People's Republic of Bangladesh
Power Division, Ministry of Power, Energy and Mineral Resources
Dhaka Electric Supply Company Limited (DESCO)
Dhaka Power Distribution Company Limited (DPDC)

Data Collection Survey on Underground Substation in Dhaka in People's Republic of Bangladesh

Final Report

May 2017

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Company Holdings, Inc.
Tokyo Electric Power Services Co., Ltd.

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Chapters

List of Figures

List of Tables

Abbreviations

RAJUK	Rajdhani Unnayan Kartripakkha
REHAB	Real Estate & Housing Association of Bangladesh
DESCO	Dhaka Electricity Supply Company
DPDC	Dhaka Power Distribution Company Ltd
MPEMR	Ministry of Power, Energy and Mineral Resources
BPDB	Bangladesh Power Development Board
PGCB	Power Grid Company of Bangladesh Ltd
MRT	Mass Rapid Transit System
DMTC	Dhaka Mass Transit Corporation
DTCA	Dhaka Transport Coordination Authority
MORTB	Ministry of Road, Transport and Bridges
IEE	Initial Environmental Examination
DOE	Department of Environment
EIA	Environmental Impact Assessment
DPP	Development Project Proposal
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
MOEF	Ministry of Environment and Forest

Chapter 1 **Preface**

1.1 Background to Survey

Bangladesh, with its firm GDP growth of approximately six percent per annum, has been confronting an enlarging power demand. The country forecasts that it will require expansion of its generation capacity by 11,000MW or more in the upcoming seven years, and the existing electricity system needs further facility development for substations, and the transmission and distribution network in order to meet the sharp demand increase as forecasted in the near future.

The strong demand is prominent in the capital city, Dhaka. The load demand in 2015 reached its peak at 880MW in the city's northern part, and 1,470MW in its south. Demands for 2030 are anticipated as 4,550MW and 6,843MW respectively. As the heart of the country's economy and industry, Dhaka has been accommodating large-scale economic activities in recent years and seen a rush to construct high-rise office buildings. Reinforcement of power supply facilities is an immediate and urgent need in Dhaka, which requires expansion of maximum substation capacity from 1,708MWA in 2015 to 9,618MWA in 2030 in the north, and from 1,838MWA to 8,55MWA in the south.

Among the demographic features of Dhaka, its high population density is noteworthy compared with the rest of the globe. Population in Dhaka Metropolitan Area (DMA) has nearly doubled in the last two decades, growing from 6.35 million in 1990 to over 12 million in 2011. Rapid growth in the population, and economic activities and urbanization, have made it difficult to find and acquire sufficient areas of land on surfaces suitable for newly constructing or reinforcing existing substation facilities and the transmission and distribution network in DMA, and such activities are also quite costly.

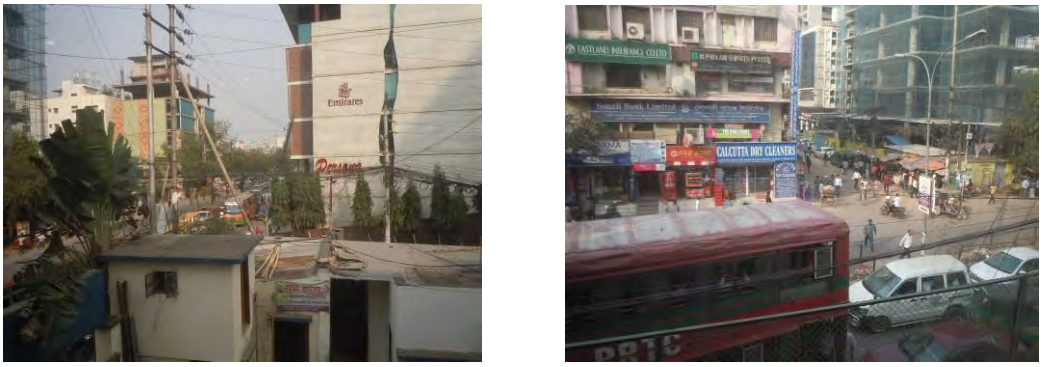


Figure 1-1: Surrounding area of New Gulshan Substation Candidate Site in METI Study

Construction of underground substation facilities and utilization of superstructures is an idea worth examining for technical and financial viability as effective solutions that will enable Bangladesh to accelerate the implementation of a transmission and distribution network enhancement plan to meet the demand. The Power Division of the Government of Bangladesh has given direction in accommodating underground substation facilities and distribution cables in the center of Dhaka city, to improve the security of public infrastructure by making best use of both surface and underground space in urban populated areas. Both Dhaka Electric Supply Company Ltd, DESCO, and Dhaka Power Distribution Company, DPDC, also showed keen interest in underground electricity facilities, although there has never been an underground substation constructed or operated in the country.

Since neither distribution company has ever constructed an underground substation, support for design and construction of an underground substation in Dhaka and its proper operation was necessary. Thus, the Power Division asked METI to assist them in conducting a preliminary feasibility study on underground substation construction, and METI deployed TTNI's Consultancy Team to examine the possibility of an underground substation in Gulshan Area, during September 2015 to March 2016. As a result, equipment specifications and preliminary layouts for underground substations were developed. Then, Power Division asked JICA to conduct a data collection survey to examine the technical, financial and environmental viability of constructing underground substations and transmission cables in the service area of DESCO and DPDC, and JICA has commissioned a technical survey from TEPCO/TEPSCO.

1.2 Objectives

This Survey sets its scope as Dhaka Metropolitan Area, and first verifies the necessity of underground substation construction based on DPDC and DESCO's network expansion plan along with PGCB's bulk-network master plan. After confirming the necessity of the underground substation project(s), the survey further studies both the financial viability of an underground substation by utilizing its superstructure for other business purposes, and the technical feasibility of the building design and construction project based on geological survey results and relevant regulations and technical requirements regarding high-rise building construction in Dhaka Metropolitan Area.

In addition, the survey team nominates possible JICA technical assistance in the fields of technical design, construction, and facility operation based on the project's study on available equipment and construction materials in Bangladesh and relevant technical information.

Then, the team investigates the possibility of a future JICA UGSS project as part of Japanese ODA, and proposes a possible JICA UGSS project if the team confirms its necessity.

1.2.1 Study Components

Table 1-1: The Survey's Major Components

1.

1.1. Enumeration of necessary information to be gathered, on-site surveys plan
1.2. Preliminary Study on UGSS project selection criteria (drafting)
1.3. Development of Inception report, questionnaire, and presentation for kick-off meeting

2. First Visit in Bangladesh in June for information collection

2.1. Kickoff meeting with relevant agencies, counterparts, and JICA Bangladesh Office
2.2. Data collection and Analysis
- **Data collection on Bangladesh's power network master plan (replacement and expansion plan for generation, transmission, substation, and distribution facilities)**
- **Study on energy-sector policies, regulations, ordinances**
- **Data collection on relevant agencies' business plans, organizations, and financial performance**
- **Identification of energy sector's current issues**

2.3. Study on Bangladesh's building codes and relevant regulations for underground substation building
2.4. Socio-economic study in Dhaka metropolitan area, Distribution companies' business plans, and their budget plans and performance
2.5. Study on organizational structure of Bangladesh's energy-sector government body, relevant authorities, and transmission and distribution companies for transmission network and distribution network construction and operation
2.6. Study on other countries' ODA programs (plans and history) for transmission, substation, and distribution facilities
2.7. Study on historical flooding and its damage on Dhaka metropolitan area
2.8. Confirmation of underground substation project's conformity to Japanese government and JICA's assistance policy, and identification of the assistance's contribution and issues

3. Second visit at end of August (replaced with Tokyo meeting for Study on UGSS candidate sites)

3.1. Cost evaluation and comparison of substation forms and transmission facilities
3.2. Nomination of candidate sites for underground substations in network plan (long-list)
3.3. Preliminary business model studies on underground substations in candidate sites
3.4. Development of site selection criteria for UGSS projects
3.5. Nomination of UGSS project sites

4. Third visit in November (replaced with Bangkok for Development of UGSS Project)

4.1. Discussions on Interim report on UGSS project site nomination
4.2. Geographical and geological study, and Hydrological survey
4.3. Study on underground substation structure, and application of Japanese technologies and experience
4.4. Study on JICA's assistance for design and construction for transmission and distribution facilities (technical issues, target areas, and technical fields)
4.5. Survey on social and environmental considerations for underground substation construction and underground transmission line installation
4.6. Identification of Survey for social and environmental issues and their countermeasures

5. Domestic work in November

5.1. Development of Draft Final Report

5.2. Technical Discussion and site visits in Japan in November

6. Fourth visit in December (replaced with Sydney for site visit for wind cooling systems of GIT)

6.1. Interview survey for advantages and disadvantages with the operational aspect of the transformer via difference in cooling method, trouble history for wind cooling system

6.2. Site survey for Substation with wind cooling system

7. Domestic work in January

7.1. Project report to counterparts, relevant donors and agencies

7.2. Project report to JICA Bangladesh Office

1.2.2 Survey Workflow

The following chart shows the project's work procedure.

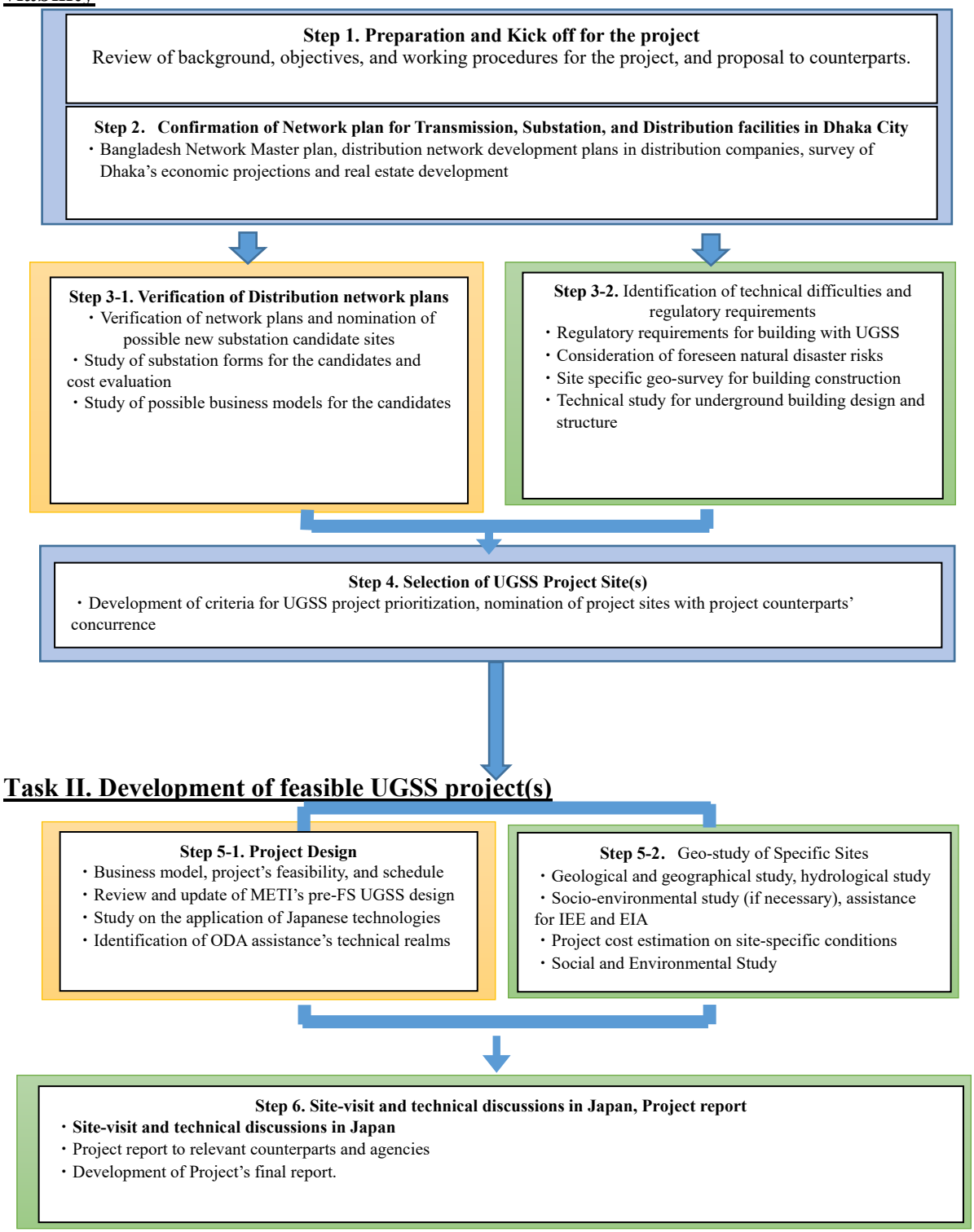


Figure 1-2: Flowchart of the project procedure

This project started on June 10th, 2016, and an inception report was developed for JICA and relevant agencies. The interim report will be developed in September 2016, and the Draft final report will be submitted by the end of December.

1.2.3 JICA Survey Team Members

The following figure shows the JICA survey team members.

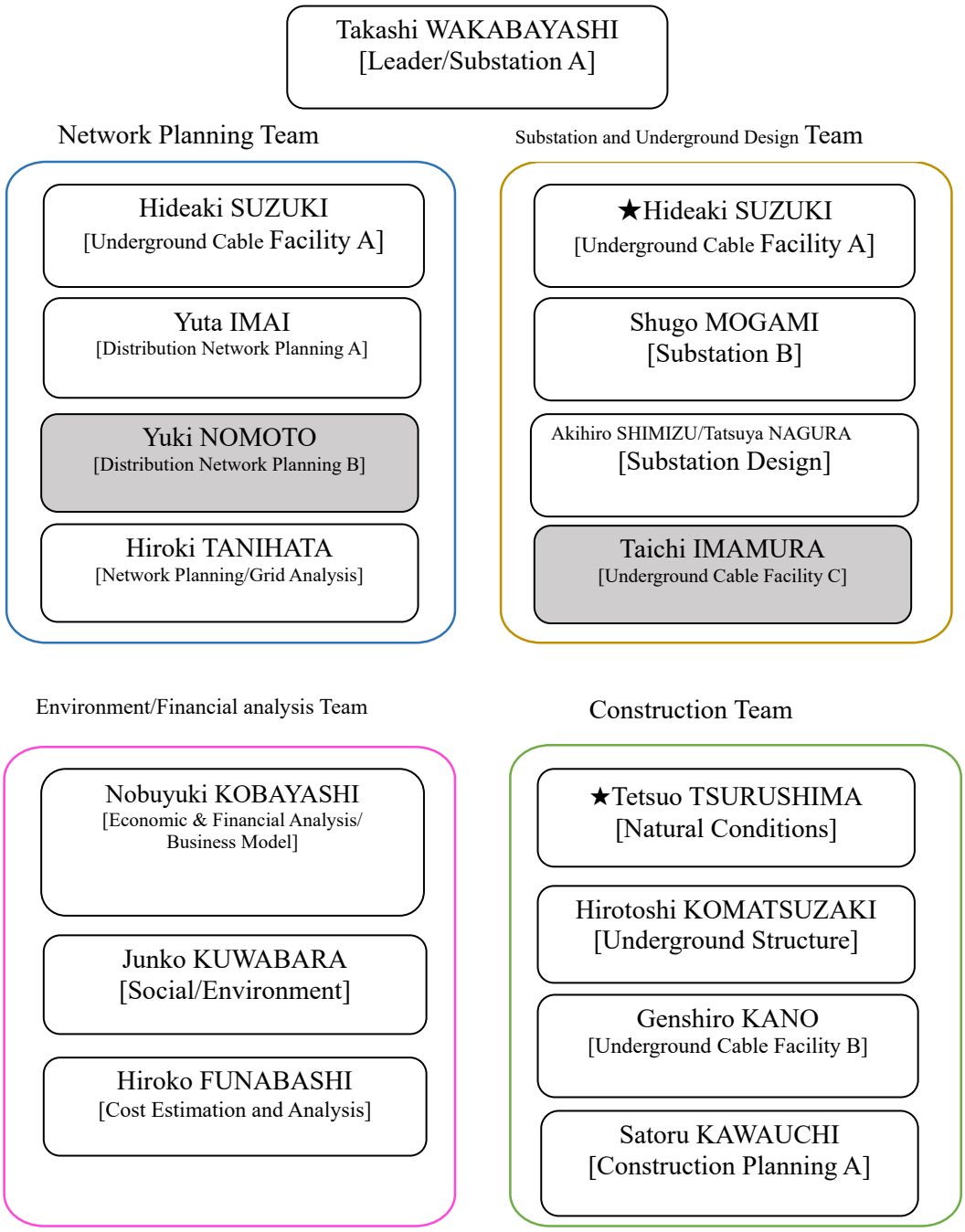


Figure 1-3 JICA Survey Team Members

1.3 Survey Project's results

This JICA project, "Data Collection Survey on Underground Substation in Dhaka in People's Republic of Bangladesh", investigated the feasibility of underground substations in DPDC and DESCO's supply area in Dhaka City. The counterpart nominated six candidate sites, and Kawran Bazar Underground substation project and Gulshan underground substation project were eventually selected as the first project set. Their selection was based on verification of the electricity demand projections in the project area, technical feasibility of underground substation building, social & environmental impacts, and the financial impact of the underground substation project including its superstructure.

This survey validated the following hypothesis: the introduction of an underground substation in the Dhaka city area, where a steep increase in electricity demand and land scarcity are observed, contributes to the construction of larger-scale distribution network components in the existing substations' plots, where existing substation components are usually operating. This hypothesis was validated by confirming supporting facts: (1) land scarcity in Dhaka city, where land owners anticipate further land price increases in the near future and are therefore not eager to sell their land now to the public sector, which may delay distribution companies' network expansion plans, (2) the expansion of the distribution networks in Dhaka city requires upgrade of the supply network voltage from 33kV to 132kV by replacing existing substations' plots, with which distribution companies can avoid or minimize new land acquisition for the higher capacity network facilities, and (3) the six nominated candidate sites for near-future substations were too small to cater for conventional outdoor- or indoor-substation construction while keeping the existing substation in operation during their construction.

Possible technological challenges and solutions for new underground substation construction were also studied, and the survey team concluded that most of the necessary civil and building construction technologies and relevant materials are already available in the Bangladesh market, and therefore Bangladesh's building construction companies are technically capable of underground substation building construction except for the particular design and construction techniques for the substation cooling system, which would require the assistance of experienced Japanese engineers during the project's implementation stages.

During the course of this feasibility study, the stakeholders - Power Division, PGCB, DESCO, and DPDC - agreed that the Gulshan project would be designed as a large-scale re-development project including the existing PGCB substation site and DPDC project offices. The Consultant also proposes the utilization of BPDB's residence plot in the Kawran Bazar Project to secure operational flexibility, especially with regard to preparation for large equipment transportation.

In contrast to the availability of construction resources in the Bangladesh market, the design techniques for an UGSS building and its superstructure may require further capacity building from experienced foreign architects and civil engineers. Co-ordination with the UGSS building and its superstructure could be the most pertinent portion in the building design, and it is also quite important to secure an underground substation's operational reliability and fast-troubleshooting features without hampering the public's activities in the superstructure portion. Since the overall project framework for the two projects is not yet finalized because the usage of their superstructures is still under discussion with stakeholders, continuous technical and engineering support for project development are necessary with the help of Japanese engineering consultants with vast experience in underground substation design and design co-ordination with superstructures.

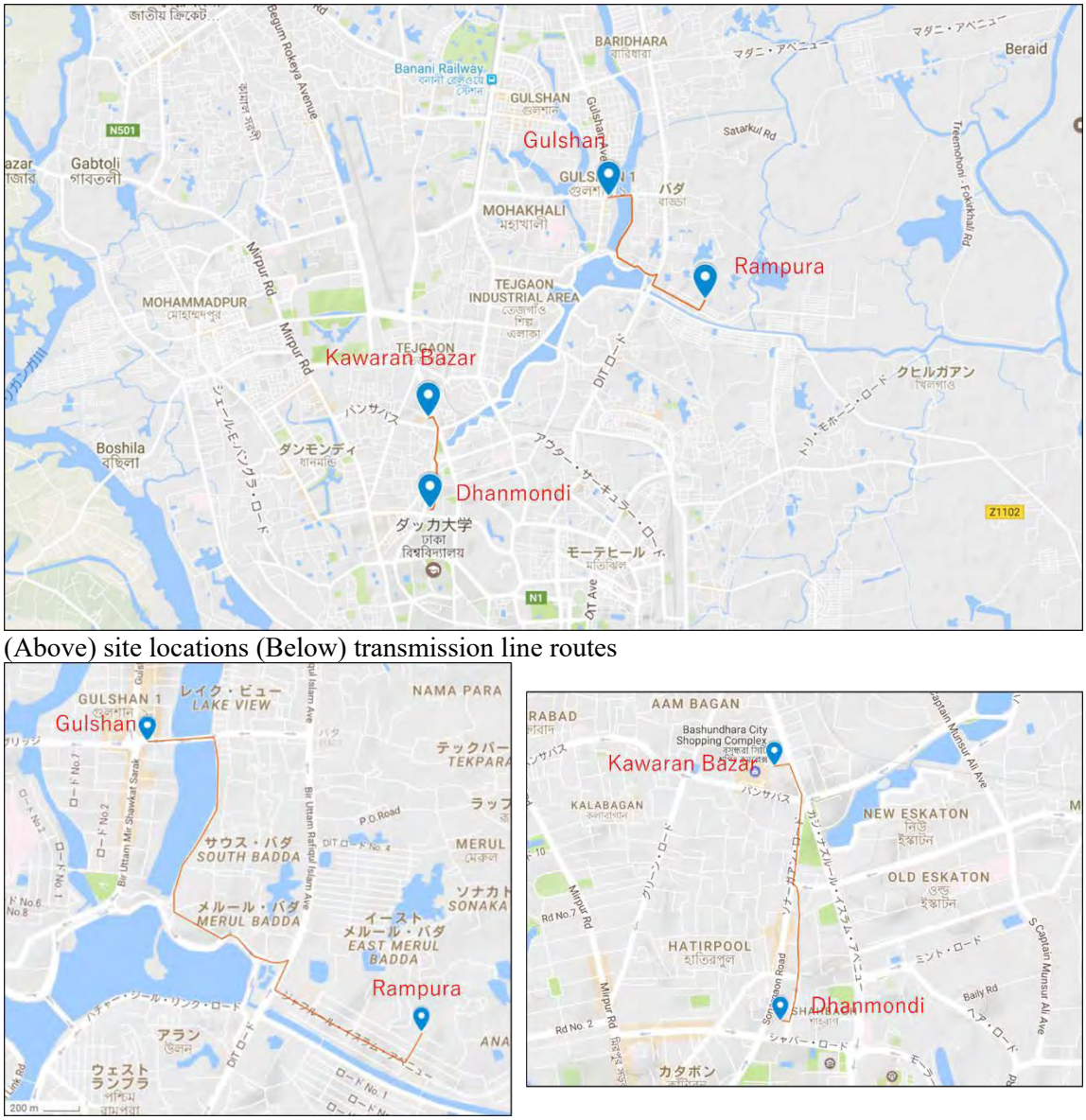
In addition, UGSS projects are designed to utilize Gas Insulated Transformers (GIT) to minimize the substation fire risk, which may be critical in an underground substation that has a superstructure

for public use. Thus, necessary technical assistance, such as developing technical specifications for GIT procurement, and capacity building for substation operation engineers for GIT operation and maintenance, must be provided for successful introduction.

The survey team also studied the social and environmental aspects of the underground substation and 132kV underground transmission line project in Dhaka, and concluded that all anticipated adverse impacts can be mitigated with proper countermeasures in the project's construction work, and therefore significant and irreversible social and environmental outcomes can be avoided. The survey team's financial study on the underground substation project found that the utilization of the UGSS superstructure for other businesses, which is not included in JICA's project framework, can improve DESCO and DPDC's financial stability in the proposed two projects, Gulshan and Kawran Bazar, and that the remaining four UGSS candidate sites may become feasible in future, when the economic benefits of the superstructure are increased along with renovation of the adjacent town.

Based on the study results, the Survey team conducted on-site surveys and developed detailed designs for the two candidate projects, Gulshan and Kawran Bazar, as nominated from the six candidates and suggested incorporating the neighboring plots owned by other power utilities and relevant organizations to maximize the projects' financial stability. The final UGSS layouts and technical specifications were agreed among the Survey team, DESCO and DPDC.

The following figures show the locations of the two project sites, and their 132kV transmission line routes and source substations.



(Above) site locations (Below) transmission line routes

Figure 1-4 Project sites, 132kV transmission line routes and their source substations

The detailed layouts for the two selected UGSS projects were developed based on topological surveys and Bangladesh's building codes for high-rise buildings that were confirmed in the Survey team's discussions with RAJUK. The buildings' loading conditions and column design were studied by referring to relevant Japanese laws and regulations, and precedent UGSS projects in Japan. The project design also proposes utilization of the neighboring plots in both sites to enhance the UGSS's operational reliability and facilitate the building construction and equipment installation work. Based on the realistic UGSS layouts revised from METI's pre-FS study, the total project costs and project scheduling were studied on JICA's basis, and Socio-Environmental studies and financial stability of the projects were examined and found to be feasible.

As the next step, DESCO and DPDC will develop designs for the superstructures based on the Survey team's study by following the decisions from the government and relevant stakeholders for the use of superstructures. Since the design co-ordination and total project design are quite important in securing the UGSS's operational reliability by avoiding any operational constraints caused by public activities in the superstructure, continuous engineering design support is

necessary. Since the projects utilize Gas Insulated Transformers, which are selectively used for densely populated cities across the world, the survey team recommends further JICA technical and financial assistance.

1.4 Discussions in Japan

Discussions and site surveys were organized in Japan during August 29th to September 7th, 2016 with the following delegations from Power Division, PGCB, DPDC, and DESCO. Sub-consultancy teams from Bti and CEGIS also joined the discussions. The topics discussed were underground network planning, facility designs, and Gulshan and Kawran Bazar's underground substation design requirements.

Table 1-2 Schedule for UGSS meetings and on-site visits in Japan

Schedule of UGSS meeting and on-site visits in Japan

(JICA's Data Collection Survey on Underground Substation in Dhaka)

Hotel Address: Dai-Ichi Hotel Tokyo Shinbashi 1-2-6 , Minato-ku, Tokyo, Japan 〒105-8621 TEL 03-3501-4411

Date		Time	Schedule:A (Enginnering Counterpart)	Schedule:B (Executives)	Plan						Accommodation
					Transport	Departure time	Origin	Transit	Arrival time	Destnation	
28-Aug	Sun	13:35 ～ 16:05	Flight （Dhaka～Bangkok）	Flight （Dhaka～Bangkok）	Flight No.TG322	13:35	Dhaka		17:00	Bangkok	
		22:55 ～ 6:55	Flight （Bangkok～Haneda）	Flight （Bangkok～Haneda）	Flight No.TG682	22:45	Bangkok				
29-Aug	Mon		Flight （Bangkok～Haneda）	Flight （Bangkok～Haneda）					6:55	Haneda	Daiichi Hotel
		15:30 ～ 16:00	Orientation	Orientation	Kick-off Meeting introducing overview of TEPCO						
		16:00 ～ 16:30	Courtesy visit to TEPCO	Courtesy visit to TEPCO	Meeting with TEPCO exectives.(venue:tepcoHQ1101,1102)						
		17:30 ～	Welcome dinner （TEPCO）	Welcome dinner （TEPCO）	at Ginza						
30-Aug		9:30 ～ 11:30	Technical Discussion	Technical Discussion	Kick-off presentation & discussion						
		12:30 ～ 16:00	Site Visit: Distribution Facility	Site Visit: Distribution Facility	TEPCO Training Center (Distribution Model)						
31-Aug	Wed	9:30 ～ 12:00	Site Visit: EHV UGSS/Distribution UGSS	Site Visit: EHV UGSS/Distribution UGSS	Higashi Uchisaiwai, & Kami Ote UGSSs						Daiichi Hotel
		13:00 ～ 16:00	Technical Discussion	Site Visit: Underground Construction Work(Tokyo Station)	Discussion on UGSS design details, demand forecast, town planning for six candate sites						
		17:00 ～ 18:00		Courtesy visit to JICA	Coutesy Visit to JICA						
1-Sep	Thu	9:30 ～ 11:30	Technical Discussion (Counterpart Eng.)	Kashima Port (Executive)	Technical Discussion for Distribution Networking, and UGSS designs in Dhaka City						Daiichi Hotel
		12:30 ～ 16:00	Technical Discussion (Counterpart Eng.)	Hitachi Naka PSS (Executive)							
2-Sep	Fri	9:00 ～ 13:00	Technical Discussion	Technical Discussion	Financial & Distribution Networking						Daiichi Hotel
		14:00 ～ 16:00	Site Visit : TEPCO NLDC & Smartmeter SCADA system(SMOC)	Site Visit : TEPCO NLDC & Smartmeter SCADA system(SMOC)							
3-Sep	Sat	AM	Site Visit	Site Visit	Rual Distribution Network						Daiichi Hotel
		PM									
4-Sep	Sun	AM	Technical Discussion (supplimental)	Technical Discussion (supplimental)							Daiichi Hotel
		PM	Technical Discussion (supplimental)	Technical Discussion (supplimental)							
5-Sep	Mon	9:30 ～ 11:30	Techinical Discussion	Techinical Discussion	Social & environment issues						Daiichi Hotel
		13:00 ～ 16:00	Meeting with JICA	Meeting with JICA							
6-Sep	Tue	10:30 ～	GIT Factory	GIT Factory	UGSS Design discussion with manufacturers, Manufacturing Quality Observation for GIT factory						Daiichi Hotel
		～ 14:30	GIS・High spec lighitning Arrester Factory	GIS・High spec lighitning Arrester Factory	Manufacturing Quality Discussion for Gas Insulated Switchgear						
7-Sep	Wed	9:30 ～ 11:30	Site Visit : 500kV UGSS	Site Visit : 500kV UGSS	500kV/275kV Shin-Toyosu Underground substation,						Daiichi Hotel
		13:00 ～ 16:00	Technical Discussion	Technical Discussion	Progress Report, Study Scheduling, Wrap-up						
					Transport	Departure time	Origin	Transit	Arrival time	Destnation	
8-Sep	Thu	0:20 4:50	Flight （Haneda～Bangkok）	Flight （Haneda～Bangkok）	Flight No.TG661	0:20	Haneda		4:50	Bangkok	
		7:05 ～ 8:30	Flight （Bangkok～Dhaka）	Flight （Bangkok～Dhaka）	Flight No.TG321	10:35	Bangkok		12:10	Dhaka	

Table 1-3 Delegation List

	Name	Organization
1	Mr. Mahbub-Ul-Alam	Power Division
2	Mr. Md. Shohelur Rahman Khan	Power Division
3	Mr. Choudhury Alamgir Hossain	PGCB
4	Mr. Arun Kumar Saha	PGCB
5	Brig. General Md. Shahid Sarwar	DESCO
6	Mr. A. K. M Akhtaruzzaman	DESCO
7	Mr. Md. Alamgir Hossain	DESCO
8	Mr. Md. Raihan Mondol	DESCO
9	Mr. Md.Monjurul Hoque	DESCO
10	Brig. General Md. Nazrul Hasan	DPDC
11	Mr. Sarwar Quainat Mohammad Noor	DPDC
12	Mr Md. Momimul Islam	DPDC
13	Mr. Haider Ali	DPDC
14	Mr. Mehedi Hasan	DPDC
15	Mr. Subrata Kumar Mondal	CEGIS
16	Mr. Malik Fida A Khan	CEGIS
17	Mr. Faizur Rahman Khan	Bti : MD
18	Mr. Zahangir Mohanmad Alam	Bti (New Vision)
19	Mr. Zaki Md. Ziaul Islam	JICA

Figure 1-5 Pictures of On-site Visits

The purpose of the Japan visit was to study underground facilities including Gas Insulated Transformers, underground tunnels with a lot of cables and disaster prevention design for underground facilities. The visitors were able to envisage the underground facilities to be installed in Dhaka and discuss detailed and practical designs through the site visit. Additionally, the

workshop enabled the Bangladesh delegates to understand the advantage of Japanese technology and to agree on the effectiveness of the project with GIT installation.

Chapter 2 **Survey Results**

2.1 Economic trends and Power Sector Overview in Bangladesh

The following table shows economic growth projection in JICA's PSMP.

Table 2-1: Projection for GDP and GNP per Capita

	2010	2015	2020	2025	2030	2035	2041
GDP (million USD) *1	93,236	126,630	181,282	258,598	351,109	453,642	587,665
GDP Growth Rate (p.a.) *1	6.1%	6.3%	7.4%	7.4%	6.3%	5.3%	4.4%
GDP per capita (USD) *1	615	787	1,063	1,444	1,883	2,357	2,970
GDP per capita (USD) *2	760	1,207	1,998	3,270	5,060	7,396	10,993

(Source: JICA PSMP Study)

Note) Average growth rate is the five-year average except in the column for 2041, which is a six-year average.

*1: Real Basis at 2005 price

*2: Nominal Basis

The following shows the maximum demand projected.

Table 2-2: Maximum demand projected to 2015 (PGCB Study results)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Comilla	1,170	1,307	1,466	1,642	1,842	2,045	2,283	2,525	2,788	3,033	3,313
Chittagong	1,017	1,134	1,318	1,449	1,591	1,743	1,910	2,071	2,257	2,405	2,618
Khulna	1,341	1,453	1,596	1,747	1,943	2,141	2,354	2,602	2,791	2,988	3,212
Bogra	1,473	1,617	1,783	1,981	2,191	2,398	2,615	2,833	3,055	3,293	3,505
Dhaka	1,869	2,106	2,334	2,589	2,954	3,286	3,629	3,943	4,279	4,589	4,903
DESCO	956	1,058	1,230	1,367	1,483	1,647	1,795	1,958	2,140	2,374	2,578
DPDC	1,510	1,675	1,934	2,101	2,321	2,581	2,868	3,173	3,535	3,880	4,242
Total	9,336	10,350	11,660	12,874	14,325	15,841	17,454	19,106	20,844	22,562	24,370

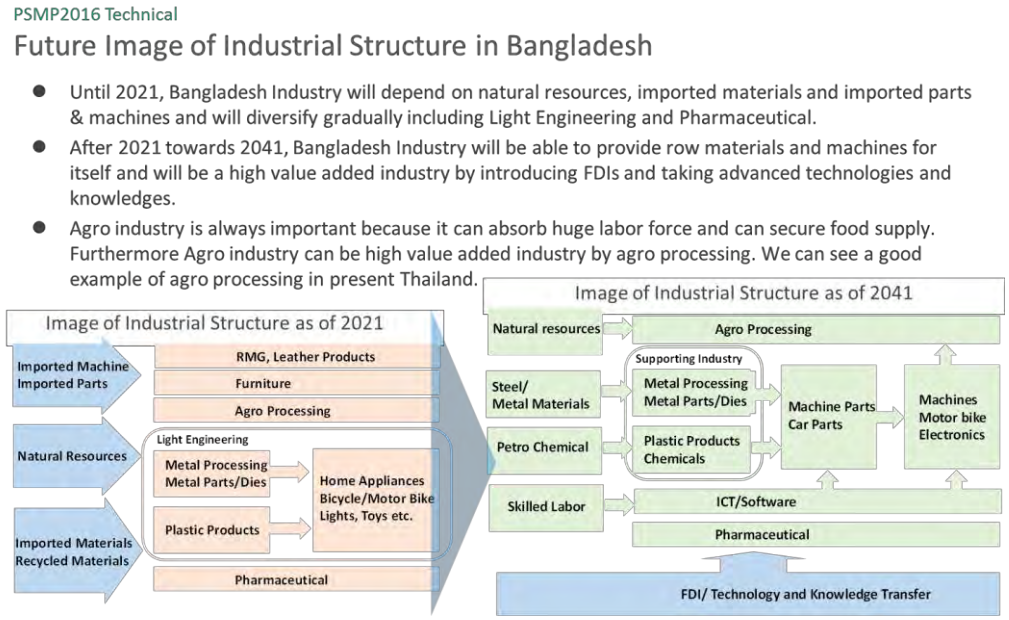
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Comilla	3,565	3,824	4,053	4,337	4,573	4,746	4,925	5,088	5,258	5,434
Chittagong	2,823	3,009	3,208	3,367	3,534	3,695	3,856	4,024	4,200	4,385
Khulna	3,407	3,595	3,805	4,036	4,262	4,424	4,557	4,712	4,865	5,024
Bogra	3,718	3,936	4,161	4,374	4,588	4,759	4,922	5,087	5,259	5,435
Dhaka	5,200	5,547	5,901	6,247	6,606	7,003	7,336	7,657	7,993	8,346
DESCO	2,807	3,032	3,274	3,580	3,853	4,081	4,326	4,565	4,818	5,089
DPDC	4,723	5,139	5,558	6,003	6,450	6,885	7,274	7,659	8,056	8,490
Total	26,243	28,082	29,960	31,943	33,866	35,593	37,195	38,793	40,449	42,203

(Source: JICA PSMP Study)

Severe constraints on urban development in the Dhaka metropolitan area lie behind the underground substation feasibility assessment. The Dhaka metropolitan area has experienced a significant population growth in recent years and this has resulted in difficulties in new land acquisition.

In 2015, the sum of electricity demand of Dhaka city, sum of demands of DESCO, DPDC, PGCB's substation and Dhaka Area, shares 46.4% of total electricity consumption in Bangladesh. In 2025 in the table above, the total consumption in Dhaka city increases to 11723MW, which is 2.3 times to the demand of 2015, and shares 48.1% of total demand projection. To supply this demand projection, approximately 34 units of 132/33/11kV, 120MVA x 3 unit substations may be necessary with the assumption that N-1 Criteria for operational capacity and power factor as 0.9.

In terms of electricity supply quality, the power sector master plan foresees that the industrial structure shift from primary processing with available natural resources and abundant price-competitive labor workforce to a technology-oriented industries, such as petrochemical, machine and parts manufacturing, light industries, and Information technology, all of which requires more stable electricity supply as a backbone system.



Source: JICA M/P 2016

Figure2-1 Industry Diversification Plan in JICA M/P 2016

The population growth declined in the Dhaka metropolitan area from 1981 to 2001 but it had been increasing since 2001. As Dhaka is the center of the ready-made garment industry, this stimulates migration in search of employment in the industry. Furthermore, migration from the areas affected by river erosion and cyclones to Dhaka has increased. According to the Population and Housing Census 2011, the population of the Dhaka metropolitan area was 14.17 million. The population in the city is expected to continuously increase in the future and to reach 25.94 million in 2035 (RAJUK (2015) "Dhaka Structure Plan").

Table 2-3: Migration trend in the Dhaka metropolitan area

Year	(A) Population growth in the Dhaka metropolitan area (%/year)	(B) Growth of migrant population (%/year)	(B) / (A) Growth caused by migration (%/year)
1974-1981	9.94%	7.62%	77%
1981-1991	7.55%	5.54%	73%
1991-2001	3.71%	2.13%	57%
2001-2011	3.96%	2.49%	63%

(Source: RAJUK (2015) “Dhaka Structure Plan”)

Dhaka has a high population density and it is difficult to acquire new land for further development in the city. The area of vacant lots including parks is less than 1% of the total area of Dhaka and the figure is far below the 20-30% for major cities in developed countries (RAJUK (2015) "Dhaka Structure Plan"). In addition, much of the incoming population has been living in urban slums, and 4500 slum areas are scatted across Dhaka. Since landownership is unclear in these slum areas, this has caused further difficulties in land acquisition.

Due to high population growth, land price has gone up significantly. The land price in Dhaka (average of 21 locations) increased almost 20 times on a local currency basis during the period of 1990-2010 and land prices per square meter of major downtown areas reached 200,000-600,000 BDT in 2010 (based on REHAB data in 2013 and calculated by JICA Survey Team).

The above data show that electricity demand will increase partially due to domestic immigrants and demand density of the city will increase as well. The demand increase requires not only t additional banks in existing substations but also new distribution substations and upgrading to 132 kV. On the other hand, distribution companies will face severe constraints on land acquisition for new substation sites and this problem will retard the construction of new substations.

This project intends to construct an underground substation and this will enable effective use of the substation site. The Bangladesh government has an urban development policy to cope with overcrowding in the Dhaka metropolitan area and the project effect to be expected from this project is consistent with this policy.

The 7th Five Year Plan FY2016-FY2020 showed sectoral development strategies. The urbanization strategy is featured in “Sector 9: Housing and Community Amenities”. The five-year plan mentioned that the urban population increased 16-fold from 1961 to 2011 and, thus, Bangladesh has been in the process of rapid urbanization. In particular, residents in the Dhaka metropolitan area accounted for 44.26% of the total urban population (urban dwellers based on the definition of Bangladesh Bureau of Statistics) and the population was larger than the sum of the second, the third and the fourth largest cities (Chittagong, Khulna, and Rashahi). In consideration of the rapid progress of urbanization, the policy objectives of the urban development included "Ensuring better utilization of land resources and mitigating increased demand for housing and urban services."

RAJUK formulated the Dhaka Structure Plan (2015) and the plan divided the Dhaka metropolitan area into five zones (Central Urban Area, Outer Urban Area, Growth Management Area, Conservation Area, Agricultural Area) and both Dhaka South and Dhaka North, where underground substations are planned to be built, were classified as Central Urban Area. While the plan pointed out that Central Urban Area has little room to develop vacant lots, the area has some advantages to promote development such as better access to employment. The plan proposed several actions such as redevelopment of old quarters, securing vacant lots, and construction of high-rise buildings with more than 10 floors. In addition, the Dhaka Structure Plan established nine policy directions, one of which is the "Effective Land Use Management for Livable Dhaka". Under the policy direction, one of the policy objectives was “to mobilize the under-utilized lands within the city." The plan proposed that RAJUK prepare a redevelopment and rehabilitation plan and that the usage density of underutilized areas be improved in Central Urban Area. The plan also mentioned that the usage density of land would be improved through infrastructure development in certain areas such as Gulshan, Banani, and Baridhara.

2.2 Transmission and distribution item enforcement system of the Bangladesh government and the associated organization

For the enforcement system of MPEMR(Ministry of Power, Energy and Mineral Resources), Power Division, PGCB, DESCO、DPDC taking a Bangladesh electricity sector, the planning, organization, human resources, budget, business operation situation is as follows.

2.2.1 **Electricity Utility Structure**

Under the jurisdiction of the Ministry of Power, Energy and Mineral Resources (MPEMR), the Power Division (PD) oversees the whole electricity utility. Electricity is generated by the Bangladesh Power Development Board (BPDB), a company spun off from BPDB, Independent Power Producers (IPPs) and private power producers. Generated electricity is supplied via the Power Grid Company of Bangladesh's (PGCB) power grid to the capital area, where it is supplied by Dhaka Power Distribution Company (DPDC) and Dhaka Electricity Supply Company (DESCO); local areas, where it is supplied by BPDB and West Zone Power Distribution Company Limited (WZPDCL); and farming areas, where it is supplied by Palli Bidyuit Samity (PBS).

Source: The Survey Team

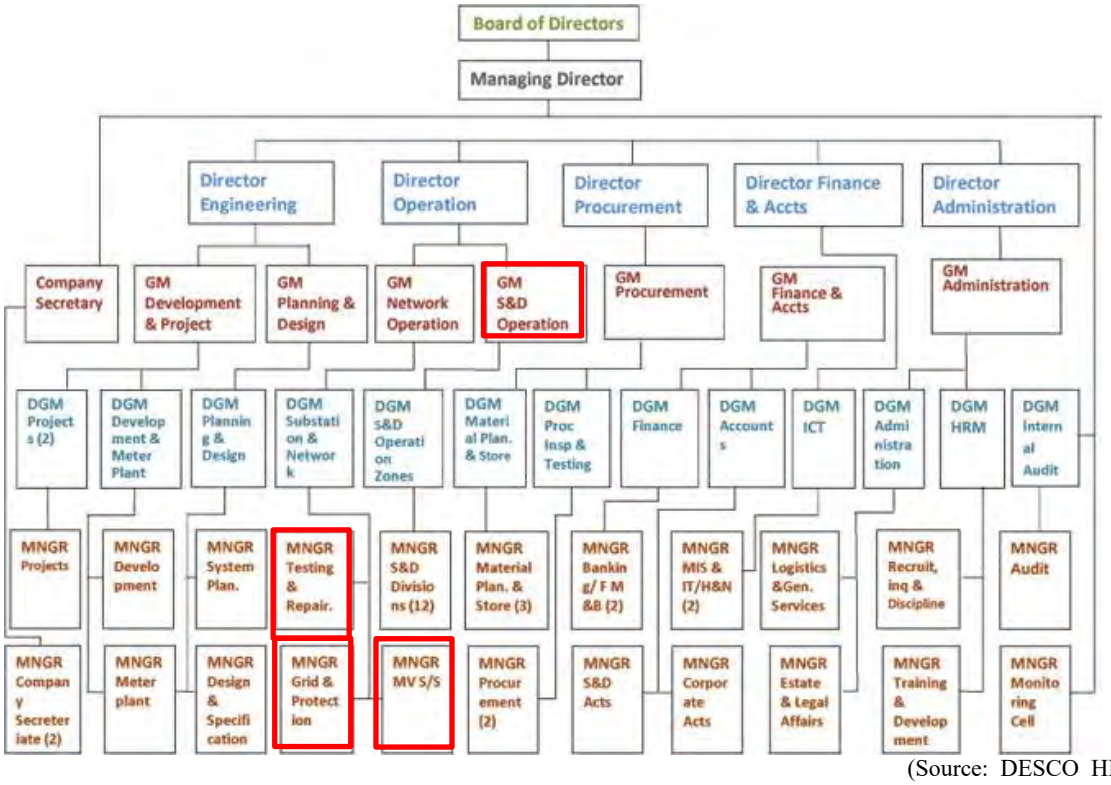
Figure2-2 Electricity sector structure in Bangladesh

2.2.2 **Organogram for project implementation organization**

There are the current organogram of DESCO and DPDC both who have candidate site for Underground Substation.

2.2.2.1 **Organization constitution for DESCO**

Dhaka Electricity Supply Company (DESCO) have north area of Dhaka city as jurisdiction.



(Source: DESCO HP)

Figure2-3 Organogram for DESCO（as of November, 2016）

According to interview, DESCO is run with the limited staff, and the sufficiency degree of the number of human resources confirms that it is around 60%.The number of total staffs is 1,506 people, and they are constructed in five Department as of November, 2016. The post about this business is Network Operation Department of the Operation section having jurisdiction over facilities use. It is performed with the following staff about the management.

