parameters, a number of key issues were identified to assess the potential impacts and their magnitudes. The key issues are: i) air quality, ii) noise quality, iii) groundwater, iv) surface water, v) drainage and water logging, vi) flooding, vii) land type, viii) landscape, ix) land use, x) crop production, xi)

[20]Important Note of Acknowledgement: The literature under this chapter is extracted or adopted from Environmental Impact Assessment (EIA) Report on Moheshkhali Economic Zone 3, by VIRID Associate in association with Shahidul Consultants, prepared for the Client BEZA. IIFC received access to the document, as part of reference materials provided by BEZA.

fish habitat, xii) fish production, xiii) fish species diversity, xiv) stock susceptibility, xv) wildlife habitat, xvi) species composition, xvii) dispossession, xviii) livelihoods loss, xix) social conflict, and xx) employment generation, xxi) off-site development, and xxii) urbanization and economic development.

5.1.1 Environmental Impacts and Mitigations

The establishment and execution of proposed Moheshkhali EZ 3 is believed to have a positive impact for sustainable economic growth of the country as well as provision of employment to the local people. However, the project may also have impacts on the existing local environment, eco-system and socio-cultural activities including land use, soil quality, pollution of water, air, noise, etc. Environmental impacts on the following attributes are envisaged:

(1) Air Quality
(2) Noise and Vibration
(3) Status quo of water resources
(4) State of land resources
(5) Topography and geology
(6) Drainage
(7) Soil
(8) Sediment
(9) Current status of agricultural resources
(10) Fisheries
(11) Ecology and biodiversity

The following table discusses the impacts on the above attributes in detail.

Table 5.1: Environmental Impacts and Mitigations

Attribute	Impact	Mitigation
1 Impact on Air Quality and Noise		
1.1 Pre-construction phase		
1.1.1 Air Quality	• Emission of dust, PM (PM2.5, PM10), gaseous emission like SOx, NOx, CO, CO2, etc. • Generation of dust is expected by land preparation, and generation of air pollutants (SOx and NOx, etc.) is anticipated from the operation of heavy machinery and trucks, but the impact will be limited only to the development stage	(1) Monitoring of wind speed and direction to manage dust-generating activities during undesirable conditions. (2) Dust suppression should be undertaken where necessary by covering and/or spraying affected land surfaces with water. (3) Prevent offsite migration of dust using appropriate screens. (4) Use or establish hard-covered roadways for vehicle movement. (5) Vehicle speed restrictions should be applied across the project site to avoid excessive dust generation. (6) Trucks transporting excavated soil and other construction raw material to and from the site to be covered to minimize fugitive dust emission. . (7) Cover all onsite construction material and construction waste storage/stockpiling locations. (8) Use low sulphur content fuel for machinery and equipment to reduce SO2 emissions from engines whenever possible. (9) Modify machinery to reduce NOx emissions. (10) All energy consuming and CO2-generating activities should be done as efficiently as possible to minimize CO2 emissions. (11) Adopt a policy of switching off machinery and equipment when not in use. (12) Appropriate maintenance, engine tuning and servicing of construction equipment to minimize exhaust emissions. (13) Minimize unnecessary journeys or equipment use.
1.1.2 Noise and Vibration	• Impacts of noise and vibration by construction machineries and vehicles • The impact of noise caused by the operation of heavy land filling machinery and trucks is predicted but will be limited to the surrounding area.	(1) Installation of sound-proofing sheet (2) Avoidance of construction at night time (3) Advanced notice for construction work time near the residential area (4) Avoidance of intensive operation of construction machineries (5) Speed limit for drivers (6) Preventive maintenance of equipment and vehicles (7) Unnecessary engine operations to be minimized (e.g. equipment with intermitted use switched off when not working) (8) DG sets to be provided with acoustic enclosures and exhaust mufflers.

Attribute	Impact	Mitigation
		The following techniques can eliminate the vibrational problems in the construction phase of the project. (9) Measures to mitigate vibration can addressed the source, the transmission path or at the receiver. Source control methods include the use an augur to install piles instead of pile driver: this would greatly reduce noise and vibration level. (10) Piles in properly selected patterns also reduce noise and vibration level. (11) Introducing barriers to the vibration waves in the transmission path can reduce vibrations that reach a building. (12) When surface waves predominate deep trenching is an effective method. (13) Other methods are to avoid demolition methods that involve impact, avoid the use of earth moving equipment, vibratory rollers and packers near sensitive areas.
1.2 Construction Phase		
1.2.1 Air Quality	• Dust emissions and gaseous emissions can adversely affect air quality and cause environmental nuisance to surrounding areas. The construction activities that will take place onsite are expected to result in considerable quantities of gaseous emissions. The contaminants of potential concern (COPC) during the construction phase may include: NOx, SOx, CO and Particulate Matter.	(1) Monitoring of wind speed and direction to manage dust-generating activities during undesirable conditions. (2) Dust suppression should be undertaken where necessary by covering and/or spraying affected land surfaces with water. (3) Prevent offsite migration of dust using appropriate screens. (4) Use or establish hard-covered roadways for vehicle movement. (5) Vehicle speed restrictions should be applied across the project site to avoid excessive dust generation. (6) Trucks transporting excavated soil and other construction raw material to and from the site to be covered to minimize fugitive dust emission. . (7) Cover all onsite construction material and construction waste storage/stockpiling locations. (8) Use low sulphur content fuel for machinery and equipment to reduce SO2 emissions from engines whenever possible. (9) Modify machinery to reduce NOx emissions. (10) All energy consuming and CO2-generating activities should be done as efficiently as possible to minimize CO2 emissions. (11) Adopt a policy of switching off machinery and equipment when not in use.

Attribute	Impact	Mitigation
		(12) Appropriate maintenance, engine tuning and servicing of construction equipment to minimize exhaust emissions. (13) Minimize unnecessary journeys or equipment use.
1.3 Post-construction phase		
1.3.1 Air Quality	• Volatile Organic Compounds (VOCs), nitrogen oxides (NOx), carbon monoxide (CO), sulphur dioxide (SO2) and particulate matter (PM10) were identified as Contaminants of Potential Concern (COPC). The impacts affecting air quality in the project area could result from the following environmental aspects: - Complex equipment testing and start-up; - Complex operations; - Raw material Transport/Use of Trucks and Vehicles; and - Operation of the marine terminal - Process furnaces, boilers and gas turbines - Particulate matter and gaseous emission also concern for air quality deterioration. - Noise generation due to operation of pumps and compressors, boilers, cooling tower etc. The VR of noise in the operation phase is considered as medium. These activities will happen throughout the operation phase, although the magnitude and extent are low, the impact of noise can be considered as Moderate.	(1) Monitoring of wind speed and direction to manage dust-generating activities during undesirable conditions. (2) Dust suppression should be undertaken where necessary by covering and/or spraying affected land surfaces with water. (3) Prevent offsite migration of dust using appropriate screens. (4) Use or establish hard-covered roadways for vehicle movement. (5) Vehicle speed restrictions should be applied across the project site to avoid excessive dust generation. (6) Trucks transporting excavated soil and other construction raw material to and from the site to be covered to minimize fugitive dust emission. . (7) Cover all onsite construction material and construction waste storage/stockpiling locations. (8) Use low sulphur content fuel for machinery and equipment to reduce SO2 emissions from engines whenever possible. (9) Modify machinery to reduce NOx emissions. (10) All energy consuming and CO2-generating activities should be done as efficiently as possible to minimize CO2 emissions. (11) Adopt a policy of switching off machinery and equipment when not in use. (12) Appropriate maintenance, engine tuning and servicing of construction equipment to minimize exhaust emissions. (13) Minimize unnecessary journeys or equipment use.
2 Impact on Water Resources		
2.1 Pre-construction phase	• The area is a coastal area and located on the bank of Bay of Bengal, and Kuhelia River is adjacent to the project site. Earth filling activities on the course, water level and quality of the river is anticipated; though the hydrological and morphological change is not significant for the development of Moheshkhali EZ 3.	(1) Limited and short-term usage of groundwater

Attribute	Impact	Mitigation
2.2 Construction Phase	• Surface run offs from construction material storage area, construction waste storage areas, hazardous waste (waste oil, used oil etc.) and chemical storage areas may lead to pollution of receiving natural drainage channels etc. As the slope of the area is towards Bay of Bengal, these surface run offs are likely to reach the Bay of Bengal. During the process of earth work (excavation and stacking of soil) will be required; the surface runoff from disturbed sites may lead to pollution of receiving water bodies. • Impact on hydrology due to water consumption used in the construction works • This situation is likely to be more pronounced considering high rainfall received in these areas. The surface run offs may contain the high sediment load, oil residues, organic wastes, etc. This may adverse impact on water quality, which ultimately leads to impacts on aquatic ecology. Generally, the project area may affect by flooding by the river during wet season. But there is no significant river erosion along the zone. • Furthermore, it is generally expected that the effect of the proposed project on regional hydrologic and hydraulic conditions would be minimum. Indeed, the comparison of flood levels between the proposed and baseline conditions indicated that there would not be any significant impact on flood level and hence on drainage through the Kuhelia River. The situation is unlikely to aggravate further from its current state. The average height of the site is about 4-5 m above mean sea level. • Generation of construction wastes	(1) Limited and short-term usage of groundwater (2) Preparation of tentative retention pond (3) Waste management plan to be prepared (4) Quantities of construction materials to be accurately estimated to minimize the potential for excess generation of waste. (5) Construction activities to be appropriately scheduled to minimize the potential for rework. (6) Sizing of storage areas/skips will be in accordance with the (7) expected waste quantities and the frequency of disposal. Waste skips/containers are to be suitably labeled for easy identification of material. Waste skips will be covered to avoid waste scattering onsite. (8) Waste bins will be installed clearly marked wherever required. Such places include eating/rest areas, next to operational areas and next to any worker assembly areas. (9) Adequate waste management, awareness and communication through training, tool box talks and posters placed across the site. (10) Engage licensed approved subcontractors to undertake all waste and recycling activities. (11) The provision of Central Solid Waste Dumping Station (CSWDS) to safe dumping of all the hazardous and non-hazardous solid wastes.

Attribute	Impact	Mitigation
2.3 Post Construction Phase		
2.3 Water Pollution	• Surface/Sea and groundwater pollution • There may be soil runoff from the exposed soil of the land development, loading unloading and cut slopes, and water pollution of the upstream area of the surrounding river is predicted. Since the project area is mainly low-lying area, soil runoff and turbid water generation will not be significant. In addition, concrete wastewater generated from industrial operation and from the sewage to have effects. Anti-diffusion membranes will be installed around the construction site to prevent diffusion of turbidity, and these measures will minimize the impact of effluent contamination of river water and underground water. Runoff of exposed soil surfaces into rivers is expected.	Pollution prevention: Surface water (1) Avoiding seepage of wastewater, fuel, oil and oily water; (2) Vessels will never be overloaded; (3) Waste disposal to marine environment are prohibited. (4) Treat accidental spills on any floating unit with spill containment and clean up (dispersant) materials; and (5) Weather and marine conditions will be assessed before work commences each day. Work activities will be suspended during thunderstorms and rough sea conditions. (6) Treating turbid water from land, such as rainwater run-off, with precipitation process and discharging the remaining water into the (7) excavated part of the zone. (8) Provision of septic tank and soak pit. Pollution prevention: Ground water (1) Control all onsite wastewater streams and ensure appropriate collection, treatment and discharge. (2) Prevent discharge of contaminants and wastewater streams to ground water. (3) Apply high quality control standards to the construction of wastewater storage trenches/tanks to avoid leakage and arrange for frequent discharge to prevent sewage spillage/overflow. (4) Good housekeeping to prevent leaks and incidental spills. (5) Minimize onsite storage of potentially contaminating materials (6) Dredged materials stored at the designated disposal area shall be appropriately handled and analyzed frequently. (7) Adequate management and proper handling and storage of construction materials, oils and fuel to avoid spillages. (8) Wastes properly managed and disposed. (9) The implementation of a continuous and regular site inspection system. (10) Frequent and regular discharge of wastewater storage tanks/trenches. (11) Conducting dredging at sea area with pump dredger or grab dredger and setting film preventing the diffusion of contamination. (12) Restrict the earth work activities during monsoon season;

Attribute	Impact	Mitigation
		(13) Channelize all surface runoff from the construction site through storm water drainage system and provide adequate size double chambered sedimentation tank; (14) Prevent and mitigate spill of paint/fuel within the construction site
3 Impact on Land Resources		
3.1 Pre-Construction phase	• Soil erosion of the bank • The topography of project site is low flat land. The land filling may affect the topography and geology of the area around the proposed site. Filling will cause change of land types. Some protection measures against slope sliding or erosion especially in rainy season need to be considered. • Land filling can disrupt the natural drainage pattern and cause drainage congestion which can affect the land resource. Protecting natural storm water drainage network and/or creating more drainage network could be a solution.	(1) Provision of temporary drainage and/or sandbag to minimize soil erosion due to rainy water
3.2 Construction Phase		
3.2.1 Topography and Geology	• The construction of the access road may affect the topography and geology of the area around the proposed site. Construction of infrastructure will cause change of land type and the entire topography of project site.	(1) Minimizing areas of excavation and work as possible
3.2.2 Soil	• Soil pollution at the construction site will be occurred possibly by leakages of oil and chemical materials from vehicles, vessels and construction machineries.	(1) Store and manage potentially contaminating materials according to best environmental practices to avoid spills and leaks; (2) Regular monitoring and maintenance and using best available techniques (3) Adopt good handling and transportation practices to avoid loss of material and soil contamination (4) Formulate a spill contingency plan and have appropriate response equipment available onsite; and (5) Implement a comprehensive Waste Management Policy which ensures the safe storage and timely treatment and removal of waste. Wastes should be properly managed and disposed of in accordance to the waste management plan.

Attribute	Impact	Mitigation
3.2.3 Sediment	• Soil and sediment contamination • Sediment pollution may occur in case of construction wastewater flows into the river. Channels, ditches and temporary settling ponds will be dug and constructed around the construction area.	(1) Minimizing areas of excavation and work as possible (2) Where possible, excavated material shall be reused during the construction works onsite as appropriate. (3) Stockpiling of soils onsite to be kept to a minimum. (4) Dredged material disposal area shall be inspected and maintained regularly. (5) Stockpiling of dredged materials to be kept to a minimum. (6) Dredged materials stored at the designated disposal area shall be appropriately handled and analyzed frequently. (7) The disposal area near the Port area will include liners or other hydraulic containment design options to prevent leaching of contaminants into adjacent soil. (8) Best practices for soil management should be followed (9) Control all onsite wastewater streams and ensure appropriate collection, treatment and discharge. (10) Good housekeeping to minimize spills/leaks. (11) Minimize onsite storage of potentially contaminating materials (12) Proper handling and management of wastes. (13) Proper handling and storage of potentially contaminating materials (e.g. diesel fuel) and wastes in appropriate secondary containment to avoid accidental release.
3.2.4 Drainage congestion	• Disruption of natural drainage system • Construction of infrastructures can disrupt the natural drainage pattern and cause drainage congestion which can affect the land resource.	(1) Storm water drainage structure will be provided to drain all the surface runoff into the sea.

Attribute	Impact	Mitigation
3.3 Post Construction Phase	• Soil pollution at the zone will be occurred possibly by leakages of oil and chemical materials from vehicles and industries. • During operation, runoff of exposed soil surfaces and drainage of wastewater from industrial operation and sewage drainage into river and ocean is expected which can lead to the contamination of the water body from unexpected substances and it can destroy fisheries ecosystem. Sea/River traffic may produce heavy noise which will disturb fish habitat.	(1) Store and manage potentially contaminating materials according to best environmental practices to avoid spills and leaks; (2) Regular monitoring and maintenance and using best available techniques (3) Adopt good handling and transportation practices to avoid loss of material and soil contamination (4) Formulate a spill contingency plan and have appropriate response equipment available onsite; and (5) Implement a comprehensive Waste Management Policy which ensures the safe storage and timely treatment and removal of waste. Wastes should be properly managed and disposed of in accordance to the waste management plan.
4 Impact on Agriculture Resources		
	• The proposed project area is used only for salt cultivation. In construction phase after land development, existing land will be converted into industrial land use with construction of different on-site and off-site infrastructure. It will require different amount of temporary construction labor and will absorb from different sectors.	(1) Minimize use of land as far as possible
5 Living and livelihood		
5.1 Pre-Construction and Construction Phase	• Impact of loss of livelihood • Accessibility to social infrastructure for local community • Employment generation, improved educational and health facilities. • The proposed EZ area is mainly saltpan. The local residents earn their livelihood by cultivating salt. Moreover, significant number of them also does fishing six months in a year in the project area. Land development work converted low lying area into flood free area, where fisheries (seasonal) habitat may reduce. Construction of jetty facilities may destruct natural habitat of fisheries. Dredging activities in the sea may reduce the quantity of fishes.	(1) Provide and create employment for local inhabitants (2) Provision of special assistance, if applicable. (3) As a mitigation measure the land owner, share croppers, lessee farmers and the salt pan workers will be appropriately compensated as per Government Rules. (4) Unskilled labor during the project construction phase should be sourced from the local community. (5) In order to ensure the appropriate livelihood of the fisherman, designated fishing route must be selected for the fisherman by consulting with the Department of Fisheries, Bangladesh. (6) There has to be alternate livelihood options for fisherman, salt farmer, share croppers and lessee farmers. (7) Control of traffic volume (8) The initiatives of the project proponents are likely to be focused on

Attribute	Impact	Mitigation
		livelihood restoration, income generation, education and provision of health facilities which can further improve the quality of life of the community in the vicinity.
6 Impact on Ecosystem		
6.1 Pre-Construction and Construction Phase		
6.1.1 Terrestrial Ecology and Biodiversity	• Clearance of existing vegetation • Degradation of the marine environment or loss of marine resources may occur due to the dredging activities as well as open-water dredging material disposal. • Loss of terrestrial biodiversity • The site is considered as 'no trees area', Therefore, there is no vegetation within the zone except some herbs. Some fauna lived and depended on food from the area will lose the habitat and source of sustenance. Plantation will provide them new home and source of sustenance by the project. The impact on flora and fauna will not be significant for this reason. Although, some scattered mangrove species are located in the west bank of Kuhelia River. During construction period a large number of migrant people will be temporarily reside in the area. Wastes generated from the construction work will include waste plastics, waste glasses and waste oil. Furthermore, household wastes discarded from the camping ground of the workers will include cans, bottles and garbage. • If such wastes are not adequately treated, flora and fauna can be affected. Segregating waste at collection, recycling and reusing waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to related regulations.	(1) Clear marking of boundary of the project site to prevent the contractor from clearing the vegetation outside of the Project site (2) Prevent unnecessary clearing or disturbance of native vegetation. (3) Vehicle tracks and roads should be used to decrease habitat destruction. (4) Minimizing areas of excavation and active work sites as far as possible. (5) All work will be undertaken during the day, as much as reasonably practical, to ensure lighting does not impact birds and noise will be reduced as much as reasonably practical to avoid fauna disturbance. (6) If protected/sensitive species are discovered or suspected, then work will be ceased and inform the relevant authority; contractor will seek expert advice and/or consult the client in order to develop and agree on an appropriate management strategy; (7) No litter or plastic bags/containers will fly off the site boundaries. (8) Vegetation removal to be minimal and limited to the zone. (9) Water sprinkling for dust suppression; and (10) Provision of dust curtains to reduce the dust emission. (11) However, in any case, to protect biodiversity of the area the following measures are always suggested: - Turning off unnecessary lights during the nesting season - Using a smaller number or lower wattage of lights - Shielding, redirecting and repositioning lights - Using low-level noise heavy machinery (concrete mixing, excavation machinery, etc.) - Planning construction activities to minimize adverse effects during the nesting season - Avoiding tall structures creating shade on the coast to maintain nest temperatures

Attribute	Impact	Mitigation
		- Control the introduction of non-native plants which may lead to impenetrable root mats.
6.1.2 Aquatic Ecology and Biodiversity	• Reduce fishery resources, disturbances to fishery habitat etc. • The impacts on aquatic ecology and biodiversity during construction phase are as follows: • Surface runoff from construction site, discharge of hydro-testing water, spillage and leakage of oil and lubricate, from construction site; • Noise and vibration due to piling activities in the sea; • Move of ship and vessels and • Illumination.	(1) Dredging activities need to be done carefully. (2) Prevention of leakage of hazardous chemicals and oils into the water bodies. (3) Fishermen will be informed about the project construction and their feedback to be taken on seasonality and routes during construction. (4) The Project will try and avoid disrupting peak fishing activities to the extent feasible. (5) A monitoring study with GPS may be undertaken by the project proponent that will monitor and assess the actual fishing routes, fishing zones and fish catch of the local fishermen that may potentially get impacted due to the project activities. (6) The project authority should make a specific route for River transportation in the Sea near the project site by consulting with the Department of Fisheries (DoF), Bangladesh in order to minimize the negative impacts on fishery resources. (7) Undertake construction activities in marine areas in a short time as possible. (8) Vessels to minimize unnecessary vessel movements, such as (9) propeller thrusting, to avoid sediment disturbance (10) Care must be taken during construction of marine jetty.
6.2 Post Construction Phase		
6.2.1 Terrestrial Ecology and Biodiversity	• During post-construction period, the major impacts on terrestrial ecology shall arise from Emission from operation of different industrial units and · Illumination, noise and vibration at site. A thick green belt of 15-20 m within and outside the project boundary will help in reducing the impacts from air emissions and noise and vibration impacts. During post-construction period residential workers shall live in the area. Household wastes discarded from the residence of the workers will include cans, bottles and garbage which can contaminate water and soil.	(1) Clear marking of boundary of the project site to prevent the contractor from clearing the vegetation outside of the Project site (2) Prevent unnecessary clearing or disturbance of native vegetation. (3) Vehicle tracks and roads should be used to decrease habitat destruction. (4) Minimizing areas of excavation and active work sites as far as possible. (5) All work will be undertaken during the day, as much as reasonably practical, to ensure lighting does not impact birds and noise will be reduced as much as reasonably practical to avoid fauna disturbance. (6) If protected/sensitive species are discovered or suspected, then work will be ceased and inform the relevant authority; contractor will seek

Attribute	Impact	Mitigation
	• Moreover, hazardous waste from industries can pollute the terrestrial eco-system. It is claimed according to the type and nature of unit industries that, no wastewater or liquid waste will be generated from the EZ. If any industry produces such waste, will be treated according to the regulations of DOE before disposal. Segregating waste at collection, recycling and reusing waste will be promoted and non-recyclable waste will be disposed at appropriate sites according to related regulations.	expert advice and/or consult the client in order to develop and agree on an appropriate management strategy; (7) No litter or plastic bags/containers will fly off the site boundaries. (8) Vegetation removal to be minimal and limited to the zone. (9) Water sprinkling for dust suppression; and (10) Provision of dust curtains to reduce the dust emission.
6.2.2 Aquatic Ecology and Biodiversity	• The major impacts sources of aquatic ecology and biodiversity during operation phase of the project include: • Spillage and leakage of fuel and lubricant; • Move of ship and vessels and • Illumination, noise and vibration.	(1) illumination lights to be set land side and not sea side, (2) restricted and limited movement of vessels during the nesting period.

5.1.2 Socio Economic Impacts

The socio economic impacts are also anticipated, unless mitigated, on the following attributes:

(1) Ownership to land and water resources
(2) Existing social infrastructure and services
(3) Social fabric
(4) Disease control
(5) Work safety conditions
(6) Health
(7) Livelihood
(8) Existing traffic conditions

5.2 Land Acquisition Requirement and Modality

5.2.1 Approach Road

Existing embankment from Mohori Guna to Panditer Dail under Dhalghata mouza will be used for approach road. Therefore, land acquisition is not to be considered, except in the following mouzas and dag numbers, which amounts to about 89.51 decimal fresh acquisition:

Table 5.2: Particulars of Land to be Considered for Acquisition as Part of the Approach Road

Name of Upazila	Name of Union	Mouza	Dag Number[21]	Land Type	Mouza Rate (৳ per decimal)
Moheshkhali	Dhalghata	Dhalghata 4	84	Salt Field	4,909
		Dhalghata 4	85	Salt Field	4,909
		Dhalghata 3	2003	Salt Field	4,909

Issue of squatters living on the land needs to be addressed separately to mitigate possible social impacts, as a separate excercise.

5.2.2 Gas

Approximately 14 acres of land required for permanent acquisition considering a 6 m Right-of-Way (RoW) of 20 inch diameter of gas transmission pipeline along a length of 12 km. The following table provides an indicative list of mouzas and dags which falls on the stretch of the land to be acquired along the alignment of the gas transmission line.

Table 5.3: Indicative List of Mouzas and Dags Falling on the stretch of the Land to be Acquired along the Alignment of the Gas Transmission Line

Name of Upazila	Name of Union	Mouza	Dag Number	Land Type	Mouza Rate (avg. ৳ per decimal)
Moheshkhali	Kalarmarchar	Kalarmarchar 4	5062, 5043, 5042, 725, 5079, 5112, 5114, 5203, 5118, 5228, 5244, 5251, 5718, 5334	Salt Field	4,385
		Kalarmarchar 5	6663, 6664, 6665, 6666, 6667, 6668, 6662, 6661, 7906, 3333, 3332, 3331, 3331, 3330, 2019, 1818, 1616, 1515, 1111, 6610, 6608, 6606, 6603, 6602, 1918, 3597, 9292, 9593, 6587, 7876, 6581, 6580, 7879, 7878, 6575, 6576, 6574, 6560	Salt Field	4,405
		Kalarmarchar 3	6561, 2622, 3066, 2671, 2648, 4119, 2647, 2646, 3119, 2642, 2639, 2638, 2637, 2636, 2634, 2633, 2632, 2019, 2442, 2014, 2012, 2011, 4016, 4115, 2019, 4021, 1966, 4006, 4011, 4008	Salt Field	4,439
		Kalarmarchar 1	532, 530, 519, 525, 520, 5180, 526, 523, 522, 521, 513, 515, 473, 437, 512, 503, 472, 441, 440, 438, 475, 4794, 435, 434, 433, 406, 399, 997, 396, 395, 394	Salt Field	4,469
		Jhapua 4	4099, 4121, 4120, 4127, 4156, 4154, 4153, 4152, 4149, 4148, 4147, 4146, 4146, 4185, 4186, 4194, 4141, 4205, 4210, 4214, 4215, 4231, 4234, 4244, 4239, 4238	Salt Field	4,498

Name of Upazila	Name of Union	Mouza	Dag Number	Land Type	Mouza Rate (avg. ৳ per decimal)
		Jhapua 3	3051, 3052, 3050, 3031, 3030, 3012, 3014, 2920, 2995, 2926, 2924, 2927, 2956, 2955, 2952, 2944, 2943, 2951, 2992, 2790, 2791, 2797, 2800, 2799, 2811, 2890, 2881, 2739, 2767, 2464, 2662, 2697, 2695, 2701, 2704, 2708, 2705, 2683, 2313, 2314, 2310, 2309, 2308, 2329, 2330, 2331, 2332, 2336, 2337, 2338, 2292, 2293, 2270, 2295, 2285, 3167, 3266, 2281, 2280	Salt Field	4,540
		Uttar Nalbila 3	203, 201, 200, 199, 207, 198, 208, 216, 117, 223, 224, 227, 226, 259, 261, 260, 256, 255, 236, 160, 152, 153, 154, 155, 121, 124, 126, 123, 105, 118, 117, 116, 115, 114, 113, 46, 436, 449, 448, 447, 446, 443, 445, 450, 455, 1284, 1285, 1287, 1266, 1288, 1308, 1290, 1321, 1292, 1293, 1294, 2342, 1325, 1326, 1329, 1328, 1327, 1330, 1331, 1366, 1402, 1253, 1252, 1404, 1408, 1404, 1393, 1409, 1417, 1415, 1416, 1447, 1448, 1454, 1453, 1483, 1485, 1530, 1529, 1527, 1526, 1426, 1525, 1520, 1515, 1514, 1510	Nul	19,248

There is no structure that falls within the RoW of the gas transmission pipeline.

In addition, 34 acres shall be required for land requisition considering 15 m RoW of both sides only during construction phase.

5.2.3 Power Line

The periphery of the approach road/embankment would be used for laying the power line from PGCB grid substation to 33/11kV substation of the EZ.

5.2.4 Compensation

A Resettlement Action Plan (RAP), a separate exercise, is needed to be prepared for identifying the loss/damage and to provide the compensation to entitled persons (EPs) under the project properly. All PAPs will be eligible for compensation, rehabilitation/resettlement assistance, and disturbance allowance based on the Entitlement Matrix. And also, all PAPs, including the vulnerable, will be assisted in their efforts to improve their livelihoods, and standard of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to beginning of project implementation, whichever is higher. A conceptual entitlement matrix has been presented in the following table.

Table 5.4: Conceptual Eligibility and Entitlement Matrix

	Type of Losses	Definition of EPs	Entitlement	Implementation Issues	Responsibility
(1)	Loss of homestead, commercial, Agricultural, pond, ditch and other types of land	• Owner(s) of a plot as recorded in title deeds • Legal owner(s) of land identified by DC through payment of CCL	• DC's Payment, Cash Compensation under the law(CCL) • Cash grant to cover the difference between DC's payment and cost equivalent to replacement land • Cash compensation for losses of profits and income due to the loss of property or access • 12% of RV as stamp and other duties on purchase of land	• Replacement value(RV) will be determined by the PVAC. The maximum amount of cash grant will be the difference between the total of DC's payment(CCL) and the replacement value (RV) determined. Payment of compensation at the replacement market value on DC's payment. This will be decided by PVAC (Property Valuation Advisory Committee). • Households living as squatters on public/private landassistance where applicable. Three months income restoration grant at the rate of ৳ 600.00 per day for marginal farmer, tenant and share cropper • Stamp duty will be refunded @12% increase on replacement value of acquired land determined by PVAC. • Project will explore to check the possibility of staggering the evacuation of PAPs to ease the resettlement process.	DC office and BEZA
(2)	Loss of homestead	• Households living as squatters on public/private land	Cash grant equivalent to the replacement market price of a 100 sq. meter land	• List of eligible persons will be finalized by (Joint Verification Inventory Team) JVIT. • PAPs opting for purchase should identify the homestead land. • Project Management will explore the possibility of staggering the evacuation of PAPs to ease the resettlement process.	DC office and BEZA
(3)	Temporary loss of land regardless of	Titled and untitled PAPs	• DC's Payment • Cash grant to cover the difference between	• The maximum amount of cash grant will be the difference between the	DC office and BEZA

	Type of Losses	Definition of EPs	Entitlement	Implementation Issues	Responsibility
	use		the DC's Payment and the PVAC assessed rental value or income/profit lost • Cash grant to reflect expenses of vacating land, reoccupying land and damages, in accordance with ARIPO	total DC's Payment and the rent of land or income & profit lost determined by PVAC. Rental Value is to be paid to the affected people • BEZA will ensure contractors reinstate land and affected common resources to pre-project levels upon project completion. Contractors will also maintain common infrastructure during construction Including irrigation and drainage.	
(4)	Loss of Aquaculture (Gher)	Legal owner of gher to get compensation for land while usufruct right holder, legal or socially recognized, PAPs to get compensation for fish stock	• DC's Payment(CCL) • Cash grant to cover the difference between DC's Payment and the replacement cost of gher, including cost of land and digging • Cash compensation for losses of profits and Income due to the loss of property • Training	• Replacement value (RV) will be determined by PVAC. Loss of profit will also be considered • If gher is on public land and not under lease from Government, AP is entitled to compensation for 50% of the existing fish stock, and allowed to retain the entire fish stock	DC office and BEZA
(5)	Loss of houses, Structures used for living and commercial activities	Legal owner(s) of structure identified by DC through CCL	• DC's Payment(CCL) • Transfer grant at the rate 12.5% on RV • House construction grant at 1/5 (15% house construction grant and 5% utility reconstruction grant e.g., electricity, gas, water supply, etc.) of on RV subject to minimum of ৳ 20,000. • PAP permitted to retain salvageable building materials • Cash compensation for losses of profits and income due to the loss of property	PVAC will find out realistic construction costs of the most common types of houses/structures. The costs determined will be used in cases of disputes/grievances regarding compensation rates for structures. Affected person will take salvageable materials, he will get dismantling and re-construction grant, PVAC will decide extra payment on DC's compensation. As replacement value	DC office and BEZA
(6)	Loss of houses/ structures used for living and commercial activities (rural and	Untitled PAPs (squatters on public/private lands)	• Replacement value (RV) of structure • Transfer grant of12.5% of RV, subject to minimum ৳ 5,000 • House construction grant at 20% (15% house construction grant and 5% utility construction	PVAC will find out realistic construction costs of the most common types of houses/structures. The costs will be determined and used in cases of disputes/grievances regarding	DC office and BEZA

	Type of Losses	Definition of EPs	Entitlement	Implementation Issues	Responsibility
	urban areas)		grant)on RV subject to minimum of ৳ 20.000 • PAP permitted to retain salvageable building materials • Cash compensation for losses of Income due to loss of property	compensation rates for structures. Affected person will take salvageable materials, he will get dismantling and re-construction grant, PVAC will decide extra payment on DC's Cash compensation at replacement value. Here on site relocation may provide in the project sites. In addition PAPs will be permitted to get salvageable building materials	
(7)	Loss of timber and fruit trees, bamboo, betel leaf, etc.	Legal owners determined by DC and untitled users of land	• DC's Payment (CCL) • Cash grant to cover the difference between the DC's Payment premium and current market price as replacement value(RV) • PAP to be permitted to cut and take away the trees and fruits and will be given 5 years fruit values for fruit bearing trees as 30% on CCL	Government will issue executive orders allowing the PAPs to cut and take away the tree and fruits. PAPs will also get Income Restoration Grant and the affected person will take Market price paid for the acquired trees, but PAPs will be permitted to get salvageable trees.	DC office and BEZA
(8)	Trees within the RoW of the approach road and gas transmission lines	Legal titleholders, Nontitle holders, sharecroppers, tenants, & socially recognized tree growers	Cash compensation at replacement cost and R & R assistance	• Cash compensation recommended by PAVC based on the type, age, productivity and lost income during the life cycle of the trees including additional compensation for fruit bearing trees. • 60 days of advance notice to the affected persons to cut- down standing trees and the right to possess the timber and any other produce. • Linkages with relevant agencies which can support tree planting programs	BEZA
(9)	Standing crops and fish stocks (in aquaculture) within the RoW of the	Legal titleholders, nontitle holders, sharecroppers and tenants	Cash compensation at replacement cost	• Cash compensation recommended by PAVC based on market value of a given variety of crop, average seasonal production of the cultivated	BEZA

	Type of Losses	Definition of EPs	Entitlement	Implementation Issues	Responsibility
	approach road and gas transmission lines			land and the number of seasons lost to the farmer not exceeding a period of one year • Assistance for restoration of the land and ponds to its previous state or better level • Assistance for sharecroppers and tenants to identify and move into alternate land • 60 days of advance notice to the affected persons to harvest standing seasonal crops	
(10)	Residential dwellings within the RoW (if partially or fully affected and displaced)[22]	Legal titleholders & non-titleholders	Cash compensation at replacement cost	• Cash compensation recommended by PAVC based on replacement value. • Reconstruction cost calculated at ৳ 10 per square feet for the affected shiftable structure. • Dismantling and reconstruction cost of the no shiftable structure (pucca & Semi-pucca) @ 10% of the structure value • Shifting allowance @5% of the structure value • Transitional allowance for affected structures @ ৳ 7/sft • Right to take away the salvage material free of cost on or before a date announced by the executing agency • Site restoration grant for households who do not have any other land except for the affected land by	BEZA

[22]Physical displacement is not anticipated; however, it is considered here in the event the project is unable to avoid impacts on the structures during construction.

	Type of Losses	Definition of EPs	Entitlement	Implementation Issues	Responsibility
				transmission line @ 7 decimal land per HHs.	
(11)	Vulnerable Allowances	Vulnerable Households	R & R assistance	• One-time grant of ৳ 10,000 per vulnerable household[23]	BEZA
(12)	Livelihood Allowances	Vulnerable Household and severely affected households	R & R assistance	• Livelihood's restoration grants of ৳ 20,000 (৳ 5,000 for training and ৳ 15,000 grant for tree planting, other livelihood restoration activities, etc.)	BEZA
(13)	Unforeseen adverse impacts on properties and livelihoods during project construction	Legal titleholders, nontitle holders, sharecroppers, tenants, daily wage laborers and vulnerable households	R & R assistance	As determined in consultation with BEZA and the stakeholders	BEZA

[23]Vulnerable households include those that are: (i) households headed by women; (ii) household headed by persons with disabilities; (iii) households whose annual incomes are lower than ৳ 90,000; (iv) elderly headed households, (v) households who are landless; and (vi) who are without legal title to land. The vulnerable status for persons without legal title is determined based on the social impact assessment/survey.

Table 5.5: Summary of Compensation for Land

	Category	Land, acre		Mouza Rate	Price and Compensation	Total
		to be Acquired	To be Requisitioned	(৳ per decimal)	(৳ per decimal)[24]	(৳)
(1)	Land acquisition for Approach Road (considering ARIPA 2017)	0.9		4,909	14,727	1,325,430
(2)	Land acquisition for Gas Transmission Pipeline (considering ARIPA 2017)	14		9,159	27,477	38,467,510
(3)	Land requisition for Gas Transmission Pipeline		34		182	620,000
	Total	**14.9**	**34**			**40,412,940**

5.3 Assessment of Disaster Resilience of the Project

This section assesses the resilience and address about uncertainties. The following key indicators are discussed:

(1) Contingency Plan for Emergency Disaster Management: The evacuation plan if required, institutional arrangement for shutting down of utility services, and general procedures to be followed by individuals during disasters will be described
(2) Business Continuity Plan: The key response and recovery priorities will be outlined. This plan will detail out how different utility services will be rendered to support the overall Emergency Management Plan
(3) Time of Recovery: Required time for rehabilitation after a disaster will be assessed

Nature of emergency and hazardous situations may be of any or all of the following categories:

5.3.1 Emergency

(1) Fire, burn injury
(2) Accidental injury
(3) Electric shock
(4) Explosion

[24] Mouza rate + 200% of the sam

(5) Any Medical emergency

5.3.2 Natural Disasters

(1) Flood
(2) Earthquake
(3) Storm/tornados/cyclone

5.3.3 Emergency Response Plan

The objectives of having an Emergency Response Plan (ERP) are to:

(1) Guide the authority/emergency response team (ERT) in determining the appropriate response to emergencies;
(2) Provide respondents/ERT with planned strategy and recognized measures;
(3) Guide to notify the appropriate ERT personnel and regulatory authorities;
(4) Manage public and media relations;
(5) Notify the next-to-kin of accident victims;
(6) Promote inter-section communications to ensure an "EZ-wide" coordinated emergency response to minimize the effects of troublesome events;
(7) Reducing recovery time and costs;
(8) Respond to immediate requirements to safeguard the environment and the community.

The following table provides a list of mitigation measures for emergency disaster management:

Table 5.6: Mitigation Measures for Emergency Disaster Management

	Issues	Expected Environmental and Social Impacts	Proposed Environmental Mitigation Measures and Environmental Management	Responsible Organization
(1)	Usages of Chemical	Risk of chemical materials	Formulation of chemical management plan as necessary Training of safety usage and preparation of the emergency response plans Implementation of the proper storage and record of usage. Applying for the acquisition of the license with management plan in accordance with the relevant law, and compliance with the law. Provision of protective equipment and clothes to workers as necessary.	BEZA, DOE
(2)	Risk of flood and cyclone	Increasing of the impact of flood in and around the projects site	Preparation of the disaster prevention equipment and management manual, preparation of disaster impact assessment and management plan etc.	BEZA, DOE
(3)	Risk of Fire	Impact on the community around the project site by increasing of risk of fire	Installation of the fire hydrants along the road Implementation of emergency drill	BEZA, DOE
(4)	Earthquake	Increasing of the damage of the earthquake in and around the projects site	Compliance with the National Standard Operational Procedure for building construction Preparation of the disaster prevention plan such as emergency contact list	BEZA, DOE

5.3.4 Contingency Plan for Emergency Disaster Management

A contingency plan is essential for undertaking immediate need-based response in a well-designed, organized and coordinated manner for facing any adverse incident during an emergency. It helps in identifying the victims at risk, responsible authority and natural disruptions. The Contingency Plan will have the following components in minimum:

(1) Accidents preventions procedures/ measures
(2) Fire prevention planning and measures
(3) Fire water storage and foam system
(4) Accident/emergency response planning procedure
(5) Communication
(6) Emergency control center
(7) Emergency information system with role and responsibility and command structure
(8) Recovery procedure
(9) Assessment of damages and rectification
(10) Evaluation of functioning of disaster management plan
(11) Accident investigation
(12) Clean-up and restoration

5.3.5 Steps of Responses for Emergency Combat

Step 1: Risk determination and immediate measures

(1) Identification of potential hazards associated with the emergency episode due to the natural events or regular activities.
(2) Taking appropriate measures by the ERT/authority for determining the type, quality, extent of involvement.

Step 2: Local investigation

Determination of the source/reason of the event resulting to the emergency and prevent further losses.

Step 3: Detail assessment

Conduct an assessment of the incident site for any further information on hazards and taking necessary actions for remedies.

Step 4: Rehabilitation

Initiating restoration/rehabilitation measures.

Step 5: Reporting

(1) Reporting of the occurrence of the incidence with all the details including the measures undertaken to the appropriate authority.
(2) Taking initiative for further steps including financial assistance etc. to the appropriate authority.

Step 6: Risk Communication

Taking steps for mass communication with addressing public and media regarding concerns and issues including human lives, property and the environment and responses to resolute the stress of the community and the country. Functioning of following units can be helpful to combat any emergency in the industrial area. Emergency Response Cell with an:

(1) Well trained emergency response team (ERT)
(2) Emergency preparedness plan

(3) Provision of periodic drill of emergency rescue operations; *e.g.* Firefighting services;
(4) Emergency medical services
(5) Provision of emergency transfer of patients

5.4 Health, Safety and Safe Work Environment

In accordance with the requirement of DoE, Moheshkhali EZ must have a plan to take adequate measures against accidents and to meet the emergency. A contingency plan should be in place to deal with any emergency or natural calamities. There should be trained emergency response teams, specific contingency plans and incidence specific equipment packages in place to deal with these types of emergencies. In case of an emergency incident occur, immediate action must be taken to mitigate the impacts. In order to minimize the possibility of injury to the responders and others it is important that emergency responders follow the steps of emergency response plan to avoid missing of any events. The Health and Safety Management Guideline is to be followed.

Work plays a central role in people's lives, since most workers spend at least eight hours a day in the workplace, whether it is on a plantation, in an office, factory, etc. Therefore, work environments should be safe and healthy. Yet this is not the case for many workers. Every day workers all over the world are faced with a multitude of health hazards, such as:

(1) Dusts
(2) Gases
(3) Noise
(4) Vibration
(5) Extreme temperatures.

As a result of the hazards and a lack of attention given to health and safety, work-related accidents and diseases are common in all parts of the world.

5.5 Costs of Occupational Injury/Disease

Work-related accidents or diseases are very costly and can have many serious direct and indirect effects on the lives of workers and their families. For workers some of the direct costs of an injury or illness are:

(1) The pain and suffering of the injury or illness;
(2) The loss of income;
(3) The possible loss of a job;
(4) Health-care costs.

It has been estimated that the indirect costs of an accident or illness can be four to ten times greater than the direct costs, or even more. An occupational illness or accident can have so many indirect costs to workers that it is often difficult to measure them. One of the most obvious indirect costs is the human suffering caused to workers' families, which cannot be compensated with money.

The costs to employers of occupational accidents or illnesses are also estimated to be enormous. For a small business, the cost of even one accident can be a financial disaster. For employers, some of the direct costs are:

(1) Payment for work not performed;
(2) Medical and compensation payments;
(3) Repair or replacement of damaged machinery and equipment;
(4) Reduction or a temporary halt in production;
(5) Increased training expenses and administration costs;

(6) Possible reduction in the quality of work;
(7) Negative effect on other workers.

Some of the indirect costs for employers are:

(1) The injured/ill worker has to be replaced;
(2) A new worker has to be trained and given time to adjust;
(3) It takes time before the new worker is producing at the rate of the original worker;
(4) Time must be devoted to obligatory investigations, to the writing of reports and filling out of forms;
(5) Accidents often arouse the concern of fellow workers and influence labor relations in a negative way;
(6) Poor health and safety conditions in the workplace can also result in poor public relations.

Overall, the costs of most work-related accidents or illnesses are very high to the workers and their families and to the employers as well. On a national scale, the estimated costs of occupational accidents and illnesses can be as high as three to four per cent of a country's gross national product. In reality, no one really knows the total costs of work-related accidents or diseases because there are a multitude of indirect costs which are difficult to measure beside the more obvious direct costs. Moheshkhali EZ will ensure health, safety and safe work environment for the officials and workers.

5.6 Business Continuity Plan

A business continuity plan is that plan business will continue operating and serving its customers and buyers, even in the face of disaster, major IT failure, or a cyber-attack. The end goal is to preserve a company's financial viability, market position, reputation, and customers, even in the face of a crisis. Business continuity planning covers every aspect of the business including:

(1) Business processes: how can a process continue working even if critical equipment or supplies were missing?

(2) Human resources: how can critical staff continue performing their work if, for example, workstations are destroyed or there is no Internet connection?

(3) Business partners and suppliers: how can suppliers continue their work with the company if, for example, lines of communication or road transport is unavailable?

An example of business continuity plan is given in the following table.

Table 5.7: Business Continuity Plan

Timeframe	Example Activities
First 4 hours	(1) Business continuity team is alerted to the crisis (2) Contact made with authorities (firefighters, police, etc.) (3) Alternate physical facility is activated, or employees directed to work from home (4) Critical IT systems switched over to remote DR site
Hours 5-24	(1) In case of casualties among employees, succession plan activated (2) Assessment of damage to physical facilities

Timeframe	Example Activities
	(3) Assessment of damage to IT resources (4) Notifying customers, press, and suppliers (5) Switching to backup vendors in case a vendor or supplier was also affected by the disaster
Days 2-4	(1) Restoring critical parts of the primary facility (2) Transitioning critical staff back to the facility (3) Restoring critical IT systems (4) Routing activity back to recovered systems
Days 5-14	(1) Fully rebuilding primary facility (2) Transitioning all staff back to the facility (3) Restoring all IT systems (4) Resuming normal operations

5.6.1 Required time for rehabilitation after a disaster

The management plan will be circulated to all concerned member of emergency team. It is essential that all concerned personnel familiar themselves with the overall on- site emergency plan and their respective roles and responsibilities during emergency. Mock drill is an essential tool in a state of perpetual preparedness at all times to meet any emergency. The plan covers information regarding the properties of the industry, type of disasters and disaster/accident prone zones. Structure of emergency management plan is as following:

(1) Mock drills
(2) Noticing the accidents
(3) Informing declarer of emergency
(4) Declaration of emergency (Public information and warning)
(5) Evacuation of Personnel
(6) Functions of declarer
(7) Interaction with outside agencies
(8) All Clear Signal
(9) Mutual aid

The primary purpose of this emergency plan is to control and contain the incident and so to prevent it from spreading. To cover eventuality in the plan and the successful handling of the emergency will depend on appropriate action and decision being taken on the spot.

5.6.2 Search and Rescue

In general, the initial search and rescue phase will last for hours or even days after the disaster. The time immediately following the event requires a fast response in order to save lives and assets in imminent danger. However, in the case of massive fire hazard, the search and rescue phase can be stretched out for weeks. While people are trapped in factories, surrounded by flood water, it may take more than one day.

5.6.3 Recovery

Early recovery can last any number of weeks or months depending on its contingency plan, execution of contingency plan, vulnerability, and access to resources, adaptability, and other considerations.

5.6.4 Reporting of residual risks: and risk reduction measures

Residual risk is the amount of risk left over after actions have already been taken to address threats. In the feasibility study, it is important to identify any risks that could potentially derail a project. Efforts should be taken to mitigate these risks, including the introduction of

security controls to either eliminate a threat completely or reduce its negative impacts. Residual risk is what remains after these controls have been implemented.

Residual risks in the Moheshkhali EZ are the risks left over after implementing mitigation controls. These are most often assumed by the employer, where other risks are transferred to the contractors. In construction, residual risk is assumed by the employer and not the contractor unless they negotiate a transfer of risk. Transfers of risk usually come with a cost because no party wants to take responsibility for risk unless they are fairly compensated for doing so.

Residual risk reporting regarding both human health and ecological risk assessments reliance on a tiered or iterative approach, beginning with a simple screening analysis and moving as warranted to a more detailed and resource intensive analyses. Each assessment will include three phases:

(1) The level of exposure being received by people from the pollutant source is estimated in the exposure assessment.
(2) The type and severity of adverse effects that can be caused by the pollutant are assessed in the hazard identification step of the effects assessment.
(3) The adverse effects of a pollutant observed at different levels of exposure and the relationship between exposure and effects are considered in the dose-response assessment step of the effects assessment.