Testing & Repairing	10 people(as of November, 2016)
Grid & Protection	43 people(as of November, 2016)
MV S/S Maintenance Coordination	6 people(as of November, 2016)

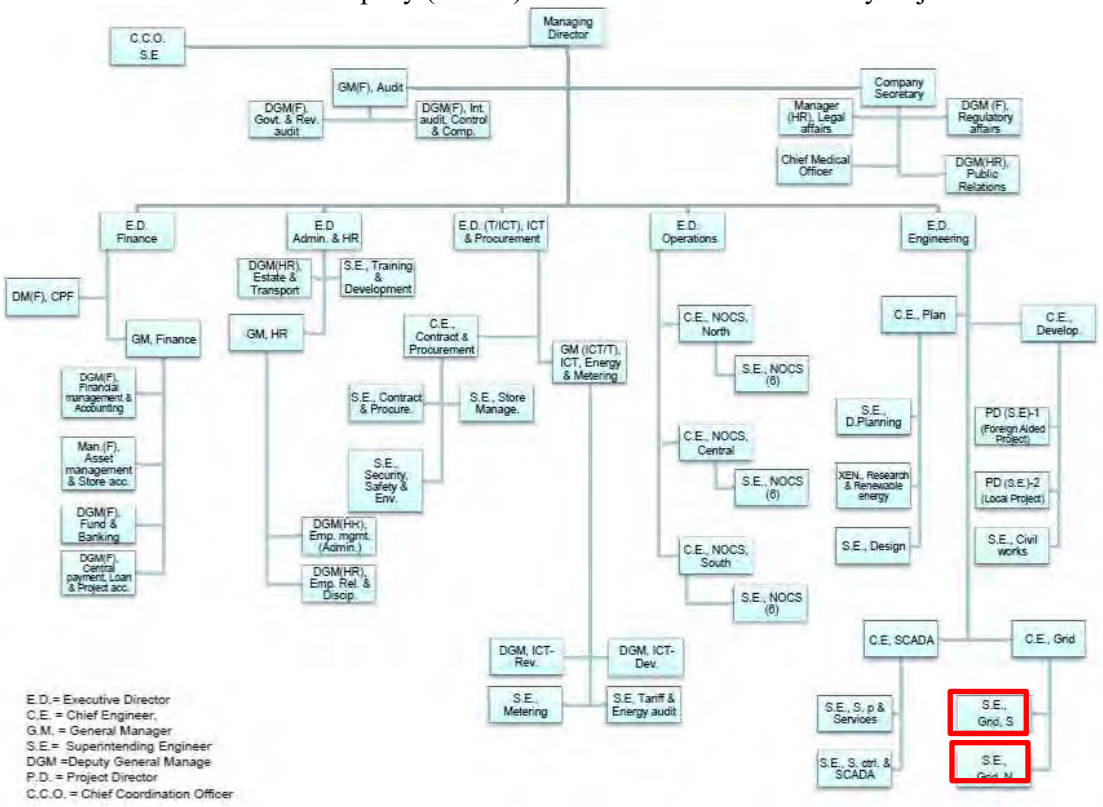
The substation facilities are performed in Medium Voltage Substation Maintenance Coordination Division (MV S/S MC) mentioned above, but it is until annual check to perform regularly. Daily maintenance is done by S & D Division under S & D Operation Department of the Operation section. It is managed by 372 people (31 substation *4 *3 shifts) as of November, 2016.

Since an audit unit is separated from the Finance Department, different divisions are in charge of internal audit and budget process (such as preparation and implementation). An audit firm (Artisan Chartered Accountants for FY2015/16) audited DESCO's financial statements in accordance with Bangladesh Financial Reporting Standards. Audit results are shown DESCO's an annual report. The audit result for FY 2015/16 is a qualified opinion (an audit firm assures financial statements as fair representation of financial position except an item with insignificant effect). The opinion is on the asset succeeded from DESA (BDT 2,790 million) in the non-current asset (BDT 16,633 million at the end of June 2016). Given the amount of DESCO's total equity (BDT 14,724 million at the end of June 2016), the value of the succeeded asset does not affect DESCO's financial health significantly.

On project implementation, DESCO established project implementation units (PIUs) for projects funded by donor agencies. PIUs are established within an executing agency and in charge of administrative function of project implementation. PIUs manage and monitor project implementation (more specifically, administrative works related with procurement and disbursement, and coordination works among departments and with contractors). Sub-divisional engineers are assigned for the PIUs implementing two projects financed by ADB. PIUs carry out its tasks under the supervision of Project Steering Committee (PSC) and DESCO. According to DESCO, the PIU for this project is expected to be consisted of eight professionals (project director, civil and construction engineers, electrical engineers, financial specialists) and supporting staff.

2.2.2.2 **Organization constitution for DPDC**

Dhaka Power Distribution Company (DPDC) have south area of Dhaka city as jurisdiction.



(Source: DPDC HP)

Figure2-4 Organogram for DPDC(as of November, 2016)

The number of total staffs is 5,334 people, and they are constructed in five Department as of November, 2016.

The post about this business is Network Operation Department of the Operation section having jurisdiction over facilities use. The following staff in Engineering Department in charge of the administration maintenance of machine parts are doing management of substation.

Grid South Circle about 200people (as of November, 2016)
Grid North Circle about 200people (as of November, 2016)

Since an audit unit is separated from the Finance Department, different divisions are in charge of internal audit and budget process (such as preparation and implementation). An audit firm (S.F. Armed & Co. for FY2014/15) audited DPDC's financial statements in accordance with Bangladesh

Financial Reporting Standards. Audit results are shown in DPDC's annual report. The audit result for FY 2014/15 is an unqualified opinion (an audit firm assures financial statements as fair representation of financial position).

On project implementation, DPDC established PIUs for projects funded by donor agencies as DESCO did. DPDC is currently implementing projects funded by ADB, AFD, and KfW. PIUs are in charge of administrative function of project implementation and carry out its tasks under the supervision of PSC and DPDC. The numbers of PIUs members differ, depending on the sizes of projects. In general, however, a PIU is consisted of more than 7 staff. For this project, a Super Intending Engineer would be assigned for a Project Director and other members are expected to be six engineers (civil, construction, electric, network), a financial specialist and some supporting staff.

2.3 Distribution and Substation Plan in Dhaka city

This survey will obtain the construction and repair plan for the Electric Power Grid facilities in Dhaka city from PGCB, DESCO and DPDC. During the investigation, the necessity, validity and problem abstraction for the facility refurbishment and expansion are also evaluated.

PGCB are in charge of 230 kV transmission and part of the 132 kV distribution in Dhaka city, and DESCO, in the north of Dhaka, and DPDC, in south of Dhaka, supply the rest of the 132 kV and 33kV or less distribution work. A summary is shown in the below table. The 132 kV facilities will be shifted to DESCO or DPDC for future reconstruction and refurbishment.

Table 2-4: Responsibility for Power Transmission and Distribution in Each Voltage class

	400kV	230kV	132kV	33kV	11kV
Dhaka (North)	PGCB	PGCB	DESCO	DESCO	DESCO
Dhaka (South)	PGCB	PGCB	DPDC	DPDC	DPDC
Other	PGCB	PGCB	PGCB	PGCB	BPDB/WZPDCL/PBS

(Source: Interview with both DESCO and DPDC)

Each company is responsible for demand forecasting and network reinforcement, and reconstruction and expansion to meet future demand, and all information is shared with other companies. In particular, DESCO and DPDC have to secure 132 kV source lines from PGCB's 230/132 kV substations in order to operate 132kV substations. PGCB determines which substation is the 132 kV source line for both companies' requests through discussion. All necessary construction work for 132kV source line is conducted by DESCO and DPDC. Also, all responsibility for this work and the necessary cost are undertaken by both companies. As reference, the current demand and capacity of both companies are shown below.

Table 2-5: The Current Capacity and Demand of DESCO and DPDC

Items	DESCO	DPDC
The number of 132/33 kV SS	2	14
132/33 kV SS Total Capacity	431 MVA	2148 MVA
The number of 33/11 kV SS	32	43
33/11 kV SS Total Capacity	2030 MVA	2506 MVA
Maximum Demand on 33/11 kV SS	1542 MVA	1756 MVA
Maximum Load Factor on 2015 (Sum total of each SS's demand)*	76.0%	70.1%

*Some load information has not been confirmed. Hence, there is some possibility that actual load factor is more than the above table. Also, diversity factor is not considered in the above table.

(Source: Interview with both DESCO and DPDC)

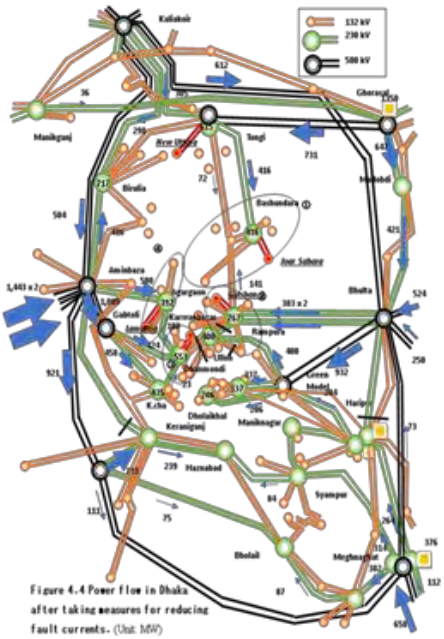
The 230 kV transmission line as the backbone for Dhaka city is operated by PGCB as below with a network of ring shape.

230 kV Substation	Transformer Capacity x Number	Total Transformer Capacity	Maximum Load in 2025	Maximum Operation Ratio at Maximum Load
Bashundara	225 MVA x 3	675 MVA	416 MW	62%
Rampura	300 MVA x 2 + 225 MVA x 3	1,275 MVA	767 MW	60%
Ullon	300 MVA x2	600MVA	400 MW	67%
Dhanmondi	300 MVA x 3	900 MVA	553 MW	61%
Agargaon	300 MVA x2	600MVA	392 MW	65%
Tongi	225 MVA x 6	1,350 MVA	615 MW	46%

Almost balanced.

132 kV Substation	230 kV Supplying Substation	Transmission Loss in Whole System Bangladesh	Differences of Loss
New Gulshan	230 kV Rampura	797.7MW	0
	230 kV Bashundhara	799.2 MW	+1.5 MW

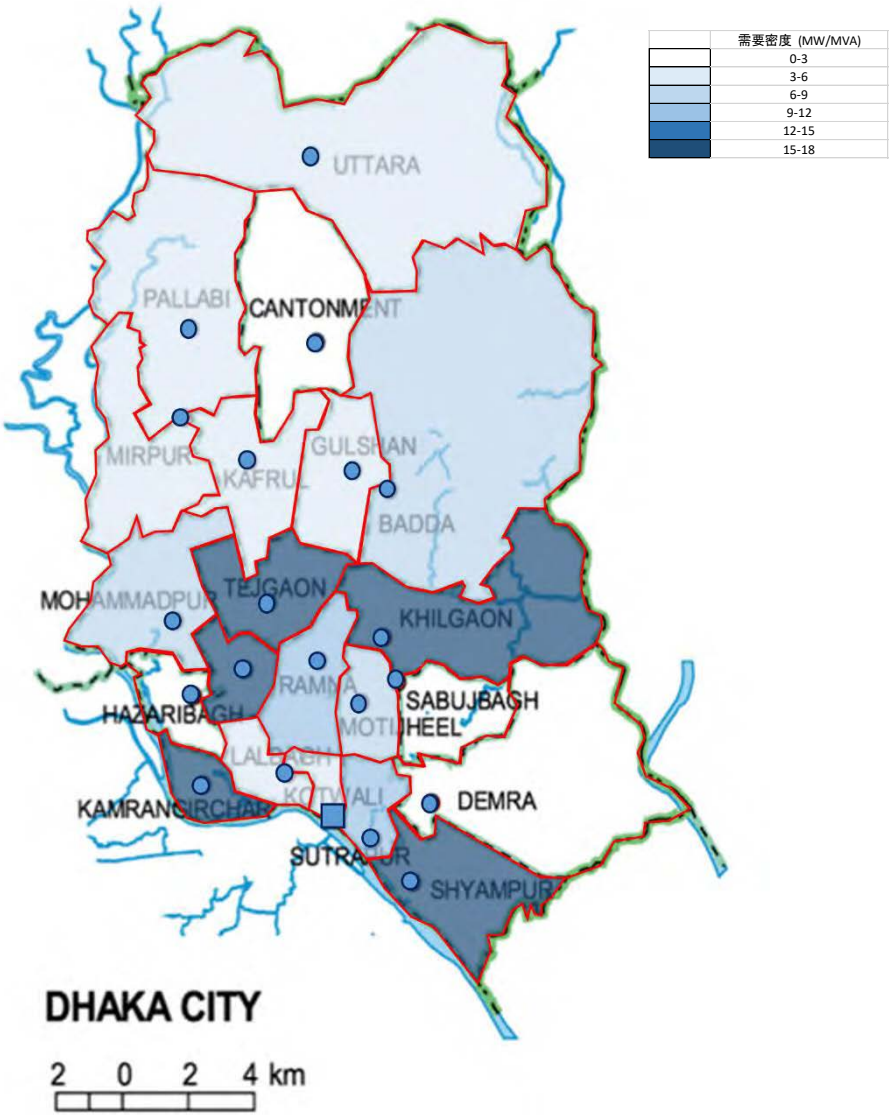
Less loss in case of Rampura connection of New Gulshan.



(Source: The FS projects on the construction of substations in Dhaka, which have already been implemented by the Ministry of Economy, Trade and Industry

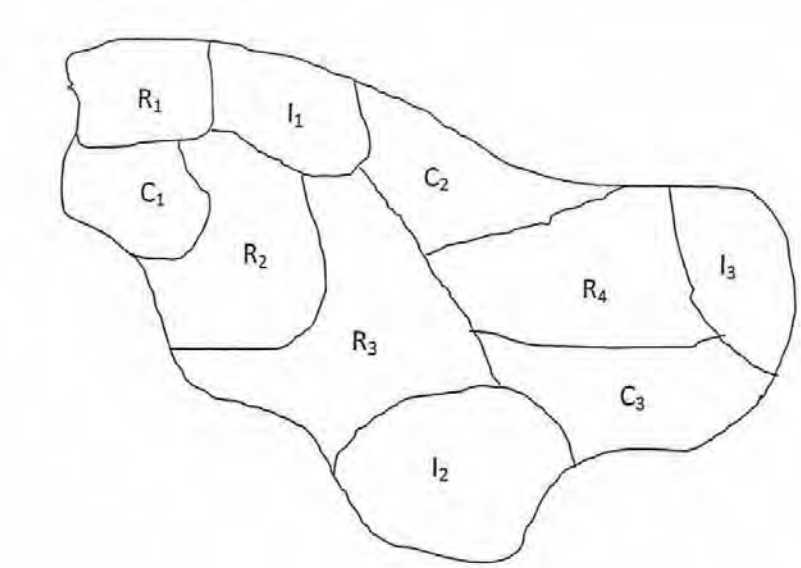
Figure 2-5: Power Flow in 2025 in Dhaka

The electricity demand in Dhaka consists of residential, commercial and industrial loads, and industrial loads are extremely concentrated in the center of the city. Each sub-region shows different load profiles with different load ratios of the three load types. Due to the higher population density in the city, distribution companies are now facing increased number of 11kV connection requests for entire building due to the increase of high-rise building constructions in the city center, and shortage of supply capacity in these region due to the short-notice of the 11kV supply requests becomes problematic according to the interview. In addition, the regional load profile is expected to change due to town-redevelopment plans of RAJUK and plans for MRT in the city. For some specific region in the city, such as Gulshan, Mirpur, Tejigaon, Dhammondi area, will require 33kV distribution line supply for larger scale customers due to the industrial and commercial development in the city center in near and middle-future.



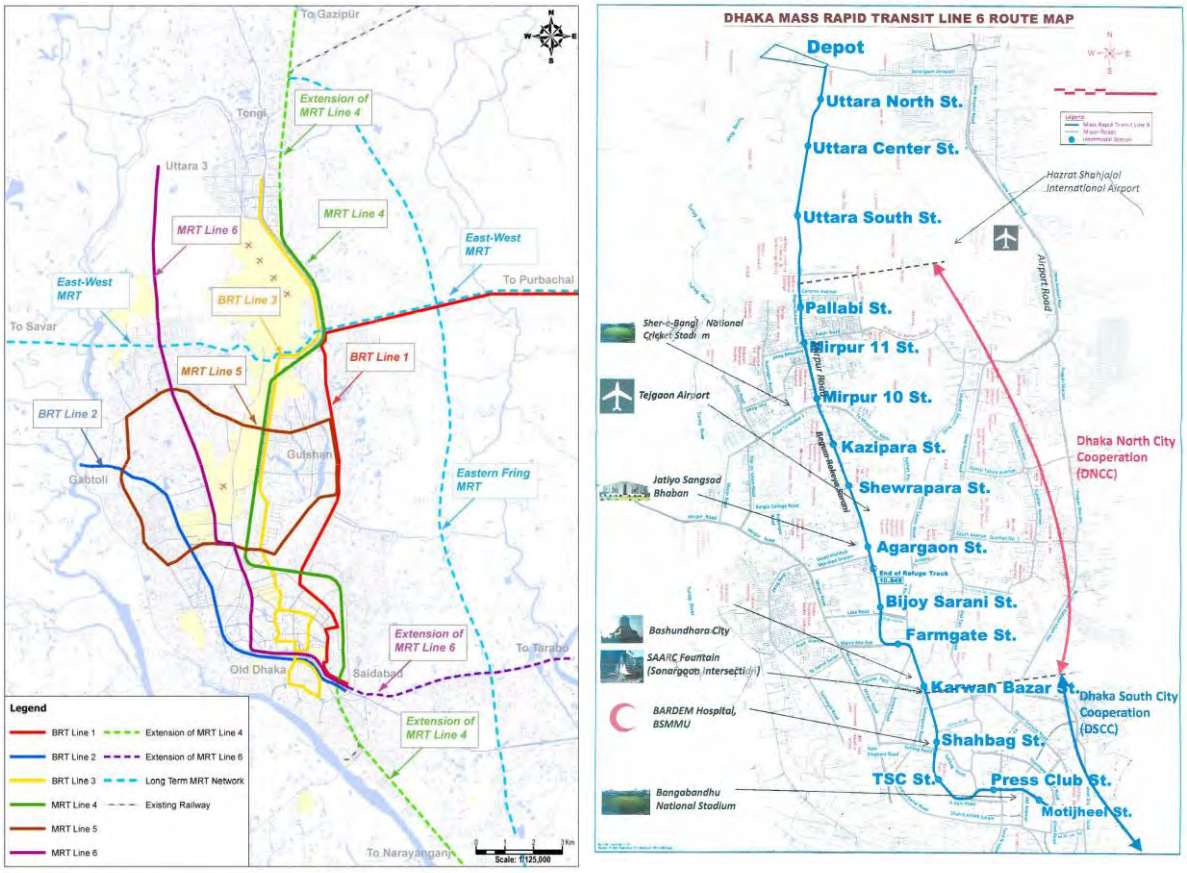
(Source: JICA Survey Team, DESCO, DPDC)

Figure 2-6 Demand Density in DPDC, DESCO Area



(Source: DPDC: Final Report on the Consultancy services for the expansion and strengthening of power system network under DPDC area (4 July、 2015 by BUET)

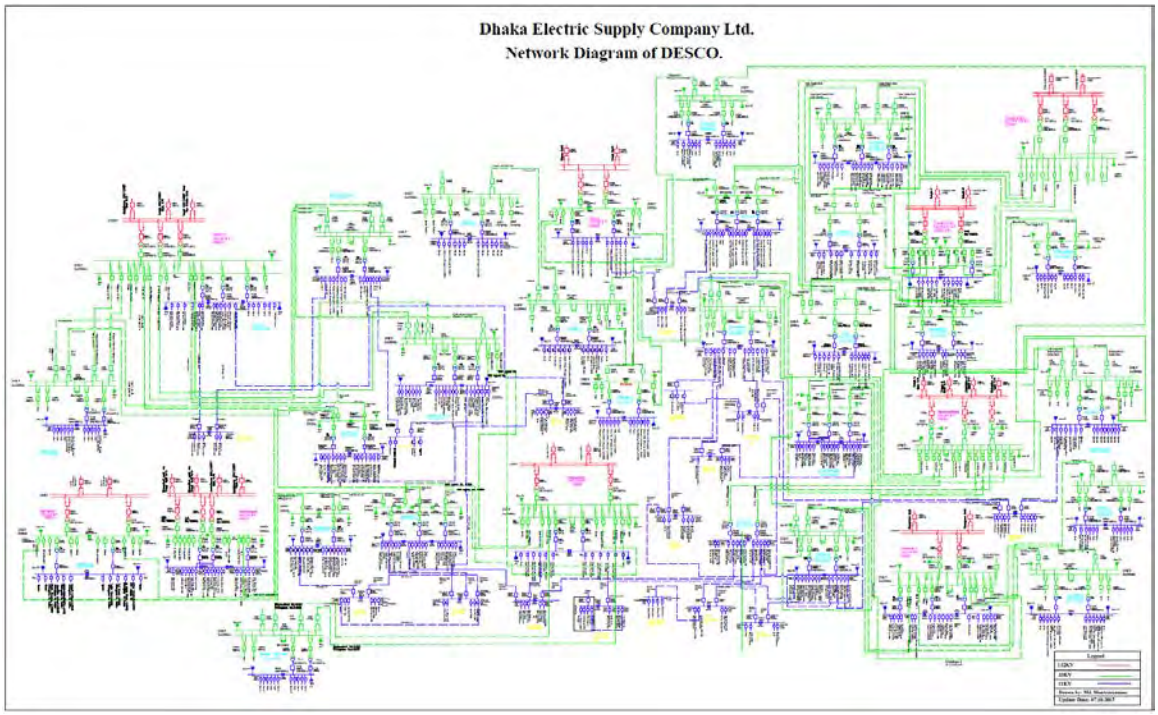
Figure 2-7 DPDC's load categorization of each sub-region



Source: JICA report and interview with MRT #6 project

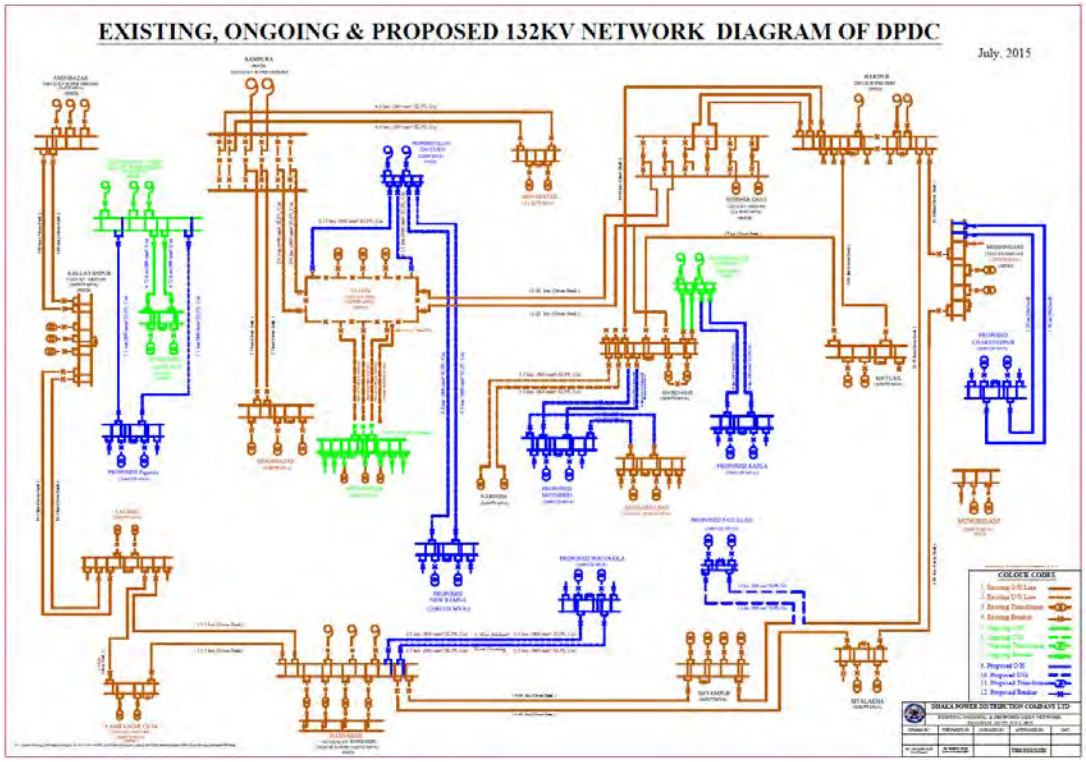
Figure 2-8 MRT introduction plan and the route map of Dhaka MRT line #6

The following shows two distribution companies' distribution networks studied in the first mission of the Survey team, for detail see the appendix. The distribution network in Dhaka city consists two voltage levels 33kV and 11kV, with substations rated 132/33kV and 33/11kV. The 132/33kV substations supply 33kV network that supplies 33/11kV substations, and most of customers are connected directly to 11kV network or supplied via 11kV/400, 210V pole transformers. This network configuration will be maintained, and a limited numbers of 33kV direct-supply for over 5MW load may increase in near future. According to the two companies' network diagram, DESCO's network has less number of 132kV network and their interconnection compared to DPDC's. According to the interview with DESCO and DPDC, they are planning to introduce double supply substation configuration to important substations as the increase of large capacity customers for the network's reliability, and the diagram shows such plans in some DESCO's 11kV substations, and DPDC's new 132kV substation proposed as FATULLAH, and 33kV existing substations.



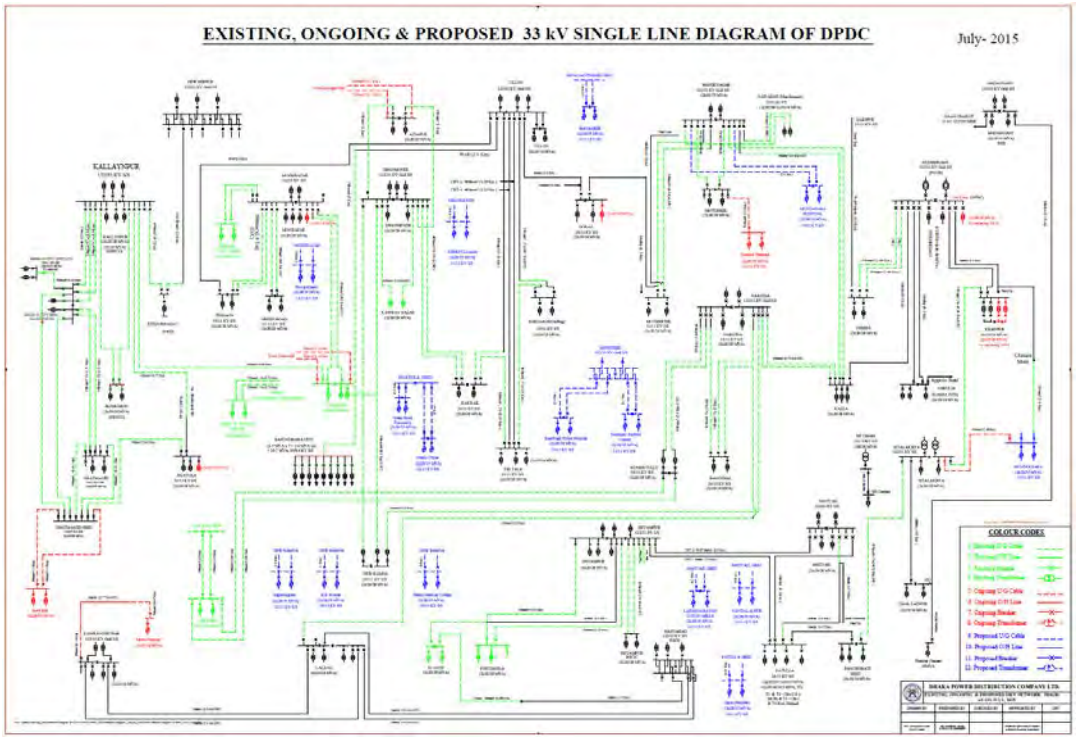
(Source: DESCO)

Figure 2-9 The Existing Network of DESCO (Red: 132kV, Green: 33kV)



(Source: DPDC)

Figure2-10The Existing network of DPDC (Yellow: 132kV)



Source: DPDC

Figure2-11: The Existing Network of DPDC (Green: 33kV）

Table 2-6: The Substation Summary of DESCO

No.	Substation	Voltage Class	132/33 KV Side [MVA]	33/11 KV Side [MVA]	Remarks
1	Gulshan	132/33 kV	2X80/120	-	PGCB
2	Bashundhara	132/33 kV	3X50/75	-	DESCO
3	Uttara Grid	132/33/11 kV	2X50/75	3x20/28	DESCO
4	Tongi new Grid	132/33 kV	3X50/75	-	PGCB
5	Digun Grid	132/33 kV	2X50/75 + 1X35/50	-	PGCB
6	Dhamalkoat	132/33/11 kV	2X80/120	2x20/28	PGCB/DESCO
7	Kallyanpur Grid	132/33 kV	3X50/75	-	PGCB
8	Agargoan-2	132/33 kV	2X80/120	-	PGCB
9	Tongi old Grid	132/33 kV	3x50/75	-	PGCB
10	Gulshan-1	33/11 kV	-	3x20/28	DESCO (Gulshan Area)
11	Gulshan-2	33/11 kV	-	2x20/28	DESCO (Gulshan Area)
12	Niketon	33/11 kV	-	2x20/28	DESCO (Gulshan Area)
13	Aftabnagar	33/11 kV	-	2x20/28	DESCO (Gulshan Area)
14	Bashundhara	33/11 kV	-	3x20/28	DESCO (Gulshan Area)
15	Joarshahara	33/11 kV	-	2x20/28	DESCO (Gulshan Area)
16	Banani	33/11 kV	-	2x20/28	DESCO (Gulshan Area)
17	Baridhara	33/11 kV	-	3x20/28	DESCO (Gulshan Area)
18	Banani-2(Kakoli)	33/11 kV	-	3x20/28	DESCO (Gulshan Area)
19	United Twin Tower	33/11 kV	-	2x10/14	DESCO (Gulshan Area)
20	Mohakhali Helth	33/11 kV	-	3x20/28	DESCO (Gulshan Area)
22	CAAB	33/11 kV	-	2x20/28	DESCO (Uttara Area)
23	Baunia	33/11 kV	-	2x10/14	DESCO (Uttara Area)
24	ADA	33/11 kV	-	2x10/14	DESCO (Uttara Area)
25	Uttara S &D	33/11 kV	-	3x20/28	DESCO (Uttara Area)
26	Nikunja	33/11 kV	-	2x20/28	DESCO (Uttara Area)
27	Tongi new Grid	33/11 kV	-	2x20/28	DESCO (Uttara Area)
28	Tongi-2	33/11 kV	-	3x20/28	DESCO (Uttara Area)
29	Tongi-3	33/11 kV	-	2x10/14	DESCO (Uttara Area)
30	BSCIC	33/11 kV	-	2x10/14	DESCO (Uttara Area)
31	Dakshinkhan	33/11 kV	-	2x20/28	DESCO (Uttara Area)
32	Purbachal	33/11 kV	-	2x20/28	DESCO (Uttara Area)
33	Digun Grid	33/11 kV	-	3X20/28	DESCO (Mirpur Area)
34	M. Sec-6	33/11 kV	-	2X20/28	DESCO (Mirpur Area)
35	Mirpur DOHS	33/11 kV	-	2X20/28	DESCO (Mirpur Area)
36	M. SS-2	33/11 kV	-	2X20/28	DESCO (Mirpur Area)
38	Kafrul	33/11 kV	-	3x20/28	DESCO (Mirpur Area)
39	Mirpur Old	33/11 kV	-	3x20/28	DESCO (Mirpur Area)
40	Kallyanpur Grid	33/11 kV	-	2X20/28 + 1X10/14	DESCO (Mirpur Area)
41	Agargoan-1	33/11 kV	-	2X20/28	DESCO (Mirpur Area)
42	Agargoan-2	33/11 kV	-	2X20/28	DESCO (Mirpur Area)
43	Kallyanpur BIHS	33/11 kV	-	3x20/28	DESCO (Mirpur Area)
		Total	1315/1970	1540/2156	

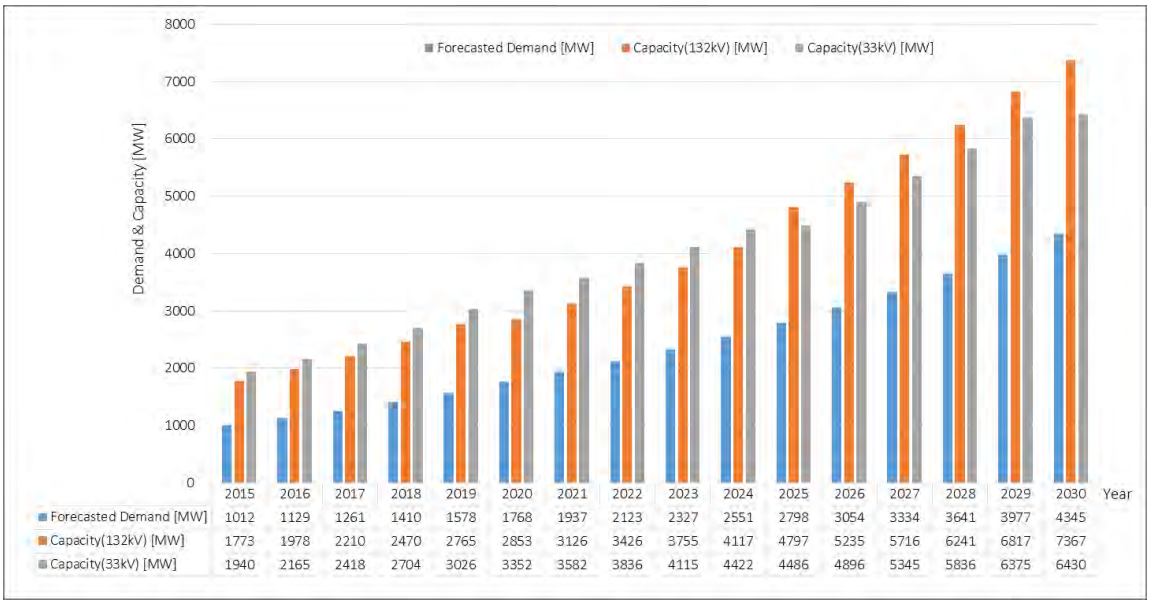
(Source: JICA Survey Team)

Table 2-7: The Substation Summary of DPDC

No.	Substation	Voltage Class	132/33 KV Side [MVA]	33/11 KV Side [MVA]	Remarks
1	Dhanmondi	132/33 kV	3x50/75	-	DPDC (North-1)
2	Kamrangirchar	132/33 kV	2x50/75	-	DPDC (North-1)
3	Lalbag	132/33 kV	2x50/75	-	DPDC (North-1)
4	Mogbazar	132/33 kV	3x50/75	-	DPDC (North-2)
5	Ullon	132/33 kV	3x35/50	-	DPDC (North-2)
6	Madartek	132/33 kV	4x50/75	-	DPDC (North-2)
7	Matuail	132/33 kV	2x50/75	-	DPDC (South-1)
8	Shitalokkha	132/33 kV	2x50/75	-	DPDC (South-1)
9	Modongonj	132/33 kV	2x35/50	-	DPDC (South-1)
10	Shyampur	132/33 kV	4x50/75	-	DPDC (South-2)
11	Maniknagar	132/33 kV	2x50/75	-	DPDC (South-2)
12	Narinda	132/33 kV	2x50/75	-	DPDC (South-2)
13	Bongobhaban	132/33 kV	2x28/35	-	DPDC (South-2)
14	MI cement	132/33 kV	1x20/28	-	DPDC (South-2)
15	Azimpur	33/11 kV	-	2x20/28	DPDC (North)
16	Lalbag	33/11 kV	-	2x20/28 + 2x10/14	DPDC (North)
17	Fatulla	33/11 kV	-	2x20/28 + 2x10/14	DPDC (South-1)
18	Dhanmondi	33/11 kV	-	2x20/28	DPDC (North)
19	Kamrangichar	33/11 kV	-	3x20/28	DPDC (North)
20	Shatmosjid	33/11 kV	-	2x20/28	DPDC (North)
21	Jigatola	33/11 kV	-	2x20/28 + 1x10/14	DPDC (North)
22	New Ramna	33/11 kV	-	3x20/28	DPDC (North)
23	Karwanbazar	33/11 kV	-	2x20/28	DPDC (North)
24	Mitford	33/11 kV	-	2x20/28	DPDC (North)
25	Kakrail	33/11 kV	-	2x20/28	DPDC (North)
26	Japan garden	33/11 kV	-	2x20/28	DPDC (North)
27	Biddut Bhaban	33/11 kV	-	2x20/28	DPDC (North)
28	Mogbazar	33/11 kV	-	3x20/28 + 1x10/14	DPDC (North)
29	Tejgaon	33/11 kV	-	2x20/28	DPDC (North)
30	Green road	33/11 kV	-	2x20/28	DPDC (North)
31	Mogbazar T&T	33/11 kV	-	2x20/28	DPDC (North)
32	Lalmatia	33/11 kV	-	2x20/28	DPDC (North)
33	Sher-E-Bangla nogor	33/11 kV	-	2x20/28	DPDC (North)
34	Ullon local	33/11 kV	-	2x10/14	DPDC (North)
35	Goran	33/11 kV	-	3x10/14	DPDC (North)
36	Xhilgaon (Gulbag)	33/11 kV	-	2x20/28	DPDC (North)
37	Taltola	33/11 kV	-	2x20/28 + 1x10/14	DPDC (North)
38	Madartek	33/11 kV	-	2x20/28	DPDC (North)
39	Matuail	33/11 kV	-	2x20/28	DPDC (North)
40	Shitolokkha	33/11 kV	-	2x20/28	DPDC (North)
41	Ponchoboti bisic	33/11 kV	-	3x10/14	DPDC (South)
42	Char sayedpur	33/11 kV	-	2x10/14	DPDC (South)
43	Sarulia	33/11 kV	-	3x10/14	DPDC (South)
44	Slddhirgonj	33/11 kV	-	2x20/28	DPDC (South)
45	Khanpur	33/11 kV	-	2x20/28 + 1x10/14	DPDC (South)
46	Demra	33/11 kV	-	2x20/28	DPDC (South)
47	Mondolpara	33/11 kV	-	2x20/28	DPDC (South)
48	Syampur	33/11 kV	-	3x20/28	DPDC (South)
49	Maniknogor	33/11 kV	-	1x20/28 + 1x10/14	DPDC (South)
50	Narinda	33/11 kV	-	2x20/28	DPDC (South)
51	Syampur bisic	33/11 kV	-	2x20/28	DPDC (South)
52	Postagola	33/11 kV	-	2x20/28	DPDC (South)
53	IG gate	33/11 kV	-	2x20/28	DPDC (South)
54	Kajla	33/11 kV	-	3x20/28	DPDC (South)
55	Motijheel	33/11 kV	-	2x20/28	DPDC (South)
56	Kumartuli	33/11 kV	-	2x20/28	DPDC (South)
57	Bongshal	33/11 kV	-	2x10/14	DPDC (South)
		Total	1551/2148	1800/2478	

(Source: JICA Survey Team)

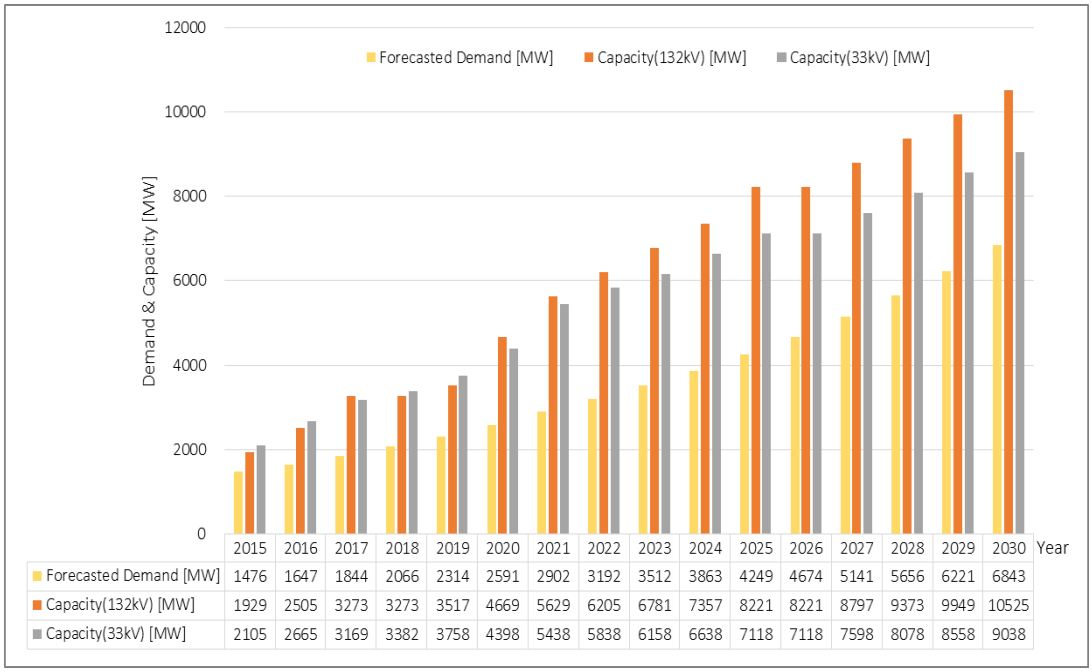
The below figures show the demand forecast and capacity development plan for both DESCO and DPDC.



Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecasted Demand [MW]	1012	1129	1261	1410	1578	1768	1937	2123	2327	2551	2798	3054	3334	3641	3977	4345
Capacity(132kV) [MW]	1773	1978	2210	2470	2765	2853	3126	3426	3755	4117	4797	5235	5716	6241	6817	7367
Capacity(33kV) [MW]	1940	2165	2418	2704	3026	3352	3582	3836	4115	4422	4486	4896	5345	5836	6375	6430

(Source: JICA Survey Team)

Figure 2-12: The Demand Forecast and Capacity Development Plan of DESCO



Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Forecasted Demand [MW]	1476	1647	1844	2066	2314	2591	2902	3192	3512	3863	4249	4674	5141	5656	6221	6843
Capacity(132kV) [MW]	1929	2505	3273	3273	3517	4669	5629	6205	6781	7357	8221	8221	8797	9373	9949	10525
Capacity(33kV) [MW]	2105	2665	3169	3382	3758	4398	5438	5838	6158	6638	7118	7118	7598	8078	8558	9038

(Source: JICA Survey Team)

Figure 2-13: The Demand Forecast and Capacity Development Plan of DPDC

Both demand forecasts are based on the GDP increase rate from GOB. In order to meet their increasing demand, it is necessary continually to install substations. Note that the capacity plans in the above tables are maximum values, so available capacity may be smaller through N-1 consideration. This means that the available capacity may be less than the necessary capacity

considering N-1. Furthermore, there is some possibility that some development plans will be stopped and become behind the initial schedule because most of them rely on foreign funds.

Considering the negative factors in the development plans, execution of the current development plans is the minimum requirement for stable supply. Furthermore, additional development plans are welcomed for future stable distribution. The current development plans of both companies are shown as below.

Table 2-8: The Development Plan for DESCO Substations (2016-2025)

No.	Substation	Voltage Class [kV]	132/33kV Capacity [MVA]	33/11kV Capacity [MVA]	Commision Date	Fund	Land acquisition	S/S type	interconnect to Gulshan-1 S/S
1	Cantonment/ Banani	132/33/11	2x80/120	3x20/28	June, 2019	ADB	Fixed	Outdoor	Yes
2	Aftabnagar	132/33/11	2x80/120	3x20/28	June, 2019	ADB	Fixed	Outdoor	
3	Dumni	132/33/11	2x80/120	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	
4	Uttara 3rd Phase (Grid-3)	132/33/11	2x80/120	3x20/28	June, 2019	ADB	Fixed	Outdoor	
5	Purbachar	132/33/11	2x80/120	3x20/28	June, 2019	ADB	Fixed	Outdoor	
6	Mazar Road	33/11 kV	-	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	
7	Kazipara	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
8	DOHS-2, Mirpur	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
9	Kalshi	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
10	Banani-3	33/11 kV	-	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	Yes
11	Satarkul-1	33/11 kV	-	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	
12	Satarkul-2	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
13	Barua	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
14	Gulshan-3	33/11 kV	-	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	Yes
15	Bashundhara Block-G	33/11 kV	-	3x20/28	June, 2019	ADB	Yet to Fixed	Yet to Fixed	
16	Solahati	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
17	Lake City Concord	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
18	Uttarkhan	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
19	Tongi-27 / Tilargati	33/11 kV	-	3x20/28	June, 2019	ADB	Fixed	Outdoor	
20	Kalshi	132/33 kV	3X80/120	-	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
21	Mohakhali Grid	132/33/11	3X80/120	Existing	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
22	United City	132/33/11	3X80/120	Existing	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
23	Uttara Grid - 2	132/33 kV	3X80/120	-	2021-2025	Yet to Fixed	Fixed	Yet to Fixed	
24	Gazipura	132/33/11	3X80/120	3X20/28	2021-2025	Yet to Fixed	Fixed	Yet to Fixed	
25	Purbachal grid - 2	132/33 kV	3X80/120	-	2021-2025	Yet to Fixed	Fixed	Yet to Fixed	
26	Mirpur Zoo	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
27	Estern Housing	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
28	Cantonment-1	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
29	Cantonment-2	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
30	Banani-4	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
31	Kalachadpur	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
32	Gulshan-4	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
33	Banani-5	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
34	Bashundhara-3	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
35	Maddhay Badda	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
36	Satarkul S/S-1	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
37	Uttara 3rd Phase-SS-3	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Fixed	Yet to Fixed	
38	Jamaldia	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Yet to Fixed	Yet to Fixed	
39	Purbachal SS-4	33/11 kV	-	3x20/28	2021-2025	Yet to Fixed	Fixed	Yet to Fixed	

(Source: JICA Team as of 2017.2)

Table 2-9: The Development Plan for DESCO Substations (2025-2030)

No.	Substation	Voltage Class [kV]	132/33kV Capacity [MVA]	33/11kV Capacity [MVA]	Commision Date	Fund	Site Location	S/S type	interconnect to Gulshan-1 S/S
40	Kachukhet	132/33/11	3X80/120	3X20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
41	Korail	132/33/11	3X80/120	3X20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
42	Gulshan grid -2 ***	132/33 kV	3X80/120	-	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	
43	Bashundhara grid - 2	132/33 kV	3X80/120	-	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
44	Satarkul	132/33/11	3X80/120	3X20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
45	Askona	132/33/11	3X80/120	3X20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
46	Kalshi	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
47	Balurghat	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
48	Rupnagar	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
49	Paikpara	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
50	Ibrahimpur	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
51	Sainik Club	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
52	Mohakhali	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
53	MES	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
54	Banani DOHS	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
55	Mohakhali DOHS	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
56	Bashundhara-4	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
57	Beraid	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
58	Bashundhara-5	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
59	Isufbpur	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
60	Bashundhara-6	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
61	Choto beraid	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
62	Khilbarir Tek	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
63	Azampur	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
64	Baunia Bazar	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
65	Turag	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
66	Chalabon	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
67	Uttara-2	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	
68	Uttara-3	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	
69	Darail	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
70	Ershadnagar	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
71	Deora	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
72	Machimpur	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Yet to Fixed	Yet to Fixed	
73	Purbachal-5	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	
74	Purbachal-6	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	
75	Purbachal-7	33/11 kV	-	3x20/28	2026-2030	Yet to Fixed	Fixed	Yet to Fixed	

(Source: JICA Team as of 2017.2)

DESCO classifies their supply area into some small areas and forecasts the future demands in each small region. These are Gulshan, Uttara, Mirpur and so on. Though they develop a substation plan to install the necessary capacity for each region, they have not prepared the budgets or sites except for the near future plan. There is a possibility that the above plan will change because they are preparing to revise their Master plan including the forecasted demand and substation development plan.