5.6.5 Categories of residual risks

Architectural

(1) Working at Height
(2) Glass Breakages during Bowl side Glazing
(3) Falls from Height during decoration of Walls and Ceilings

Mechanical

(1) Working at Height - Fan Coil Units
(2) Electric Shock - Fan Coil Units and Extract Fans

Electrical

(1) Working at Height
(2) Toxic Substances
(3) Confined Spaces
(4) Electric Shock

Financial

(1) Unexpected increases in the cost of supplies
(2) Poor financial planning leading to an insufficient budget
(3) Poorly defined scope leading to higher supply costs than expected
(4) Labor shortages leading to increased costs of labor
(5) Changes in exchange rates due to inflation

Contractual

(1) Managing change orders from the client
(2) Incomplete blueprints and drawings
(3) Design errors or omissions
(4) Design process takes extra time
(5) Poorly defined scope leading to poor time planning
(6) Poorly written contracts with suppliers and subcontractors

Operational

(1) Safety hazards leading to worker injuries and accidents
(2) Labor shortages leading to slowdowns

Environmental

(1) Natural disasters
(2) Harsh weather leading to delays
(3) Incomplete environmental analysis

(3) Damage to equipment
(4) Theft of equipment
(5) Failure to work per contracts
(6) Public objections
(7) Inexperienced workers
(8) Staff turnover
(9) Delayed deliveries of supplies
(10) Scheduling errors and delays
(11) Conflicts within the project team

(4) New environmental impact requirements
(5) Fire risk from technique, waste, or arson
(6) Unidentified gas pipelines and other utilities discovered underground

5.6.6 Risk Reduction Measures

Managing residual risk comes down to the organization's willingness to adjust the acceptable level of risk in any given scenario. For any residual risk present, organizations can do the following:

(1) Assuming the residual risk is below the acceptable level of risk in any endeavor, organizations simply accept that the implemented controls have proven effective enough to reduce the risk to an acceptable level.
(2) In the case that residual risk is still above an acceptable risk level, new or modified controls and processes may be needed to reduce the inherent risk to a level that is deemed acceptable.
(3) Keeping record of every incident occurred in the project site to evaluate the risks.
(4) Identifying trend of the incidents and find out the gap or reasons leading to these incidents.

6 Cost-Benefit Analysis

6.1 Financial Analysis

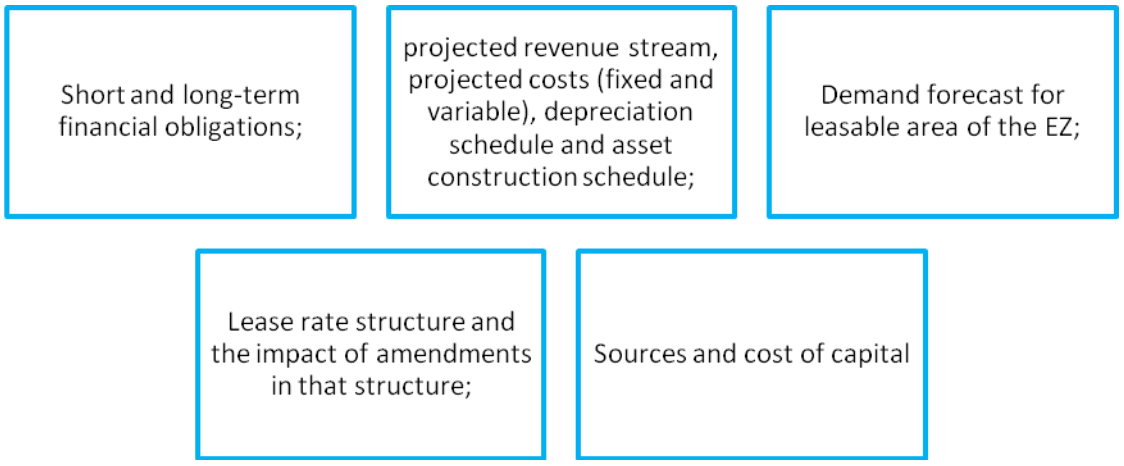
In this section the components of costs and benefits at market prices including their analysis are discussed:

(1) Identified the components of cost and benefit
(2) Translated them in monetary value
(3) Constructed cash flow
(4) Identified the Key Assumptions considered in exercises; then
(5) Computed the following indicators and interpreted the results:

- Financial Net Present Value (FNPV)
- Financial Benefit Cost Ratio (FBCR)
- Financial Internal Rate of Return (FIRR)

The main approach was to determine the financial viability of the project on the basis of an assessment of demand forecast for industrial plots, revenue collection from commercial areas, capital cost estimate for the project, revenue projection and financing structure. Financial analysis of the project considered such factors as follows.

Figure 6.1: Factors Considered for Financial Analysis



Financial analysis was carried out by developing a financial model. The key objectives of preparing the financial model were:

(1) to demonstrate the financial viability of development of the EZ based upon demand forecast, expected lease rates, cost estimates, planning parameters and other information.
(2) to illustrate the sensitivity of the financial and commercial viability to key parameters and to identify the areas which could be adjusted (lease rates or other parameters) to influence the profitability of the project.

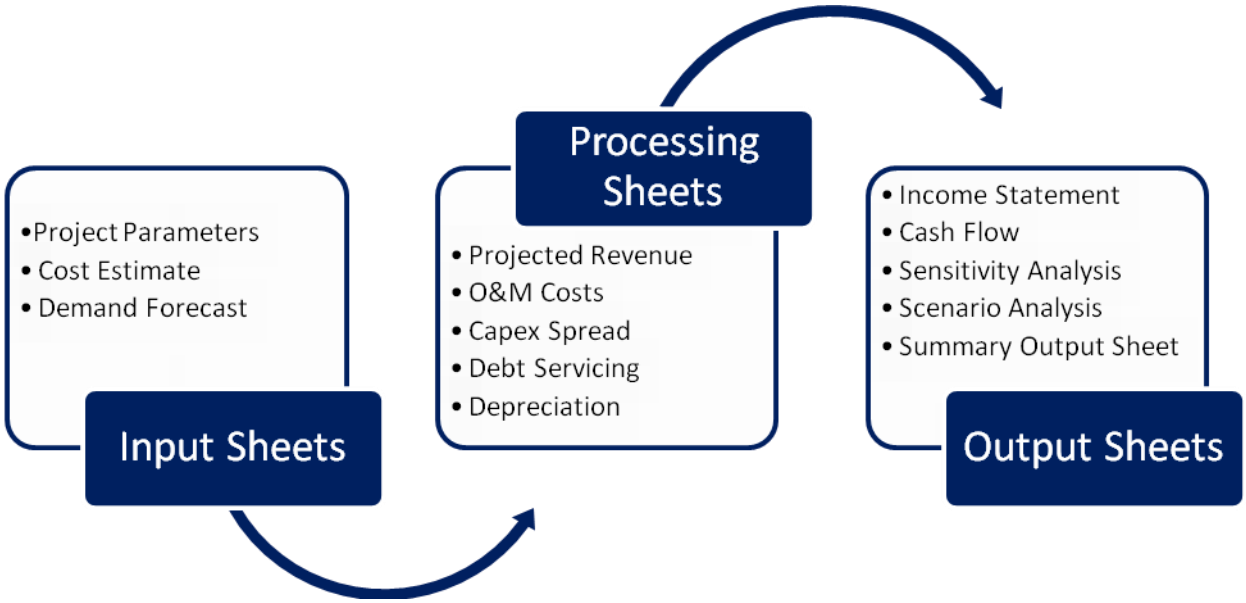
(3) to determine the requirement of initial support and later on to implement project on a commercial footing

6.1.1 Financial Model

The financial model covers the following:

(1) Determination of the revenue projection, projection income statements and cash flow statements over the life of the project.
(2) Calculation of various matrices such as IRR, payback periods and debt-service coverage ratio for assessment of project viability.
(3) Sensitivity analysis on the major parameters including capital cost, O&M cost, lease rate etc. in order to explore its sustainability under different changing situations.
(4) Financial analysis on options for cost recovery of capital investments and recurrent costs under different demand forecast scenarios.

Figure 6.2: Flow Chart of the Financial Model



The model contains interlinked sheets as shown in above figure keeping in view of the available data and information. The input and input support sheets accommodate all the basic inputs of the project required for the financial model. These inputs have connection with other sheets (processing/intermediate calculation) where specific calculations are made. Then the outcomes of the individual sheets were connected to the result sheets to obtain the final results. Sensitivity analysis is also included in the model to test its sensitiveness on change of different important parameters. The interlinked sheets as used in the financial model are briefly described as follows.

6.1.2 Components of Financial Model

Input and Input Support Sheets:

The input sheets include (1) Capex Assumption sheet (2) capital cost summary sheet, and (3) demand forecast sheet.

Capex and Opex Assumption Sheet: These two sheets contain all the major parameters of the project which will act as inputs to the model. The parameters include: (1) leasable commercial area and (2) cost escalation factors, etc.

Capital Cost Summary Sheet: Capital cost summary includes land development, off-site infrastructure, on-site infrastructure, project management costs.

This worksheet provides a summary of the project costs for the development of the economic zone. This worksheet has an onward relationship with depreciation, Capex year and cash flow sheet.

Demand Forecast: The sheet provides different demand projections based on different space take up scenarios. The projected demand was used for determining the projected revenue and projected variable costs for the project. This sheet has an onward relationship with the revenue and O&M.

Processing Sheets: The processing sheets compute and process data as provided in the Capex assumption and capital cost sheets. The processing sheets are (1) sources of finance (2) revenue, (3) depreciation, (5) O&M Costs and (6) Capex year.

Sources of Finance: This worksheet sets out a consolidated summary of finance stating separately the yearly amount of equity in Bangladeshi ৳. The computation of yearly equity is derived from capital cost, and debt equity ratio. This sheet has link to the cash flow sheet.

Revenue: This worksheet calculates the projected revenue of the Economic Zone from sources such as:

(1) Rent from Land Lease
(2) Rent from Training Centre Space
(3) Rent from Commercial Facilities Space
(4) Rent from SFB
(5) W&S service charge from tenants
(6) Power service charge from tenants
(7) CETP service charge from tenants

Revenue was calculated based on the demand forecast and the lease rates. The output of the revenue sheet is processed in the income statement sheet to calculate the projected net income of the operator.

Depreciation: Depreciation sheet calculates the depreciated value of the assets annually. It takes data from Capex assumption sheet and after computation, depreciation expenses from this sheet goes to the income statement.

O&M Costs: It receives data from the input sheet and input support sheets regarding operation cost, maintenance cost and fixed costs of the project. The output of the O&M costs sheet is used in the income statement sheet to calculate the projected net profit of the business.

Capex Year Sheet: The Capex year is used for incorporating capital cost phasing of the project year by year. Phasing of construction cost during construction is also projected in this sheet.

Financial Statements: Results of operating performance and financial position at periodic intervals are the essence of financial statements. The financial model provides projected financial statements such as, income statements and cash flow statements depicting profitability, liquidity and overall financial health of the entity. The result sheets include (1) Income Statement and (2) Cash Flow Analysis.

Income Statement: The financial model provides income statements for each year for 20 years. The revenue stream over the years is shown in the income statement. The statement also shows the operating expenses (fixed and variable), financing expenses and depreciation expenses as deductions from the revenues to obtain net income before tax. After deducting applicable tax, the net income for the equity holder is derived.

Cash Flow Analysis: Cash flow statement is an important financial output in the model, especially to work out the appropriate cash requirements of the project. The financial model incorporates the cash flow analysis for the project and determines the Project and Equity IRR.

Result (Financial Indicator) Sheets

Summary Output Sheet: The key requirement for financial viability is that the business is able to earn profit and keep up cash flow sufficient to finance all necessary future investments. This sheet gives the results of the model run in summarized form. The key results indicators are:

(1) Financial Net Present Value (FNPV)
(2) Financial Benefit Cost Ratio (FBCR)
(3) Financial Internal Rate of Return (FIRR)
(4) Total Capital Payback Period
(5) Equity Payback Period

Scenario Analysis Sheet: The model incorporates different demand forecast scenarios. This sheet analyses the results of these scenarios in different combinations.

6.1.3 EZ Businesses

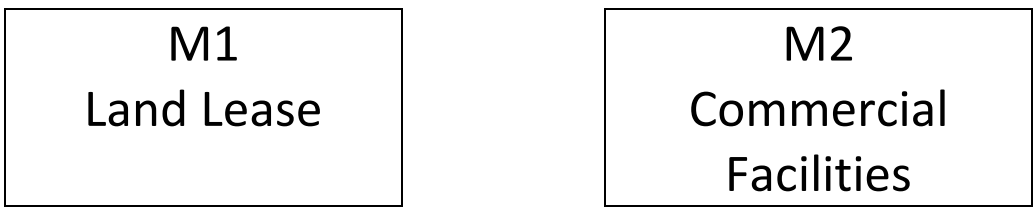
The Economic Zone Act 2010 provides mandate to recover charges and fees from the tenants. The financial model considers broadly two types of businesses of the EZ owner.

(1) Core/Main Business (designated as M1, M2)

(2) Component Businesses (designated as C1, C2, C3, C4 and C5)

The core business is leasing out land to different industries and rents collected from the floor space and other facilities of training center and commercial amenities.

Figure 6.3: Main Businesses



6.1.4 M1: Land Lease

It has been assumed that 95% of the leasable space will be taken up at full capacity. 5% of the leasable area is estimated to be transitional, *i.e.* in-between lease and unoccupied. The capital cost covers the cost for boundary wall, internal road, common zone facilities, etc.

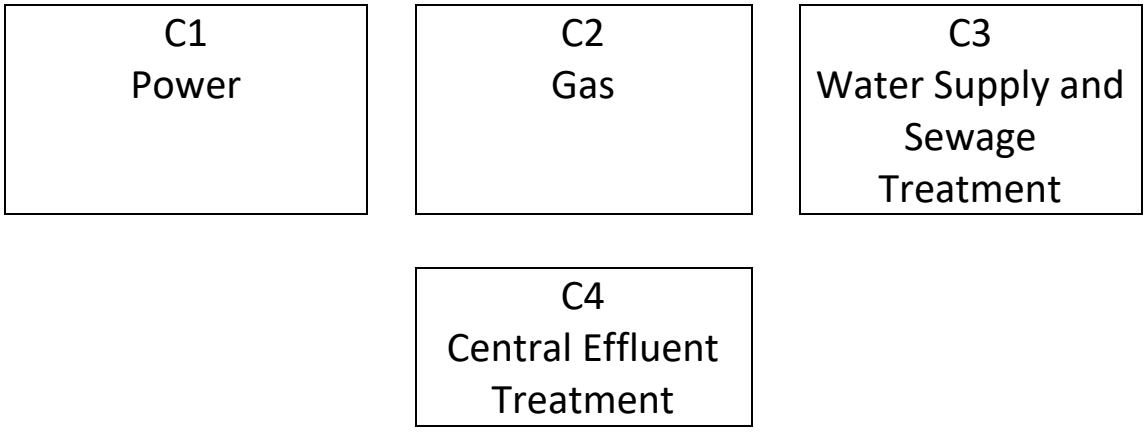
In this study, the cost of land acquisition within the defined boundaries of the proposed EZ and revenues from land lease have been excluded from the financial analysis, being outside the scope of this particular assignment. However, land acquisition for utility lines as required has been included, being part of the assignment.

The component businesses are premised on different sub-components of the project that have individual cost recoveries, such as power supply, gas supply etc. The capital, O&M costs and revenues for the component business have been matched exactly so that the resulting tariffs do not have any element of cross subsidization.

6.1.5 M2: Commercial Facilities

This is also excluded from the analysis for the reason mentioned above.

Figure 6.4: Component Businesses



6.1.6 C1: Power

The zone is responsible for providing power connections to industrial enterprises to be located within the zone. Therefore, the authority has to draw power from the national grid and supply power to the zone tenants/industries. Tariff (৳/kWh) will be charged to the industries for the electricity supplied.

Major assumptions and estimates have been made for power supply on the following items:

(1) Power Tariff (৳/KW)
(2) O&M Expense for operating the power supply system
- Maintenance
- Salary and Allowance

The Plant Load Factor (PLF) has been considered for different categories of industries.

6.1.7 C2: Gas

The EZ will supply gas to industrial enterprises to be located within the zone. Therefore, the EZ needs to enter into an agreement with the relevant gas supplying entity to install the gas transmission and distribution lines to supply gas to the tenants/industries. Tariff (৳/m3) will be charged to the industries for the gas supplied.

Major assumptions and estimates have been made for gas supply on the following items:

(1) Gas Tariff (৳/m3)

(2) Capacity of the supply
(3) Capital Cost for constructing the gas line
(4) O&M Expense for running the gas supply system
- Maintenance
- Salary and Allowance

6.1.8 C3: Water Supply and Sewerage Treatment

Water and sewerage services may be treated as a component business to determine the tariff rate for water and sewerage services to be charged to the industries. The EZ will have deep tube wells, water treatment plant for providing these services. The EZ will also lay water and sewerage pipes and pumps, and also be responsible for operation and maintenance of the water and sewerage system. The EZ will charge tariff to different industries for these services. The tariff will be charged based on the amount of water supplied (৳/m3) to the industries. Major assumptions are as follows:

(1) W&S Charge (tariff to be charged from tenants)
(2) Capacity of the system
(3) Total Capital Cost for constructing the system
(4) O&M Expense for running the system
- Maintenance
- Salary and Allowance
- Utilities

6.1.9 C4: CETP

Central Effluent Treatment may be treated as a component project to determine the tariff rate to be charged to the industries for providing effluent treatment services. The tariff will be charged based on the amount of effluent treatment (৳/m3) to the industries. The financial model contains major assumptions and estimates that have been made with respect to CETP for the following items:

(1) Charge (tariff) for effluent treatment
(2) Capacity of the CETP
(3) Capital Cost for constructing the CETP
(4) Operation and Maintenance Expense
- Maintenance
- Salary and Allowance
- Utilities

6.1.10 Term/Business Period

The business period over which the EZ would receive a profitable return on his investment is very important. However, this would depend on the following factors:

(1) sources of capital and its repayment terms;
(2) economic life of major depreciable assets;
(3) revenue earnings;
(4) capability of the tenants/ buyers to pay the cost; and
(5) Phasing of the Zone's infrastructure.

The financial model is prepared considering a period of 20 years, although law permits for 50 years lease period. From financial point of view, longer project period will not carry any

significant impact on the results of the financial model. Moreover, 50 years, a very long investment recovery period will eventually discourage the investment.

6.1.11 Capital Cost

Capital costs have been estimated both at the base year (2022) and subsequently at the point when they will be incurred with escalation during time elapsed. It comprises cost of land development, land filling, external/ off-site infrastructure, which include connectivity infrastructure like road, gas or power. The social infrastructure ensures proper living conditions of the people inside the zone, which includes administrative buildings, a mosque, and commercial facilities.

These are parts of capital cost but some of the social infrastructure like mosque, etc. will not generate direct revenue. The capital cost also include the commercial facilities like shops, restaurants, banks, etc. are essential for day-to-day life of the tenants inside the Zone.

6.1.12 Cost Escalation and Contingency

It is assumed that all costs are escalated from the time of their estimation to the time the cost is actually incurred at the rates shown in the following table:

Table 6.1: Cost Escalation Rates

	Cost Item	Escalation Rate (per year)	Comments
(1)	Land Filling Cost Escalation	5%	Percentage adopted as per industry norms
(2)	Cost Escalation for Off-site infrastructure	15%	Average of Construction Material Price Indices and recent trend, Bangladesh Bureau of Statistics
(3)	Cost Escalation for On-site infrastructure	15%	As above

6.1.13 Depreciation

Depreciation is a non-cash expense. Though it does not directly influence cash flow, it influences tax obligations from income of the business, by offering tax savings adding to depreciation. Depreciation like interest is a tax-deductible item considered by the tax authorities.

Basis of Depreciation: The Income Tax Ordinance, 1984 allows deduction of depreciation of assets from the income of the particular year to determine the taxable income for that period. Section 29(1) (VII) and (IX) of the Income Tax Ordinance provides provisions for the following methods of depreciation:

- Normal Depreciation
- Accelerated Depreciation

The ordinance also provides prescribed rates of depreciation irrespective of actual life of the assets. Normal Depreciation method is used in the model. It is briefly described in the following section. The Income Tax Ordinance prescribes the depreciation schedule.

The "Normal Depreciation Method" is considered as base case for the financial model. The following table provides the prescribed rates for normal depreciation.

Table 6.2: Schedule for Normal Depreciation

	Types of Assets	Depreciable amount[25]
(1)	Building (general)	10%
(2)	Furniture and fixture	10%
(3)	Machinery and plant (general rate)	20%

Each year, depreciation has been charged by the above prescribed % age on the written down value *i.e.* the value of asset less accumulated depreciation in the previous years. In accounting concept, it is referred to as declining balance method. Depreciation each year will be reduced as the same % age as applied on a declining balance. This method of depreciation has been used in the financial model as the base case, as the depreciation is mainly calculated for determining taxable income and thereby tax to be paid.

According to S.R.O No. 227 and S.R.O No. 229 of Finance Act 2015, Developers of Economic Zone in Bangladesh will enjoy the following Income Tax Exemption:

Duration of Tax Exemption	Rate of Tax Exemption
Year 1-10	100%
Year 11	70%
Year 12	30%

As tax exemptions are already provided in the front-end of the years of operation, accelerated depreciation will not be beneficial as such, as that would not result any tax saving. Rather normal depreciation may result some tax saving for the developer at the back-end as this method will result some level of depreciation over the whole period of operation.

6.1.14 Operating Expenses

Each of the facilities developed and constructed by the Economic zone has operational costs, which include salary and allowances of employees, maintenance costs, and utilities costs. In addition, the cost of fuel used in the power plant is also an operational cost. Maintenance costs associated with training center and commercial facilities are based on the amount of revenue generated from each item. The O&M cost will be higher if the buildings are in full capacity and lower if not all leasable spaces are taken up.

Fuel costs associated with running the power plant, operation and maintenance costs and salary of staff of the power plant has been estimated and incorporated in the model.

O&M Cost of W&S and CETP have also been considered. Maintenance of roads, sewerage system all have yearly operations and maintenance costs associated with them. Estimates on the amount of O&M cost has been made on the basis of investment. In addition to the

[25] As percentage of written down value

internal infrastructure, there are also costs associated with the operations of the Zone such as security, etc. All such costs have been incorporated in the model.

For O&M expense calculation of both main and component business, the salary and allowance is based on the latest rate (pay scale 2015) declared by the pay commission of Bangladesh. The allowance including medical, festival and New Year bonuses, house rent, conveyance, education for children etc.

Table 6.3: O&M Cost Escalation Estimates

Salary and Allowances Escalation Rate	5%	per yr
Other O&M Expenses Escalation Rate	2.5%	per yr

6.1.15 Return from the Project

The internal rate of return (IRR) on a project is the annualized effective compounded return rate or discount rate that makes the net present value of all cash flows from the project equal to zero. Internal rates of return give an indication on the desirability of investments or projects. The higher a project's IRR, the more desirable it is to undertake the project. Among other factors, returns depend upon tariff rates.

Net Present Value (NPV): Computation of Net Present Value has been shown in the following table.

Table 6.4: Net Present Value

Discount Rate	FNPV ৳ lakh	ENPV ৳ lakh
12%	16,200	39,400
14.08%	-	16,700
30%	(48,300)	(48,900)
25%	(41,100)	(39,500)
16%	(12,000)	-

The above table shows the present value of net cash flow is zero at discount rate of 14.08% and FNPV ৳ 16,200 and ENPV 39,400 lakhs at 12% rate of discount.

Table 6.5: Scenario Analysis

	FIRR	EIRR
Base Case	14.08%	16.09%
Aggressive Case	14.74%	17.09%
Conservative Case	13.49%	15.21%

Difference of results obtained from base case and aggressive case is significant which indicates IRR sensitive to land take-up.

6.2 Economic Analysis

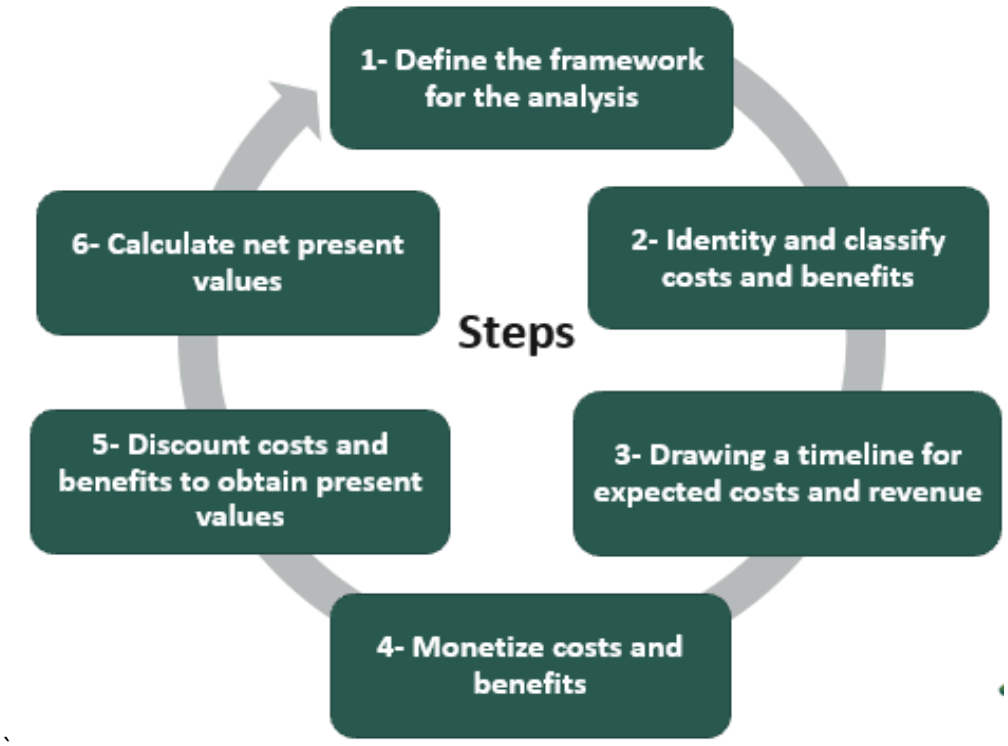
In this section economic adjustments were made from financial data using standard conversion factor; after that costs and benefits are appraised from the point of view of the entire economy.

(1) Identified the direct, indirect and associated cost and benefit components;
(2) Converted the value of cost and benefit components into economic price by using Standard Conversion Factor (SCF) determined by the Government;
(3) Constructed the cash flow;
(4) Mentioned the Assumptions;
(5) Computed the following indicators and interpreted the results:

- Economic Net Present Value (ENPV)
- Economic Benefit Cost Ratio (EBCR)
- Economic Internal Rate of Return (EIRR)

The purpose of the economic analysis is to quantify the economic and social benefits of the project with its costs of implementation and operations. In conducting the economic impact analysis of the EZ, an economic model was framed to identify and quantify costs and benefits associated with the zone development business. The outputs of the model are the Economic Rate of Return (ERR), Benefit Cost ratio (BCR) and Net Present Value (NPV) of the project. Unquantifiable benefits were identified and linked with the project to evaluate the overall economic and social impact of the project.

Figure 6.5: Steps of Economic Modeling



The approach and methodology adopted for the economic analysis of the EZ is shown below:

(1) Comparison between scenarios where Project is implemented and where Project is not implemented: To identify the benefits and costs of the EZ, a matrix was designed to portray the economic and social impacts of implementing the project. The matrix helped to identify the service and facilities gap as well as to assess the needs of the project.

(2) Compare Benefits with Costs: Project investment decisions involve large up-front costs, with benefits that are achieved over time. The costs and benefits of the proposed EZ were identified and the relevant benefits and costs were classified into two subcategories: (a) Quantifiable and (b) Unquantifiable. Then a framework was developed to define the value and to measure the quantifiable benefits and costs associated with the EZ. It is envisaged that the industries which will be set up in the EZ will be able to achieve higher efficiencies and hence better productivity.

(3) Prepare Economic Model incorporating Results of Financial Model: The financial profits/(losses) (considering capital expenditure, operational expenditure, and revenue) were converted into economic equivalent terms in designing the economic model. Economic benefits of the EZ were estimated and added to the financial profit. Costs, including economic costs and taxes, were subtracted to attain the net economic benefit of the project.

(4) Discounting Benefits and Costs to Present Values: The team designed the economic model to calculate the Economic Rate of Return (ERR) and Cost Benefit ratio. In this context, corresponding costs and benefits which would be generated during the development of the EZ, were quantified. Thereafter, all pertaining quantifiable future costs and benefits were converted into present value terms by applying Net Present Value (NPV) principle.

6.2.1 Components of costs

Costs associated with the development of land, technical support, development of green belt, solid and hazardous waste management, waste and wastewater, construction safety etc. have been included as part of capital expenditure. Operational expenditure includes maintenance salaries and allowance of the officers and employee, operation and maintenance costs for created facilities like CETP, Fire Service and Civil Defence Station, maintenance of the existing structures to be used for providing one stop services (OSS), residential building of the officials of OSS, waste treatment facilities, and other establishment for providing services to the investors. Environmental costs due to increased CO2 emission from the industrial enterprises have also been included in the economic model.

6.2.2 Components of Benefits

Economic benefits considered are:

(1) Earnings from the sale/rent of land/building space within the economic zone;
(2) Economic benefit through earning revenue as service charges from the entities operating within the proposed EZ;
(3) Employment generation owing to the development of the proposed economic zone. Minimum wage rate prevalent in Bangladesh. Value addition from the earnings through employment creation;
(4) Employment generation through infrastructure development in the island;

(5) Secured industrial activities increase the workplace safety of the workers, so, lower the industrial accident and lower doctor visits by the workers.
(6) Value addition through increase in export and decrease in import by producing import substitute goods.

6.2.3 Adjustment of Costs and Benefits

Revenue generated from direct and indirect benefit and cost incurred through different direct and indirect cost components have been adjusted by inflation. Besides, in case of salary and allowances, annual increment has been considered to adjust their income with the price inflation. General market prices of the components of benefits and costs without taxes have been used in the analysis.

6.2.4 Conversion of the Value of Cost and Benefit Component into Economic Prices

Cost Stream

The cost stream covered both direct and indirect cost. The direct costs include capital expenditure, operation and maintenance cost, and the indirect cost includes the cost of environmental degradation through emitting greenhouse gases by increased use of fossil fuel, increased concentration of people in the industrial belt and so development of urbanization in the reference area.

Benefit Stream

Development activities enhance growth. The economy to be in the steady state and take the opportunity of conversing growth and development to the developing countries, development activities *viz.* technological improvement is necessary. Such technological improvement is possible by employing latest technology in production process, which not only increase the level of output but secure the workplace also. Developing an economic zone create opportunity to set up industries with modern technology in confined areas of scarce land. But all the benefits are not quantifiable in nominal term but have greater impacts in the economy. In this project, both direct and indirect benefits have been considered. Direct benefits consist of the earnings of the zone authority against the services and rents of plots and facilities to the investors, and on the other hand, indirect benefits consist of those which are not directly accrued to the implementing agency, but to the economy. In this project, benefits from employment generation, accident reduction, better health, foreign exchange earnings through increase in export, etc. have been considered. The benefits have been first calculated and then converted into economic prices using conversions factors.

6.2.5 Assumptions and Data

All values in market prices were obtained from the engineering team/financial model in the previous section. Apportionment of all on-site project costs into net of relevant taxes and 'para-tariffs' (such as supplementary duties and the like), and government's tax yield has been done, with the latter being added to the government revenue from the implementation of the economic zone in question.

All off-site costs are incorporated net of tax and para-tariff(s), with the difference that such taxes are *not* deemed to be government revenue. The details regarding the conversion to

economic prices as determined by using market prices are presented subsequently in this narrative. The following assumptions were considered to obtain the profitability indicators such ENPV, EBCR, and EIRR:

(1) Capital Expenditure (Capex): The Capex incurred for various components (for both on-site and offsite infrastructure) of the project has been obtained from the financial model.

(2) Operating Expenditure (Opex): Operation and maintenance costs cover the salary and allowances of the zone management, maintenance of the building and equipment, vehicles, and other materials of the zone. The operating cost for personnel has been calculated separately in the economic model.

(3) Import of Equipment: We have assumed that most of the equipment and machinery used for the project would be imported. This is based on the standard practice and market benchmark of similar industries in Bangladesh.

(4) Costs have been converted to economic equivalents/ market costs.

(5) Wage Rate: Average Wage rate considered for the direct and indirect employment is ৳ 8000. These figures are in conformity with the information provided by Bangladesh Planning Commission and ADB economic analysis reports for Bangladesh.

(6) VAT rate (for both Capex and Opex) has been considered as 15% according to the prevailing rate for Bangladesh.

(7) Tax Treatment: Since taxes and subsidies are treated as transfer payment, it will not be considered in the economic analysis.

(8) Excess Capacity and Value Addition: All the industrial units of the zone are considered to have excess of 20%, and average value addition has been assumed to be 25% of the FOB value of export item. Therefore, total value addition has been calculated as (Production Capacity of the Industrial Unit x 80% x 25%)

6.2.6 Profitability Indicators

The economic analysis has been performed based on the threshold social discounting rate of 12%, provided by the Planning Commission, Government of Bangladesh. The results are presented below:

Indicators	Financial	Economic
NPV (৳ lakh) @12%	16,157	39,410
IRR	14.08%	16.09%
BC Ratio	1.01	1.02

The estimates indicate that the project is economically viable in all respects *i.e.*, economic net present value, economic benefit-cost ratio, and economic internal rate of return.

7 Human Resources and Administrative Support Analysis

This section describes functional structure and institutional capacity of BEZA (in terms of both technical and financial) required for implementation and operation of the project(s). It also discusses Types of managerial and skilled workforces that are needed during implementation and operational phases of the project. Sources of the workforce and financing are also identified and discussed:

BEZA has been empowered by the government to develop the zone infrastructure, manage, operate the zone and facilitate the investors and stakeholders. To provide these services, BEZA need to appoint engineers having experiences in zone development and some officials for accounts and administrative support services in the implementation phase. In the operational phase, BEZA will require skilled engineers (Civil, Electrical, Mechanical) for utility services, skilled officials for trade facilitation, industrial relations and factory inspection, security services to ensure discipline in the zone and secure the life and property of the investors as well as the government in the zone. Besides, official for providing administrative and accounts support services are to be appointed in the operational phase.

7.1 Organisational Mandate of BEZA

Bangladesh Economic Zones Authority (BEZA) was created by Bangladesh Economic Zones Act, 2010 and it was officially instituted by the government on 9 November 2010. BEZA aims to establish economic zones in all potential areas in Bangladesh including backward and underdeveloped regions with a view to encouraging rapid economic development through increase and diversification of industry, employment, production and export. BEZA is attached with the Prime Minister's Office (PMO) and is mandated to establish, license, operate, manage and control economic zones in Bangladesh. BEZA has envisaged setting up 100 economic zones by 2030 and creating a land bank of about 100,000 acres. At present the authority has selected site of 98 economic zones in different locations of the country.

IPAs, which have been briefly described above, play a significant role in attracting foreign and local investment in Bangladesh. All foreign and local investments are required to be registered as per prescribed procedure with the concerned agency before setting up an industry. Bangladesh Economic Zones Authority is entitled to allot plots in Economic Zones/Special Economic Zones. For utility connection and other facilities for conducting business activities, BEZA has a one stop service center, and the service providing agencies are linked with them. Private sector is allowed to set up economic zones/special economic zones. PPP Authority is the concerned agency for PPP concession. As per decision of the government, projects with the government of foreign countries (G to G agreement) will also fall under PPP.

Main functions of BEZA are as follows:

(1) Identify and select sites for industrial or similar sectors on availability of local resources;

(2) Acquire land for economic zones identified by own initiative or public-private partnership and take possession of the acquired land on behalf of the Government;

(3) Appoint economic zone developer;

(4) Prepare infrastructure development plans of economic zones;

(5) Allot or lease or rent of land, building or site;

(6) Ensure infrastructure development of economic zones within specified period;

(7) Create opportunities for employment through establishing backward linkage industries within or outside economic zones;

(8) Ensure efficient use of land in the light of clustering principles;

(9) Encourage more efficient management and monitor programs for implementing commitments on environment and other matters;

(10) Take steps to establish backward linkage industries in economic zones to meet the requirements of local economy;

(11) Encourage business organizations to relocate polluting and unplanned industries from metropolitan cities through establishing separate economic zones for different industries;

(12) Encourage public-private partnership in the development and operation of economic zones;

(13) Take necessary steps to implement social and economic commitments;

(14) Establish the due rights of workers, to ensure their welfare and to establish conducive relationships between owners and workers;

(15) Take appropriate steps to implement poverty reduction program;

(16) Expedite implementation of industrial policy of the country by promoting planned industrialization of the thrust manufacturing and service sectors; and

(17) Convert the areas declared as economic zones into economic centers by developing industrial cities, agro-based industrial zones, trade zones and tourism zones through investment of banking sectors and to facilitate availability of skilled labour and efficient service provisions.

7.2 Human Resources and Financial Capability of BEZA

(1) BEZA's ability to provide the managerial and skilled workforces needed for implementation of the project: BEZA has been successfully operating the EZs in Bangladesh. The institution has skilled officials for providing services in implementation and operations phases.

(2) Institutional capacity (financial and technical) of BEZA to retain the project output functional: The main sources of income that are envisaged are rents from industrial plots and SFBs, charges from utility services, etc. However, currently no economic zone is yet operational to the stage of earning significant operational revenue. Therefore, BEZA is short of own fund for development of new zones. However, it has the opportunity to borrow fund from the government and the development partners. It has also technical capacity to operate the zones, as senior engineers are already in place in the organogram in BEZA. Upon implementing the project, a separate organogram for

Moheshkhali EZ will be in effect against which BEZA needs to recruit manpower for operation of the zone.

(3) Adequacy of skilled and experienced workforce to operate the project: BEZA has adequate skilled manpower to operate the project. However, a project office need to setup with provisions for sitting a Project Director, engineers, and other supporting staff.

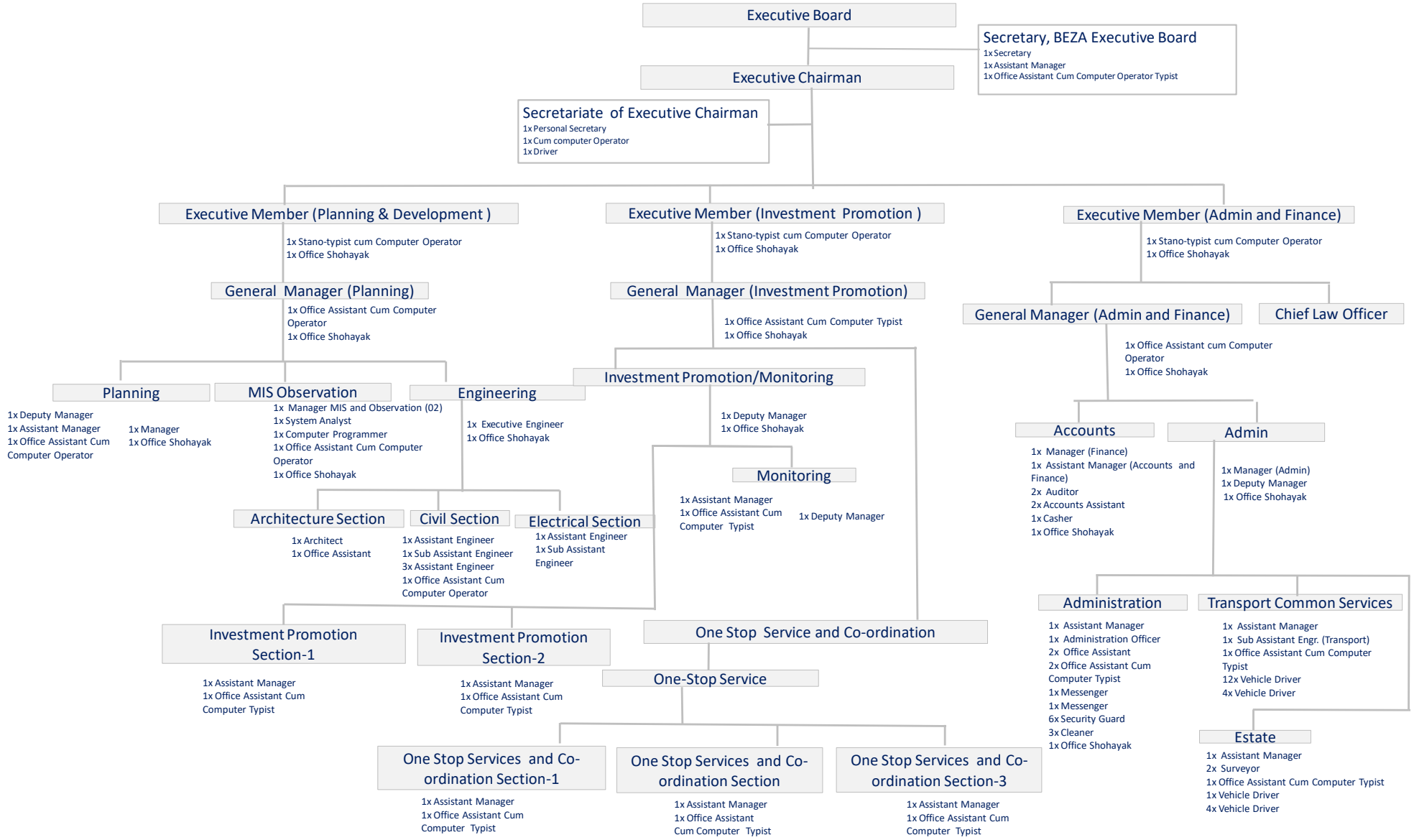
(4) Adequacy of fund under its recurring budget to bear the operational expenditure of the project output: Generally, BEZA develops the new zones with funds borrowed from the government or from the government through multilateral donors. It has now inadequate fund to run the EZ from own funding source.

(5) Consistency of timing of the project with organizational capacity (in terms of quantity and other): As EZ is already a success in attracting foreign and local investors, utilization of the same is needed to meet the challenges of graduating Bangladesh to a developing country. Therefore, it is a high time to set up more new EZs under BEZA.

7.3 Management of BEZA

The day to day activities of BEZA is conducted by the two sets of administrative structures- one is BEZA Management and the other is the One Stop Services (OSS) Office. Besides, BEZA assigns some manpower based on the project entity. The administrative structure (Organogram) of BEZA Headquarter has been mentioned in the following figure.

Figure 7.1: Organogram of BEZA



7.4 One Stop Service Center at BEZA

The operational activities are conducted through the OSS Office, which is created with the power conferred to the Authority as per the OSS Act, 2018 and OSS Rules, 2018. The detailed schedule of the OSS Rules mentioning different services required to operate business activities in economic zones has been mentioned in Table 7.1.

Table 7.1: Schedule of One Stop Service

		Service	Service Providers/ Authority
(1)		**Investment Clearance**	Bangladesh Economic Zones Authority
	1.1	Investment Registration	
	1.2	Investment Clearance	
(2)		Company Registration	Office of the Registrar of Joint Stock Companies and Firms
	2.1	**Name Clearance**	
	2.2	Certificate of Incorporation	
	2.3	Share Transfer	
	2.4	Change of Shareholder	
	2.5	Change of Director	
	2.6	Increase of approved capital	
(3)		**Trade License**	Union Council/ Municipality/ City Corporation
(4)		**Tax relevant Registration**	
	4.1	TIN Registration Certificate	National Board of Revenue
	4.2	VAT Registration Certificate	
(5)	5.1	Land Purchase Deed/ Lease Agreement Registration	Relevant Sub Register Office, Directorate of Registration
	5.2	Issuance of the Certified Copy of the Original Deed	
(6)		**Mutation**	Relevant Upazila Office
(7)		Resident and Non-resident Visa	
	7.1	Visa recommendation	Bangladesh Economic Zones Authority
	7.2	Issuance of business visa	Bangladesh Embassies/High Commissions, Ministry of Foreign Affairs
	7.3	Issuance of Initial 'e' Visa	Bangladesh Embassies/High Commissions, Ministry of Foreign Affairs
	7.4	Issuance of Initial 'e1' Visa	Bangladesh Embassies/High Commissions, Ministry of Foreign Affairs
	7.5	Issuance of Initial 'p1' Visa	Bangladesh Embassies/High Commissions, Ministry of Foreign Affairs
	7.6	Issuance of Initial 'p3' Visa	Bangladesh Embassies/High Commissions, Ministry of Foreign Affairs
	7.7	Extension of Validity of 'e' Visa	Directorate of Immigration and Passport
	7.8	Extension of Validity of 'e1' Visa	
	7.9	Extension of Validity of 'p1' Visa	
	7.10	Extension of Validity of 'a3' Visa	
	7.11	Visa Extension with Category Change (Subject to the recommendation of BEZA/ Security Clearance/ Report of the Special Branch)	Security Service Division, Ministry of Home Affairs
	7.12	Submission of Report of the Special Branch (SB) for Visa	Special Branch (SB)
	7.13	Submission of Report of the Special Branch (SB) for Security Clearance	Special Branch (SB)
	7.14	Submission of Report of the NSI for Security Clearance	NSI
	7.15	Issuance of Security Clearance for Visa (Subject to receipt of report)	Security Service Division, Ministry of Home Affairs
(8)		**Work Permit**	

		Service	Service Providers/ Authority
	8.1	**Issuance of Work Permit**	
	ka	Issuance of Work Permit	Bangladesh Economic Zones Authority
	kha	Issuance of Security Clearance	Public Security Division, Ministry of Home Affairs
	8.2	Extension of Validity of Work Permit	
	ka	Extension of Work Permit	Bangladesh Economic Zones Authority
	kha	Issuance of Security Clearance	Public Security Division, Ministry of Home Affairs
(9)		**Environmental Clearance**	
	9.1	**Green Category Industries**	Department of Environment
	ka	Issuance of Environmental Clearance	
	kha	Renewal of Environmental Clearance	
	9.2	**Orange A Category Industries**	
	ka	Issuance of Environmental Clearance	Department of Environment
	kha	Renewal of Environmental Clearance	
	9.3	**Orange B Category Industries**	
	ka	Issuance of Environmental Clearance	Department of Environment
	kha	Renewal of Environmental Clearance	
	9.4	**Red Category Industries**	
	ka	Approval of ToR for EIA (including inspection)	Department of Environment
	kha	Approval of EIA	
	Ga	Issuance of Environmental Clearance	
	Gha	Renewal of Environmental Clearance	
(10)		**Building Construction**	
	10.1	Approval of the existing land use Plan	Bangladesh Economic Zones Authority
	10.2	Clearance for Construction (Approval of the Drawing and Design of the Building)	
	10.3	Final inspection and Issuance of Certificate of Use	
	10.4	Approval of Design Change	
	10.5	Approval for partial use of the building	
(11)		**Firefighting Services and Clearance**	
	11.1	Approval of Fire Safety Plan	Fire Service and Civil Defence
	11.2	Approval of Fire Safety License (with final inspection)	
	11.3	Renewal of Fire Safety License	
(12)		**Electricity Connection**	
	12.1	Approval of Electricity Plan/NOC	Office of the Chief Electric Inspector
	12.2	Approval of Electrical Connection and Issuance of Certificate	
	12.3	Renewal of Electrical Safety Certificate	
(13)		**Installation of Generator**	
	13.1	Issuance of permission to import/ installation of generator	Bangladesh Economic Zones Authority
	13.2	Issuance of Certificate for using generator (with inspection)	
	13.3	Renewal of certificate for using generator (with inspection)	
(14)		**Installation of Boiler**	
	14.1	NOC for Boiler Import	Office of the Chief Inspector of Boilers
	14.2	Boiler Registration and Issuance of Certificate	
	14.3	Renewal of Boiler Certificate	
	14.4	Ownership (Name/ Address) change	
(15)		**License of Factory**	
	15.1	Approval of machine layout design in the factory	
	15.2	Licensing of factory or organization	
	15.3	Renewal and amendment of license of factory or organization	

		Service	Service Providers/ Authority
(16)		**Issue Bond license (with inspection)**	National Board of Revenue
(17)		**Gas connection to industrial unit**	Gas distribution agencies under Energy and Mineral Resources Division
(18)		**Telephone/Internet Connection**	
	18.1	Installation of telephone connection	Bangladesh Telecommunication Company Limited/ Others Company
	18.2	Installation of internet connection	
(19)		**Explosives' License**	
	19.1	Issuance of Explosives' license	Department of Explosive
	19.2	Renewal of Explosives' license	
(20)		**Recommendations for different types of incentives**	Bangladesh Economic Zones Authority
(21)		**Approval of Foreign loans and repatriation of Remittance**	
	21.1	No Objection Certificate for foreign loan	Bangladesh Economic Zones Authority
	21.2	Foreign loan approval	Bangladesh Bank
	21.3	NOC for Bank Loan	Bangladesh Economic Zones Authority
	21.4	NOC for Off-shore Banking	Bangladesh Economic Zones Authority
	21.5	Off-shore Banking License	Bangladesh Bank
	21.6	Approval for repatriation of technical knowledge and assistance fee (if the amount is more than 6% of the value of imported machinery)	Bangladesh Economic Zones Authority
	21.7	Approval for repatriation of Royalty (6% of the sales declared in the Income Tax Return last year)	
	21.8	Recommendation for repatriation of profit and dividend	
	21.9	Return of profits and dividends	Bangladesh Bank
(22)		**Import/ Export and Customs Clearance**	Bangladesh Economic Zones Authority
	22.1	Import/ Export Clearance	
	ka	Import Approval	
	kha	Export Approval	
	Ga	Design Approval (Import)	
	Gha	Design Approval (Export)	
	Ng	Customs related Clearance	National Board of Revenue
	22.2	Customs Clearance	
	ka	Local purchase approval	Bangladesh Economic Zones Authority
	kha	Local sales approval	
	Ga	Sub- Contractor approval	
	Gha	Customs related Clearance	National Board of Revenue
(23)		Certificate of Origin	
	23.1	Country of Origin Certificate (GS)	Bangladesh Export Promotion Bureau/ Chamber of Commerce
	23.2	Country of Origin Certificate (General)	Chamber of Commerce
	23.3	Utilization Declaration (UD)	BGMEA
	23.4	Utilization Permission (UP)	National Board of Revenue
(24)		Electricity Substation	
	24.1	No objection letter for installation of electricity substation	Bangladesh Economic Zones Authority
	24.2	Issuance certificate of use (with inspection)	Office of the Chief Electric Inspector
(25)		Other Physical Infrastructure (Utilities)	
	25.1	Installation of power generation plant	
	ka	No objection letter of installation of power generation plant	Bangladesh Economic Zones Authority
	kha	Approval of ToR for EIA	Department of Environment
	Ga	Approval of EIA	
	Gha	Issuance of environmental clearance	
	Ng	Renewal of environmental clearance	
	25.2	Installation of water treatment plant	

		Service	Service Providers/ Authority
	ka	No objection letter of installation of water treatment plant	Bangladesh Economic Zones Authority
	kha	Approval of ToR for EIA	Department of Environment
	Ga	Approval of EIA	
	Gha	Issuance of environmental clearance	
	Ng	Renewal of environmental clearance	
	25.3	Installation of CETP	
	Ka	No objection letter of CETP	Bangladesh Economic Zones Authority
	kha	Approval of ToR for EIA	Department of Environment
	Ga	Approval of EIA	
	Gha	Issuance of environmental clearance	
	Ng	Renewal of environmental clearance	
	25.4	Construction/ installation of sewage refinery	
	ka	No objection letter of sewage refinery installation	Bangladesh Economic Zones Authority
	kha	Approval of ToR for EIA	Department of Environment
	Ga	Approval of EIA	
	Gha	Issuance of environmental clearance	
	Ng	Renewal of environmental clearance	
(26)	26.1	Issurance of Mark license	Bangladesh Standards and Testing Institution, Ministry of Industries
	26.2	Patent/ Design Registration	Department of Patents, Designs and Trademarks (DPDT)
	26.3	Trade mark Registration	
(27)		Certificate of commencement of commercial activities	Bangladesh Economic Zones Authority

8 Institutional and Legal Analysis

This section illustrates any legal restrictions that may obstruct or impede the project during its implementation and functional stage of the project outputs. Key issues discussed are:

(1) the project with regard to the legal boundary (allocation of business or mandate) of BEZA
(2) Utilisation of capabilities and facilities
(3) Need for adjustment (reforms) in the policy and/or institutional setup
(4) Adjustments that may be required before the project is implemented
(5) Suitability of skills and capacity in line with the project requirement
(6) Incentives or penalties to ensure the project delivery on time and within the budget
(7) Any critical governance issues that may affect implementation
(8) Challenges related to cross-cutting issues

The economic zone regime of Bangladesh is in the primary stage. Although Bangladesh has a success story in implementing EPZs, it is confined to only the export orientation. Setting up of the import substitute industries, which can capture the local market is beyond the purview of EPZ. Therefore, industries with concentration to domestic market have been set up in an unplanned way. The promulgation of Bangladesh Economic Zones Act, 2010 and the government policy to clustering the industries in the specialized zones has created the opportunity to effective utilization of the scarce land and help conserve the environment. But the power and the mandate of BEZA is yet to be properly utilized. Still now, no satisfactory improvement is visualized in investment promotion and facilitation. Therefore, specific planning and guidelines to set priority in making the economic zones operational.

8.1 Legal Jurisdiction of BEZA

BEZA is a “statutory public authority” as defined in Article 152 of the Constitution of People’s Republic of Bangladesh. Under Article 152, a statutory public authority means any authority, corporation or body the activities or the principal activities of which are authorised by any Act, ordinance, order or instrument having the force of law in Bangladesh. Bangladesh Economic Zones Act 2010 was promulgated under which Bangladesh Economic Zones Authority was established with broad objectives to:

(1) Identify and select sites for Economic Zones for industrial activities
(2) Acquire land for Economic Zones
(3) Ensure off-site infrastructure development for the Economic Zones
(4) Establish Economic Zones through Public-Private Partnership (PPP)
(5) Provide One Stop Service

The act provides for legislations for developing economic zones about the powers and functions of the authority. BEZA is governed by a 3-level management structure.

The Governing Board is headed by the honorable Prime Minister.

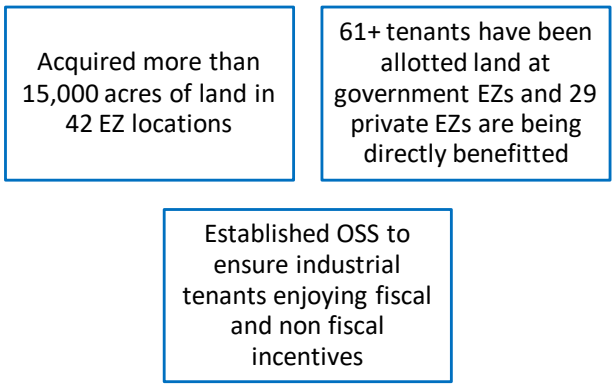
8.2 Legal Provisions Regulating BEZA Activities

Under section 13(p) of the BEZA Act, the Government may, by notification in the official Gazette, exempt a zone or any organization therefrom from the application of all or any of the provisions of any act, or may pass order that the acts or any provision thereof shall, in its application to a zone, be subject to such modifications or amendments as may be specified therein. Government has from time to time issued such gazette[26].

BEZA has been empowered by the government to deal with all types of economic zones in accordance with the Bangladesh Economic Zones Act, 2010. Besides, many other laws including the Foreign Private Investment (Promotion and Protection) Act, 1980, the One Stop Services Act, 2018, the Companies Act, 1994, the Acquisition and Requisition of Immovable Property Ordinance, 1982, etc. are to be applicable for some specific activities.

8.3 Utilisation of Capabilities and Facilities

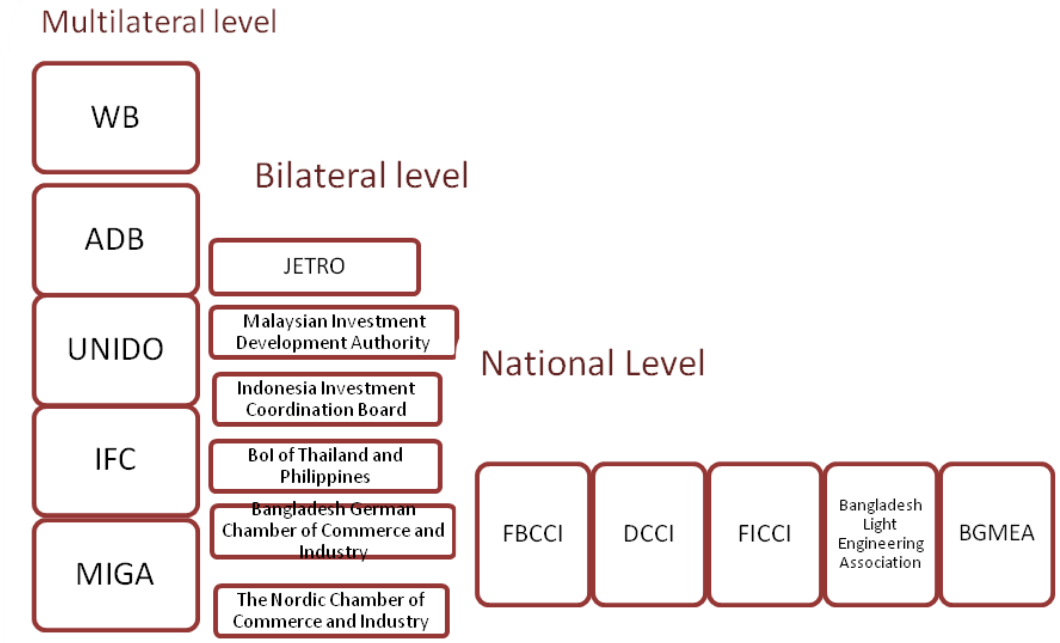
Presently, BEZA conducts its day to activities from its headquarters located in Dhaka. Although the basic operational activities will be held in the concerned zone, no separate set up of required HR is yet to be operational. The HQ functions with 130 persons provision in its organogram. All the positions are yet to be filled up. However, within the existing strength the organization performed a tremendous task of acquiring a huge land bank for EZ development within 5-7 years. In that sense BEZA has been an example of removal barriers in land acquisition. Following are key achievements of BEZA:



BEZA has established a close working relationship with a number of mulitilateral, bilateral and national organizations.

[26]SRO 108-Law/2016, dated 21st April 2016excluded operation of Bangladesh Board of Investment Act 1989 to any Economic Zone or any company within such zones.

Figure 8.1: BEZA's Liaison Initiatives at Different Levels



8.4 Need for Adjustment

Project office of the zone located in Dhaka. A full-fledged project office headed by the Project Director and engineers, and other officers and staff with ancillary facilities is needed to be set up in the zone itself, so that development activities can be properly monitored the prospective investors be facilitated as per their requirement.

Investment promotion, investment climate in the country and that in the other neighbouring and strategically located countries, world economic situation, and obviously the scenario of trade facilitation activities is responsible for operationalizing an economic zone. The commitment of the direct stakeholders including the officials concerned and the developers is the main striking force to implement an economic zone project.

In the previous trend of setting up of the economic zones, generally, location is chosen based on government's policy of uniform development. However, there are other factors which sometimes become secondary. This is not an appropriate approach in setting up of economic zones. Most of the developing countries in the world tried to make an economic zone successful. But a handful of them have been succeeded. Therefore, setting up of a zone without prior improvement of the communication and other required facilities will not be successful. Besides, international best practices relating to trade facilitation should be ensured to make the economic zone regime successful.

8.5 Suitability of Skills and Project Management Capacity of BEZA and Suggested Incentives

Although there is a strong organizational structure functioning at the HQ, currently there no separate structure to execute activities at the project level. To perform the activities in the project phase a separate administrative structure shall be required, which is suggested in Figure 8.2, and in the operational phase in each zone following indicative organizational structure in Figure 8.3 is suggested. Special incentives like on-site service allowance and

extra allowances for working in new areas at development stage needs to be provided for encouraging personnel for EZ development and operation.

Figure 8.2: Proposed Organogram for Zone Development (Project Phase)

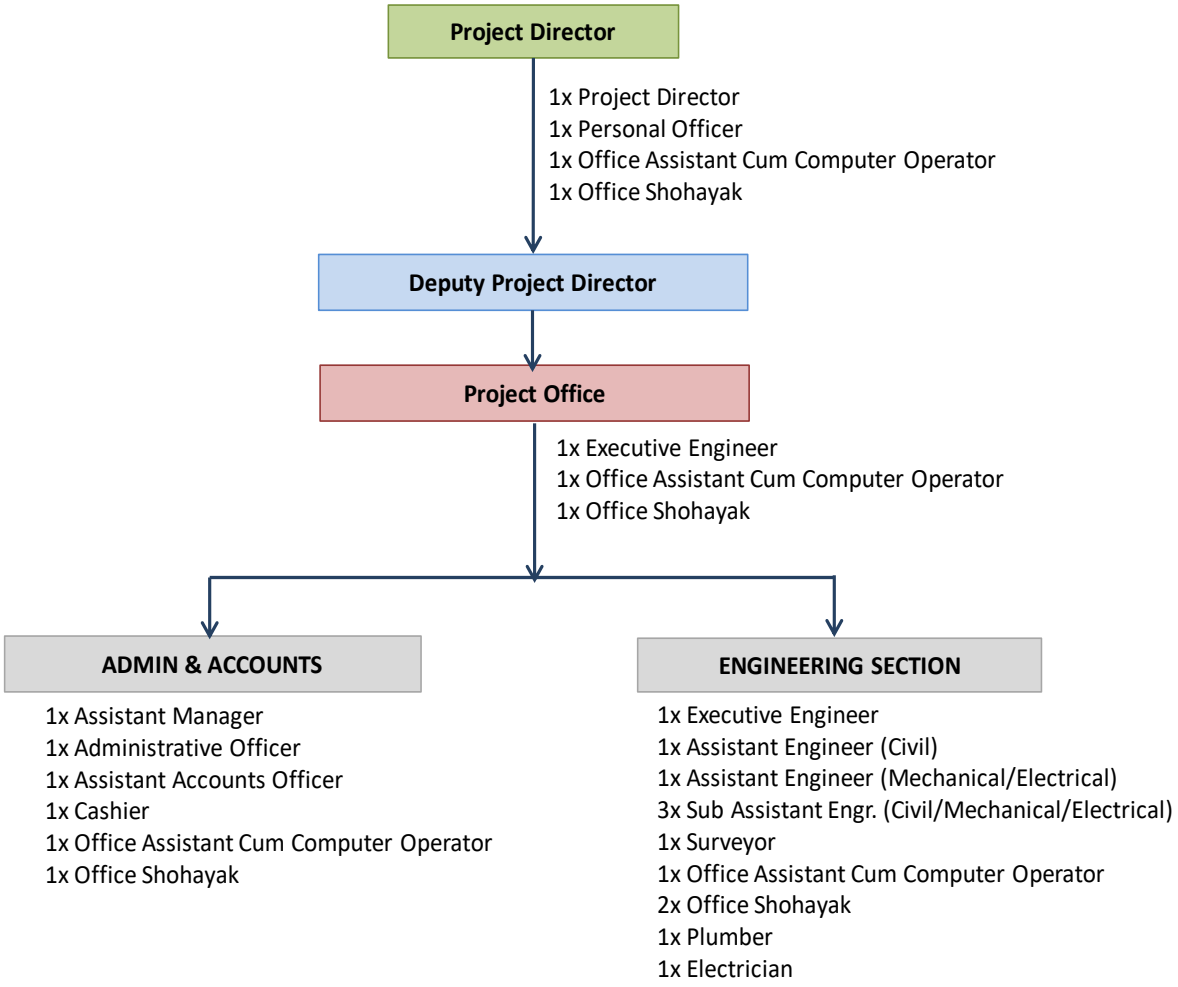
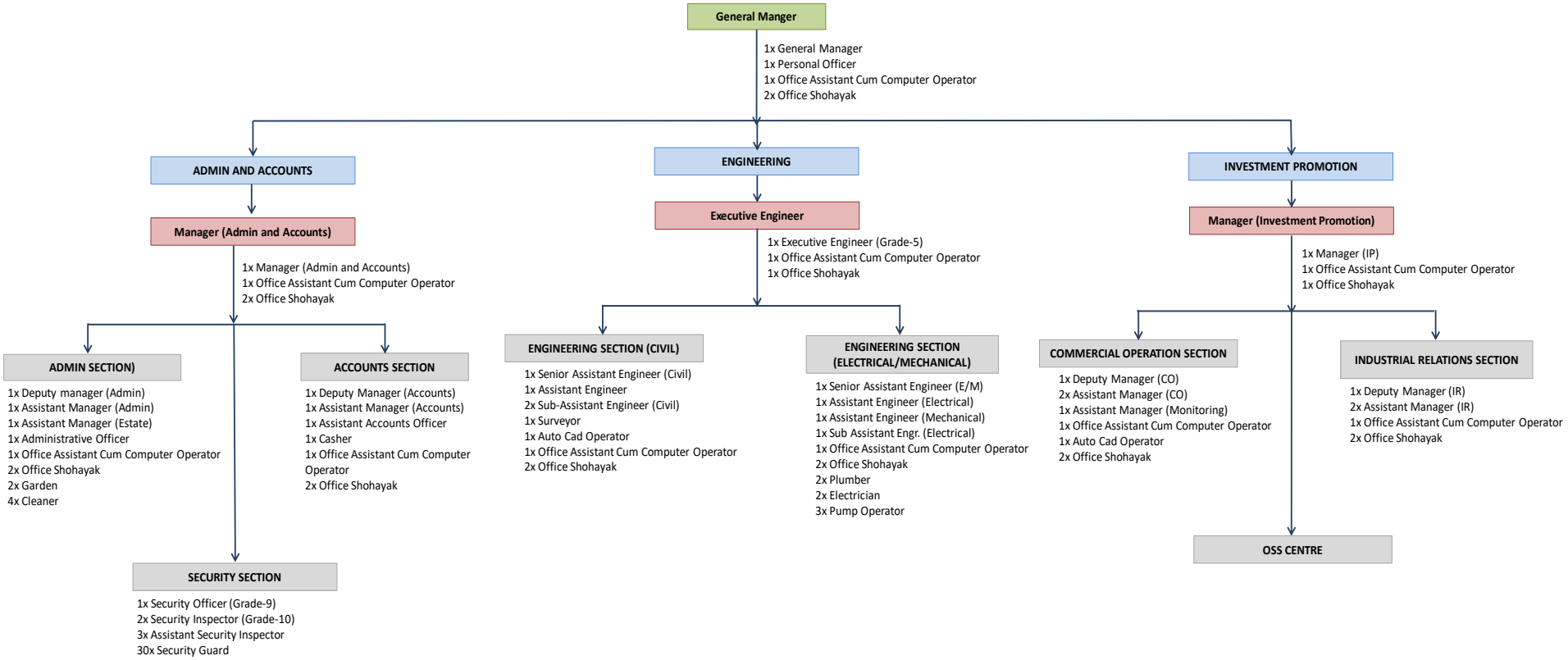


Figure 8.3: Proposed Organogram for EZ Operation



8.6 Challenges Related to Cross-cutting Issues

Bangladesh is on the way to graduating from least developed country to developing country. Upon graduation, Bangladesh will lose several facilities like development assistance, duty and quota free entry of the Bangladeshi products to markets of the developed countries. On the other hand, Bangladesh will be able to attract more FDI in the manufacturing sector due to the increase of GNI per capita and enhancement of socio-economic conditions of the people, although successful implementation of economic zone with diversified facilities is yet to be achieved. If BEZA does not keep pace in facilitating the foreign and local investors, it may detract foreign as well as local investment.

Therefore, timely implementation of an economic zone project with all the facilities for the investors needs to be ensured. Besides, economic diplomacy with developed and larger developing countries shall also be strengthened. Moreover, political stability, transparency, and accountability in the policies of implementing authorities be ensured, international best practices for the trade facilitation to followed, full professional HR set-up to be established, and finally, all the concerned ministries, agencies, officials, political leader, and other stakeholders have to be committed to provide services properly and support the activities of the government in this regard.

9 Risk and Sensitivity Analysis

This chapter emanates from the fact the flow of costs and benefits throughout the project life is uncertain. Given that uncertainty, considerations have to be given to the costs and benefits with weightage of risks. The objective is to simulate various scenarios and generate guidance on how to reduce the risk exposure through relevant contractual clauses. The following aspects have been covered in this report:

(1) Major risks that may affect project
(2) Magnitude of impact if the risk event materialized
(3) Possible mitigation measures
(4) Sensitivity to the assumptions used in the financial and economic models in an environment that differs significantly
(5) Risks of, legal and regulatory obligations that could increase costs or decrease the benefits

9.1 Risk Analysis

The effective identification, valuation, allocation of risk and successful management and reward between the contracting parties is key to the structure of all successful projects. Successful implementation of the exercise, therefore, dependent on how the risks associated with the project are mitigated. Before the risks are mitigated and allocated to either party, IIFC will identify the risks in details. Hence, as a step toward making a choice about the option to be implemented; all the risks associated with the project would be listed.

The allocation of risk is the central issue in contractual arrangement between the parties. The deal would set out the optimality principle governing risk transfers: the principle governing risk transfer is that risk will be allocated to whoever is best able to manage it at least cost, taking into account public interest considerations.

For meaningful analysis and optimum allocation of risk to be made, detailed contractual documentation is required to crystallise the extent of the obligations of each project participant.

9.2 Risk Mitigation

It is difficult to generalize the risk characteristics of the project in the context of multiple changes in technologies in ports sector. Each country, each infrastructure sector, indeed each specific project has its own risk profile. The different types of risks projects are exposed to may, however, be divided into two broad categories for the purpose of risk identification. These are as follows:

(1) General or country risks, which are associated with the political, economic and legal environment of the host country and over which the project sponsors generally have little or no control
(2) Project Specific risks, which to some extent are controllable by the project sponsors

9.3 General or Country Risks

General or country risks refer to factors such as the country's economic growth, its political environment, tax code and the prevailing currency exchange regime. Such factors will affect demand for land in EZs, because private sector investors are not in a position to influence a country's economic and commercial regime, which is more a function of macro-economic management. Similarly, unfavorable inflation, interest or exchange rate movements can result in rapid deterioration of cash flow of the tenants, if BEZA is unable to respond rapidly by adjusting the tariffs it charges. The general risks may be divided into three major categories:

9.3.1 Political Risks

These are related to the internal and external political situation and the stability of Bangladesh as a whole. GoB's approach towards allowing the private sector investment may change in the country's fiscal regime, including taxation, the risk of expropriation and nationalization of the assets of the tenants within and outside the EZ, cancellation of the contracts with the tenants, and similar factors.

9.3.2 Commercial Risks

These are risks related to the convertibility of revenue of the EZ tenants from their businesses into foreign currencies, foreign exchange and interest fluctuation and inflation. They have their impact on the cost of finance, which is usually high for infrastructure projects and foreign investment.

9.3.3 Legal Risks

Project implementation rely heavily on the contract signed by the parties and the legal framework supporting project financing arrangements. The risks to EZ tenants and lenders are that legislation that is relevant to the project may change after the contract has been signed and being implemented. Such changes may substantially undermine the long-term viability of the project located at EZ if the tenants are not compensated for them.

The importance of these risks can vary substantially from time to time. In the context of Bangladesh such risks are likely to surface out if not very common. The environment of Bangladesh is generally considered to be oriented towards investment and trade.

9.4 Project Specific Risks

Specific project risks, which EZ tenants and lenders to the tenants face in addition to the general risks discussed above, refer to risks that are generally within the control of the EPC contractors or EZ tenants, such as the management capabilities. The project specific risks may be broadly divided into the following categories in accordance with the phases of a project cycle:

9.4.1 Development Risks

For large projects like an EZ development, development and bidding costs of the government can be very high as such projects require detailed design, comprehensive planning, preparation of extensive bid documents and lengthy clarifications. The development risks my also include losses caused by delays in planning and approval, which can be particularly acute in the case of transnational projects like those established in EZs by

foreign investors, where the foreign investor has to deal with the authorities of two or more governments.

9.4.2 Construction/Completion Risks

The primary risks here are the following:

(1) The actual cost of construction may be higher than projected
(2) Completion takes longer than projected
(3) The construction of the project is not completed

In most of the cases, funds invested in a partially completed infrastructure project may be lost, while the return on investment will certainly suffer. The degree of construction/completion risk differs from project to project. For example, it can be considerable for the design and construction of a nuclear power plant or a distant off the road project site, while it is not very high for a conventional motor-way in an urban area. For an EZ development project like in Moheshkhali, the construction risks may be significant as there are number of components that needs to be synchronized or harmonized to save cost, human resources and time involvement.

9.4.3 Operating Risks

Operating risks result from insufficiency in performance, revenue income, material supply etc. and from higher than expected operating costs. They may be divided into six main categories:

9.4.3.1 Associated infrastructure Risks

These risks are associated with facilities outside the project. Such as approach roads and transmission lines for which construction responsibility lies with third parties rather that the project sponsors them. They are nevertheless essential to the operational success of the scheme. This being the case, the proposed project is subject to the risk that the associated facilities many not be constructed or completed in time, thus jeopardizing its operations. Associated infrastructure risks can be especially high where multiple government agencies are involved.

9.4.3.2 Technical Risks

These include design defects and latent defects in project. Projects, especially EZ development project, are usually required to meet certain performance targets specified by the government and the private sector investors, the concerned authority or the contracted purchaser of project output. Design, construction or equipment defects may be important risks. Particularly in some EZ development projects like in Moheshkhali that may involve highly sophisticated technologies.

9.4.3.3 Demand Risks

Most projects that rely on market-based revenues face demand risks related to volume and / or prices; in case the actual demand for land and utilities generated by the EZ may be lower than forecast, thereby lowering the return of the government from the project. Forecasting of revenues can demonstrate a high degree of inaccuracy.

9.4.3.4 Supply Risks

Supply risks have two components, volume and price. Some projects face the risk of an uncertain supply of critical raw materials. If the raw materials supply is uncertain or insufficient to meet the needs of a project, the project's ability to meet output commitments and debt repayment obligations will be compromised. In some cased, raw materials supply are controlled by the either the state or a monopoly, which means that projects being supplied would be at the mercy of sudden increases in price over which they have little or no control, but which would nevertheless have an adverse impact on the operations of the project.

9.4.3.5 Management Risks

The quality of management in every project is always a critical success factor.

9.4.3.6 Force Majeure Risks

Force majeure risks denote losses from certain exceptional types of events beyond the control of the parties to the project that impede the performance of their obligations. The losses include casualty losses from events such as fire, flood and earthquake and non-casualty losses from events such as war, civil disturbance, strikes and lockouts. If a force majeure event occurs and continues for a long period the construction or tenancy contracts may be terminated. Force majeure risks may also be borne by key suppliers of raw materials or services such as transportation.

Some force majeure risks may be covered by insurance from private or government sources. The main issue is therefore the allocation of those force majeure events and losses that are not insurable. There are a number of stakeholders who will be involved in the processes of project development. Since all parties have interests in the process, risks associated with the project implementation need to be allocated proportionally. The risk allocation matrix is laid out as follows:

Table 9.1: Risk Allocation Matrix

	Risks	BEZA	EPC Contractor	Tenants	Insurance Company	Other Contractors
(1)	Political risks	✓	✓			
(2)	Taxation risks	✓	✓			
(3)	Expropriation/nationalisation risks			✓		
(4)	Forced buy-out risks			✓		
(5)	Termination of Construction contract due to Contractor's default		✓			
(6)	Import/export restrictions		✓	✓		
(7)	Failure to obtain or renew approvals		✓	✓		
(8)	Currency inconvertibility risks			✓	✓	
(9)	Foreign exchange risks			✓	✓	
(10)	Devaluation risks			✓	✓	
(11)	Inflation risks		✓			
(12)	Interest risks		✓			
(13)	Country Legal Risks					
(14)	Changes in laws and regulations	✓	✓			
(15)	Law enforcement risks	✓				
(16)	Bidding risks	✓				
(17)	Planning Risks	✓	✓			
(18)	Approval risks		✓			
(19)	Construction Risks		✓	✓		
(20)	Time overrun risks		✓			✓
(21)	Cost overrun risks		✓			✓
(22)	Re-performance risks		✓			
(23)	Force majeure risks	✓	✓			✓
(24)	Loss or damage to work due to FM		✓			
(25)	Operating Risks	✓		✓		
(26)	Linked infrastructure risks drainage etc	✓		✓		
(27)	Technical risks	✓	✓	✓		
(28)	Demand risks	✓	✓	✓		
(29)	Supply risks		✓			
(30)	Cost escalation risks	✓	✓	✓		
(31)	Management risks	✓	✓	✓		

For mitigation of impacts, a number of measures are envisaged. They are laid out below:

(1) The mitigation measures that needs to be taken during construction and operation phases of the project to eliminate or offset adverse environmental impacts, or reduce to acceptable limits;
(2) The actions needed to implement these measures; and
(3) A monitoring plan consists of concrete monitoring indicator require to assess the effectiveness of the mitigation measures employed.

A mitigation mechanism has to be established regarding various risks. Following are the broad components of impact mitigation strategy:

Table 9.2: Risks and Mitigations

Attribute	Impact	Mitigation
1. Political Risk	The project may need to be abandoned	In the EPC contract there need to be special provision for compensation for wilful acquisition of the project by the government, changes in tax regime etc.
2. Commercial Risk	The EPC Contractor may not be able to repatriate the capital due to not being able to convert local currency into foreign currency.	Specific provision has to be there with the responsibility of BEZA to facilitate such conversion with best effort basis.
3. Legal Risks	The financial health of the project may change significantly for the costs incurred to comply with new laws.	There has to be specific provisions regarding the fall-back in case laws of country dramatically affects the business from the project.
4. Development Risk	The project may get stuck in the middle due to required approvals not achieved.	Same as above
5. Environmental Risks	Separately covered	
6. Socio Economic Risk	Separately covered	
7. Construction/Completion Risks	• The actual cost of construction may be higher than projected • Completion takes longer than projected • The construction of the project is not completed	Penalty provisions on the EPC Contractor need to be there in the contract for not completing construction in time.
8. Operating Risks	• Performance, revenue income, material supply etc. may turn insufficient • Operating costs may be higher than expected	There are no mitigation measures as such to cover operating risks.
9. Linked Component Risks	• Linked components like roads and transmission lines for which construction responsibility lies with third parties like RHD rather than the private investor or BBA, may be delayed	Delay in completion of such facilities may be mitigated through inter-ministerial committees
10. Technical Risks.	• During construction or operation a large defect is detected either due to faulty design or non standard construction materials	There are no mitigation measures as such to cover faults in design, except falling back to the consultants responsible for detail design. For fault in construction, there need to be penalty provision in the EPC contract on the EPC Contractor.
11. Demand Risks	• Land up-take may be less than expected.	Incentives may be provided to the officers and employees stationed in the zone for attracting quick take up of the land.

Attribute	Impact	Mitigation
12. Management Risks	• Management of the EZ operation may turn to be poor.	There need to be minimum performance standard provisions in the employee contracts.
13. Force Majeure Risks	• Casualty losses from events such as fire, flood and earthquake and non-casualty losses from events such as war, civil disturbance, strikes and lockouts.	Proper insurances for mitigation of force majeure and remedies shall need to be made.

9.5 Sensitivity Analysis

We have considered two variables- capital expenditure and selling price of electricity to check the sensitivity.

Table 9.3: Sensitivity Analysis on Change in Capital Expenditure

Capital Cost Change	ENPV (৳ lakhs)	FNPV (৳ lakhs)	EIRR (%)	FIRR (%)	EBC Ratio	FBC Ratio
0%	39,410	16,157	16.09%	14.08%	1.025	1.011
10%	30,961	10,641	15.05%	13.30%	1.019	1.007
5%	35,134	13,364	15.55%	13.68%	1.022	1.009
-5%	43,786	19,022	16.67%	14.53%	1.028	1.013
-10%	48,264	21,958	17.31%	15.01%	1.030	1.015

As shown above, the economic net present value varies from ৳ 309.61 crore to ৳ 482.64 crore due to increase in capital expenditure up to 10% and decrease the same upto 10% respectively. Similarly, the economic benefit cost ratio also varies from 1.007 to 1.015, and economic internal rate of return varies from 15.05% to 17.31%.

10 Alternative/Options Analysis

It covers analysis of different relevant options with recommendations and justifications. Technology and strategy recommended to achieve the goals and objectives of the proposed project have been discussed considering various technologies and strategies applicable. Advantages and disadvantages of different options have also been analysed.

10.1 Traditional Subsistence vs. Industry

Bangladesh is an extremely densely populated country (about 170_{mn} people living in less than 150,000 square kilometers). Despite this density, the country relies mainly on agriculture to support the majority of its population. Although Bangladesh has a historical reputation for producing the finest quality textiles and jute products, and long has been a hub for trade, the country has a low industrial and manufacturing base. Jute was the main export of Bangladesh for decades: during the 1950s to the 1960s, almost 80% of the world's jute was produced in Bangladesh. However, from the 1970s onward, the global jute industry faced a long period of decline as a result of the development of synthetic substitutes. The gap in exports was filled by the textile and garment sectors, which gained a quick foothold in international markets, taking advantage of Bangladesh's low labor costs to attract investors from other Asian economies (particularly the Republic of Korea, Taiwan, China, and Hong Kong SAR) that faced quotas resulting from the MFA.

The Bengal Delta (Bangladesh) is very fertile and most of the land is arable. Historically, Bangladesh became populated with a view to cultivate this fertile land and harvest crop at lower cost. Since 1990s, Bangladesh has been experiencing the structural change in different sectors to face the competition with the other countries. Per capita income of the people has been increased by about five-fold. Although high yielding variety of crops have been invented, it is not sufficient to increase the national income in line with the other competitors. Currently traditional subsistence at Moheshkhali is mostly through fishing, shrimp culture and salt cultivation. However, these are less profit intensive businesses and deplete the nature. Therefore, there is no alternative to industrialization to survive in the global competition. However, effective utilization of land is necessary to increase the contribution in the national economy as our land resource is scarce. Considering this idea, the government has initiated land use zoning particularly, industrial zoning system and emphasized on clustering the industries.

The proposed Moheshkhali EZ is located in geographically strategic location, which is one of the largest islands of Bangladesh. Transport communication and connectivity, specifically being on the sea side is very good for export and import. Setting up of an economic zone will help become boon for increasing economic activities and enhance socio-economic condition of the people in the region.

10.2 Alternative Technology and Raw Materials

The technologies proposed in the project are labor intensive. Minimum mechanical equipment will be used during construction work. All these works will be done by labor force

with minimum mechanical equipment except in the case of piling. This action will produce minimal environmental impacts. Care should be taken and adequate protective measures should be applied for the working persons at and nearby the pilling site.

11 Conclusion and Recommendation

11.1 Conclusion

The Government of Bangladesh has undertaken development of economic zones for the rapid economic development in Bangladesh, including in the backward and less developed areas. In line with that the proposed Moheshkhali EZ project has been developed. This report has assessed the technical, financial, social and environmental feasibility of the project.

The project appears as a key to the country's diversification of development activities to islands. This can be a major scope for creating employment opportunities. Similar to other development projects, this project will bring some consequences for the local environment, landowners and dependent communities, but these would be mitigated with proper measures, management plans and monitoring. In the long run, the project will also bring immense positive impacts for local, regional and national economy and socio-economic benefits for the communities.

Review of various reports and activities carried out under this study concludes that development of the economic zone is suitable in the area and is expected to play a key role in improving the industrial and business opportunities in Moheshkhali. It will facilitate organized industrialization in the island, with provisions for the development of backward linkages and an industrial ecosystem with all the required utilities and amenities.

11.2 Recommendations

(1) The implementation of the project is recommended to proceed following the findings of this Feasibility Study report and the recommended mitigation measures as outlined in the ESIA report.

(2) Government of Bangladesh may opt for going ahead with the project for implementation.

(3) BEZA with due approvals may submit a DPP to the Planning Commission for implementing the project.

(4) BEZA may organize inter-departmental arrangements, for timely planning, implementation and timely completion of the project with effective coordination.

12 References

(1) Bangladesh Economic Zones Act, 2010

(2) BEZA Vision Document

(3) Industrial Policy, 2010

(4) Investment Regulations and Policies

(5) Foreign Private Investment (Promotion and Protection) Act, 1980

(6) The Environmental Conservation Act, 1995

(7) The Environmental Conservation Rules, 1997

(8) Acquisition and Requisition of Immovable Property Act (ARIPA), 2017

(9) Seventh Five Year Plan, Government of Bangladesh, 2016-2020

(10) "Liquefied Petroleum Gas (LPG) Bottling Process and Required Safety During Bottling: A Case Study;" Petroleum Science and Engineering. Vol. 3, No. 1, 2019, pp. 5-9. doi: 10.11648/j.pse.20190301.12; Mohammad Shimul Hossain*, Mohammad Golam Muntasir Shehab, Soumik Mahmood Leon, Simanto Kumar Pal, Rafsanjani Rafi, Rashed Alom Emon, Sujon Kumar Gain, Mohammad Shaheen Shah; Department of Petroleum and Mining Engineering, Jashore University of Science and Technology, Jashore, Bangladesh

(11) "Process Design and System Layout for an Automobile Manufacturing and Assembly Plant;" D. Phanindra Kshatra, S. Akhil, Ch. Uday Kiran, Ch. Yaswanth, M. Vineeth; International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019. Revised Manuscript Received on December 05, 2019.

(12) "Energy Consumption and Conservation in Shipbuilding;" ISSN 2278 – 0211 (Online); Ch. Rajeswar Harish, Scientist – B (NA); SMDR, Indian Maritime University, Visakhapatnam campus, Visakhapatnam, India; Soumya K. Sunil, Scientist – B (ELE), SMDR, Indian Maritime University, Visakhapatnam campus, Visakhapatnam, India

(13) "Energy Efficient Technologies and Best Practices in Steel Rolling Industries (Indonesia);" The Energy and Resources Institute, Darbari Seth Block, IHC Complex Lodhi Road, New Delhi – 110003 (India)

(14) "Energy Use in Petroleum Refineries;" V. O. Haynes; Oak Ridge, Tennessee 37830; operated by Union Carbide Corporation for the Energy Research and Development Administration; U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

(15) "Energy Use in US Steel Manufacturing;" Nikolas Martelaro; December 4, 2016; Submitted as coursework for PH240, Stanford University, Fall 2016

13 Annexures

13.1 A1: Meetings and Site Visits Conducted

	Subject	Date
(1)	Site visit at Moheshkhali Economic Zone (Dhalghata)area	17-18 Nov21
(2)	Meeting with TK Group at Moheshkhali	17 Nov 21
(3)	Meeting with TK Group at IIFC	5 Dec 21
(4)	Meeting with BEZA at BEZA office	6 Dec 21
(5)	Presentation on Inception Report at BEZA with BEZA and all team members of IIFC	7 Dec 21
(6)	Meeting with Mr. Md. Foyezur Rahman, Secretary to Vice Chairman, Bashundhara Group and Team at Bashundhara Group office	13 Dec 21
(7)	PGCB	30 Jan 22

13.2 A2: Suitability Scoring Matrix with Filled-up Scores

	Parameter	Weightage	Suitability	Score	Weighted Score
1	**Oil Refinery and Petrochemicals**				
1.1	Suitability for proximity to Port Facility or Sea	25%	4	15	3.75
1.2	Labor availability in the region	15%	4	15	2.25
1.3	Growth Prospect/Export Competitiveness	15%	4	15	2.25
1.4	Import substitution Prospect	20%	4	15	3
1.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	4	15	3.75
	Total	100%			**15**
2	**Ship Building and Repairing**				
2.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
2.2	Labor availability in the region	15%	2	5	0.75
2.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
2.4	Import substitution prospect	20%	3	10	2
2.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6.75**
3	**Steel Manufacturing/Rerolling**				
3.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
3.2	Labor availability in the region	15%	2	5	0.75
3.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
3.4	Import substitution Prospect	20%	3	10	2
3.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6.75**
4	**Light Engineering**				
4.1	Suitability for proximity to Port Facility or Sea	25%	1	0	0
4.2	Labor availability in the region	15%	3	10	1.5
4.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5

	Parameter	Weightage	Suitability	Score	Weighted Score
4.4	Import substitution Prospect	20%	3	10	2
4.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**5**
5	**Marine Fish Processing**				
5.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
5.2	Labor availability in the region	15%	3	10	1.5
5.3	Growth Prospect/Export Competitiveness	15%	1	0	0
5.4	Import substitution Prospect	20%	1	0	0
5.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	3	10	2.5
	Total				**6.5**
6	**Logistics Hub/Gas Bottling**				
6.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
6.2	Labor availability in the region	15%	3	10	1.5
6.3	Growth Prospect/Export Competitiveness	15%	2	5	0.75
6.4	Import substitution Prospect	20%	3	10	2
6.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6.75**
7	**Renewable Energy Generation**				
7.1	Suitability for proximity to Port Facility or Sea	25%	1	0	0
7.2	Labor availability in the region	15%	1	0	0
7.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
7.4	Import substitution Prospect	20%	3	10	2
7.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**3.5**
8	**Automobile and Heavy Engg**				

	Parameter	Weightage	Suitability	Score	Weighted Score
8.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
8.2	Labor availability in the region	15%	1	0	0
8.3	Growth Prospect/Export Competitiveness	15%	2	5	0.75
8.4	Import substitution Prospect	20%	3	10	2
8.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	2	5	1.25
	Total				**6.5**
9	**Agro Processing**				
9.1	Suitability for proximity to Port Facility or Sea	25%	1	0	0
9.2	Labor availability in the region	15%	1	0	0
9.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
9.4	Import substitution Prospect	20%	3	10	2
9.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**3.5**
10	**Textile and Jute**				
10.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
10.2	Labor availability in the region	15%	1	0	0
10.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
10.4	Import substitution Prospect	20%	3	10	2
10.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6**
11	**RMG**				
11.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
11.2	Labor availability in the region	15%	1	0	0
11.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
11.4	Import substitution Prospect	20%	3	10	2

	Parameter	Weightage	Suitability	Score	Weighted Score
11.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6**
12	**Plastic**				
12.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
12.2	Labor availability in the region	15%	1	0	0
12.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
12.4	Import substitution Prospect	20%	3	10	2
12.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6**
13	**Cement and Ceramics**				
13.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
13.2	Labor availability in the region	15%	1	0	0
13.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
13.4	Import substitution Prospect	20%	3	10	2
13.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6**
14	**Leather and Leather Goods**				
14.1	Suitability for proximity to Port Facility or Sea	25%	2	5	1.25
14.2	Labor availability in the region	15%	1	0	0
14.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
14.4	Import substitution Prospect	20%	3	10	2
14.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**4.75**
15	**Electrical and Electronics**				

	Parameter	Weightage	Suitability	Score	Weighted Score
15.1	Suitability for proximity to Port Facility or Sea	25%	1	0	0
15.2	Labor availability in the region	15%	1	0	0
15.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
15.4	Import substitution Prospect	20%	3	10	2
15.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**3.5**
16	**ICT**				
16.1	Suitability for proximity to Port Facility or Sea	25%	1	0	0
16.2	Labor availability in the region	15%	1	0	0
16.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
16.4	Import substitution Prospect	20%	3	10	2
16.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	3	10	2.5
	Total				**6**
17	**Pharmaceuticals/Chemicals**				
17.1	Suitability for proximity to Port Facility or Sea	25%	3	10	2.5
17.2	Labor availability in the region	15%	1	0	0
17.3	Growth Prospect/Export Competitiveness	15%	3	10	1.5
17.4	Import substitution Prospect	20%	3	10	2
17.5	Suitability with respect to existing demand of the products in Bangladesh in competition with similar industry in the main land	25%	1	0	0
	Total				**6**

13.3 A3: Liquefied Petroleum Gas (LPG) Bottling Process and Required Safety During Bottling: A Case Study

Petroleum Science and Engineering
2019; 3(1): 5-9
http://www.sciencepublishinggroup.com/j/pse
doi: 10.11648/j.pse.20190301.12
ISSN: 2640-4486 (Print); ISSN: 2640-4516 (Online)

SciencePG
Science Publishing Group

Petroleum Science and Engineering. Vol. 3, No. 1, 2019, pp. 5-9. doi: 10.11648/j.pse.20190301.12

Mohammad Shimul Hossain*, Mohammad Golam Muntasir Shehab, Soumik Mahmood Leon, Simanto Kumar Pal, Rafsanjani Rafi, Rashed Alom Emon, Sujon Kumar Gain, Mohammad Shaheen Shah

Department of Petroleum and Mining Engineering, Jashore University of Science and Technology, Jashore, Bangladesh

Email address: *Corresponding author

To cite this article: Mohammad Shimul Hossain, Mohammad Golam Muntasir Shehab, Soumik Mahmood Leon, Simanto Kumar Pal, Rafsanjani Rafi, Rashed Alom Emon, Sujon Kumar Gain, Mohammad Shaheen Shah.

Received: January 26, 2019;

Accepted: March 13, 2019;

Published: April 10, 2019

Abstract: Energy security is very important in the current world. Liquefied Petroleum Gas (LPG) is one of the significant energy sources. LPG can be produced from natural gas processing as well as crude oil refining.

Now LPG is available in different sizes of cylinder. The bottling system of LPG in the cylinder is the main discussion topic of this paper. Safety requirement during bottling work is also explained in this research article. LPG cylinder can be filled in both automatically and manually. The automatic filling system is more secure and effective. A visible check of the cylinder is needed before refilling. Washing and drying are also conducted before filling if necessary.

To avoid gas leakage from cylinder valve "O" ring must be checked before gas filling, if it is missing in valve must put it. After putting the cylinder body weight, modern machine carousel runs to fill the LP gas in the cylinder. The automatic carousel machine can fill several cylinders at a time. Cylinder checked by automatic weight checking scale to be ensured filling the stipulated value. After this to check the valve leak of LPG filled cylinder for security and safety. If all the process is positive, it is needed to put a safety cap on the cylinder valve and attach the thermo-sleeve for more safety. Then the filled cylinders are kept in the storage for distribution. The Personal Protection Equipment's (PPEs) is must to wear during filling the cylinder.

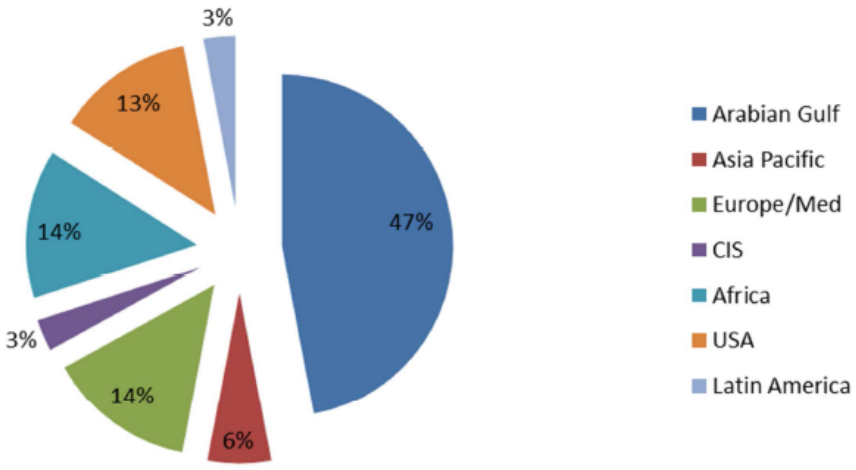
Keywords: Liquefied Petroleum Gas (LPG), Bottling Process, Carousel Machine, Hazards, Safety

13.3.1 Introduction

Liquefied Petroleum Gas (LPG or LP Gas) refers to a mix of gaseous hydrocarbon compounds, primarily propane and butane. The high flammable LPG is an odorless and colorless substance. The non-toxic gas is heavier than air. LPG is made during natural gas processing and oil refining. LPG is separated from unprocessed natural gas using refrigeration. LPG is extracted from heated crude oil using a distillation tower. This LPG can be separated into its three primary parts: propane, butane, and isobutene.

LPG is a clean and efficient fuel that emits 20% less carbon dioxide (CO2) than heating oil, 50% less CO2 than coal and 70% less CO2 than wood. LPG is used for cooking, heating and generating electricity in an environmentally friendly process. The demand of LPG is increasing in every year in the whole world. The highest LPG importers are USA, EU as well as northeast Asia such as China, Japan, and South Korea. On the other hand, the largest exporters are Middle East, West Africa and Norway. China imported 7.1 million tons of LPG in 2014 (propane, butane and mixed) and 4.2 million tons in 2013. USA exported about 14 million tons of LPG in 2014. Arabian Gulf region exported highest percentages of LPG in 2013 [9, 14].

Figure 13.1: Global LPG Exports by Region



The work was conducted on the LPG cylinder filling process and the safety during filling time. LP gas filled in different sizes of cylinders. Step by step of this process has been explained in this paper. Probable hazard and required safety during the work are also explained in this paper. Most of the LPG cylinders are made of steel. Plastic and aluminum are becoming popular alternatives to steel where weight is an issue. Composite type LPG cylinders are also interesting alternative to steel. The capacity of LPG Cylinders range from under 1kg to 50kg of LPG.

Figure 13.2: Variety of LPG Cylinders

LPG, having high inflammability has fire and explosion hazards from production, distribution, transportation till been used and disposed. Boiling Liquid Expanding Vapour Explosion (BLEVE) is the most destructive explosion hazard associated with LPG which can lead to highly destructive blast wave. LPG may leak as a gas or a liquid. If it is leaked as liquid, it will expand to vapour by a factor or more than 200. Since LPG vapour is heavier than the air, it will settle down in the confined spaces and low-lying areas.

Accumulation of LPG vapour may result in the development of an oxygen-deficient atmosphere which carries a risk of asphyxiation. When the gas meets a source of ignition it can burn or explode. Other hazards include lack of adequate ventilation is inadequate, Carbon monoxide produces from combustion may lead to narcotic effects, and LPG will cause cold burns if it comes into contact with the skin. The poor quality control in LPG refining and production processes can lead to compromise in the safety and thus resulting in hazards during distribution and use. Thus, it is necessary to regulate and monitor the steps bottling process to minimize the potential risks during transport, distribution and finally utilization by the consumers because carelessness in any step might lead to hazard. Moreover, safety measures for the workers involved in the manufacture are crucial.

13.3.2 LPG Bottling Process

Automatic bottling process is running in most of the LPG industry in the world. In all industries, there is also an alternative manual way to fill the cylinder. The manual filling process is needed when it faces problem in the automatic process. The automatically filling process is more secure and effective. At first LPG cylinders are checked before filling for safety purpose. If it is needed to repair the cylinder then it is kept in the storage for future repair. If it is fit, the cylinder runs on the chain conveyor line for the filling process. Various online equipments are used for cylinder filling.

The filling equipment is not exactly the same for all LPG industries but the following general steps for filling are followed by the industry. All the bottling processes are also shown by a flowchart in Figure 13.4.

13.3.2.1 Washing Unit

The Washing unit is that unit which is used to wash incoming cylinder. Multiple forced jet of water is used to remove mud, dirt, stains etc. from the outer surface of the cylinder. Most of the industries setup the on-line washing unit equipment. Some industries wash the outside of the cylinder by washing unit. There has a drying unit with washing unit to dry the cylinder after washing. It is needed to operate the unit by expert. When washing is needed, it could be run to wash the cylinder.

13.3.2.2 "O" Ring Checking Unit

Before filling the cylinder, "O" ring in cylinder valve should be checked. "O" is needed to remove LP gas leakage. After washing and drying, most of the industry put "O" ring in cylinder valve if the ring is missing there. Some industry put this after visible check. It is very important to prevent gas leakage from cylinder.