Table 2-10: The Development Plan for DPDC Substations (1)

No.	Substation	Voltage Class [kV]	132/33kV Capacity [MVA]	132/33/11 kV Capacity [MVA]	33/11kV Capacity [MVA]	Commision Date	Fund	Site Location	S/S type	Interconnect to Kawran Bazar S/S
1	BGB	33/11 kV	-	-	2x28/35	2018-2019	Own funded	Fixed	Indoor GIS	
2	Kamrangirchar	33/11 kV	-	-	2x28/35	2018-2019	Own funded	Fixed	Indoor GIS	
3	Lalbag new	33/11 kV	-	-	2x28/35	2018-2019	Own funded	Fixed	Indoor GIS	
4	Madartek	33/11 kV	-	-	2x28/35	2018-2019	Own funded	Fixed	Indoor GIS	
5	New Ramna/ DU	132/33 kV	2x80/120	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
6	Postogola	132/33 kV	2x80/120	-	-	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
7	Kazla	132/33 kV	2x80/120	-	-	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
8	Zigatola	132/33 kV	2x80/120	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
9	Char Sayedpur	132/33 kV	2x80/120	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
10	Motijheel	132/33 kV	2x80/120	-	-	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
11	Fatullah	132/33 kV	2x80/120	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS, X-former outdoor	
12	B B Avenue	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	
13	BSMMU	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	o
14	Rajarbag Police Hospital (P & T)	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	
15	Monipuripara	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	o
16	Green Road Dormitory	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	o
17	Dhaka Udyan	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	
18	Segunbagicha	33/11 kV	-	-	2x28/35	2018-2019	AFD funded	Fixed	Indoor GIS	
19	Mugdapara Hospital	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
20	Dhapa (Fatullah)	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
21	Dhaka Medical College (DMC)	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
22	Kamlapur Railway Hospital/Colony	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
23	Mondalpara	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
24	Nandalalpur	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
25	Laxminarayan Cotton Mill (LNCM)	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
26	Banasree	33/11 kV	-	-	2x28/35	2018-2019	ADB Funded	Fixed	Indoor GIS	
27	Tejgaon*	132/33/11 kV		2x120/120/50	2x50	2020-2021	Chinese Gov	Fixed	Indoor GIS	
28	English Road*	132/33/11 kV		2x120/120/50	2x50	2020-2021	Chinese Gov	Fixed	Indoor GIS	
29	Kakrail	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS	
30	Goran	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS	
31	Taltola	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS	
32	Matuail Extension	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS, X-former outdoor	
33	Nabinagar	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	

(Source: JICA Team as of 2017.2)

Table 2-11: The Development Plan for DPDC Substations (2)

No.	Substation	Voltage Class [kV]	132/33kV Capacity [MVA]	132/33/11 kV Capacity [MVA]	33/11kV Capacity [MVA]	Commision Date	Fund	Site Location	S/S type	Interconnect to Kawran Bazar S/S
34	Basila	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	
35	Sign Board Local	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	
36	Chashara	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	
37	Pagla	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	
38	Mohammadpur	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS, X-former outdoor	
39	Green Model Town	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS, X-former outdoor	
40	Adamjee	132/33 kV	3x80/120	-	3x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS, X-former outdoor	
41	Dhanmondi	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Fixed	Indoor GIS	○
42	Goran-2	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
43	Banasree-2	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
44	Nakhalpara	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
45	Mohakhali	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
46	Delpara-1	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
47	Munshikhola	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
48	Lamapara	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
49	Delpara-2	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
50	Munsurabad	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
51	Basila -2	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
52	Basila -3	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
53	Bhuighar	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
54	Sanarpar	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
55	Baily Road	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
56	Holy Family Hospital	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	○
57	Dakshingaon	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
58	Dhanakunda	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
59	BUET	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
60	Shipaibagh	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
61	Raizbag (2x35/50 MVA)	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
62	Shibu Market	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
63	Fatullah Stadium	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
64	Shymoli	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
65	Adabar	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	
66	Manda	33/11 kV	-	-	2x35/50	2020-2021	Chinese Gov	Not Fixed	Indoor GIS	

(Source: JICA Team as of 2017.2)

DPDC plans for the 33/11 substations to be built from now on to have 35/50 MVA transformers, which is bigger than conventional capacity. Most of the 33/11 kV substations will be indoor to make the best use of their land.

As mentioned above, there are two substation classes, 132/11 kV and 33/11kV for distribution in Dhaka city. Specifically, 132/33 kV is in charge of 33 kV supply for 33/11 kV substations, and 33/11 kV is in charge of 11 kV supply for most of the customers. This distribution style will be continued in the near future because the number of 33 kV customers will not steeply increase. According to the above, some 132/33 kV substations will be necessary in order to supply a lot of 11 kV customers as direct customers. The following will appear.

✓ Land acquisition for substations

It is necessary to secure a large amount of land for substation construction to install the necessary equipment. Because of land scarcity, rising land prices in recent years and bad impressions caused by fires and accidents in substations, land acquisition for substations is quite difficult. In particular, it is more difficult to secure 132/33 kV substation land because of the need for larger land area than for a 33/11 kV site.

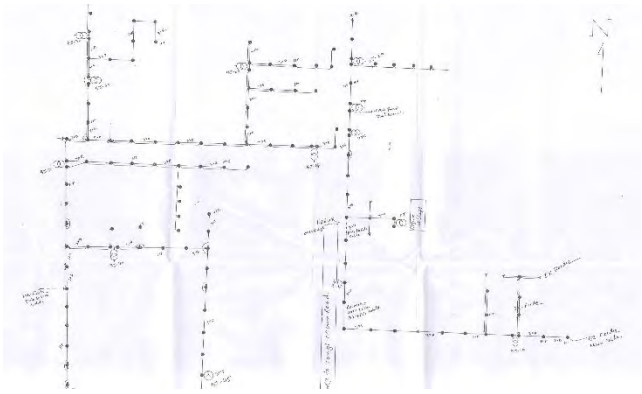
✓ Route acquisition for underground lines

The maximum number of cables to be installed is limited since the main method of installing underground lines is direct buried style. Additionally, some detours in the underground route happen with new installations because the space under some roads is already full with other cables.

As mentioned above, 33/11 kV substations in DPDC use 50 MVA transformers, which is larger than the conventional one. This means that more 33 kV source lines will be necessary. According to the current situation, it is necessary to consider the other buried methods to install more underground cables and reduce the total number of underground cables for the future underground network.

2.4 Existing distribution network facility

The Survey team interviewed relevant departments of DESCO and DPDC to learn current distribution network configuration and substation functions. Current 33kV and 11kV distribution network of both companies are configured as radial system from distribution substation, and another ends of the distribution lines are not connected to any of neighboring substation feeder nor distribution line. With current configuration, load switching of substations is impossible, therefore single trouble on the distribution line tends to interrupt entire length for a longer time, which results in longer SAIDI index. Thus, more reliable distribution network configuration may be adopted to improve the network's supply reliability.



Source: DESCO

Figure 2-14 Example of distribution line diagram of Uttala's line of DESCO

In terms of system reliability index, DESCO's newest ones are SAIDI 795.3 (min/year/consumer), and SAIFI 30.09 (times/year/consumer), which is 37 times and 231 times more respectively to the indices of 10 power utilities (SAIDI 21, SAIFI 0.13). DPDC's indices are not disclosed, but the target performance indices for 2016 are set to SAIDI 300, and SAIFI 60, both of which are similar to DESCO's. Thus, the Survey team concluded that current supply reliability of the distribution lines are relatively lower than Japanese, and there's a plenty of room for the improvement by interconnecting distribution lines and introducing remote-operation of distribution disconnectors.

33kV Distribution system in Dhaka consists 60% of underground system and 40% of overhead system, while most of the 11kV system are overhead system. Both distribution companies design their distribution lines to be connected to neighboring lines as shown in their diagram, but not physically connected on site. In case the interconnection is necessary, distribution engineers connect the conductor to enable temporary interconnection. Thus, the Survey team and representatives of DESCO and DPDC concluded that the permanent interconnections among distribution lines with proper line capacity design may significantly improve the supply reliability by enabling load switching among distribution liens. Furthermore, online monitoring and remote control of distribution line sections are also helpful to enable immediate load shifting without going on site for switching in crowded traffic in the city. In case the enhancement of distribution line interconnection, increased number of distribution lines will be connected to a source substation, thus underground tunnel to cater power cables will be necessary.

2.5 Regulations/Standards Relevant to Construction of Underground Substations in Bangladesh

2.5.1 Summary of Regulations/Standards for Underground Substation Construction

Information on regulations/standards relevant to construction of underground substations in Bangladesh was gathered and summarized as below. As this is the first time to construct an underground substation in Bangladesh, the survey team refers to the applicable Japanese construction standards, relevant regulations for underground substations and their superstructures, and technology standards such as those for fire protection equipment. And the survey team checked with the subcontractor Bti and DESCO/DPDC regarding restrictions on regulations in the cases of designs which were based on the actual construction of buildings in the Gulshan area and the Building Code of Bangladesh. The Building Code of Bangladesh was revised in 2014. JICA is now considering reviewing said regulations due to an accident with a building collapse. Thus, the survey team conducted an interview with members of OYO International Corporation, who are engaged

in the project supporting the revision of the Building Code in Bangladesh which JICA is currently implementing, and summarized the current situation of the relevant regulations.

Table 2-12: **Outcomes of the Interviews on Regulations and Standards in Constructing Underground Substations in the City of Dhaka**

Relevant Regulations	Contents of the Standards	Corresponding Regulatory Standards / Source of Confirmation
Building use limit	Unlimited	Building Code
Height limit	Unlimited It is feasible up to 450ft（137.19m） for the highest of a construction building in Gulshan District.	(Limited by floor-area ratio in Building Code.) Civil Aviation Authority
Floor number limit	Unlimited	(Limited by floor-area ratio in Building Code.)
Floor area ratio (Total floor area / Site area)	For office use, 950% limitation is applied when the width of the front road is over 12m For the width of calculation floor-area ratio, as applied same as the road specifications, a part of the site could be inclusive. The underground is exclusive.	Building Code RAJUK BTI
Building coverage ratio (Building area[1] / Site area)	There are limitations: 50% for the above ground; and 75% for the underground. The limitation is, however, 75% eased for the areas below 12m over the ground.	Building Code RAJUK
Rule of the complex building	If the area of the main purpose of the building is 90% or more, the main purpose is applied. In case of less than 90%, consultations are required.	Building Code
Setback for architecture	For placement, setback distance suitable for the size of the building needs to be secured. The whole circumferences of 3m for a building with height of 33m or more /more than 10 stories needs to be secured. If the site is facing the road and there is a sidewalk, setback distance can be eased from the sidewalk. The underground is excluded from the rule. The structure building fame cannot be included within 1.5m from the property line. Thus, the least setback distance is 1.5m.	Building Code RAJUK
Next to building interval	The distance of 4m or more is required if more than 2 buildings are constructed within a site.	Building Code
Fireproof compartment	There are no regulations for designing of the fire-proof compartment in constructing of the underground buildings. Fire extinguishing systems (gas fire extinguishing systems) must be installed for the underground buildings.	Fire Code Building Code
Mandatory construction of parking lots	Parking installation is required one every 200 square meters.	Building Code

[1] Building area means the floor space of building when looking down at it from sky.

Mandatory green space installation	12.5% of the green space installation is required.	Building Code
Septic tank installation	Unlimited	For a permit application, installation of septic tank is strongly recommended.
Emergency stairs	Installation of one emergency stairs every 23-30m radius is required. The substation area is exclusive.	Building Code Building Code
Evacuation distance	The evacuation distance of 30m needs to be secured.	Building Code
Mandatory EV installation	Unlimited	Building Code
Mandatory EG room installation	Unlimited	Building Code
Construction of underground transmission facilities	There are no specific regulations for underground substations. Construction application has been submitted to Dhaka City Corporation. Cable tunnels including vertical shafts have been installed after construction permitted. Construction has begun, after submission of transmission line designs and security materials. Currently, compensation of 5600Tk is required per 1m³.	DESCO, DPDC Confirmed by interviews

［How the regulations are applied］

・Architectural standards for buildings are applicable with RAJUK2008. (2008 standards are eligible even after new standards are issued.)

・Regulations for noise, fire prevention, and the road use require consultations with the City Corporation.

・For planning, any regulations need to be confirmed with relevant organizations such as RUJUK and DOL.

There may be unwritten local rules unique to each jurisdiction. Also, as constructions of the underground substations are unprecedented, negotiations based on validities of designing underground substation structures are necessary in both the future process and the implementation phases.

As a result, the largely influential constraint in designing of the underground substations is a setting of the building coverage ratio (of 50% for the ground level of 12m or more and 75% for the ground level of 12m below and the underground), which will also be a great constraint in examining of a substation layout.

The following diagram shows the preliminary layout study for Lalmatia indoor Substation, which does not fit the maximum available building coverage area (1086m2) of the site considering the setback distance from the borders (1.5m). If the utilization of a superstructure for office use is also considered, the total necessary footprint for the building footprint must be increased due to the installation of elevators, staircases, and a lobby for the public and workers.

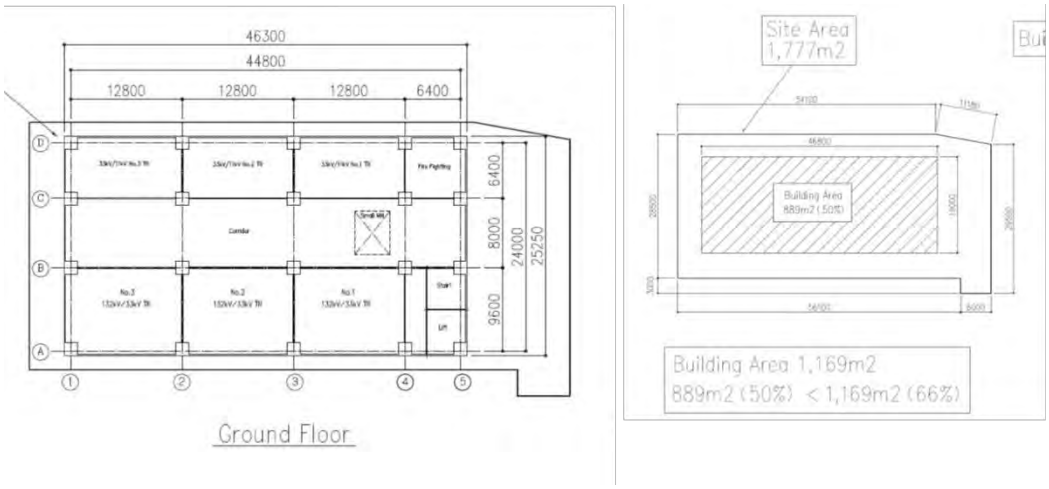


Figure 2-15**: Layout Study for Indoor Substation in Lalmatia**

Likewise, outdoor substation form, which requires a larger footprint, may not fit most of the available plots for existing substation properties, even with all the current loads evacuated.

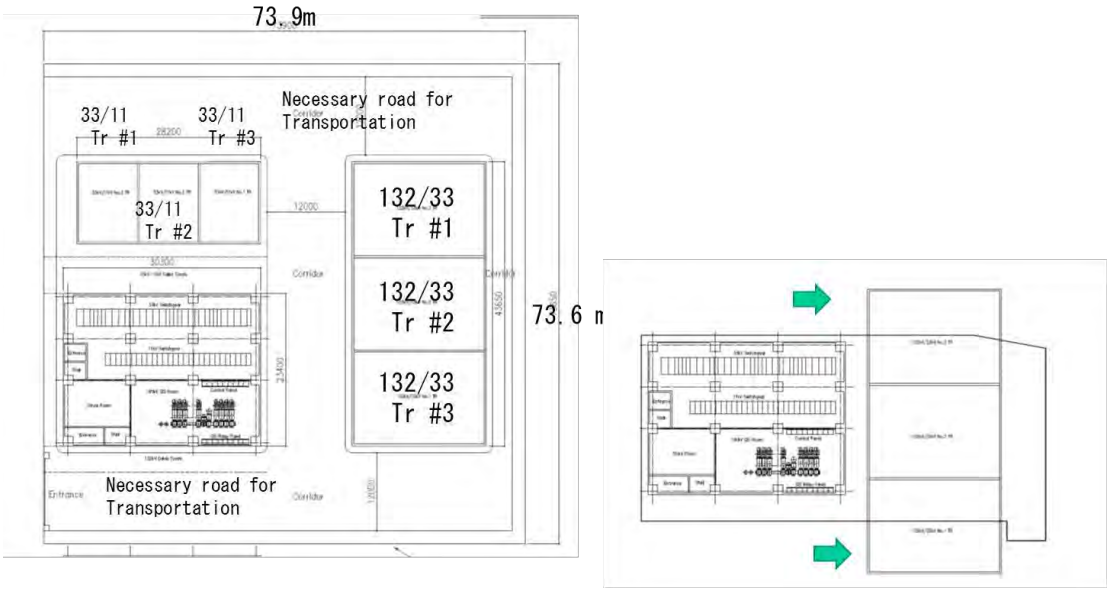


Figure 2-16**: Layout Study for Indoor Substation in Lalmatia**

In most cases of the upgrade of existing 33kV substations, the required plot area for conventional outdoor substation form and indoor substation form may not satisfy this ground coverage ratio regulation, which is necessary for building permission. Thus, utilization of underground space benefits both distribution companies in expanding their network capacity to supply the increasing demand.

2.5.2 Laws and Regulations relevant to Environmental and Social Issues for the Construction of Underground Substations

It is the Ministry of Environment and Forests (MOEF) that administers the environment of Bangladesh, handles all the issues related to environmental policies and regulations, and governs official permits relevant to the environment. Among the departments and a corporation[2] for which MOEF supervises their activities, the Department of Environment (DOE) suggests policy decisions and implementation measures for environmental management, and is responsible for ensuring application of environmental laws and the issuance of necessary clearances in industrial and development activities.

For the stipulation of laws related to land, it is the Land Reform and Land Acquisition Directorate of the Ministry of Land that is responsible. The Deputy Commissioner's Office at District level deals with the acquisition and requisition of land and pays compensation on behalf of the project proponents for infrastructure development. Line ministries and their departments, such as the Bangladesh Water Development Board (BWDB), and the Directorate of Fisheries of the Ministry of Fisheries and Livestock, are two of the bodies that provide sector standards for estimating values of products at their existing rates.

Among the laws on the natural environment, environmental management, environmental assessment, and land acquisition, the following are relevant to this project.

(1) Protected areas and ecologically critical areas

The Wildlife Preservation Act (1974) designates the list of protected areas and declares ecologically critical areas (ECAs) in Bangladesh.

There are seventeen national parks, seventeen wildlife sanctuaries, and five botanical gardens and eco-parks, having a total area of 2,722.4 km2. There are nine ecologically critical areas (ECA). Although industrial development is restricted within ECAs, IEE will be implemented as an exception and DOE will render a judgment concerning project implementation if the project possesses a high development possibility and a high priority for the nation.

Out of the protected areas and ECAs, there are two botanical gardens and two ECAs (lake and rivers[3]) in Dhaka where this project is planned.

(2) Environmental standards

The domestic law that is referred to most for this project is the Environmental Conservation Act, 1995 (revised in 2010). The Act aims at conservation of the natural environment, improvement of environmental standards, and management and mitigation of environmental pollution. Details of the environmental standards applicable in the country are described in the Environmental Conservation Rules of 1997 (revised in 2002). For the implementation of this project, the project proponent is obliged to be compliant with the Bangladesh National Environmental Quality Standards as regulated in the Rules for air quality, water quality, noise, emissions from motor vehicles or ships, odors, sewage discharge, waste from industrial units and industrial effluents or emissions.

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[2] They are: Department of Environment, Department of Forests, Bangladesh Forest Research Institute, Bangladesh National Herbarium, and Bangladesh Forest Industries Development Corporation.

[3] Botanical gardens are: National Botanical Gardens and Baldha Garden, and ECAs are: Gulshan-Banani-Baridhara Lake and Rivers (Buriganga, Bait, Turag, and Sitalakhya).

(3) Implementation of environmental assessments

The procedures and requirements for EIA in the power sector are stipulated under the Environmental Conservation Rules of 1997. The Rules classify projects for DOE's prior approval in four categories (Green, Amber-A and -B, and Red). Among the projects in its attached list, this project falls in the RED CATEGORY ("60 Engineering works with capital over one million BDT", and "64 Water, Power and Gas distribution line laying/relaying/extension"), which require EIA implementation. Subject to a satisfactory review of the environmental assessment, the DOE issues an authorization for projects to proceed by granting an Environmental Clearance Certificate, ECC.

(4) Land acquisition

The Acquisition and Requisition of Immovable Property Ordinance of 1982 and its subsequent amendments in 1993 and 1994, and Electricity Act 1910 provide the key legal instruments for the acquisition of private land for development activities in Bangladesh.

For this project, both sides have agreed to exclude those candidate areas that need large-scale land adjustment and/or entail large-scale involuntary resettlement due to land acquisition.

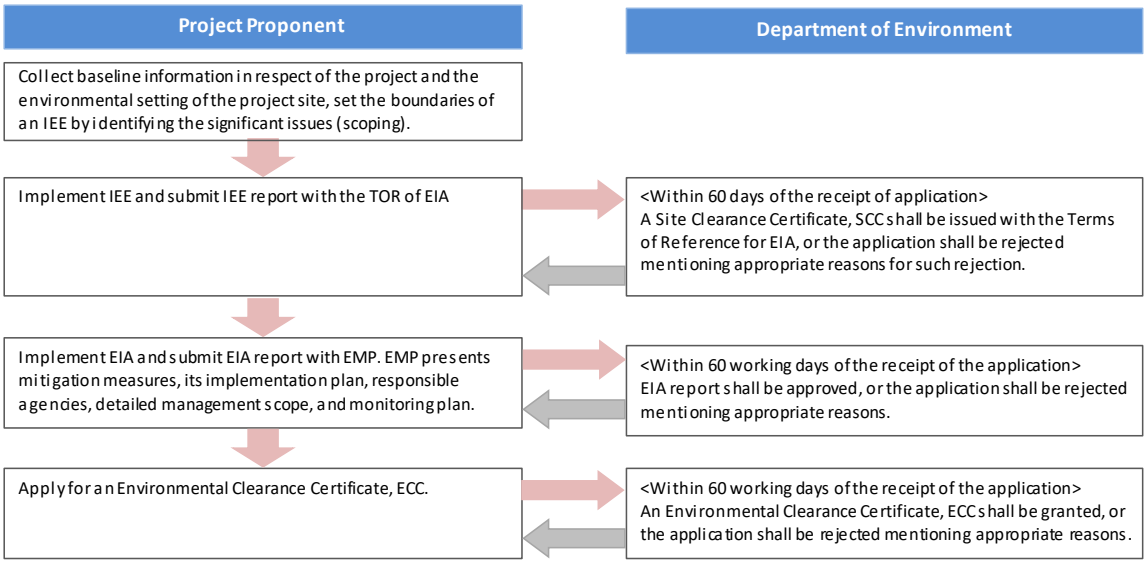
2.5.3 Procedures for EIA Implementation and Land Acquisition

(1) EIA Procedures

The project proponent shall apply to the DOE in the prescribed format for the application of clearances. The application shall contain the following documents:

a. Report on the feasibility of the industrial unit or project
b. IEE report, terms of reference (TOR) for EIA and process flow Diagram
c. Report on Environmental Monitoring Plan (EMP) and process flow Diagram, layout plan
d. No Objection Certificate from the local authority
e. Emergency plan relating adverse environmental impact and plan for mitigation of the effect of pollution
f. Outline of the relocation/rehabilitation plan (where applicable)
g. Other necessary information (where applicable)

The authorization consists of two parts: a "site clearance", which gives approval for the proposed site, and an "environmental clearance", which approves the project content with thorough environmental reviews and countermeasures to mitigate the anticipated adverse impacts. The steps for environmental clearances and periods to be taken are shown in the following figure.



(Source: Environmental Conservation Rules, 1997)

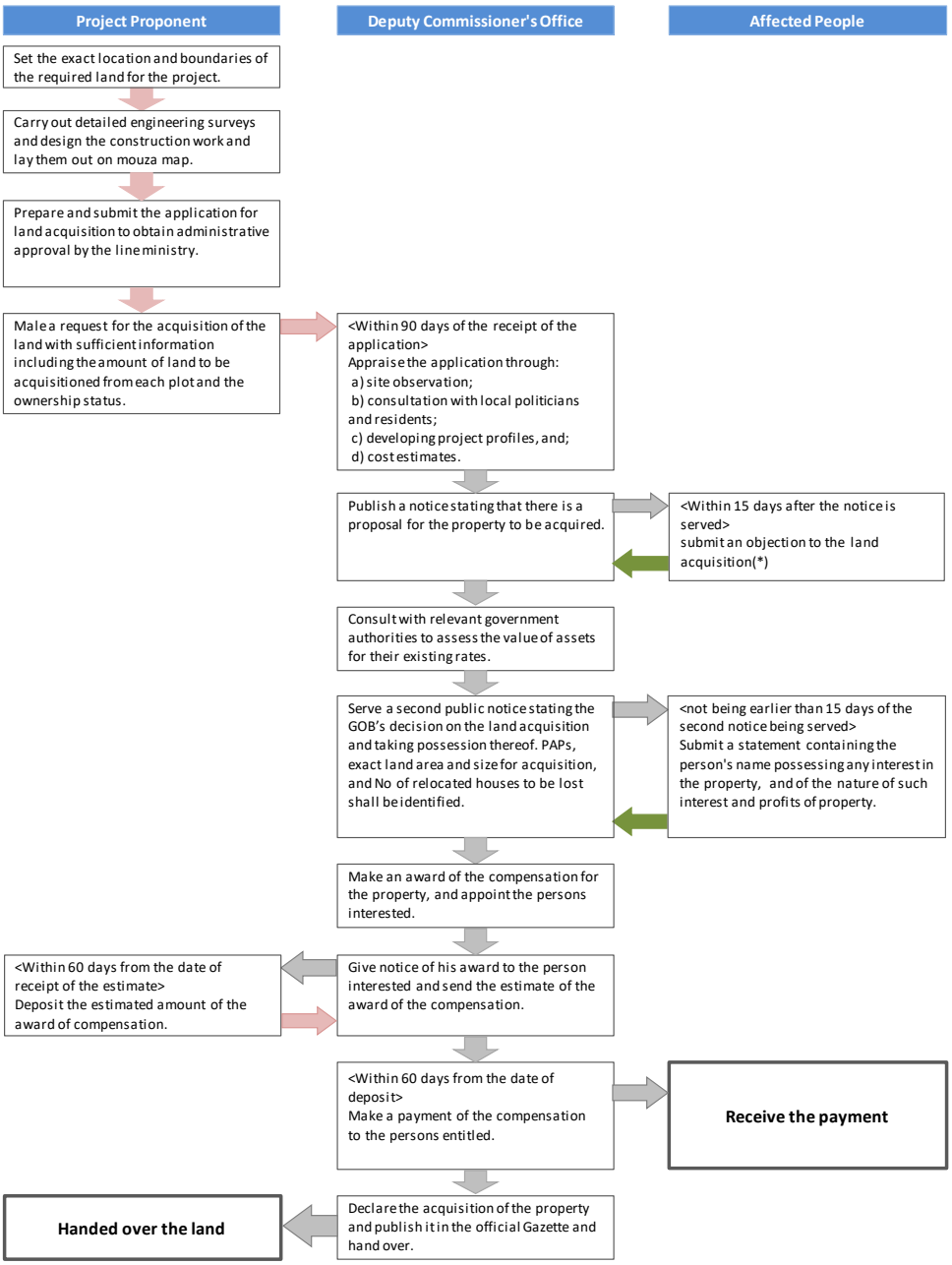
Figure 2-17: Appraisal Procedures of Red Category Project Implementation

The DOE also may, without issuing a SCC at the first instance, directly issue an ECC if it, on the application of an industrial unit or project, considers it appropriate to issue such certificate to the industrial unit or project. The period of validity of an ECC shall be three years for Green Category projects and one year for the other categories, including Red4.

(2) Procedures for land acquisition

Large-scale land acquisition and involuntary resettlement are not anticipated in this project, whereas small-scale land acquisition may not be avoided. The project proponent, in line with the relevant government authorities, will be required to take the following steps as shown in the figure below.

[4] For renewal of the ECC, the project owner shall satisfy the environmental standards as well as the on-site inspection as required by the DOE. The DOE has authority stipulated by law to cease any activities deemed to have harmful effect on human lives or to the environment.



Note: All the legal titleholders will be advised to show their ID cards and other documents that verify their rights. For those with no registrations, the DC Office will call for circumstantial evidence from community leaders, local elite people, and religious leaders, etc., to add these people to the list

(Source: the Acquisition and Requisition of Immovable Property Ordinance, 1982)

Figure 2-18: Flow of Acquisition of Immovable Properties and Compensation

2.6 Technical study for the underground substation construction in Bangladesh

Since, there are no precedents of underground substation construction in Bangladesh, the required information and technology for design and construction of the underground substation in Bangladesh is examined and surveyed.

In this study, outline surveys for geological conditions, hydrological conditions and natural physical environment in Dhaka City have been performed, because the design and construction method for subterranean facilities shall be adopted based on the site conditions, such as geological conditions, topological conditions and the surrounding environment. Based on the results of this outline survey, the design concept for the subterranean part including anti-inundation and drainage measures is designed. In addition, the design concept is examined by the technology adopted in the existing underground substations in Japan. (Please refer to Chapter 3 below).

2.6.1 **Anti-inundation measures: flood, underground water and drainage**

Bangladesh had experienced devastating flood 4times in this 30years (1988, 1998, 2004 and 2007), those floods caused over 2,000 causalities and 3/4 of domain was submerged. According to the DESCO report, Gulshan area in Dhaka City was covered with 0.8 to 1.0m depth water in those floods.

In this study; estimated high-water level in this project is designed as 1.0 m in depth by reference to;

- Document of the past JICA project for the flood control in Dhaka City （The Project for the Improvement of the Storm Water Drainage System in Dhaka City （Phase I）（Phase II））
- Benefit and adverse of above projects
- Survey reports of damage situation of the past flood in the candidate sites

Heightening of the Ground Floor Level of the building, the recent popular and usual design in Dhaka City is adopted for the main anti-inundation measure. Since supplementary countermeasure methods, such as tide protection plate device shall be inexpensive, those measures will be examined in the detail design stage.

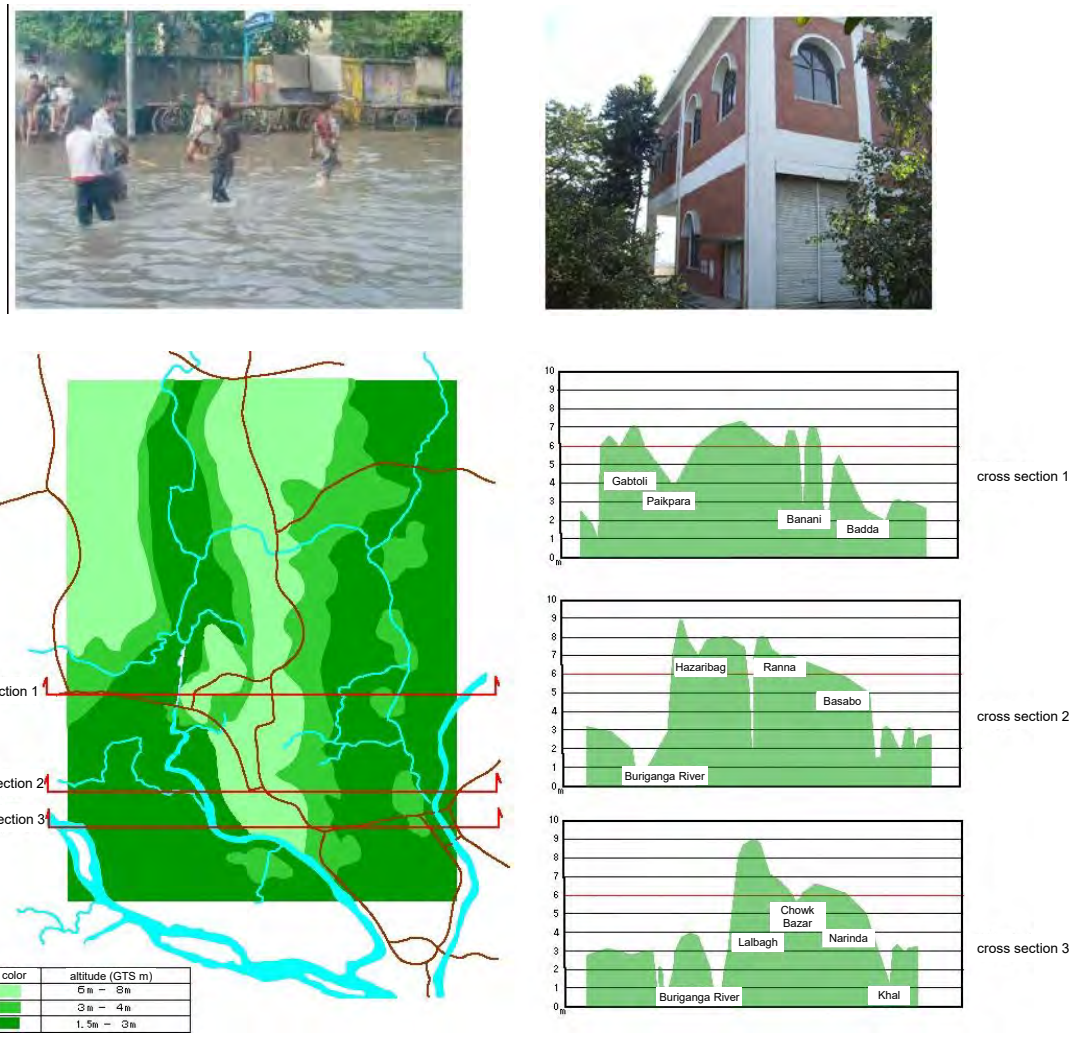
Table 2-13: Benefits and Adverse Effects of the Project for the Improvement of the Storm Water Drainage System in Dhaka City (Phase I)

	Actual Damage Situation in Dhaka City	
	Average Flood Water Depth	Average Period of Flooding (Receding flood water)
Before the Project		
Flood in 1988	1.8m	Approximately a month
After the Project		
Flood in 1998	0.7m	Approximately 15~20 days
Flood in 2004	0.6m	Approximately 7~10 days
The rainy season every year	0.3m in the poorly-drainable area	Within a week

Source: JICA, 1987 Evaluation Report: Project for the Improvement of the Storm Water Drainage System in Dhaka City (Phase I), Tokyo: JICA
JICA, 2012 Evaluation Report: Project for the Improvement of the Storm Water Drainage System in Dhaka City (Phase II), Tokyo: JICA

A non-fecal wastewater sewer system which can drain surface water (rainwater and/or flood water) has been constructed in the Dhaka City. There are several efficient water stopping materials and water stopping construction methods to prevent the leakage of groundwater (seeped surface water) available in Dhaka City, such as the water sealing plate method and/or expansion joint method, installed at concrete placing joints.

Since the geographic features in Dhaka City show cohesive and low permeability, it can be assumed that the amount of seepage water is small. For the outflow surface water countermeasure methods, appropriate methods shall be adopted in the design, such as heightening of the Ground Floor Level of the building to 1.5m from the ground level and/or drainage facilities along the outside of buildings.



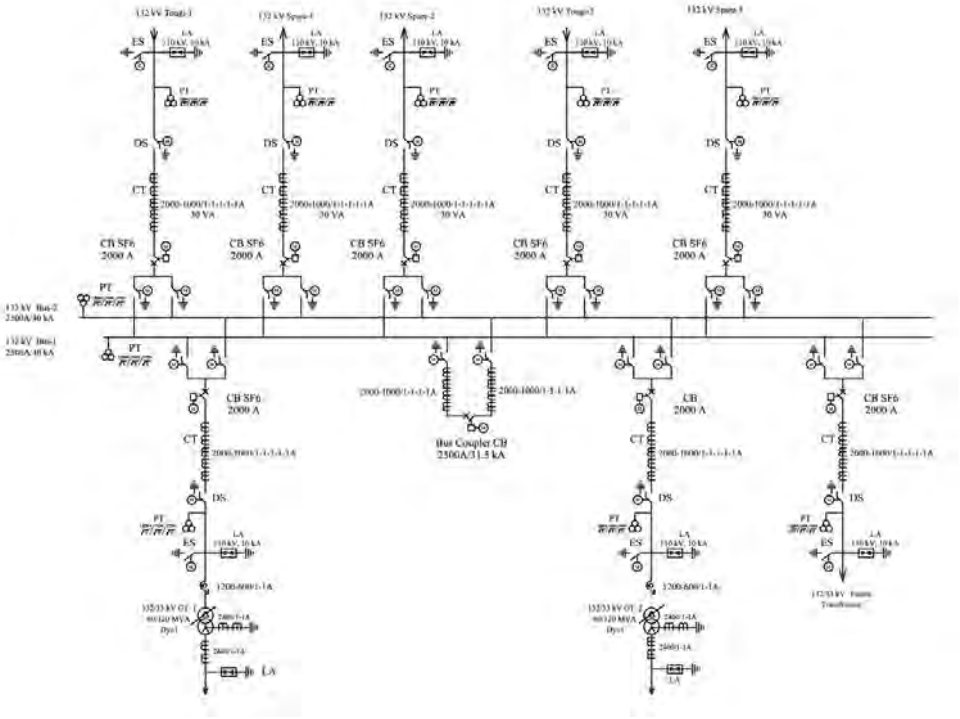
(Source: JICA, 2012 Evaluation Report: Project for the Improvement of the Storm Water Drainage System in Dhaka City (Phase II), Tokyo: JICA)

Figure 2-19**: Actual situation in Dhaka City during the 2004 Flood (above)**

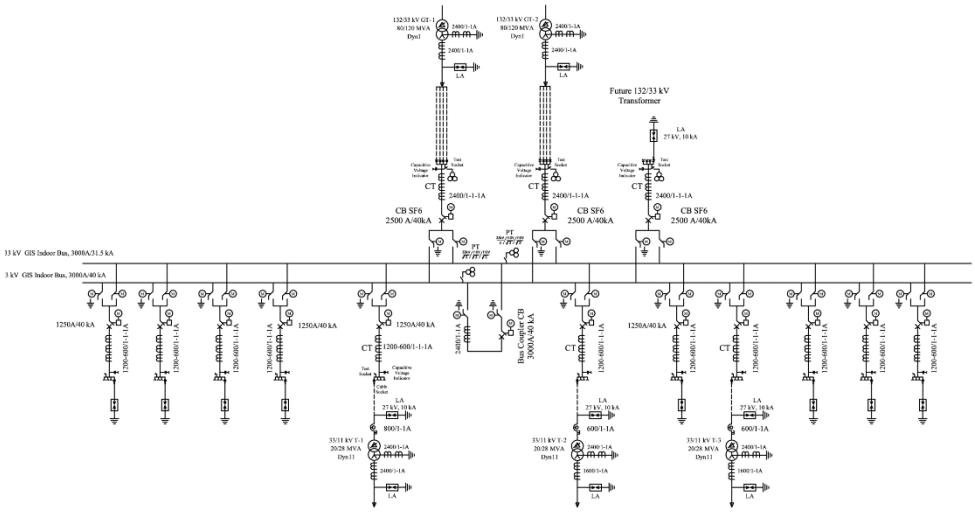
2.6.2 **Investigation of Underground Substation's Electrical Design Specification and Applicable Japan Technology**

We interviewed with both DESCO and DPDC about their Substation Design Standard for indoor and outdoor type, the standardized specification of substation equipment for underground substation is confirmed as follows.

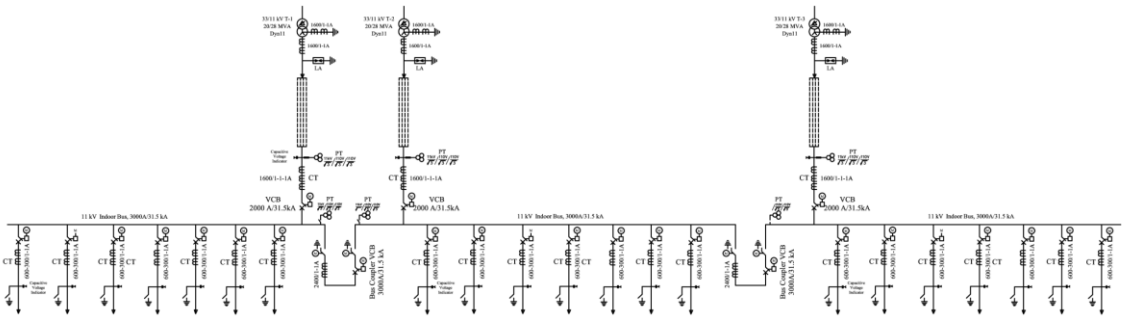
(132 kV side equipment)



(33 kV side equipment)



(11 kV side equipment)



(Source: JICA Survey Team (according to DPDC, DESCO interviews))

Figure 2-20: **132/33/11kV Underground Substation Standard Single-line Diagram**

Table 2-14: DESCO Standard Equipment Specification

	Description	Rated	Quantity
132kV GIS Double Bus	Incoming feeder Inc. line VT	145kV 2,000A / 50kA** 3s	5 (2+3 spare)
	Tr feeder Inc. line VT	145kV 2,000A / 50kA** 3s	3
	Bus VT		2
	Bus Coupler	145kV 2,500A / 50kA** 3s	1
	132/33kV Power Tr.	132/33kV 80 /120MVA with on-load tap. Dyn11	3
	33/11kV Power Tr.	33/11kV 20/28MVA with on-load tap. Dyn11	3
	33/0.4kV Station Tr.	33/0.4kV min. 200kVA*(Existing) * Depending on power consumption for UGS	2 * (Existing)
	Description	**Rated**	**Quantity**
33kV GIS Double Bus	In com.Tr feeder	36kV 2,500A / 40kA 3s	3
	Tr feeder	36kV 1,250A / 40kA 3s	3
	Outgoing feeder	36kV 1,250A / 40kA 3s	8
	Bus VT		2
	Line VT		3
	Bus Coupler	36kV 2,500A / 40kA 3s	1
11kV MCSWG Single Bus	In com.Tr feeder	12kV 2,000A / 31.5kA 3s	3
	Outgoing feeder	12kV 630A / 31.5kA 3s	18
	Bus VT		3
	Line VT		3
	Bus Coupler	12kV 3,000A / 31.5kA 3s	2

(Source: JICA Survey Team)

** As discussed with DESCO, the rated short current is specified as 50kA.
Because the rated 63 kA in DESCO's bidding specification is not based on their master plan and also employing upper voltage specification will lead to higher cost.

Table 2-15: DPDC Standard Equipment Specification

Description		Rated	Quantity
132kV GIS Double Bus	Incoming feeder Inc. line VT	145kV 2,000A / 40kA 3s	5
	Tr feeder Inc. line VT	145kV 2,000A / 40kA 3s	3
	Bus VT		2
	Bus Coupler	145kV 2,500A / 40kA 3s	1
132/33kV Power Tr.		132/33kV 80 /120MVA with on-load tap. Dyn11	3
33/11kV Power Tr.		33/11kV 50/35 or 35/28 or 20/28MVA with on-load tap. Dyn11	3
33/0.4kV Station Tr.		33/0.4kV min. 500kVA*(Existing) * Depending on power consumption for UGS	2 * (Existing)

Description		Rated	Quantity
33kV GIS Double Bus	In com.Tr feeder	36kV 2,500A / 40kA 3s	3
	Tr feeder	36kV 1,250A / 40kA 3s	3
	Outgoing feeder	36kV 1,250A / 40kA 3s	9
	Bus VT		2
	Line VT		3
	Bus Coupler	36kV 3,000A / 40kA 3s	1
11kV MCSWG Single Bus	In com.Tr feeder	12kV 3,000A / 31.5kA 3s	3
	Outgoing feeder	12kV 800A / 31.5kA 3s	24
	Bus VT		3
	Line VT		3
	Bus Sectionalizer	12kV 3,000A / 31.5kA 3s	2

(Source: JICA Survey Team)

According to the specification above, to reduce fire hazard risk for the entire building by improving disaster prevention capability of the substation, DESCO and DPDC are looking into the Japan-technology Gas Insulated Transformer. Additionally, in case of limited substation space, at the MV, LV sides of the 3-winding transformer, 33kV, 11kV distribution line can also be used for connecting configuration. Furthermore, to introduce relatively large transformers with the rated power of 120MVA into the system, the design needs to include 18 (DESCO) or 24 (DPDC) 11kV outgoing feeders and 8 (DESCO) or 9 (DPDC) 33kV outgoing feeders. For the underground

substation cable layout and the connection of underground transmission facilities, more technology study is needed. Moreover, both companies have their short circuit capacity specifications higher than normal so the system configuration restructuring to increase capacity needs to be future-proof.

According to the survey team, the suitability of Gas Insulated Transformer for the specification above needs to be confirmed with available transformer manufacturers. As for 3-winding transformer (132/33/11kV), 1 company confirmed to be able to supply the equipment, and for 2-winding transformers (132/33kV, 33/11kV), 3 companies are available. Assuming that the dimensions and transportation weight is as following. However, since the external dimension of the device is depend on the winding methods, reconfirmation between engineering stages is essential.

Table 2-16: Substation equipment's weight and dimensions

Rated Voltage (kV)	Type	L (mm)	W (mm)	H (mm)	Transportation weight (kg)
132	Tr	11,500	4,000	5,100	140,000
	GIS	7,500	2,538	3,700	11,000
33	Tr	9,500	3,500	5,000	100,000

(Source: JICA Survey Team)

In case of 3-winding transformer, the disadvantages on technical and cost point are as follows. Thus 2-winding transformer will be introduced for underground substation design.

- No great reduction of space for transformer grounding.
- Voltage adjustment for individual structures at MV, LV sides can become costly, and there is a probability of failure if the voltage adjustment system allows voltage fluctuation.
- In case of 3windings transformer with 3 phases separated tanks, the cost and needed space will go up, however there is a possibility of implementing 2 windings transformer with 3 phases 1 tank.
- Several manufacturers cannot meet the requirement of both technical and cost aspects.
- There is a possibility that the winding type will be changed, this will impact other existing substations in the network in term of earth fault protection and phase angle matching. (The existing power network has been employing Δ-Y for both 132/33kV and 33/11kV transformers, but Y-Y-Δ will be employed if in case of 3 winding 132/33/11kV transformers.)

Moreover, the Gas Insulated Transformer is not the only Japan-technology that can improve disaster prevention capability, but comparing to Oil Insulated Transformer, the cooling gas pipe bending and lengthening are easier to add in, and the layout design for transformer and cooling system arrangement is flexible. Therefore it is suitable for underground substation.

2.6.3 **Outline Design of Underground T&D Cable**

Underground Transmission Cable Design

The preliminary design of the 132 kV cable has been performed in the pre-feasibility study and we adopt this design.

The preliminary design of the 132 kV cable is:

132 kV single core, copper conductor, cross-linked polyethylene insulated, aluminum sheathed and HDPE jacketed power cable, mainly in accordance with IEC standards.

The typical cross section of the 132 kV cable is shown below.

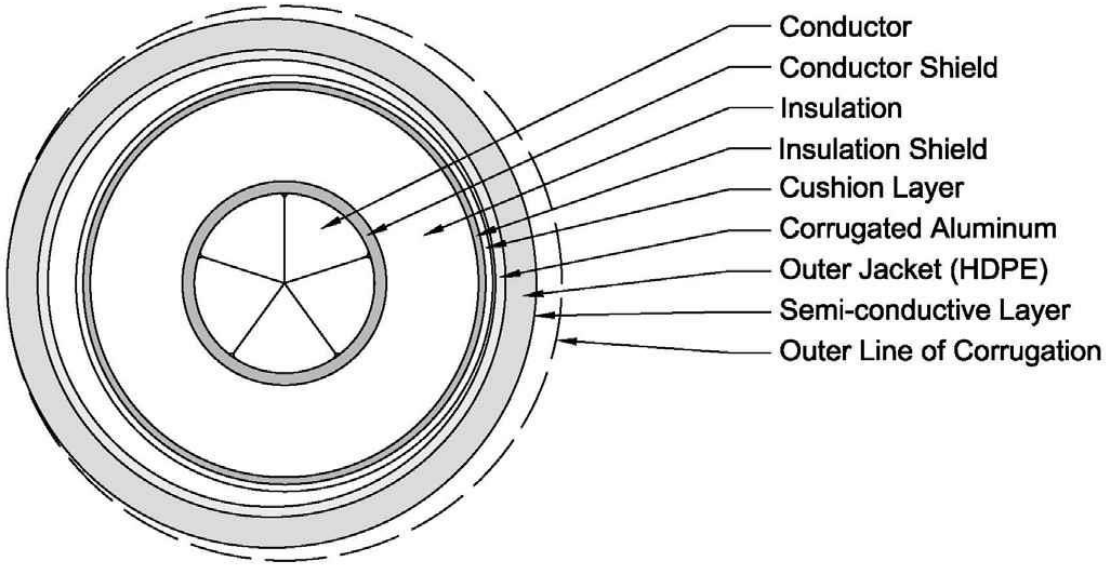


Figure 2-21: Typical Cross Section of 132 kV Cable

Installation Design of 132 kV Cable

The cables are installed and buried by the following methods.