13.3.2.3 Tare Weight Unit

Tare weight unit is the cylinder weight putting unit in a device. It is used to put the cylinder body weight so that the prescribed weight of LP gas can be filled accurately in the cylinder. All cylinders are not the same as body weight. So it is needed to set up the body weight of cylinder before filling. An operator put the tare weight by reading the body weight. Then transitional unit pushes the cylinder to carousel.

13.3.2.4 Automatic Filling Carousel

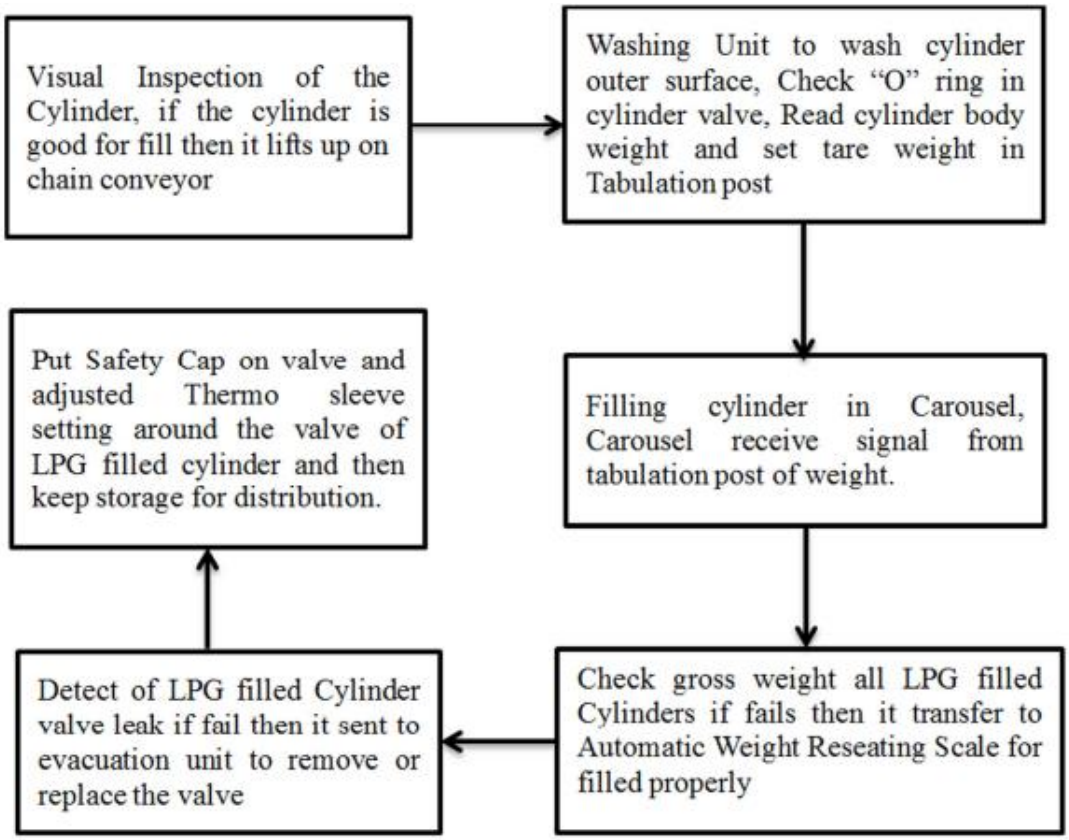
A filling carousel is a modern machine projected for filling LP gas cylinders in large groups. It contains a frame with running wheels, rails, a central column for LP gas and air, and a driving unit around the central column. The principal behind carousels is to use filling heads configured in a circular way where the empty cylinder enters the carousel, gets filled as it rotates around and then leaves the carousel filled at the point where it entered. The carousel can be fewer heads (*e.g.* eight) to larger heads (*e.g.* Seventy-two). The carousel can be filled in cylinder automatically. Every LPG industry has an alternative way to fill cylinder manually.

Figure 13.3: Cylinder Filling Carousel

13.3.2.5 Weight Checking Scale

Weight checking scale or weighing scale is a device to measure weight. It is used for industrial and commercial application as well as for many other objects for sale. Weighing scale can be manual or automatic in purpose. The scale can be various types as requirements. Generally, Automatic weight checking scale is designed to check the gross weight of the filled LPG cylinder. Manual scales are also needed for any LPG industry. Rejected cylinder automatically to bypass line for filled properly manually if the gross weight of the cylinder more or less than the stipulated value. If the filled cylinder weight is good then it passed for leak detection.

Figure 13.4: LPG Bottling Process



13.3.2.6 Leak Detector Unit

Leak detector is a device that is used in various industries to detect leak from an object. LPG industry uses it to detect LP gas filling cylinder leak. The leak can be of various types such as cylinder head leak, bottom leak, valve leak etc. A compact valve testing unit is on-line equipment designed to test cylinder valve leakage and rejects cylinder to bypass line for repairing if detect a leak. Remove or replace the leak valve of the cylinder by unscrewing or screwing at other places or on-line valve changing unit [1, 4]. Commonly, almost all LPG filling industry use automatic leak detector devise for checking valve and cylinder heal leak. Body leak is checked by soap water mostly manually.

13.3.2.7 Safety Cap and Thermo-Sleeve Setting

Safety cap is a protection cap that is used on cylinder valve. It is used for more safety to protect the gas leakage. After leak detection, safety cap fixes on the valve of LPG cylinder. Safety cap can be fixed manually in on-line running or can be used auto cap fixer on-line equipment. After capping, on-line equipment used to crimp aluminum cap seal/Thermo sleeve around the cylinder valve as a final operation and finishing safety of LPG cylinder filling [4]. After completing all the above process, the LPG filled cylinder keeps in storage for distribution to the customer.

13.3.3 Probable Hazards and Required Safety during Bottling

Safety is most important for any industry. Personal Protection Equipment (PPE) is used during working time for safety. In average, the hazards can be leakage, hand and leg injury, sound pollution, firing etc. Leakage of LPG from the cylinder can be occurred during filling in the carousel. LPG leakage can also be occurred during unscrewing/screwing. Hand and leg can be injured during lift up cylinder on-line chain conveyor. Sound pollution is also a

problem during bottling [1, 4, 21-22]. To prevent hazards or getting injured during LPG cylinder filling, PPEs should be used. There are various types of PPEs such as safety shoe, hard hat (Helmet), safety glasses and gloves, reflective jacket, air muff, safety goggles etc. Safety shoes and gloves are always used to prevent leg and hand injury. Sound pollution can be minimized by using air muff.

Face mask are always needed to use during the working time. Fire extinguishers are required to keep ready always for control any types of firing. [1, 4]. The initial check of the cylinder is needed to ensure that it is fit for filling. Cylinder valve is most important. Normally it is used for dual purpose, to refill and supply gas to the consumer. Filling a large number of cylinders at a time is very risky so it is safe to fill the cylinder automatically [1, 22].

13.3.4 Conclusion and Suggestion

Uses of LPG are safe and cheap. Use of LPG is getting popular day by day. Now, LPG is found in variety size cylinder due to customer demand. LPG filled in various types' cylinder such as steel cylinder, composite cylinder as well as the plastic cylinder. It can be filled both automatically and manually. The automatic filling process is more effective and can be filled more cylinder in a short time.

For the safety, personal protection equipment should be used during whole working period. The succeeding recommendation should be followed during bottling process for more effective work and safety. a. Always use required Personal Protection Equipment's (PPEs) while working in Bottling hall. b. No smoking in bottling hall. c. Safety shoes and gloves must be used all times. d. Inspect each tool before use. Never use any defective cylinder. e. It is needed to check initially whether the cylinder is fit for refilling. f. Unauthorized persons should not be allowed in the working area. g. Must go in Safety place when siren whistling.

Acknowledgements

The authors like to thank to the respectable reviewers for giving proper instruction to improve the quality of this paper. The authors also like to thank to Mir Raisul Islam for his cooperative help to improve the paper quality.

References

[1] Guide to Good Industry Practices LPG Cylinder Filling, 26 July 2017, World LPG Association, www.wlpga.org

[2] General Specification for Liquefied Petroleum Gas Installation in Government Buildings of the Hong Kong special administrative region, 2012.

[3] Paczuski, M., Marchwiany, M., Puławski, R., Pankowski, A., Kurpiel, K. and Przedlacki, M., 2016, Liquefied Petroleum Gas (LPG) as a Fuel for Internal Combustion Engines, Alternative Fuels, Technical and Environmental Conditions, pp. 105-136.

[4] Guidelines for Good safety practices in the LP Gas Industry, 08 July 2008, World LPG Association, www.wlpga.org

[5] Bahadori, A., Liquefied Petroleum Gas (LPG) Recovery, 2014, Natural Gas Processing.

[6] World LP Gas Association Annual Report 2017.

[7] Guidelines for Good business practices in the LP Gas Industry, 08 July 2008, World LPG Association, www.wlpga.orgCho. C. P., Kwon, O. S., Lee, Y. J., Effects of the sulfur content of liquefied petroleum gas on regulated and unregulated emissions from liquefied petroleum gas vehicle, 2014, Fuel, Vol. 137 pp. 328-334.

[9] Shah, M. S., Hossain. M. S., Nip, F. Y., Pa, S. K., Islam, M. R., Sany, S. M. S. Future Prospect Analysis of Liquefied Petroleum Gas (LPG) and Liquefied Natural Gas (LNG) in Bangladesh: Economic and Technological Case Studies, July 2018, Journal of Nature Science and Sustainable Technology, Volume 12, Issue 3. Elgas Ltd. (2016). http://www.elgas.com.au (Accessed on 25 September, 2016).

Karim, M. (2016).Encouraging the use of LPG by households. Published: April 28, 2016 Thursday.

Ahmad, R. M.; Majed, A.; Osama, E. D. H.; Marcos, S. F.; and Usman, M. A. Fractionation of Natural Gas Liquids to produce LPG. TPG4140 Natural Gas, Norway, 2011.

Shipman MBE, R. H., MIMechE, MIGasE, MInstE, Liquefied petroleum gas, 2002, Plant engineer's Reference Book, Second Edition.

Poten and Partners. LPG in the world market, A Monthly Report on International Trends in LPG, February, 2015. ISO 22991 - Gas cylinders -Transportable Refillable Welded Steel Cylinders for Liquefied Petroleum Gas (LPG) – Design and Construction.

ISO 10691 - Gas Cylinders – Refillable welded steel cylinders for liquefied petroleum gas (LPG) -- Procedure for checking before, during and after filling.

Kosan Crisplant (www.kosancrisplant.com)
Siraga (www.siraga.com)
Carrousel Filling Systems, 02 February 2017, Kosan Crisplant.
LPG Filling Carrousel, 2018, Siraga.www.siraga.com
UK's Health and Safety Executive.

Guide to Gas Cylinder, 2013, Environmental Protection Authority, Technical Guide, New Zealand Government.

World LPG Association (WLPGA), Guidelines for Good business practices in the LP Gas Industry, 2017.
Oueidat D., Guarniere F., Gorbolino E. and Rigaud E., Evaluating the safety operations procedure of the LPG storage and distribution plant with STAMP, Elsevier Ltd., 2015
Singh, S. and Premi, S. R., Hazard Identification and Risk Assessment in LPG Bottling Plant, International Journal of Science Technology and Engineering, 1(12), pp 19-22, 2015.

13.4 A4: Process Design and System Layout for an Automobile Manufacturing and Assembly Plant

D. Phanindra Kshatra, S. Akhil, Ch. Uday Kiran, Ch. Yaswanth, M. Vineeth

International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-2, December 2019
Revised Manuscript Received on December 05, 2019.

Correspondence Author
D. Phanindra Kshatra*, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Vijayawada, India, phanindra@kluniversity.inS.Akhil, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Vijayawada, India. Ch. Uday Kiran, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Vijayawada, India.

Ch. Yaswanth, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Vijayawada, India. M. Vineeth, Department of Mechanical Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Vijayawada, India.

Abstract: The Automobile is the most complex product, and the development of a vehicle will take years of Research and Development (R&D) starting from designing, analyzing the product structure from sub-levels, building prototypes, testing the prototypes, finalizing the vehicle to manufacture. It is also essential to find the correct suppliers to manufacture the components, parts for the vehicle, assembly of all these to the vehicle, and go through examination and analysis of various stages of the processes in building the vehicle, and it is a herculean task. With the increase in competitiveness in the Automobile industry, the Original Equipment Manufacturers (OEM's) want to reduce their investments in manufacturing, keeping core competencies of R&D within the industry, and outsourcing remaining functionaries to Tire companies. The main goal of this paper is to illustrate the step by a step manufacturing process that is needed to produce an Automobile.

And explaining each step that takes the Automobile from sheet metal to complete product, this helps to understand the process chain, logistical and distribution network that an Automobile follows throughout its Product Life Cycle (PLC).Keywords: Manufacturing, System, Automotive, Stamping, BIW, Painting, Final Assembly

13.4.1 Introduction

Automobile Industry is one of the most complex and most dynamic industries in the engineering division, and it is the engineering marvel created by humankind. In recent years there is an increase in demand in the industry due to fierce competition, product life cycle change, and an increase in customer demand [1]. With faster growth in the sector, Automobile industry's major issues concerned with customers' need for variety, variants, design stylings, safety, comfort, and within the industry's internal problems related to Elimination of Waste in processes, Process Efficiency, Manufacturing Efficiency and improvement in Overall Equipment Effectiveness (OEE). Due to these global concerns, most of the Original Equipment Manufacturers (OEM's) are shifting the manufacturing scenario

where they concentrate only on core components of the Automobile in-house and outsourcing most of the Automobile components to the reliable vendors and suppliers depending on their availability [3].

These OEM are concentrating mostly on R&D functions and manufacturing critical, value-added, technologically advanced operations of high capital investments in-house and leave the rest to vendors and suppliers [3].In the Automobile industry, there is a lot of manufacturing processes that happen to start from the selection of different materials for the requirement of the Automobile [5]. People in the Automobile industry will have a lot of research going on the range and designing of a single component [4]. The present-day industry does not compromise on the aspect of the quality of its products [4] by maintaining a benchmark standard to sustain in the market [5].In case of selection of material for the chassis, the R&D department of any Automobile industry will carry on different kinds of analysis for the chassis by considering different materials into considerations [5]. One of the fewer weight materials available in the market is aluminium [5]. They will be the diverse composition of aluminium is possible; the behaviours of these materials will vary [4]. So, the suitable material will be taken into the consideration of design by Research and Development engineers [5]. Aluminium is used only for high speed and sports vehicles due to its cost factor.

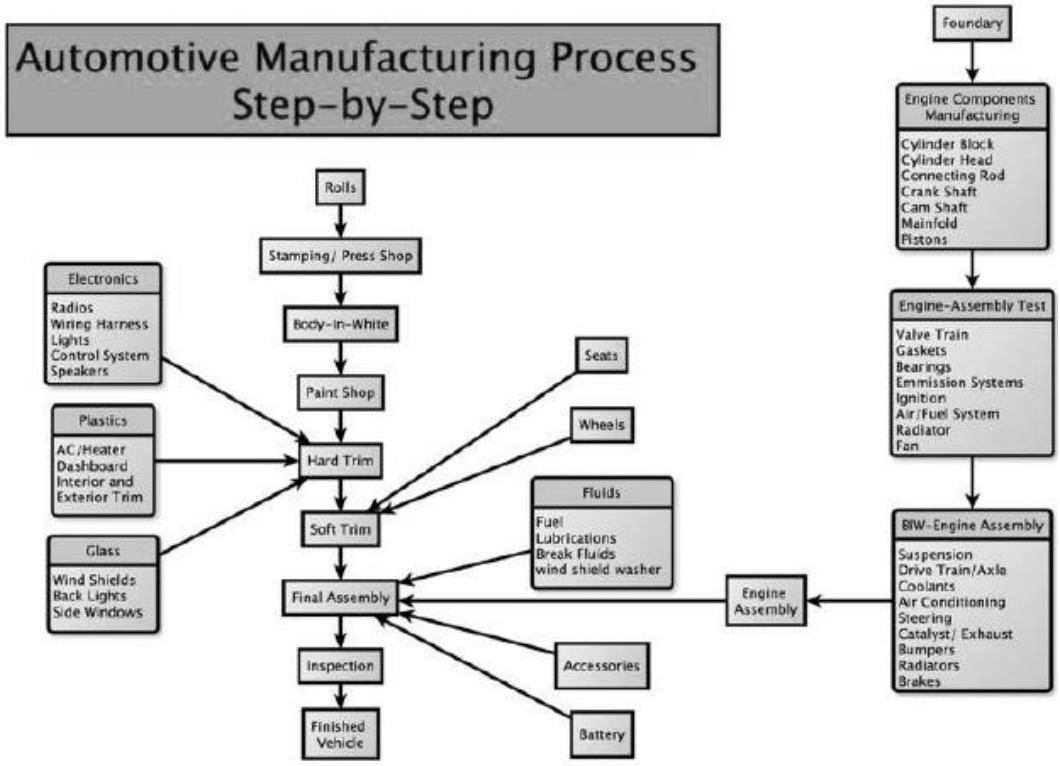
But by using aluminium, it reduces the weight of the Automobile, and thereby it reduces the load on the prime mover. It will directly impact the overall Efficiency of the Automobile [5].And after the selection process is over, we will again make the prototype of the BIW or Chassis, and we will still do the analysis for the prototype and will observe the results [7]. In our Automobile, we also involve FMS systems for the mobility of the components or raw materials of the industry. Will reduce a lot of random times in the industry and thereby increasing the overall Efficiency of the Automobile industry [6].

Even in the welding process, which is a significant part of the joining Process in the Automobile industry will be undergoing different tests to know the strength of the weld and which type of welding process will have a better life [8].

13.4.2 Step-By-Step Automotive Manufacturing Process

Major departments that involve in Automotive Manufacturing are Stamping Department, Body-In-White Department, and/or Chassis Department, Foundry Department, Painting Department, Manifold Department, Final Assembly Department [2].

Figure 13.5: Major Departments and Workflow for Automotive Plant



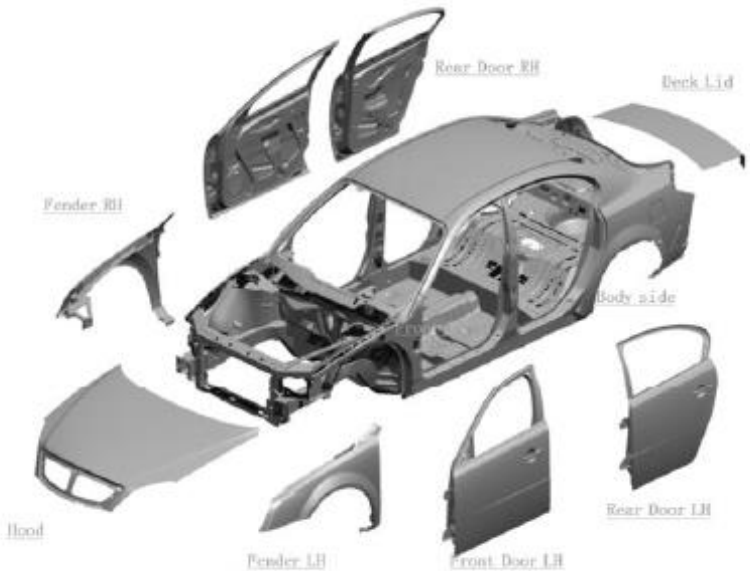
13.4.3 Limitations

In this paper, the discussion is about the entire outline of the plant layout for the Automobile industry and divided into two-part, one is the main process flow from stamping to the final assembly, and the second part is foundry. The foundry treated as the secondary part of the Automobile industry, and again, it is brought back into the main process flow in the assembly operation. So, for the simplified analysis, this paper is excluding the foundry part and mainly concentrating on the main process flow of the Automobile industry. The Assumptions and/or Limitations that considered in the deriving process flow of the Automobile industry are 1. The chassis that discussed in this paper for the analysis is a monocoque chassis. 2. The most parts and/or components of an Automobile manufactured within the industry itself. 3. The analysis was done by neglecting small parts of the Automobile. 4. This paper is through the outline of the Automobile industry. 5. This paper does not follow any single Automobile industry or model of vehicle. 6. This process flow and specifics of the production process may vary from one industry to another. 7. This paper only reflected the main process flow and had excluded the foundry part of the industry.

13.4.4 Department Wise Processes

Stamping Department. The press shop/stamping is a department in the automotive industry and is the foremost Process in the manufacturing of an Automobile production and use dies and punches to cut the sheet metal into required shapes [9], . The stamping department is responsible for the production of a complete vehicle body [9]. Stamping It involves a metal cutting process where the coils of metal cut into uniform dimensions into smaller sheets, and particular shape formed with the help of different presses for different components for an Automobile Body [9].

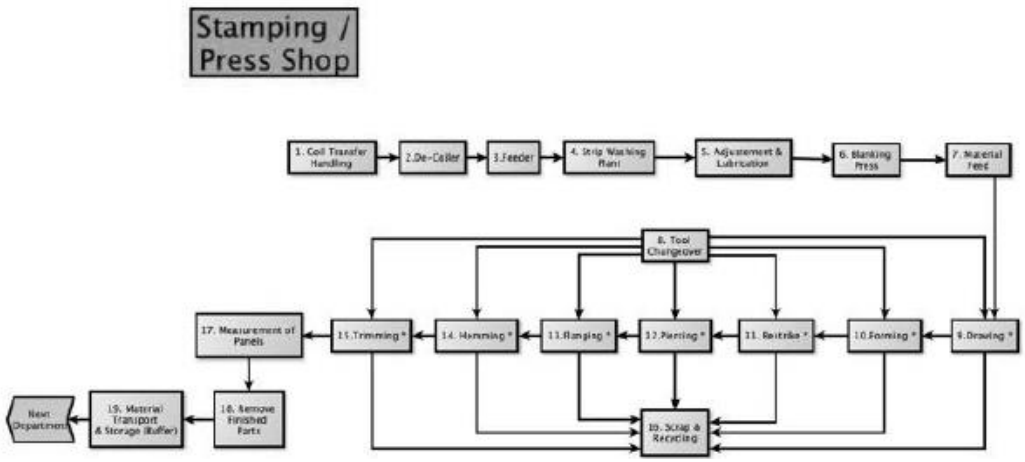
Figure 13.6: Sheet Metal Panels for a Car Body



It is a forming process in which extreme pressure is applied on the sheet metal blank within its plasticity limit to obtain the desired shape. The main reason for the stamping process is to produce parts of any dimension and shape out of sheet metal. The stamping department is responsible for making Automobile Body parts like the bonnet, hood, doors, roof, etc. It consists of various sheet metal operations like blanking, coining, hemming, flanging, embossing, etc. Every part may not undergo every process in stamping, as it depends on the complexity of the piece. Stamping operations performed in various stamping stations that use a die and a Mechanical press of a specific part for forming the desired shape.

A Stamping department produces the car's complete external shape. An Automobile requires around 40 to 50 significant panels, and most of them are produced in house and don't want to outsource because of the defined geometry and quality of the Automobile. Most of the smaller sheet metal components manufactured by Tire Companies. To produce these panels, it will take 100- 200 dies and change-over of these dies, depending on the variant of the vehicle, which is the most essential and crucial Process in stamping , .

Figure 13.7: Stamping Department



Stamping Process is divided into two parts 1) Material Production Process and 2) Panel Production Process. The Material Production Process starts from the wounded coil till the

blanking press where the coil transferred from de-coiler, feeder, strip-wash, and lubrication and cuts into panels by dies in Blanking Processes. In Panel Production Process, Press Machines are used to produce the designed panel components of required shapes and sizes. The flowchart describes the flow of different operations sequentially in the stamping process. The flowchart is drawn, keeping in view of every all the parts of a car body.

So every operation may not be performed on the sheet metal blank. The processes involved in the Stamping Department are

(1) Coil Transfer Handling
(2) De-Coiler
(3) Feeder
(4) Strip Washing
(5) Adjustments and Lubrication
(6) Blanking Press
(7) Material Feed
(8) Tool Change-over (or) Tool Set-up
(9) Drawing
(10) Forming
(11) Re-Strike
(12) Piercing
(13) Flanging
(14) Hemming
(15) Trimming
(16) Scrap and Recycling
(17) Panel Measurements according to dimensions
(18) Finished part removal
(19) Material Transport and Storage

Firstly, the sheet metal coil fed through a de-coiler to the strip washing plant. After washing, necessary adjustments and lubrication did. Depending on the size of the body panel, the blanking of the strip done to the required dimensions. The blanked sheets fed to the stamping press, and the punching done with the appropriate die. Other operations like hemming, flanging, piercing, restrike are done if the required product has a complex shape. Trimming is done to remove the excess material is present in it. It is to ensure the precision of the part that had produced, inspection will be done on it, and the approved parts sent to the inventory storage. The scrap produced during this stamping process recycled for reusing the material. Every part will not require all operations. So, changing of tool or die will be done for the required parts.

An Automobile body may contain more than 1500 stampings, and nearly 60-70% of metal parts of an Automobile made by plastic forming. Hydroforming is a newly constituted technology in the automotive industry as it offers distinguished advantages compared to conventional manufacturing processes. In this Process, fluid pressure is applied to the metallic blanks to form desired component shapes. The amount of scrap material observed for the conventional stamping process is 20-30%, whereas, for hydroforming, it reduced to 0-10%. Hydroforming has many applications like automotive engine cradle, camshafts, exhaust pipes.

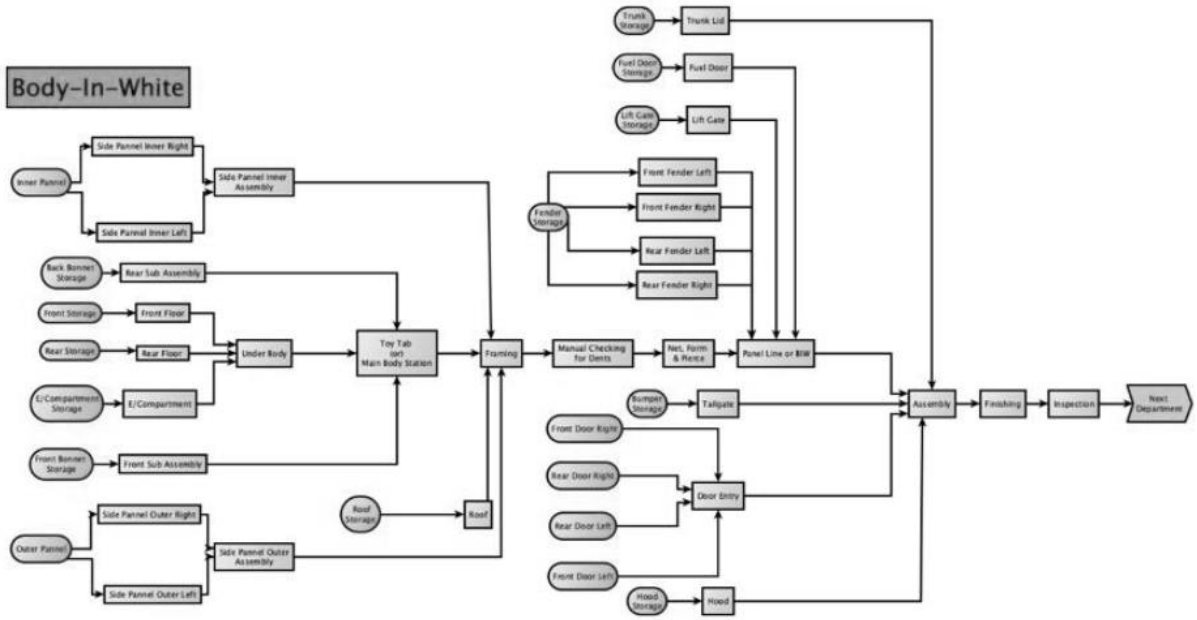
B. Body-In-White Department BIW standards for Body-In-White. BIW is a stage in Automobile manufacturing. Here the complete body shell of the Automobile is welded and structure from all the sheet metals formed into sub-assemblies The assemblies of all the Frames and Panels of both Structural Components, as well as the exterior parts of an

Automobile combined with homogeneous materials, form car body structure. BIW does not include doors, engines, and other moving parts.

Components of BIW are:

1) A-Pillar
2) B-Pillar
3) C-Pillar
4) D-Pillar (Depends on Car Variant)
5) Roof Frame/ Roof Structure / Roof Panel
6) Floor and other Panels
7) Front and Rear Longitudinal Beam
8) Rocker/ Side Sill
9) Dashboard Mounting Panel
10) Hood (Frame and Panel)
11) Front Fenders (Right and Left)
12) Rear Fenders (Right and Left)
13) Deck lid/ Trunk lid/ Tailgate (Frame and Panel)
14) Doors (Frame and Panel)
15) Dashboard Mounting Panel
16) Cross Member
17) Fire Wall
18) Floor, Seat and Boot Pan

Figure 13.8: B-I-W Department



BIW consists of a different kind of joining Processes like welding, soldering, brazing, adhesive bonding and mechanical joints we use all this joining Process according to the need of the components that we join. In BIW, one can come across different types of components with different shapes. And there is a material property of each material vary that from the other, and the metallurgical processes might also need to join dissimilar metals that are used to join different components together and derive the desired shape .In BIW, the most commonly used material for the manufacturing of the components is steel, and there will be

different compositions of steels that we use in the Automobiles according to usage and the loads that applied to the members.

In BIW, the hot-stamped steel is used up to 30% of the total material that we use in BIW. The main reason for the usage of hot-stamped steel is that it has relatively low weight when compared to most of the steels, and it also has more crash resistance and high strength at a very low cost. The HSS (High-Speed Steel) is the major material used in the structural components of the BIW.

The weight of any material and its strength plays an important role in the selection of the material. Most of the panels and components in the BIW will be coming from the Stamping process, where we will convert the sheet metal rolls into different panels and components. At an average, the BIW will have 2206 weld spots involved, the majority part of this welding process is to join the pillar parts of the Automobile chassis.

The maximum part of the welding operations done by robots .The BIW in our will be mainly having five major assembly stations. They are listed below 1. Under Body 2.Side panel assembly (exterior and interior) 3.Toy tab 4.Framing 5.Panel line 6.Assembly .In the Automobile industry, we will maintain storage for every component to reduce the entire manufacturing time in the industry . So, in our design of BIW, consideration of storage for every component that is coming out from the Stamping shop and directly takes out components that need to assemble from the storage only .In the BIW process plan that we have adopted, we can clearly say that the Process in Underbody and side panel assembly (exterior and interior) are independent Processes and can be done simultaneously with any interference. In contrast, the toy tab is dependent on the Underbody and the sub-assemblies of the front and rear. So, by this, we can say that BIW consists of both independent and dependent process flow ,.

Under Body: - Under Body assembly, majorly consists of 3 parts that are the front floor, rear floor and engine compartment this will make a platform for the entire BIW and each component is assembled on the Underbody , . And the type chassis that we are taking into the consideration for the entire layout is a monocoque chassis, where we will not find and ladder structure to assemble the BIW ,. So, in our analysis of monocoque chassis, the Underbody will act as a basic structural frame to assemble the components ,.

Side Panel Assembly: - This side panel assembly consists of both outer and inner panels like in Underbody. They will also come from the stamping process. They will be taken from the store directly. These inner panels will also be housing the guide-ways for the electrical lining. In contrast, the outer panels will be like smooth finished work without any penetrations on them ,. This panel assembly will mainly have the pillars of the Automobile like A pillar, B pillar, and C pillar according to the design of the Automobile this pillar may vary , .

This side panel assembly will be directly going to the framing process, and this assembly might have some buffer time to it because the framing is dependent on the toy tab ,.Toy Tab: - Toy Tab can also be called as main body station because the Underbody and the sub-assemblies of front and rear are taken together and joined here ,.

The toy tab is a dependent process because it mainly depends on the underbody assembly and sub-assemblies ,. The further step of the toy tab is the framing Process. The toy tab prominently uses welding operation and some hemming operation. All these operations are carried out by robots ,.Framing: - In framing, we will get an almost integrated outlook of the chassis. The parts that assembled in this framing process are the toy tab and side panel

assemblies and the roof of the Automobile ,. All the parts of the framing process assembled on the toy tab ,. On the toy tab, the assembly will be on the side panels of the Automobile, and then after the roof of the Automobile is assembled on the panels ,.

This process is the most important step in the BIW to get an integrated chassis or body ,. And this body after framing will be sent for a manual inspection for the checking of the dents in the body and this framed body is sent to the piercing of any required holes on the frame for further processing , .Panel line: - This is the final stage of the BIW, where we assemble the fenders, lift gate, and fuel door. So, this panel assembly will have all the entire part of BIW except the doors of the Automobile ,.Assembly: - This final assembly in BIW will mainly have the assembly of the doors, hood, and tailgate, trunk lid ,.

By this assembly, the entire Process of BIW completed, and this complete assembly is taken out for the finishing process. Then there will be a final inspection for each assembly, and then the certified body will only be allowed to the next department, *i.e.*, Paint shop ,.Paint application is the most required process for vehicle production, and it is not exclusively done for covering but also for the safety of body surface, it also increases the visual interest by adding the shades as well as the shine and imperative offering focus , .

Car paint will be paint used on cars for both embellishment and security reasons ,. The mostly used water-based acrylic polyurethane lacquer paint is presently utilized paint for the painting process is done after the body of the vehicle is assembled ,. The painting process is done to give more attraction to the vehicle, good appearance, and to provide a protective layer against the corrosion as well as the weathering. There are main four major process involved in the paint shop ,. They are 1. Pre-treatment, and Electrode position or E-Coating, 2.PVC sealing, 3. Primer coat painting, 4. Top coat painting ,.

Pre-Treatment: After completion of B-I-W, it is important to clean the body surface to get rid of all the deposits obtained during different operations, and this cleaning process is done through three dipping processes, 1. Degreasing, 2. Conditioning, 3. Phosphating. After cleaning, the Pre-Treatment process done where it acts as a primer to bond onto the metal ,.

Electrode position or E-Coating: The next Process is Electrode position or E-Coating, where this Process is done to prevent the metal body from corrosion, this Process is done and depends upon various types of sheets that are used for car body materials ,.

Rust Proof Materials: PVC Sealing: PVC is Polyvinyl Chloride Sealing and applied to doors, trunk, hood, dashboard, and all the exterior and interior joints. And also used mostly for Underbody to achieve noise-proof platform and to reduce the vibrations that occur in B-I-W, this also helps the Underbody from rust and corrosion and chipping protection ,.Primer: After PVC Sealing the next step is applying primer to the body, and it is of three types 1) Powder Type, 2) Water-borne, 3) Solvent-borne, Primer helps as an adhesive between the E-Coating and Topcoat providing the corrosion protection and appearance of the vehicle , .

Topcoat: The next step in this process is topcoat, and it has two steps a) Basecoat and b) Clearcoat a) Basecoat: The Basecoat is usually for the primary coloring pigment for the vehicle ,.b) Clear coat: The Clearcoat is usually for the protection of UV light, environmental effects, and provide a smooth finish for the vehicle ,.

Spray Coating: The last and final process is Spray Coating, where tiny droplets of paint are absorbed in a continuous gaseous phase that applies to the parts and complete body. This Process gives the fine finish of the paint, and the appearance furnished with the quality look.

After this process, the heat generation process is done for sticking the paint to the body, while this Process continues other small parts from the storage is also in Process of the above coatings and join in another line.

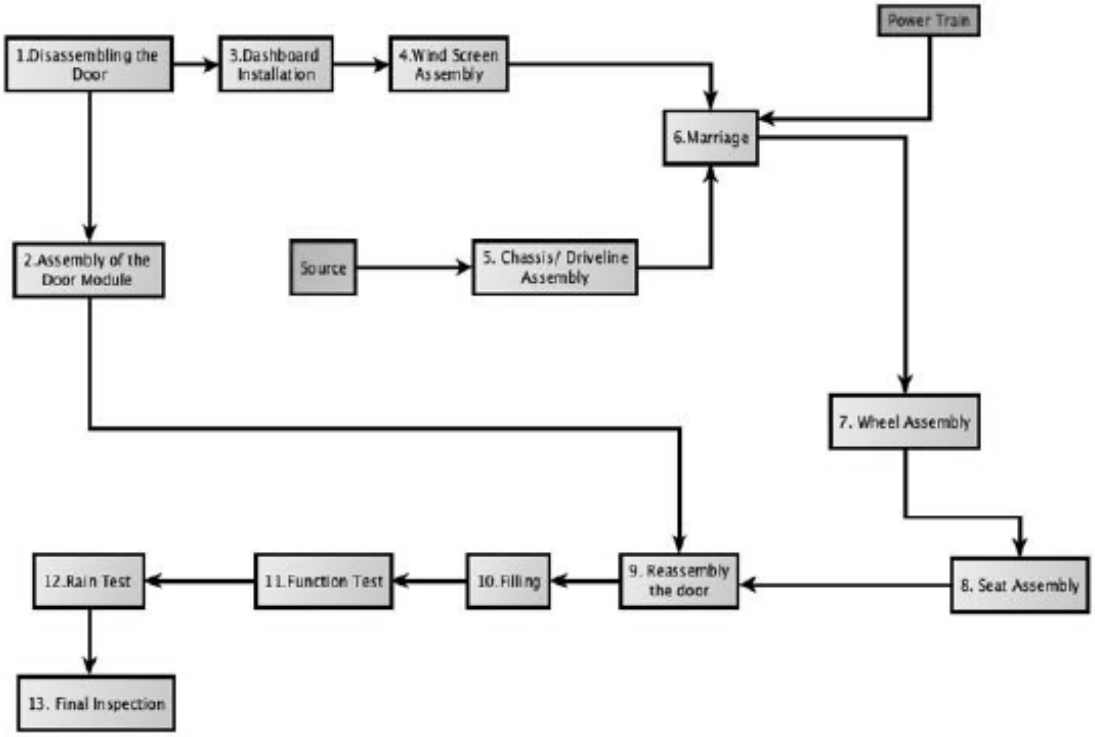
They both get assembled, and the painting process is completed ,.Inspection and Storage: After the last spray coating operation, the final steps are to inspect the quality of the painting operation, a thorough check for every part of the body done, and this Process is done either manually or in automated testing condition. Only after thorough and rigorous inspection, the vehicle sent to assembly. Otherwise, the vehicle has the repeat all the processes again till the final quality standards are met, and the car body is sent to Storage / Assembly department ,.

D. Final Assembly

Assembly line usually consists of many numbers of workstations, and it is important where all the components of the B-I-W and Mostly, the Powertrain of the Automobile are assembled sequentially in a fixed pattern .

In this assembly process and/or department, most of the work carried out manually, and the workers move along with the conveyor to complete the task at that station. They will scale back to the initial position to work on the next automobile in the line (Figure 13.6). After the painting process completed, the B-I-W will move to the final assembly department. In the first station, the primary operation is to dis-assemble the doors from the rest of the body, dashboard, and other instrumentation panels are fixed.

Figure 13.9: Final Assembly



This process is completed manually by the workers. The next station is the most important, and it is the assembly of B-I-W to Powertrain, which is termed as marriage station, here the

body and powertrain meet together. A lot of many assembly works are carried out, and this station the Automobile gets its complete structure and final appearance, in the next station's wheels, seats. Finally, the doors installed to the Automobile, which previously removed for assembly process to the Automobile and all the necessary tests for the engine, chassis did, and a thorough final inspection is conducted to the vehicle and stored in the warehouse for distribution around the world .

13.4.5 Result and Discussion

In this paper, the complete manufacturing of the main automobile line had discussed, and step by step production processes had explained according to their departments in each section, respectively. As the Technological advancements in the Automobile Industry is growing day by day globally, and with increase in customers demand for variety of variants in Automobile it is important to understand the flow and complexity of Automobile in order to reduce the lead time for faster production, better use of equipment and an increase in Overall Equipment Effectiveness (OEE), and its near to impossible to change the system .

13.4.6 Conclusion

To apply Discrete Event Simulation (DES) for an Automotive OEM and increase the OEE with a reduction in Bottlenecks. It is important and necessary to recognize the complexities involved in manufacturing of Automobile and to understand the Process and/or Product flow to identify the bottlenecks, improve the equipment efficiency and overall improve the plant productivity, This work helps to identify the complete processes that are operating in Automobile industry and will help to study and implement DES for overall improvement in OEE .

13.4.7 Future Scope

The next step for this work is to use the layout described in this paper with the help of DES to create a simulation environment using the methodology proposed by law and Andres Skoogh and try to remove the bottlenecks and improve performance and Efficiency this layout and check the overall improvement in the plant layout. One of the biggest challenges that the Automobile OEMs will face in the future is to realize change and the need to adapt to the electric vehicle’s technology. This paper can be useful to simulation experts to observe the process changes that happen in different departments and can act accordingly how well the plant is performing during these changes , .

Acknowledgment

This paper presents some of the conclusions obtained while working for a Discrete Event Simulation project by the team through studying various research articles and examining the Automotive systems. We want to thank Dr. A. Srinath and Dr. D. Kiran Kumar for their valuable insights and suggestions throughout this work and guided us in the right direction.

References

1. Engineering Change Management in the Automotive Industry When are you Finally Market Ready? Prolim, web Source: https://prolim.com/wp-content/uploads/2015/09/Engineering-change-management-in-automotive-industry.pdf

2. Vehicle Manufacturing, GAPS Guidelines (GAP.17.19.0), web Source: https://axaxl.com/-/media/gaps/hj0____0.pdf

3. Processes in the Automotive Industry, web Source: https://www.ifm.com/download/files/ifm-processes-in-the-automotive-industry-gb/ $file/ifm-processes-in-the-automotive-industry-gb.pdf

4. Baburaja K., Venkatasubbaiah K., Kalluri R., Hybrid materials of aluminium, Materials Today: Proceedings Volume 3, Issue 10, 2016, Pages 4140-4145, International Conference on Materials Research and Applications, ICMRA 2016

5. Rao, K.S., Kumar, K.P., Kumar, B., Suseel, D., Krishnan, R.H., Design and analysis of light weighted chassis, International Journal of Mechanical Engineering and Technology Volume 8, Issue 5, May 2017, Pages 96-103

6. Nageswararao, M., Scheduling of machines and automated guided vehicles in FMS using shuffled frog leap algorithm, International Journal of Mechanical Engineering and Technology Volume 8, Issue 5, May 2017, Pages 496-503

7. Matta, A.K., Prasad Kodali, S., Ivvala, J., Kumar, P.J., Metal prototyping the future of Automobile industry: A review, Materials Today: Proceedings Volume 5, Issue 9, 2018, Pages 17597-17601, 8th International Conference on Materials Processing and Characterization, ICMPC 2018; Hyderabad; India; 16 March 2018 through 18 March 2018; Code 140097

8. Balasubramanyam, P.N.V., Uzwalkiran, R., Kumar, M.N.V.R.L., Ramgopal, M., Strength improvement of welded joint by using random vibrations, ARPN Journal of Engineering and Applied Sciences Volume 11, Issue 18, 2016, Pages 11068-11073

9. Maw MawHtay, GuoShunsheng, Asa Romeo Asa- ―Quality Management Information in Automotive Stamping Process‖- School of Management, Wuhan University of Technology, Wuhan, China.

10. D. Phanindra Kshatra et al., Development of virtual modelling for optimization and Bottleneck analysis of an automotive stamping Using plant simulation, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), ISSN(P): 2249-6890; ISSN(E): 2249-8001, Vol. 9, Issue 3, Jun 2019, 931-938

11. Metal Forming and Stamping Presses, improve productivity and safety in forming and stamping applications, Rockwell Automation, web Source: https://literature.rockwellautomation.com/idc/groups/literature/documents/wp/oem-wp012_-en-p.pdf

12. SeunghoKuk, Soon Ill Soh, Soo Min Lim, Seon Hwa Joung, Sang Do Noh, Construction and Application of a Virtual Press Shop, Proceedings of the International Multi Conference of Engineers and Computer Scientists 2009 Vol II, IMECS 2009, March 18 - 20, 2009, Hong Kong.

13. Maw MawHtay, GuoShunsheng, Asa Romeo Asa, Quality Management Information in Automotive Stamping Process, American Journal of Industrial Engineering, 2013, Vol. 1, No. 1, 1-4 Available online at http://pubs.sciepub.com/ajie/1/1/1, DOI:10.12691/ajie-1-1-1

14. Aminu Saleh Mohammed- ―The hydro-forming process of an Automotive Part‖- hydraulic equipment development institute kumbosto.

15. D. Phanindra Kshatra et al., Analyze the Production System of a Body-In-White System Through Modelling and Perform Bottleneck, Optimization Using Simulation Software, International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-8 Issue-2S4, July 2019.

16. Ultra Light Steel Auto Body Final Report: https://www.yumpu.com/en/document/read/5349987/ultralight-steel-auto-body-final-report-american-iron-steel-

17. Automotive metal components for car bodies and chassis, Global market study by Ronald Berger group. Munich, February 2017: https://docplayer.net/51087601-Automotive-metal-components-for-car-bodies-and-chassis-global-market-study.html

18. Abdo Al-Zaher, Waguih El Maraghy, Design Method of Under-Body Platform Automotive Framing Systems, Procedia CIRP, Volume 17, 2014, Pages 380-385, DOI: https://doi.org/10.1016/j.procir.2014.03.116

19. Annamalai Pandian, BIW Process Modeling and Simulation Analysis‖, International Conference on Industrial Engineering and Operations Management (IEOM) Bristol, UK, July 24-25, 2017

20. John Pfanstiehl (1998). Automotive Paint Handbook: Paint Technology for Auto Enthusiasts and Body Shop Professionals. Penguin. ISBN 978-1-55788-291-2.

21. Nelson K. Akafuah, Sadegh Poozesh, Ahmad Salaimeh, Gabriela Patrick, Kevin Lawler and Kozo Saito, Evolution of the Automotive Body Coating Process—A Review, Coatings 2016, 6, 24; DOI:10.3390/coatings6020024

22. Arun B. Rane, Vivek K. Sunnapwar, Assembly line performance and modeling, Journal of Industrial Engineering International, September 2017, Volume 13, Issue 3, pp 347–355.

23. Amith A Kulkarni, Dhanush P, Chetan B S, Thamme Gowda C S, Prashant Kumar Shrivastava, Recent Development of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8, Issue-6S4, April 2019

24. D. Phanindra Kshatra et al., A Methodology to Adapt and Understand a Manufacturing System and Operations using Discrete-Event Simulation, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-8 Issue-6, August 2019.

Authors' Profile

Mr. D. Phanindra Kshatra, working as Assistant Professor in the Department of Mechanical Engineering of Koneru Lakshmaiah Educational Foundation of Andhra Pradesh state in India. He has published many international journals in various reputed Journals. His area of interest is in Discrete Event Simulation, DES in Lean, Lean Flow, Kanban Systems, and Simulation methodologies. At present, his area of research is going on Discrete Event Simulation for Automobile Manufacturing.

S. Akhil is an IV Year, B-Tech Mechanical Engineering Student at Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur (DT)Ch. Uday Kiran is an IV Year, B-Tech Mechanical Engineering Student at Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur (DT)Ch. Yaswanth is an IV Year, B-Tech Mechanical Engineering Student at Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur (DT) M. Vineeth is an IV Year, B-Tech Mechanical Engineering Student at Koneru Lakshmaiah Educational Foundation, Vaddeswaram, Guntur (DT)

13.5 A5: Energy Consumption and Conservation in Shipbuilding

ISSN 2278 – 0211 (Online)

Ch. Rajeswar Harish, Scientist – B (NA), SMDR, Indian Maritime University, Visakhapatnam campus, Visakhapatnam, India

Soumya K. Sunil, Scientist – B (ELE), SMDR, Indian Maritime University, Visakhapatnam campus, Visakhapatnam, India

Abstract: Transportation of goods and people across water is a necessary engineering activity for the economic growth of individuals and society. But does this growth affect sustainable development through environmental degradation? A ship's life cycle consists of mainly the following stages: concept exploration, design, production, operation and maintenance and dismantling.

Among them, the major energy consuming stages can be identified as (i) shipbuilding (ii) ship operation and maintenance and (iii) ship dismantling. The energy consumed in building a ship can be grouped under major heads as establishment energy, direct energy in materials and its transportation, direct energy consumed in construction of the particular ship and indirect or overhead energy consumed in the shipyard which cannot be billed to a ship. A shipyard is erected to build ship. Therefore a portion of the energy spent in building a shipyard has to be billed to the ship's account built in that yard. One could assume a numbers of years (day, N) of productive life of a shipyard and knowing the CGT (Compensated Gross Tonnage) built per year (CGTy), one can calculate the energy to be accounted for in that ship's account.

The energy consumed in the shipbuilding process can be grouped under three heads. a) Direct Materials (energy contained in the materials of a ship and their transportation). b) Direct (energy consumed in construction of the particular ships such as electricity consumed due to welding, cutting, use of cranes, transportation of block etc). c) Indirect or overhead (energy consumed in the shipyard which cannot be billed to a particular ship, such as electricity and fuel consumed in administration, design, planning, transportation of personnel etc.).

For reduction of energy consumption in shipbuilding, the measures to be considered are Optimal design and procurement, Use of alternative materials which are biodegradable or re-usable, use of improved and modernised machinery, Elimination of rework, Indirect energy consumption by optimal ship production or maximizing CGTy and Use of alternative / renewable energy sources. A fraction of the energy consumed in building a ship can be recovered by recycling. Ideally, for recycling to be effective, recycling yards should require minimum investment.

Keywords: Sustainable development, Ship life cycle, Direct and process energy, Energy conservation

13.5.1 Introduction

Our shipbuilding practices have not kept pace with global industry standards which have already graduated to a 'womb-to-tomb' concept called Concept, Assessment, Demonstration, Manufacture, In-Service, Disposal or CADMID in short. The challenge of maintaining high product quality while simultaneously reducing production costs can often be met through investments in energy efficiency, which can include the purchase of energy efficient technologies and the implementation of process-wise energy efficiency practices. Energy efficient technologies can often offer additional benefits, such as quality improvement, increased production, and increased process efficiency, all of which can lead to productivity gains. Energy efficiency is also an important component of a company's overall environmental strategy, because energy efficiency improvements can lead to reductions in emissions of greenhouse gases and other important air pollutants. A study has been undertaken in order to observe the energy consumption pattern in the Indian ship building yards and dismantling facilities. The energy consumption pattern for a single ship construction and dismantling was also tried to calculate.

13.5.2 Indian Shipbuilding Industry Structure and Characteristics

Shipbuilding industries are located in India along the coastline. Apart from the government shipyards like Cochin shipyard, Mazagon dock, GRSE, Hindustan Shipyard limited etc, there are above fifteen major shipyards in the private sector. We, in our study, have tried to include shipyards from all sectors. The study, consisting of two phases, was carried out as follows: Phase 1: Establishment energy- Estimating the energy spent in establishment of a shipyard. Phase 2: Specific energy - Estimating the energy, in all possible forms, that was actually spent in constructing a specific vessel.

13.5.2.1 Phase 1: Establishment Energy

For sustainability, a Greenfield shipyard must be 'greener' than an established yard. Therefore, one can consider alternative shipyard designs for energy reduction by horizontal transfer of ships such as end or side launching or use of ship lift systems without the use of a dry dock. Since most of the shipyards in India were constructed at an early date, the accurate data for the same was not available. The major raw materials in the shipyard construction, as in any other construction, were identified to be reinforced concrete cement (RCC), bricks and asphalt (roads).

The methodology adopted here was to do a reverse estimation, starting with the data in hand, *i.e.* with the available building dimensions, standard energy values and calculated quantities of raw materials; the total energy spent in the establishment of the shipyard was arrived. The dimensions of various shipyards being different, total energy of the shipyard has been categorised into 4 sections and per unit values were calculated in order to present an average energy from shipyards. Calculated section wise average energy is shown in Table 13.1.

Table 13.1

Energy in workshops and warehouses	21GJ/m^2 (approx.)
Energy in buildings	10 GJ/m^2 (approx.)
Energy in docks, slipways, berths and jetties	3 GJ/m^2 (approx.)
Energy in roads	33 MJ/m (approx.)

13.5.2.2 Phase 2: Specific Energy

a) Direct energy: The major consumables utilised in the construction of a ship were identified to be Steel, Electrodes, Paint, Oxygen and acetylene, electricity used in various ship building processes like cutting, molding, welding etc. b) Indirect energy: Electricity consumed in the common area like drawing office, warehouse, canteen etc and fuels used for transport of raw materials, which cannot be segregated vessel wise.

Methodology Adopted

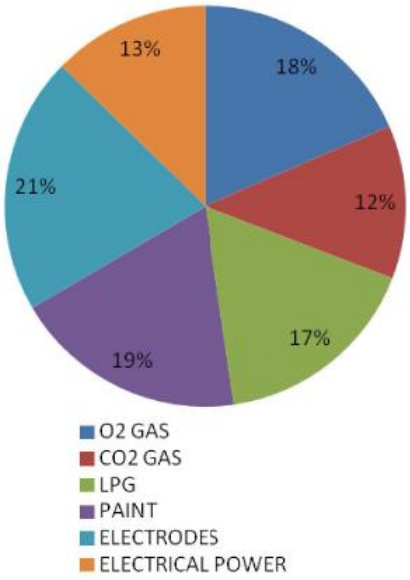
i. From each shipyard, two or three specific vessels were selected, depending on the availability of data. ii. Steel, paint and electrode consumption details were obtained from the warehouse. iii. Electrical power consumption details were obtained from the concerned department. iv. Oxygen/acetylene consumption data roughly was collected from warehouse.

Table 13.2

Consumable	Quantity	Energy	MJ
O_2 GAS	100 Cu. Met. / 1 Ton net steel	5.04 MJ/M^3 [i]	504.00
CO_2 GAS	33 kgs. / 1 Ton net steel	10204 MJ/TON [ii]	336.73
LPG	10 kgs. / 1 Ton net steel	45845 MJ/TON [iii]	458.45
PAINT	7.9 kgs. / 1 Ton net steel	514 MJ/TON [iv]	514.00
ELECTRODES	625Nos. (or) 34kgs / 1 Ton net steel	34.3 GJ/TON	566.37
ELECTRICAL POWER	96 KWH/ 1 Ton net Steel	3.60 MJ/KWH	345.60

Consumables required for ship construction, as mentioned in Table 13.2 can be known from approximated quantity calculated per 1 tonne of net steel work. This data is used to calculate required respective quantities with known total ship net steel weight. This is then converted to energy terms using references of embodied energy for unit weight or volume.

Figure 13.10: Consumable Energy per Ton Net Steel



Above Figure 13.10 shows percentage contribution of each consumable per tonne net steel weight of ship construction. Total energy required from fabrication to hull berths for 1 Ton net ship steel work from above Table 13.2 is 2.73 Gigajoules.

13.5.3 Merits of Ship Dismantling

The vessels after becoming decommissioned are taken to ship dismantling yards. Ship dismantling is the reverse process of ship building. Therefore, the components of energy consumption will be similar to shipbuilding except that the energy in materials will not be there since no new material is added. The Indian subcontinent accounts more than 70 percent of the global demolition. The importance of this industry can be gauged from the fact that the ships steel continues up to 8.5 percent of annual steel production in India. Hence, it is clear that the ship is not dismantled but it is recycled, as world life fund defines recycling as the processing of waste or rubbish back into raw materials so that it can be made into new items.

Table 13.3

Consumable	Quantity	Energy	MJ
LPG	15 kg/ton	45.8 GJ/ton	687.7
Oxygen	70 m3/ton	5.04 MJ/m3	352.8
Diesel	3.5 liters/ton	37.4 MJ/liter	130.8
Electricity	0.3 kWh/ton	3.6 MJ/kWh	0.9

In life cycle of a ship, last stage is dismantling and energy consumed in extracting one tonne of steel from ship is 1.17 Gigajoules (Table 13.3).

13.5.4 Energy Conservation Measures for construction of Shipyard

Energy saving measures to be considered while constructing a shipyard is detailed under each section.

13.5.4.1 Replacing Portland Cement by Ternary Cement[v]

From results of adiabatic temperature rise tests, concrete mixture mixed with Type IV cement displays the higher rate of heat evolution generated from hydration than those of concrete mixtures of ternary cements; PSLB-352 [ordinary Portland cement (30%), blast furnace slag (50%), and class C fly ash (20%) and PSLB-442 [ordinary Portland cement (40%), blast furnace slag (40%), and class C fly ash (20%).] It indicates that the ternary cements can be used as an alternative of Type IV cement for massive members. Ternary cements provide economical and environmental advantages by reducing Portland cement production and CO2 emission, since it makes use of a high percentage of slag.

13.5.4.2 Development of Sustainable Construction Material Using Construction and Demolition Waste

[vi] A sustainable construction material (brick) using construction and demolition (C&D) waste is used as fine and coarse aggregates. Recycling is a major productive area in which considerable quantity of waste can be utilized for manufacturing new building materials. Embodied energy is such bricks (also known as eco-bricks) are found to be minimum. Eco bricks are energy and resource efficient bricks made with waste materials and produced using cleaner production techniques. With improved quality, they result in reduced carbon footprints while also reducing the stress on virgin resources.

13.5.4.3 Moisture Susceptibility of Warm Mix Asphalt[vii]

In case of asphalt pavement construction especially with hot asphalt mix (HMA), a high mixing and compaction temperature is required throughout the construction process to

maintain sufficient workability. This high mixing and compaction temperature is required throughout the construction process to maintain sufficient workability. It has been found that warm mix asphalt (WMA) can be used to replace WMA because it is produced at 20-40 deg C lower temperature than HMA but provides the same level of workability. WMA also provides other advantages such as: Better working condition due to absence of harmful gases Lower energy consumption in mix production. Quicker turnover to traffic. Longer hauling distances. Extended paving season Also, lower void content due to improved compaction make the pavement more durable.

13.5.5 Energy Conservation Measures for Ship building processes

Majority of the ship building processes like cutting, welding, lifting, bending, molding, blow drying etc. make use of electricity.

13.5.5.1 Energy Efficiency in Manufacturing Operations.

[viii] Energy consumed by a CNC machine tool consists of two parts: a fixed part and a variable part; the fixed part attributed by start up and certain running operations, whereas variable part varies with machine loads. Total power consumed can be calculated as a sum of the standby power, cutting power and additional power losses. By optimizing the cutting parameters (spindle speed, feed rate and cutting depth), balance of process efficiency and carbon emissions can be achieved.

13.5.5.2 Increasing Energy Efficiency for Welding

[ix] Selecting and applying the right welding technology saves energy, material and manpower. To be as energy-efficient as possible, welding processes must reduce spatter, achieve high weld speed, and significantly improve gap “bridge ability,” while offering controllable heat input. Three intelligent and practical solutions are— cold metal transfer (CMT), Laser Hybrid, and Delta Spot, the spot welding process — that improve efficiency and offer a quick return on investment. Robotic welding may be cost-effective, but it must be a continuous, uninterrupted operation. Robots equipped with conventional metal active gas (MAG) welding systems must stop frequently in order to clean welding spatter from the nozzles.

This offers plenty of scope for savings in time, energy and material. Switching to the CMT process results not only in far less welding spatter, but in a considerably more stable metal transfer and a significant reduction in the tilt angle of the electrode. This alone reduces the stoppage time of the robot welding cells by more than 60%, and increases the efficiency of the electrical energy used. If gap bridge ability is as high as possible, the time and costs required in preceding production stages is reduced and there is no need to fix the parts to be welded in position.

Compared with conventional MIG or laser processes that use a cold wire feed, Laser Hybrid achieves three times the welding speed and, due to the lower energy input, consumes far less electrical energy while simultaneously reducing thermal distortion. Conventional spot welding, especially of aluminium components, is characterized by high electrical consumption and high levels of electrode wear. The result is frequent stops while the electrodes are changed and high electrode costs.

The Delta Spot spot-welding system features a continuous process tape that runs between the electrodes and the sheets. This protects the electrodes, brings clean, fresh material to the contact points before each weld, and reduces total energy consumption. The flexible and totally controllable process permits continuous spot welding of a consistently high quality —

regardless of the material to be welded. The demonstrable increase in product quality and system productivity, the reduced waste, and energy and material consumption savings all come together to provide a more efficient and stable production process.

13.5.5.3 Aspects of Energy Efficiency in Machine Tools

Besides the use of energy-efficient motors in the auxiliary components, many possibilities for reducing the base load can be found in proper energy management. Measures to support the operator during setup also increase energy efficiency, because they shorten nonproductive phases and reduce the influence of the base load.

A requirement-oriented deactivation of auxiliary components therefore offers substantial potential energy savings. The CNC can be used as the central control unit for the energy management of a machine tool and its associated periphery.

13.5.5.4 Reduction of Machine Idle Time through Optimal Support during Setup

To reduce the energy requirement per part, non-cutting periods such as tool and set-up times should be kept as small as possible.

13.5.5.5 Minimising the Scrap through Closed Loop Technology

Analyses of metal-cutting processes show that the power consumption of a CNC control with feed-axis and spindle motors frequently comprise only 25 to 30% of the total required power. On the other hand, the auxiliary components in the machine or its environment play a dominant role in the energy balance. The selection of the position encoder can have a decisive effect on the efficiency of spindle motors and direct drives. Position encoders with high line counts are essential for the high efficiency of servo-controlled drives. It has been proven that linear encoders increase accuracy and therefore contribute to higher precision and reproducibility of machining results. This makes it possible to reduce waste in production and, as an immediate result, the energy requirement per good part.

13.5.5.6 Energy Efficiency using Fibre Laser Cutting System

[xi] Fibre laser technology has a series of advantages over CO_2 laser systems, in that it requires "virtually no maintenance," is more energy efficient, and occupies less space on the shop floor. A laser power supply is smaller than a CO_2 supply; yet fibre delivery allows a laser beam to travel greater distances so larger cutting tables can be used.

13.5.6 Measurement and Verification Process for Calculating and Reporting on Energy and Demand Performance

The desired outcome of each of these project-specific M&V plans is to quantify the impact, or performance, to a stated degree of certainty, as a result of a particular Energy Efficiency and Demand Side Management EEDSM measure implemented. In addition to the primary energy impacts (*e.g.* kWh consumption and kW demand during a certain period), an Energy Conservation Measure (ECM) often has secondary impacts such as extending equipment life cycles, increased worker productivity, increased quality control, etc. The aim of measurement and verification (M&V) is to quantify the impact of implemented EEDSM projects. This impact is quantified by comparing the energy use before and after the intervention of EEDSM. The "before" case is referred to as the baseline; the "after" case is referred to as the post intervention or modified (actual) consumption.

13.5.6.1 Codes, Standards and Practices

a) Energy Regulations, Codes and Standards – The use of available energy regulations, codes, and standards is encouraged in order to provide a convenient, clearly defined, and consistent baseline energy use. b) Common Practice – under certain circumstances, the use of "standard practice" or "market standard" may be more appropriate for baseline development.

The key issue is to have the actual baseline development process well-documented and replicable. c) Performance of similar systems (or buildings) without any of the proposed energy savings measures implemented – The use of standard technologies are often documented for use in similar systems or facilities and in similar economic sectors. d) A benchmark determined by a national policy, regulation of administration and/or jurisdiction – This case is especially important when a grant for a new (Greenfield) project is introduced.

13.5.6.2 Measurement and Verification (M&V) Stages

a) Understanding of the planned Scope of Work b) Development of the M&V Plan c) Secure agreement for the M&V Plan d) Pre-Implementation Measurements (in order to obtain the baseline) e) Development of baseline according to the M&V Plan f) Secure agreement for the Pre-Implementation (initial) baseline g) Post Implementation Verification/Audit h) Post Implementation Measurements i) Adjustment of Baseline and Calculation of Performance j) Produce and Submit M&V Performance Report k) Repeat Cycle for Project or Contract Duration

13.5.6.3 Standard Elements

a) Operating hours. b) Load/Requirement. c) System efficiencies. It is through changing any one, or any combination, of these three standard elements that savings are generated.

13.5.7 Conclusions

Sustainable shipping means environmental protection which includes less energy consumption and pollution free and safe ship operation over ship lifecycle. The energy consumption for building a ship has been discussed. It has been stated that energy consumption during shipbuilding can be reduced by improved production methods, techniques and processes and mostly by elimination of rework and having a full order book position. Design of a green ship means reduced energy consumption leading to sustainable environment. The paper enlists energy consumption in shipbuilding in various sectors. However, there is need for further studies in order to validate the results. These results would stand as reference for any kind of energy estimation. Conservation methods have been discussed to preserve the non-renewable resources of energy.

13.5.8 Practical Observations

a) Due to ordering consumables on a refill basis for maintaining a minimum fixed stock in the warehouse, ship specific records regarding the ordering and utilization of consumables is not maintained by majority of the shipyards presently. b) Most of the consumables are not issued ship-wise and procurement is done for a group of vessels. c) A trivial amount of embodied energy is wasted as scrap, accurate value of which cannot be ascertained. d) Entire shipyard has single energy meter, which reads the consumption of the electricity of the entire yard. This may include activities totally unrelated to shipbuilding (like ship repair activities carried out in the yard).

13.5.9 Acknowledgement

The authors would like to thank Ministry of Shipping for sanctioning the study on the Energy consumption in ship building and ship dismantling Industry and Director of Indian Maritime University, Visakhapatnam Campus, various shipyards and colleagues for their guidance, assistance and support for carrying out the study.

13.5.10 References

(1) Energy Efficiency in Steel Industry and Clean development Mechanism, by Steel Authority of India Limited.
(2) Report by Climate Registry Default Emission Factors U.S. and EPA United States 2012.
(3) G.P. Hammond and C.I. Jones (2006) Embodied energy and carbon footprint database, Department of Mechanical Engineering, University of Bath, United Kingdom.
(4) Paint Energy by Hempel, Corporate Responsibility Report 2013.
(5) Paper on Influence of cement type on heat of hydration and temperature rise of mass concrete, by MH Lee in Indian Journal of Engineering and material sciences.
(6) Paper on Development of sustainable construction material using construction and demolition waste, by V A Dakwale and R V Ralegaonkar in Indian Journal of Engineering and material sciences.
(7) Paper on Moistures susceptibility of warm mix asphalt, by Mehmet Bayazit in Indian Journal of Engineering and material sciences.
(8) Paper on Quantitative approach to analyse carbon emission of CNC based machining systems, by Ying Tang from Research Gate.
(9) Article from www.weldingdesign.com.
(10) Article from www.heidenhain.us.
(11) Press release from www.hypertherm.com.
(12) Article from www.cleanenergyministerial.org

13.6 A6: Energy Efficient Technologies and Best Practices in Steel Rolling Industries (Indonesia)

The Energy and Resources Institute, Darbari Seth Block, IHC Complex Lodhi Road, New Delhi – 110003 (India)

13.6.1 Certificate of originality

Original work of TERI done under the UNEP supported component of the project titled "Pilot Asia-Pacific Climate Technology Network and Finance in Asia and the Pacific". This document may be reproduced in whole or in part and in any form for educational and non-profits purposes without special permission, provided acknowledgement of the source is made. UNEP and TERI would appreciate receiving a copy of any publication that uses this document as a source.

Disclaimer. This document is an output of an exercise undertaken by TERI through a project funded by the United Nations Environment Programme for the benefit of steel rolling industries in Indonesia. While every effort has been made to avoid any mistakes or omissions, UNEP or TERI would not be in any way liable to any person or institution by reason of any mistake/ omission in the publication. Published by T E R I Press The Energy and Resources Institute Darbari Seth Block IHC Complex, Lodhi Road New Delhi-110 003IndiaFor more information Project Monitoring Cell T E R I Tel. 2468 2100 or 2468 2111Darbari Seth Block E-mail pmc@teri.res.inIHC Complex, Lodhi Road Fax 2468 2144 or 2468 2145New Delhi – 110 003 Web www.teriin.orgIndia India +91 • Delhi (0)11

13.6.2 Acknowledgements

The Energy and Resources Institute (TERI) expresses its sincere gratitude to the United Nations Environment Programme (UNEP) for providing opportunity to work in the GEF project titled "Pilot Asia-Pacific Climate Technology Network and Finance Centre in Asia and the Pacific". The focus of TERI's activities in the project was on energy efficiency in steel reheating furnaces in Indonesia. We express our gratitude to Mr. Rajiv Gag, Programme Officer (Climate Change), UNEP for his support and guidance in preparation of the manual on 'Energy Efficient Technologies and Best Practices in Steel Rolling Industries' in Indonesia. TERI is also thankful to the National Council on Climate Change, Indonesia and Agency for the Assessment and Application of Technology (BPPT), Indonesia for their valuable inputs, cooperation, and support for identification of the units for detailed assessment study in Indonesian steel rolling industries.

The interactions with Center for Technology Assessment and IPR (Ministry of Industry) and other key stakeholders in Indonesia provided valuable inputs during the detailed assessment and preparation of manual. We also take this opportunity to express our deep appreciation for the excellent support and baseline information provided by following Steel Rolling Industries in Indonesia, which was extremely useful for preparation of manual. PT Bhirawa Steel, Surabaya~~ PT Java Pacific, Surabaya~~ PT Hanil Jaya Steel, Surabaya~~ PT Krakatau Wajatama, Cilegon Last but not the least, we are also thankful to the project advisors from TERI, Mr. Girish Sethi, Director and Mr. Prosanto Pal for their inputs and support.

13.6.3 Project Team

- Mr. Rajiv Garg UNEP
- MrZakiyodin, Ministry of Industries (Indonesia)
- Ms Widiatmini Sih Winanti NCCC/BPPT (Indonesia)
- Mr Girish Sethi TERI
- Mr Prosanto Pal TERI Project Implementation
- Mr N Vasudevan TERI
- Mr Pawan Kumar Tiwari TERI
- Mr Arvind Kumar Asthana GIZ
- Mr Moko Nugroho Ministry of Industries (Indonesia)
- Mr Denny Novionsyah, Ministry of Industries (Indonesia)
- Ms Amita Indah Sitomurni BPPT
- Mr Wiharja BPPT
- Mr Rizky Pratama Adhi BPPT
- Mr Prasetyadi BPPT
- Mr Reba AnindyajatiPratama BPPT
- Ms Saraswati Diah, BPPT
- Ms Siti Zulaikha, BPPT
- Ms Laras Andria, BPPT
- Mr Emod Tri Utomo, NDE Editors
- Mr N Vasudevan TERI
- Mr Pawan Kumar Tiwari TERI Reviewer
- Mr Arvind Kumar Asthana GIZ Secretarial Assistance
- Mr G Gopalkrishnan TERI
- Ms Kavita Sisodia TERI Publishing
- TERI Press Collaborating Industries
- PT Bhirawa Steel, Surabaya PT Java Pacific, Surabaya
- PT Hanil Jaya Steel, Surabaya
- PT Krakatau Wajatama, Cilegon

13.6.4 About the Project

The Asian Development Bank (ADB) and the United Nations Environment Programme (UNEP) are working in partnership with funding from the Global Environment Facility (GEF) and co-funding from the governments of Japan, Republic of Korea, Denmark and Finland, and VITO-Flemish Institute for Technological Research NV to pilot a climate technology finance center in Manila, managed by ADB, and a climate technology network secretariat in Bangkok, managed by UNEP. These pilot institutions directly address key barriers to climate technology transfer and deployment in Asia and the Pacific. The climate technology network secretariat managed by UNEP focuses on creating capacity readiness and enabling conditions for market transformation interventions in the region through fostering knowledge sharing, public-private partnerships and the development of institutional capacity and climate technology policies. The secretariat is implementing three main sets of activities:

(1) Facilitating a network of national and regional technology centers, organizations and initiatives.
(2) Building and strengthening national and regional climate technology centers and centers of excellence.
(3) Designing, developing, and implementing country-driven climate technology transfer policies, programmes, demonstration projects, and scale-up strategies. This broad range of activities will support countries in designing the technical and financial policy mechanisms for climate technology transfer and country-driven climate technology transfer initiatives.

This will include development of monitoring and evaluation (M&V) tools for technology transfer policy, setting up of demonstration projects, designing strategies to scale-up environment friendly technologies, the costs of specific adaptation and mitigation measures and to advice on technology regulations and standards. This project on 'Energy Efficient Technologies and Best Practices in Steel Rolling Industries in Indonesia' primarily focuses on activity "3" *i.e.* country driven programmes and scale-up strategies. The overall objective of

the project is to assess the potential for technology upgradation and energy saving in steel rolling industries in Indonesia. The specific objectives of the project include the following: ~~

(1) Assessing the performance of steel reheating furnaces in terms of scale of operation, product types, production capacity, energy consumption and technology adopted Identification of energy efficient technology (EET) and best operating practices (BOP) that can be implemented to save energy and reduce GHG emissions
(2) Development of monitoring, reporting and verification (MRV) guidelines for reheating furnaces
(3) Awareness on improved technology and BOP among industry stakeholders The industry sector in Indonesia is one of the major consumers of commercial energy. Among the industries, steel rolling is one of the most energy intensive process steps in steel making after casting which involves reheating and shaping of cast steel into desired forms. Studies conducted in steel rolling industries in Indonesia indicate substantial scope for energy saving and improvements in employed technology. Energy efficiency improvements in reheating furnaces may lead to substantial reduction in energy input cost, enhanced competitiveness, and low emissions of GHG.

13.6.5 Executive Summary

The manual “Energy Efficient Technologies and Best Practices in Steel Rolling Industries” focuses on energy efficiency improvement options in steel rolling mills in Indonesia. It outlines technological options and practices, which may be adopted to enhance the efficiency of the existing installations as well as for augmentation of the capacities. The manual has been prepared by TERI based on the field assessment studies undertaken during September–November, 2014 in selected steel rolling mills in Indonesia. The adoption of new and modern technologies will not only help the Indonesian steel rolling industries to be competitive at global level but also help in reducing emission levels. The manual is also expected to act as a knowledge resource for the industry personnel and energy practitioners for incorporating energy efficient options in their regular operating procedures. The total energy consumption of Indonesia in the year 2012 was about 162 million tonnes of oil equivalent. Industrial sector contributes to the final energy consumption of 29.9 per cent, closely followed by households (28.5%) and transportation (26.8%).

Thus, the industry sector is one of the important consumers of commercial energy, which is mainly attributed to significant development in textile, automobiles, infrastructure, and other associated sectors. The steel industry is also one of the leading sub-sectors with expectations of increased investments and competitiveness in the coming years. The domestic demand for crude steel in Indonesia was about 8.6 million tonnes in 2011; while domestic production was 6.01 million tonnes. Indonesia is ranked 36th in the world in terms of steel production. The per capita consumption of steel in the country has increased from 22.8 kg to 62.3 kg during the last decade (2003–2012).

However, per capita consumption of the country is still lower than the per capita consumption of Asian countries (262 kg).The downstream steel industries sector, which comprises various finishing operations, is an extremely important sub-sector, but largely remains unattended. One of the important finishing operations in steel sub-sector is steel rolling mills. There are about72 steel mills operational in Indonesia. A detailed field assessment study in a few typical steel rolling industries (selected based on installed capacity, energy consumption, technology used, raw materials and products and location) located in Surabaya (East Java) and Cilegon (Banten) was carried out by TERI.

Steel rolling industries are highly energy intensive and the specific energy consumption of the four units that were studied was in the range of 2.36–4.37 Giga Joule per tonne. The weighted average specific energy consumption is estimated to be 3.13 Giga Joule per tonne of rolled steel for hot rolling, whereas the world average is about 2.2 Giga Joule per tonne, which indicates significant potential for energy conservation and energy efficiency improvements. Summary of the key findings from the field assessment is given below:

(1) A wide variation in the specific thermal energy consumption was observed, which is mainly attributed to age of the furnace, technology employed, and capacity utilization.xiv Energy Efficient Technologies and Best Practices Manual in Steel Rolling Industries (Indonesia) -Reheating Furnace
(2) Recovery of heat – Regenerative burners
(3) Recovery of heat – Self-recuperative burners
(4) Oxy-fuel combustion technology
(5) Hot charging of continuous cast billets
(6) New reheating furnace technology –Walking beam furnace
(7) Optimization of combustion – Oxygen level control and VSDs on combustion fans
(8) Improved insulation and refractories of reheating furnace
(9) Optimization of operation – Furnace pressure
(10) Optimization of operation – Temperature of material
(11) Optimization of operation – Capacity utilization STEEL ROLLING MILL
(12) Capacity optimization and use of energy efficient electric motors
(13) Improved lubrication system
(14) Minimum waste – crop length optimization
(15) Use of cast-in-carbide rolls
(16) Anti-friction roller bearing
(17) Computerized roll pass design AUXILIARIES
(18) Process cooling system – Automation and control and use of Energy efficient pumps
(19) Compressed air – Optimum pressure, capacity utilization and prevention of leaks
(20) Ultra high efficiency transformers
(21) Quantity control of transformers
(22) Energy efficient lighting
(23) Natural gas is the primary fuel used in the reheating furnaces across the country due to lower price in comparison with other developed countries as well as easy availability. Reheating furnaces are the major consumers of energy in the form of thermal energy, accounting for about 60–65 per cent of total energy consumption of rolling industries.
(24) The utilities associated with reheating furnaces and rolling mills (compressed air system, process cooling system, etc.) are of conventional type and the efficiency levels were not up to the design mark.

This is mainly due to lack of proper selection of equipment, overdesigning, absence of periodic maintenance practices, and lack of adoption/ awareness about new and energy efficient technologies. The use of modern era technologies and process automation and control system can lead to substantial reduction in energy consumption and greenhouse gas (GHG) emissions.

- The average GHG emissions have been estimated based on the type of fuel used and its share in the total consumption. The emission level from steel rolling industries in Indonesia is estimated to be 363 kg CO_2 per tonne of product. Various energy efficient technology options have been identified for reheating furnaces, rolling mills, and auxiliaries. These options are summarized below. *Energy efficiency options for steel rolling mills in Indonesia* Modern technologies such as enhanced recovery of the waste energy and optimum use of auxiliary system provide opportunities for minimizing heat input to reach upto the required

temperature profiles in reheating furnaces. Along with technological advancements, adoption of control and automotive process technology and adhering to regular and preventive maintenance practices will help in improving the performance of reheating furnaces and rolling mills. A large number of steel rolling mills in Indonesia are equipped with small and medium capacity reheating furnaces (typically up to 40 tonnes per hour).

High-end technological options may not be the appropriate solution for such mills as large investment would be required resulting in high payback periods. Instead, these mills can improve the performance through adoption of energy efficient technologies and practices provided in this manual. High investment technologies such as regenerative burner technology maybe suitable only for rolling industries having reheating furnaces of capacities more than40 tonne per hour or more and utilization factor in the range of 75–100 per cent. As per the information collated during the field interaction, the number of such mills present in Indonesia is very limited. This manual describes the general methods for energy saving as well as success stories and practical examples that can serve as reference for the industries and energy practitioners, who deal with the operation of rolling mills.

The primary objective of the manual is to highlight the energy efficient technologies and best operating practices that can be adopted/ implemented to save energy and reduce GHG emissions. Also, creating awareness on improved technologies and best operating practices among industry stakeholders is one of the goals of the project. The manual discusses both the measures, which may be retrofitted in the existing system as well as replacement options for minimizing energy consumption. The technical options are provided along with their applicability, availability, investments, energy usage, and monetary benefits. Suitable case studies have also been provided to validate the worldwide use of the suggested technologies. Special emphasis has been given in the manual on best operating practices and Operations and Maintenance (O&M) guidelines that should be followed in reheating furnaces, rolling mills, and other utilities. It is envisaged that this document will help various stakeholder industries to adopt suitable technologies and practices in their mills. The industries in steel rolling sector will have to scrutinize the level of technology used and their specific energy consumption to assess the current level of performance.

The preliminary analysis would help them to decide on the changes required to achieve optimum performance levels and remain competitive with international market. Industries may also seek the help of energy practitioners and technology suppliers for detailed plant specific performance assessment studies. Modification in existing designs, retrofits of control and automation systems and adoption of new technologies along with improved O&M practices and monitoring can lead to a significant reduction in operating and maintenance cost of the facilities. An energy saving potential of 20–35 per cent exists in rolling industries of Indonesia. The realization of this potential will not only lead to reduction in energy consumption and energy costs for the mills but also contribute to the overall international goal of reducing the GHG emissions from various sources.

13.7 A7: Energy Use in Petroleum Refineries

V. o. Haynes
OAK RIDGE NATIONAL LABORATORY
OPERATED BY UNION CARBIDE CORPORATION FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Oak Ridge, Tennessee 37830
Operated by
Union Carbide Corporation
for the Energy Research And Development Administration

U.S. Department of Commerce
5285 Port Royal Road, Springfield, Virginia 22161

13.7.1 Foreword

The information contained in this report was obtained primarily from open-literature sources, supplemented by discussions with authors) and by information obtained from a few representatives of the petroleum refining industry. Although it was not possible in this limited effort to quantify precisely the energy used in refining petroleum, the information is believed to be sufficiently representative to support the conclusions. Detailed descriptions of the various petroleum-refining processes are well documented in several publications; thus, this report describes the processes only to the extent felt necessary to make them relevant to their energy requirements. Appreciation is hereby expressed to D. C. Azbill, Shell Oil Company; R. W. Wendes, Amoco Oil Company; R. B. James, Universal Oil Products; and several of their associates for detailed information on some specific processes and for general discussions.

However, the information contained in this report should not be construed to be representative of these sources. Appreciation is also expressed to those who offered many helpful comments after reviewing a draft of the report: R. W. Wendes, Amoco Oil Company; 0. L. Culberson, University *u[* Teunessee; J. H. Smithson, U. S. Energy Research and Development Administration; and R. S. Carlsmith and S. A. Reed, Oak Ridge National Laboratory. In view of the present accepted practice in this country for the petroleum refining industry, common U. S. units of measurement have been used throughout this publication. In recognition of the position of the U.S. as a signatory to the General Conference on Weights and Measures, which gave official status to the metric SI system of units in 1960, appropriate conversion factors have been provided as follows:

To convert	To	Multiply by
Btu	joule	1.055×10^{3}
kWhr	joule	3.600×10^{6}
barrels (bbl)	m3	1.590×10^{-1}
ft3	m3	2.832×10^{-2}
Btu/bbl	joules/m3	6.635×10^{3}

13.7.2 Abstract

Refining petroleum accounts for about 4% of the total energy consumed in the United States and about 15% of all industrial consumption.

The kinds of energy used and the manner in which energy is used are discussed on a process-by-process basis. Emphasis is placed on existing processes to identify and quantify process and equipment substitutions which might significantly conserve energy. General industry and process information is given and estimates of potential savings are made. A few research and development opportunities are identified and nontechnical factors are discussed.

Nearly one-half the energy consumed by refineries is obtained from by-product refinery gas and coke, and about one-third is supplied by natural gas. On a regional basis, refineries were found to vary by a factor of two in the amount of energy used to refine a unit of crude oil. Refineries in regions traditionally abundant in inexpensive natural gas were found to use relatively more natural gas and energy. About 36% of the energy used by petroleum refineries is consumed in the distillation units to separate the refinery streams into their basic components. Including energy for manufacturing hydrogen, about 24% of the total is used for cracking of the heavier components.

Most of the remainder is used for reforming, hydrogen treating, and alkylation, distributed about 11, 17, and 6% respectively. Potential energy savings discussed in this report total 61 x 1013 Btu/yr based on 1974 capacities, a figure which represents about 20% of the energy consumed to refine petroleum.

13.7.3 Summary

Petroleum refineries use slightly over 3 x 10^{15} Btu of energy annually- about 4% of yearly US energy consumption. Plant size, product, and location affect refinery energy consumption.

Processing has become more complex as plant size has increased, requiring more energy per unit output. Refineries in Texas and along the Gulf Coast use considerably more energy than the national average because their design was based on a relatively mild climate and inexpensive natural gas. A little over half of the energy used to refine petroleum comes from refining streams- refinery gas, oil, liquefied petroleum gas (LPG), and coke. The average energy required per unit output has declined about 0.8%/year since 1960 to a 1974 value of 707, 000 Btu/bbl crude, but there are large regional variations in both the trend and the consumption.

The increasing price of fuel will lead to more effective use of energy. However, because the growth of capacity is anticipated to be slow, conservation will have to be achieved by retrofitting existing plants and as a result will be more expensive and less effective. The fuel, steam, and electricity-energy requirements, energy quality, and energy savings are estimated for most of the refining processes. Processes that are most important relative to energy consumption are distillation, thermal cracking, hydrocracking, hydro-treating, reforming, and alkylation. It appears that about 20% of the energy used to refine petroleum could be saved by the following measures:

	Conservation Measure	Saving 10^{13} Btu/year
(1)	Adding distillation trays and reducing refluxing, operating with high tray flooding, and refining to minimum product quality	3.2
(2)	Use of more energy-efficient fluid catalytic crackers	15
(3)	Use of cyclic, bimetallic-catalyst reformers instead of semi-regenerative units	5.0
(4)	Hydro-treating with no makeup hydrogen when possible	1.2

	Conservation Measure	Saving 10^{13} Btu/year
(5)	Use of hydrofluoric acid (HF) alkylation when analyses indicate it is more energy-efficient	0.6
(6)	Improved furnace design, furnace control, and furnace heat recovery	13
(7)	Greater use of heat exchange between process ·streams and exchanging to a lower temperature	10
(8)	Use of vacuum pumps instead of steam jets	1.1
(9)	Use of back-pressure turbines instead of condensing turbines for both direct drive and electricity generation Savings (1013 Btu/year)	4.7
(10)	Conservation measure Use of turbo-expanders and hydraulic turbines when feasible	1.2
(11)	Use of more efficient pumps and motors and proper sizing	4.6

Other factors that affect energy consumption in petroleum refining and cart thus be explored tor their practicability in conserving energy are: availability and price of fuel; product specifications; industry standards for products, equipment, operation, and maintenance; quality of crude oil to be refined; and integration of refineries with electric utilities and other industries.

13.8 A8: A Reference Oil Refinery Complex Project under Implementation in Bangladesh by Private Sector[1]

All set for mega oil refinery

Bashundhara Group to set up the ৳ 10,000 cr. refinery in Sitakunda

Bashundhara Group is set to build the country's largest oil refinery plant in Chittagong, which is expected to meet about 80 percent of the national demand for refined oil. Bashundhara Oil and Gas Company Limited, an affiliate of the local conglomerate, will construct the plant on 220 acres land near the seashore at Sitakunda in the port city. The land is owned by Bashundhara. The construction is expected to start in July this year and complete by July 2022. The plant will produce liquefied petroleum gas (LPG), diesel, petrol, furnace oil and aviation fuel (Jet A-1).

The project will require an investment of ৳ 10,000 cr. and create about 700 jobs. Of the investment, 64 percent or ৳ 6,400 cr. will come from the banking sector. The rest will be arranged by the Group in the form of equity investment, according to project documents.

Led by Bank Asia, as many as 24 public and private banks are now working to arrange the funds through syndicated loan. This is the largest syndicated loan arrangement in the banking sector. The loan will be repaid in 11 years, project documents show.

Before this, the highest syndicated loan was ৳ 1,200 cr., given to GPH Ispat Ltd, a steel manufacturer. Currently, Bashundhara has bank loans of ৳ 4,000 cr. and the syndicated loan will take its total loan to ৳ 10,000 cr.

Of the expected bank financing, ৳ 3,300 cr. has already been approved by nine private banks. Bank Asia sanctioned ৳ 500 cr. Over the last few months, seven private banks have made policy decisions to finance the project. Another eight public and private banks are considering the proposal. Three state banks -- Agrani, Sonali and Janata -- are expected to lend ৳ 1,500 cr. Islami Bank, the largest private bank in the country, may sanction ৳ 1,500 cr., according to project documents. A number of banks have sought approval from Bangladesh Bank for financing beyond the limit set for a single borrower (15 percent of the bank's capital).A senior official of the BB said they were positive about the project. The BB also asked Bank Asia, the lead bank of the project, to send the proposal of all banks together for approval, the official told The Daily Star.

Mohammad Shams-Ul Islam, managing director of Agrani Bank, acknowledged that the project would lead to a loan concentration. But the risk is not that high as the government will be one of its customers, he said. Project documents show Bashundhara will sell its products to state-run Bangladesh Petroleum Corporation (BPC) as well as to other local buyers. Once in operation, the plant will refine 1 lakh barrels of crude oil per day whereas Eastern Refinery Limited, the only refinery company in the public sector, refines 33, 000 barrels, according to a feasibility study report prepared by Bank Asia. The plant is expected to produce 4.7 million tonnes of petroleum oil every year against the existing local demand for 5.89 million tonnes.

Of the demand, only 1.2 to 1.3 million tonnes come from local sources and the rest is imported. A 2016 estimate by the Japan International Cooperation Agency shows the demand for refined fuel in Bangladesh will rise by six times to above 30 million tonnes by 2041.Bashundhara has been planning to set up the plant for the last two years and approached various banks for financing four months ago, said Mohammed Belayet Hossain, senior deputy managing director of the Group."Banks have responded positively about financing and the construction of the plant will start in due time," he said. Currently, the Group's asset is worth around ৳ 50, 000 cr., he said.

[1] The Daily Star, 3 January 2022

The business group has signed an Engineering, Procurement and Construction contract with Prokop Engineering Brno of Czech Republic. The company, founded in 1990, is an expert in the construction of industrial plants, especially in the fields of processing crude oil and oil products and gas processing. In the South Asian region, India can meet its own demand and even exports its surplus production of refined oil. In 2016, Pakistan and Sri Lanka produced 40 percent and 30 percent of their demand for refined oil, according to the project documents. In the same year, Bangladesh produced only 20 percent of its demand and imported the rest.

13.9 A9: Energy Use in US Steel Manufacturing

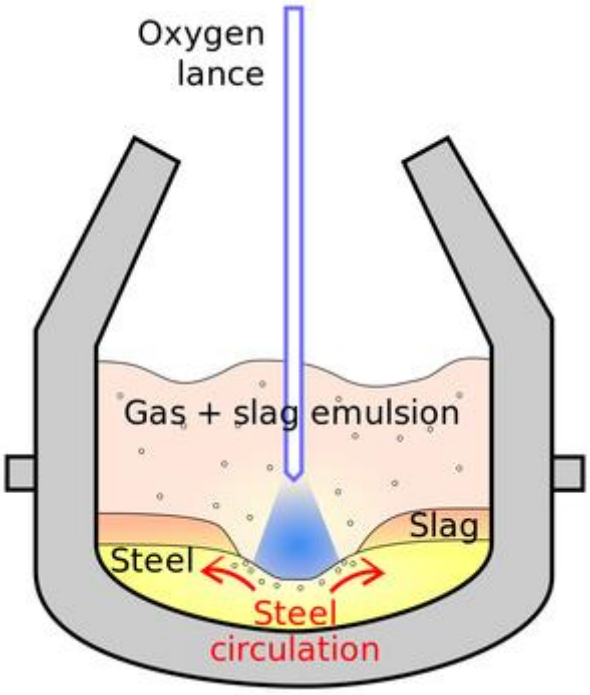
Nikolas Martelaro
December 4, 2016
Submitted as coursework for PH240, Stanford University, Fall 2016

13.9.1 Introduction

The US steel industry has been a cornerstone of American manufacturing since the Industrial Revolution. Andrew Carnegie and Carnegie Steel helped to industrialize the Bessemer process for steel manufacture. With the possibility for newly minted wealth to be had, there was a rise in many steel making companies, all competing against each other to increase their tonnage of steel production.

These companies would later be consolidated by J.P. Morgan into the near monopoly of US Steel. While the story of US steel is often one of tenacious industrialists, it is also a story of the utilization of America's vast energy reserves for the creation of manufactured goods.

Figure 13.11: Basic Oxygen Furnace[2]



[2](Source: Wikimedia Commons)

Without the abundant natural energy resources within the US, most notably coal, there would not be a US Steel industry. While early steel manufacturing was predominantly coal powered, modern approaches to steel making have seen a rise in natural gas and electric powered furnaces. Still, coal and coke are significant sources of energy in steel production. On this page, I examine the energy usage in US Steel production. I will review the basic process of creating steel, and then outline the various energy sources and amount used in its production.

I will then discuss the present and potential futures of energy use in the manufacture of steel and how this may relate to overall energy usage in the US. While the entire production chain, from mining to final manufactured product, adds to the total energy cost of producing steel goods, analysis of the entire chain is too large for this short article. As such, this article will focus primarily on the energy use of raw steel production, from the production of pig iron to the casting of raw steel.

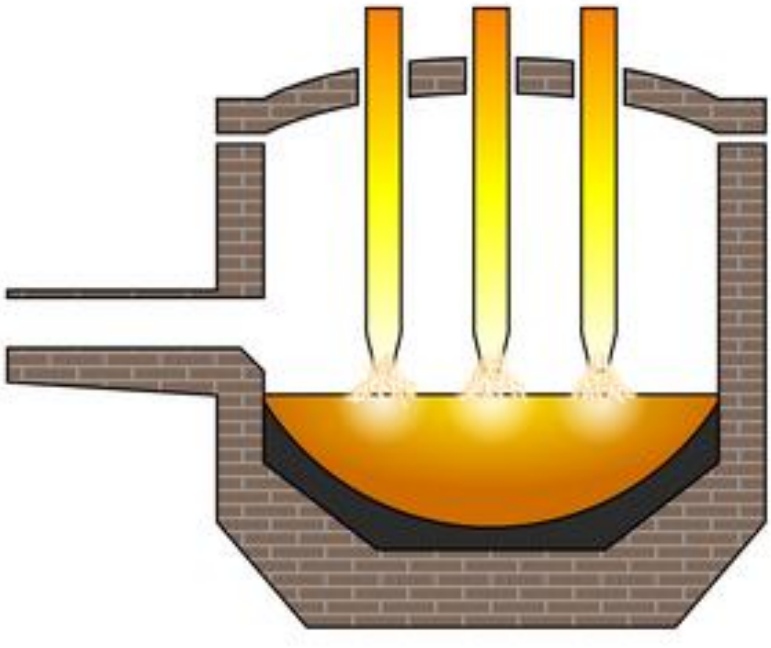
13.9.2 Basics of Steel Production

In this section, I will outline the basics of steel production. This is in no way meant to be a full review of the steel production process, but rather a shallow introduction to help describe where in the process energy is used. This section is based on a nice overview of steel production in Fruehan and Section 3 of Worrell *et al.*

13.9.3 Extracting Iron

Steel is simply low-carbon iron. As such, the steel manufacturing process begins by smelting iron ore (Fe_2O_3 or Fe_3O_4) in a blast furnace. This smelting process melts out and separates iron from the original rock material. Iron ore is mixed with coke, a form of very pure coal. The blast furnace burns the coke to heat the iron ore causing it to react into iron (Fe_2), nitrogen (N_2), and carbon dioxide (CO_2). This iron is often known as "pig iron" or "hot metal" as it is a liquid iron that flows from the bottom of the blast furnace. This iron can be used for ironworks or as the starting material for creating steel.

Figure 13.12: Electric Arc Furnace[3]



13.9.4 Making Steel

To create steel, carbon is released from the iron through either mechanical means or high temperatures. To understand how we mechanically create steel, imagine a blacksmith pounding on a hot piece of iron, say to create a sword. This pounding not only shapes the object but also gives it strength by forcing out the carbon. Carbon can also be released through high temperatures (~ 1800+ °C). These high temperatures are created by blowing air (and really the oxygen in air) through the iron. The oxygen raises the temperatures and reacts with carbon, creating carbon monoxide (CO). This reduces the carbon content of the iron, producing low carbon steel.

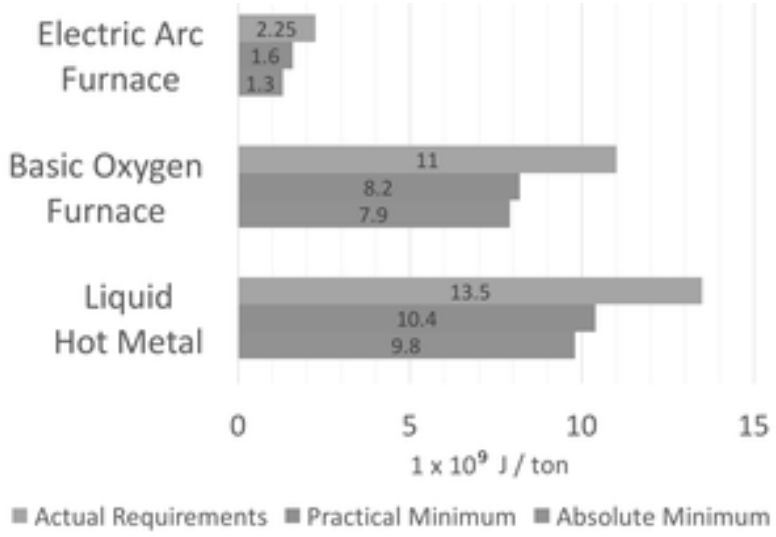
While the "Bessemer process" of steel production is widely known as the defining technology in the mass production of steel, modern steel is manufactured through two primary processes, the "Basic Oxygen Furnace" and "Electric Arc Furnace".

13.9.4.1 Basic Oxygen Furnace

In a basic oxygen furnace, oxygen is blown through liquid pig iron, increasing its temperature and releasing carbon. Pure oxygen is used as it improves the efficiency of the reaction between carbon and oxygen. Hydrocarbon fuel injection (coal, natural gas, oil, and tar) is also used to increase temperature and speed throughput.

[3]Source: Wikimedia Commons

Figure 13.13: Energy usage across various steel making processes[4]



13.9.4.2 Electric Arc Furnace

In an electric arc furnace, scrap steel and solid pig iron is melted using an electric arc. The electric current passes through the steel, heating it a high degree. Since electricity is used to heat the metal, new steel can be created entirely from scrap steel. This avoids the step of creating pig iron from iron ore.

Once the liquid steel is created it can then be cooled, rolled, cast, and formed into a wide variety of products.

13.9.5 Energy Usage of Steel Production Processes

Each process in the production of steel uses a certain amount of energy. This section gives an overview of the energy requirements of major production processes including the creation of pig iron, basic oxygen furnace production, and electric arc furnace production. Fruehan *et al.* have calculated the theoretical minimums for creating steel as well as collected data on practical minimum as and real-world energy use among US steel plants. [4] Fig. 3 shows comparisons of theoretical, practical, and real-world energy requirements for major steel manufacturing processes. Energy is given in units of Joules × 10^9 per metric ton of steel produced.

Table 13.4: Steelmaking energy use (1 × 109 J / metric ton). [4]

Process	Absolute Minimum	Practical Minimum	Actual Average Requirement	% Over Practical Minimum
Liquid Metal "Pig Iron"	9.8	10.4	13.5	23%
Liquid Hot Metal: Basic Oxygen Furnace	7.9	8.2	11	25%
Liquid Hot Metal: Electric Arc Furnace	1.3	1.6	2.25	29%
Hot Rolling Flat	0.03	0.9	2.2	59%
Cold Rolling Flat	0.02	0.02	1.2	98%

[4] Source: N. Martelaro

From the data it is apparent that the production of hot metal or pig iron is the most energy intensive process for steel production at roughly 13.5 × 10^9 joules per ton (1000 Kg) of pig iron produced. The basic oxygen furnace is the second most energy intensive process at 11 × 10^9 joules per ton or steel produced. The Electric arc furnace has significantly less energy required at 2.25 × 10^9 joules per ton. Finally, the two rolling processes have the least amount of energy required below 2.2 × 10^9 joules per ton.