- Trench
- Duct Bank

All of the above are common and conventional methodologies and there is no newly developed or developing technology. Each design is described hereunder.

Trench

132 kV cables are installed in the trench for the most of the route. The typical cross section of the trench is shown below.

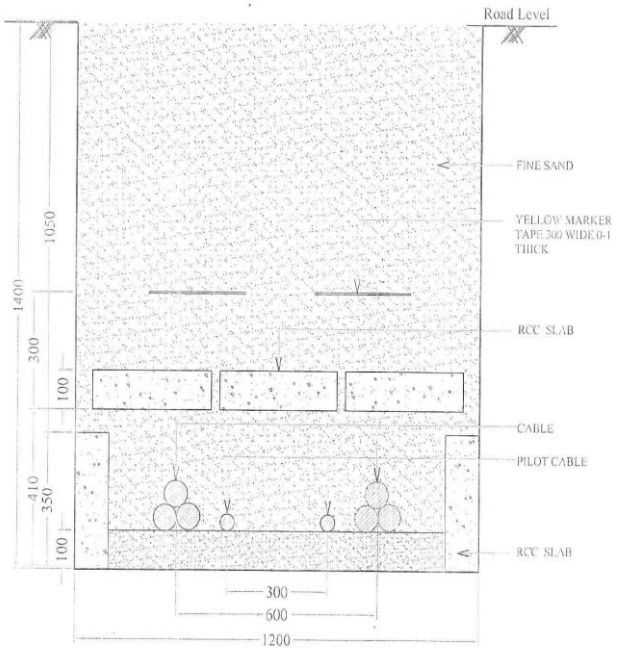


Figure 2-22: Typical Cross Section of Cable Trench

The trench is constructed by open cut/excavation. The side of the trench shall be supported by shuttering and side wall to prevent collapse during the installation period.

Duct Bank

The duct banks are constructed at the road crossing, the junction and/or beneath the existing underground facility. The duct bank shall be constructed section by section, e.g. traffic lane by traffic lane, to minimize any disturbance to the traffic. It is constructed, backfilled and reinstated, then the traffic resumes as normal. Usually, the duct bank is constructed in advance of the construction of the trench, and it is interconnected with the trench.

The typical cross section of the duct bank is shown below.

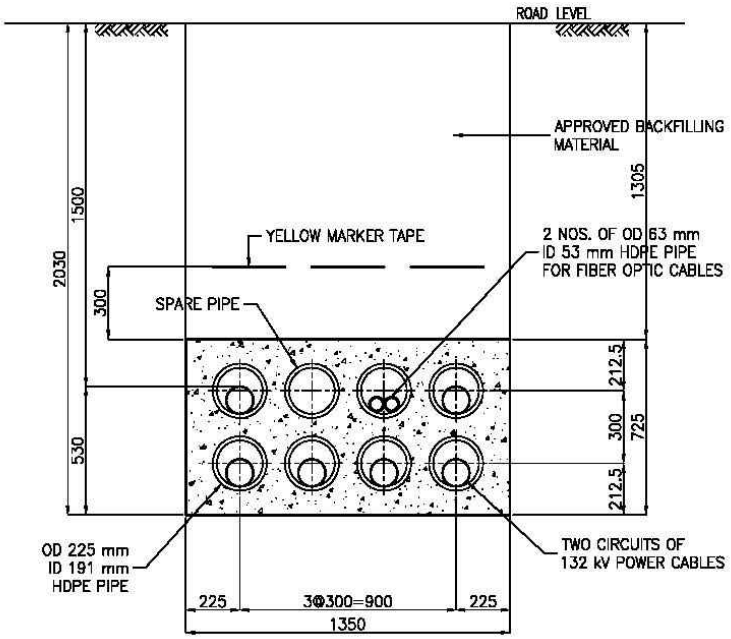


Figure 2-23: Typical Cross Section of Duct Bank

Consideration of Cable Installation

The 132 kV cables are pulled into the trench by the conventional "Nose Pulling" method. The cables are pulled from the joint bay to the next joint bay of the span. The pulling tension shall not exceed the permissible pulling tension of the cable at any time. The typical arrangement of nose pulling method is shown below.

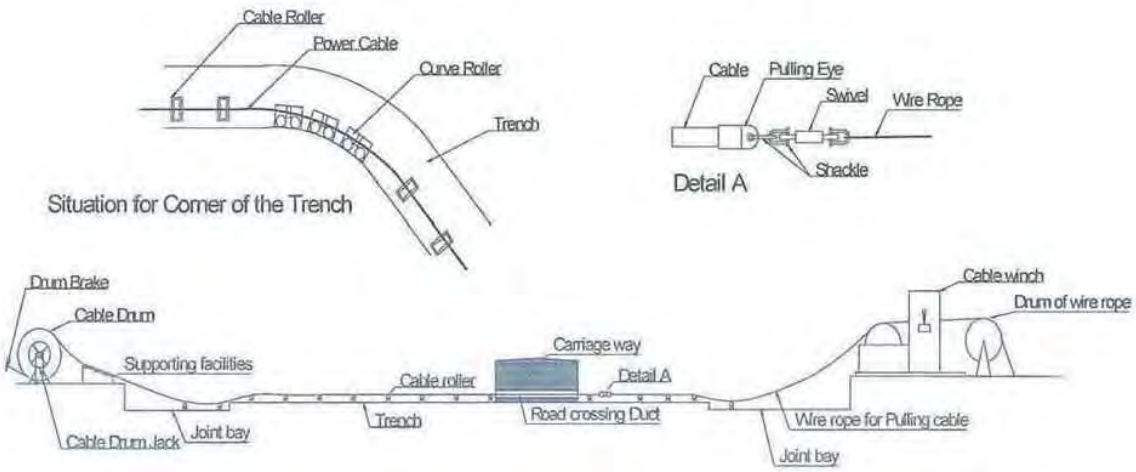


Figure 2-24: Typical Arrangement of Nose Pulling

If there are a number of bends in the span, and higher pulling tension is expected, the following cable pulling methods are considered.

- Bond Pulling

With this technique the pulling tension applied by the winch is taken by a wire bond to which the cable is tied at regular intervals. At bends, the bond is passed through a snatch block and the ties attaching the cable are removed before the bend and reapplied after the bend in a continuous operation. The tension required to install the cable is therefore distributed along its full length and sidewall pressure at bends is reduced to a minimum. It can be used in conjunction with nose pulling.

- Caterpillar or hauling machine

Caterpillars apply a pulling/pushing force directly onto the cable outer sheath and can be used to install the cable in conjunction with nose pulling.

2.6.4 Construction Technology and Construction Methods for the Underground Substation

There are three important points to be noted here which are the construction technology of the underground substation, applied construction methods and cooperation with the upper part of building design.

As a result of having geological features in Dhaka, investigation of local construction manners and studying actual building construction sites, direct foundation at the depth of 27m is proposed for the building structure. It is the most advantageous design from both economic and construction aspects.

Those related construction techniques have been already accomplished enough in Bangladesh. Thus, it is also confirmed that import of the specific technique or the materials for the project from Japan is not necessary.

（Refer to a following chapter for the screening geological survey result of the candidate spots in this F/S）

(Source: Local Contractor's Construction Record)

Figure 2-25: Example Pictures of Construction Stage of Underground Structure (Earth Support System and disposal of Excavated Material)

- ✓ Because of a heavy traffic at daytime, it is necessary to limit import/export of construction materials to/from the site in the night.
- ✓ Due to the reason that the land for the project is limited, a temporary steel platform will be installed just above excavation area. All loading/unloading works and temporary storage of materials are on the platform even during excavation underneath.
- ✓ The distance between disposal area of excavated soil (over 30,000m3) and the construction site have an influence on the project in various meanings.

These important points were reflected accordingly in this construction plan, schedule and cost estimation. It is recommended to prepare disposal area of the excavated soil by the owner before tender in order to save the project cost and shorten the construction period when proposed sites are decided.

2.6.4.1 **Geological Survey in Dhaka and Methods of Investigation of Structure**

Following six subjects were studied;

(1) the evaluation of geological survey at Gulshan spot conducted by DESCO
(2) the interview with major Japanese construction company who has construction experience in Bangladesh
(3) the interview with three local construction companies who has been worked at Gulshan district
(4) hearing to Japanese engineers of Nippon Koei Co. Ltd. engaging in JICA Dhaka subway project
(5) our field survey at proposed sites during the first visit
(6) the interview with Thai contractors about possibility of undertaking construction in Dhaka (particularly braces, wales, temporary platform, and waterproofing membrane)

The evaluation of the investigation is summarized in next paragraph. The final construction methods will be subject to further geological survey.

2.6.4.2 **Examination of the Underground Permanent Structures**

The bearing layer of structure foundation (over 50 N-value) is found about 20m deep in Dhaka from the geological pre-survey and the results of the interview. Therefore, it is confirmed that foundation of the building will be directly on that bearing layer.

Generally, when the solid layer is relatively in shallow depth, excavation to that layer is conducted in order to save piling works and utilize underground space (for example car parking). Thus, the effective building design can be realized. The findings of our survey show in the same way.

The different characteristics in underground structure design were compared in the following table.

It is concluded that instead of piling approximately 20m, over 20m excavation and direct foundation with utilizing the underground space is the most advantageous way in terms of technical and economic aspects.

However, type of structure will be finally decided by the comparison among cost of building underground structure, economic value of basement, cost of piling works, and etc.

Table 2-17: Merits and demerits by type of foundation and basement

Item	① On Ground	② Partial underground	③ Underground
1) Earth Support	none	No advantage due to good ground condition	Cast-in-situ pile (φ800～1000) with wales and strut (H-beam)
2) Excavation	none	Variable according to the depth	Approximately 30,000m3
3) underground water	none	none	none
4) Piling Works	20m deep	Not advantage	none
5) Comments at the present	A short pile is necessary so non-efficiency.	No advantage	Good because a bottom of the basement and bearing layer is same depth.
6) Trial calculation of cost (basement)	Basic design ・cast-in-situ piles		Basic design ・excavation and earth support without piles
● Final evaluation	Comparison of construction costs(three stories in underground VS piling works and three stories on ground)		

(Source: JICA Survey Team)

2.6.4.3 **Studies of local contractor's performance and capability relation with underground substation works**

There are no technical difficulties for construction of underground structure by local contractors since they have number of experience. Their resources and equipment which are necessary for underground works are already lined up. Their performance in terms of quality of works are also satisfied our requirement level so that cost estimations from them are available with reasonable standards.

Major method of temporary retaining wall in this report is by cast-in-situ RC-concrete piles. It has been commonly used at Glushan area. If the excavation is shallower than 15m, steel sheet piles may be applied instead as a temporary retaining wall. Diaphragm wall for both temporary and permanent use is not possible to adopted in this time being since there is no proper execution in Dhaka before. It is subject to future studies.

Assembling, dismantling wales and struts including procurement of materials under proper design are possible without special correspondence by local contractors.

2.6.4.4 **Studies of Procurement (Major Materials for Underground Structure)**

Most important technical survey in this study for major material of underground structure is design, procurement and construction of waterproofing membrane. By the local interview, there is

an answer that procuring materials and construction of waterproofing works is possible. On the other hand, farther study of the waterproofing design (including not applying waterproofing) with required quality and function is necessary after the selection of the site with consideration of third county's (Thailand) specialist of waterproofing. This is because to apply the certain level of specification on the waterproofing has a large influence on the cost under following two conditions. Such as the differences of cost between local contractor and Thailand specialist are relatively small. And field condition is relatively good with shallow underground water level.

Similarly, major materials such as steel materials, cement, re-bar, and etc. are available in the local market. It was confirmed that the special size (more than H350) may be necessarily imported.

In addition, the quality control methods and various testing items of major materials are future confirmation matters. It is important to control a cost of construction by putting structure specifications in order to meet local standards. It will be farther study at the detail design stage after selection of the site with having confirmed what kind of examination with certain level of precision can be done on site.

2.7 Necessity of Financial and Economic Analysis on Underground Substation

Construction of an underground substation requires advanced technical knowledge in the design and construction of buildings and equipment, as well as civil work such as excavation. Furthermore, the recipient government undertakes an expensive investment since an underground substation demands more reliable equipment than an outdoor substation does. Nevertheless, an underground substation often plays a vital role in terms of power supply. This type of substation enables construction of a superstructure to enable more efficient use of the substation site and, in terms of finance, rent revenue is a crucial factor. Although the eligible portion of the ODA loan project is the construction of underground substitution, the executing agencies need to pay appropriate attention to the construction cost of superstructure and rent revenue in the financial and economic analysis. Therefore, the analysis on the expensive investment covers not only the cost of an underground substation but also that of a superstructure. Similarly, revenue forecast takes both power sales and rent revenue into consideration.

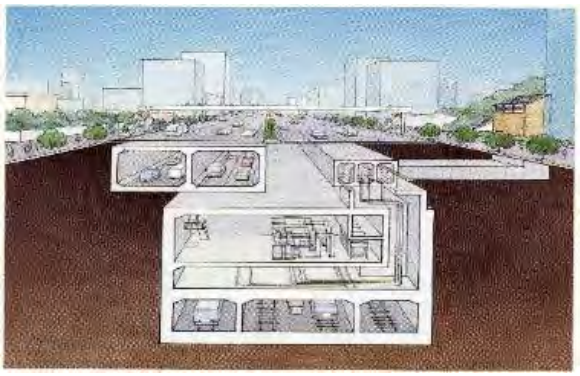
On the use of superstructures above underground substations, internal use (such as offices, warehouses, and corporate housing) is prevalent in Japan and other countries mainly due to the flexibility of superstructure design, effective utilization of own land, and easiness of emergency response for substation trouble. In some cases and development plans, underground substations were installed underneath public land such as parks in consideration of difficult land acquisition in urban areas, security issues, and stable operation in the long run. On the other hand, third parties have commercial facilities in superstructures of several underground substations and these cases are mostly in Tokyo, where land acquisition is quite difficult. Both cases - the electric company is

the land owner and obtains a leasing fee from users of the superstructure or, conversely, an electric company rents an underground section of property from a land owner on a long-term contract - can be found. Given that an underground substation is constructed at a place with strong energy demand and plays a crucial role in power supply in an urban area, long-term and sustainable operation is quite essential. In terms of operational reliability and economic and financial benefits, it is best to utilize one's own land for underground substations.

In Australia: Installed in own property

In Germany: Installed in a park

In Tokyo: Under a commercial property



In Tokyo: Below a Highway

(Source: website of property owner, TEPCO)

Figure 2-26: Cases for the Use of Superstructures above UGSS

2.8 Environmental and Social Viability of Underground Substations

2.8.1 Comparative Analysis of Substation Design

Following the technical and financial examination of project viability, it is worth analyzing the gaps in environmental and social impacts caused by ground, semi-underground, and underground substations[5]. The degrees of impacts evaluated here are those that are anticipated if there is no

[5] Examination of zero option and comparison of environmental impacts among alternatives, which are exercised in the strategic environmental assessment (SEA), are described respectively in the next chapter.

single avoidance or mitigation effort taken. The anticipated negative impacts, which need further technical examination for confirmation, are therefore all listed in the following two tables.

Not only the substation analysis by level, i.e., 1) "ground substation" (indoor/outdoor), "semi-ground", and "underground", but also difference of transmission/distribution network location: 2) "overhead wire" or "underground cable" has been compared to analyze the degrees of environmental and social impacts during the construction and operation periods.

There have been found slight gaps among the three different types of substations such as earth and sand production from excavation work, necessity of confirming topographic strength and harmonization with underground structures. On top of these, other factors such as waste from demolition and removal work for the existing facilities need to be taken into consideration. It is more important to identify a) if it is necessary to acquire land, b) if there is a possibility of involuntary resettlement, and c) where the site is located (residential area/commercial area) than to examine the substation design concerning whether ground, semi-ground, or underground is suitable. Impacts on the current land use and local community depend considerably on the above a), b) and c). If the above a) and b) cannot be avoided, it will entail longer procedures and require much coordination before construction. If the Government of Bangladesh wishes to have investment from the Government of Japan, international financial organizations[6], or private banks and other financial institutions that adopt and observe the equator principles[7], they are requested to take extrajudicial measures or examine doable alternative measures that satisfy the social requirements of funders' guidelines and principles such as payment of compensation not only for immovable properties acquired for the project but for the losses of livelihood means and incomes.

A more stable power supply in Dhaka is expected from securing greater safety and increasing disaster preparedness via the designing of an underground substation, and indirect positive impacts such as quality improvement of the social infrastructure and services, and contribution to the

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[6] JICA, World Bank and ADB have an alignment to harmonize their environmental and social safeguard guidelines for their project investments. JICA Guidelines for Environmental and Social Guidelines require partner countries to prioritize provision of alternative land over cash compensation, provide compensation and/or assistance for livelihood restoration and improvement of relocated people, provide compensation based on the replacement cost, pay special attention to socially vulnerable people, and provide transitional assistance. There is no stipulation in Bangladesh for the project proponent to prepare a budget to provide compensation and assistance for livelihood restoration and improvement. If this project causes losses of livelihood means, reduction of their income, or damage to the livelihood activities for any reason, they will be regarded as "affected people" eligible for compensation.

[7] The Equator Principles are a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in large-scale projects and are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. The financial institutions that apply equator principles commit to implementing the principles in their internal environmental and social policies, procedures and standards for financing projects based on the IFC Performance Standard and World Bank Group Environmental, Health and Safety Guidelines. They will not provide project finance or project-related corporate loans to projects where the client will not, or is unable to, comply with the equator principles.

betterment of local businesses and household livelihoods will be achieved from a longer-term perspective.

Table 2-18: Comparison of Environmental Impacts (Substation)

Impact Item	Surface	Semi-ground	Underground
Environmental Pollution	➢ Air quality is anticipated to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work. ➢ There will be wastewater from construction machinery and vehicle cleaning, muddy water and oil runoff from surface runoff during rainfall, and other water. ➢ Construction waste and general waste from workers is anticipated. General waste from workers could produce offensive odors. ➢ There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste. ➢ Noise and vibration is anticipated from work vehicles and construction machinery. ➢ If there are any facilities existing in the site that need to be demolished, waste such as debris and other construction waste (metal and wood) will be produced.		
Soil from Construction	➢ -	➢ Excavated soil will be produced to a certain extent. It is necessary to secure primary storage and examine final treatment method. ➢ It is necessary to confirm if there is any hazardous substance contained in excavated gravel before treatment.	➢ Excavated soil will be produced to a large extent. It is necessary to secure primary storage and examine final treatment method. ➢ It is necessary to confirm if there is any hazardous substance contained in excavated gravel before treatment. ➢ Construction with boring, excavation or pile work that does not meet technical standards could impact the ground stratum.
Protected Area & Ecosystem	➢ It is necessary to confirm if there are any protected areas, historical sites, cultural heritage or tourism spots around the site and its vicinity. ➢ Cutting trees and plants in and around the project site, or transplanting them to other places will be required. It is necessary to confirm if there are any flying birds, inhabiting insects, reptiles, or small mammals there.		
Topography & Geology	-	-	➢ It is necessary to measure topographic strength in and around the project site and confirm if there is any soft ground or any chance of landslides.
Land Acquisition & Land Use	➢ If land acquisition is required, it is necessary to secure suitable land for the substation that will need land adjustment. Land acquisition will also cause large-scale involuntary resettlement in dense Dhaka, which will require long-term resettlement procedures. (See 「用地取得手続き」). ➢ Land acquisition and involuntary resettlement will not be caused if the project is implemented in acquired land or within a site where the existing facilities are replaced. ➢ During construction period, transportation of construction equipment and vehicles, and workers will cause restriction of access and traffic blocking in the surrounding area. Temporary requisition of land and/or roads could also be required in the surrounding area for protection and safety purposes.		
Social Impact	➢ During construction period, transportation of construction equipment and vehicles, and numerous laborers will cause restriction of access and traffic blocking in the surrounding area. It could cause an increase in traffic volume at certain places, and traffic jams and accidents, and thus local activities will be affected. If the site is located in a residential area or adjacent to one, adverse effect on people's day-to-day living there will become serious. In a commercial area, negative impacts on the livelihood means of local merchants around the site are		

Impact Item	Surface	Semi-ground	Underground
	anticipated. Their shops or hats could be removed or temporarily closed due to the project implementation. ➢ If the site is located in a residential area or adjacent to one, people feel noise and vibration in a relatively worse way compared with that in a commercial area. Learning environment of children will deteriorate if there are schools or education facilities near the site. Impacts on the landscape and the right to sunshine shall be considered. ➢ There will be a contribution to the promotion of local employment. ➢ During operation, social infrastructure and services, local businesses, and household livelihood activities could be improved by the improvement of the power supply.		
Accidents	➢ It requires numerous maintenance work. More accidents are anticipated.	➢ It is necessary to confirm if there are any underground structures close to the ground.	➢ It requires less maintenance work. Fewer accidents are anticipated. ➢ It is necessary to confirm if there are any underground structures.
Disaster Preparedness	➢ Natural disasters such as floods, earthquakes, or fire accidents are the potential risks.	-	➢ Natural disasters such as floods and earthquakes will be prevented and minimized. ➢ It is likely that power supply will remain stable in disasters.
Others	➢ Coughs or allergies could be caused by the dust produced during construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.		

(Source: JICA Survey Team)

2.8.2 **Comparative Analysis of Transmission/Distribution Design**

The following table shows a comparative analysis of design in the development of the transmission and distribution network, which is also one of the crucial parts of the project.

It has been found that underground cable installation could cause certain impacts through creating earth and sand from excavation work, and would require harmonization with underground structures. Apart from the environmental impact, underground cable installation will bring social benefits through minimizing adverse impacts only temporarily during the construction period, increasing disaster preparedness, and maintaining the flexibility of land use as much as in the pre-construction period.

Table 2-19: Comparison of Environmental Impact (Transmission and Distribution Network)

Impact Item	Overhead Wire	Underground Cable
Environmental Pollution	➢ Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work. ➢ The discharged water from the site could be contaminated by domestic wastewater from construction workers, wastewater from construction machinery and vehicle cleaning, sediment and oil runoff from surface runoff during rainfall, and other water. ➢ Construction waste and general waste from workers is expected. General waste from workers could produce offensive odors. ➢ There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste. ➢ Noise and vibration is expected from work vehicles and construction machinery.	
Soil from Construction & Sediment	-	➢ Gravel and sediment deposits from surface runoff could accumulate in the surrounding area and obstruct the flow of water. ➢ Excavated soil will be produced to a large extent. It is necessary to secure primary storage and examine the final treatment method. ➢ It is necessary to confirm if there is any hazardous substance contained in excavated gravel before treatment.
Protected Areas	➢ It is necessary to confirm if there are any protected areas, historical sites, cultural heritage or tourism spots around the site and its vicinity.	
Ecosystem	➢ Cutting trees and plants in and around the project site, or transplanting them to other places will be required not only during construction period but operation period as well to avoid interruptions and prevent accidents. ➢ It is necessary to confirm if there are any flying birds, inhabiting insects, reptiles, or small mammals there.	
Land Acquisition & Land Use	➢ Temporary restriction to access to ROW and surrounding area during construction period will be required. ➢ It is necessary to identify land owner of the places to install poles.	➢ Temporary restriction to access to ROW and surrounding area during construction period will be required. ➢ It is necessary to identify land owner of the places to install poles. ➢ There will be no impacts during operation. Land can be used for other purposes as previously.
Landscape	➢ Although installation of overhead wires may disturb people's views, it will not have a severe effect on the urban landscape.	➢ No effect on landscape is anticipated as cables are installed underground.
Social Impact	➢ During construction period, transportation of construction equipment and vehicles, and numerous laborers will cause restriction of access and traffic blocking in the surrounding area. It could cause an increase in traffic volume at certain places, and traffic jams and accidents, and thus local activities will be affected. If the route passes a residential area or is adjacent to one, adverse effect on people's day-to-day living there will become serious. If the route passes a commercial area, negative impacts on the livelihood means of local merchants around the route are anticipated. Their shops or hats could be removed or temporarily closed due to the project implementation. ➢ If the route passes a residential area or is adjacent to one, people feel noise and vibration in a relatively worse way during the construction period, compared with that in a commercial area. Learning environment of children will temporarily deteriorate if there are schools or education facilities near the site. ➢ There will be a contribution to the promotion of local employment. ➢ During operation, social infrastructure and services, local businesses, and household livelihood activities could be improved by the improvement of the power supply.	
Accidents	➢ Rain, wind and cyclones could cause	➢ Underground structures are not in ducts or

	interruptions and accidents.	sealed in Dhaka. Both construction work and maintenance work during night could cause more accidents as it is more difficult to detect underground structures due to the darkness than in daytime. It is necessary to confirm if there are any structures close to the ground.
Disaster Preparedness	➢ Poles can collapse and wire can expire due to natural disasters such as floods. There are risks of fire accidents, which may take people's lives.	➢ Natural disasters such as floods and earthquakes will be prevented and minimized. ➢ It is likely that power supply will remain stable in disasters.
Others	➢ It is possible that infectious pathogens in domestic wastewater could contaminate the soil or groundwater. ➢ With people gathering from various different regions, infections could spread or be communicated by mosquitoes or other intermediaries. ➢ Dust could impact respiratory organs and eyes, noises could impact hearing, and high temperatures and humidity could be a factor affecting workers' health during hot season.	

(Source: JICA Survey Team)

Chapter 3 **Validation and Verification of Underground Substation Project**

3.1 Evaluation factors for Underground Substation Project

As discussed in chapter 2, underground substation construction can be a solution to enable power utilities to construct a power system network in a heavily populated city area where new land acquisition is quite difficult. Thus, each underground substation project must be validated and verified in terms of the following criteria: 1) necessity of underground network with UGSS to meet the growing electricity demand in the area, 2) technical feasibility of the project, especially for Dhaka-specific difficulties in civil and architectural technologies and available materials in the market, and 3) justifiable investment amount that does not cause any severe negative impacts to each power utility's business and to be accepted by all related stakeholders.

3.2 Validation for Underground Substation Project for Supply Network Expansion Plan for Dhaka City Area

Section 2.4 summarizes the future network plan for Dhaka's distribution supply network and substations, and validated the necessity of new substation constructions to meet the increasing demand. This section validates the necessity of an underground substation in Dhaka from the network plan, and the feasibility of UGSS construction while maintaining sufficient electricity supply in every stage of the network plan.

As discussed in previous chapters, the construction of 132/33kV substations in Dhaka city often faces difficulties in land acquisition and the laying of the necessary power cables to interconnect the source substation, the substation constructed, and customers to be supplied who are geographically scattered in the crowded city. Based on the scarcity of available plots for substations, the Survey team developed the following comparison table of possible distribution forms of a new 132kV substation to supply power in the demand area.

Table 3-1: Comparison Table of Distribution Forms

	Plan - A	Plan - B	Plan - C	Plan - D
Distribution Image				
Advantages	✓ No land acquisition ✓ Short UG line	✓ No land acquisition ✓ Short UG line	✓ Short UG line ✓ Only conventional skills (No special skills)	✓ Easy land acquisition ✓ Only conventional skills (No special skills)
Disadvantages	✓ Special attention to fire and flood ✓ Additional cost (Excavation)	✓ Special attention to fire and flood ✓ Limited capacity	✓ Special attention to fire and flood ✓ Severe land scarcely ✓ Expensive land price	✓ Constraint of UG routes (Limited roads) ✓ High fault frequency (Long UG line and Many cable joints)
Feasibility	○ Higher cost?	○ But, limited capacity	△ Severe (Impossible?) to acquire land	× Limited distribution lines Low reliability

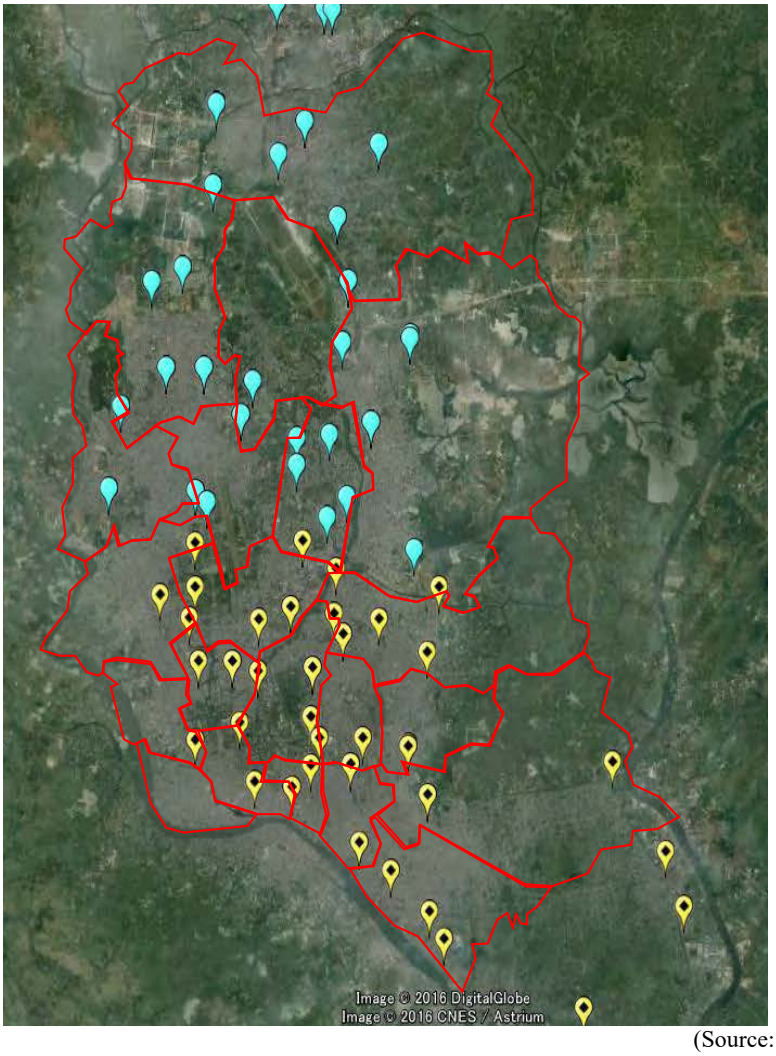
(Source: JICA Survey Team)

The table shows that the underground substation in Plan-A is the best solution to secure sufficient capacity in the metropolitan area. In the case of Plan-B, it is difficult to establish a 132/33/11 kV substation because the available area is limited based on the fact that an indoor substation requires almost the same footprint as a UGSS does, and the lower maximum coverage area permitted by the building code. Installing an outdoor substation in Plan-C is quite difficult because of land scarcity, and rising land prices in recent years. Even if it is possible to acquire enough land for an outdoor substation in the demand area, the acquisition cost seems expensive. Finally, Plan-D is to install an outdoor substation in a rural area, which is far from the center of the demand area. It may be easy to secure enough land area at a reasonable price. However, a lot of long distribution lines need to be installed from the outdoor substation to the center of the demand area, and there is a high possibility that available roads to install the lines are limited. Hence, other installation methods, not only direct buried cables, should be taken into consideration, such as tunnels, which are more expensive than the conventional method. Additionally, low reliability would be a concern as well as high cost because of the long distribution distance and many cable joints.

Thus, the conversion of 33/11kV substation sites that are owned by DESCO and DPDC to the plots for new 132kV substations and re-use of the existing distribution system must be a viable solution for land scarcity and new distribution line spaces. However, a 132/33kV conventional-design substation has a larger footprint, and does not fit the current plots of 33/11kV substations.

Thus, indoor or underground substation forms, which employ multi-floored substation structures, often enables one to minimize the substation's footprint to fit the available plot area and the switching of existing distribution lines to a new substation with higher voltage and capacity. From this effective land usage perspective, multiple numbers of UGSS candidate sites are nominated from DESCO and DPDC's network expansion plans, and these candidates sites are to be studied for validation.

The following map shows the current locations of DESCO and DPDC substations. The map shows that substations are densely constructed over the Dhaka city area. To meet the increasing demand, more substations must be constructed in between existing substations, or capacity expansions in current substations will be required. Also, the limited availability of wide roads throughout Dhaka city shows that substations must be constructed near to the demand center, to minimize the cable laying distance.

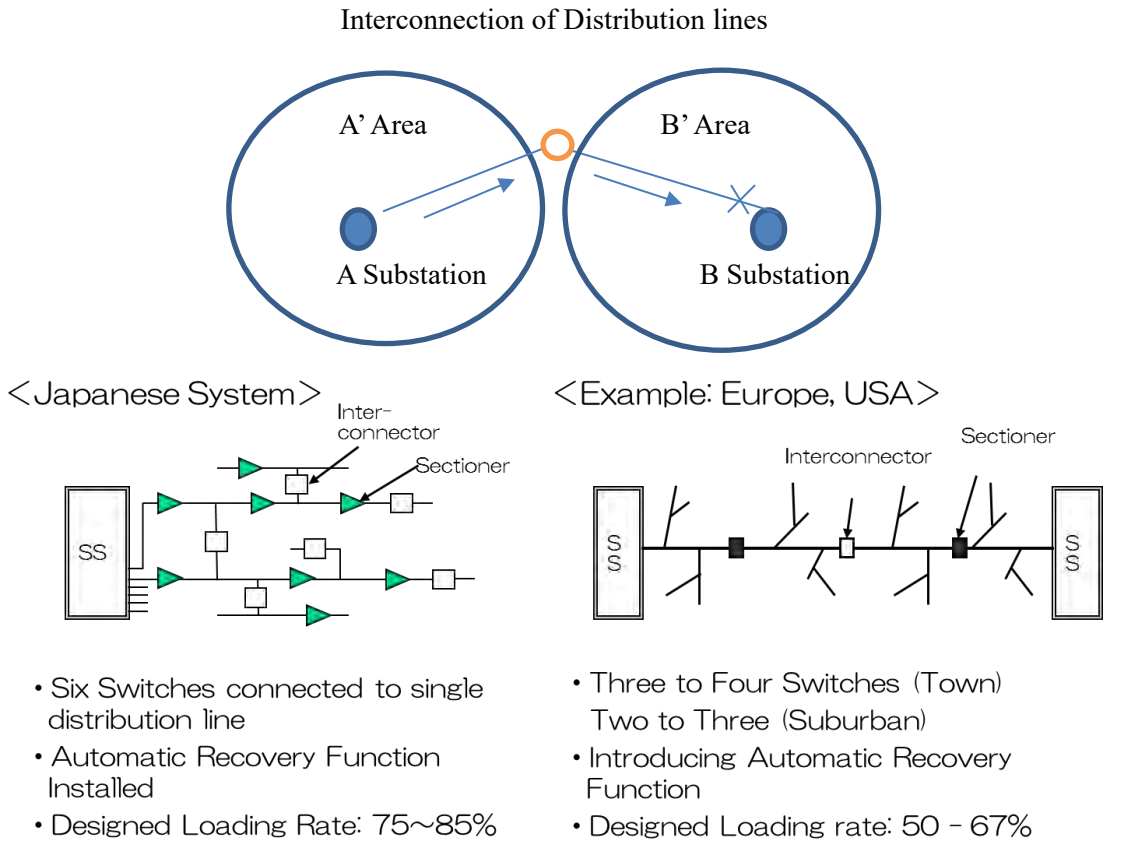


(Source: The Survey Team)

Figure 3-1: Substation Locations in Dhaka City

3.2.1 Network Expansion Plans of DESCO & DPDC

As discussed in the previous section, both distribution companies must expand their supply capacity with a new 132kV distribution network and substations by utilizing existing 33kV substation plots and newly acquired sites. To utilize 33kV substation sites for 132kV system installation, load evacuation from the existing 33kV facilities while continuing electricity supply to customers is critical. If full loads on the existing substation can be evacuated, the entire area of the plot can be converted to the new facilities. In the case where existing facilities must be operated to sustain the electricity supply during new facility construction, only a limited area of the plot can be utilized. Thus, the strategic interconnection of distribution lines is quite important, and is to be planned as part of the UGSS construction project as preparation work. For example, the following diagram shows Substation A supplies its supply area A', and B supplies B' area. In any trouble or planned outages where substation A cannot supply its area, loads in A' can be diverted to substation B with sufficient capacity, and this results in the minimum outage time and no supply shortage. Thus, this loop configuration of distribution lines must be introduced to enhance electricity supply reliability in metropolitan areas.



(Source: JICA Survey Team)

Figure 3-2: Conceptual diagram for distribution line interconnection, and TEPCO's interconnection practice (3 section with 3 interconnection scheme)

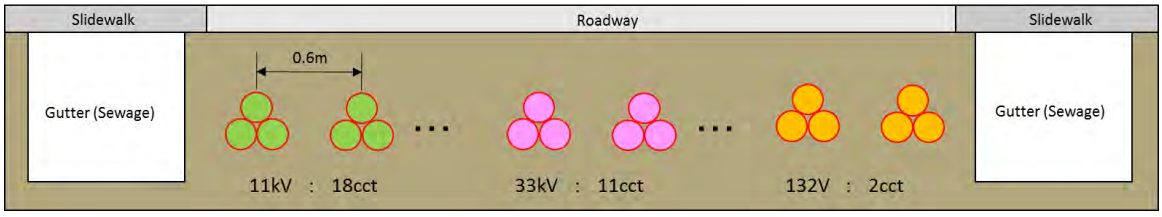
After introducing distribution interconnection, the interconnecting point may be manually operated by field workers on-site as an initial step. However, considering the workers' travelling time amid Dhaka's traffic congestion, remote control of critical interconnecting switches must be introduced to achieve quick restoration of system faults by segregating the faulty area from other healthy parts and supplying with other sources. Also, distribution load dispatching can be done with on-line monitoring system for individual distribution loading and available supply capacity of each substation.

The frequency of load evacuations for new substation construction is anticipated to increase so as to utilize each utility's land properties. Also, load evacuation for the current conventional distribution scheme results in power supply interruption with no remote switching operation. Thus, remote control of distribution interconnection must be introduced along with the distribution system expansion.

After re-configuring the distribution network with sufficient numbers of interconnection switchgears with remote-control features, smart meters and other smart-grid related machines can be introduced to gather "big-data" from the distribution network for better customer experiences, business efficiency improvement, and provision of other types of customer services such as energy management, and megawatt transactions based on the existing telecommunication infrastructure throughout Dhaka city. As an initial part of this distribution system renovation, interconnection facilities among distribution lines must be introduced strategically.

3.2.2 **The need for underground T&D and substation facilities in the network plan**

In this section, we describe the need to place the substation in Dhaka city. The figure below shows a cross section of the underground T&D cables in the case that underground T&D cables are installed from outside of Dhaka city to Dhaka city.



(Source: JICA Survey Team)

Figure 3-3: Cross Section of Underground T&D Cables

In the case that underground T&D cables are installed from outside of Dhaka city, the 11kV (18cct) and 33kV (11cct) cables must be installed from outside of Dhaka city to the demand area in Dhaka city as well as 132kV cables (2cct).

As per the above figure, the sidewalks are occupied by the gutter (sewage) so T&D cables must be installed in the roadway.

If cable separation between circuits is 0.6m, roadway with a width of at least 18m is needed for T&D cable installation. This is physically difficult. If existing underground facilities are buried, the situation is even more severe. Therefore, realistically the substation shall be placed in Dhaka city.

If the substation is placed in Dhaka city, installation of underground T&D cables is also physically difficult near the peripheral part of the substation. Therefore, it is necessary to construct a cable tunnel in which cables can be installed (see figure below). We will consider the possibility of cable tunnel installation.

(Source: TEPCO Power Grid Inc.)

Figure 3-4: Cable Tunnel

3.3 Investigation of Six DESCO and DPDC Candidate Sites

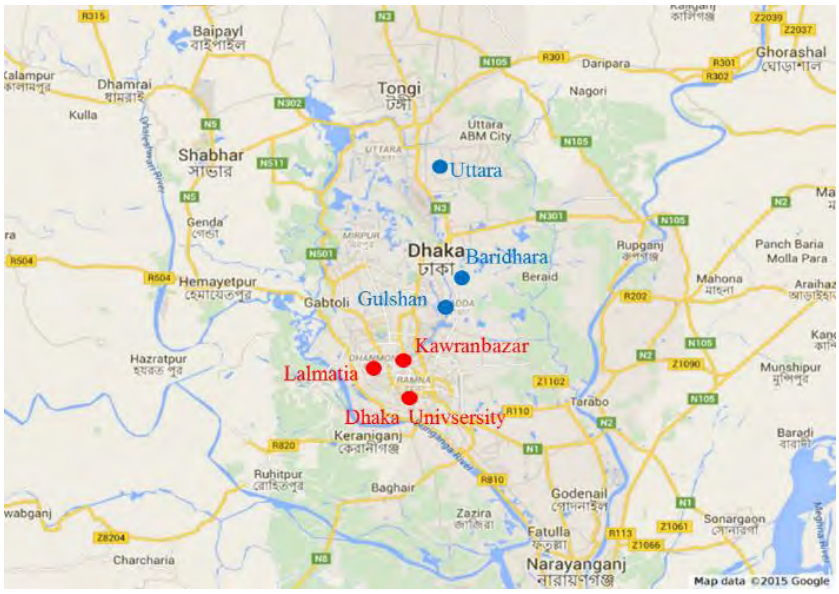
This survey investigated six DESCO and DPDC candidate sites for an underground substation in terms of their geographical characteristics, network-wise necessity and interconnection, proposed substation design, economic characteristics, and necessary social and environmental considerations.

3.3.1 **Characteristics of the candidate sites**

Table 3-2: Underground Substation Candidate List

	Name	Current Usage	Owner	Co-ordinates
DESCO	Gulshan	Existing SS	DESCO	23.780076°, 90.417387°
	Uttara	Existing SS	DESCO	23.868456°, 90.405078°
	Baridhara	Existing SS	DESCO	23.797486°, 90.424506°
DPDC	Dhaka University	Cement Factory	Power Division	23.725169°, 90.399897°
	Kawran Bazar	Existing SS	DPDC	23.751394°, 90.391714°
	Lalmatia	Existing SS	DPDC	23.751491°, 90.371149°

(Source: JICA Survey Team)



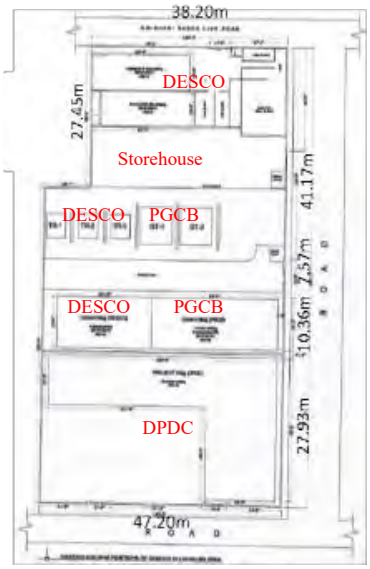
Note: Candidate sites shown in blue are DESCO; red are DPDC.

(Source: JICA Survey Team)

Figure 3-5: Candidate Sites

3.3.1.1 Gulshan

The Gulshan site is situated in the Gulshan area, where many embassies, office buildings and top-tier hotels are operating and being constructed, and the site is located at the intersection of Gulshan Ave and Bir Uttam AK Khandakar RD. The entire site is owned by Power Division, and is sub-rented to DESCO, DPDC, and PGCB partially, and DESCO's plot has DESCO's office building, and warehouses. PGCB's plot has a 132/33kV substation of PGCB, and 33/11kV substation of DESCO.



(Source: DESCO)

Figure 3-6: Gulshan Layout

3.3.1.2 Uttara

The Uttara site is located 2km north of the airport and is owned by DESCO, using a 33/11kV substation, with DESCO's office building, warehouse, and complaints center. Load evacuation from the operating substation is reported to be quite impossible, thus the whole plot cannot be used for new substation construction.

(Source: DESCO)

Figure 3-7: Uttara Layout

(a) (b) (c)

(Source: JICA Survey Team)

Figure 3-8: Photos of Uttara

3.3.1.3 Baridhara

The Baridhara site is owned by DESCO for an existing 33/11kV substation. The site layout and photos are as shown below.

(Source: DESCO)

Figure 3-9: Baridhara Layout

(a) (b) (c)

(Source: JICA Survey Team)

Figure 3-10: Photos of Baridhara

3.3.1.4 Dhaka University

This site is owned by Dhaka University, which has agreed to rent the plot for DPDC's substation. The layout and photos of Dhaka University are shown below.

(Source: DPDC)

Figure 3-11: Dhaka University Layout

(a) (b)

(Source: JICA Survey Team)

Figure 3-12: Photos of Dhaka University Site

3.3.1.5 Kawran Bazar

The Kawran Bazar site is now used for a 33/11kV substation and company residence for DPDC's employees in a commercial area. The Kawran Bazar site's layout and photos are shown below.

(Source: DPDC)

Figure 3-13: Kawran Bazar Location and Layout

(a) (b)

(c) (d)

(Source: JICA Survey Team)

Figure 3-14: Photos of Kawran Bazar

3.3.1.6 Lalmatia

The Lalmatia site has DPDC's 33/11kV substation and company residences for employees. Its layout and photos are shown below.

(Source: DPDC)

Figure 3-15: Lalmatia Layout

(a)

(b)

(b)

(d)

(Source: JICA Survey Team)

Figure 3-16: Photos of Lalmatia

3.4 Underground Transmission Route

In this section, we will describe the underground transmission line route from the 6 candidates to each source substation. The source substations were selected based on PGCB, DESCO and DPDC's opinions.

We selected the route with the most basic condition which may make the minimum distance. But the final cable route shall be decided after field survey and gathering information such as existing underground facilities (gas, water, etc.), traffic conditions, regulations, etc.
The source substations and distances of the route are as shown below.

Table 3-3: Underground Substation Candidate List

	Candidate Site	Source Substation	Distance of the route
DESCO	Gulshan	Rampura	3.32km
	Uttara	Basundhara	12.4km
	Baridhara	Basundhara	10.3km
DPDC	Dhaka University	Kamrangirchar	3.34km
	Kawran Bazar	Dhanmondi	1.49km
	Lalmatia	Dhanmondi	3.94km

(Source: JICA Survey Team)

And the routes we selected are shown below.