To understand where these numbers come from, let's estimate the minimum energy for the electric arc furnace. Since the electric arc furnace is using pure electricity to melt steel, we can compute the minimum theoretical energy required based on the energy to heat the steel from the ambient temperature to the melting point. This is given by:

$$Q_{heat} = m \times \int_{Ta}^{T_m} c_I(T)\, dT$$

where m is the mass of steel we are heating, T is the temperature in Kelvin, and c_I is the specific heat as a function of temperature. In addition to the energy required to heat the steel, we must also include the energy required for phase changes. The energy required during a phase change is given by

$$Q_\Delta = mH$$

where m is the mass of steel and H is the latent heat of the phase change. To calculate the total energy used to heat and melt scrap steel we will assume that the steel is pure iron (Fe). During the melting process, iron's specific heat varies greatly from an ambient temperature of 298 °K to iron's melting point of 1811 °K, ranging between 0.45 - 1.5 J $°K^{-1}$ g^{-1}. Iron also goes through three phase changes during this process, from α -> γ, γ -> δ, and δ -> liquid. Desai has compiled the thermodynamic properties of iron over a range of temperatures and also provides the latent heat for each phase change. [5] Using these values, summarized in Table 13.2, we can estimate the energy to melt scrap steel:

$$Q_{total} = m \times \int_{Ta}^{T_m} c_I(T)\, dT + mH_{\alpha\text{-}\gamma} + mH_{\gamma\text{-}\delta} + mH_{\delta\text{-}L} = 1.29 \times 10^9 \text{ J}$$

The python script that performed this integration is available here. This result agrees very well with the theoretical minimum for the electric arc furnace in Table 13.1 and calculated in Fruehan *et al.* [4]

Table 13.5: Thermo-physical Properties of Iron

Quantity	Symbol	Value
Mass of Steel to melt	m	1.0 × 106 g
Specific Heat of Iron		
(T-dependent)	cI	0.45 - 1.5 J °K-1 g-1
Melting Temperature	Tm	1811 °K
Ambient Temperature	Ta	293 °K
Latent Heat α → γ		
(1185 °K)	Hα-γ	16.1 J g-1
Latent Heat γ → δ		
(1667 °K)	Hγ-δ	15.2 J g-1
Latent Heat δ → liquid		
(1811 °K)	Hδ-l	247 J g-1

The higher energies required for producing pig iron and the basic oxygen furnace, are most likely associated with the chemical reactions that occur. These reactions are endothermic and require energy input. For example, the reduction of iron ore to iron will require energy beyond simply heating the iron ore to complete.

With an understanding of the energy required for each of the major subprocesses in steel production, we can now discuss how much energy is used to create a steel object. This does assume that the energy input is only in the processes that I have listed above; however, by just looking at the orders of magnitude for each process, we can see that processes of pig iron creation, basic oxygen furnace, and electric arc furnace requires the majority of the energy. Most likely, manufacturing processes further in production will not be as energy intensive as the raw production of steel itself.

13.9.6 Discussion

Based on the data from Fruehan *et al.* we can see that raw steel production from iron ore to steel using a basic oxygen furnace will require approximately 24.5×10^9 J per ton of steel produced. [4] This includes the reduction of raw iron ore into pig iron and then conversion of pig iron to steel. Alternatively, energy use with an electric arc furnace is often done with recycled steel rather than pig iron. This means that energy use for electric arc furnace production will be approximately 2.25×10^9 J per ton of steel, 10× less energy than production from raw iron ore. Even if the electric arc furnace is used to melt scrap steel and then the molten steel is reheated in a basic oxygen furnace, you will still on have 15.25×10^9 J per ton of steel.

This is about half of the use when creating pig iron and then using a basic oxygen furnace. This, of course, does not take into account the energy that has already been used to create the scrap steel (most likely using the basic oxygen furnace), however, this is still a very useful number for understanding future steel production as it is becoming more difficult to mine high-quality iron ore. One of the benefits of steel is that it is highly recyclable and can be remelted and reused ostensibly forever. This gives a strong reason to recycle any steel possible and gives great motivation for waste management companies to separate and sell steel scrap as raw material for future steel products.

The primary goal of this article is to discuss the basic energy requirements of steel production. However, while energy efficiency may be one goal of production, so too is cost efficiency. The price of steel (at the time of writing this) is about $550 per ton. We can estimate the production costs due to the energy required by assuming that the creation of pig iron and the basic oxygen furnace use coal or natural gas to power the process and an electric arc furnace uses pure electricity.

Coaking coal from the Appilachia region of the US and US natural costs the same at about $2.50 per million BTU or 2.4×10^{-9} per J. [6] Electricity for industrial use is about $0.07 per kWh or 1.94×10^{-8} per J (estimate for Pensylvania). Given these energy costs per joule, we can estimate the costs of production for each process, as shown in the following Table 13.6.

Table 13.6: Estimated energy costs for steel production. Energy cost. [6]

Production Process	Energy Required (Joules per ton)	Energy Source	Energy Cost per Joule	Energy Cost per ton	Percent Total Cost
Pig Iron	13.5 × 109	Coal	$2.37 × 10-9	$31.98	6%

Basic Oxygen Furnace	11 × 109	Coal	$2.37 × 10-9	$26.06	5%
Basic Oxygen Furnace	13.5 × 109	Natural Gas	$2.37 × 10-9	$31.98	6%
Electric Arc Furnace	2.25 × 109	Electricity	$1.94 × 10-8	$43.74	8%
Pig Iron + BOF	24.5 × 109	Coal	-	$58.05	11%
Pig Iron + EAF	15.75 × 109	Coal + Electricity	-	$75.72	14%

From this basic cost analysis, we can see that percentage cost of the energy to produce steel is the same across each process. Even the highest cost of production of pig iron to electric arc furnace production is only 14% of the total market price of steel. Thus, at this time, while there are significant energy savings by using scrap steel and an electric arc furnace to produce new steel, there is little cost savings. The benefits of using electric arc furnaces will mostly come from the use of scrap steel. As high-quality iron ore reserves run out, lower iron content ore will need to be processed to create steel. This may raise energy requirements in the future and could raise costs. For there to be any appreciable difference in the costs of production between energy sources, we will need to see a divergence in the cost per joule. It is possible that natural gas prices will fall below that of coal, making natural gas more affordable. However, at this time, the costs of energy are basically the same across energy sources, most likely due to all these energy sources being ultimately sourced from carbon (electric power plants running on coal or natural gas).

13.9.6.1 Conclusion

In this article, I have given a basic introduction to steel production and the energy requirements for the production of pig iron, basic oxygen furnace steel, and electric arc furnace steel. From the analysis of the energy requirements for each of the major processes, the electric arc furnace is by far the most energy efficient in producing steel. Overall, the production of steel is highly energy intensive.

While one may think that increased energy efficiency may lead to cost savings, at current market rates for coal, natural gas, and electricity, there is little difference in the cost of production. As we move forward and think about alternative energy futures, it will be imperative to better recycle already produced steel. If someday the costs of coal and natural gas become much higher per joule than the cost of electricity per joule, the electric arc furnace will become a more attractive production method. We will then see more and more reliance on the efficient collection of scrap steel and less on the mining of raw iron ore. In the future, we will be mining landfill for steel that was unfortunately tossed out before the introduction of efficient sorting at waste management facilities.

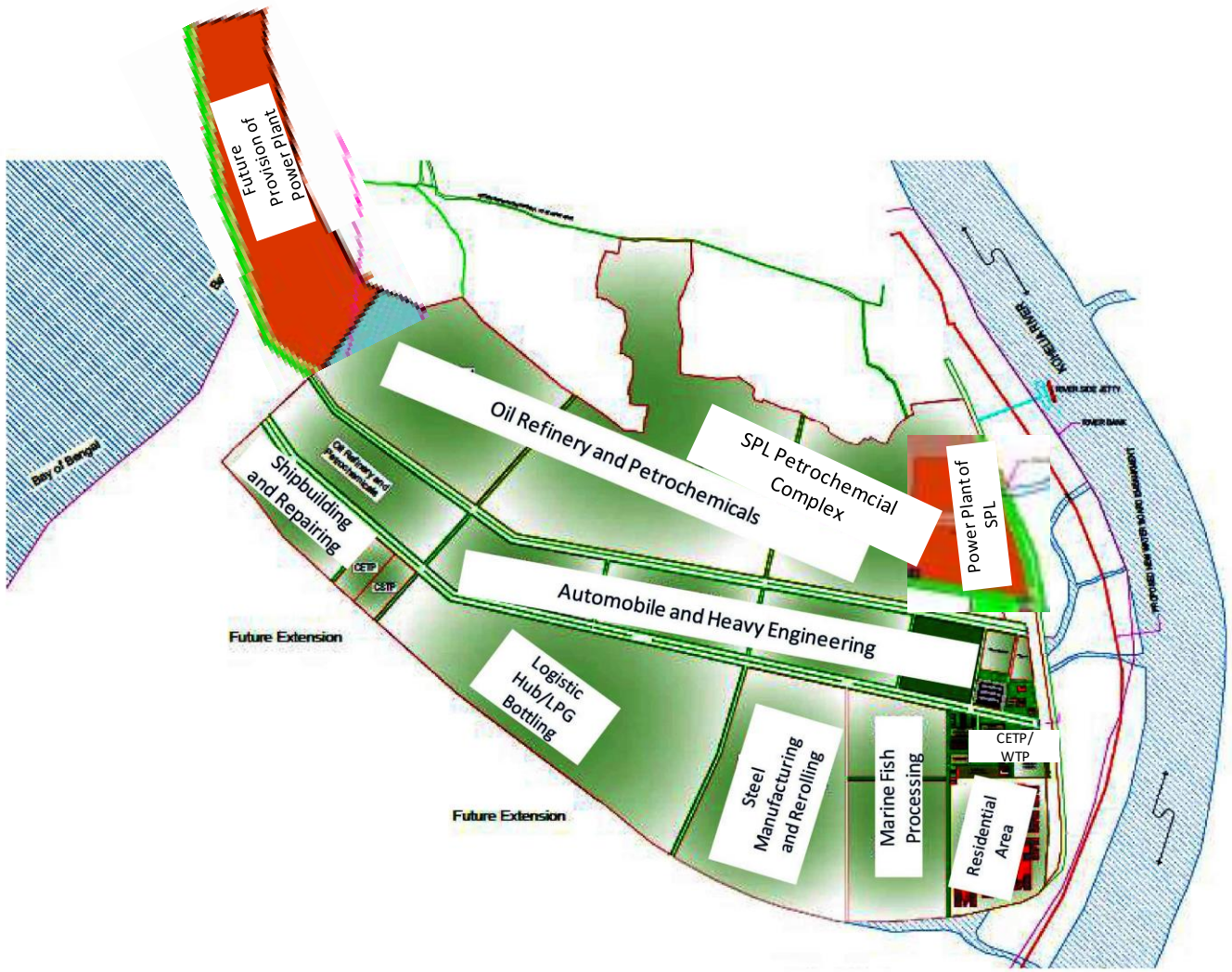
13.9.6.2 References

[1] A. Cotter, The Authentic History of the United States Steel Corporation (Moody Magazine and Book Company, 1916).
[2] R. J. Fruehan, The Making, Shaping and Treating of Steel (AISE Steel Foundation, 1999) pp. 1-35.

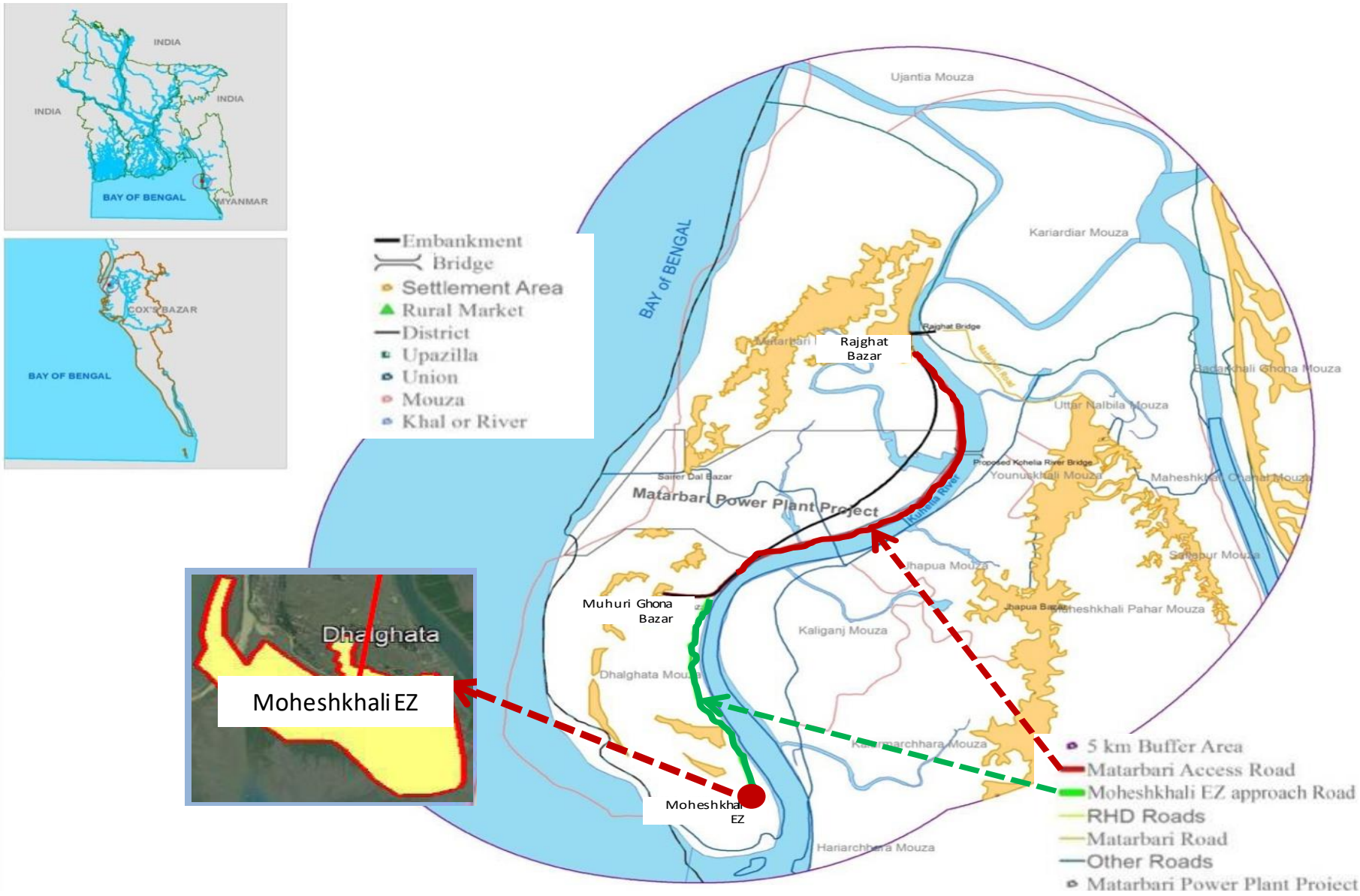
[3] E. Worrell et al. "Energy Efficiency Improvement and Cost Saving Opportunities for the U.S. Iron and Steel Industry, " LBNL-4779E, October 2010.
[4] R. J. Fruehan et al., "Theoretical Minimum Energies to Produce Steel, " Energetics, Inc., March 2000.
[5] P. D. Desai, "Thermodynamic Properties of Iron and Silicon, " J. Phys. Chem. Ref. Data 15, 967 (1986).
[6] "Annual Energy Outlook 2016, " U.S. Energy Information Administration, DOE/EIA-0383(2016), August 2016.

13.10 A10: Master Plan and Engineering Drawings

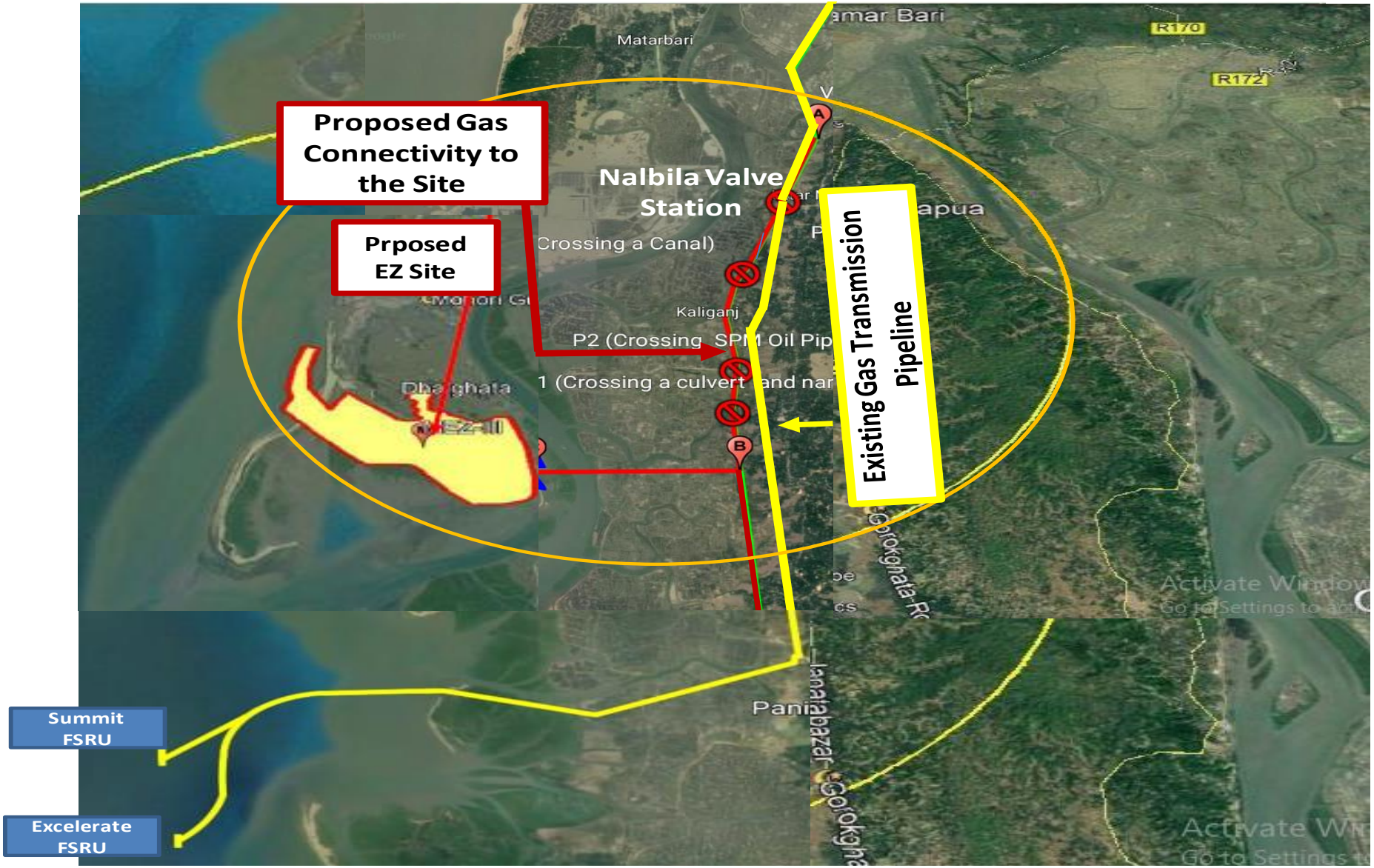
13.10.1 Zone



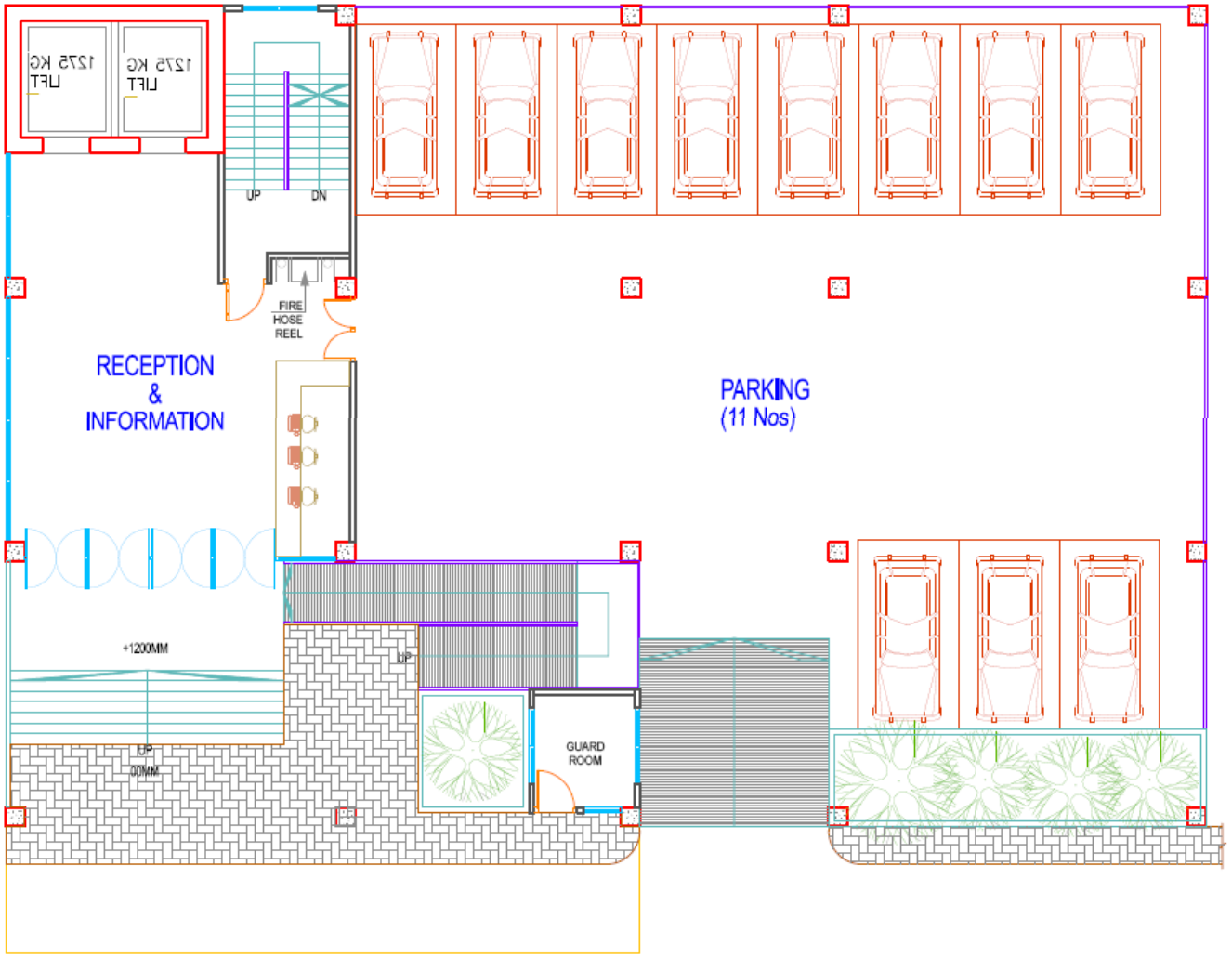
13.10.2 Approach Road



13.10.3 Gas Pipeline Route

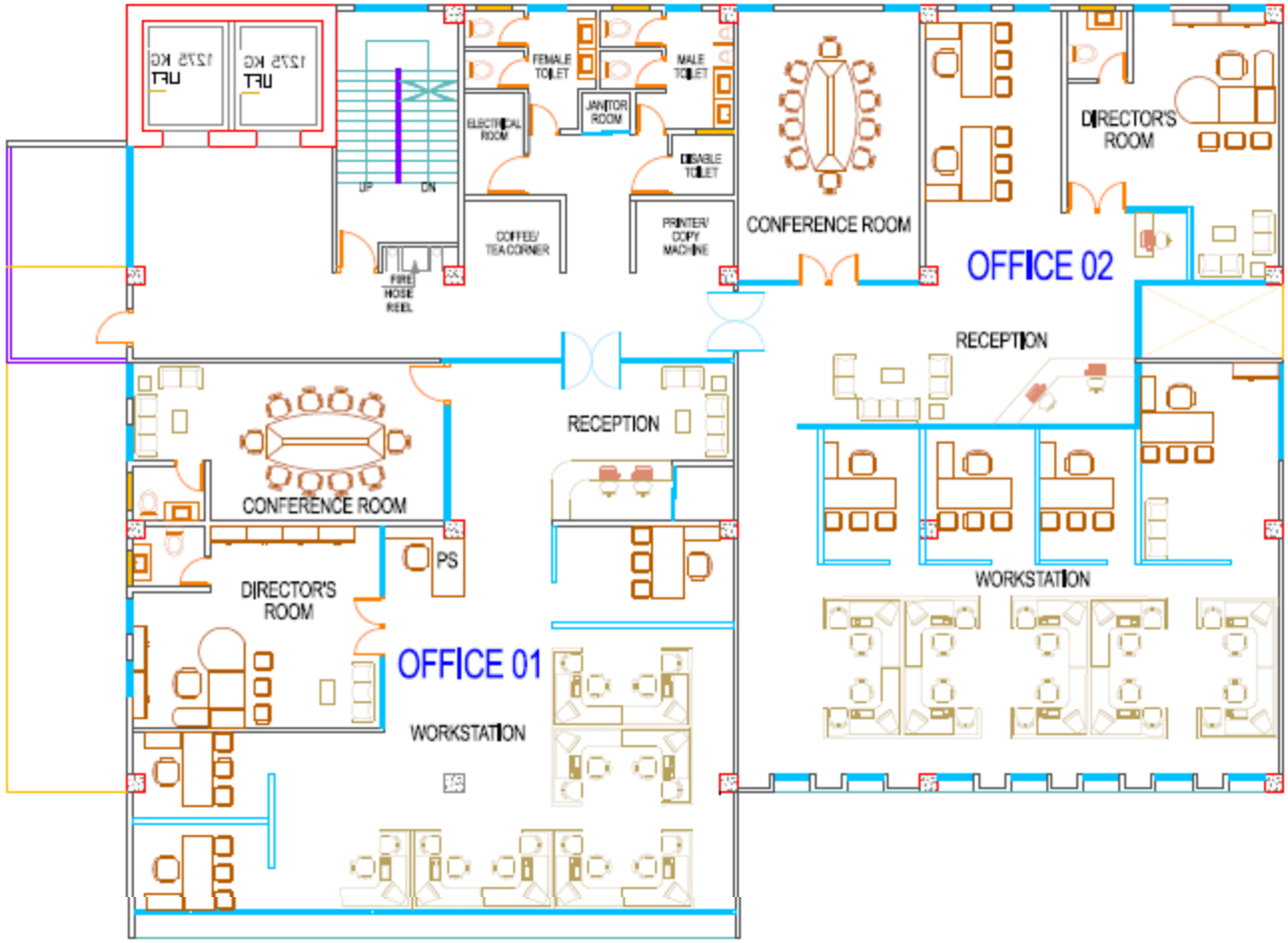


13.10.4 Admin Building



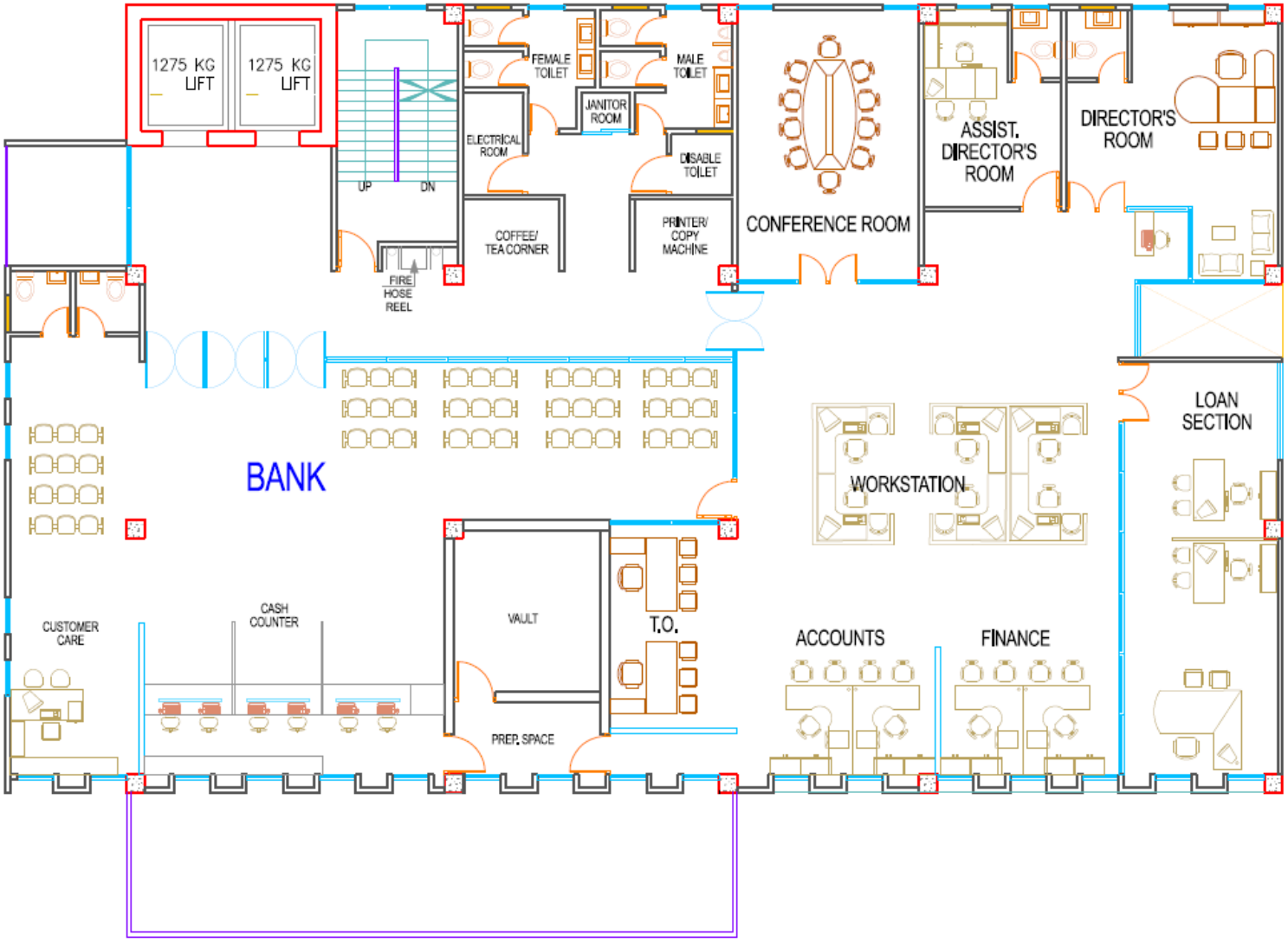
GROUND FLOOR PLAN

AREA - 558 SQ.M



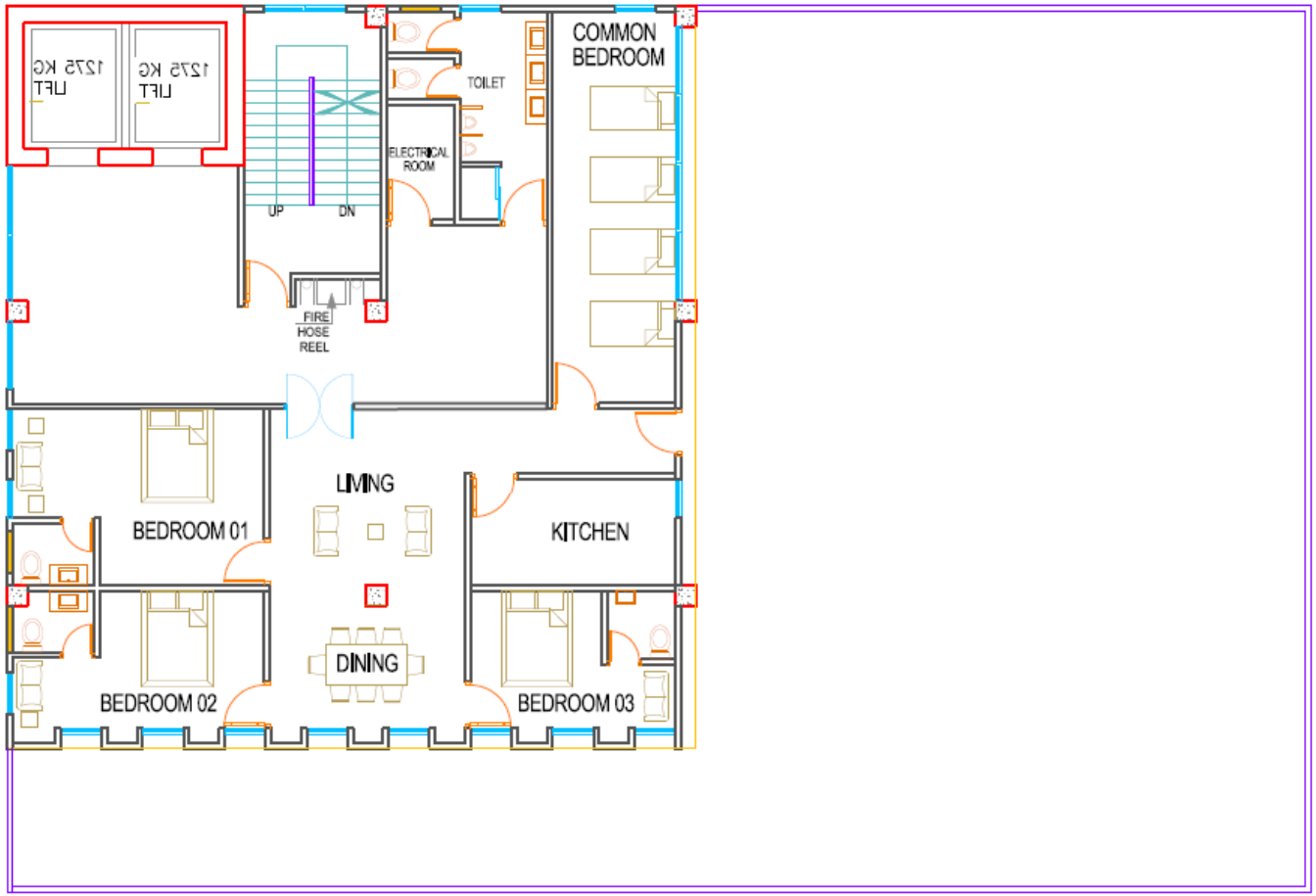
FIRST FLOOR PLAN

AREA - 612.6 SQ.M



SECOND FLOOR PLAN

AREA - 597 SQ.M



ROOF PLAN

AREA - 243 SQM

13.11 A11: Utility Requirement

13.11.1 Oil Refinery

Process	Process Feed	Energy requirement			
		Fuel		Electricity	
	% of Crude	10^3 BTU/Barrel to Feed Process	10^3 BTU/Barrel Crude Oil	10^3 BTU/Barrel to Feed Process	10^3 BTU/Barrel Crude Oil
Desalting	80%	0.05	0.04	0.6	0.48
Atm. Distillation	100%	80	80	6	6
Vac. Distillation	35.2%	75	26.4	3	1.056
Gas separation	10.0%	0	0	1.8	0.18
Cracking			0		0
Thermal	1.4%	700	9.8	15	0.21
Visbreaking	1.4%	160	2.24	10	0.14
Coking			0		0
Delayed	5.7%	80	4.56	70	3.99
Fluid	0.8%	0	0	15	0.12
Catalytic					
Fluid	26.5%	0	0	0.88	0.23
Gas IIFC	2.4%	140	3.36	22	0.528
Hydrocracking					
W/O Hydrogen	5.4%	200	10.8	100	5.4
W Hydrogen	5.4%	588	31.752	119	6.426
Reforming					0
Cyclic					0
W/O Hydrogen	6.0%	280	16.8	50	3
W Hydrogen	6.0%	2	0.12	36	2.16
Semi regenerative					0
W/O Hydrogen	15.2%	355	53.96	75	11.4
W Hydrogen	15.2%	189	28.728	67	10.184
Hydrorefining					
W/O Hydrogen	6.4%	73	4.672	22	1.408
W Hydrogen	6.4%	228	14.592	30	1.92
Hydrotreating					
W/O Hydrogen	29.9%	39	11.661	14	4.186
W Hydrogen	29.9%	106	31.694	17	5.083
Alkylation					
H2SO4	3.4%	100	3.4	48	1.632
HF	2.0%	13	0.26	15	0.3
Isomerization					
C4 Feed	0.5%	32	0.16	12	0.06
C5/C6 feed	0.2%	42	0.084	15	0.03
Miscellaneous				20.9	20.9

[Source: Energy Use in Petroleum Refineries; VO Hayness, OAK Ridge National Laboratory, Union Carbide Corporation, National Technical Information Service, US Department of Commerce]

Calculation of Power Requirement

		87.025	10^3BTU/Barrel Crude Oil
		87,025	BTU/Barrel Crude Oil
Conversion Factor		3412.14	BTU/kwh
Power Requirment Rate		25.50	kwh/barrel crude oil
Bashundhara Refinery Project (at Mirsarai)			
	Area	220	acre
	Capacity	100,000	barrel crude oil/day
		300	days/year
		30,000,000	barrel crude oil/year
Power Requirement		765,139,673	kwh/year
Operating hours in a year		7200	hrs/year
		106,269.40	KW
		106.27	MW
		0.48	MW/acre

Calculation of Gas Requirement

		335	10^3BTU/barrel crude oil
(for refining crude oil)		335,000	BTU/barrel crude oil
Gas (equivalent energy)		0.0353	mmBtu/m^3 gas as fuel
		35,300	BTU/m^3 gas as fuel
Gas requirement Rate (as fuel)		9.49	m^3 gas as fuel/barrel crude oil
Bashundhara Refinery Project (at Mirsarai)			
Area		220	acre
Capacity		100,000	barrel crude oil/day
Gas Requirement (in Bashundhara Refinery)		949,008	m3 gas as fuel/day
		4,314	m3/day/acre
Conversion Factor		35.31	cubic foot/m3
		33.514	mmcfd (or million cubic foot per day)
		0.152	mmcfd/acre

1,037	Btu/cubic foot
29.36454	BTU/m3

13.11.2 Shipbuilding and Repairing

Reference Shipyards/Dockyards	Ship Built or Repaired	Area	Avg. DWT	Avg. LWT	Steel Required	
	/year	acre	ton	ton	ton/ year	ton/acre / year
Western Marine Shipyard 2019-2020 (New Building)	8	22.9	2380	580	4,640	202.62
FMC Dockyard Ltd (Repair)	15	17.03	1800	420	6,300	369.94
Dockyard and Engineering works Ltd (Repair)	10	21.5	1600	380	3,800	176.74
Chattogram Dry Dock Ltd (Repair)	18	38.2	2000	450	8,100	212.04
Average		**24.91**			**5,710**	**240.34**

13.11.2.1 Calculation of Power Requirement

Electricity Requirement 96 Kwh/ton

[Source: Energy Consumption and Conservation in Ship Building;
Ch. Rasjeshwar Harish, Soumya K. Sunil; Indian Maritime University]

Steel consumption	240.34	ton/acre/year
Electricity Consumption	23,072	Kwh/acre/year
Operating hours in a year	7,200	hrs/year
Load Factor	0.75	
Power Requirement	4.27	KW/Acre
Land	24.91	acre
	0.0043	MW/acre

13.11.2.2 Calculation of Gas Requirement

Gas Consumption	10	kg/ton	[Source: Same as above]
Steel Consumption	5,710	ton/year	
	57,100	Kg/year	
	31,177	m^3/year	[1.8315 kg/m3]
Operating days in a year	300	days/year	
Gas Requirment	103.92	m^3/day	
	4.17	m^3/day/acre	

13.11.3 Steel Rerolling

13.11.3.1 Calculation of Power Requirement

Reference Steel Plant:BSRM	816,494	ton/year	
Electricity Bill	4,225,000,000	৳/year	
	8.55	৳/kwh	BERC
	494,152,046.78	kwh/year	
	605.21	kwh/ton	
	1,749	ton/year/acre	
	466.76	acre	
	5,400	hrs/year	
	91,509.64	kw	
	91.51	MW	
	0.196	MW/acre	
Land	1,715	acres	
Steel Amount	3,000,000	ton/year	

http://steel.gov.in/sites/default/files/ru440.doc#:~:text=
Total%20land%20requirement%20for%203,cost%20for%203%
20mtpa%20%E2%80%93%20Rs.

13.11.3.2 Calculation of Gas Requirement

Gas Bill	316,000,000	৳/year	
	10.7	৳/m^3	BERC

29,532,710	$m^{3/}$year
300	days/year
98,442	m^3/day
211	m^3/day/acre

13.11.4 Steel Manufacturing

Reference Steel Plant:

Land	1,715	acres
Capacity	3,000,000	ton/year

Source: http://steel.gov.in/sites/default/files/ru440.doc#:~:text=Total%20land%20requirement%20for%203,cost%20for%203%20mtpa%20%E2%80%93%20Rs.

13.11.4.1 Power Requirement

Production Capacity (reference plant)	3,000,000	ton/year
Energy Requirement	2,250,000	kj/ton
	3,600	kj/kwh
Power Requirement	625	kwh/ton
	1,715	acre
	1,875,000,000	kwh/year
	5,400	hrs/year
	347,222.22	kw
	347.2222	MW
	0.202	MW/acre

[Source: Energy Use in US Steel Manufacturing; Micolas Martelaro; Stanford University]

Energy Use in US Steel Manufacturing

Nikolas Martelaro
December 4, 2016

Submitted as coursework for PH240, Stanford University, Fall 2016

Introduction

The US steel industry has been a cornerstone of American manufacturing since the Industrial Revolution. Andrew Carnegie and Carnegie Steel helped to industrialize the Bessemer process for steel manufacture. With the possibility for newly minted wealth to be had, there was a rise in many steel making companies, all competing against each other to increase their tonnage of steel production. [1] These companies would later be consolidated by J.P. Morgan into the near monopoly of US Steel. While the story of US steel is often one of tenacious industrialists, it is also a story of the utilization of America's vast energy reserves for the creation of manufactured goods. Without the abundant natural

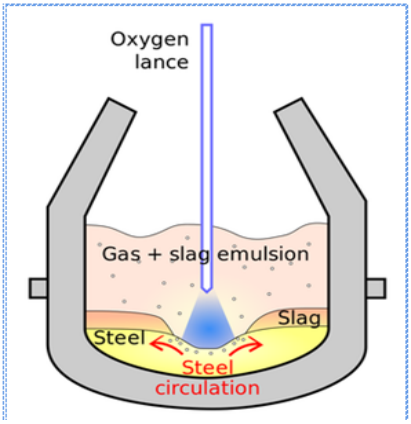


Table 13.7: Estimated Energy Costs for Steel Production

Production Process	Energy Required (Joules per ton)	Energy Source	Energy Cost per Joule	Energy Cost per ton	Percent Total Cost
Pig Iron	13.5×10^9	Coal	$\$2.37 \times 10^{-9}$	$31.98	6%
Basic Oxygen Furnace	11×10^9	Coal	$\$2.37 \times 10^{-9}$	$26.06	5%
Basic Oxygen Furnace	13.5×10^9	Natural Gas	$\$2.37 \times 10^{-9}$	$31.98	6%
Electric Arc Furnace	2.25×10^9	Electricity	$\$1.94 \times 10^{-8}$	$43.74	8%
Pig Iron + BOF	24.5×10^9	Coal	-	$58.05	11%

13.11.4.2 Gas Requirement

Production Capacity (reference plant)	3,000,000	ton/year
Energy Requirement	13,500,000	kj/ton
	40,500,000,000,000	kj/year
Energy Content in Gas	38.3	mj/m3
Gas Requirement	38,300	kj/m3
	1,057,441,253	m3/year
	300	days/year
	3,524,804	m3/day
	2055	m3/day/acre

13.11.5 Automobile and Heavy Engg

13.11.5.1 Power Requirement

Electricity Consumption	700	kwh/vehicle
Reference Factory:	6	acres
	5,000	vehicles/year
	3,500,000	kwh/year
	7200	hrs/year
Load Factor	83%	
Power Requirement	583	kw
	0.58	MW
	0.097	MW/acre

Source: An Empirical Study of the Energy Consumption in Automotive Assembly A. Fysikopoulosa , D. Anagnostakisa , K. Salonitisa , G. Chryssolourisa,*
"According to Bhaskar et al. , the manufacturing of a car (Press, body, paint and assembly shops) may consume up to 700kwh/vehicle."

A brief look at the auto industry in Bangladesh, The Daily Star, 5 January 2022
"Fair Technology Limited, the sole distributor of Hyundai cars in Bangladesh, is the most recent car company to make moves toward local production.
The company signed a contract with Bangladesh Hi-Tech Park Authority (BHTPA) to establish an assembly plant on six acres of land.

The company plans to invest $125 million in the next three to five years to set up a plant capable of churning out 5,000 vehicles a year."

13.11.6 LPG Bottling

13.11.6.1 Power Requirement

1.1	Reference Plant (Bharat Petroleum Corporation):		
1.1.1	Capacity	44,000	ton LPG/year
1.1.2	Power Requirement	250	KVA
		0.8	KW/KVA
		200	KW
1.1.3	Load Factor	0.93	
		7,200	hours/year
1.1.4	Electricity Requirement	1,339,200	kWh/year
		30	kWh/ton
1.2	Reference Plant (Bangladesh Petroleum Corporation):		
1.2.1	Area	4	hectare
		2.47105	acre/hectare
		9.8842	acre
1.2.2	Capacity	100,000	ton LPG/year
1.2.3	Electricity Requirement	3,043,636	kWh/year
		7200	hours/year
1.2.4	Load Factor	0.93	
1.2.5	Power Requirement	454.55	kW
		46	kW/acre
		0.046	MW/acre

13.11.6.2 Gas in Bottles (not part of the main gas grid)

2.1	Reference Plant (Bangladesh Petroleum Corporation):		
2.1.1	Capacity	100,000	ton LPG/year
2.1.2	Area	9.884	acre
2.1.3	Conversion Factor	868	tons LPG/million m3
		1,152	m3/ton LPG
2.1.4	Gas Consumption	115,207,373	m3/year
2.1.5	Operating Days in a year	300	days/year
		384,025	m3/day
		38,852	m3/day/acre

Source: Market Research.com

(1) "Bangladesh Petroleum Corporation (BPC) is planning to build a LPG bottling plant in Chattogram, Bangladesh.

The project involves the construction of a LPG bottling plant with a capacity of 100,000 TPA on 4ha of land. It includes the construction of storage tanks, a jetty and related infrastructure, the installation of machinery, and the laying of pipelines between the jetty and the bottling plant."

(2)Project Feasibility Report for the proposed LPG Bottling Plant at Tilda, Raipur
Bharat Petroleum Corporation Limited

"BPCL proposes to provide NEW 44 TMTPA LPG Bottling Plant conforming to OISD 144 with LPG Storage in the form of 3 x 300 MT Mounded Storage Vessels which will be distributed through LPG Cylinders in entire Chhattisgarh Region. DG Sets of capacity 1 x 250 KVA and 1 x 125 KVA having acoustic enclosures will be provided adjoining to MCC room in open shed.250 KVA set will be used for full load plant operation while 125 KVA unit will take care of light load and emergency power requirement."

(3)LPG Bottling Plant Case Study in Energy Savings

https://pdfcookie.com/documents/lpg-bottling-plant-case-study-in-energy-savings-eg27ppzqo320
"Improving and maintaining the power factor from 0.93 to near unity by providing additional capacitors having kVAh billing system."

13.11.7 Fish Processing

13.11.7.1 Power Requirement

1.1	Electricity Consumption per ton	307.75	MJ/ton
		3.6	MJ/kWh
		85.49	kWh/ton
1.2	Reference Factory: MU Sea Foods, Jashore		
1.3	Area	50,000	sft
		43,560	sft/acre
		1.15	acre
1.4	Capacity	1,500	tons/year
1.5	Electricity Consumption	128,229	kwh/year
		7,200	hrs/year
1.6	Load Factor	80%	
		22	KW
		0.02	MW
		0.019	MW/acre

13.11.7.2 Gas Requirement

2.1	Fuel Energy Requirement	787.75	MJ/ton product
		38.61	MJ/m3 gas
2.2	Gas Requirement	20.40	m3 gas/ton
		30,604	m3/year
2.3	Operating Days in a Year	300	days/year
		102	m3/day
		89	m3/day/acre

794

Table 2 Energy use for production of different food products in the Netherlands in 2001 (adapted from Ramirez et al. 2006a)

Product	Specific electricity consumption	Specific fuels and heat consumption	Unit
Meat sector			
Beef and sheep	341	537	MJ/t dress carcass weight
Pig	465	932	MJ/t dress carcass weight
Poultry	1,008	576	MJ/t dress carcass weight
Processed meat	750	3,950	MJ/t product
Rendering	234	1,042	MJ/t raw material
Fish sector			
Fresh fillets	129	6	MJ/t product
Frozen fish	608	6	MJ/t product
Prepared and preserved fish	482	1,062	MJ/t product
Smoked and dried fish	12	2,077	MJ/t product
Fish meal	684	6,200	MJ/t product
Fruits and vegetable			
Potato product	5,722	MJ/t product	
Un-concentrated juice	250	900	MJ/t product
Tomato juice	125	4,789	MJ/t product
Frozen vegetables and fruits	738	1,800	MJ/t product
Preserved mushrooms	2,898	MJ/t product	
Vegetables preserved by vinegar	2,178	MJ/t product	
Tomato ketchup	380	1,700	MJ/t product
Jams and marmalade	490	1,500	MJ/t product
Dried vegetables and fruits	1,500	4,500	MJ/t product
Crude and refined oil	672	MJ/t product	

Source:"Energy Efficiency Technologies for Sustainable Food Processing," Lijun Wang https://d1wqtxts1xzle7.cloudfront.net/55500096/s12053-014-9256-8-with-cover-page-v2.pdf?