(Source: JICA Survey Team)

Figure 3-17: Cable Route between Gulshan and Rampura

(Source: JICA Survey Team)

Figure 3-18: Cable Route between Uttara and Basundhara (Source)

(Source: JICA Survey Team)

Figure 3-19: Cable Route between Baridhara and Basundhara

(Source: JICA Survey Team)

Figure 3-20: Cable Route between Dhaka University and Kamrangirchar

(Source: JICA Survey Team)

Figure 3-21: Cable Route between Kawran Bazar and Dhanmondi

(Source: JICA Survey Team)

Figure 3-22: Cable Route between Lalmatia and Dhanmondi

3.5 Economic Conditions in Candidate Sites

The six candidate sites chosen for this survey have different local characteristics and the expected levels of rent vary across the sites. Local characteristics of the UGSS sites are as follows:

Table 3-4: Characteristics of Candidate Sites

	Candidate Site	Characteristics
DESCO	Gulshan	The surrounding area of the candidate site is a premiere commercial district near Gulshan Circle-1. There are many medium- and high-rise buildings with 6-20 floors. The residential buildings are mainly for condominiums and tenants accounted for 10-30% of the residents across MZAs.
	Baridhara	Block-J, an MZA in which the candidate site is located, is a residential district and many medium-rise apartments with 6-10 floors are found there. There are some office buildings along Shaheed Suhrawardi Avenue. Approximately half of the residents are tenants. The candidate site is a convenient place within 10 minute-ride from Gulshan.
	Uttara	The candidate site is located at the boundary of Sector 4 and Sector 6. Many medium- and high-rise buildings with 6-13 floors are found there. Office buildings are scattered along the Dhaka-Mymensingh Highway but this area is mainly residential. Tenants accounted for 50-80% of the residents across MZAs.
DPDC	Kawran Bazar	The candidate site is adjacent to a mega shopping mall (Bashundhara City Shopping Mall) and its neighborhood is a business district where large corporations have offices. Many high-rise buildings with 9-18 floors are used as offices.
	Lalmatia	The candidate site is located at the boundary of Dhanmondi Thana and Mohammadpur Thana. Many medium- and high-rise buildings with 6 to 13 floors are found there. The area is a luxurious residential district but there are some office buildings along Satmasjid Road. Tenants accounted for 30-50% of residents across MZAs.
	Dhaka Univ.	While the northern side of the candidate site is a government district and university campuses, the south is the old quarter where aged buildings exist. In the residential area (mainly the southern side of the candidate site), tenants accounted for 60-80% of the residents.

(Source: JICA Survey Team, Bangladesh Bureau of Statistics “Population and Housing Census 2011”)

This survey collected data at 46 commercial buildings at the above candidate sites in June-July 2016. The buildings were located within a 0.5km radius of the candidate sites. They had five floors or more and were mostly aged 10 years or less. If there were several eligible buildings, those closer to the candidate sites were selected. Both office and apartment data were collected except for Gulshan and Kawran Bazar, both of which are classified as commercial districts. Baridhara contained an area where many foreigners resided. No sample was taken in this area because the rent level differed significantly from that of the candidate site. In addition, the site in Dhaka University is located among government offices and university buildings. These characteristics made it difficult to collect enough samples and, thus, reduced the sample size. Rent levels of the candidate sites in July 2016 are as follows:

Table 3-5: Rent Levels of Candidate Sites

	Gulshan	Baridhara	Uttara
Office rent	1,318.6 BDT/m^2	354.2 BDT/m^2	216.4 BDT/m^2
Sample size	8 buildings	4 buildings	4 buildings
Apartment rent	—	204.8 BDT/m^2	210.2 BDT/m^2
Sample size	—	4 buildings	4 buildings
	Kawran Bazar	Lalmatia	Dhaka Univ.
Office rent	652.5 BDT/m^2	435.3 BDT/m^2	153.2 BDT/m^2
Sample size	8 buildings	4 buildings	3 buildings
Apartment rent	—	262.2 BDT/m^2	140.8 BDT/m^2
Sample size	—	4 buildings	3 buildings

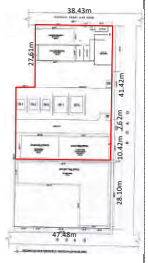
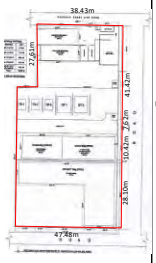
(Source: JICA Survey Team)

3.6 Building Construction Constraints in the Six Candidate Sites

Based on the study results of the building construction constraints discussed in section 2.4.1, the maximum footprints for the underground building and its superstructure, and possible office room spaces are evaluated as follows. Notably, some sites with narrow attaching roads yield fewer floors for the superstructure, which may result in a decrease of rent income. For example, the size of superstructure in Gulshan changes if the project includes the demolition of the existing PGCB 132kV Substation (Case: Gulshan-B) and construction of PGCB's new underground substation (Case Gulshan-C), which is under study for a prospective project for JICA's next funding. In a similar manner, the size of superstructure in the Kawran Bazar plot changes as the road expansion of the attaching road is done (with suffix "-2"), and with the addition of the neighboring BPDB residence building for the project scope (with suffix "-B"). Thus, width expansion of the attaching road can be a solution for the improvement of the project's financial viability.

Table 3-6: Building Constraints on DESCO's Candidate Sites

2016/9/8

Candidate site		DESCO					Note
		Gulshan-A	Gulshan-B	Gulshan-C	Uttara	Baridhara	
Site information	Layout drawing (Non scale)						[Legend] Red line : Development area Grenn area : Un construction architecture
	Site area (㎡)	2,700	2,700	4,030	2,690	2,290	・Outline area
	Floor area ratio	9.5	9.5	9.5	9.5	8.5	・Building code is F-1 in RAJUK. ・There is no limit of the floor area ratio in road width in 18m or more
	Building coverage ratio (%)	50	50	50	50	50	
	Floor number limit	15	15	15	–	–	
	Height limit	–	–	–	–	–	
	Road width (m)	more than 12 meters	more than 12 meters	more than 12 meters	more than 12 meters	11	
	Existing building (㎡)	427.50	0.00	0.00	0.00	0.00	
The area that construction is possible	Maximum total floor space (㎡)	25,650.00	25,650.00	38,285.00	25,555.00	19,465.00	
	Ground (㎡)	922.50	1,350.00	2,015.00	1,345.00	1,145.00	
	Underground (㎡)	2,025.00	2,025.00	3,022.50	2,017.50	1,717.50	・Underground architecture coverage ratio : 75%
The plan are	ground section (㎡)	11,992.50	17,550.00	26,195.00	17,485.00	14,312.50	・Number of layer to assume : 13th
	UGSS (㎡)	6,075.00	6,075.00	6,075.00	6,052.50	5,152.50	・Limit of the underground area is 75% for development area. ・The basement assumes the third floor. ・Spec of substation put underground.
	office (㎡)	6,918.75	10,125.00	15,112.50	10,087.50	8,158.13	・Between second layer and 13 layer : 75% rentaburu ratio ・This number of area without parking space.
Others	Number of a necessary parking lot	60.00	88.00	131.00	88.00	72.00	・It is one every 200 square meters
Note		・The substation is specifications to put underground. ・When the areas of the UGSS increased, A areas under the ground increase.					

(Source: JICA Survey Team)

Table 3-7: Building Constraints on DPDC's Candidate Sites

2016/9/8

Candidate site		DPDC						Note
		Dhaka University	Kawranbazare-A-1	Kawranbazare-A-2	Kawranbazare-B-1	Kawranbazare-B-2	Lalmatia	
Site information	Layout drawing (Non scale)							[Legend] Red line : Development area Grenn area : Un construction architecture
	Site area (㎡)	1,680	2,790	2,790	3,680	3,680	1,780	・Outline area
	Floor area ratio	9.5	3.8	9.5	3.8	9.5	9.5	
	Building coverage ratio (%)	50	60	50	60	50	50	・Building code is F-1 in RAJUK. ・There is no limit of the floor area ratio in road width in 18m or more
	Floor number limit	–	–	–	–	–	–	
	Height limit	–	–	–	–	–	–	
	Road width (m)	more than 12 meters	Width of the road is not enough	more than 12 meters (Construction to widen a road)	Width of the road is not enough	more than 12 meters (Construction to widen a road)	more than 12 meters	
	Existing building (㎡)	0.00	0.00	0.00	0.00	0.00	0.00	
The area that construction is possible	Maximum total floor space (㎡)	15,960.00	10,462.50	26,505.00	13,800.00	34,960.00	16,910.00	
	Ground (㎡)	840.00	1,674.00	1,395.00	2,208.00	1,840.00	890.00	
	Underground (㎡)	1,260.00	2,092.50	2,092.50	2,760.00	2,760.00	1,335.00	・Underground architecture coverage ratio: 75%
The plan are	ground section (㎡)	10,920.00	4,185.00	18,135.00	7,522.50	23,920.00	11,570.00	・Number of layer to assume : 13th
	UGSS (㎡)	3,780.00	6,277.50	6,277.50	6,277.50	6,277.50	4,005.00	・Limit of the underground area is 75% for development area. ・The basement assumes the third floor. ・Spec of substation put underground.
	office (㎡)	6,300.00	1,883.25	10,462.50	4,290.38	14,133.75	6,675.00	・Between second layer and 13 layer: 75% rentaburu ratio ・This number of area without parking space.
Others	Number of a necessary parking lot	55.00	21.00	91.00	38.00	120.00	58.00	・It is one every 200 square meters
Note		・The substation is specifications to put underground. ・When the areas of the UGSS increased, A areas under the ground increase.						

(Source: JICA Survey Team)

3.6.1 Results of Ground Investigation at Planned Area

Six places were planned for test bowling, such as Gulshan planned site of the northern part of Dhaka City, Baridhara planned site, Uttara planned site, southern planned site in the Dhaka University, Kawaran Bazar planned site, and Lalmatia planned site.

Due to overhead wire found during our field survey in Uttara, the test bowling was given up and estimated it from findings of the planned site in the Dhaka University and the Baridhara planned site which were located on coaxial.

In addition, the Kawaran Bazar planned site is next to an apartment complex living in, with electric wires, and undergrounding pipes of sewage and water.

During our site survey, location of underground utilities did not become clear so that tests of bowling are not possibility without underground exploration and a trial pit by man power. The

ground condition of the Kawaran Bazar planned site is predicted from findings of the neighboring Dhaka University planned site.

The bowling test carried out in each proposed site are in-situ test (on site water permeability test) that assumed 50m a maximum and laboratory tests (particle size distribution test and water permeability test)

- Underground Water Table

As a result of pre-boring survey, it is founded that there is the groundwater (rainwater penetration water) in 0 to GL-4.0m in around proposed site, but the groundwater existence layer is not confirmed in shallow layer (0-20.0m).

The groundwater with the spring around Dhaka City is estimated to be "the crack water" that the underflow water from the Himalayas springs out of the depths of the diluvium.

Therefore, examination of ground expansion, heaving, boiling, and piping phenomenon by water level drops during underground construction are not necessary.

- Supporting Layer

Pre-boring test results shows that there are very dense, stable and thick bearing layer (sandy clay etc.) at about 20m below ground in each planned site. There are no concern with subsidence due to facilities own load, since there are enough thickness (over 10m) base support sand layer and there are no cray layer which may subside.

- Retaining Wall Structure (earth retaining wall, wales and struts)

Simple kinds of retaining wall structure have been carried out in Gulshan area. It was confirmed throughout test boring in other planned area that the ground conditions are not much different. As a result, the retaining wall design shall be possibly applied to other planned area. Actual design of retaining wall structure shall be done in further stage with test boring information conducted after selection of project location.

3.6.2 **Feasible substation type at each site**

There are three types of substation that can be installed: the first is an outdoor substation, which is used as the major method in Bangladesh; the second is an indoor substation, installing equipment on the 1st and 2nd floors of a building; and the third is an underground substation, installing equipment in the underground space of a building. The survey team has prepared preliminary layouts as per the below four cases in order to confirm the feasibility of setting each style of substation on the available land dimensions, based on the building coverage information in section 2.4.1. The preconditions follow the contents of section 2.5.2, and the survey team sets the extra

condition that transformers must be installed on the bottom floor because a transformer is an extremely heavy object.

In the four cases of underground substation with oil-insulated transformers, only three winding transformers can be installed to fit the available plot because OIT requires an air duct to be installed nearby on the same floor.

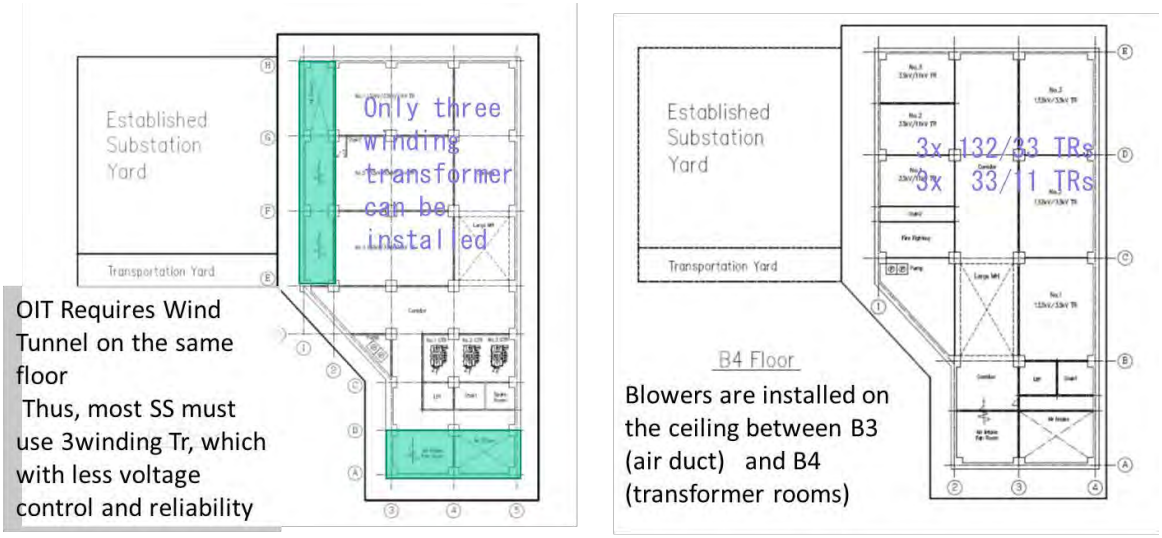


Figure 3-23: Study on oil insulated transformer installation in Kawran Bazar

The summary tables for the substation form study in the candidate sites are shown below with the following legend.

[Case-1] Combination of GIT and GIS in UGSS
[Case-2] Combination of OIT and GIS in UGSS
[Case-3] Combination of OIT and GIS in Outdoor substation
[Case-4] Combination of OIT and GIS in Indoor substation

Table 3-8: Feasible Substation Type at DESCO's sites

	Gulshan	Uttara	Baridhara
Case-1 GIT+GIS on UGSS	○ Possible under building coverage limitation (75%)	○ Possible under building coverage limitation (75%)	○ Possible under building coverage limitation (75%)
Case-2 OIT+GIS on UGSS	△ Possible under conbination with three winding transformer (132/33/11kV) and earthing transformer	○ Possible under building coverage limitation (75%)	○ Possible under building coverage limitation (75%)
Case-3 OIT+GIS on Outdoor SS	× No enough space for installation of 6 transformers and control building	× No enough space for installation of 6 transformers and control building	× No enough space for installation of 6 transformers and control building
Case-4 OIT+GIS on Indoor SS	× No enough space for installation of 6 transformers and green belt	× No enough space because of tentative 33/11 kV installation on 3.3.1 clause	× No enough space for installation of 6 transformers and green belt

○ : Possible installation △ : Possible with constraint × : Impossible installation

(Source: The survey team)

It is confirmed that Case-1 is possible at each site. As for Case-2, there is not enough space at the Gulshan site because the transformer and its cooling system should be installed on the same floor. If a 132/33/11 kV transformer with three winding is used at the Gulshan site, Case-2 becomes feasible. However, it is not preferable because of the difficult voltage control of a three winding transformer.

As for Case-4, the survey team can confirm the feasibility of installing an indoor substation at the Gulshan and Baridhara sites from the preliminary layouts. However, it is difficult to use the upper floors above the building because there is not enough space for a lift and stairs at Gulshan and Baridhara.

The survey team suggests a semi-underground substation, installing some equipment in the underground space, as one of the solutions to secure spaces for the lift and stairs.

Table 3-9: Feasible Substation Type at DPDC's sites

	Dhaka University	Kawranbazar	Lalmatia
Case-1 GIT+GIS on UGSS	○ Possible under building coverage limitation (75%)	○ Possible under building coverage limitation (75%)	○ Possible under building coverage limitation (75%)
Case-2 OIT+GIS on UGSS	△ Possible under conbination with three winding transformer (132/33/11kV) and earthing transformer	△ Possible under conbination with three winding transformer (132/33/11kV) and earthing transformer	△ Possible under conbination with three winding transformer (132/33/11kV) and earthing transformer
Case-3 OIT+GIS on Outdoor SS	× No enough space for installation of 6 transformers and control building	× No enough space for installation of 6 transformers and control building	× No enough space for installation of 6 transformers and control building
Case-4 OIT+GIS on Indoor SS	× Over 50% of building coverage under installation of 6 transformers	× Possible for only semi-UGSS	× Over 50% of building coverage under installation of 6 transformers

○ : Possible installation △ : Possible with constraint × : Impossible installation

(NOTE: the plot for Kawran Bazar does not include BPDP's residence area, the availability of which cannot be guaranteed so far)

(Source: The survey team)

Case-1 is feasible at all candidate sites as well as at DESCO's sites. Case-2 is not feasible at any site because of the same reasons as DESCO's sites. As for Case-3 and Case-4, no sites can accept indoor or outdoor substations due to insufficient dimensions.

3.7 Project Cost Analysis

Basic method of calculating substation cost (equipment and construction)

The results of substation cost for each case are as follows. The difference in substations cost is mainly due to building and civil works cost and depends on site condition. If appropriate site area is secured, the least expensive outdoor substation is applicable. In case of indoor substation, the cost is increased by 1.1 times and for underground substation is by 1.6 times compared with the outdoor one. In addition, the gas insulated transformer in underground substation costs 1.6 times more than oil insulated transformer.

The estimation of substation equipment cost and construction cost is as follows:

- According to DPDC and DESCO, with the breakdown of outdoor substation cost track record in recent years, at the time of applying the underground substation, the single-line diagram is referred to for the cost of the main equipment.
- The main equipment, which is the main transformer (oil insulated), gas insulated switchgear (GIS), metal-clad switchgear, electric cable, and control and protection panels, is estimated from the cost records of DPDC and DESCO.

■ Domestic transportation fee, device installation fee, spare parts, etc. are estimated from the cost records of DPDC and DESCO.
■ Reference cost value from DPDC and DESCO is taken from the bidding stage and was calculated assuming the market price equivalent
■ The main transformer (gas insulated) from a domestic manufacturer is calculated.
■ Estimated cost is in JPY; the exchange rate is as follows
1 USD = 105.85 JPY , 1 BDT = 1.35 JPY (2016.7.21)

Table 3-10: Approximate Project Cost for Each Substation Type

Candidate site			DESCO			DPDC		
			Gulshan	Uttara	Baridhara	Dhaka University	Kawranbazare	Lalmatia
Approximate Substation Construction cost (hundred million JPY)	**Case-1** GIT+GIS on UGSS	Equipment & Installation work	34.3					
		Civil & Buiding Work	10.5	12.6	12.3	10.8	11.6	12.0
		Total	**44.8**	**46.9**	**46.6**	**45.1**	**45.9**	**46.3**
	Case-2 OIT+GIS on UGSS	Equipment & Installation work	15.9					
		Civil & Buiding Work	11.3	14.1	13.7	10.9	11.1	12.0
		Total	**27.2**	**30.0**	**29.6**	**26.8**	**27.0**	**27.9**
	Case-3 OIT+GIS on Outdoor SS	Equipment & Installation work	15.9					
		Civil & Buiding Work	2.4					
		Total	**18.3**					
	Case-4 OIT+GIS on Indoor SS	Equipment & Installation work	15.9					
		Civil & Buiding Work	3.2	3.5	3.5	3.5	3.5	3.6
		Total	**19.1**	**19.4**	**19.4**	**19.4**	**19.4**	**19.5**
Construction Cost for Evaluation		Average of UGS(GIT and OIT)	**36.0**	**38.5**	**38.1**	**36.0**	**36.5**	**37.1**

(note) This preliminary cost evaluation will be reviewed at the next project stage for detailed project feasibility study for the selected sites, and the cost elements can change significantly due to the detailed study.

3.8 Environmental and Social Considerations

As part of the examination of alternatives, “non-implementation of the project” (zero-option) was examined, with an assumption that the existing substations and transmission/distribution lines keep operating, in order to assess potential impacts on the environment, society and economy.

From an environmental and social considerations point of view, non-construction of substation or transmission/distribution lines will cause no adverse impacts during the construction period. However, it is anticipated that the power supply amount and capacity will remain as it has been and even become worse in the longer term. This will cause quality deterioration of social infrastructure and services, and adverse impacts on local businesses and household economies. They may increase electricity purchase fees, which will be a burden on customers. The potential environmental impact in the case of non-implementation of the project is described in the following table. “Implementation of the project” has so far been found more viable than “non-implementation”.

Table 3-11: Comparison of Environmental Impacts (Zero Option)

Major Impact Item	Positive Impact (+)	Negative Impact (-)
Power Demand, Stable Power Supply	N/A	There has been a huge gap between power supply and demand. It will be more difficult to cope with the increasing power demand in Dhaka; time and frequency of load shedding and power failures may increase if this project is not implemented. Other projects should be examined and implemented at the earliest.
Environmental Pollution	There will be no temporary environmental pollution anticipated during construction period.	In longer term, the existing facilities will deteriorate. Drainage system will become dysfunctional, and soil within the site could be contaminated by the leaked pollutants in the wastewater. Odor could occur.
Natural Environment	There will be no impact on natural environment as no project is implemented.	N/A
Socio-economic Conditions	Temporary restriction in access and traffic blocking caused by the installation of underground cables will not occur.	There will be no contribution to the promotion of local employment if the project is not implemented.
Others	N/A	There will be no immediate improvement in power supply if the existing facilities continue to be used. Quality of social infrastructure and services could deteriorate, and negative impacts will be caused for local businesses and household livelihoods. In longer term, electricity sales price will be forced higher, which could increase electricity purchase fee. In that case, the cost increase could be reflected in government subsidies, or the amount customers pay.

(Source: JICA Survey Team)

Salient features of the candidate sites of DESCO and DPDC were identified through secondary data and information, which was supplemented by interviews with stakeholders for their reconfirmation, and quick measurement surveys such as noise level on-site and boring tests at four sites. The following tables show the results of draft scoping of each candidate site based on the above findings.

The degrees of impacts evaluated in this draft scoping are those that are anticipated if there is no single avoidance or mitigation effort taken. This scoping exercise identifies important (and likely important) environmental and social items, their scopes and study methods among all of them at the highest-prioritized site chosen later.

The results show that no significant positive/negative impacts (A+/-) are anticipated at any of the candidate sites. Mitigation measures shall be examined and implemented in the project for cases in which positive/negative impacts are expected to some extent. These will then be reflected in the environmental management plan and environmental monitoring plan.

Table 3-12: Draft Scoping Results (Gulshan Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, muddy water and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system to the Salidabad Treatment Plant through the edge of the Hatirjheel Lake and discharged into the Balu River.	D	Wastewater discharged from the buildings in the site will be collected into D-WASA's drainage and sewage system so that no water pollution is anticipated.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery.	B+	Noise and vibration is expected less as new facilities are more environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	D	The soil condition is good according to the findings in the boring test. Construction with boring, excavation or pile work will not impact the ground stratum.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts such as offensive odors are not expected as there is no problem with the current drainage system.
Sediment	D	No sediment will be produced. .	D	Given the low chances of sediment runoff into the Gulshan Lake during operation, it is unlikely that sediment deposits could impact the bank material of the lake.
Protected Areas	B-	Underground cable will be installed across and along the Gulshan Lake, which is already polluted and designated as an Environmental Critical Area (ECA), and special attention shall be paid. On the other hand, the site has no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests.	D	The site has no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests.
Ecosystem	B-	The site has already been levelled and the surrounding area is well developed as both residential and commercial areas. Impacts on the ecosystem are not expected as no rare species have been reported. On the other hand, underground cable will be installed across and along the Gulshan Lake, which could affect the urban ecosystem along the cable.	D	The site and its surrounding area are well developed as residential as well as commercial areas where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	Wastewater collected at the site will be treated and will not impact the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Land Acquisition/ Resettlement	B-	The existing substation facilities will be replaced within the present site, which will cause no involuntary resettlement. On the other hand, temporary requisition such as restriction to access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to be the shortest among all DESCO potential sites.	D	No further land acquisition or resettlement is expected after the operation starts.
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities or indigenous people have been found in the surrounding area.	D	No ethnic minorities or indigenous people have been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected that job opportunities will be available at the construction site and the local economy will grow accordingly.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected as an indirect positive impact that their employers will benefit from a more stable power supply.
Land Use and Utilization of Local Resources	B-	Land use will not change, and no severe impact on local resource usage is anticipated. On the other hand, temporary requisition such as restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to be the shortest among all DESCO potential sites.	D	Land usage will not change and there will be no severe impact on local resource usage anticipated.
Water Usage	D	The dependency ratio to groundwater in the site area was 0 to 2.1% as of 2011, and 97.7 to 100% of people use tap water. It is expected that there will be no impact on water use.	D	There will be no impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers.	B+	Social infrastructure and services could be improved by the improvement of power supply.
Social Capital and Local Institutions such as decision-making organizations	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is expected to positively impact social capital, local decision-making bodies and other social institutions via better power supply.
Misdistribution of Benefits and Damages	D	No parties have been found to receive any special benefits or damages from the project.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	D	No impacts will be caused by fences installed during the construction period on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.	D	No impacts are anticipated on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children’s rights.	D	The project is not expected to have any negative impact on children’s rights.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will not become worse compared with the existing facilities' operation which is to be replaced in the project.
Working Environment (including Occupational Safety)	B-	Workers' health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers' health during the hot season.	B+	Workers' health could be improved compared with the present situation due to the operation of advanced facilities with better working environment.
Accidents	B-	As the traffic volume in the surrounding area is currently heavy, increase in traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited and do no harm to the climate.	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 3-13: Draft Scoping Results (Uttara Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, muddy water and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system.	D	Wastewater discharged from the buildings in the site will be collected into D-WASA's drainage and sewage system so that no water pollution is anticipated.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery, of which the impacts are felt more as the surrounding area of the site is a residential area where current noise level measured in the baseline survey was lower than the other sites.	B+	Noise and vibration is expected less as new facilities are more environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	B-	There is a chance that construction with boring, excavation or pile work could impact the ground stratum.	D	Impacts on topography and geology are not expected as the geological strength of the site is secured to a certain extent since there is no case of soil fall reported on the existing facilities' site.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts such as offensive odors are not expected as there is no problem with the current drainage system.
Sediment	D	No sediment will be produced.	D	Given the low chances of sediment runoff during operation, it is unlikely that sediment deposits could impact the bank material.
Protected Areas	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in the surrounding area.	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in the surrounding area.
Ecosystem	B-	The site has already been levelled and the surrounding area is well developed as a residential area. Impacts on the ecosystem are not expected as no rare species have been reported. On the other hand, underground cable will be installed across the Uttara Lake, which could affect the urban ecosystem along the cable.	D	The site and its surrounding area are well developed as a residential area where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	Wastewater collected at the site will be well treated in the existing system and will not impact the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Land Acquisition/ Resettlement	B-	The existing substation facilities will be replaced within the present site, which will cause no involuntary resettlement. On the other hand, temporary requisition such as restriction of access to the surrounding area and traffic blocking may be forced due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	No further land acquisition or resettlement is expected after the operation starts.
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities or indigenous people have been found in the surrounding area.	D	No ethnic minorities or indigenous people have been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected that job opportunities will be available at the construction site and the local economy will grow accordingly.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected as an indirect positive impact that their employers will benefit from a more stable power supply.
Land Use and Utilization of Land Resources	B-	Land use will not change, and no severe impact on local resource usage is anticipated. On the other hand, temporary restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	Land usage will not change and there will be no severe impact on local resource usage anticipated.
Water Usage	D	The dependency ratio to groundwater in the site area was 1.2 to 15.1% as of 2011, and 83.2 to 98.6% of people use tap water. It is expected that there will be no severe impact on water use due to the construction work.	D	There will be no severe impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers.	B+	Social infrastructure and services could be improved by the improvement of power supply.
Social Capital and Local Institutions such as decision-	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is expected to positively impact social capital, local decision-making bodies and other social institutions via better power supply.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
making organizations				
Misdistribution of Benefits and Damages	B-	The site is located in the residential area. There may be local people who claim damages caused by noise and vibration due to the construction work. On the other hand, no parties have been found to receive any special benefits from the project.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	D	No impacts will be caused by fences installed during construction period on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.	D	No impacts are anticipated on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children's rights.	D	The project is not expected to have any negative impact on children's rights.
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will not become worse compared with the existing facilities' operation which is to be replaced in the project.
Working Environment (including Occupational Safety)	B-	Workers' health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers' health during hot season.	B+	Workers' health could be improved compared with the present situation due to the operation of advanced facilities with a better working environment.
Accidents	B-	As the traffic volume in the surrounding area is currently heavy, increase in traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited and do no harm to the climate	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 3-14: Draft Scoping Results (Baridhara Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, muddy water and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system.	D	Wastewater discharged from the buildings in the site will be collected into D-WASA's drainage and sewage system so that no water pollution is anticipated.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery, of which the impacts are felt more as the surrounding area of the site is a residential area where current noise level measured in the baseline survey was lower than the other sites.	B+	Noise and vibration is expected less as new facilities are more environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	B-	There is a chance that construction with boring, excavation or pile work could impact the ground stratum.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts are not anticipated.
Sediment	D	No sediment will be produced.	D	Given the low chances of sediment runoff during operation, it is unlikely that sediment deposits could impact the bank material.
Protected Areas	D	The site has no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests.	D	The site has no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests.
Ecosystem	B-	The site has already been levelled and the surrounding area is well developed as a residential area. Impacts on the ecosystem are not expected as no rare species have been reported. On the other hand, there is a seasonal wetland close to the Baridhara site, Bhatara, and destruction of the urban ecosystem along the cable could occur.	D	The site and its surrounding area are well developed as a residential area where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	Wastewater collected at the site will be well treated in the existing system and will not impact the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Land Acquisition/ Resettlement	B-	The existing substation facilities will be replaced within the present site, which will cause no involuntary resettlement. On the other hand, temporary requisition such as restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	No further land acquisition or resettlement is expected after the operation starts.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities or indigenous people have been found in the surrounding area.	D	No ethnic minorities or indigenous people have been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected that job opportunities will be available at the construction site and the local economy will grow accordingly.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected as an indirect impact that their employers will benefit from a more stable power supply.
Local Use and Utilization of Local Resources	B-	Land use will not change, and no severe impact on local resource usage is anticipated. On the other hand, temporary restriction to access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	Land usage will not change and there will be no severe impact on local resource usage anticipated.
Water Usage	D	The dependency ratio to groundwater in the site area was approximately 8.5% as of 2011, and 89.9% of people use tap water. It is expected that there will be no severe impact on water use.	D	There will be no severe impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers.	B+	Social infrastructure and services could be improved by the improvement of power supply.
Social Capital and Local Institutions such as decision-making organizations	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is expected to positively impact social capital, local decision-making bodies and other social institutions via better power supply.
Misdistribution of Benefits and Damages	B-	The site is located in the residential area. There may be local people who claim damages caused by noise and vibration due to the construction work. On the other hand, no parties have been found to receive any special benefits from the project.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	D	No impacts will be caused by fences installed during construction period on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.	D	No impacts are anticipated on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children’s rights.	D	The project is not expected to have any negative impact on children’s rights.
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will not become worse compared with the existing facilities' operation which is to be replaced in the project.
Working Environment (including Occupational Safety)	B-	Workers’ health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers’ health during hot season.	B+	Workers' health could be improved compared with the present situation due to the operation of advanced facilities with a better working environment.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Accidents	B-	As the traffic volume in the surrounding area is currently heavy, increase in traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited.	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 3-15: Draft Scoping Results (Dhaka University Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, muddy water and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system.	D	The water drainage system is in good condition and impacts from water pollution are not expected.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery. Although the surrounding area is regarded as a "quiet area", the noise level measured in the baseline survey in June 2016 turned out to be as bad as the other sites.	D	Noise and vibration is not expected as new facilities are environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	D	The soil condition is good according to the findings in the boring test. Construction with boring, excavation or pile work will not impact the ground stratum.	D	Impacts on topography and geology are not expected as the geological strength of the site is secured.
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts such as offensive odors are not expected as the current drainage system is in good condition.
Sediment	D	Given the low chances of sediment runoff during construction, it is unlikely that sediment deposits could impact the bank material.	D	Given the low chances of sediment runoff during operation, it is unlikely that sediment deposits could impact the bank material.
Protected Areas	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in the surrounding area.	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in the surrounding area.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Ecosystem	B-	The site has already been levelled and the surrounding area is well developed as a university campus. Impacts on the ecosystem are not expected as no rare species have been reported. Impacts on the existing flora are expected as they will be cut down for construction work, and impacts on birds such as swallows and starlings, and small animals are also expected.	D	The site and its surrounding area are well developed as a university campus where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	Wastewater collected at the site will be well treated and will not impact the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.
Land Acquisition/ Resettlement	B-	No land will be acquired nor any involuntary resettlement be needed. It is Dhaka University who owns the site area, and land use right should be transferred from Dhaka University to DPDC. It is vacant land within Dhaka University campus to be utilized for new substation facilities, which will not cause demolition of any existing facilities. On the other hand, temporary requisition such as restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	No further land acquisition or resettlement is expected after the operation starts.
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities or indigenous people have been found in the surrounding area.	D	No ethnic minorities or indigenous people have been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	B+	No adverse impacts on people's livelihoods as there is no residence in the site area. It is expected that job opportunities will be available at the construction site and the local economy will grow accordingly.	B+	No adverse impacts on people's livelihoods as there is no residence in the site area. It is expected as an indirect positive impact that they will benefit from a stable power supply.
Land Use and Utilization of Local Resources	B-	Land use will change from university campus to substation. On the other hand, temporary restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	Land usage will not change after the operation starts, and there will be no severe impact on local resource usage anticipated.
Water Usage	D	The dependency ratio to groundwater in the site area was 0 to 0.1% as of 2011, and 99.4 to 100% of people use tap water. Although they take groundwater in the university campus, it is expected that there will be no severe impact on their water use as their residential quarters and university buildings are distant enough.	D	There will be no severe impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers.	B+	Social infrastructure and services could be improved by the improvement of power supply.
Social Capital and Local Institutions such as decision-making organizations	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Misdistribution of Benefits and Damages	D	No parties have been found to receive any special benefits or damages from the project.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	B-	Land use right should be transferred from Dhaka University to DPDC. Conflicts could occur between the two parties if the procedures do not go well.	D	No local conflicts are expected as this project develops new public facilities in the given vacant land.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	B-	Although this project will be located at the center of the city, there is no high-rise building nearby. A tall building with modern design could destroy the existing landscape in the surrounding area. In addition, certain impacts on views and the urban landscape could be caused by fences installed during construction period as this project is new in the given site at the capital center.	B-	Certain impacts could be anticipated on views and the urban landscape as this project is new in the given site.
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children's rights.	D	The project is not expected to have any negative impact on children's rights.
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will be good in new facilities.
Working Environment (including Occupational Safety)	B-	Workers' health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers' health during hot season.	D	Workers could stay well via the operation of advanced facilities with a better working environment.
Accidents	B-	As the traffic volume in the surrounding area is currently heavy, increase in traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited and do no harm to the climate.	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 3-16: Draft Scoping Results (Kawran Bazar Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, sediment and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system.	D	Wastewater discharged from the buildings in the site will be collected into D-WASA's drainage and sewage system so that no water pollution is anticipated.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery.	B+	Noise and vibration is expected less as new facilities are more environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	D	Construction with boring, excavation or pile work will not impact the ground stratum.	D	Impacts on topography and geology are not expected as the geological strength of the site is secured. .
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts are not anticipated.
Sediment	D	Given the low chances of sediment runoff during construction, it is unlikely that sediment deposits could impact the bank material.	D	Given the low chances of sediment runoff during operation, it is unlikely that sediment deposits could impact the bank material.
Protected Areas	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in surrounding area.	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in surrounding area.
Ecosystem	D	The site has already been levelled for residential quarters and substation facilities, and the surrounding area is well developed as a commercial area. Impacts on the ecosystem are not expected as no rare species have been reported.	D	The site and its surrounding area are well developed as a commercial area where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	The existing water drainage system is in good condition and there will be no impact on the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Land Acquisition/ Resettlement	C-	The existing substation facilities will be replaced within the present site, which will cause no land acquisition or involuntary resettlement. On the other hand, expansion of the road in front of the substation could cause requisition of road area from the people who run shops and who built their houses there. Further study is required to identify who they are and their tenure conditions. Temporary requisitions such as restriction of access to the surrounding area and traffic blocking could also be anticipated due to the installation of underground cable. The total length of underground cable is expected to be the shortest among all DPDC potential sites.	D	No further land acquisition or resettlement is expected after the operation starts.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities and indigenous people have been found in the surrounding area.	D	No ethnic minorities and indigenous people have been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	C-	Local market may be affected, which lies on the nearest narrow street from the site entrance to the main road. Adverse impacts on the livelihoods of people who run shops and who built their houses in the surrounding area may occur. Further study is required to clarify their socioeconomic status. On the other hand, it is expected that job opportunities will be available at the construction site	B+	No adverse impacts on the livelihoods of local merchants in the surrounding area any longer. Reconstruction of road in front of substation will provide better surrounding conditions. It is expected as an indirect impact that employers will benefit from a more stable power supply.
Land Use and Utilization of Local Resources	B-	Land use will not change and there will be no severe impact on local resource usage anticipated. On the other hand, expansion of the road in front of the substation could cause a change in local resources, and temporary requisition such as restriction of access to the surrounding area and traffic blocking may be forced due to the installation of underground cable. The total length of underground cable is expected to be the shortest among all DPDC potential sites.	D	Land usage will not change and there will be no severe impact on local resource usage anticipated.
Water Usage	D	According to the baseline survey, people generally use groundwater for drinking purposes and domestic purposes, but the project will not affect local merchants' water use working nearby as groundwater is taken through water pipelines, not directly from tube wells.	D	There will be no severe impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers. Severe impacts are also expected on the traffic of the main street.	B+	Social infrastructure and services could be improved by the improvement of power supply.
Social Capital and Local Institutions such as decision-making organizations	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is expected to positively impact social capital, local decision-making bodies or other social institutions via better power supply.
Misdistribution of Benefits and Damages	C-	The livelihoods of local merchants may be affected due to the project implementation. Their socioeconomic status and tenure condition shall be identified in further studies.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	C-	The existing substation will be replaced with a new one within the current site. Local conflicts of interest may occur among people who occupy the road for running their shops and who have built their houses nearby, due to the road expansion in front of the substation. Further study is required to clarify their identities.	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	D	No impacts will be caused by fences installed during construction period on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.	D	No impacts are anticipated on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children's rights.	D	The project is not expected to have any negative impact on children's rights.
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will not become worse compared with the existing facilities' operation which is to be replaced in the project.
Working Environment (including Occupational Safety)	B-	Workers' health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers' health during hot season.	B+	Workers' health could be improved compared with the present situation due to the operation of advanced facilities with a better working environment.
Accidents	B-	As the traffic volume in the surrounding area is currently very heavy, increase in traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited and do no harm to the climate.	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 3-17: Draft Scoping Results (Lalmatia Site)

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Air Pollution	B-	Air quality is expected to worsen at the work site and in the surrounding area due to airborne pollutants and dust from construction work.	D	Impacts from air pollution are not expected.
Water Pollution	B-	There will be wastewater from construction machinery, drainage from vehicle cleaning, sediment and oil runoff from surface runoff during rainfall, and other water. They will be collected into D-WASA's drainage and sewage system	D	Wastewater discharged from the buildings in the site will be collected into D-WASA's drainage and sewage system so that no water pollution is anticipated.
Waste	B-	Construction waste and general waste from workers is expected.	B-	General waste is expected from the buildings in the site.
Soil Pollution	B-	There could be soil pollution from workers' domestic wastewater, wastewater runoff containing oil from construction machinery or vehicles, and waste.	D	There will be no hazardous waste produced from the project facilities and waste will not pollute the soil.
Noise and Vibration	B-	Noise and vibration is expected from work vehicles and construction machinery.	B+	Noise and vibration is expected less as new facilities are more environmentally advanced. Traffic volume is not expected to increase.
Ground Subsidence	D	The soil condition is good according to the findings in the boring test. Construction with boring, excavation or pile work will not impact the ground stratum.	D	Impacts on topography and geology are not expected as the geological strength of the site is secured to a certain extent since there is no soft ground which may cause soil fall reported on the existing facilities' site.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Offensive Odors	B-	General waste from workers could produce offensive odors.	D	Negative impacts are not anticipated.
Sediment	D	Given the low chances of sediment runoff during construction, it is unlikely that sediment deposits could have an impact.	D	Given the low chances of sediment runoff into the Dhanmondi Lake during operation, it is unlikely that sediment deposits could impact the bank material of the lake.
Protected Areas	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in surrounding area.	D	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site and in surrounding area.
Ecosystem	D	The site has already been levelled, and the surrounding area is well developed as a residential area. Impacts on the ecosystem are not expected as no rare species have been reported.	D	The site and its surrounding area are well developed as a residential area where no rare species have been reported. Impacts on the surrounding ecosystem are not expected from the facility operation.
Hydrology	D	Wastewater collected at the site will be treated and will not impact the hydrology.	D	Wastewater collected at the site will be treated and will not impact the hydrology.
Topography and Geology	D	Geological strength is secured at the site, and no data has reported that there is soft ground at the site that may cause soil fall. No impact is thus anticipated on the topography and geology.	D	Impacts on topography and geology are not expected as there is no case of soil fall reported on the existing facilities' site.
Land Acquisition/ Resettlement	B-	The existing substation facilities will be replaced within the present site, which will cause no involuntary resettlement. On the other hand, temporary restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than ideal.	D	No further land acquisition or resettlement is expected after the operation starts.
Poverty	D	There is no poor settlement reported in the surrounding area.	D	There is no poor settlement reported in the surrounding area.
Ethnic Minorities/ Indigenous People	D	No ethnic minorities and indigenous people has been found in the surrounding area.	D	No ethnic minorities and indigenous people has been found in the surrounding area.
Local Economy such as employment, livelihood, etc.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected that job opportunities will be available at the construction site and the local economy will grow accordingly.	B+	No adverse impacts on the livelihoods of residents in the site area. It is expected as an indirect positive impact that their employers will benefit from a more stable power supply.
Land Use and Utilization of Local Resources	B-	Land use will not change and there will be no severe impact on local resource usage anticipated. On the other hand, temporary restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to be the shortest among all DPDC potential sites.	D	Land usage will not change and there will be no severe impact on local resource usage anticipated.
Water Usage	D	The dependency ratio to groundwater in the site area was 0 to 0.4% as of 2011, and 99.3 to 100% of people use tap water. Although they use groundwater for water supply within the site, there will be no severe impact on water use.	D	There will be no severe impact on water use.
Existing Social Infrastructure and Services	B-	Increase in traffic volume will be caused by the transportation of construction materials and workers.	B+	Social infrastructure and services could be improved by the improvement of power supply.

Impact Item	Before/During Construction		During Operation	
	Evaluation	Reasons for Assessment	Evaluation	Reasons for Assessment
Social Capital and Local Institutions such as decision-making organizations	D	The project is not expected to negatively impact social capital, local decision-making bodies or other social institutions.	B+	The project is expected to positively impact social capital, local decision-making bodies and other social institutions via better power supply.
Misdistribution of Benefits and Damages	B-	The site is located in the residential area. There may be local people who claim damages caused by noise and vibration due to the construction work. On the other hand, no parties have been found to receive any special benefits from the project.	D	No parties have been found to receive any special benefits or damages from the project.
Local Conflicts of Interest	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.	D	No local conflicts are expected as this project replaces public facilities with new ones in the given site.
Cultural Heritage	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.	D	The project is not expected to have any direct impact on cultural heritage as there is no item of cultural heritage in the site.
Landscape	D	No impacts will be caused by fences installed during construction period on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.	D	No impacts are anticipated on views or the urban landscape as this project replaces public facilities with new ones in the given site at the center of the capital.
Gender	D	The project is not expected to have any negative impact on gender relations.	D	The project is not expected to have any negative impact on gender relations.
Children's Rights	D	The project is not expected to have any negative impact on children's rights.	D	The project is not expected to have any negative impact on children's rights.
Infectious Diseases	B-	Coughs or allergies could be caused by the dust produced during the construction work. Cold infections and/or other infections communicated by mosquitoes or other intermediaries could spread among workers.	D	Hygienic environment will not become worse compared with the existing facilities' operation which is to be replaced in the project.
Working Environment (including Occupational Safety)	B-	Workers' health could be impacted by the construction work. Dust could impact respiratory organs and eyes, noises could impact hearing and high temperatures and humidity could be a factor affecting workers' health during hot season.	B+	Workers' health could be improved compared with the present situation due to the operation of advanced facilities with a better working environment.
Accidents	B-	Although the traffic volume is not too heavy in the surrounding area as it is in a residential area, traffic accidents on and out of the construction site may occur. Besides, fire, falling or electrocution, work accidents and sickness can occur. Increase in traffic volume will be caused by the transportation of construction materials and workers.	B-	Occupational accidents, fire, electrical accidents, traffic accidents, sickness, and secondary disasters from underdeveloped rescue systems may occur.
Transboundary Impacts/ Climate Change	D	No transboundary environmental impacts are expected. There may be possible air pollution such as dust in the construction work, but its impacts will stay very limited and do no harm to the climate.	D	No transboundary environmental impacts are expected. Impacts on climate caused by power transmission and distribution, and power transformation will stay very limited.

(Source: JICA Survey Team)

Note: A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

3.9 Review, Assessment, and Improvement of Business Plans by DESCO and DPDC

3.9.1 Business Plan for Candidate Sites

A business plan paid careful attention to two factors: 1) A control center is required to be built adjacent to the substation and 2) the building is required to have a certain space for parking. These constraints limit the available floor area. Out of 13 floors in the superstructure, the control center for the UGSS (1 floor) and a parking lot (2 floors) are excluded and, thus, 10 floors are considered available for leasing and internal use. For this reason, this project needs to pay more attention to revenue per available floor area than a usual commercial property with all floors usable for business does. Since the neighborhoods of Baridhara, Uttara, Lalmatia, and Dhaka University are residential districts, the new building can be used for apartments. As previously mentioned, however, office rent per square meter was higher than apartment rent at all of the above locations. Therefore, this analysis assumed the new building to be used for office purposes.

3.9.2 Estimation of Investment Return

(1) FIRR and NPV

Financial Internal Rate of Return (FIRR) was employed for comparing the investment returns of the candidate sites. From the viewpoint of an entity to implement the project, both expenditure (financial cost) and revenue (financial benefit) of the project are estimated. Investment return on the total capital put into this project (Project FIRR) was then calculated. This analysis assessed whether FIRR surpassed Weighted Average Capital Cost (WACC), an average financing cost of the capital invested in this project. In the case that FIRR does not reach WACC, this result suggests that the project cannot bear enough cash flow for payment of the capital (interest expense for debt plus dividends for equity). For reference purposes, Net Present Value (NPV) is also calculated. While FIRR shows efficiency of investment, NPV presents net size of financial benefit.

(2) Assumptions

The following assumptions were made for the analysis of investment return.