13.11.7.3 Water Requirement

		35.3	m3/ton product
	52,950		m3/year
		300	days/year
	176.50		m3/day
		153.7668	m3/day/acre

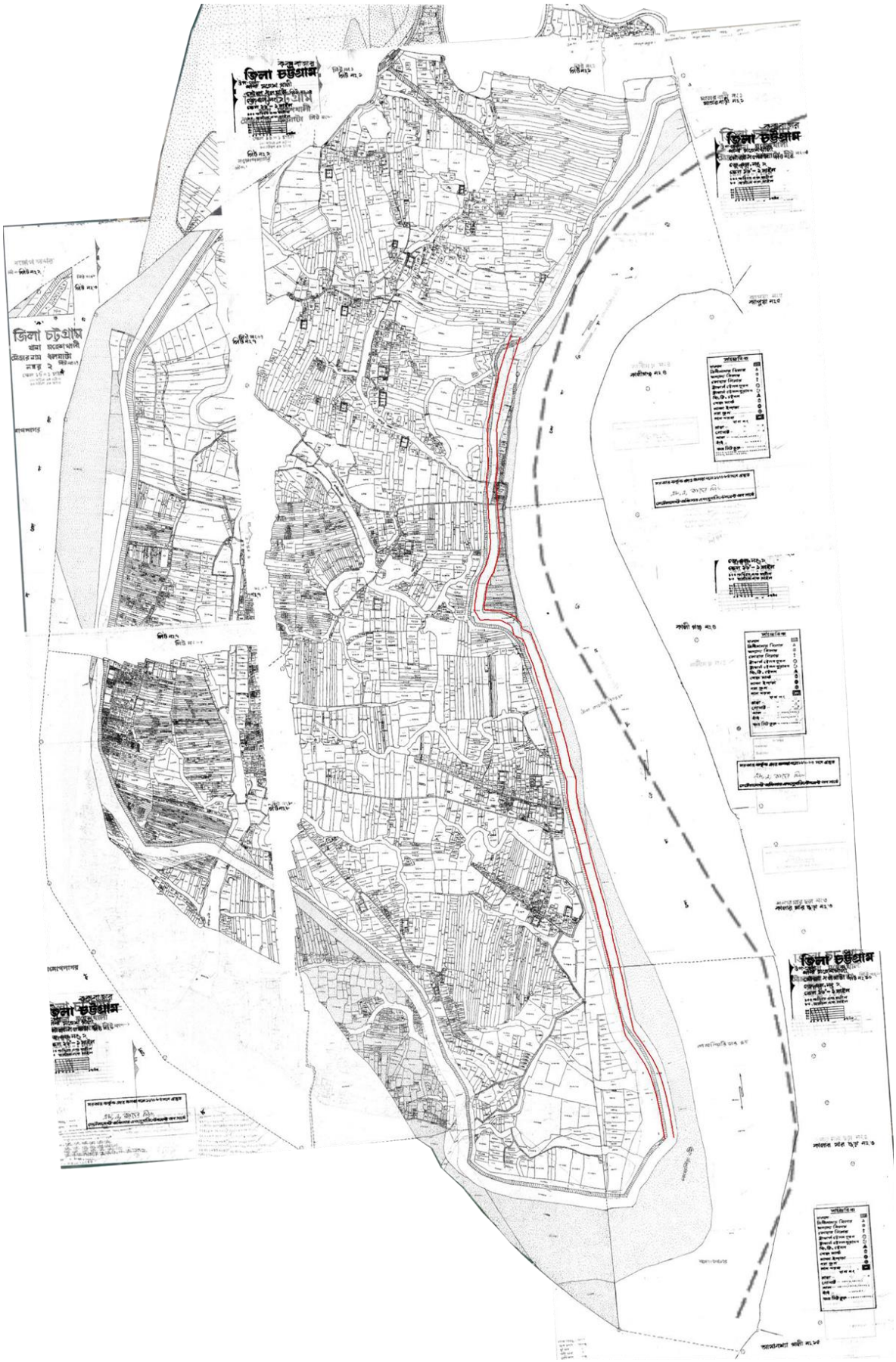
Source: Reducing water use in fish and seafood processing, Adana, Turkey https://www.waterscarcitysolutions.org/wp-content/uploads/2016/02/A-Reducing-Water-Consumption-in-Fish-Processing.pdf

13.12 A12: Indicative List of Mouzas and Dags Falling on the Alignment of Approach Road and Gas Transmission Pipeline

13.12.1 Approach Road (land to be acquired)

Name of Upazila	Name of Union	Mouza	Dag Number[5]	Land Type	Mouza Rate (৳ per decimal)
Moheshkhali	Dhalghata	Dhalghata 4	84	Salt Field	4,909
		Dhalghata 4	85	Salt Field	4,909
		Dhalghata 3	2003	Salt Field	4,909

Figure A 13.1: Mouza Map Superimposed on the Alignment of Approach Road



IIFC

13.12.2 List of Mouzas and Dags Falling on the Alignment of Gas Transmission Pipeline

Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
Moheshkhali	Kalarmarchar	Kalarmarchar 4	5062	Salt Field	4,385
		””	5043	””	4,385
		””	5042	””	4,385
		””	725	””	4,385
		””	5079	””	4,385
		””	5112	””	4,385
		””	5114	””	4,385
		””	5203	””	4,385
		””	5118	””	4,385
		””	5228	””	4,385
		””	5244	””	4,385
		””	5251	””	4,385
		””	5718	””	4,385
		””	5334	””	4,385
		Kalarmarchar 5	6663	””	4,386
		””	6664	””	4,387
		””	6665	””	4,388
		””	6666	””	4,389
		””	6667	””	4,390
		””	6668	””	4,391
		””	6662	””	4,392
		””	6661	””	4,393
		””	7906	””	4,394
		””	3333	””	4,395
		””	3332	””	4,396
		””	3331	””	4,397
		””	3331	””	4,398
		””	3330	””	4,399
		””	2019	””	4,400
		””	1818	””	4,401
		””	1616	””	4,402
		””	1515	””	4,403
		””	1111	””	4,404
		””	6610	””	4,405
		””	6608	””	4,406
		””	6606	””	4,407
		””	6603	””	4,408
		””	6602	””	4,409
		””	1918	””	4,410
		””	3597	””	4,411
		””	9292	””	4,412
		””	9593	””	4,413
		””	6587	””	4,414
		””	7876	””	4,415
		””	6581	””	4,416
		””	6580	””	4,417
		””	7879	””	4,418
		””	7878	””	4,419
		””	6575	””	4,420
		””	6576	””	4,421
		””	6574	””	4,422

[6] 16.79 acres of land is to be acquired for the gas transmission pipeline on the dags mentioned.

Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
		“”	6560	“”	4,423
		Kalarmarchar 3	6561	“”	4,424
		“”	2622	“”	4,425
		“”	3066	“”	4,426
		“”	2671	“”	4,427
		“”	2648	“”	4,428
		“”	4119	“”	4,429
		“”	2647	“”	4,430
		“”	2646	“”	4,431
		“”	3119	“”	4,432
		“”	2642	“”	4,433
		“”	2639	“”	4,434
		“”	2638	“”	4,435
		“”	2637	“”	4,436
		“”	2636	“”	4,437
		“”	2634	“”	4,438
		“”	2633	“”	4,439
		“”	2632	“”	4,440
		“”	2019	“”	4,441
		“”	2442	“”	4,442
		“”	2014	“”	4,443
		“”	2012	“”	4,444
		“”	2011	“”	4,445
		“”	4016	“”	4,446
		“”	4115	“”	4,447
		“”	2019	“”	4,448
		“”	4021	“”	4,449
		“”	1966	“”	4,450
		“”	4006	“”	4,451
		“”	4011	“”	4,452
		“”	4008	“”	4,453
		Kalarmarchar 1	532	“”	4,454
		“”	530	“”	4,455
		“”	519	“”	4,456
		“”	525	“”	4,457
		“”	520	“”	4,458
		“”	5180	“”	4,459
		“”	526	“”	4,460
		“”	523	“”	4,461
		“”	522	“”	4,462
		“”	521	“”	4,463
		“”	513	“”	4,464
		“”	515	“”	4,465
		“”	473	“”	4,466
		“”	437	“”	4,467
		“”	512	“”	4,468
		“”	503	“”	4,469
		“”	472	“”	4,470
		“”	441	“”	4,471
		“”	440	“”	4,472
		“”	438	“”	4,473
		“”	475	“”	4,474
		“”	4794	“”	4,475
		“”	435	“”	4,476
		“”	434	“”	4,477
		“”	433	“”	4,478
		“”	406	“”	4,479
		“”	399	“”	4,480

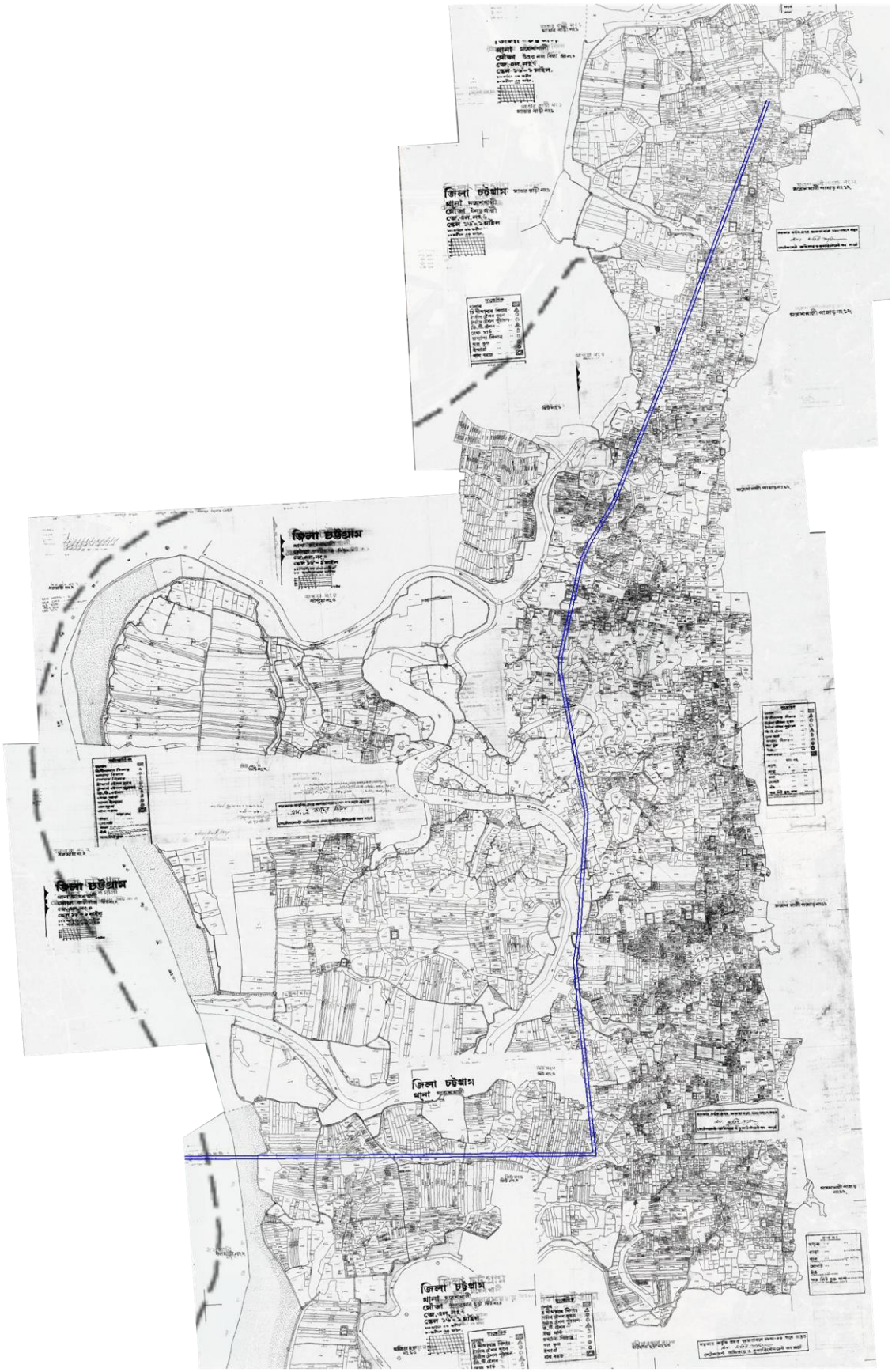
Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
		“”	997	“”	4,481
		“”	396	“”	4,482
		“”	395	“”	4,483
		“”	394	“”	4,484
		Jhapua 4	4099	“”	4,485
		“”	4121	“”	4,486
		“”	4120	“”	4,487
		“”	4127	“”	4,488
		“”	4156	“”	4,489
		“”	4154	“”	4,490
		“”	4153	“”	4,491
		“”	4152	“”	4,492
		“”	4149	“”	4,493
		“”	4148	“”	4,494
		“”	4147	“”	4,495
		“”	4146	“”	4,496
		“”	4146	“”	4,497
		“”	4185	“”	4,498
		“”	4186	“”	4,499
		“”	4194	“”	4,500
		“”	4141	“”	4,501
		“”	4205	“”	4,502
		“”	4210	“”	4,503
		“”	4214	“”	4,504
		“”	4215	“”	4,505
		“”	4231	“”	4,506
		“”	4234	“”	4,507
		“”	4244	“”	4,508
		“”	4239	“”	4,509
		“”	4238	“”	4,510
		Jhapua 3	3051	“”	4,511
		“”	3052	“”	4,512
		“”	3050	“”	4,513
		“”	3031	“”	4,514
		“”	3030	“”	4,515
		“”	3012	“”	4,516
		“”	3014	“”	4,517
		“”	2920	“”	4,518
		“”	2995	“”	4,519
		“”	2926	“”	4,520
		“”	2924	“”	4,521
		“”	2927	“”	4,522
		“”	2956	“”	4,523
		“”	2955	“”	4,524
		“”	2952	“”	4,525
		“”	2944	“”	4,526
		“”	2943	“”	4,527
		“”	2951	“”	4,528
		“”	2992	“”	4,529
		“”	2790	“”	4,530
		“”	2791	“”	4,531
		“”	2797	“”	4,532
		“”	2800	“”	4,533
		“”	2799	“”	4,534
		“”	2811	“”	4,535
		“”	2890	“”	4,536
		“”	2881	“”	4,537
		“”	2739	“”	4,538

Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
		“”	2767	“”	4,539
		“”	2464	“”	4,540
		“”	2662	“”	4,541
		“”	2697	“”	4,542
		“”	2695	“”	4,543
		“”	2701	“”	4,544
		“”	2704	“”	4,545
		“”	2708	“”	4,546
		“”	2705	“”	4,547
		“”	2683	“”	4,548
		“”	2313	“”	4,549
		“”	2314	“”	4,550
		“”	2310	“”	4,551
		“”	2309	“”	4,552
		“”	2308	“”	4,553
		“”	2329	“”	4,554
		“”	2330	“”	4,555
		“”	2331	“”	4,556
		“”	2332	“”	4,557
		“”	2336	“”	4,558
		“”	2337	“”	4,559
		“”	2338	“”	4,560
		“”	2292	“”	4,561
		“”	2293	“”	4,562
		“”	2270	“”	4,563
		“”	2295	“”	4,564
		“”	2285	“”	4,565
		“”	3167	“”	4,566
		“”	3266	“”	4,567
		“”	2281	“”	4,568
		“”	2280	“”	4,569
		Uttar Nalbila 3	203	“”	4,570
		“”	201	“”	4,571
		“”	200	“”	4,572
		“”	199	Nul	19,743
		“”	207	“”	19,743
		“”	198	“”	19,743
		“”	208	“”	19,743
		“”	216	“”	19,743
		“”	117	“”	19,743
		“”	223	“”	19,743
		“”	224	“”	19,743
		“”	227	“”	19,743
		“”	226	“”	19,743
		“”	259	“”	19,743
		“”	261	“”	19,743
		“”	260	“”	19,743
		“”	256	“”	19,743
		“”	255	“”	19,743
		“”	236	“”	19,743
		“”	160	“”	19,743
		“”	152	“”	19,743
		“”	153	“”	19,743
		“”	154	“”	19,743
		“”	155	“”	19,743
		“”	121	“”	19,743
		“”	124	“”	19,743
		“”	126	“”	19,743

Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
		“”	123	“”	19,743
		“”	105	“”	19,743
		“”	118	“”	19,743
		“”	117	“”	19,743
		“”	116	“”	19,743
		“”	115	“”	19,743
		“”	114	“”	19,743
		“”	113	“”	19,743
		“”	46	“”	19,743
		“”	436	“”	19,743
		“”	449	“”	19,743
		“”	448	“”	19,743
		“”	447	“”	19,743
		“”	446	“”	19,743
		“”	443	“”	19,743
		“”	445	“”	19,743
		“”	450	“”	19,743
		“”	455	“”	19,743
		“”	1284	“”	19,743
		“”	1285	“”	19,743
		“”	1287	“”	19,743
		“”	1266	“”	19,743
		“”	1288	“”	19,743
		“”	1308	“”	19,743
		“”	1290	“”	19,743
		“”	1321	“”	19,743
		“”	1292	“”	19,743
		“”	1293	“”	19,743
		“”	1294	“”	19,743
		“”	2342	“”	19,743
		“”	1325	“”	19,743
		“”	1326	“”	19,743
		“”	1329	“”	19,743
		“”	1328	“”	19,743
		“”	1327	“”	19,743
		“”	1330	“”	19,743
		“”	1331	“”	19,743
		“”	1366	“”	19,743
		“”	1402	“”	19,743
		“”	1253	“”	19,743
		“”	1252	“”	19,743
		“”	1404	“”	19,743
		“”	1408	“”	19,743
		“”	1404	“”	19,743
		“”	1393	“”	19,743
		“”	1409	“”	19,743
		“”	1417	“”	19,743
		“”	1415	“”	19,743
		“”	1416	“”	19,743
		“”	1447	“”	19,743
		“”	1448	“”	19,743
		“”	1454	“”	19,743
		“”	1453	“”	19,743
		“”	1483	“”	19,743
		“”	1485	“”	19,743
		“”	1530	“”	19,743
		“”	1529	“”	19,743
		“”	1527	“”	19,743

Name of Upazila	Name of Union	Mouza	Dag Number[6]	Land Type	Mouza Rate (৳ per decimal)
		“”	1526	“”	19,743
		“”	1426	“”	19,743
		“”	1525	“”	19,743
		“”	1520	“”	19,743
		“”	1515	“”	19,743
		“”	1514	“”	19,743
		“”	1510	“”	19,743
				Avg. Rate	**9,158.93**

Figure A 13.2: Mouza Map Superimposed on the Alignment of Gas Transmission Pipeline



13.13 A13: Cost Estimates with Unit Rates

13.13.1 Approach Road

Summary

	Description	Magnitude	Unit	Unit Rate	Amount
				৳/decimal	৳ lakh
1	Land Acquisition	0.8951	acre	14,727	13.18
2	General & Site Facilities				492
3	Earthwork				7,489
4	Pavement Work				2,520
5	Incidentals				6,626
Subtotal					**17,140**
Sluice Gates		8		48,500,000	**3,880**
Additional expense for remote area					**1,050**
Total					**22,070**

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
General and Site Facilities					
Divisions 1: General and Site Facilities					
1.1.1	Maintenance and Protection of Traffic	30	mon	70, 000	21.00
1.2.1a	Provide Engineers Permanent Office Building	300	sqm	12, 000	36.00
1.2.1b	Provide Semi-permanent Engineers Office Building	200	sqm	8, 000	16.00
1.2.1b(i)	Provide Semi-permanent Engineers Residential Accommodation.	450	sqm	800	3.60
1.2.1c	Provide Semi-permanent Engineers Field Laboratory Building	100	sqm	8, 000	8.00
1.2.1d	Provide Inspection Hut	1		500, 000	5.00
				Subtotal	**90**
Division 1: General and Site Facilities					
1.2.2	**Maintenance and Service Buildings**				
1.2.2a	Maintain and Service Engineer's Permanent Office	30	mon	60, 000	18.00

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
1.2.2b	Maintain and Service Semi-Permanent Engineer's Field office	30	mon	50, 000	15.00
1.2.2b	Maintain and Service Semi-Permanent Engineer's Residential Accommodation	30	mon	50, 000	15.00
1.2.2c	Maintain and Service Semi-Permanent Engineer's Field Laboratory	24	mon	50, 000	12.00
1.2.2d	Maintain and Service Inspection Hut	24	mon	30, 000	7.20
				Subtotal	**67**
Division 1: General and Site Facilities					
1.2.3	**Furnish and Equip**				
1.2.3a	Furnish and Equip Engineer's Permanent Office		PS	4, 000, 000	40.00
1.2.3b	Furnish and Equip Semi-permanent Engineer's Field office		LS	3, 000, 000	30.00
1.2.3b	Furnish and Equip Semi-permanent Engineer's Residential Accommodation		LS	1, 000, 000	10.00
1.2.4a	Maintain Office Furniture and Equipment and Supply of Office Consumables for Engineer's Permanent Office	30	mon	20, 000	6.00
				Subtotal	**86**
Division 1: General and Site Facilities					
1.2.4b	Maintain Office Furniture and Equipment and Supply of Office Consumables for Semi-Permanent Engineer's Field Office	30	mon	20, 000	6.00
1.2.4c	Maintain Furniture and Equipment and Supply of Consumables for Semi-Permanent Engineer's Accommodation.	30	mon	15, 000	4.50
1.2.4d	Maintain Office Furniture and Equipment and Supply of Office Consumables for Semi-Permanent Engineer's Laboratory	24	mon	10, 000	2.40
1.2.6	**Engineer's Communication**				
1.216a	Provide and Maintain Land Phones	30	mon	10, 000	3.00
				Subtotal	**16**
Division 1: General and Site Facilities					
112.6b	Provide and Maintain Mobile Telephone	30	mon	20, 000	6.00
1.2.6c	Provide and Maintain Internet Service	30	mon	5, 000	1.50
1.3.1	Provide and remove site laboratory and equipment		LS	331, 843	3.32
1.3.2	Maintain Site Laboratory	30	mon	7, 699	2.31
1.3.3	Special or Additional Test	-	PS	1, 000, 000	10.00
1.4.1	Operate and Maintain Vehicles				
				Subtotal	**23**
Division 1: General and Site Facilities					
1.4.1a	Operate and Maintain 4WD Pickup with covered canopy (Used)	20	veh-mon	70, 000	14.00

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
1.4.2b	Operate and Maintain 4WD Pickup with covered canopy (Rental)	20	veh-mon	100, 000	20.00
1.4.2c	Operate and Maintain Microbus (Used)	20	veh-mon	70, 000	14.00
1.4.2d	Operate and Maintain Microbus (Rental)	20	veh-mon	100, 000	20.00
1.4.2e	Operate and Maintain Motorcycle (Used)	50	veh-mon	6, 000	3.00
1.4.2f	Operate and Maintain Motorcycle (Rental)	50	veh-mon	8, 000	4.00
				Subtotal	**75**
Division 1: General and Site Facilities					
1.4.2g	Operate and Speed Boat (Rental)	600	veh-day	7, 500	45.00
1.5.1	Relocation of Public Services	-	PS	2, 500, 000	25.00
1.10.1	Environmental Management by Contractor		PS	5, 512, 860	55.13
1.11.1	Payment for Dispute Review Board (ORB)		PS		10.00
				Subtotal	**135**
Total (Divisions-1: General and Site Facilities)					**492**
Earthwork					
Division 02:Earthwork					
2.1.1	Clearing and Grubbing	124, 500	sqm	55	68.48
2.1.1a	Bailing out of water with all leads and lifts by motor pump or manual labour	90, 000	cum	4	3.28
2.1.2a	**Remove and uproot trees**				-
2.1.2a	Trees with girth 300 mm to 800 mm	20	No.	660	0.13
2.1.2b	Trees with girth 801 mm to 1500 mm	15	No.	1, 320	0.20
2.1.2c	Trees with girth beyond 1500 mm	5	No.	2, 640	0.13
2.2.1	Channel Excavation	20, 750	cum	211	43.78
				Subtotal	**116**
Division 2: Earthwork					
2.5.1	Excavation and Backfill for Structures	-	cum	447	-
2.5.3	Sand Backfill for Structures	-	cum	1, 174	-
2.6.2	Embankment Fill	752, 135	cum	397	2, 985.97
2.6.5	Cladding Layer	84, 609	cum	689	582.96
2.6.5	Shoring for Slope protection of foundation trench, canal etc	1, 243	sqm	944	11.74
2.7.1	Preparation of Subgrade 300 mm Depth	42, 164	sqm	24	10.12
				Subtotal	**3, 591**
Division 2:Earthwork					
2.8.1	Improved Subgrade	12, 649.00	cum	1, 099	139.01

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
2.9.01	Dismantling Existing Structures (Box Culvert/ Sluice gate/ Pipe Culvert/ Bridge) including disposal and Backfilling		LS		5.00
2.10.1	Construction of Soil Earthen Shoulders	22, 368.50	cum	840	187.90
2.13.2	Prefabricated Vertical Drain	-	m	149	-
2.13.3	Geotextile Fabric -Separation (Non-woven)	171, 434.00	sqm	215	368.58
2.13.3	Geotextile Fabric - High Strength One way (Woven)	109, 637.00	sqm	236	259.18
				Subtotal	**960**
Division 2:Earthwork					
2.13.4	Geotextile Fabric- High Strength Two way (Woven)	505, 832.00	sqm	236	1, 195.79
2.13.6	Granular Drainage Blanket	74, 700.00	cum	1, 697	1, 267.66
2.13.8 (a&b)	Settlement Plate and Settlement Pin	130		10, 800	14.04
2.13.10	Lateral Displacement Observing Stake	434		12, 000	52.08
2.13.10	Observation Well	8		12, 000	0.96
2.13.11	Piezometer	16		14, 400	2.30
				Subtotal	**2, 533**
Division 2: Earthwork					
2.13.12	Inclinometers	16.00		14, 400	2.30
2.13.13	Placement of Preload (Surcharge) which will be removed	36603.00	cum	499	182.65
2.13.14	Removal of Preload (Surcharge) and disposal.	36603.00	cum	286	104.68
				Subtotal	**290**
Total (Division 2: Earthwork)					**7, 489**
Pavement Work					
Division 3: Pavement Work					
3.2.1	Sub-Base	8, 445.00	cum	5, 174	436.94
3.3.1	Aggregate Base Type I	6, 627.00	cum	8, 273	548.25
3.3.2	Aggregate Base Type II	6, 627.00	cum	5, 662	375.22
3.6.1a	Bituminous Prime Coat (Plant Placed)	32, 785.00	cum	113	37.05
3.7.1a	Bituminous Tack Coat (Plant Placed)	32, 785.00	sqm	50	16.39
3.10.1	Dense Bituminous Surfacing-Base Course (Plant Method) (Bitumen Grade 60/70)	3, 279.00	cum	22, 133	725.74
3.10.2	Dense Bituminous Surfacing - Wearing Course (Plant Method) (Bitumen Grade 60/70)	1, 639.00	cum	23, 195	380.17

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
Total (Division 3: Pavement Work)					**2, 520**
Incidentals					
Division 6: Incidentals					
06.01.02	**Concrete Slope Protection**				
06.01.02a	Concrete Slope Protection (thickness 50mm)	19, 661.00	sqm	858	168.69
06.01.02b	Concrete Slope Protection (thickness 200mm)	37, 077.00	sqm	3, 232	1, 198.33
06.01.02c	Concrete Slope Protection (thickness 300mm)	212.00	sqm	4, 952	10.50
06.01.02d	Concrete Slope Protection (thickness 350mm)	52.00	sqm	5, 862	3.05
06.01.02e	Concrete Slope Protection (thickness 400mm)	21, 102.00	sqm	6, 766	1, 427.76
				Subtotal	**2, 808**
Division 06: Incidentals					
06.01.02f	Concrete Slope Protection (thickness 500mm)	23, 213.00	sqm	8, 466	1, 965.21
06.01.02g	Graded Khoa	59.00	cum	6, 102	3.60
06.01.02h	Coarse Gravel	9, 112.00	cum	5, 085	463.35
06.01.02i	Sand of FM 1.0 to 1.5 thickness 1OOmm	9, 112.00	cum	1, 831	166.84
06.01.04	Concrete Cut-Off	3, 089.00	cum	18, 321	565.94
06.07.02	Grass Turfing	24, 900.00	sqm	42	10.46
				Subtotal	**3, 175**
Division 6: Incidentals					
06.08.01	Beam Gurad rail	8, 398.00	m	3, 754	315.26
06.09.02	Concrete Post	200.00		2, 322	4.64
06.10.01	Traffic Signs	21.00		5, 651	1.19
06.10.02	Sign Post	21.00		3, 140	0.66
06.11.02	Road Marking Thermoplastic Material (by spray)	2, 490.00	sqm	1, 078	26.84
06.12.01	Geotextile Filter Fabric	91, 123.00	sqm	217	197.74
06.16.01	Concrete Mile Posts	5.00		8, 825	0.44
06.17.02	Expansion Joint, PVC Water Stop, Bitumen Paint, etc	-	LS	900, 000	9.00
				Subtotal	**556**
Division 6: Incidentals					
06.17.03	Sheet pile	50.00	Ton	146, 400	73.20
06.17.03a	Driving Sheet pile up to designed depth	608.00	sqm	1, 423	8.65
06.17.05	Steel Ladder	4.00		120, 000	4.80
6.17.05	M.S work in Plate Channels	185.00	Kg	126	0.23

Item No.	Description	Magnitude	Unit	Unit Rate	Amount
				৳/unit	৳ lakh
6.17.06	Provision for Mechanical works		LS		-
				Subtotal	**87**
Total (Division 6: Incidentals)					**6, 626**

13.13.2 Internal Road

		Magnitude	Unit	Unit Rate	Amount
				৳	৳ lakh
1	Provision of Office Equipment and Consumables (01/02/03)	18	mon	7, 888	1.42
2	[LGED-5.01.01] Layout and benchmark the site from nearby BM pillar, demarcating property lines, existing ground level	55, 400	sqm	12	6.45
3	Embankment Fill (2/6/2)	261, 600	cum	397	1, 038.55
4	Roadway Excavation in suitable Soil (RHD - 2/2/02)	38, 776	cum	144	55.84
5	[RHD-2/8/01] Improved Subgrade (Sand F.M >0.80)	15, 720	cum	1, 099	172.76
6	Geotextile Fabric- High Strength Two way (Woven) (2/13/4)	130, 800	sqm	236	309.21
7	Granular Drainage Blanket (2/13/6)	29, 430	cum	1, 697	499.43
8	Placement of Preload (Surcharge) which will be removed (2/13/13)	58, 860	cum	499	293.71
9	Removal of Preload (Surcharge) and disposal. (2/13/14)	58, 860	cum	286	168.34
10	[RHD-03/02/Ol (a)I Sub-Base (Sand F.M > 1.0 and Brick Khoa<40 mm)	13, 100	cum	5, 174	677.79
11	(RH D_03/03/02a) Aggregate base type-II(Stone Chips)	10, 480	cum	5, 662	593.38
12	(RHD-03/03/01a) Aggregate base type-I (Stone Chips)	10, 480	cum	8, 273	867.01
13	[RHD-03/06/1a] Bituminous Prime Coat (Plant Placed)	50, 000	sqm	113	56.50
14	[RH D.03/07/1a] Bituminous Tack., Coat (Plant Work)	50, 000	sqm	50	25.00
15	Surfacing. Base Course (Plant Method) Bitumen[RHD-03/10/I (b)] 110 mm Dense Bituminous Grade 60/70 (Coarse Sand F.M >2.5, Crushed	5, 500	cum	22, 133	1, 217.32
16	Surfacing wearing course (Plan method) Bitumen [RHD_03/10/02 (b)] 50mm Dense bituminous Grade 60/70	2, 500	cum	23, 295	582.38
17	[RHD.3/13/Ol (a)I 125 mm Thick Brick on End Edging (1st Class)	4, 000	Lin M	189	7.56
18	Foot path (Rough estimate)	10, 000	sqm	2, 000	200.00
19	Concrete Side Ditch/ U-Drain [2.0 times of PWD Additional cost chart, Item 15 (ii)].	4, 000	Lin M	9, 760	390.40
20	[RHD. 6/4/01] Concrete Kerb (as detailed on the drawings)(Rough estimate)	4, 000	Lin M	500	20.00
21	[RHD. 6/4/02] Combined Concrete Kerb and Gutter (as detailed on the	4, 000	Lin M	750	30.00

		Magnitude	Unit	Unit Rate	Amount
	drawings) (Rough estimate)				
22	[RHD-6/5/Ol] Road Marking (Thermo-plastic material (indicate lf screed or by spray)	2, 340	sqm	1, 114	26.07
23	Tree plantation	200	Nos.	500	1.00
24	(RHD-06/10/0 I) Traffic Signs	16	Nos.	5, 651	0.90
25	(RHD.06/10/02) Sign Post	16	Nos.	3, 140	0.50
					7, 241

13.13.3 Gas Transmission

	Description			Magnitude	Unit	Rate			Amount	
						৳/ unit	USD/ unit		৳ lakh	
1	Feasibility Study									8
2	Route survey									10
3	IEE, EIA and RP									15
4	Soil and Subsurface Investigation									5
5	Microbus (Hiring upfront)			1						24.91
6	Line Pipes				-					2,319.48
	6.1	20-inch DN, 10.3 mm Thick API 5L X 60 (PSL-2) LSAW 3LPE Coated		8200	m		227		1,600.80	
	6.2	20-inch DN, 10.3 mm Thick API 5L x 60 (PSL-2) LSAW CWC Coated		3000	m		257		663.06	
	6.3	20-inch DN, 10.3 mm Thick API 5L x 60 (PSL-2) LSAW Bare		60	m		208		10.73	
	6.4	24-inch DN, 12.7 mm Thick API 5L Gr. B FBE Coated Casing Pipe		120	m		338		34.88	
	6.5	Station Pipes		LS	-	-	-		10	
7	Line Pipe mountings and materials									
	7.1	Valves								246.44
		7.1.1	20-inch DN Ball Valve ANSI Class 600 Trunion Mounted Actuator Operated	2			41,210		70.88	
		7.1.2	20-inch DN Ball Valve ANSI Class 600 Trunion Mounted Gear Operated with Hand-Wheel	3			21,455		55.36	
		7.1.3	30-inch DN Ball Valve ANSI Class 600 Trunion Mounted Gear Operated Hand with Wheel	3			33,806		87.22	
		7.1.4	1-inch Gate Valve Class 2000 lb.	15			93.02		1.20	

	Description			Magnitude	Unit	Rate		Amount	
						৳/ unit	USD/ unit	৳ lakh	
	7.1.5	1/2-inch Gate Valve Class 3000 lb.		15			69.77	0.90	
	7.1.6	8-inch DN RF Flange Plug Valve ANSI Class 600		4			3,667	12.61	
	7.1.7	4-inch DN RF Flange Plug Valve ANSI Class 600		10			1,188	10.22	
	7.1.8	2-inch DN RF Flange Plug Valve ANSI Class 600		15			624	8.05	
7.2	Line Pipe Material								
	7.2.1	Induction Bends							59.71
		90 Degree		1			5,921	5.09	
		45 Degree		5			3,721	16.00	
		30 Degree		2			2,962	5.09	
		22.5 Degree		12			2,581	26.64	
		15 Degree		4			2,000	6.88	
	7.2.2	Fittings, Coating and Wrapping Materials and CP Materials including TR Set							115.97
	7.2.3	Pig Traps							168.19
8	Pre-Shipment Inspection Fee								8.52
	8.1	Line Pipes	2319.48	0.09%	of '6'			2.09	
	8.2	20-inch DN 8D Induction Bends	59.71	0.48%	of '7.1'			0.29	
	8.3	Fittings, Coating and Wrapping and CP Materials including TR Set	115.97	0.48%	of '7.2'			0.56	
		(5% of Pipe Cost)							
	8.4	Valves API 6D	246.44	0.18%	of '7.3'			0.44	
	8.5	Pig Traps	168.19	0.48%	of '7.4'			0.81	
	8.6	Materials for River Crossing	461.43	0.12%				0.55	
	8.7	Materials for Town Bordering Station	3,395.51	0.09%				3.06	
	8.8	Materials for SCADA	30					0.41	
9	Pipeline Construction including Installation of CP System								1,051
	9.1	Preparation of Right-of-Way (ROW)		11.2	km	219,375		24.57	
	9.2	Transportation, hauling of Pipes		2,817	ton/ km	72		2.03	
	9.3	Transportation, Storage of Pipeline Materials		282	ton/ km	118		0.33	
	9.4	Stringing of Line Pipes along ROW		11,200	m	331		37.07	
	9.5	Fabrication of Field Bends		50	m	4,170		2.09	
	9.6	Welding (20-inch thro' 1-inch)		1,121		-		1,121	

	Description		Magnitude	Unit	Rate		Amount
					৳/ unit	USD/ unit	৳ lakh
	9.7	External Cleaning of Pipes by Sand Blasting	70	m	624		0.44
	9.8	Semi-Mechanical C&W Detection	70	m	1,518		1.06
	9.9	Joint Coating by Heat Shrink Sleeves	1,027		1,702		17.48
	9.10	Trenching	11,200	m	579		64.85
	9.11	Lowering of Pipes	11,200	m	497		55.66
	9.12	Fabrication and Installation of Set-On-Weight	600		14,231		85.39
	9.13	Back Filling with proper compaction	11200	m	303		33.94
	9.14	Hydro-test/Pneumatic Test	12000	m	739		88.68
	9.15	Cleaning and Reinstatement of ROW	11200	m	291		32.59
	9.16	Hook-up/Tie-in Works	2	LS	379,688		7.59
	9.17	Pigging and Commissioning	12	৳/m	71,791		8.61
	9.18	Road Crossing by Trust Boring	120	৳/m	12,403		14.88
	9.19	khal, Pond Ditches Crossing	500	৳/m	10,716		53.58
	9.20	Installation of Pig Launcher and Receiver with all Civil Works	2	LS	7,396,484		147.93
	9.21	Radiography (20-inch thro' 1-inch)	1121		7,737		86.73
	9.22	Construction and Placement of Marker Post	125		4,113		5.14
	9.23	Installation of CP System	-	LS	-		
	9.24	Mobilization and Demobilization	1	LS	5,062,500		50.63
							-
	Other Facilities						-
	(a)	Fully furnished and equipped temporary site office for the employer, the Engineer and their designated staff	LS	LS	8		8.00
	(b)	Site office equipment and stationaries, inspection an safety equipment and all facilities	LS	LS	1		1.00
	(c)	Fully furnished and equipped living accommodation and messing facilities for Employer, 4 Engineer and their designated staff	LS	LS	4.5		4.50
	(d)	One vehicle (8 seated microbus equipped with AC, CD etc. including supply of POL, all tolls for use of the Employer, the Engineer and their designated staff at site, along the ROW, purpose of the work both site and Dhaka Office and anywhere in Bangladesh	LS	LS	5		5.00
10	River Crossing by HDD Method on EPC Basis						

	Description		Magnitude		Unit	Rate		Amount	
						৳/ unit	USD/ unit	৳ lakh	
	10.1	Kuhelia River crossing by HDD		0.8	km	2,307			1,846
11	Installation of 250 mmscfd TBS on EPC Basis								
	11.1	250 mmscfd capacity TBS including 2-storied 3000 sft Control Room, Fence, Internal Roads etc. on EPC basis							4,527.35
12	Installation of SCADA System on EPC Basis								40
13	Bank Charge								
	13.1	LC Value in Equivalent ৳	8,602						
	13.2	Commission per Quarter *i.e.* 90 days @ 0.01009% of LC value	0.87						
	13.3	Total number of Quarters except First Quarter	7						47.36
		Total Commission (Commission per quarter x total quarters)						6.08	
	13.4	SWIFT Charge						-	
	13.5	Other charges/Document Collection Charge						_	
	13.6	VAT (0.40% of LC value x 15% x No. of quarters)						41.29	
14	C&F Commission, Port Charge, Landing Charge, Yard Rent								32.65
15	Inland Transportation Charge								23.88
	15.1	Loading	2 times	3,099	tons	6.00		0.37	
	15.2	Unloading	2 times	3,099	tons	17.00		1.05	
	15.3	Transportation from Chattogram Port to Nabila Stack Yard (৳ /Ton/Km)	90 km	3,099	tons	8.05		22.45	
16	Computer and Accessories								2.5
	16.1	Desktop Computer	1	0.70		Set		0.7	
	16.2	Laptop	1	0.80		No.		0.8	
	16.3	Other Accessories (CD, Pen drive, Hard Disk, Ram, Router etc.	Lot	LS		LS		1	
17	Computer Consumable								3
18	Other Stationeries								3
19	Photocopy								5
20	Publicity and Advertisement Expenses		12	3		1.50			18
21	Fees for different agencies								8.25
	21.1	Permission from CIE (Chief Inspector of Explosive) for Pipeline Construction		12	km	2,100		0.25	

	Description		Magnitude		Unit	Rate			Amount	
						৳/ unit	USD/ unit		৳ lakh	
	21.2	BIWTA for River Crossing		1		150,000			1.5	
	21.3	Road and Highways crossing		LS					1	
	21.4	LGED (LGED's Road Crossing)		LS					0.5	
	21.5	Fire Service and Other Departments		-	-				5	
22	Honorariums									
	22.1	Tender of Goods (5 Package)								5.64
		(a) Opening of Tenders	5	3		2,500			0.375	
		(b) Evaluation of Tenders with 3 meetings	15	7		2,500			2.625	
	22.2	Tender of Works (4 package)								
		(a) Opening of Tenders	4	3		2,000			0.24	
		(b) Evaluation of Tenders with 3 meetings	12	7		2,000			1.68	
	17.3	Tender of Services (3 Package)								
		(a) Opening of Tenders	3	3		1,000			0.09	
		(b) Evaluation of Tenders	9	7		1,000			0.63	
23	Entertainment Expenses									5.54
	23.1	Tender Evaluation Committee – ৳ 500 per member	7	12		96			3.36	
	23.2	Tender Opening Committee – ৳ 500 per member	5	12		12			0.18	
	23.3	Other Related Entertainment Expenses							2	
24	GTCL Service Charge (10% of Sub-Total) in Local Currency:		8,602	1,998						1,060
25	CD VAT									2,837
	25.1	Line Pipes	2,319	37.62%	of '6'				873	
	25.2	8D Induction Bends	126	50%					63	
	25.3	Fittings, C&W and CP Materials (including TR Set)	116	52.72%	of '7.2'				61	
	25.4	Valves	246	31.82%	of '7.3'				78	
	25.5	Pig Traps	168	21.36%	of '7.4'				36	
	25.6	Materials for River Crossing	461	40%					185	
	25.7	Materials for Regulating and Metering Station	3,396	45%					1,528	

	Description		Magnitude		Unit	Rate		Amount
						৳/ unit	USD/ unit	৳ lakh
	25.8	Materials for Installation of SCADA	30	45%				13.5
26	Land Acquisition and Requisition							
	26.1	Land Acquisition						390
	26.1.1	Land Acquisition: 6.00 meter strip as per Natural Gas Safety Rules 1991 (Amended in 2003) for laying 0f 11.2 km long gas transmission pipeline	14		acre	2,747,679		385
	26.1.2	Land Acquisition for one Pig Launcher (25mx30m) at Uttar Nalbila	0.19		acre	2,747,679		5.09
	26.2	Land Requisition						6.31
	26.2.1	Land Requisition: 15 meter strip for 1 year period temporary requisition for providing working area during pipe works and other construction works for 11.2 km long gas transmission line.	34		acre	18,235		6.20
	26.2.2	Land Requisition: For HDD Crossing (Payment for crop/trees/structure etc. to be damaged.	0.617		acre	18,235		0.11
27	Land Development							
	27.1	Land Development with Mechanical Compaction for Pig Launcher Station at Uttar Nalbila	25m x 30m x 2m	1,500	cum	720		10.8

	Description		Magnitude		Unit	Rate			Amount
						৳/ unit	USD/ unit		৳ lakh
	27.2	Land Development with Mechanical Compaction for approach road at Uttar Nalbila	100m x 3m x 2m	600	cum	720			4.32
		Total							**15,818**

13.13.4 Gas Distribution

	Description	Magnitude	Unit		Rate	Amount
				USD/unit	৳/unit	৳ lakh
1	Pipe Line: 20”	3,000	m	125		322.5
2	Valve	4			80,000	3.2
3	Coating and Wrapping					
4	M S Fittings	L.S			500,000	5
5	Cathodic Protection	L.S			1,500,000	15
6	CD VAT and Tax	30% of above				51.9
7	Transportation Cost	LS				30
8	Handling Cost	LS				9
6	Misc.	L.S			500,000	5
	Total					**442**

13.13.5 Power

	Description	Magnitude	Unit	Unit Rate	Amount		
				৳ lakh/unit	৳ lakh	৳ lakh	৳ lakh
1	Equipment and Installations						**2,225**
1.1	33/11KV, 2x20/28 MVA Indoor SS						
1.1.1	Hot dip galvanized steel structure Gantry (10 towers, 23 beams, 2 LAPIs, 2 DSs and 05 VCB and CT steel structure) Tower, beam, VCB, CT, Steel Structure with all necessary accessories for installation of equipment, VCB, CT, PT, DS/ES, LA mounting		L.S	36.92	36.92		
1.1.2	33KV, OVCB (2000A, 31.5 kA, 3s) for Incoming feeder along with Control Panel	2	set	16.50	33		

	Description	Magnitude	Unit	Unit Rate	Amount		
				৳ lakh/unit	৳ lakh	৳ lakh	৳ lakh
	having interrupter unit including anti-pumping features with all necessary structures including tripping coil, closing coil, Directional relay, instantaneous Over-current relay, Over-current relay IDMT, Earth fault relay IDMT and Energy meters (accuracy-0.2s) three analog ammeter, analog Voltmeter, analog Wattmeter, analog VAR meter, analog Power Factor meter, analog Watt-hour meter.						
1.1.3	33KV, OVCB (1250A, 31.5 kA, 3s) for Outgoing feeder along with Control Panel having interrupter unit including anti-pumping features with all necessary structures including tripping coil, closing coil, instantaneous Over-current relay, Over-current relay IDMT, Earth fault relay IDMT and Energy meters (accuracy-0.2s) three analog ammeter, analog Voltmeter, analog Wattmeter, analog VAR meter, analog Power Factor meter, analog Watt hour meter	2	set	16.50	33		
1.1.4	33KV, OVCB (1250A, 31.5 kA, 3s) for Transformer -Incoming feeder along with Control Panel having interrupter unit including anti-pumping features with all necessary structures including tripping coil, closing coil, instantaneous Over-current relay, Over-current relay IDMT, earth fault relay IDMT and Energy meters (accuracy-0.2s), three analog ammeter, analog Voltmeter, analog Wattmeter, analog VAR meter, analog Power Factor meter, analog Watt hour meter	2	set	16.50	33		
1.1.5	33/11 KV, 10/14 MVA, OLTC Power Transformer with RTCC Control Panel and all necessary accessories including 33 and 11 KV Surge arrester as per approved design and drawing and instruction of engineer-in-charge.	2		375.00	750		
1.1.6	and installation of 33KV, Single Phase Lightning Arrestor (Z Type)	18		0.48	8.64		
1.1.7	Design and drawing 33KV, Isolator (2500A 31.5 kA, 3s Twin martin) without Earth Blade for Bus-section.	1	set	3.00	3		
1.1.8	33KV, Isolator (2000A 31.5 kA, 3s) without Earth Blade for Incoming feeders at Bus side.	2	set	2.70	5.4		
1.1.9	33KV Isolator (2000A 31.50kA, 3s) with Earth Blade for Incoming feeders at load side.	2		3.00	6		
1.1.10	33KV, Isolator (1250A 31.5 kA, 3s) without Earth Blade for outgoing feeders at Bus side.	4	set	1.83	7.32		
1.1.11	33KV Isolator (1250A 31.50kA) with Earth Blade for outgoing feeders at load side.	2		2.16	4.32		
1.1.12	33KV, Single Phase Current Transformer for incoming feeder (2000-1000:5-5-5A, 0.2, 30VA for core -1 indicating meters on control panel and 2000-1000:5-5-5A, 0.2, 30VA for core-2 energy meters on control panel and 2000-1000:5-5-5A, 5P20, 30VA for protection).	6		0.91	5.45		
1.1.13	33KV, Single Phase Current Transformer for outgoing feeder (800-400:5-5-5A, 0.2,	6		1.38	8.25		