Table 3-18: Assumptions for FIRR

	DESCO	DPDC
Maximum Receiving Capacity	240MVA	Same as left
Power Demand	Estimated for Each Site	Same as left
Power Factor	0.90	0.80
Load Factor	0.58	0.57
Distribution/Transmission Loss	8.37%	9.41%
Unit Price of Power Purchase	5.63 BDT/kWh	5.56 BDT/kWh
Unit Price of Power Sales	6.91 BDT/kWh	6.90 BDT/kWh
Rentable Ratio	75%	Same as left
Rentable Area	Estimated for Each Site	Same as left
Rent	Estimated for Each Site	Same as left
O&M Cost (UGSS)	1% of construction p.a.	Same as left
Service Cost (superstructure)	2,910 BDT/m2 p.a.	Same as left
Major Repairs (superstructure)	3% of construction/20 years	Same as left
Project Life	50 years after construction	Same as left

	DESCO	DPDC
Exchange Rate	JPY 105.85/USD BDT 78.4180/USD	Same as left

(Source: DESCO and DPDC Annual Report, Estimation by JICA Survey Team)

a) Financial Benefit

The project is expected to generate four types of financial benefit: 1) additional sales from an increase in power distribution, 2) a reduction of distribution loss, 3) rent revenue from commercial estate business by using superstructure, and 4) savings of rent expenses from internal use.

The substation facility to be installed will enhance distribution capacity and, thus, the increase in power sales will contribute to revenue growth. Power demand is based on the demand forecast in "2.3 Substation and Power Distribution Planning in Dhaka." Power factor is based on the assumptions in the master plans of the two companies. Load factor is estimated by using the maximum power demand, the amount of power supply, and power transmission/distribution loss, all of which were taken from the annual reports (FY2014/2015) of DESCO and DPDC. The unit price of power purchase and that of power sales for each company are also based on the annual reports (FY2014/2015). The project is expected to reduce distribution loss by 1.2GWh per year.

For rent revenue and a reduction of rent expenses, this survey collected data on 46 commercial buildings in the six candidate sites for the last five years and a regression analysis was conducted with the data. Based on the regression analysis, estimation models for rent and rent changes were created.

(Estimation model for rent)

$R=28.26 - 8.49d_1 + 79.20d_2 + 42.89d_3 + 9.62d_4 - 2.22d_5 + 9.95\ office + 0.000004tf - 0.37height - 2.33age$

F-test p-value: 0.0000002499 R-squared: 0.71

R: rent (occupancy adjusted), $d_1 \cdots d_5$: dummies for candidate sites, office: a dummy for office

tf: total floor area, height: number of floors, age: age of buildings

The estimation model shows an expected rent at each candidate site in 2016. A dependent variable of the model is an occupancy-adjusted rent (estimated rents are presented in "Table 37 FIRR and NPV of Candidate Sites").

(Estimation model for rent change)

$S=41.63 + 1.44time$

F-test p-value: 0.0103 R-squared: 0.92

S : Standard rent, time : Year (Year 2012 = 1)

Based on the estimation model, a standard rent (the average rent of the six candidate sites) in the urban area of Dhaka for a corresponding year was calculated. By using the standard rents, annual changes (real terms) in the standard rent were estimated and, then, these changes were applied to all candidate sites. The average annual rent change during the project life was 1.79% on a real basis.

b) Financial Cost

The financial cost of this project can be divided into two types: 1) capital expenditure and 2) O&M costs. While capital expenditure is expected to occur during the project implementation period (March 2017 - January 2022), O&M cost will be expensed after the completion of the project implementation (February 2022 and afterward).

Capital expenditure consists of 1) earth work, 2) building work (including internal/external work), 3) M&E work, 4) consulting services, and 5) demolition work. Cost estimation for earth work, building work, and M&E work is based on preliminary estimation in this survey. For consulting services, a simple assumption (USD 5 million, approximately 5% of the total for earth work, building work, and M&E work) was made. Demolition cost is expected to be BDT 230 million (approximately USD 3 million) at the candidate sites, except for Dhaka University.

For O&M costs for an underground substation, a general assumption, 1% of capital expenditure, is applied as annual expenditure. Service cost for a superstructure (maintenance costs and utility costs for common areas) is based on the actual expenses in Dhaka for 2016. For major repair work for a superstructure (such as waterproofing, cosmetic work on walls, replacement of air-conditioners), 3% of construction cost is expected to occur every 20 years after the construction completion.

c) Hurdle Rate/Discount Rate

For the calculation of FIRR, cash flow before corporate income tax was employed. The effective tax rate on corporate income is independent of business models but the tax rate significantly affects FIRR. For this reason, this analysis used cash flow before corporate income tax in order to show the differences in profitability originating from the localities of candidate sites.

In line with the above assumption for cash flow estimation, WACC does not take tax effect (a reduction in cost of debt due to tax payment) into consideration. Since both financial benefit and financial cost are on a real basis, both cost of equity and cost of debt are adjusted from real rates to nominal rates. For financing mix, an ODA loan covers the total for earth work, underground portions of building work cost and consulting services, and M&E work. The executing agencies finance the rest of the project cost with equity contribution. The cost of an ODA loan is based on the interest payment of on-lending from the Bangladesh government to the executing agencies. The cost of equity can be considered an expected return on investment for the executing agencies. Since an underground substation and a superstructure have different expected returns, a weighted average of equity costs was calculated on a pro-rata basis with the costs of both components. Assumptions for WACC are shown in the following table.

Table 3-19: Assumptions for WACC

	Debt	Equity
Financing Cost (%)	5%	UGSS: 15% Superstructure: 20%
Currency	Japanese Yen	Bangladesh Taka
Inflation Rate (CPI, 2015)	0.2%	6.1%

(Source: Estimation by JICA Survey Team, IMF "International Financial Statistics Yearbook 2015")

(3) Calculation Results

In order to clearly show the profitability of the superstructure, this analysis calculated FIRR and NPV for the whole project, the superstructure, and the underground substation, separately. FIRR and NPV for the six candidate sites are shown in the following table.

Table 3-20: FIRR and NPV for Candidate Sites (The tables are to be revised).

	Gulshan	Baridhara	Uttara
Superstructure Floor Area (m^2)	17,550	14,313	17,485
Rentable Area (m^2)	10,125	8,158	10,088
Rent (2016, BDT/m^2)	1,195.4	341.4	319.0
FIRR (Whole, %)	11.77%	8.67%	7.94%
FIRR (Superstructure, %)	12.19%	1.35%	1.02%
FIRR (UGSS, %)	11.66%	9.72%	9.04%
NPV (Whole, US mil.)	74.48	41.36	32.12
NPV (Superstructure, US mil.)	17.64	-6.97	-8.76
NPV (UGSS, US mil.)	56.84	48.33	40.88
WACC (%)	5.82%	5.58%	5.66%

	Kawran Bazar	Lalmatia	Dhaka Univ.
Superstructure Floor Area (m^2)	18,135	11,570	10,920
Rentable Area (m^2)	10,463	6,675	6,300
Rent (2016, BDT/m^2)	804.8	443.6	248.5
FIRR (Whole, %)	8.64%	7.50%	6.92%
FIRR (Superstructure, %)	8.14%	3.39%	-0.88%
FIRR (UGSS, %)	8.77%	8.07%	7.80%
NPV (Whole, US mil.)	33.71	23.89	17.24
NPV (Superstructure, US mil.)	5.77	-3.11	-6.79
NPV (UGSS, US mil.)	27.95	27.00	24.03
WACC (%)	5.89%	5.52%	5.36%

Note: Rents are occupancy-adjusted.

All candidate sites satisfy the requirement (FIRR(UGSS)>WACC). In addition, the construction of UGSS alone does not utilize the site effectively and it is not considered a primary option for a project owner. Therefore, by focusing FIRR (Whole) and FIRR (Superstructure), the above calculation results can be classified into two groups:

1) FIRR (whole) > WACC and FIRR (superstructure) > WACC
For this group, it is strongly recommended to utilize the superstructure and launch a property leasing business since the leasing business contributes to the profitability of the whole project. Gulshan and Kawran Bazar are in this group.

2) FIRR (whole) > WACC and WACC > FIRR (superstructure)
For this group, the whole project is financially feasible but the leasing business utilizing the superstructure does not contribute to the profitability of the whole project. Thus, it is necessary to prepare measures for revenue enhancement and cost reductions, and to restructure the business plan. Baridhara, Uttara, Lalmatia, and Dhaka University are in this group.

As previously mentioned, capital expenditures for the six candidate sites are based on estimation at a very preliminary level and, therefore, it is required to reassess these amounts thoroughly. Nevertheless, change in capital expenditure is expected to occur to similar extents at all candidate sites. The change in capital expenditure affects levels of FIRR but it has little impact on the order of FIRR among the candidate sites. Therefore, it is appropriate to select Gulshan and Kawran Bazar for further assessment despite the possible change in capital expenditures.

It should be noted that FIRR in the above tables is on a real basis. If both financial benefit and financial cost are adjusted from real price to nominal price by using the inflation rate in 2015 (CPI 6.1%), FIRR (whole) is 18.58% for Gulshan and 15.27% for Kawran Bazar. In September 2016, private banks charge a nominal interest rate of 10-14% on the term loan to large and medium scale industry. In the two candidate sites, FIRR surpassed the above hurdle rate on a nominal basis.

3.9.3 Recommendations to Improve Project Feasibility

Three recommendations can be made for improvement of project feasibility. The recommendations are 1) improvement of financing methods, 2) large-scale redevelopment, and 3) support for power distribution operation.

On improvement of financing methods, it is desirable to assess borrowing from the Bangladesh government. An ODA loan cannot finance some cost items and they accounted for approximately 20% of the total project cost. The aforementioned analysis assumed that the ineligible portion is to be funded by equity from the executing agencies. Cost of equity is more expensive than the interest rate for borrowing from the Bangladesh government (approximately 5% in local currency terms). By partially replacing equity contribution with government borrowing, WACC can be reduced.

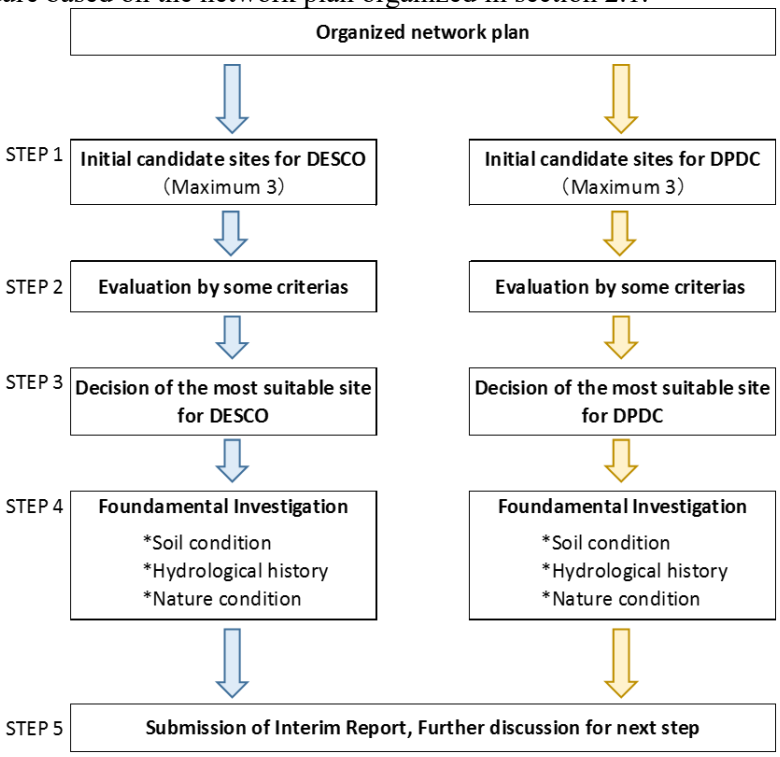
When redeveloping urban areas in Japan, landowners often provide their own lands and this procedure enables large-scale redevelopment by using an equivalent exchange scheme. Adding more value to real estate is an advantage of large-scale redevelopment for landowners. This urban development scheme is now being paid more attention in Bangladesh. The Dhaka Structure Plan (2015), which RAJUK formulated, mentioned this scheme as a policy to be implemented. The most financially viable sites, Gulshan and Kawran Bazar, are also suitable for large-scale redevelopment. In Gulshan, DPDC owns a building adjacent to the substation site used by DESCO. In Kawran Bazar, BPDB owns a building adjacent to the substation site used by DPDC. Large-scale redevelopment increases the size of net benefit and contributes to project sustainability. Thus, it is recommended to carry out large-scale redevelopment by using the adjacent lands in Gulshan and Kawran Bazar.

As for support for power distribution operation, the executing agencies will be able to offer not only cash compensation but also a substitute area to land owners. Land acquisition for substation sites will be more difficult due to ongoing urban congestion. It is an advantage for the executing

agencies to increase the available options for a land owner during the land acquisition negotiation. Large-scale redevelopment, as mentioned above, will increase the available floor area and enhance this advantage even more.

3.10 Site Selection for UGSS Project

In order to pick the most suitable site for UGSS, the survey team conducts the survey via the following procedure based on the network plan organized in section 2.1.



* 1 : Refer to the later chapter in this Clause

(Source: The JICA team)

Figure 3-24: Procedure for UGSS Site Selection

3.10.1 Selection Process Step 1: Initial Candidate Site

The JICA team picks the initial candidate sites for UGSS by discussion with counterparts and the network plan in section 3.2.1. The following procedures are evaluations to select the most suitable site for each company.

3.10.2 Selection Process Step 2: Evaluation Criteria to select the Project Site

In order to evaluate the suitability of UGSS at the initial candidate sites, the survey team establishes some criteria from the financial, technical and environmental points of view. Each criterion has a different evaluation score based on the individual background.

The survey team sets the most important policy as “Necessity” to install UGSS at each candidate site. Considering each company’s situation - that it is necessary to meet the continued increase of power demand - high evaluation should be given to the candidate with viable installation at the necessary timing. Also, contribution to load evacuation during reinforcement of neighboring substations should be taken into consideration.

As a second priority, the survey team sets “Economic evaluation”. Total evaluation including construction cost and financial benefit from superstructure business will be conducted.

As a third priority, “Qualification” should be evaluated. The survey team confirms some obstacles and difficulties at each site in installing an underground substation.

The contents and importance are determined as follows through discussion with the counterparts.

Table 3-21: Selection Criteria for feasible UGSS Project

No.	Evaluation	Selection Criteria for UGSS Project	Points
1	Pre-condition	Site Conditions of Each Site	Pass or Fail
2	Necessity	Contribution to Future Network	20
3	Necessity	Importance and Number of Customers	20
4	Necessity	Available Land Dimensions	20
5	Economics	Preliminary Project Cost	10
6	Economics	Financial Benefit from Business	10
7	Viability	Environmental and Socioeconomic Conditions	10
8	Viability	Distance of Underground Network	10
Total Score			100

(Source: JICA Survey Team)

[No. 1] Pre-condition: Site Conditions of Each Site

A set of pre-requisites, "avoidance of significant negative impacts on environmental and social aspects", is agreed for site selection, i.e., site without large-scale land adjustment and involuntary resettlement shall be selected, no matter which design is adopted. Any site that does not fulfil this pre-condition will be excluded.

[No. 2] Necessity: Contribution to Future network

The difficulty of acquiring new land for substations and the necessity of reinforcement on existing substation land are described in section 3.1. However, tentative reclamation work after load evacuation to other substations is necessary to make the best use of the existing land area. Additionally, interconnection of distribution grids as the method of load evacuation can be applied to neighboring substations. However, there is no suitable substation with sufficient capacity for future load evacuation.

It is necessary to continue the reinforcement of existing substations and new constructions for the current network condition, which has a high load factor at existing substations, and implement future network expansion to meet the continued increase in load demand. Hence, the survey team confirms the contribution to future load evacuation considering the number of neighboring substations and their current load.

[No. 3] Necessity: Importance and Number of customers

The importance and the number of customers to be supplied from the underground substations to be studied, to identify DESCO and DPDC's need for the supply.

[No. 4] Necessity: Degree of Land Utilization based on Available Land and Usage Constraints

Each candidate site is evaluated in terms of its land utilization based on the building code's constraints. Also, the town redevelopment plan for the candidate sites will be investigated to confirm whether the project design is realistic. Possible substation forms will be examined by satisfying the maximum permissive ground coverage ratio, with a lower point to be given if an outdoor conventional substation and/or indoor substation can be constructed.

[No. 5] Economics: Project cost estimation

The cost of an underground substation compared to outdoor and indoor substations is higher, so it is necessary to compare the estimated construction cost for each type. Additionally, for each

proposed site, it is necessary to create the optimal layout and site requirements (the necessary area and building coverage ratio) to confirm the possibility of constructing an indoor or outdoor type.

The construction cost for the substation type for which construction is viable will be evaluated.

[No. 6] Economics: Financial Benefit of Business Models

An underground substation will enable one to utilize a superstructure as commercial real estate and, thus, this type of substation will generate rent revenue as well as additional power sales from enhancement of the power distribution facility. Nevertheless, the expected amounts of power sales and rent revenue differ across the candidate sites and so does profitability. For this reason, it is necessary to assess whether sufficient profit to meet the project cost for an underground substation, which is more expensive than that of an outdoor substation, can be obtained. The IRR method is employed for the analysis of the financial benefits of business models. All candidate sites satisfy the requirement (FIRR (UGSS) >WACC) and, thus, it is difficult to grade candidate sites by using FIRR (UGSS) alone. In addition, the construction of UGSS alone does not utilize the site effectively and it is not considered a primary option for a project owner. Therefore, the evaluation is based on FIRR (Whole) and FIRR (Superstructure),

[No. 7] Viability: Environmental and Socioeconomic Conditions

For the sake of comparison among candidate sites, their salient features from the aspects of environmental pollution, natural environment and social environment (see the following 29 items to evaluate) have been identified through secondary data and information. Some items are found to have nothing to do with this project, and why this is shall be described clearly.

(1) Air Pollution, (2) water Pollution, (3) waste, (4) soil pollution, (5) noise and vibration, (6) ground subsidence, (7) offensive odors, (8) sediment, (9) protected areas, (10) ecosystem, (11) hydrology, (12) topography and geology, (13) land acquisition/resettlement, (14) poverty, (15) ethnic minorities/indigenous people, (16) local economy such as employment, livelihood, etc., (17) local resources and water usage, (18) existing social infrastructure and services, (19) social capital and local institutions such as decision-making organizations, (20) misdistribution of benefits and damages, (21) local conflicts of interest, (22) cultural heritage, (23) landscape, (24) gender, (25) children's rights, (26) infectious diseases, (27) working environment (including occupational safety), (28) accidents, (29) transboundary impacts/climate change

In addition to the qualitative assessment by scoring one of A+/- (significant positive/negative impact is expected), B+/- (positive/negative impact is expected to some extent), C+/- (extent of positive/negative impact is unknown), or D (no impact is expected), the results of comparisons among candidates are reflected in quantitative scores of +3, +2, +1, 0, -1, -2 or -3.

They are the basis for predicting the degree of environmental and social impacts during the project implementation period, and for examining countermeasures to cope with the anticipated impacts.

[No. 8] Adequacy: Underground Transmission Distance from Source Substation

Since underground transmission is hardly affected by external factors such as thunder, it is highly reliable. But the installation cost of underground transmission is higher than that of overhead transmission, and the use of underground transmission is a factor in delaying the day of operation significantly.

Furthermore, if underground transmission suffers an accident, it takes a lot of time to recover. The point where accidents most frequently occur is the joint. So, the greater the number of joints (the longer the underground transmission cable) is, the greater the accident possibilities are.

Therefore, we evaluated on the distance of the underground transmission cable. It is difficult to cross a river when installing an underground cable, so we also evaluated on whether river crossing was necessary.

3.10.3 Selection Process Step 3: Evaluation Results by the Criteria

The survey team picked the best site evaluated by the criteria in section 2.5.2. The below table shows the evaluation results. Gulshan is evaluated as the best site for DESCO, and Kawran Bazar is the best site for DPDC.

Table 3-22: Evaluation Summary by the Criteria

DESCO				
No.	Evaluation Criteria	Gulshan	Uttara	Baridhara
1	Site Conditions of Each Site	Pass	Pass	Pass
2	Contribution to Future Network	14	7	10
3	Importance and Number of Supplied Customers	20	10	15
4	Available Land Dimensions	20	20	20
5	Preliminary Project Cost	10	9	9
6	Financial Benefit from Business	10	5	5
7	Environmental and Socioeconomic Conditions	10	5	0
8	Distance of Underground Network	7	2	2
	Total	**91**	**58**	**61**

DPDC				
No.	Evaluation Criteria	Dhaka Univ	Kawran Bazar	Lalmatia
1	Site Conditions of Each Site	Pass	Pass	Pass
2	Contribution to Future Network	9	20	17
3	Importance and Number of Supplied Customers	18	19	18
4	Available Land Dimensions	20	20	20
5	Preliminary Project Cost	10	9	9
6	Financial Benefit from Business	5	10	5
7	Environmental and Socioeconomic Conditions	5	10	0
8	Distance of Underground Network	8	10	8
	Total	**75**	**98**	**77**

(Source: The survey team)

The following explains the survey team's evaluation of each criterion.

[No. 1] Pre-condition: Site Conditions of Each Site

All candidate sites except Dhaka University are owned by the project proponents, i.e., DPDC or DESCO, or Power Division. If replacing the existing buildings and substation facilities within the given boundary, additional land acquisition will not be required. The Gulshan site, with Power Division's authority, is used and managed by DESCO, DPDC and PGCB for their own complexes, and no problems will occur if they continue using the site. Staff quarters will be demolished and removed from the Kawran Bazar and Lalmatia sites, and DPDC will arrange alternative government quarters for those whose family members currently live there to move to. Dhaka University site, which is presently vacant, is owned by Dhaka University. DPDC has already obtained verbal consent from them to transfer the ownership to DPDC if the project is implemented there. Land transfer between public organizations will be documented according to the government procedures, which will not cause any disputes when acquiring the land.

As for the possibility of land modification, an underground substation will require excavation as deep as 20m within the present site boundary. All candidate sites have already been reclaimed and no further land development will be required.

Table 3-23: Land Conditions of Potential Sites

Note: Large-scale involuntary resettlement is over 200 people. Land modification refers to processes such as landfill, land reclamation, etc.

	Gulshan	Uttara	Baridhara	Dhaka University	Karwanbazar	Lalmatia
Current Owner	Power Division	DESCO	DESCO	Dhaka University	DPDC	DPDC
Current Use of Land	DESCO (office building and substation facilities) DPDC (office building) PGCB (substation facilities)	office building substation facilities storehouse customer relations center	office building and substation facilities	vacant land	substation facilities and staff residential quarters	substation facilities and staff residential quarters
Land Area	2,700m2	2,700m2	2,300m2	1,700m2	2,800m2	1,800m2
Necessity of New / Additional Land Acquisition for the Project	Not required	Not required	Not required	Ownership transfer required	Not required	Not required
	Managed by Power Division and no restriction in use	-	-	Ownership transfer between government organizations through document procedure does not expect any difficulty.	DPDC will arrange alternative quarters and they will resettle voluntarily.	DPDC will arrange alternative quarters and they will resettle voluntarily.
Large-scale Involuntary Resettlement caused by the Project	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated
Possibility of Land Modification and its Scale	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.	Excavation up to 20m in depth may occur within the given land area which has been already reclaimed.
Large-scale Land Modification caused by the Project	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated	Not anticipated
Result	Pass	Pass	Pass	Pass	Pass	Pass

(Source: JICA Survey Team)

In conclusion, large-scale land modification or involuntary resettlement due to additional land acquisition is not anticipated at any candidate site. All of them are thus qualified for this site selection process.

[No. 2] Necessity: Contribution to Future network

The below table shows each candidate site and its neighboring substations with maximum load factor in 2015.

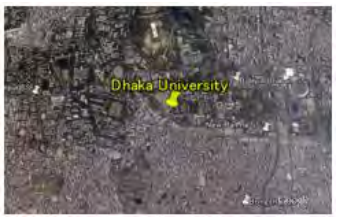
Table 3-24: Each Candidate and its neighboring substations with maximum load in DESCO

	Gulshan	Uttara	Baridhara
Location Map			
SS Max Load on 2015	Gulshan-1 SS : 85.4%	Uttara SS : 61.5%	Baridhara SS : 64.3%
Neighbor SS & Max Load on 2015	(1) Gulshan-2 SS : 94.6% (2) Banani SS : 83.3% (3) Niketon SS : 49.6% (4) Aftab Nagar SS : 34.7%	(1) Uttara Grid SS : 55.0% (2) CAAB SS : 42.1% (3) Dashkinkhan SS : 71.4%	(1) Gulshan-2 SS : 94.6% (2) Joar Sahara SS : 84.3%
Up-coming & On-going Projects	(1) Gulshan-3 (2) Mohakhali	(1) ADA (2) Dakshin Kahn	(1) Banani-2 (2) United Twin Tower
Evaluation	14	7	10

(Source: JICA Survey Team)

On the DESCO side, the existing substation in the Gulshan site has high loads over N-1 consideration, and there are two neighboring substations with high loads, which are Banani and Gulshan-2 substations. The Uttara site has lower loads compared to the Gulshan site. Also, the current load in Baridhara is lower than Gulshan's existing substation, and there are two surrounding substations for Baridhara, which is fewer than the number surrounding Gulshan. Hence, the survey team concluded that the Gulshan site is the project site for UGSS on the DESCO side because Gulshan has the most severe condition.

Table 3-25: Each Candidate and its neighboring substations with maximum load in DPDC

	Dhaka University	Kawranbazar	Lalmatia
Location Map			
SS Max Load on 2015	- : -	Kawranbazar SS : 88.9%	Lalmatia SS : 85.7%
Neighbor SS & Max Load on 2015	(1) New Ramna SS : 92.0 % (2) Azimpur SS : 72.1 % (3) Bongshal SS : 107.1 %	(1) Green road SS : 82.4 % (2) Mogbazar T&T SS : 54.7 % (3) Tejgaon SS : 94.3 % (4) Lalmatia SS : 85.7 % (5) Kakrail SS : 83.7 %	(1) Kawranbazar SS : 88.9 % (2) Jigatola SS : 81.3 % (3) Shatmosjid : 86.2 %
Up-coming & On-going Projects	(1) DMC (2) BUET (3) Biddut Bhaban SS	(1) Green Road Domitory (2) Monipuripara	(1) Asadgate SS (2) Basila-1
Evaluation	9	20	17

(Source: JICA Survey Team)

On the DPDC side, the existing substation at Kawran Bazar has a high load, and there are four neighboring substations with high loads. The Dhaka University site doesn't have an existing substation and Biddut Bhaban substation, which is a neighbor of the Dhaka University site, has affordable capacity to receive load evacuation from neighboring substations, though the Dhaka University site has three neighboring substations with high loads. As for the Lalmatia site, there is the existing substation and three substations with high level loads. However, it doesn't have a less severe condition because of Asadgate substation, with enough available capacity, compared to the Kawran Bazar site. Hence, the survey team concluded that the Kawran Bazar site is the project site for UGSS on the DPDC side

Score: Conditions
Eight points: The existing substation has high load over N-1 consideration
Four points: The existing substation has loads less than N-1 consideration
[Additional points]
Three points: Neighboring substation with high loads per one substation

[No. 3] Necessity: Importance and Number of customers to be Supplied

The following table shows load density and load types, and projection for the six candidate sites. Also, the supply areas for the new substation in the candidate sites are summarized in the following maps.

Table 3-26: Load density and its future forecast

Area	Typical Demand Category	Current Moment			Future Projection (2020)			
		Maximum Demand (MW)	Supply Area (km2)	Demand Density (KW / km2)	Maximum Demand (MW)	Supply Area (km2)	Demand Density (KW / km2)	Growth Ratio of Demand Density
Gulshan	Commercial Buildings (over 10 stories) (under 10 stories)	71.7	1.20	59,750	120.00	1.20	100,000	1.14
Uttara	Residential houses Factories	42.5	3.57	11,905	78.00	3.57	21,849	1.16
Baridhara	Residential houses Factories	48.0	3.33	14,414	85.00	3.33	25,526	1.15
Dhaka Univ	Commercial Building Residential houses Factories	15.0	2.19	6,849	38.00	2.2	17,352	1.26
Kawran Bazar	Commercial Buildings (over 10 stories) (under 10 stories)	40.0	2.08	19,231	103.00	2.1	49,519	1.27
Lalmatia	Residential houses	38.0	1.83	20,765	80.94	1.8	44,230	1.21

Source: JICA Survey Team

The annual demand growth of the candidate sites are expected to be approximately more than 14%, which is higher than country's average based on projected economic growth. Thus shortage of supply capacity in the current network is anticipated, which justifies the construction of new substations and distribution network facilities. Gulshan and Kawranbazar project expects higher demand density growth rate among both companies' candidate sites, and the amount of projected demands are more than 100MW. Thus, higher priorities are to be assigned to these two candidates.

Also, since Gulshan and Kawranbazar supply large commercial and residential buildings where economic activities are strong and stable, a reliable distribution network must be constructed to minimize supply interruption frequency and duration in the event of facility trouble. From this standpoint, the new substation must be constructed in the center of the growing demands to

minimize the total length of the supply network, instead of employing a long network over congested areas. Also, distribution interconnection must be provided to achieve a reliable network.

[No. 4] Necessity: Degree of Land Utilization based on Available Land and Usage Constraints

The survey team identified any regulations, including Dhaka Metropolitan City Planning, Town Improvement Act, and Dhaka Metropolitan City Building Rules, which define plot usage for Dhaka city where two distribution companies supply electricity. However, the building code stipulates that the plot owner must satisfy the maximum ground coverage ratio and Floor area ratio building constraints, as summarized in the table in section 2.6.1.

The survey team confirmed the feasibility of an underground substation at all the DESCO candidate sites. An outdoor substation cannot be constructed at these candidate sites due to the shortage of available area. An indoor substation can be constructed in Gulshan and Baridhara assuming no superstructure can be utilized for other business purposes, which requires additional facilities. Thus, DESCO can build an underground substation when it is justified, if financial and other factors are reasonable when comparing the features of an indoor substation.

Among DPDC's candidate sites, neither an indoor nor an outdoor form substation can be constructed due to the limited available plot area, but an underground substation can be built.

Based on the evaluations above, all candidate sites can be used for underground form. An indoor-form substation, which has economic features, cannot be built in most of the substation sites, except at Dhaka University. Thus, 20 points are added to all candidate sites.

[No. 5] Financial: Preliminary Project Cost Evaluation

In all of the candidate sites from DESCO and DPDC, the areas are not suitable for constructing an outdoor substation; therefore, in order to construct an outdoor substation, the sites need to be changed. Furthermore, in the case of an indoor substation, although the building coverage ratio is under 50%, none other than the standard layout of the Baridhara site (DESCO) is suitable. So, at each candidate site, only an underground substation is possible for construction. Cost evaluation relies on the comparison of underground substations. Each candidate site has a slight difference in the underground construction area, so it is difficult to know if this can affect the cost. However, when comparing gas insulated transformer (GIT) to oil insulated transformer (OIT), the equipment cost will be double, so the evaluation cost is based on the average of GIT and OIT.

Comparing the cost of an underground substation, there is almost no difference between the proposed sites, so the best site capable of reducing cost is the most suitable one (10 points), and other costs will reduce it to 9 points.

Points: Conditions
9 points: Proposed sites other than 10 points
10 points: The largest cost reduction proposed site

[No. 6] Economics: Financial Benefit of Business Models

The scores (Zero, Five, or Ten points) are based on FIRR (whole), FIRR (superstructure) and WACC. Zero points means that the project is financially unacceptable and the leasing business utilizing the superstructure does not contribute to the profitability of the project. Five points suggests that the project is financially acceptable but the leasing business utilizing the superstructure does not contribute to the profitability of the project. Ten points means that the project is financially acceptable and that the leasing business utilizing the superstructure contributes to the profitability of the project. The analysis results suggest that Gulshan is the most desirable among DESCO's candidate sites and that Kawran Bazar is the most desirable among DPDC's candidate sites. Both sites receive 10 points. Uttara, Baridhara, Lalmatia, and Dhaka University receive five points. No site falls under zero points.

Score: Conditions
Zero points: WACC > FIRR (whole) and WACC > FIRR (superstructure)
Five points: FIRR (whole) > WACC and WACC > FIRR (superstructure)
Ten points: FIRR (whole) > WACC and FIRR (superstructure) > WACC

[No. 7] Viability: Environmental and Socioeconomic Conditions

Based on the environmental and social baseline survey results in which secondary information and data were collected and a quick site survey was conducted, a comparison among candidate sites on the environmental items (from (1) to (29)) was performed as described above. The following two tables show a comparison of anticipated impacts during the construction and operation periods for the DESCO and DPDC sites respectively.

As a result of principal component analysis among the three candidates, as well as zero-option, Gulshan is the first choice in terms of impacts during both the construction period and operation period. Total evaluation for both periods has ranked Gulshan, Uttara and Baridhara from top to bottom among DESCO candidate sites.

Table 3-27: Comparison of Anticipated Environmental and Social Impacts (DESCO Sites)

<table>
<tr><th colspan="4">Before/During Construction</th></tr>
<tr><th></th><th>Gulshan</th><th>Uttara</th><th>Baridhara</th></tr>
<tr><td>Common Features ("No impact" or "No difference")</td><td colspan="3">Ambient air, water, soil, offensive odors, ecosystem, infectious diseases, and working environment are anticipated to have negative impacts, with which there is no difference among the three sites.
There are no impacts anticipated on sediment, hydrology, topography & geology, water use, social capital and local organizations' decision-making, local conflict of interest, cultural heritage, landscape, gender, children's rights, or transboundary issues & climate change.
Poor settlements and minorities have not been confirmed in the surrounding areas of three sites.
The existing substation facilities will be replaced within the present site, which will cause no change in land use or resettlement.</td></tr>
<tr><td rowspan="2">Influence on the surrounding area</td><td>Waste, noise and vibration is anticipated from construction work, of which impacts are felt relatively moderately as the surrounding area of the site is a commercial area where current pollution level is already high enough. There is no severe disturbance to local people as none lives there.</td><td colspan="2">Waste, noise and vibration anticipated from construction work will impact people living nearby as the surrounding area of the site is mainly residential, and they may complain if no appropriate countermeasures are taken. (Current noise level measured in the baseline survey was lower than Gulshan site).</td></tr>
<tr><td>The traffic volume in the surrounding area is currently very heavy. Transportation of construction materials and workers, temporary restriction of access and road blocking will increase traffic volume; traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness may occur.</td><td colspan="2">Transportation of construction materials and workers, temporary restriction of access and road blocking will increase traffic volume; traffic accidents on and out of the construction site, fire, falling or electrocution, work accidents and sickness may occur. It will affect local activities and lives of local people residing in the surrounding area.</td></tr>
<tr><td rowspan="2">Land Condition</td><td>The soil condition is good according to the findings in the boring test. Construction work will not impact the ground stratum.</td><td>There is a chance that construction work impacts the ground stratum.</td><td>There is a more severe chance that construction work impacts the ground stratum.</td></tr>
<tr><td>The total length of underground cable is expected to be the shortest among all DESCO</td><td colspan="2">The total length of underground cable is expected to become longer than the Gulshan one. Temporary restriction of access and traffic blocking will thus be on a wider scale and impact more on the</td></tr>
</table>

	potential sites, which will minimize the degree of impact on the surrounding area.	surrounding area due to the installation of underground cable.	
	Underground cable will be installed across and along the Gulshan Lake, which is already polluted and designated as an Environmental Critical Area (ECA), and special attention shall be paid. On the other hand, the site has no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests.	There are no protected areas, historic or cultural heritage sites, tourist areas, or any natural forests on the site or in the surrounding area.	
Evaluation	Best Option	Second Best Option	Third Option
During Operation			
	Gulshan	Uttara	Baridhara
Common Features ("No impact" or "No difference")	Ambient air, water, soil, ground subsidence, offensive odors, sediment, protected areas, ecosystem, hydrology, topography & geology, land acquisition/resettlement, poverty, minorities, land use and local resource utilization, water use, misdistribution of damages and benefits, local conflicts of interest, cultural heritage, landscape, gender, children's rights, infectious diseases and transboundary impacts/climate change have no impact anticipated. Although negative impacts are anticipated from waste, and accidents, they are within manageable levels and no difference will be seen among the three sites.		
Positive influence on the surrounding area	Noise and vibration is expected to be less than present level as new facilities are more environmentally advanced.		
	-	It will benefit people living in the surrounding residential area.	
Benefits to the local area	It is expected as an indirect positive impact that the local economy will benefit from a more stable power supply. The project will positively impact social capital, local decision-making bodies and other social institutions via better power supply. Social infrastructure and services could be improved by the improvement of power supply.		
	Number of people benefitting from this project is more in Gulshan area than in the other two sites. Most of those in Gulshan work there.	-	
Comparison with "Zero Option"	The following negative impacts are anticipated if the project is not implemented to avoid or mitigate them: ・ Deterioration and aging of the existing facilities (for instance, the existing drainage pipe and its system will become deteriorated, and offensive odors and soil contamination will occur due to the leakage) ・ Increase in time and frequency of load shedding and power failures due to insufficient power supply, quality deterioration of social infrastructure and services, losses of business opportunities, negative impacts on household livelihoods, increase in environmental loads, occupational accidents, fire, electrical accidents, and O&M cost.		
Evaluation	Best Option	Second Option	Second Option
TOTAL	BEST OPTION	SECOND OPTION	THIRD OPTION

Note: Ranking is the result of principal component analysis among the three candidates as well as zero-option.

(Source: JICA Survey Team)

As per DPDC candidate sites, Dhaka University is the best choice in terms of the degree of impacts during the construction period; Kawran Bazar and Lalmatia are the first pick during the operation period although further study is necessary to identify the degree of social impact at Kawran Bazar. Total evaluation for both periods has ranked Kawran Bazar, Dhaka University, and Lalmatia from top to bottom.

Table 3-28: Comparison of Anticipated Environmental and Social Impacts (DPDC Sites)

Before/During Construction			
	Dhaka University	Kawran Bazar	Lalmatia
Common Features ("No impact" or "No difference")	Although there are negative impacts anticipated to some extent regarding ambient air, water, soil, ground subsidence, and infectious diseases, no difference will be seen among the three sites. No impacts are anticipated on ground subsidence, sediment, protected areas, hydrology, topography & geology, social capital and local organizations' decision-making, cultural heritage, gender, children's rights or transboundary impacts/climate change. Poor settlements and minorities have not been confirmed in the surrounding areas of the three sites.		
Influence on the surrounding area	Construction waste and general waste from workers is anticipated. There will be less construction waste as there are no existing facilities to demolish.	Construction waste and general waste from workers is anticipated. There are existing facilities to demolish, which will produce debris, metal and wood waste and others.	
	Noise and vibration is anticipated from work vehicles and construction machinery. There will be, however, less social impact as it is located on a university campus area and nobody lives nearby.	Noise and vibration is anticipated from work vehicles and construction machinery. There will be, however, less social impact as it is located in a commercial area and nobody lives nearby.	Noise and vibration is anticipated from work vehicles and construction machinery. There will be more social impact anticipated as it is located in a residential area.
	General waste from workers could produce offensive odors. There will be, however, less social impact as it is located on a university campus area and nobody lives nearby.	General waste from workers could produce offensive odors. There may impact on people working nearby as it is located in a commercial area and numerous people work there.	General waste from workers could produce offensive odors. There will be more social impact as it is located in a residential area and people live nearby.
Land Condition	No land acquisition or involuntary resettlement is anticipated.		
	It is Dhaka University who owns the site area, and land use right should be transferred from Dhaka University to DPDC. It is vacant land within Dhaka University campus to be utilized for new substation facilities. Land use will change from university campus to substation.	The area around the site is a well-developed commercial area, and no change in its land use is anticipated as the project replaces the existing substation with a new one in the given land area. However, local people's access to their working places and employment may be affected as expansion of the road in front of the substation is anticipated and requisition of the road will occur accordingly, where they run shops. Their income may decline; they may be forced to close their shops temporarily. Further study is required to identify the degree of social impact and who will be affected.	The site is located in the residential area, and there may be local people who claim damages caused by noise and vibration due to the construction work. However, it is not anticipated to cause impacts on their livelihoods and other activities. The existing substation facilities will be replaced within the present site, which will cause no involuntary resettlement. No change in land use.
	Temporary restriction of access to the surrounding area and traffic blocking may be necessary due to the installation of underground cable. The total length of underground cable is expected to become longer than the Kawran Bazar one.	The total length of underground cable is expected to be the shortest among all DPDC potential sites, which will minimize the degree of impact on the surrounding area.	The total length of underground cable is expected to become longer than the Kawran Bazar one. Temporary restriction of access and traffic blocking will thus be on a wider scale and impact more on the surrounding area due to the installation of underground cable.
Evaluation	Best Option	Second Best Option	Third Option
During Operation			

	Dhaka University	Kawran Bazar	Lalmatia
Common Features ("No impact" or "No difference")	Ambient air, water, waste, soil, ground subsidence, offensive odors, sediment, protected area, ecosystem, hydrology, topography & geology, land acquisition/resettlement, poverty, minorities, land use and local resource utilization, water use, misdistribution of damages and benefits, local conflict of interest, cultural heritage, gender, children's rights, infectious diseases, accidents and transboundary impacts/climate change have no impact anticipated. Although accidents may occur to some extent, no difference will be seen among the three sites.		
Positive influence on the surrounding area	-	Noise and vibration is expected to be less than present level as new facilities are more environmentally advanced, which will benefit people living in the surrounding residential area.	
	It is expected as an indirect positive impact that the local economy will be benefit from a more stable power supply. The project will positively impact social capital, local decision-making bodies and other social institutions via better power supply. Social infrastructure and services could be improved by the improvement of power supply.		
	-	Number of people benefitting from this project is greater.	
Comparison with "Zero Option"	The following negative impacts are anticipated if the project is not implemented to avoid or mitigate them: Deterioration and aging of the existing facilities (for instance, the existing drainage pipe and its system will become deteriorated, and offensive odors and soil contamination will occur due to the leakage) Increase in time and frequency of load shedding and power failures due to insufficient power supply, quality deterioration of social infrastructure and services, losses of business opportunities, negative impacts on household livelihoods, increase in environmental loads, occupational accidents, fire, electrical accidents, and O&M cost.		
Evaluation	Second best option	Best option (further study required)	Best option
TOTAL	**SECOND BEST OPTION**	**BEST OPTION** (further study required)	**THIRD OPTION**

Note: Ranking is the result of principal component analysis among the three candidates as well as zero-option.
(Source: JICA Survey Team)

In conclusion, from an environmental and social perspective, Gulshan and Kawran Bazar are the best places to implement the project in the DESCO coverage area and DPDC circle area respectively.

[No. 8] Adequacy: Underground Transmission Distance from Source Substation

"Underground Transmission Distance" counts for 6 points and "Crossing River" counts for 4 points.

Underground transmission distances for Uttara and Baridhara are longer than those for the other candidates. Thus, the installation cost becomes high and the possibility of an accident increases. The routes of Uttara and Baridhara cross rivers. These candidates need to consider measures such as installing the cables along a bridge.

Table 3-29: Evaluation of Underground Transmission Distance

	Gulshan	Uttara	Baridhara	Dhaka University	Karwanbazar	Lalmatia
①Underground Transmission Distance	4	2	2	4	6	4
②Crossing River	3	0	0	4	4	4
Evaluation Results	**7**	**2**	**2**	**8**	**10**	**8**

(Source : JICA Survey Team)

3.11 Selection Process Step 4: Site Investigation of the Highest-Prioritized Sites

This section discusses the project framework for the two selected projects, Gulshan and Kawran Bazar, and proposes some important studies for the subsequent detailed project design study.

Gulshan and Kawran Bazar UGSS projects have been selected for subsequent project feasibility study out of the six candidate sites (Uttara, Baridhara, Gulshan, Kawran Bazar, Lalmatia, and Dhaka University) nominated in the 1st mission, because of the urgent need for new 132kV substations with larger supply capacity in the Dhaka distribution network, limited area for UGSS candidate sites, and the UGSS superstructure's business model study, which confirms that Gulshan and Kawran Bazar are the most promising among the six candidate sites in terms of profitability. Both Gulshan and Kawran Bazar UGSS projects utilize Gas Insulated Transformers for improved fire safety, fewer constraints in transformer cooling component, and better supply reliability.

Since the project sites have been selected, preliminary consultation with RAJUK for clarification of the building design, town planning for the two nearby sites, and regulatory advice will help significantly in terms of creating the most realistic and effective UGSS project development.

3.11.1 **Gulshan Project's Framework**

Gulshan project's design will include the area currently used for PGCB's existing 132kV substation and DPDC's building, which is located in the south part of the overall plot, in order to utilize Power Division's plot for the three companies concerned by securing a space for PGCB's 230kV underground substation underneath the building complex.

The survey team proposes the sequence for the entire project, which consists of three major phases: 132kV DESCO UGSS, 230kV PGCB UGSS, and Superstructure(s) shared by utilities as decided by Power Division. Then, the survey team conducts a project feasibility study for DESCO's 132kV UGSS. JICA may be requested to perform the detailed feasibility study for the 230kV UGSS if PGCB confirms that the project schedule meets its network expansion planning, and the necessity for such a technical feasibility study.

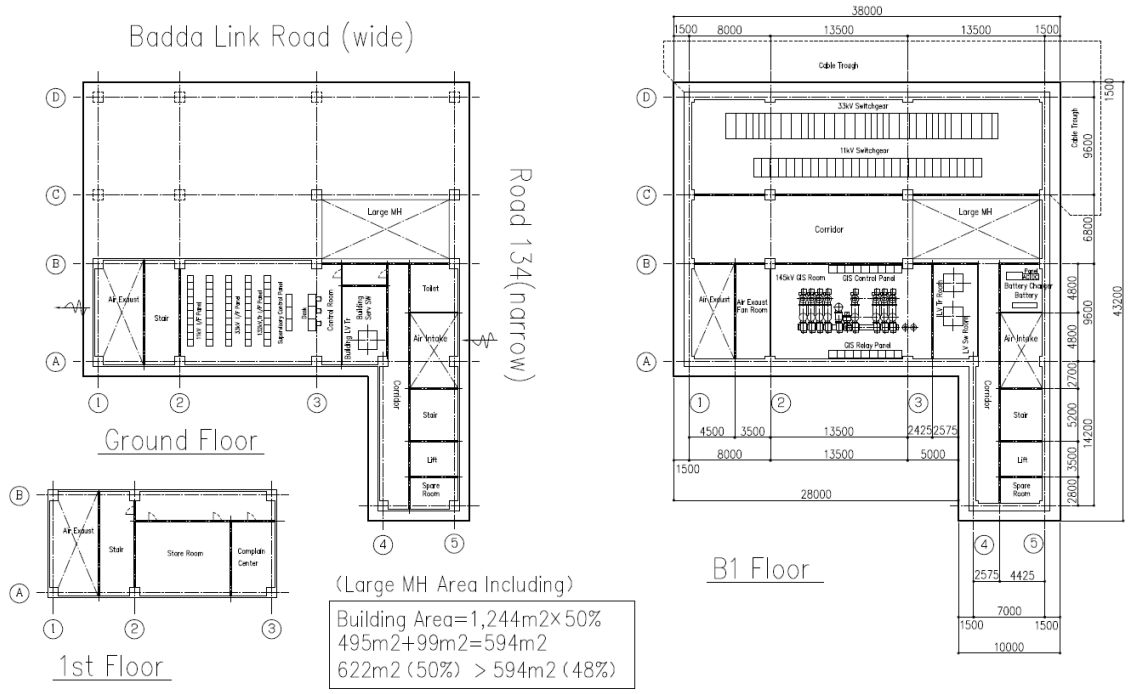


Figure 3-25: Preliminary Layout Design for Gulshan 132/33/11kV Underground Substation

(Step 1. 132kV UGSS building) (Step 2. Demolition) (Step 3. 230kV UGSS & Superst.)

Figure 3-26: Overall Project Plan and Steps to Full utilization of Gulshan Site

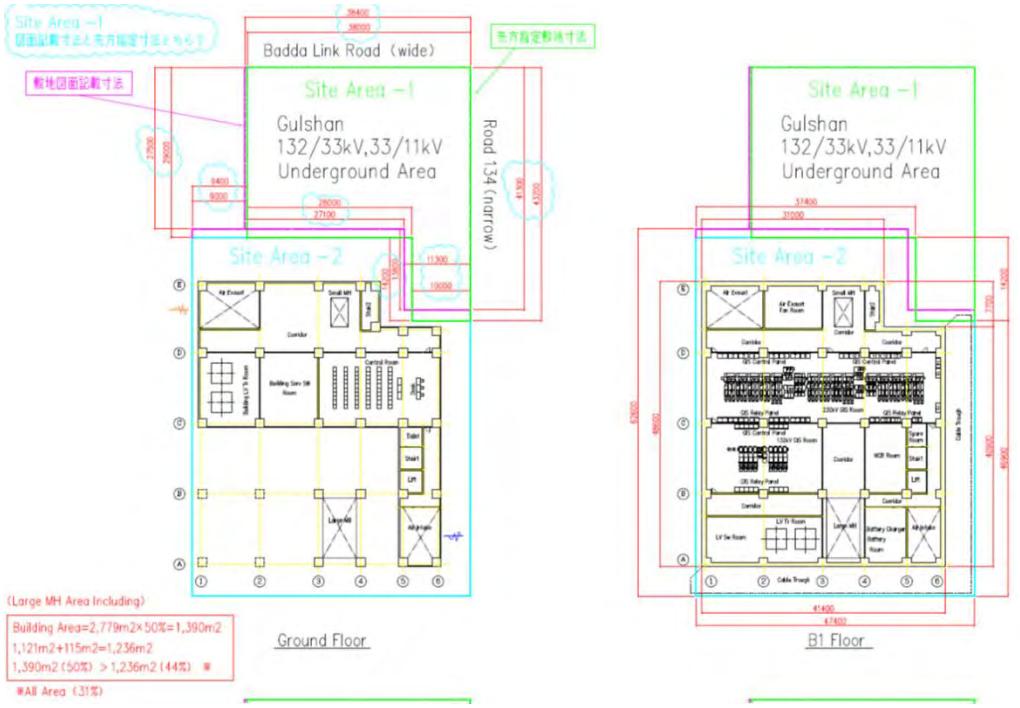


Figure 3-27: Preliminary Study for 230kV Gulshan UGSS for Future FS Project

According to the digital survey results given by DESCO in the third discussion, actual area of the DESCO's office portion is smaller than it is given in the METI's pre-feasibility study, and the shape of the site is not a proper recutangular. Thus, by considering RAJUK's building setback regulation, which requires 3 meter from site boundary to other plot and 1.5 meter from road, the Consultant concluded that the available land area in the current DESCO's office portion can not cater for six transformer units on single UGSS floor.

In order to utilize available plot for Gulshan project for underground substations, the following UGSS construction options were proposed by the Consultant, and DESCO is now making decision on the project design, and arranging necessary concensus among stakeholders.

(Plan A) Installing UGSS on the DESCO's office portion, by installing transformers in multiple floors and installing its control room and switchgears on the above-ground portion to minimize the excavation depth as of Dec. 7th.

(Plan B) Based on the mutual agreement among Power Division, PGCB,DPDC and DESCO, DESCO's 132kV underground substation will be constructed on current DPDC's project office building portion first, then the remaining plot to be utilized for PGCB's 230kV UGSS if required, and superstructure will be constructed on the whole plot .

Figure 3-28: The result of detailed digital survey of the Gulshan plot

The Consultant considers Plan A as the last resort of UGSS construction on the DESCO's office's portion because the design does not satisfy DESCO's request for full underground substation, and complicated design co-ordination of the superstructure portion for sharing functions for UGSS and Offices is necessary during actual project implementation. In addition, DESCO is also looking Plan B as more preferable solution. Since the construction cost between Plan A and B is quite marginal, and Plan B yields higher cost, the Consultant selected Plan B as the most feasible design for further budget and environmental studies in this report.

3.11.2 **Kawran Bazar Project's Framework**

The Kawran Bazar site has a narrow road (approx. 5.5m) on only one side, which constrains distribution lines' routes, equipment transportation during its installation, and the maximum floor area for the superstructure. Thus, an underground cable tunnel facility must be constructed underneath the road to install an increased number of distribution lines, and distribution networking must be well studied to utilize the new substation's capacity. The forthcoming project feasibility study will seek a way to increase the total floor area in order to improve the project's financial stability with DPDC. Power Division and DPDC will seek the possibility to include BPDB's land on the west side of Kawran Bazar's perimeter in the plot for the substation, and the Survey team will conduct the project feasibility study based on the expanded plot area. The survey team reports the revised FIRRs (with/without BPDB's land & wide/narrow road) by 22nd September. The availability of the BPDB land should be confirmed to the JICA Survey team by 15th October to proceed with the detailed layout design for the project. If this is not confirmed by the aforementioned date, the survey team proceeds with the project design using a layout without BPDB's land.

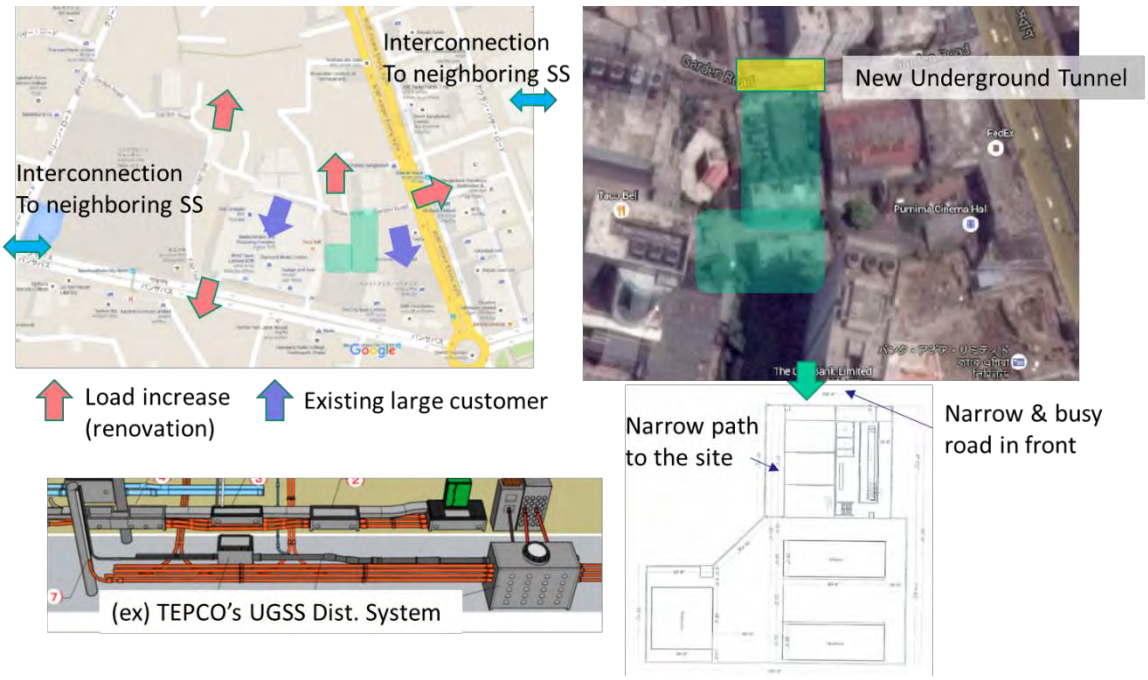


Figure 3-29: Geographical Conditions for Kawran Bazar UGSS Substation

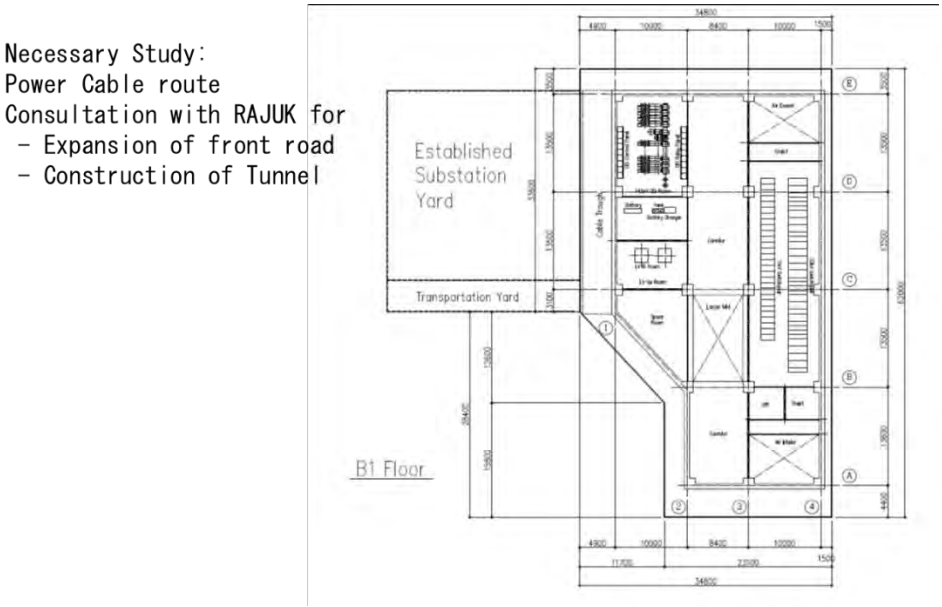


Figure 3-30: Preliminary Layout Design for Kawran Bazar 132/33/11kV Underground Substation

Since Kawran Bazar Project was not studied in the METI's pre-feasibility study, the Consultant reviewed the project design by refering DPDC's equipment specifications and Gulshan project's design. According to the digital survey result of Kawran Bazar site, the borders of the plot are not crossing perpendicular nor parallel, which results in somewhat skewed plot shape. Also, RAJUK building code requires 3m setback on three plot borders, and the area is a bit bigger than the preliminary site dimensions given by DPDC in the first meeting. Also, the setback between building in the Kawran Bazar plot and BPDB's residences is set 4 meter, which requires 2 meter from the border to the building, the inclusion of BPDB's plot will reduce the area for setbacks , and thus enable DPDC to utilize entire project plot with complete building design.

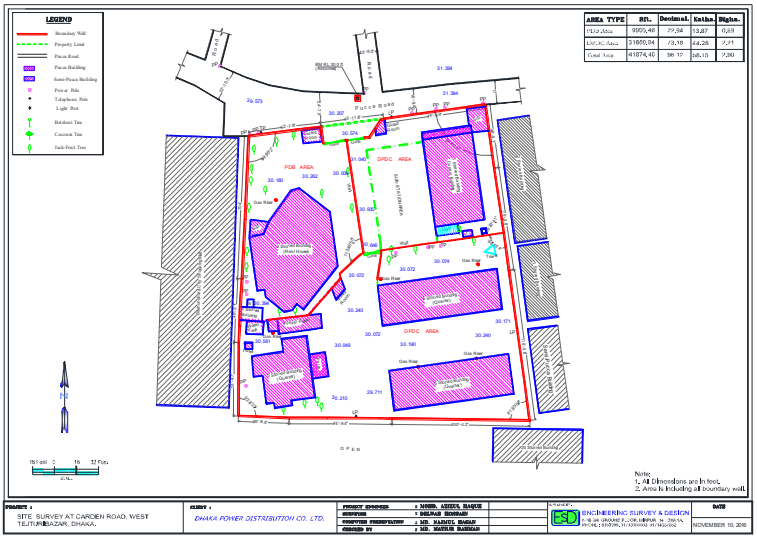


Figure 3-31:The result of detailed digital survey of the Kawran Bazar plot

The necessary setbacks are 1.5m from road and 3m from borders as RAJUK's Building Code specifies, however, 6m setback from roadside is necessary to maximize the volume of superstructures as a result of DPDC's preliminary consultation to RAJUK. Even with these setback requirements, six transformers can be installed on single floor in current DPDC's plot without BPDB's residential area. However, a part of BPDB's site must be secured for UGSS's lifetime for the sake of installation, emergency repair or extension of large piece of equipment in UGSS, and consequently, special agreement between BPDB and DPDC is necessary and the entire plot may not be utilized.

Thus, the Consultant studied two cases with/without BPDB's site, and proposes to include current BPDB's residential apartment plot for larger scale re-development, and secure necessary floors to replace BPDB's residential function in the newly constructed superstructures. This decision will be made by DPDB with the consultation and agreements with stakeholders.

Figure 3-32:Plan A: Kawran Bazar UGSS plan without BPDB's residence plot (1)

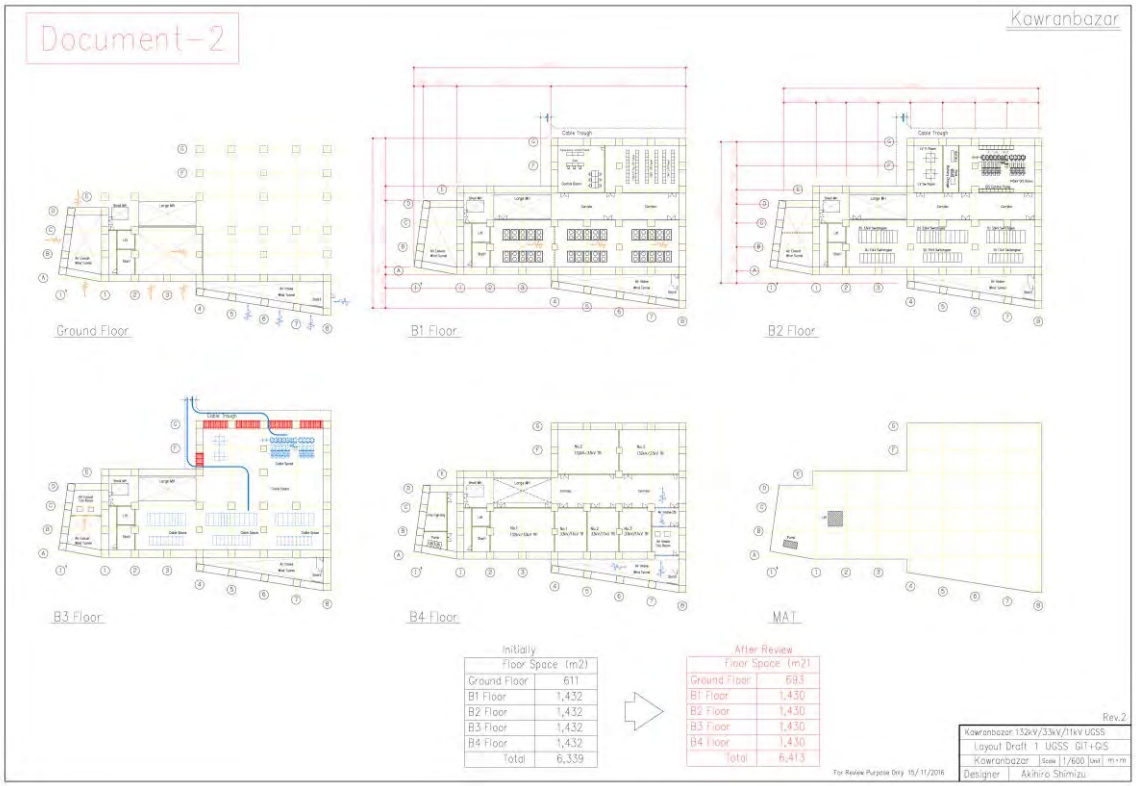


Figure 3-33:Plan A: Kawran Bazar UGSS plan without BPDB's residence plot (2)

To assess an acceptable option for an underground substation (UGSS) in Kawran Bazar in terms of financial return, the Survey team conducted a preliminary study with different UGSS site options and road width conditions. It should be noted that key assumptions such as cost estimation and financing plan are still preliminary and they may change in the course of the JICA survey on UGSS in Dhaka.

Four cases are defined with two variables: Road Expansion and Site Area. If the width of the road is expanded to more than 12m, floor area ratio is increased from 3.8 to 9.5. Both variables affect the size of rentable area and financial return. A-2 (Road expansion and without BPDB's area) is the same case as Kawran Bazar in the Chapter 3.9. The cases to be assessed are the following:

A-1: No road expansion and without BPDB's area
A-2: Road expansion and without BPDB's area
B-1: No road expansion and with BPDB's area
B-2: Road expansion and with BPDB's area

1. Assumptions

(1) Common Assumptions

The following assumptions are applied to all cases.

Table 3-30: Common Assumptions

	Assumption
Maximum Receiving Capacity	240MVA
Power Demand	70.19 MW (2021), 10% p.a.
Power Factor	0.80
Load Factor	0.57
Distribution/Transmission Loss	9.41%
Unit Price of Power Purchase	5.56 BDT/kWh
Unit Price of Power Sales	6.90 BDT/kWh
Rentable Ratio	75%
Rent	BDT 804.8/m^2
O&M Cost (UGSS)	1% of construction p.a.
Service Cost (superstructure)	2,910 BDT/m^2 p.a.
Major Repairs (superstructure)	3% of construction/20 years
Project Life	50 years after construction
Exchange Rate	JPY 105.85/USD BDT 78.41/USD

(2) Financial Benefit

The size of control center and parking space affects rentable area. On the control center, A-1 and A-2 are considered benchmarks for B-1 and B-2, respectively. The assumption marginally increases rentable areas for B-1 (534 m^2) and B-2 (445 m^2).

On the parking space, an unused part of the site area is fully utilized for A-1 and B-1, where the height of the superstructure is highly constrained by the building code. A-1 does not require parking space within its superstructure and B-1 needs to have a small space for parking (128 m^2). For A-2 and B-2, 2 floors (2,790 m^2 for A-2 and 3,680 m^2 for B-2) of the superstructure are used as parking space and excluded from the total space of building.

(3) Financial Cost

The capital expenditure for UGSS is the same across all cases but that for superstructure varies along with size of superstructure. The construction cost for the superstructure is assumed at JPY 88,000/m^2 (approximately BDT 6,000/s.q.f.). Capital expenditure for each case is shown in the following table.

Table 3-31: Capital Expenditure for Four Cases at Kawran Bazar

A-1	A-2	B-1	B2
USD 65.7 mil.	USD 77.8 mil.	USD 68.7 mil.	USD 82.9 mil.

(4) Hurdle Rate

For financing mix, an ODA loan covers the total for civil engineering, underground portions of construction cost and consulting services, and equipment. The executing agencies finance the rest of the project cost with equity contribution. The cost of an ODA loan (5%) is based on the interest payment of on-lending from the Bangladesh government to the executing agencies. The cost of equity can be considered an expected return on investment for the executing agencies. Since a UGSS and a superstructure have different expected returns (15% for UGSS and 20% for superstructure) a weighted average of equity costs was calculated on a pro-rata basis with the costs of both components.

2. Results

In order to clearly show the profitability of the superstructure, this analysis calculated FIRR for the whole project, the superstructure, and the underground substation, separately. NPV is calculated for reference purposes. In all cases, FIRR (whole) surpassed WACC and, therefore, all cases are financially viable. FIRR (whole) varies marginally across all cases because a major part of the financial benefits comes from the UGSS. FIRR (superstructure) is also higher than WACC in all cases and this suggested that office leasing is feasible at Kawran Bazar. FIRR (superstructure) for A-1 is lower than those for A-2 and B-1. Both road expansion and size of site area notably affect efficiency of investment because of the larger rentable area; DPDC therefore may seek possibilities for both road expansion and the usage of BPDB's site to improve the project's finances. It should be noted that WACC also increased along with the floor area of the superstructure. This is mainly due to the assumption that the superstructure is financed with DPDC's equity. The cost of equity is higher than that of debt and, therefore, a larger superstructure space increases the amount of equity contributed by DPDC. It is highly recommended to reduce the amount of DPDC's equity, borrowing from the Bangladesh government, in the case of large-scale redevelopment such as B-2.

Table 3-32: FIRR and NPV for Four Cases at Kawran Bazar

	A-1	A-2	B-1	B-2
Superstructure Floor Area (m^2)	4,185	18,135	7,523	23,920
Rentable Area (m^2)	1,883	10,463	4,290	14,134
Rent (2016, BDT/m^2)	804.8	804.8	804.8	804.8
FIRR (Whole, %)	8.66%	8.64%	8.70%	8.65%
FIRR (Superstructure, %)	6.56%	8.14%	8.03%	8.29%
FIRR (UGSS, %)	8.77%	8.77%	8.77%	8.77%
NPV (Whole, US mil.)	40.19	33.71	39.43	31.03
NPV (Superstructure, US mil.)	0.88	5.77	3.14	6.89
NPV (UGSS, US mil.)	39.32	27.95	36.29	24.14
WACC (%)	5.19%	5.89%	5.36%	6.17%

Chapter 4 **Technical Considerations for UGSS Project**

4.1 Future Network for Underground Substation Operation

New Gulshan SS and Kawran Bazar SS will have three 132 kV / 120 MVA transformers. Each SS will distribute 240 MVA as its maximum transmission capacity considering N-1 criteria. Available capacity per 132 kV underground line is assumed as 170 MVA because the surrounding conditions and buried method are mostly the same as METI's Pre-Feasibility study conditions. Hence, in order to secure 240 MVA, the necessary capacity for underground SS operation, each SS will be able to get 340 MVA, which is the capacity from two 132 kV lines, via three 132 kV underground lines under N-1 criteria.

It is a rule that the specific source SS is determined through discussion with PGCB, as shown in Clause 2.3. New Gulshan SS will receive three 132 kV lines from 230/132 kV Rampura SS; also, three lines will be installed from 230/132 kV Dhanmondi SS to new Kawran Bazar SS as per the below figure. According to the discussion with DESCO/DPDC, two 132 kV lines from Rampura SS and three 132 kV lines from Dhanmondi would be the target for the project. The other 132 kV line from Rampura SS will prepared by DESCO in the coming years.

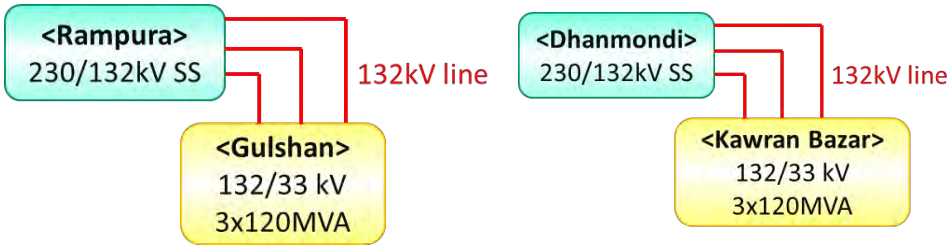


Figure 4-1 Future Network as of operation start

In the case that one 132 kV line is dropped under the above network, power supply can continue without any outage. However, this scheme is not reliable because all source lines depend on one source SS. There is some possibility of two or more source lines dropping if a fault occurs at a busbar on the source SS. As confirmed in Clause 3.5, the new underground SSs are so important for the future network that higher reliability is preferable. Therefore, both SSs will aim to improve their networks as per the below figure, which is interconnected with another 33 kV SS with another 132 kV source line.

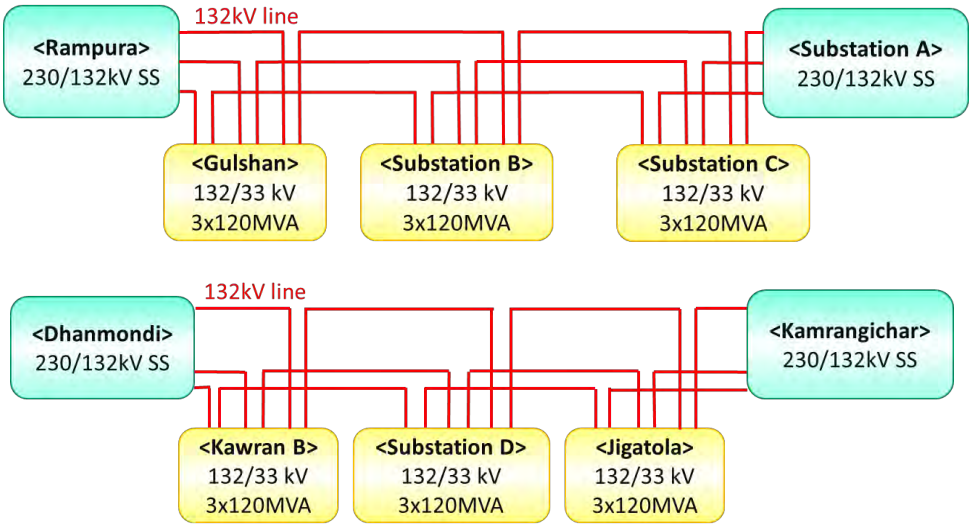


Figure 4-2 Future Network recommended by the JICA Team

The project scopes are shown as follows.

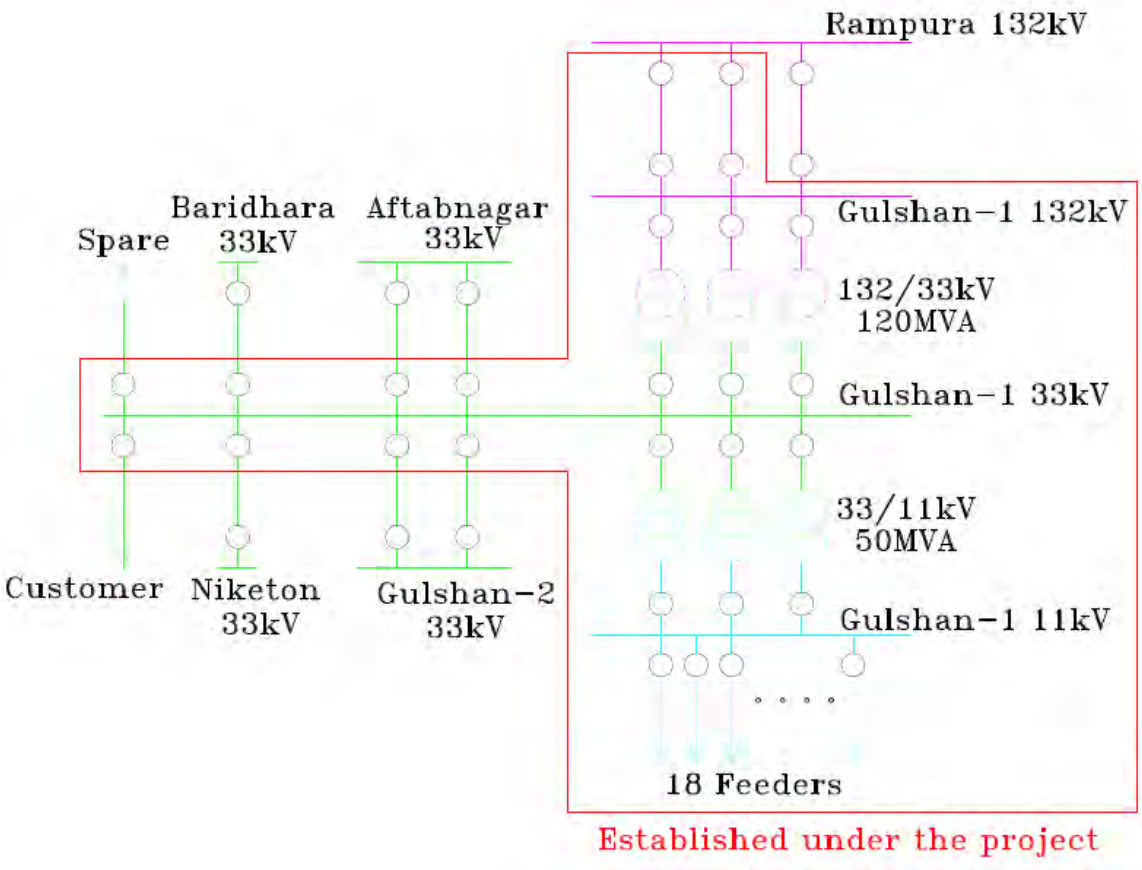


Figure 4-3 The Project Scope for New Gulshan SS

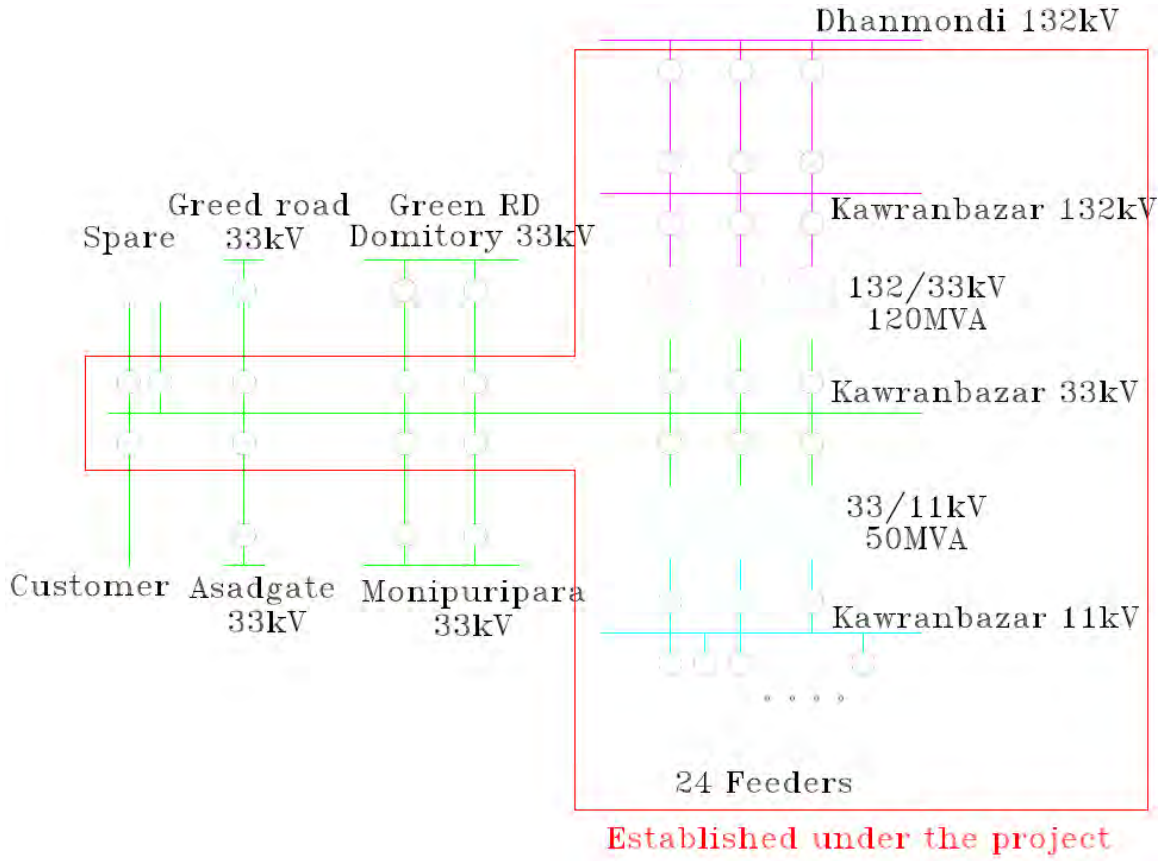


Figure 4-4 The Project Scope for New Kawran Bazar SS

4.2 Contribution of the Project in the Target Area

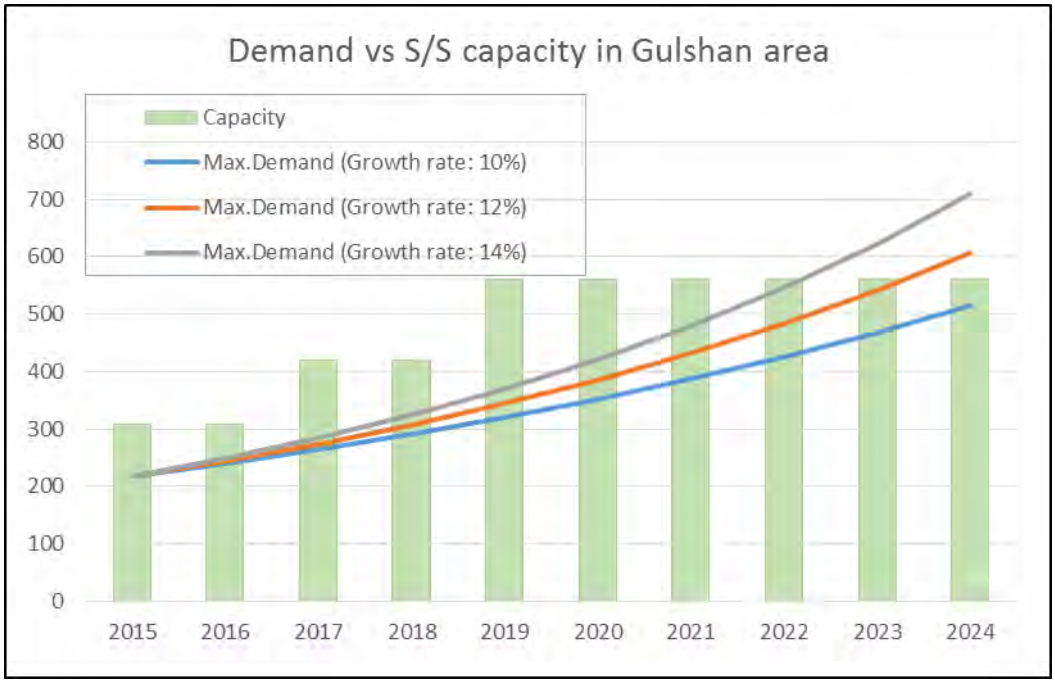
The previous clause described two things, one being the ineffectiveness of a long distribution line. The other is that interconnection of two substations requires them to be next to each other. This means that some substations with sufficient capacity should be at the center of, or near to, the power demand in order to efficiently distribute the power to the center of the demand area.

Hence, the JICA survey team refers to the effectiveness of installing a UGSS in the center of the power demand from the viewpoint of the balance between power demand and substation capacity in the target area.

Specifically, future power demand in the target area is calculated by multiplying the increase rate based on the master plan of both companies by the actual records of power demand in 2015. In addition, the total amount of substation capacity in the target area is estimated by accumulating the additional capacity of substations in the development plan. As for the increase rate based on the master plan of both companies, the JICA survey team simulates three cases: 12% as the base case, 10% as the ease case, and 14% as the severe case.

4.2.1 Demand and Capacity in Gulshan area

The figure below shows the balance of demand and capacity in the Gulshan area.



(Source: JICA Survey team)

Figure 4-5 Demand and Capacity in Gulshan area

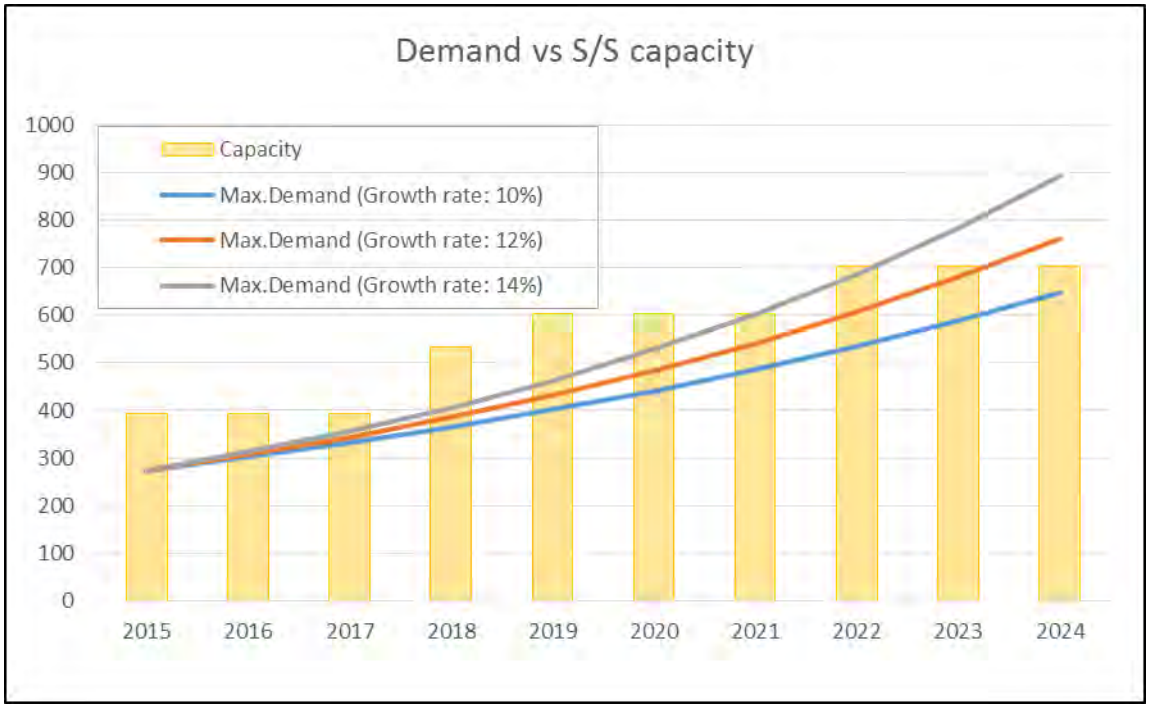
The above figure shows that there is a possibility of maximum demand exceeding total capacity in 2024 in the base case, in 2023 in the severe case, and in 2025 in the ease case. This means power demand may not be satisfied without new substations or additional capacity.

There are no more plans to install substations to interconnect to Gulshan SS in their development plan. This means DESCO cannot accumulate additional capacity after 2024 according to the current development plan. Hence, the coming UGSS, in 2023, is expected not only to increase substation capacity but also to be a load haven for the replacement or renovation of surrounding substations.

Additionally, considering N-1 criteria as the target for stable power supply, it is preferable that maximum power demand is less than total capacity with some margin from 50% to 66%. However, it should be noted that all cases cannot meet this.

4.2.2 Demand and Capacity in Kawran Bazar area

The below figure shows the balance of demand and capacity in the Kawran Bazar area.



(Source: JICA Survey team)

Figure 4-6 Demand and Capacity in Kawran Bazar area

As is the case for DESCO, the above figure shows that maximum demand may exceed total capacity in the Kawran Bazar area in or around 2023.

As factors to be noted in the above, there is a possibility of decreased maximum demand and increased substation capacities. Hence, DESCO/DPDC may not face a shortage of substation capacity in or around 2023.

[Factors that would increase substation capacity]

- ✓ Installing an additional transformer in the existing substations if available space is prepared. However, the expected capacity to be added may be less than 100 MVA as a maximum.
- ✓ Installing a new substation in the area. However, it is obviously quite difficult to secure substation land in the target area.

[Factors that would decrease maximum demand]

- ✓ Some possibility of the expected demand being below their Master Plan.
- ✓ Installing a new interconnection between the target area and another area. However, the expected capacity would be 50 MVA as a maximum.
- ✓ Actual maximum demand is expected to be less than the expected Diversity factor of peak demand at each customer.

It is understandable for DESCO/DPDC to continue to be bothered by the shortage of substation capacity in the case of there being no additional capacity via new construction. The UGSS in the project will start to operate in 2023. Its timing is last-minute in order to receive loads transferred from other substations because the load of surrounding substations will exceed the acceptable load via the UGSS after 2023. Additionally, UGSS will be the leading choice for DESCO/DPDC, who are suffering from land scarcity in addition to their obligations to secure stable power distribution in the Dhaka area.

4.3 Electric Design of Underground Substations

The consultant studied the detailed design of the underground substations based on the digital surveys reported by DPDC and DESCO, and pillar sizes and locations in the building structure design to hold the superstructure while verifying METI's pre-feasibility design.

This detailed design for underground substations is based on the Japanese building code with some modifications to reflect Bangladesh's building conditions, such as the seismic forces anticipated, and assuming that a 13 story superstructure with Japanese design will be constructed above the underground building. Since usage of the Japanese building code imposes stricter design restrictions on pillar design, the superstructure's structure and additional costs for building reinforcement, the underground substation building design must be reviewed to co-ordinate the substation's operational design, maximum superstructure floors, and superstructure building design in order to conform to Bangladesh's Building Code during the actual building design and construction after the design of the superstructure has been finalized.

The detailed design assumes no pillar transposition between superstructure and underground building, and most of the pillars, including the perimeters' pillars, must be shared for maximum building structure strength. To maximize the available space in the underground portion while maintaining the necessary supporting structure for both underground portion and superstructure, an SRC (Steel and Reinforced Concrete) structure is partially used in the underground substation portion. This assumption is to ensure the technical feasibility of the detailed design during the feasibility stages, though a design review must be done when the usage and preliminary design of

the superstructure are determined at the actual project implementation stage, and design approvals from relevant authorities must be obtained. Thus, the Consultant concluded that technical support for the building design co-ordination will be necessary during the project implementation stages, which will be discussed in the subsequent sections.

4.4 Detailed Design for Gulshan Underground Substation

As discussed in the previous section, the digital survey of the site revealed the reduced area of the DESCO office building space and skewed shape of the plot, thus the usage of DPDC's office building space will be technically reasonable. The following detailed design for the substations assumes the usage of DPDC's office building, and design considerations are discussed as follows.

Equipment Layout:

Since the transformers are the heaviest parts among substation equipment, the bottom floor is designed to support three (3) units of 132/33kV transformers and three (3) units of 33/11kV transformers, and is also provided with the necessary transportation spaces and air ventilation spaces. Major substation components, including control room, switch gears and C-GISs, are installed in the underground portion as DESCO requested. This detailed substation design results in a depth of 27m for the underground building. Further cost-reduction and operational condition improvements may be possible by installing a control room and switchgears, which can be discussed along with superstructure design during the project implementation. The width of the outer walls and dimension of pillars are set to 1.5m. The machine hatch is designed to enable equipment transportation inside the underground substation, and it is located on the east side of the plot. A multi-floor layout is employed to minimize the underground footprint, and B4 floor is designed for three units of 132kV/33kV transformers and three units of 33/11kV transformers. B3 is for the transformers' cooling system, B2 is for cable laying spaces, and B1 is for GIS, C-GIS, control panels, and the Control Room. The ground floor is usually utilized for public and business usage for the superstructure, such as building entrances, and yields the highest economic value for businesses. Thus, the minimum number of underground substation parts, such as machine hatch, substation entrance, and ventilation ports, will be exposed and the remaining portion will be utilized for other purposes. The required height for the ground floor substation parts is approximately 10 meters.

Figure 4-7 Ground floor layout of Gulshan Underground Substation (Plan B)

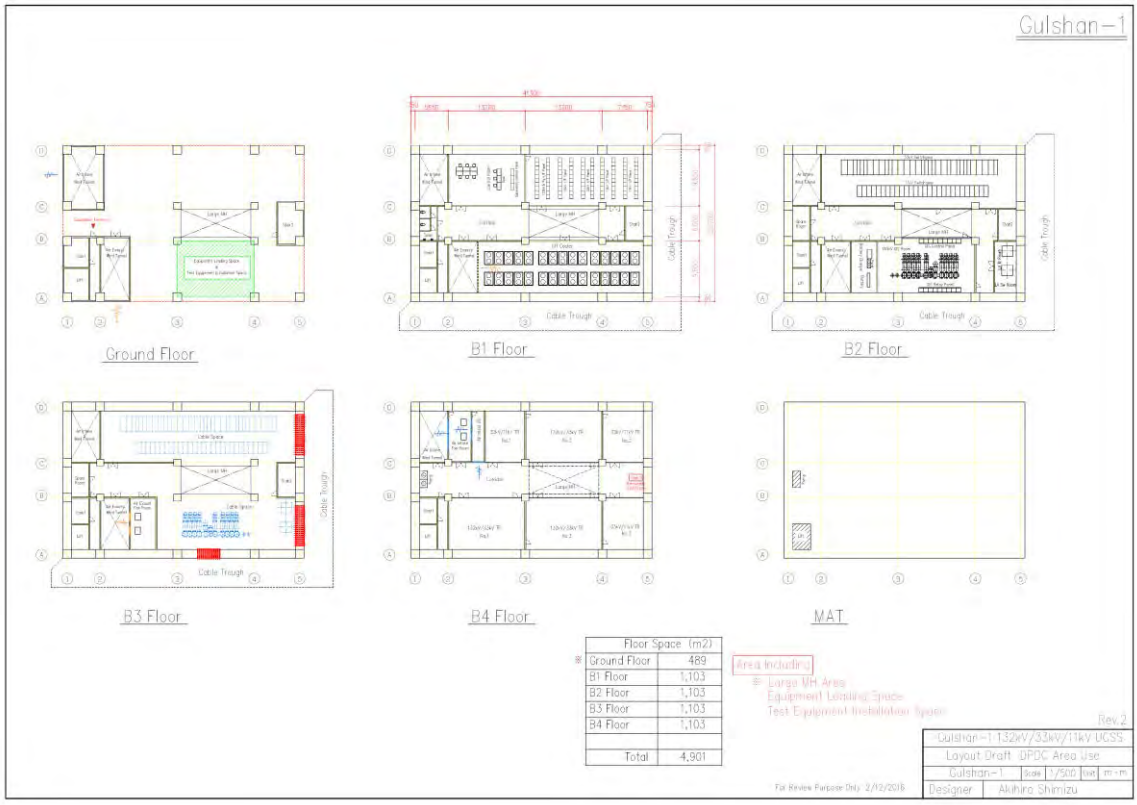


Figure 4-8 Ground floor layout of Kawran Bazar Underground Substation (Plan B)

4.5 Detailed Design for Kawran Bazar Underground Substation

Similar to the Gulshan project, the Consultant studied the detailed design for Kawran Bazar for technical feasibility verification and further budget evaluation. The digital survey of the site shows a sufficient area for the current substation and company building space for installing six transformers on a single underground floor. However, due to the necessity of a transportation route for large equipment and the setback requirement for borders, the usage of BPDB's guest house spaces is highly advisable for the underground substation's operability and the superstructure's commercial value by facing a wider area to the road, so the Consultant has studied two cases (with/without BPDP's plot). The following detailed design for the substations assumes the usage of BPDB's guest house building, and design considerations are discussed as follows.

Since the transformers are the heaviest parts among substation equipment, the bottom floor is designed to support three (3) units of 132/33kV transformers and three (3) units of 33/11kV transformers, and it is also provided with the necessary transportation spaces and air ventilation spaces. Major substation components, including control room, switch gears and C-GISs, are installed on a single floor of the underground portion as DPDC requested. For better operator working conditions and the shortest evacuation route, the control room is located on B1 floor. Further cost-reduction and operational condition improvements may be possible by installing a

control room and switchgears, which can be discussed along with superstructure design during the project implementation. Considering power cable routing, the switchgears are installed on the north-side of the floor. Another floor is provided for cable connection and installation among equipment and other substations. This full underground substation design results in a four-basement underground floor design with 27m building depth. The width of the outer walls and dimension of pillars are set to 1.5m. The machine hatch is designed to enable equipment transportation inside the underground substation, and it is located on the north side of the plot. The location of the machine hatch requires a transportation route to the road through BPDB's plot, thus the planned transportation route on the current BPDB guest house portion must be secured entirely by coordinating the superstructure design at the project implementation stage.

A multi-floor layout is employed to minimize the underground footprint, and B4 floor is designed for three units of 132kV/33kV transformers and three units of 33/11kV transformers. B3 is for the transformers' cooling system, B2 is for cable laying spaces, and B1 is for GIS, C-GIS, control panels, and the Control Room. The ground floor is usually utilized for public and business usage for the superstructure, such as building entrances, and yields the highest economic value for businesses. Thus, the minimum number of underground substation parts, such as machine hatch, substation entrance, and ventilation ports, will be exposed and the remaining portion will be utilized for other purposes. The required height for the ground floor substation parts is approximately 10 meters.