	Description	Magnitude	Unit	Unit Rate	Amount		
				৳ lakh/unit	৳ lakh	৳ lakh	৳ lakh
	30VA for core -1 indicating meters on control panel and 800-400:5-5-5A, 0.2, 30VA for core-2 energy meters on separate metering panel and 800-400: 5-5-5A, 5P20, 30VA for protection) .						
1.1.14	33KV, Single Phase Current Transformer for Transformer feeder (800-400:5-5-5A, 0.2, 30VA for core -1 indicating and energy meters on control panel and 800-400, 5-5-5A, 0. 30VA, 5P20 for core-2 and 3 for protection) .	6		0.91	5.45		
1.1.15	33KV, Single Phase Voltage Transformer PT (Secondary winding for core-1 accuracy class-0.2, burden 50 VA dedicated for metering and for core-2 accuracy class-3p, burden 50 VA.	6		0.77	4.6		
1.1.16	11KV indoor Switchgear VCB (2000 Amps, 31.5kA, 3s) for 11KV Incoming-Feeder with inbuilt CT (1600-800:5-5-5A) where Core-1(CL-0.2, 20VA) dedicated for metering panel, Core- 2and3 (20VA, CL-5P20) dedicated for protection including Digital Master Relay, Trip relay, Directional relay, Trip circuit supervision Relay, Energy meter (Accuracy-0.2s) with Export and Import and 03 analog Ammeter and volt meter, KW meter, KVAR meter, Power factor meter etc. with in-built 11 KV 2500Amps copper bus-bar where closing and tripping coil must be operated by 110 Volt DC. in control room building.	2		17.29	34.58		
1.1.17	11KV indoor Switchgear, VCB (2000 Amps, 31.5kA, 3s) for 11KV Bus-Coupler with inbuilt CT (2000-1000:5-5A) in control room building where Core-1(CL-0.2, 20VA) dedicated for Metering panel and core-2(20VA, 5P20) dedicated for protection including digital meter relay, trip relay, trip ckt supervision relay, energy meter (Accuracy-0.2s) with export and import and 3 analog ammeter and volt meter, KW meter, KVAR meter, PF meter, etc. with inbuilt 11KV 2000A copper Bus bar where closing and tripping coil must be operated by 110 Volt DC.	1		16.50	16.5		
1.1.18	11KV indoor Switchgear/ VCB (630 Amps, 31.5kA, 3s) for 11KV Outgoing Feeder with inbuilt CT (600-300:5-5A) in control room building where Core-1(CL-0.2, 20VA) dedicated for metering panel and core-2(20VA, 5P20) dedicated for protection including digital meter relay, trip relay, trip ckt supervision relay, energy meter (Accuracy-0.2s) with export and import and 3 analog ammeter and volt meter, KW meter, KVAR meter, PF meter, etc. with inbuilt 11KV 2000A copper Bus bar where closing and tripping coil must be operated by 110 Volt DC.	8		16.50	132		
1.1.19	11KV Single phase Lightening Arrestor (Z Type).	30		0.02	0.72		
1.1.20	11KV Bus- Riser as with inbuilt 11KV 2000A copper Bus bar where closing and tripping coil must be operated by 110 Volt DC per approved design and drawing and instruction of engineer-in-charge.	1		10.00	10		
1.1.21	11KV indoor Bus PT (11000/√3:110/√3:110/√3) inbuilt with switchgear in	2	set	10.00	20		

	Description	Magnitude	Unit	Unit Rate	Amount		
				৳ lakh/unit	৳ lakh	৳ lakh	৳ lakh
	extended control room building.						
1.1.22	11 KV, 1c×500 mm2 armor power cable (XLPE, Copper Cable) including all termination kits and accessories for connection between 33/11 KV Power Transformer T-1 and T-2 to 11 KV Switchgear as per approved design and drawing and instruction of engineer in charge.	800	m	0.10	83.7		
1.1.23	11KV, 3c×185 mm^2 Power Cable including all termination kits and accessories for 11KV Outgoing Feeders from 11KV Switchgear/ VCB to Over-Head Line.	1000	m	0.12	118.13		
1.1.24	Battery (250Ah, 110V DC) and Battery Charger.	1	Set	27.20	27.2		
1.1.25	33/0.4KV Auxiliary 200KVA Transformer.	1		9.17	9.17		
1.1.26	33KV Drop out Fuse Isolator for 33/0.4KV for 200KVA Auxiliary Transformer.	1	set	2.42	2.42		
1.1.27	Miscellaneous equipment including multicore control cables required for works, earthing materials, 33 kV Bus-bar (4 new Span, 2x Martine, 2500A) including loop conductor and Connector, Insulator and other related required fittings, LV cables, AC.DB, DC.DB, MK Box, sub-station lighting etc.		LS	50.00	50		
	Subtotal (1.1)					**1,449**	
1.2	Civil Works						
1.2.1	Site Development/Improvement for approach road with pipe drain for water passing by carted earth or sand, sandy silt (free from organic, foreign, environmental hazardous substances) carried by head or truck or any other means in/c cost of cutting or by dredging of sand, sandy silt, all; in/c local carrying, placing the earth/sand, sandy silt in the designated area, maintaining slopes, breaking lumps, leveling and dressing in layers up to finished level etc. With Mechanical compaction of earth beyond plinth area, required for per-approved specific engineering purpose in 150 mm layers including leveling, watering and consolidation each layer.		LS	153.16	153.16		
1.2.2	Two (02) storied Control Room Building (with five storied foundation)).	683	sqm	0.36	245.88		
1.2.3	Foundation of all Equipments and gantry Structure.	LS	LS	50.52	50.52		
1.2.4	Surface Finishing with gravels for new Sub-station area.	450	sqm	0.02	10.8		
1.2.5	Approach and internal road as per approved design and drawing and direction of the engineer in charge	368	sqm	0.05	19.87		
1.2.6	Surface drain as per approved design and drawing and direction of the engineer in charge.	240	m	0.05	12.96		
1.2.7	Fencing as per approved design and drawing and direction of the engineer in charge.	58	m	0.05	3.13		
1.2.8	RCC Cable Trench for power cable laying.	60	m	0.14	8.64		

	Description	Magnitude	Unit	Unit Rate	Amount		
				৳ lakh/unit	৳ lakh	৳ lakh	৳ lakh
1.2.9	RCC Cable Trench for control Cable laying.	65	m	0.14	9.36		
1.2.10	Retaining wall with boundary wall.	180	m	1.08	194.4		
1.2.11	Spare Parts for future maintenance work.	L.S	L.S	43.82	43.82		
1.2.12	Testing and Commissioning of 33/11 KV Sub-Station.	1	Lot	4.50	4.5		
	Subtotal (1.2)					**757**	
1.3	Miscellaneous Items						
1.3.1	Furniture and well-furnished Control Room building for Office Room, chair, 12 visiting chairs, 2 file cabinets, 3 file racks, 2 sets (5 seated sofa), 1 set computer table and chair. 2 almirah and as required)	L.S	L.S	6.00	6		
1.3.2	Air Conditioning System (each 2 ton) for Control Room including all accessories/ components required for fitting and fixing up to commissioning.	6		1.38	8.28		
1.3.3	Desktop Computer	1		0.61	0.61		
1.3.4	Water Pump Motor Set including all accessories/ components required for fitting and fixing up to Commissioning (complete in all respect).	1	Set	2.18	2.18		
1.3.5	Fire Detection and Protection Facilities for control room building including all accessories/ components required for fitting and fixing up to Commissioning.	1	L.S	1.80	1.8		
	Subtotal (1.3)					**18.87**	
2	Land Development for SS						**153**
2.1	Land development by sand filling	35,052	cum	223.00	78.17		
2.2	Geotube filling for construction of geotube dyke	162		16,500.00	26.73		
2.3	Slope protection work by placing geosheet, polythene and sand bags	100	m	150.00	0.15		
2.4	Geotube (L25m & D2.5m; Thick>4mm, GSM>400)	162		26,500.00	42.93		
2.5	Polythene (0.8mm)	93	kg	60.00	0.06		
2.6	Sand bags (PP Woven 20"x34")	1, 500		15.00	0.23		
2.7	Geo-sheets (3mm)	4, 600	sqm	106.50	4.9		
3	Transmission Line (not applicable)						
	Total						**2,378**

13.13.6 Admin Building

Type of Structure	RCC frame Structure with f'c = 32 Mpa
Foundation	For 6-Storied
Location of Site	Coastal area and Saline Zone

Floor height	Standard
Type of Foundation	Pile foundation (Cast in Situ)

Plinth area:

Ground floor	558	sqm
1stFloor	612.6	sqm
2nd Floor	597	sqm
3rd Floor	243	sqm
Total area	**2, 011**	**sqm**
	21, 642	**sft**

		Magnitude	Unit	Unit Rate	Cost	
				৳/unit	৳ lakh	
1. Soil Investigation						
1.1	Mobilization and Demobilization of boring equipment	1		11, 693	0.12	
1.2	Sub-Soil investigation	10	bores	30, 418	3.04	
	Subtotal (1)					**3.16**
2. Construction of Building						
2.1 Foundation Cost						
2.1.1	Foundation (6 Storied)	558	sqm	23, 389	130.51	
2.1.2	Extra depth of pile (Upto 30m)	558	""	16, 615	92.71	
2.1.3	Add Extra Cost for Cast in Situ Pile	20%	of 2.1.1		26.10	
2.1.4	Add Extra Cost for Saline zone	1%	""		1.31	
2.1.5	Add Extra Cost for Coastal area	3%	""		3.92	
2.1.6	Add Extra Cost for 32 mpa concrete	4%	""		5.22	
	Subtotal (2.1)					**259.77**
2.2 Super Structure Cost						
2.2.1	Ground floor (Habitation)	558	sqm	27, 275	152.19	
2.2.2	Add member weightage	558	""	1, 177	6.57	
2.2.3	1st floor	612.6	""	25, 882	158.55	
	Add. member weightage	612.6	""	942	5.77	
2.2.4	2nd floor	597	""	26, 270	156.83	
	Add. member weightage	597	""	706	4.21	
2.2.5	3rd floor	243	""	26, 664	64.79	
	Subtotal (2.2)					**548.93**
2.3. Additional Super Structure Cost						

		Magnitude	Unit	Unit Rate	Cost	
				৳/unit	৳ lakh	
2.3.1	Addl. Cost for Wind and Earthquake load resisting Structure	2%	of Subtotal (2.2)		10.98	
2.3.2	Addl. Cost for Coastal area	3%	""		16.47	
2.3.3	Roof top O/H water tank	5, 000.00	gal	155	7.75	
	Anti-termite treatment (CE's 29.1)	558	sqm	287	1.60	
	Curtain Wall with tempered glass (all sides)(CE's 14.18)	2, 180.00	""	10, 303	224.61	
2.3.4	False Ceiling					
	a) All floors except GF (CE's 18.1.1)	1, 453	""	2, 913	42.33	
	b) Ground floor (CE's 18.1.2)	558	""	3, 147	17.56	
2.3.5	Wall Panelling (CE's 18.3.1)	1, 000	""	3, 317	33.17	
2.3.6	Safety Canopy	105	""	1, 913	2.01	
2.3.7	Safety net	450	""	42	0.19	
	Subtotal (2.3)					**356.66**
3. Other Building Cost						
3.1 Internal Sanitary and Water Supply						
3.1.1	GF to 3rd floor	2, 011	sqm	1, 700	34.19	
3.1.2	Add. Cost for Special type of fittings and Fixture beyond the scope of PWD PLAR	15%	of 3.1.1		5.13	
	Subtotal (3.1)					**39.32**
3.2 Internal Electrification						
3.2.1	GF to 3rd floor	2, 011	sqm	1, 750		**35.19**
3.3 External Water Supply and Sanitation						
3.3.1	U/G water reservoir	10, 000	gal	77	7.70	
3.3.2	Water Hydrant system	LS			10.00	
3.3.4	Septic tank	2	.	233, 848	4.68	
3.3.5	Waste water and Sewage disposal pipe	100	m	4, 822	4.82	
	(CE's 26.32.1.4)					
3.3.6	Inspection pit (CE's 26.83.3)	10	.	9, 993	1.00	
	Subtotal (3.2)					**28.20**
3.4. External Electrification						
3.4.1	500 KVA X-former, HT and LT Switchgear, PFI	1		6, 500, 000	65.00	
3.4.2	REB charge	400	kW	2, 000	8.00	
5.4.3	Feeder Cable	LS			2.00	
3.4.3	Pump motor with stand by in/c cable and others accessories	1	Set		8.00	
	1275 kg. 6-stop lift in/c AVR and other accessories	2		650, 000	13.00	

		Magnitude	Unit	Unit Rate	Cost	
				৳/unit	৳ lakh	
3.4.4	Fire Extinguisher, fire Detection and Protection system	Ls			10.00	
3.4.5	150KVA Diesel generator (ATS and canopy)	1			45.00	
3.4.6	PABX and intercom system	LS			10.00	
	Security and Guard light	LS			15.00	
3.4.7	Central Air Conditioner	50	ton	130, 000	65.00	
3.4.8	Access control system	LS			20.00	
3.4.9	Conference system, Computer networking etc, Sound system	LS			200.00	
3.4.10	CCTV Installation	LS			5.00	
3.4.11	Force Ventilation System	LS			15.00	
	Subtotal (3.4)					**481.00**
3.5 Site Development (CE's 02.16.4.1)		2904	Cum	302		**8.77**
3.6. Boundary Wall						
3.6.1	RCC boundary wall	30	Rm	75, 896	22.77	
3.6.2	Add. Cost for Extra height of B/Wall	20%	on 3.6.1		4.55	
3.6.3	Decorative Grill (CE's 21.2)	72	sqm	4, 685	3.37	
3.6.4	Add. Cost for Ornamental Works at the front of Boundary Wall	72	m	2, 300	1.66	
	Subtotal (3.6)					**32.35**
3.7. Material Test and Digital Survey		L.S				10.00
3.8. Furniture and related ancillaries		L.S				100.00
3.9. Contingency						
3.9.1	Honorarium (TEC, TOC, PIC, PSC etc.)	L.S			10.00	
3.9.2	Foundation Stone laying and Inaugural Ceremony	L.S			50.00	
3.9.3	Construction of Engineer's Site office	L.S			5.00	
3.9.10	Architect Consultation Fee	L.S			5.00	
	Subtotal (3.9)					**70.00**
Total						**1, 973**

13.14 A14: Project Implementation Schedule

	Tasks / mons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1	**Preparation Work**																																				
1.1	Mobilization and Document finalization																																				
1.2	Organization of Staff																																				
1.3	Organization of Materials & Machines																																				
1.4	Construction of Site camp																																				
1.5	Construction of Construction Yards																																				
1.6	Site Survey works																																				
2	**Ground Improvement**																																				
2.1	Clearing & Grabbing																																				
2.2	Site leveling																																				
2.3	Sand Filling																																				
2.4	Leveling & Compacting																																				
3	**Security fencing, Boundary wall, Gate house & Gates**																																				
4	**Internal Road and Plots/area demarcation works**																																				
5	**Infrastructure & Utility networks**																																				
5.1	Underground pipe network																																				
5.2	Road foundation																																				
5.3	Road surface work																																				
5.4	Drainage																																				
5.5	Pedestrian Footpath																																				
5.6	Street Lighting																																				
5.7	Electrical power works																																				
5.8	Telecommunication																																				
5.9	Gas works																																				
5.1	Water supply network																																				
5.11	Fire fighting system																																				
6	**Construction Group-I (Administrative & Residential Buildings)**																																				
6.1	Foundation works																																				
6.2	Upto floor level construction																																				
6.3	Superstructure RCC (columns, beams and slabs)																																				

	Tasks / mons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
6.4	Brick & plaster works and Door, windows & glass works							■	■	■	■	■	■	■																							
6.5	Internal electrical and plumbing works												■	■	■																						
6.6	Electrical and mechanical installations												■	■	■																						
6.7	Flooring and Decorative works													■	■																						
6.8	Finishing works and hand over															■																					
7	**Construction Group-II (Commercial Buildings and Utility structures)**						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■													
7.1	Foundation works						■	■																													
7.2	Upto floor level construction						■	■	■																												
7.3	Superstructure RCC (columns, beams and slabs)								■	■	■																										
7.4	Brick & plaster works and Door, windows & glass works										■	■	■	■	■	■	■	■	■	■	■	■	■	■													
7.5	Internal electrical and plumbing works																				■	■	■	■													
7.6	Electrical and mechanical installations																						■	■													
7.7	Flooring and Decorative works																					■	■	■													
7.8	Finishing works and hand over																						■	■													
8	**Water body development and Landscaping**																					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
9	**Project inspection period**																								■	■	■	■	■	■	■	■	■	■	■	■	■
10	**Project handover**																																				▲

13.15 A15: Financial and Economic Model

F&E1: Assumptions

0.00	Dimensions					
	Area	1,240	acre			
	Admin Building	2,011	sqm			
	Approach Road	4.15	km			
	Internal Road	275,000	sqm			
	Gas Transmission Pipeline	11	km			
	Gas Distribution Line	3	km			
	Substation Building	3,000	sqm			
	Generator Building	3,000	sqm			
	Emergency Generator	5	MW			
1.00	Tariffs		৳/unit			
	Power	9.41	৳/kWh	Ishwardi EPZ	Financial IRR	14.1%
	Gas Supply	11.77	৳/m3	(10% margin)	Economic IRR	16.1%
	Water Supply	38.26	৳/m3	Ishwardi EPZ		
	CETP	38.54	৳/m3	Cumilla EPZ		
2.00	Land Acquisition and Requisition			Rate		
	Approach Road (Mouza Rate)	89.51	decimal	4,909	৳ per decimal	
	Gas Transmission Pipeline:					
	Land Acquisition (Mouza Rate)	14	acre	9,159	৳ per decimal	
	Land Requisition	34	acre	18,235	৳ per acre	
	(considering ARIPA 2017)					
2.01	Cost of Utilities					
	Power (industrial use)			BERC Notification, 2020 (MT Line)		

BERC		৳/kWhr	hrs	৳/KW/month
Normal		8.55	10	
Off-Peak Time		7.70	10	
Peak Time		10.69	4	
Demand charge				60

Gas	10.7	৳/m3	Daily Sun, 1 July 2019
Water	31.82	৳/m3	CWASA, Commercial Use Water Tariff (Source: New Age, 4 Nov 2021)

2.00	Cost Rates[6]						
Base Rates (PWD and others)							
2.01	Pre-operating Expenses (R&R Expenses, legal fees, upfront payments etc)	1,000	৳ lakh LS				
2.02	Preparation of LAP, RAP and Updating ESIA	50	৳ lakh LS	2.13	Gate	30	৳ lakh LS
				2.12	Plumbing work	incl. in 2.03	৳/ sqm
2.03	Administrative building	1,973	""	2.13	Electrical Work	'	""

2.04	ETP Building	5,000	""	2.14	HVAC	'	LS
2.05	Generator Building	1,000	""	2.15	ETP	3,063	৳ lakh LS
2.06	Substation Building	1,000	""	2.16	Power Supply System	2,378	""
2.07	Security Post, Parking Area for Loading and Unloading	1,000	""	2.17	Gas Transmission System	15,818	""
2.08	Brick Wall/ Boundary	0.75	৳ lakh/m	2.18	Gas Distribution System	442	""
2.09	Internal Roads	4,125	৳/sqm	2.18	Vehicles	40	৳ lakh/each
2.09.1	Footpath	2,000	৳/ sqm				
2.09.2	Drainage	3,115	""				
2.10	Approach Road	5,318	৳ lakh/km	2.20	Fire Fighting System	50	৳ lakh LS
2.11	Water Supply System	500	৳ lakh LS	2.21	WTP		""
2.12	Sluice Gate	48,500,000	৳ each	2.22	Emergency Generator	1,000	৳ lakh LS
2.12	Construction Non-material Cost	16	৳ lakh/mon				

2.01	Depreciation Rate				
2.0.1	Civil Structures	10%	of written down value		
2.0.2	Plant and Equipment	20%	""		

3.00	Escalation				
3.01	Capex Escalation				
	Civil Structures	15%	per year		
	Machinery and Equipment	10%	""		
3.02	Tariff escalation (land)	10%	every	5	years
	[not part of this assignment]				
3.03	Electricity charge escalation	5%	every	3	years
3.04	Gas Tariff Escalation	5%	every	10	years
3.05	Water Tariff Escalation	5%	every	10	years

4.00	Financial		
4.01	Average Remuneration per worker	15,000	৳/month
4.02	Waste Reduction	50%	
4.03	Value enhancement due to quality enhancement	20%	
4.04	Share of Export in Operating Profit Margin Generated by the Project		
	Y1	10%	
	Y2	15%	
	Y3	20%	
	Y4	25%	onward

5.00	Economic/Environmental				
5.01	Fuel Consumption		liter/km		
5.02	CO2 Emission	1.86	kg/m3 gas		
5.03	Environmental Cost of CO2 Emission	7.00	$/ton of CO2	Source: IWG	https://www.edf.org/true-cost-carbon-pollution
		0.007	$/kg of CO2		

			0.0130	৳/m3 gas
		Employment Generation	20,000	
		Average Salary	15,000	৳/mon
6.00	Social			
	6.01	Avg. Fee Rate of Doctors	300	৳/visit
	6.02	Number of usual visits to Doctors by the Workers	0.50	/worker/month
	6.03	Reductions of Visits to Doctors	25%	for each worker
	6.04	Avg. Number of Industrial accidents in Bangladesh	50	/year
	6.05	Reductions in Number of Industrial Accidents	1%	
	6.05.1	Average loss in each industrial Accident	500	৳ lakh/accident
	6.06	Number of affected households		
	6.07	Average income of households		৳/month
	6.08	Loss of Income due to loss of livelihood		৳ lakh/household
7.00	Capacity Utilisation			
		Y1	19%	
		Y2	27%	
		Y3	45%	
		Y4	65%	
8.00	Share of Benefits			
	8.01	Share of Financial Benefits	100	% of _____
	8.02	Share of Economic Benefits	100	% of _____
9.00	Conversion Rates			
	9.01	Exchange Rate	86	৳/৳
	9.02	Area conversion	4,046.86	sqm/acre
	9.04	Area to Perimeter	254.46	m/acre

F&E3: Sources of Finance

				2023	2024	2025	..	..
(1)	**Cost of the Project**	৳ lakh						
	Total Hard Cost		91,862	26,163	29,527	36,171		
	Interest During Construction (IDC)		11,465	1,727	3,676	6,063		
	Total Project Cost	"	**103,327**	**27,890**	**33,203**	**42,234**		

(2)	**Debt Equity Ratio**	%	৳ lakh	
2.1	Debt	60%	61,996	
2.2	Equity	40%	41,331	
	Total	100%	**103,327**	
	Interest Rate	11%		

				2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2045
(3)	**Equity**		Years→	1	2	3	4	5	6	7	8	9	10	11	12	13	23
3.1	Beginning Balance			-	11,156	36,745	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638
3.2	Drawdown from Equity	40%	৳ lakh	11,156	13,281	16,894											
3.3	Ending Balance			11,156	24,437	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638	53,638

(4)	**Loan**		
4.1	Loan Amount	61,996	৳ lakh
4.2	Source of Debt	IDCOL, BIFFL, Commercial Bank	
4.3	Mode of Repayment	yearly	
4.4	Nominal Interest Rate	11%	
4.5	Loan Tenure	10	years
4.6	Grace Period	3	years

			2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2045
(5)	**Debt Servicing Schedule**	Years→	1	2	3	4	5	6	7	8	9	10	11	12	13	23
	Beginning Balance		-	17,425	38,817	66,582	59,924	53,266	46,608	39,949	33,291	26,633	19,975	13,316	6,658	
	Loan drawdown		15,698	17,716	21,703	-										
	Principal Repayment		-	-	-	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	6,658	
	Interest Accrued		1,727	3,676	6,063	-	-	-	-	-	-	-	-	-	-	
	Interest Payment		-	-		7,324	3,296	2,930	2,563	2,197	1,831	1,465	1,099	732	366	
	Ending Balance		17,425	38,817	66,582	59,924	53,266	46,608	39,949	33,291	26,633	19,975	13,316	6,658	0	

F&E4: Depreciation Schedule

				2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2045
			Years	1	2	3	4	5	6	7	8	9	10	20
1.01	Admin Building			10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		53	48	43	39	35	31	28	25	23	20	7
	Depreciation	""		5.28	4.75	4.28	3.85	3.47	3.12	2.81	2.53	2.27	2.05	0.71
	Addition	""		-										
	Ending Balance	""		48	43	39	35	31	28	25	23	20	18	6
1.02	Internal Road		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		15,100	13,590	12,231	11,008	9,907.1	8,916.4	8,024.7	7,222.3	6,500.0	5,850.0	2,039.8
	Depreciation	""		1,509.99	1,359.00	1,223.10	1,100.79	990.71	891.64	802.47	722.23	650.00	585.00	203.98
	Addition	""		-	-									
	Ending Balance	""		13,590	12,231	11,008	9,907	8,916.4	8,024.7	7,222.3	6,500.0	5,850.0	5,265.0	1,835.8
1.03	Footpath	৳ lakh	-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	""		5,325	4,792	4,313	3,882	3,493	3,144.1	2,829.7	2,546.7	2,292.0	2,062.8	719.3
	Depreciation	""		532.45	479.21	431.28	388.16	349.34	314.41	282.97	254.67	229.20	206.28	71.93
	Addition	""		-	-									
	Ending Balance			4,792	4,313	3,882	3,493	3,144.1	2,829.7	2,546.7	2,292.0	2,062.8	1,856.5	647.3
1.04	Approach Road		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		29,378	26,440	23,796	21,417	19,275	17,348	15,613	14,051	12,646	11,382	3,969
	Depreciation	""		2,938	2,644	2,380	2,142	1,928	1,735	1,561	1,405	1,265	1,138	397
	Addition	""		-	-									
	Ending Balance	""		26,440	23,796	21,417	19,275	17,348	15,613	14,051	12,646	11,382	10,244	3,572

				2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2045
		Years		1	2	3	4	5	6	7	8	9	10	20
1.05	Boundary Wall		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		8,946	8,051	7,246	6,521	5,869	5,282	4,754	4,279	3,851	3,466	1,208
	Depreciation	""		895	805	725	652	587	528	475	428	385	347	121
	Addition	""												
	Ending Balance	""		8,051	7,246	6,521	5,869	5,282	4,754	4,279	3,851	3,466	3,119	1,088
1.06	Drain & Sewage Line		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		2,488	2,239	2,015	1,814	1,632	1,469.1	1,322.2	1,189.9	1,070.9	963.9	336.1
	Depreciation	""		248.79	223.91	201.52	181.37	163.23	146.91	132.22	118.99	107.09	96.39	33.61
	Addition	""												
	Ending Balance	""		2,239	2,015	1,814	1,632	1,469.1	1,322.2	1,189.9	1,070.9	963.9	867.5	302.5
1.06	Water Supply		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		4,576	4,119	3,707	3,336	3,002	2,702.2	2,432.0	2,188.8	1,969.9	1,772.9	618.2
	Depreciation	""		457.62	411.86	370.67	333.61	300.25	270.22	243.20	218.88	196.99	177.29	61.82
	Addition	""												
	Ending Balance	""		4,119	3,707	3,336	3,002	2,702.2	2,432.0	2,188.8	1,969.9	1,772.9	1,595.6	556.4
1.07	Power Supply System		-	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Beginning Balance	৳ lakh		4,576	3,661	2,929	2,343	1,874	1,500	1,200	960	768	614	66
	Depreciation	""		915.24	732.19	585.75	468.60	374.88	299.91	239.93	191.94	153.55	122.84	13.19
	Addition	""												
	Ending Balance	""		3,661	2,929	2,343	1,874	1,500	1,200	960	768	614	491	53
1.08	Vehicles		-	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Beginning Balance	৳ lakh		145.6	117	93	75	60	48	38	31	24	20	2
	Depreciation	""		29.13	23.30	18.64	14.91	11.93	9.54	7.64	6.11	4.89	3.91	0.42
	Addition	""												
	Ending Balance	""		117	93	75	60	48	38	31	24	20	16	2
1.09	Security Post, Parking, Loading and Unloading A		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		55	49	44	40	36	32	29	26	24	21	7
	Depreciation	""		5.46	4.92	4.42	3.98	3.58	3.22	2.90	2.61	2.35	2.12	0.74

				2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2045
		Years		1	2	3	4	5	6	7	8	9	10	20
	Addition	""												
	Ending Balance	""		49	44	40	36	32	29	26	24	21	19	7
1.10	Gate		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		36.41	33	29	27	24	21	19	17	16	14	5
	Depreciation	""		3.64	3.28	2.95	2.65	2.39	2.15	1.93	1.74	1.57	1.41	0.49
	Addition	""												
	Ending Balance	""		33	29	27	24	21	19	17	16	14	13	4
1.11	ETP		-	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Beginning Balance	৳ lakh		3,718	2,974	2,379	1,903	1,523	1,218	975	780	624	499	54
	Depreciation	""		743.54	594.83	475.87	380.69	304.55	243.64	194.91	155.93	124.75	99.80	10.72
	Addition	""												
	Ending Balance	""		2,974	2,379	1,903	1,523	1,218	975	780	624	499	399	43
1.12	Gas Supply System		-	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
	Beginning Balance	৳ lakh		19,734	17,760	15,984	14,386	12,947	11,652	10,487	9,438	8,495	7,645	2,666
	Depreciation	""		1,973	1,776	1,598	1,439	1,295	1,165	1,049	944	849	765	267
	Addition	""												
	Ending Balance	""		17,760	15,984	14,386	12,947	11,652	10,487	9,438	8,495	7,645	6,881	2,399
1.12	Fire System		-	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
	Beginning Balance	৳ lakh		61	49	39	31	25	20	16	13	10	8	1
	Depreciation	""		12	10	8	6	5	4	3	3	2	2	0
	Addition	""												
	Ending Balance	""		49	39	31	25	20	16	13	10	8	7	1
	Total			10,269	8,660	7,658	6,784	6,018	5,347	4,756	4,236	3,777	3,371	1,120

F&E6: Remuneration

	Persons		Remuneration		
					Departmental
			৳/mon/person	৳ lakh/year	৳ lakh/year
(1) GM	1		80,000	10	10
(2) GM's Office				-	-
2.1 Engineering				-	-
2.1.1 Officers	3		60,000	22	
2.1.2 General Staff/Workers	15		20,000	36	58
2.2 Security					
2.2.1 Officers	3		60,000	22	
2.2.2 Workers	30		15,000	54	76
2.3 Social Welfare					
2.3.1 Officers	1		60,000	7	
2.3.2 General Staff/Workers	2		30,000	7	14
2.4 Environmental Monitoring					
2.4.1 Officers	1		60,000	7	
2.4.2 General Staff/Workers	3			-	7
2.5 HR				-	-
2.5.1 Officers	2		60,000	14	
2.5.2 General Staff/Workers	3		30,000	-	14
2.6 Finance and Accounts				-	-
2.6.1 Officers	2		60,000	14	
2.6.2 General Staff/Workers	3		30,000	11	25
2.7 Personnel employed in common facilities	5		35,000	21	21
Total	**-**	**74**		**225**	**225**

F&E7: Electricity Consumption and Expenses

		Indicative Load	Load Factor	Electricity Usage	Electricity Usage Charge[4]	Demand Charge	Total Electricity Charge
		MW	%	kWhr/ mon	৳ lakh/ mon	৳ lakh/ mon	৳ lakh/ mon
1.1	Oil Refinery and Petrochemicals	260.30	100%	187,417,485	16,830	156.18	16,986
1.2	Marine Fish Processing	0.94	75%	505,097	45	0.56	46
1.3	Ship Building and Repairing	0.11	60%	46,221	4	0.06	4
1.4	Steel Manufacturing	5.07	100%	3,650,357	328	3.04	331
1.4.1	Steel Rerolling	4.91	100%	3,534,785	317	2.95	320
1.5	Logistics Hub/Gas Bottling	6.16	75%	3,325,534	299	3.70	302
1.6	Automobile and Heavy Engg	4.69	75%	2,531,969	227	2.81	230
1.7	Misc. Industrial Use	4.00	75%	2,160,000	194	2.40	196
2	Other than Industrial Use	5.54	60%	2,395,085	215	3.33	218
	Total	**291.72**		**205,566,533**			**18,635**

Average (৳/kWh) 9.07

BERC Notification, 2020 (MT)

		৳/kWhr	৳/KW/mon
Normal		8.55	
Off-Peak Time		7.70	
Peak Time		10.69	
Demand Charge			60

MT = Medium Tension

F&E9: Margin (Power)

				2026	2027	2028	2029	2030	2035	2045
	Unit		Years	1	2	3	4	5	10	20
(1)	Capacity	MW	291.72							
(2)	Capacity Utilisation	%		20%	29%	49%	69%	79%	94%	94%
(3)	Service Volume	MW		57.49	85.08	142.57	202.41	231.84	273.19	273.19
(4)	Unit Tariff	৳/kWh	9.41	9.41	9.41	9.41	9.9	9.9	10.9	12.6
(5)	Price Escalation	"0" = no, "1" = yes	-	-	-	1	-	-	-	-
			1	1	1	1	1.05	1.05	1.16	1.34
(6)	Revenue	৳ lakh		45,743	67,699	113,443	169,120	193,709	251,646	291,312
(7)	Power Consumption	kWhr/mon	205,566,533							
		kWhr/mon		40,509,484	59,953,156	100,463,528	142,638,159	163,376,459	192,509,398	192,509,398
(8)	Less: Cost of electricity	Tk/kWh	9.07							
	Total	৳ lakh		44,067	65,218	109,286	162,922	186,610	242,424	280,636
	Usage Charge	Tk/kWh	8.98	8.98	8.98	8.98	9.43	9.43	10.40	12.03
		৳ lakh		43,653	64,606	108,259	161,392	184,857	240,147	278,000
	Demand Charge	৳/KW/mon	60	60	60	60	63	63	69.46	80.41
		৳ lakh		414	613	1,026	1,530	1,753	2,277	2,636
(9)	Less: Depreciation	৳ lakh		915	732	586	469	375	123	13
(10)	Less: Remuneration of personnel employed in the Department	৳ lakh		40	59	99	141	162	190	190
(11)	Operating Profit Margin	৳ lakh		721	1,690	3,472	5,588	6,562	8,909	10,472

F&E8: Gas Consumption and Expenses

		m3/day	৳ lakh/mon
1.1	Oil Refinery and Petrochemicals	2,324,553	248.73
1.2	Marine Fish Processing	4,292	0.46
1.3	Ship Building and Repairing	104	0.01
1.4	Steel Manufacturing	51,467	5.51
1.4.1	Steel Rerolling	5,281	0.57
	Total	**2,385,698**	**255**

Tariff[2] 10.7 ৳/m3

[2] Daily Sun, 1 July 2019

F&E9: Margin (Gas)

	Unit		Years	2026 1	2027 2	2028 3	2029 4	2030 5	2035 10	2045 20
(1) Capacity	m3/day	2,385,698								
(2) Capacity Utilisation	%			20%	30%	50%	71%	80%	95%	95%
(3) Service Volume	m3/day			477,129	712,652	1,192,404	1,683,297	1,916,631	2,266,414	2,266,414
(4) Unit Tariff	৳/m3	11.77		11.77	11.77	11.77	11.77	11.77	12	12
(5) Price Escalation	"0" = no, "1" = yes		0	0	0	0	0	0	1	1
			1	1	1	1	1	1	1.00	1.05
(6) Revenue	৳ lakh			20,498	30,616	51,226	72,315	82,339	97,366	102,235
(7) Less: Cost of Gas	৳/m3	10.7		10.7	10.7	10.7	10.7	10.7	10.7	11.2
	৳ lakh			18,634	27,833	46,569	65,741	74,854	88,515	92,941
(8) Less: Depreciation	৳ lakh			1,973	1,776	1,598	1,439	1,295	765	267
(9) Less: Remuneration of personnel employed in the Department	৳ lakh			21	21	21	21	21	21	21
(10) Operating Profit Margin	৳ lakh			(131)	986	3,038	5,115	6,170	8,066	9,006

F&E9: Margin (Water)

				2026	2027	2028	2029	2030	2035	2045
	Unit		Years	1	2	3	4	5	10	20
(1) Capacity	m3/day	8,594								
(2) Capacity Utilisation	%			20%	25%	41%	52%	71%	95%	95%
(3) Service Volume	m3/day			1,709	2,177	3,500	4,473	6,108	8,134	8,134
(4) Unit Tariff	৳/m3	38.26		38.26	38.26	38.26	38.26	38.26	38	40
(5) Price Escalation	"0" = no, "1" = yes		0	0	0	0	0	0	1	1
			1	1	1	1	1	1	1.00	1.05
(6) Revenue	৳ lakh			239	304	489	625	853	1,136	1,193
(7) Cost of Water	৳/m3	31.82								
(8) Less: Cost of Water	৳ lakh			198	253	406	519	709	945	992
(9) Less: Depreciation	৳ lakh			706	636	572	515	463	274	95
(10) Less: Remuneration of personnel employed in the Department	৳ lakh			21	21	21	21	21	21	21
(11) Operating Profit Margin	৳ lakh			(687)	(606)	(511)	(431)	(341)	(103)	84

F&E9: Margin (CETP)

					2026	2027	2028	2029	2030	2035	2045
	Unit		Years		1	2	3	4	5	10	20
(1) Capacity	m3/day	7,427									
(2) Capacity Utilisation	%				18%	23%	36%	45%	63%	86%	86%
(3) Service Volume	m3/day				1,337	1,671	2,674	3,342	4,679	6,350	6,350
(4) Unit Tariff	৳/m3	38.54			38.54	38.54	38.54	38.54	38.54	39	40
(5) Price Escalation	"0" = no, "1" = yes		0		0	0	0	0	0	1	1
				1	1.00	1.00	1.00	1.00	1.00	1.00	1.05
(6) Revenue	৳ lakh				188	235	376	470	658	893	938
(7) Cost of Water	৳/m3	NA									
(8) Less: Cost of Water	৳ lakh	NA									
(9) Less: Depreciation	৳ lakh				744	595	476	381	305	100	11
(10) Less: Remuneration of personnel employed in the Department	৳ lakh				21	21	21	21	21	21	21
(11) Operating Profit Margin	৳ lakh				(576)	(381)	(121)	68	333	772	906

F&E10: Consolidated (all departments)

			2026	2027	2028	2029	2030	2035	2045
		Years	1	2	3	4	5	10	20
(1)	Revenue								
1.1	Power		45,743	67,699	113,443	169,120	193,709	251,646	291,312
1.2	Gas		20,498	30,616	51,226	72,315	82,339	97,366	102,235
1.3	Water		239	304	489	625	853	1,136	1,193
1.4	CETP		188	235	376	470	658	893	938
	Total Revenue		66,668	98,854	165,535	242,530	277,560	351,042	395,677
(2)	O&M Expenses								
2.1	Power		45,022	66,010	109,971	163,532	187,146	242,737	280,840
2.2	Gas		20,629	29,630	48,189	67,201	76,170	89,300	93,228
2.3	Water		727	657	593	536	484	295	116
2.4	CETP		765	616	497	402	326	121	32
	Total O&M Expenses		67,143	96,912	159,250	231,671	264,126	332,453	374,216
(3)	Operating Profit Margins from component businesses								
3.1	Power	৳ lakh	721	1,690	3,472	5,588	6,562	8,909	10,472
3.2	Gas	৳ lakh	(131)	986	3,038	5,115	6,170	8,066	9,006
3.3	Water	৳ lakh	(687)	(606)	(511)	(431)	(341)	(103)	84
3.4	CETP		(576)	(381)	(121)	68	333	772	906
(4)	Total Operating Profit Margin	৳ lakh	(674)	1,689	5,878	10,340	12,724	17,644	20,469
(5)	Profit before Interest and Taxes	৳ lakh	(674)	1,689	5,878	10,340	12,724	17,644	20,469
(6)	Less: Interest Expense	৳ lakh	7,324	3,296	2,930	2,563	2,197	366	0
(7)	Profit before taxes	৳ lakh	(7,998)	(1,606)	2,949	7,777	10,527	17,278	20,469
(8)	Tax Exemption	৳ lakh	100%	100%	100%	100%	100%	100%	100%
(9)	Taxes	৳ lakh	-	-	-	-	-	-	-
(10)	Net Profit after tax	৳ lakh	(7,998)	(1,606)	2,949	7,777	10,527	17,278	20,469

Consolidated Financial Cash Flow and Return

						2026	2027	2028	2029	2030	2035	2045
		Years				1	2	3	4	5	10	20
(1)	Revenue	৳ lakh				66,668	98,854	165,535	242,530	277,560	351,042	395,677
(2)	O&M Expenses	৳ lakh				67,143	96,912	159,250	231,671	264,126	332,453	374,216
(3)	Depreciation	৳ lakh				10,269	8,660	7,658	6,784	6,018	3,371	1,120
(4)	Cash Generated by the Project	৳ lakh				9,794	10,602	13,943	17,643	19,452	21,959	22,582
(5)	Capital Expenditure	৳ lakh	103,327	27,890	33,203	42,234						
(6)	Cash Flow wrt the Project	৳ lakh		(27,890)	(33,203)	(42,234)	9,794	10,602	13,943	17,643	19,452	21,959	22,582
(7)	Financial IRR		14.08%									

F&E12: FNPV_FBCR

Years		Financial Costs		Total Yearly Cost	Discount Factor	Discounted Value of Total Cost	Benefits	Discounted Value of Benefits
		Investment	O&M Cost (cash basis)				Yearly Revenue	
								12%
		৳ lakh	৳ lakh	৳ lakh	12%	৳ lakh	৳ lakh	৳ lakh
Col. 1		Col. 2	Col. 3	Col. 4 = Col. 2 + Col. 3	Col. 5	Col. 6 = Col. 4 / Col. 5	Col. 7	Col. 8 =Col. 7 / Col. 5
	2023	27,890		27,890	1	27,890		
	2024	33,203		33,203	1.12	29,645		
	2025	42,234		42,234	1.25	33,669		
1	2026		56,874	56,874	1.40	40,482	66,668	47,453
2	2027		88,252	88,252	1.57	56,085	98,854	62,824
3	2028		151,592	151,592	1.76	86,017	165,535	93,929
4	2029		224,887	224,887	1.97	113,935	242,530	122,873
5	2030		258,108	258,108	2.21	116,755	277,560	125,554
6	2031		290,270	290,270	2.48	117,235	311,630	125,862
7	2032		316,751	316,751	2.77	114,224	339,059	122,268
8	2033		317,042	317,042	3.11	102,079	339,059	109,168
9	2034		317,303	317,303	3.48	91,217	339,059	97,471
10	2035		329,083	329,083	3.90	84,467	351,042	90,104
11	2036		333,720	333,720	4.36	76,480	356,012	81,589
12	2037		333,910	333,910	4.89	68,325	356,012	72,847
13	2038		346,202	346,202	5.47	63,250	368,594	67,341
14	2039		346,356	346,356	6.13	56,498	368,594	60,126
15	2040		346,495	346,495	6.87	50,465	368,594	53,684
16	2041		359,347	359,347	7.69	46,729	381,805	49,650
17	2042		359,459	359,459	8.61	41,736	381,805	44,330
18	2043		359,560	359,560	9.65	37,274	381,805	39,581
19	2044		373,014	373,014	10.80	34,526	395,677	36,624
20	2045		373,096	373,096	12.10	30,834	395,677	32,700
		103,327				1,519,818		**1,535,975**

FNPV : ৳ lakh

∑Column 8 - ∑Column 6 16,157

FBCR :

∑Column 8/∑Column 6 1.01

Consolidated Economic Cost Benefit and Return

					2026	2027	2028	2029	2030	2035	2045
	Years				1	2	3	4	5	10	20
(1) Revenue	৳ lakh				66,668	98,854	165,535	242,530	277,560	351,042	395,677
(2) O&M Expenses	৳ lakh				67,143	96,912	159,250	231,671	264,126	332,453	374,216
(3) Operating Profit Margin					-475	1,942	6,285	10,860	13,433	18,589	21,461
(4) Cash Generated by the Project	৳ lakh				-475	1,942	6,285	10,860	13,433	18,589	21,461
(5) CO2 Emission	kg/day				887,460	1,325,533	2,217,872	3,130,932	3,564,934	4,215,529	4,215,529
(6) Environmental Cost of Enhanced CO2 Emission	৳ lakh				1,950	2,913	4,873	6,880	7,833	9,263	9,263
(7) Employment Generation					3,833	5,485	9,067	13,008	15,581	18,483	18,483
(8) Value Addition from Employment Generation	৳ lakh				6,900	9,873	16,321	23,415	28,046	33,269	33,269
(9) Share of Infrastructure in Employment Generation	%				53%	59%	55%	49%	52%	55%	54%
	৳ lakh				3,688	5,850	8,961	11,419	14,526	18,385	17,800
(10) Reduction in Doctor Visits	/mon/person				0.13	0.13	0.13	0.13	0.13	0.13	0.13
	৳ lakh				17	25	41	59	70	83	83
(11) Reduction in Industrial Accidents	/year				0.50	0.50	0.50	0.50	0.50	0.50	0.50
	৳ lakh				48	69	113	163	195	231	231
(12) Share of Operating Profit Margin in Export	%				10%	15%	20%	25%	25%	25%	25%
	৳ lakh				(48)	291	1,257	2,715	3,358	4,647	5,365
(13) Capital Expenditure	৳ lakh	27,890	33,203	42,234							
(14) Cash Flow wrt the Economy	৳ lakh	(27,890)	(33,203)	(42,234)	1,280	5,264	11,783	18,336	23,749	32,673	35,678
(15) Economic IRR	16.09%										

F&E11: ENPV_EBCR

		Cost to Economy						
Years		Investment	O&M Cost	Environmental Cost of Enhanced CO2 Emission	Loss of Income due to loss of livelihood	Total Cost to Economy	Discount Factor	Discounted Value of Total Cost
		৳ lakh	৳ lakh	৳ lakh	৳ lakh	৳ lakh	12%	৳ lakh
Col. 1		Col. 2	Col. 3A	Col. 3B	Col. 3C	Col. 4 = Col. 2 + ∑Col. 3	Col. 5	Col. 6 = Col. 4 / Col. 5
	2023	27,890	-			27,890	1	27,890
	2024	33,203	-			33,203	1.12	29,645
	2025	42,234	-			42,234	1.25	33,669
1	2026	-	67,143	1,950		69,093	1.40	49,179
2	2027		96,912	2,913		99,824	1.57	63,440
3	2028		159,250	4,873		164,123	1.76	93,128
4	2029		231,671	6,880		238,550	1.97	120,857
5	2030		264,126	7,833		271,959	2.21	123,021
6	2031		295,617	8,788		304,405	2.48	122,944
7	2032		321,507	9,263		330,770	2.77	119,279
8	2033		321,278	9,263		330,541	3.11	106,425
9	2034		321,080	9,263		330,343	3.48	94,966
10	2035		332,453	9,263		341,716	3.90	87,710
11	2036		336,731	9,263		345,993	4.36	79,293
12	2037		336,602	9,263		345,864	4.89	70,771
13	2038		348,610	9,263		357,873	5.47	65,382
14	2039		348,512	9,263		357,774	6.13	58,361
15	2040		348,425	9,263		357,688	6.87	52,095
16	2041		361,077	9,263		370,339	7.69	48,159
17	2042		361,010	9,263		370,273	8.61	42,991
18	2043		360,951	9,263		370,214	9.65	38,379
19	2044		374,262	9,263		383,525	10.80	35,499
20	2045		374,216	9,263		383,479	12.10	31,692
								1,594,774

		Benefits to Economy								
Years		Revenue	Employment Generation	Value Addition from Employment Generation	Share of Infrastructure in Employment Generation		Reductions in Doctor visits	Savings from Reduction of Industrial Accidents	Share of Increase in exports	Discounted Value of Benefits
		৳ lakh			%	৳ lakh	৳ lakh	৳ lakh	৳ lakh	৳ lakh
Col. 1		Col. 7A				Col. 7F	Col. 7G	Col. 7H	Col. 7I	Col. 8 =[∑Col. 7] / Col. 5
	2023									
	2024									
	2025									
1	2026	66,668	3,833	6,900	53%	3,688	17	48	(48)	50,090
2	2027	98,854	5,485	9,873	59%	5,850	25	69	291	66,785
3	2028	165,535	9,067	16,321	55%	8,961	41	113	1,257	99,814
4	2029	242,530	13,008	23,415	49%	11,419	59	163	2,715	130,146
5	2030	277,560	15,581	28,046	52%	14,526	70	195	3,358	133,764
6	2031	311,630	17,862	32,152	52%	16,816	80	223	4,003	134,393
7	2032	339,059	18,483	33,269	54%	18,099	83	231	4,388	130,490
8	2033	339,059	18,483	33,269	54%	18,099	83	231	4,445	116,528
9	2034	339,059	18,483	33,269	54%	18,099	83	231	4,495	104,057
10	2035	351,042	18,483	33,269	55%	18,385	83	231	4,647	96,096
11	2036	356,012	18,483	33,269	53%	17,715	83	231	4,820	86,825
12	2037	356,012	18,483	33,269	53%	17,715	83	231	4,853	77,529
13	2038	368,594	18,483	33,269	54%	18,002	83	231	4,996	71,600
14	2039	368,594	18,483	33,269	54%	18,002	83	231	5,021	63,932
15	2040	368,594	18,483	33,269	54%	18,002	83	231	5,042	57,086
16	2041	381,805	18,483	33,269	53%	17,504	83	231	5,182	52,641
17	2042	381,805	18,483	33,269	53%	17,504	83	231	5,199	47,003
18	2043	381,805	18,483	33,269	53%	17,504	83	231	5,214	41,968
19	2044	395,677	18,483	33,269	54%	17,800	83	231	5,354	38,796
20	2045	395,677	18,483	33,269	54%	17,800	83	231	5,365	34,640
		6,285,570								**1,634,184**

ENPV :

∑Column 8 - ∑Column 6 39,410 ৳ lakh

EBC Ratio :

∑Column 8/∑Column 6 1.02