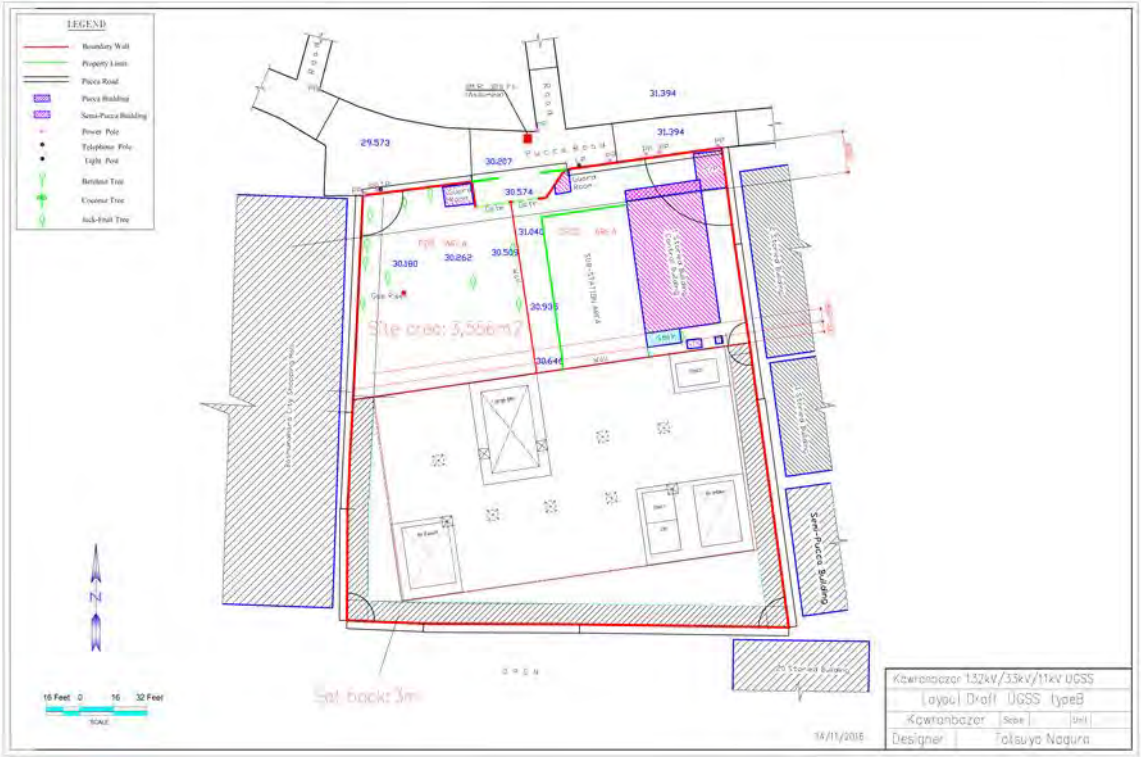
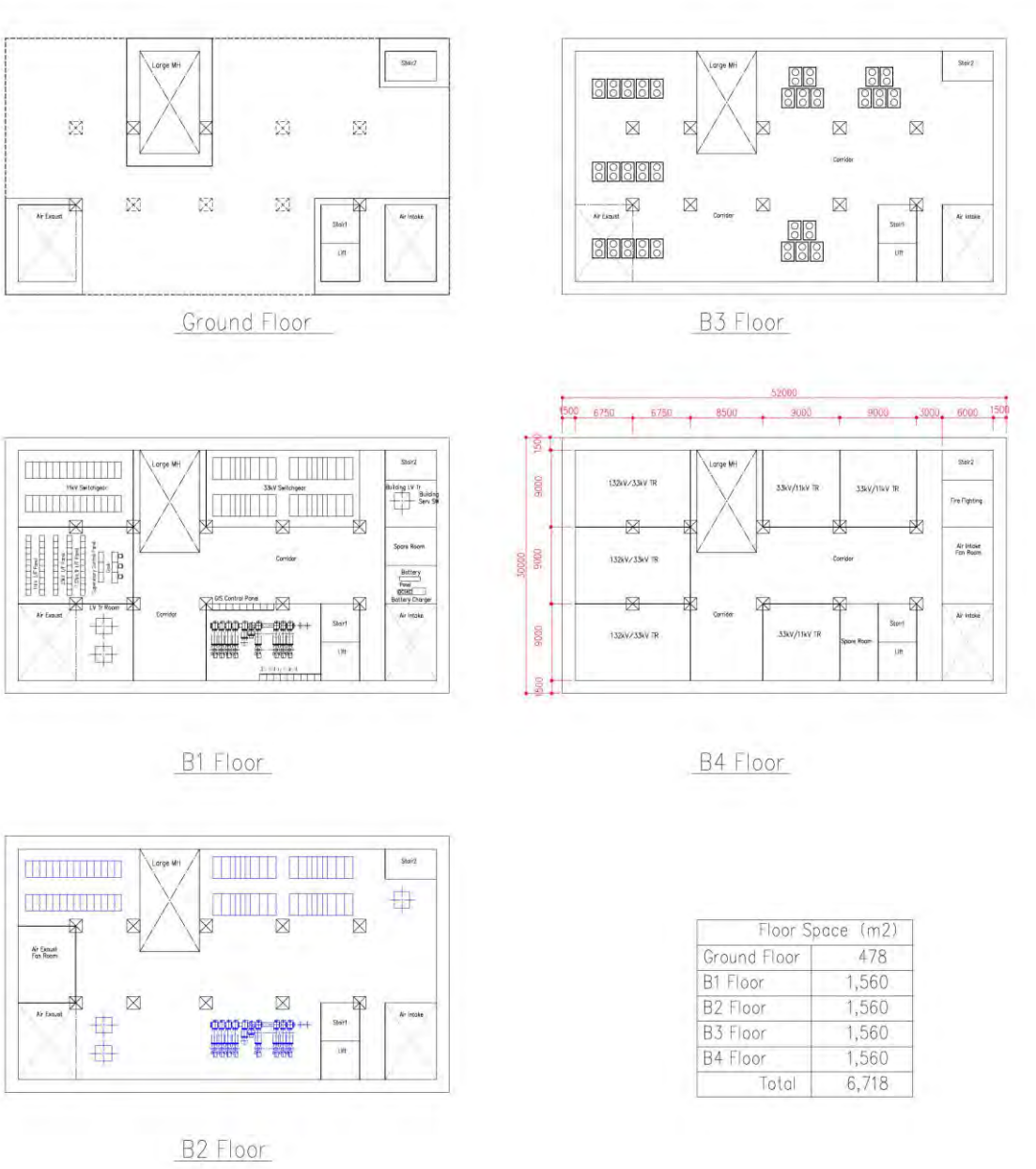


Figure 4-9 Ground floor layout of Kawran Bazar Underground Substation (Plan B)



Floor Space (m2)	
Ground Floor	478
B1 Floor	1,560
B2 Floor	1,560
B3 Floor	1,560
B4 Floor	1,560
Total	6,718

Figure 4-10 Floor layout of Kawran Bazar Underground Substation (Plan B)

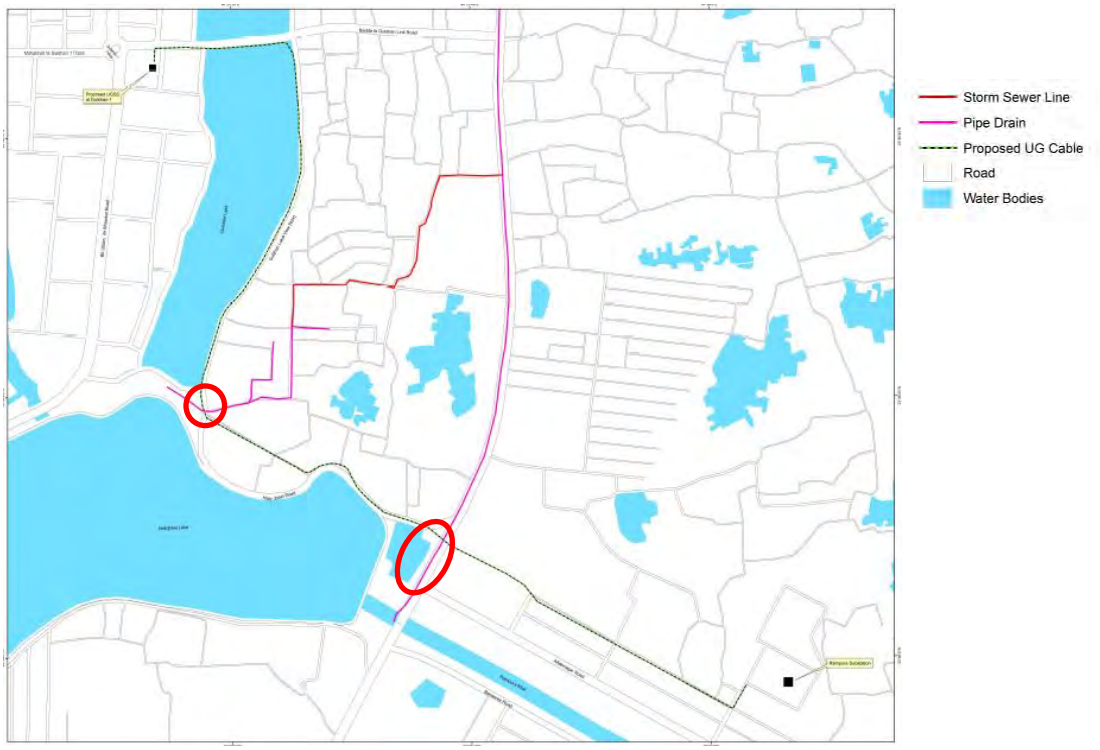
4.6 T&D Facility Design

4.6.1 Underground Transmission Line Route

As the JICA survey team considered the underground transmission line route in Chapter 3, below we consider whether other buried infrastructure influences the proposed underground transmission line.

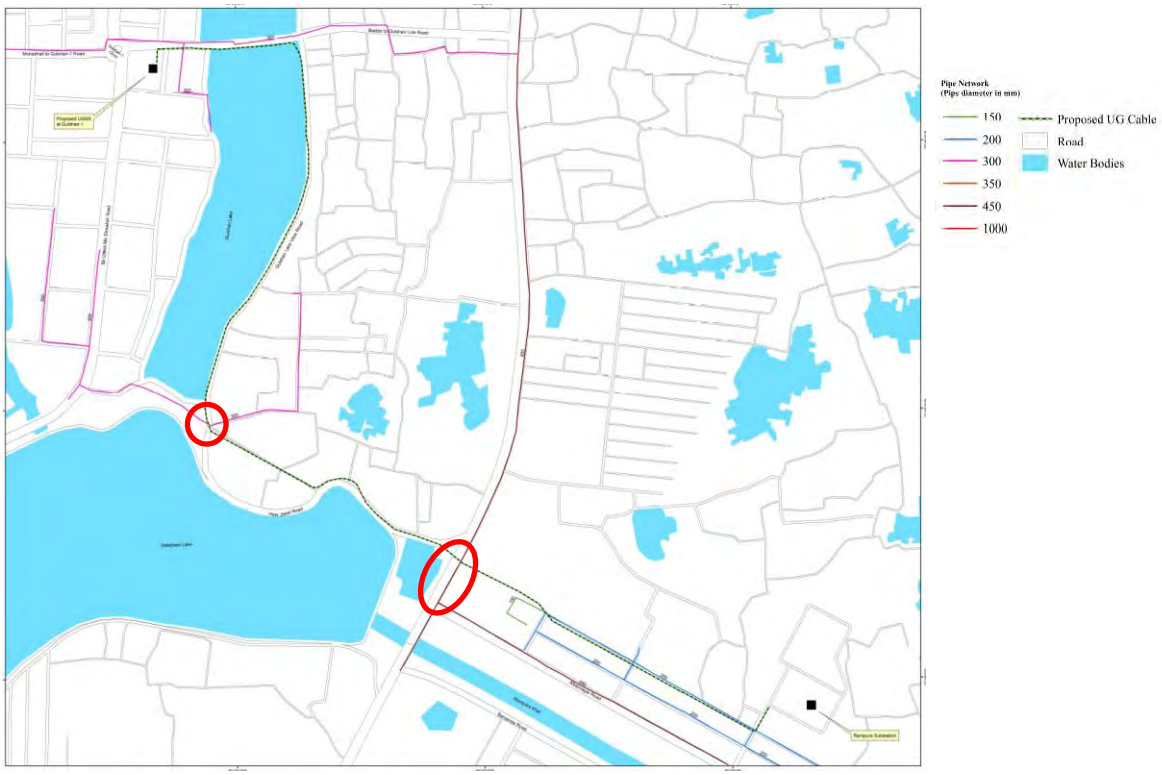
4.6.1.1 Underground Transmission Line Route (Gulshan SS – Rampura SS)

The following figures show the drainage pipe and water pipe network between Gulshan SS and Rampura SS.



Source: CEGIS, JICA Survey Team

Figure 4-11 Drainage pipe network between Gulshan SS and Rampura SS



Source: CEGIS, JICA Survey Team

Figure 4-12 Water pipe network between Gulshan SS and Rampura SS

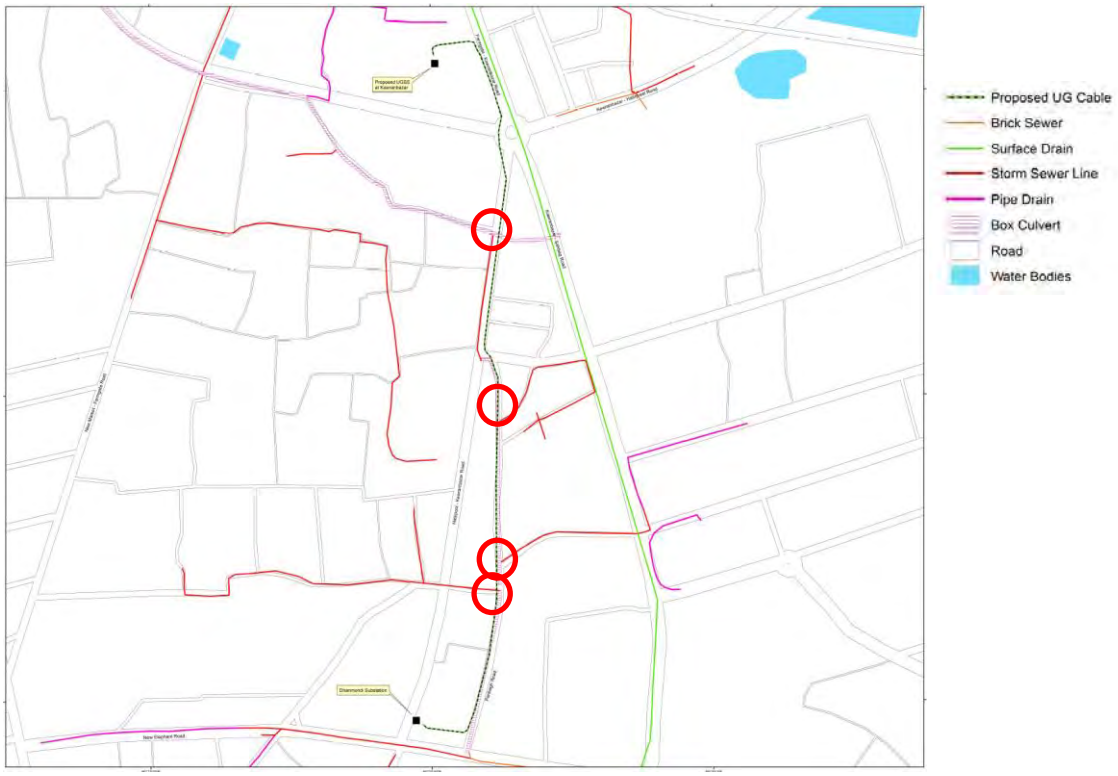
The red circles drawn in the above figure show the places that underground transmission cable will cross drainage pipes and water pipes. It is necessary to discuss this with WASA in advance. It is also necessary to excavate and confirm the exact position of buried pipes at these crossing places. The JICA survey team found that a water pipe was buried on the road crossing Gulshan Lake. An existing 132kV cable was also buried in this road. Thus, it is necessary to excavate and confirm whether there is space for installing cables. If there is no space to install cables, the constructor needs to take measures such as attaching cables to the side of the road.

4.6.1.2 **Underground Transmission Line Route (Kawaran Bazar SS - Dhanmondi SS)**

As underground transmission line route from Kawaran Bazar SS - Dhanmondi SS was shown in Chapter 3. This route was changed through discussion with DPDC in order to avoid heavy traffic on Sonargaon Road. The following figure shows the reconsidered route between Kawaran Bazar SS and Dhanmondi SS (Orange line: old route, Blue line: new route).

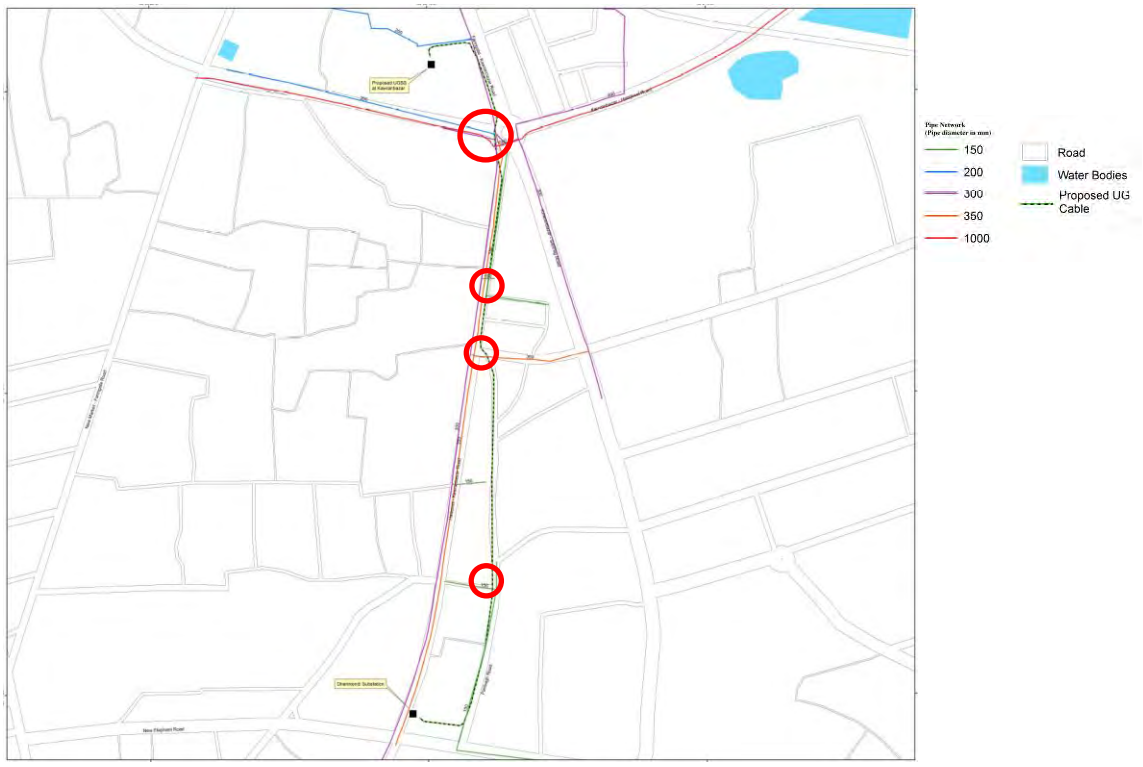
Source: JICA Survey Team

Figure 4-13 Cable Route between Kawran Bazar SS and Dhanmondi SS (Reconsideration)



Source: CEGIS, JICA Survey Team

Figure 4-14 Drainage pipe network between Kawran Bazar SS and Dhanmondi SS



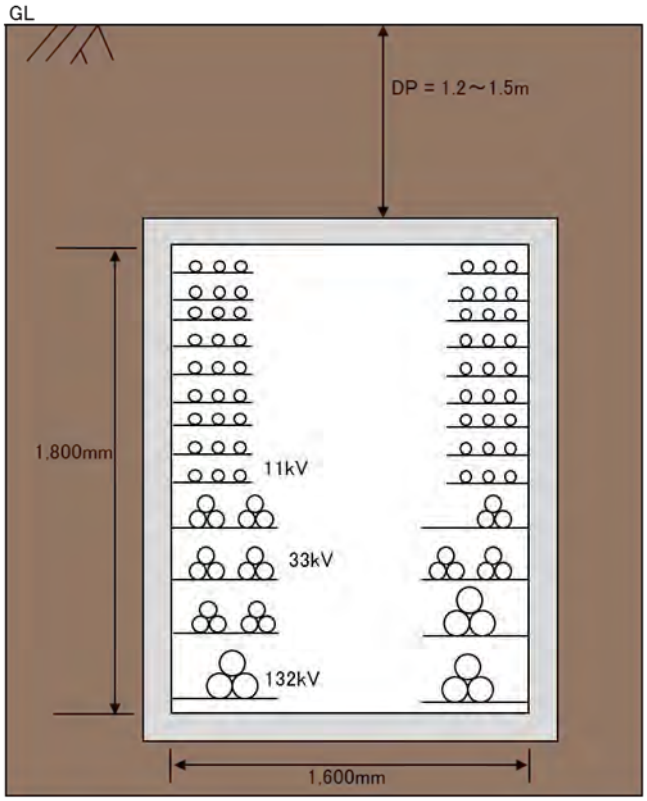
Source: CEGIS, JICA Survey Team

Figure 4-15 Water pipe network between Kawran Bazar SS and Dhanmondi SS

The red circles drawn in the above figure show the places that underground transmission cable will cross drainage pipes and water pipes. It is necessary to discuss this with WASA in advance. It is also necessary to excavate and confirm the exact position of buried pipes at these crossing places. In particular, water pipes are congested at Pant path junction. Thus, it is necessary to carefully check the conditions of the buried infrastructure.

4.6.2 **Cable Tunnel Design**

As shown in 3.2.2, installation of underground T&D cables is physically difficult near the peripheral part of the substation. Therefore, we propose to install a cable tunnel. A cross section of the tunnel is shown below.



(Source: JICA Survey Team)

Figure 4-16 Cross section of the cable tunnel (concept)

As per the above figure, we suppose that the inner size of the cable tunnel is w 1,600 × h 1,800mm. This enables installation of all the cables (132kV×3cct, 33kV×9cct, 11kV×18cct) that we envisage. We suppose that the depth of the cable tunnel is 1.2 – 1.5m.

The figure below shows the layout of the cable tunnels at the Gulshan and Kawran Bazar sites.

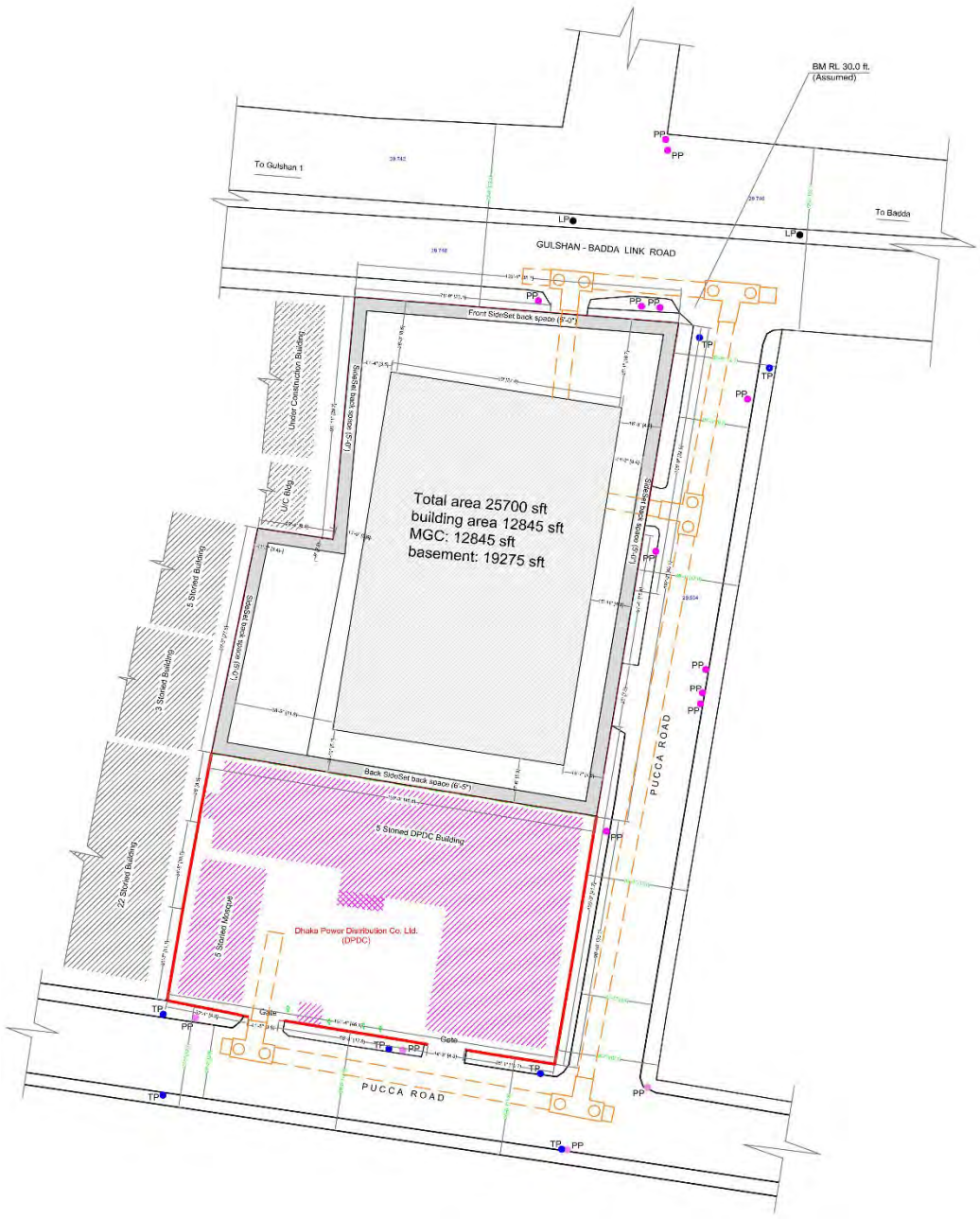


Figure 4-17 Layout of cable tunnel (Gulshan)

Figure 4-18 Layout of cable tunnel (Kawran Bazar)

The dotted line in orange shows the cable tunnel. However, the cable tunnel route depends on the cable inlet position, and it is decided by the design of the UGSS. Both substations have power poles along these walls. We locate the cable tunnel, which is set back more than 1.0m from the power poles, so as not to become an obstacle during its construction. We assume that the cable tunnel lengths for Gulshan and Kawran Bazar will be around 200m and 120m respectively.

4.7 Civil Design

Since none of the Bangladesh distribution companies have constructed underground substations, the survey team studied basic designs for building structures based on on-site surveys.

4.7.1 Assumed Flooding and Countermeasures

- Hydrological factors

Dhaka is located in the North Central Region of the country, underlying the Brahmaputra basin. The overall river system in this region is interconnected and interdependent. The river system of the North Central Region is characterized and influenced by the three major rivers, the Jamuna, the Padma and the Old Brahmaputra-Shitalakhya-Meghna system forming its boundary. These rivers act as both a source of flooding from overbank spillage during periods of high discharges and as a restriction to the outflows of drainage water. This region is surrounded by the Brahmaputra, Old Brahmaputra, Padma and Meghna rivers. Dhaka city area is surrounded by the distributaries of these major rivers. The study area is bound by six rivers, namely the Shitalakhya and Banar on the eastern side, the Turag, Buriganga and Dhaleswari on the western side and the Tongi canal in the northern portion. In the northern portion, the Tongi Canal meets the Turag River in the northwest of the area and the Balu river in the northeast of the area. The Turag River is 75 km in length and is connected to the Bangshi River at its upstream and to the Buriganga River at its downstream. The Buriganga River is connected to the Dhaleswari River at the downstream. The Dhaleswari, along with the combined downstream portion of the Buriganga River, defines the southern boundary of Dhaka city. Shitalakhya falls into this combined flow.

The city rainfall runoff is accumulated in the retention and detention areas and discharged to the surrounding rivers through the canals. The Dhaka West has 13 canals having a total length of more than 31 km while the Dhaka East has 27 canals with a total length of about 60 km. Approximately 80% of the city area is drained through these channels to the surrounding rivers.

In recent times, rapid urbanization and increased population have degraded both the quantity and quality of flow in the canals. Due to encroachment, some canals no longer exist in the core city area.

The existing drainage system of Dhaka city includes surface drains, storm sewer pipes, and open channels that carry mainly storm water and a portion of the generated waste water to the surrounding rivers.

Approximately 43 natural canals, with a total of about 145 km, form the canal system. In conjunction with the open channels and lakes, about 280 km of storm sewer lines covering 140 sq km and 10.5 km of box culverts make up the storm water drainage system of Dhaka.

Storm water drainage from Old Town Dhaka is primarily accomplished through the pump station located at the downstream end of Dholai Canal at Mill Barrack. Besides this, temporary pumps are

installed at various locations surrounding the western embankment and flood walls for storm water drainage during monsoons and heavy rainfall.

The less infrastructural-developed eastern portion of Dhaka suffers from water logging mainly due to the abundance of low lying lands and an absence of proper drainage network, leading to scattered intrusion of flood water. The drainage system in the Savar, Keraniganj, Narayanganj and Gazipur areas outside the core Dhaka city is mainly comprised of canals, open drains and rivers.

Due to the more natural landscape, gravity flow is predominant in these areas. Due to rapid urbanization, many areas are facing water logging due to inadequate drainage facilities and disconnection from natural systems.

A large portion of the western part is defined as flood flow zone and this area covers a buffer area around the Turag, the Buriganga and the Dhaleswari rivers. This portion, which acts as a major factor in containing a portion of river overflows, is part of the future urban development zone. Due to a lack of integrated urban development planning and fragmented jurisdiction in decision making, unplanned residential development is destroying the potential of these natural flooding zones.

- Rainfall

Annual average rainfall of Dhaka is about 2050 mm, which is below the country average of 2300 mm. The highest average rainfall of approximately 375 mm takes place in the month of July, with a wet season (June-November) rainfall of approximately 1545 mm. Maximum rainfall per day has been estimated as 341 mm in 2004-05, which is the highest among all other years. In 2004-05, 2-day, 3-day and 5-day consecutive maximum rainfall have been estimated as 497 mm, 526 mm and 600 mm respectively. Second highest maximum rainfall has been found during 2009-10, which is 333 mm, 422 mm, 439 mm and 499 mm for 1-day, 2-day, 3-day and 5-day events respectively.

Dhaka gets the lowest amount of rainfall during 2012-13 according to annual successive rainfall analysis results. Successive rainfall analysis has been carried out using 1-day, 2-day, 3-day and 5-day consecutive annual maximum rainfall data and storm events for different return periods (2, 2.33, 5, 10, 20, 50, 75 and 100) have been determined.

Table 4-1: Storm Events for Different Return Periods (Year) in the Revised DAP Area (mm)

Return Period (Year)	1 day	2 day	3 day	5 day
2	121	170	201	235
2.33	129	181	214	250
5	160	228	270	316
10	185	265	314	368
20	209	301	357	418
50	239	346	411	482
75	252	366	435	510
100	262	380	452	530

- Water Level

Frequent analysis of annual maximum water level has been assessed for 11 stations (Nayarhat, Demra, Pubail, Mirpur, Dhaka (Mill Barrack), Tongi, Kalatia, Savar, Kalagachia and Narayanganj) from 1972 to 2013, which almost covers the peripheral rivers of Dhaka. Log normal distribution analysis of those data is shown in the following table.

Table 4-2: Frequency Analysis of Annual Maximum Water Level for Stations on Surrounding Rivers of Dhaka City

Station	River/Canal	Return Period (Yr)					
		2.33	5	10	20	50	100
		Flood Level (m PWD)					
Nayarhat (14.5)	**Bangshi**	**6.90**	**7.61**	**8.13**	**8.58**	**9.11**	**9.49**
Savar (69)	**Dhaleswari**	**6.79**	**7.42**	**7.88**	**8.28**	**8.75**	**9.08**
Kalatia (70)		**6.52**	**7.04**	**7.41**	**7.74**	**8.11**	**8.38**
Mirpur (302)	**Turag**	**6.13**	**6.64**	**7.00**	**7.32**	**7.69**	**7.94**
Tongi (299)	**Tongi Canal**	**6.06**	**6.53**	**6.85**	**7.14**	**7.47**	**7.70**
Dhaka (Mill Barrack) (42)	**Buriganga**	**5.69**	**6.13**	**6.44**	**6.72**	**7.03**	**7.26**
Pubail (7)	**Balu**	**5.96**	**6.42**	**6.74**	**7.02**	**7.35**	**7.57**
Demra (7.5)		**5.91**	**6.27**	**6.52**	**6.74**	**6.99**	**7.16**
Demra (179)	**Shitalakhya**	**5.81**	**6.15**	**6.39**	**6.59**	**6.82**	**6.98**
Narayanganj (180)		**5.71**	**6.06**	**6.30**	**6.51**	**6.75**	**6.92**
Kalagachia (71)	**Dhaleswari**	**5.33**	**5.71**	**5.98**	**6.21**	**6.47**	**6.66**

- Flood Characteristics

A number of severe floods have struck Dhaka since the intervention has been initiated both upstream and downstream. Severe floods in Greater Dhaka City are mainly caused by spillover from surrounding rivers flowing to and from the major rivers of the country, as well as internal

water logging. In recent history, Greater Dhaka City experienced major floods in 1954, 1955, 1970, 1974, 1980, 1987, 1988, 1998, 2004, 2007 and 2009 due to the overflow of surrounding rivers and drainage problems.

Among these, the 1988 and 1998 floods were catastrophic. Flooding due to rainfall is also a severe problem for certain parts of Dhaka city due to drainage congestion. Impacts of the riverine floods are more severe and disrupt economic activities and the livelihoods of people dependent upon urban activities.

4.7.2 Flood Risk for Sub-Station Sites

Due to geographical positioning and its unique hydrological setting, flooding is a recurrent event for Bangladesh. Over the past few decades, the country has been devastated by severe occurrences of colossal magnitudes, which flooded both urban and rural settlements. In 1988, one of the most severe floods in recent history hit Dhaka and inundated 85% of the core Dhaka city. The 1988 flood was an extreme event of a more than 100-year return period. Depths of inundation exceeded 4.5 meters, and more than 60% of city dwellers were affected. The entire eastern part of Dhaka and the entire low-lying area of the western part of Dhaka were under floodwater. The aftermath of the event spurred the authorities into taking emergency preventive measures in the form of the Flood Action Plan (FAP) studies. Under these studies, various structural and non-structural measures were adopted for flood protection and improvement of the city's overall drainage system through the implementation of the western embankment and installation of additional pump houses. The immediate effect of these measures can be observed in the 1998 flood, also a 100 year event. It can be seen that, despite the high water levels and flooded surroundings, the core city remained flood free and as a result, the designated sub-station sites are in the flood free zone.

Due to quite a lot of flood control countermeasures having been taken, including several JICA Projects, the estimated maximum flood water level in the Project Site is 1.0m.

Heightening of the Ground Floor Level of the building shall be adopted for the main anti-inundation measure. This is the same design as is usual in that area.

Supplementary countermeasure methods, such as tide protection plate devices, may be excluded at this stage.

A non-fecal wastewater sewer system is already present in the Gulshan area and Kawran Bazar area. The water sealing plate method and expansion joint method installed at concrete placing joints shall be adopted in the Project.

4.7.3 Study of Methods on Excavation of Underground Structures

The examination items here are the influence of the temporary work on permanent work, the construction plan for temporary work, and the cost of construction.

Local characteristics related to earth work in the Gulshan and Kawran Bazar areas are as follows.
(1) There is a bearing layer for a high-rise building at around -20m as a result of on-site soil investigation.
(2) Soil at excavation area is sandy clay with stable good conditions.
(3) Thirdly, there is relatively little groundwater.
(4) Working site is surrounded by existing buildings and roads in the center of the city.

With regard to the connection with the permanent structure design, it was decided not to use piles due to the form of the structure under the ground. Not only fulfilling the purpose of building an underground substation but also, as a result, the cost of driving piles, are eliminated together with effective utilization of underground space.

Three cases have been studied:

(1) No underground facilities.
(2) Shallow underground structure with short piles.
(3) Underground structure to reach the bearing layer without any piles.

In each case, term of work, expense, and cost-effectiveness are compared as shown in 2.6.4.2 Table 2-16 and case (3) is chosen in general.
Therefore, in the future, during detailed underground design to coordinate with the upper structure, a cost saving will be possible with following two ideas: (a) Bottom of the underground structure shall be lower than bearing layer (b) When undersurface for bottom of structure is designed shallower than bearing layer, ground improvement shall need examination.
The construction method assumed is for these facilities to be constructed by local methods. At the time of the investigation, the local construction situation and technology are confirmed by interviewing material suppliers, specialized contractors, and consultants and by visiting construction sites. As a result, major work can be accomplished using local resources.
In addition, by checking projects in Bangkok and Japan, it was confirmed that some construction materials for special use in underground substation facilities and technology for waterproofing shall be applied in this project.
Those items studied here will be finalized in a future detailed design. However, items which have an impact on the construction schedule and cost estimation are examined in a concrete manner with possible methods in this F/S.
As a special note, because disasters during construction of subterranean parts have a high risk of extending to heavy damage, all the possible measures have been considered in order to prevent disasters during underground construction. In addition, because expensive electricity apparatus

coherent with public interests is to be operated after completion for a long period, stability of the underground structure is essential. Knowledge regarding waterproofing is obtained from outside of Dhaka. Dual safety measures for preventing water leakage are the installation of external waterproofing via membranes and the maintenance of water tightness in concrete.

The external waterproofing, together with measures for the junctions, is carried out before concrete casting at walls and the bottom area. All the materials for waterproofing are imported directly from Europe. It was confirmed during interviews that on-site work for membrane joints in Dhaka can be carried out by a Thai supplier. Local contractors have no experience.

Concrete itself has high water tightness, so this can be maintained by specifications with casting methods and inspection procedures at the time of construction. Quality of the concrete material and concrete compaction are the important points. During the actual construction stage, whether or not specifications are observed is crucial. Quality checks after the construction, for instance non-destructive testing and testing of concrete core, shall be carried out in order to identify faults and any required measures shall be followed. It is necessary to put these in the method statement.

The main temporary work is earth work, such as excavation and earth support, to build a structure under the ground. Here, use of local technology in Dhaka leads to a reduction in cost. However, such underground facilities have not yet been employed in Dhaka and unlike the subterranean part of general commercial facilities, special considerations must be taken into account regarding safety. To that end, a third nation's and Japanese knowledge and techniques have been adopted.

The methods of construction in this study must cope with the present local conditions and, after researching local materials, local experience and considerations of consistency regarding quality and methodology are to be required at the time of construction. Comments regarding the issues that require support via techniques from a third nation or Japan, methods of construction, and the materials enabled in the future are attached in particular.

The following five conditions are taken into account in this study: (1) soil condition, (2) surrounding environment, (3) procurement of possible materials, (4) past experience of similar structures, and (5) inquiry regarding permanent structure design. For these conditions, the actual situation becomes clear through local investigations. Based on this, a realistic construction plan and cost estimation can be achieved accordingly.

Matters that require attention during excavation for construction of an underground substation are as follows.

4.7.3.1 **Results of boring Exploration and Soil Tests**

The geological features of Gulushan are an organic quality-rich and high permeable sabulosity alluvial layer at 0-2.0m from the results of the investigation. Under this layer is a diluvium plateau of fine sandy silt. It is flat and continuous stratum.

Penetrated water such as rainwater stays as groundwater above this diluvium.
The upper part of diluvium from 0 to 8m deep is a reddish-brown hard clay layer with an N value of about five. The layer from 8 to 11m deep is brown fine sandy silt with an N value of around 10. The layer from 11 to 20m deep is light brown sandy silt with non-viscosity whose N value is from 10 to 20. All these layers show non-permeability with the quality of fine sandy silt and performed well compacted. The layer deeper than 20m is hard ground with an N value of more than 50. It is non-permeable with the quality of fine sandy silt of the hyper-compaction state.
The Kawaran Baza spot is assumed to be land which was developed for housing, with filing viscous soil on the ground of the diluvium, in the past according to the information obtained in Dhaka. This filing layer has a thickness of approximately 4.0m from the current ground level. Therefore, there is groundwater from penetration water such as rainwater at a depth of around 4.0m.
This characteristics of the diluvium layer deeper than 4m are the same as those of the Gulushan district. The diluvium layers in both districts were good silty sand. It is stable at the time of excavation. It was confirmed that there was a bearing layer with a very stable N value of more than 50 from around 20m in depth.
From the results of the soil examination, groundwater and a good sandy silt layer stable at the time of excavation is confirmed. There is also a very stable bearing layer from around 20m in depth.
With the results being reflected in the main structure design - (1) relatively shallow bearing layer for structure (around 20m deep) and (2) requirements of underground structure with certain depth – the idea of direct foundation for the whole structure is proposed in this F/S. This is advantageous with regard to both construction characteristics and cost. It involves building the bottom of the structure directly on the bearing ground.

4.7.3.2 **Major Underground Work from Temporary Staging**

The construction site of Gulshan is surrounded by existing buildings and public roads. The site will become an approximately full-scale excavation, and the above ground part does not have a working place. Therefore, temporary staging will be arranged for part of the excavation work and construction work for the main structure. Staging is carried out in various ways such as parking crawler cranes and trucks during excavation, the in and out of materials at the site, and casting concrete.
The temporary staging area is 20m x 20m square, and the surface structure is a deck plate. Its major parts like beams are type I and H beams. (Some steel materials shall be imported from Southeast Asia and most of those of ordinal sizes are available in a local market.) Procurement will be buy-back basis or rental during the construction period. Columns are cast-in-situ piles and will eventually be permanent pillars of the structure. Loads on temporary staging are assumed to be one crawler crane of 150 tons and two dump trucks with full load. The position of staging shall be in

an effective place with consideration of the permanent structure design and working radius of the crawler crane.

Figure 4-19 Example of Temporary Staging

4.7.3.3 **Construction Method for Earth-retaining Wall**

Three types of wall are comparatively evaluated, which are (1) diaphragm wall, (2) steel sheet piles, (3) cast-in-situ RC piles. A diaphragm wall for temporary wall and main structure use is effective, but this is not adopted in Dhaka because of lack of experience, as discovered via interviews with local construction companies. It is expected to become a common method in the future in Dhaka city because it is very effective in unifying temporary constructions and permanent walls. At the actual design stage, there are other institutional problems such as the distance between the permanent structures and boundary. Steel sheet piles are commonly used at sites of shallow excavation in Dhaka. However, due to the following reasons, which negatively affect procedure and the construction schedule, steel sheet piles will not be adopted. Firstly, the depth of excavation is over 27m and there is no experience of such a deep excavation here. Secondly, after completion of the underground work, there will not be enough space for machines to extract sheet piles. A cast-in-situ RC pile retaining wall is commonly used in Dhaka, so the contractors have a lot of experience with various kinds of machines, and its design adjustability has high flexibility regarding the on-site requirements.

Design of concrete piles for retaining walls is basically diameter φ 800, which is commonly used in Dhaka, with an embedded depth of 10m into the hard ground layer in order to prevent leaked underground water from the bottom. In addition, the layout of piles is double layer, overlapped to prevent water leakage from the side. There are various kinds of cast-in-situ concrete piles in Dhaka so the actual design shall be changed according to future circumstances. The top of the retaining wall has a pile cap, which connects all piles on the top and prevents water caused by floods. Tentative design of the pile cap is 1m high and 2m wide.

Kawran Bazar is a morass with a filing layer of approximately 4.0m on the surface through sandy silt in the past. Filing thickness is around 4m. When the quality of ground is compared with the neighboring alluvium soil and diluvium of the same depth, no large difference is seen. Notice should be paid to the construction of the retaining wall at the applicable spot, but big design changes are not expected.

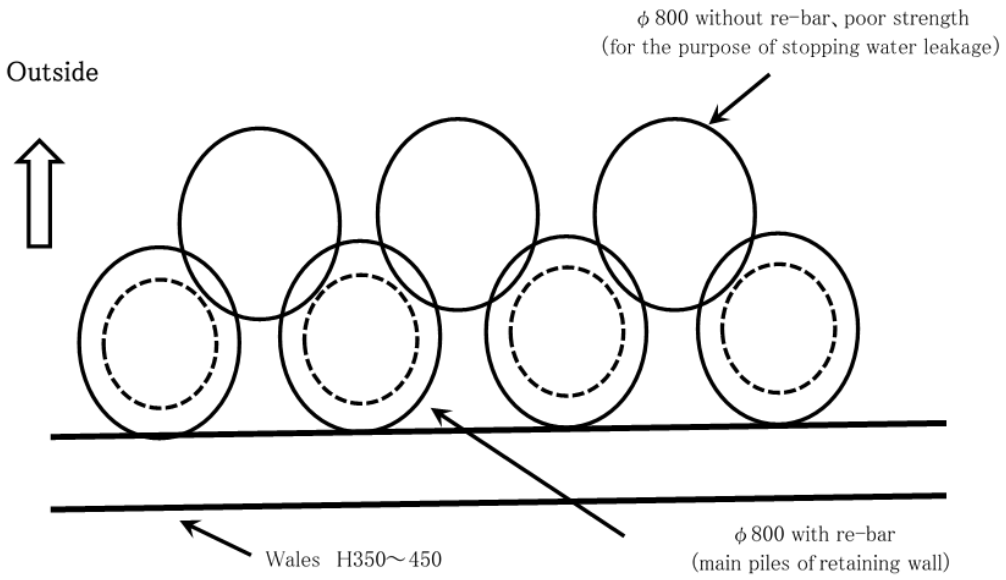


Figure 4-20 Layout Plan for Retaining Wall

4.7.3.4 **Wales/Struts and Intermediate Piles**

The predetermined design of wales and shore struts here is based on calculated earth pressure and takes into consideration the water level under the ground from the results of soil tests.

The profile of the earth support system is an excavation-depth of 25m, and a shoring system with five layers of wales and struts using H350~H500 type steel beams. Intermediate piles to prevent buckling of shore struts are designed as follows. Location is every 5m pitch with root of 1.5m deep and material of H350. Procurement of steel materials is possible in Dhaka except for those over H500. Steel materials are not special earth support steel members but raw materials, and they are

to be purchased, assembled on site by welding, dismantled after completion of underground work, and finally sold in the local market.
The ground condition is very stable. In this F/S, all design is relatively on the safe side so there is some room to change to a light design at the actual design stage with more information.

4.7.4 Excavation Methods

Soil conditions are stable silty sand. In shallow places, excavation will be conducted with ordinal excavator and tracks. At excavation places over 5m deep, it will be double handling together with crawler crane and tracks on the temporary stage. This is due to the condition that the site area will be under excavation. Besides, excavation over 20m reaches the bearing ground so a special machine shall be arranged accordingly.
The procedure for the excavation starts together with piling work for the retaining and other walls. The first step is from the surface to 5m deep. An excavator and tracks are to be on the ground. The second step is excavation over 5m deep. An excavator and bulldozer are to be on the surface of the excavated area and excavated material will be loaded on track by crawler crane with buckets on the staging. The third step is the hard bearing layer that is expected to appear at over 20 m deep and a supplementary special machine like a breaker will facilitate excavation work. Each shoring layer of wales and struts will be installed without delay following the progress of the excavation.

4.7.4.1 **Disposal of and Dumping Area for Excavated Material**

Excavated material will be carried out from the site by dump trucks to the appointed dumping area. Because surrounding roads are congested during the daytime, export of excavated material is limited to the night-time (six hours from 11:00pm - 5:00am the next morning).
Usually, the successful contractor after the bidding has decision rights on the dumping ground.
It is recommended that the client prepares a proposed dumping site beforehand in the neighboring area and stipulates this at the time of the bid. In this case, if the contractor were not able to find a proper dumping area nearby within a reasonable duration, such a stipulation would prevent delays in the schedule and cost increases due to the dumping area being located a long distance away.
Because excavated material is of a good quality, it may be possible to use it for backfilling material in another project. It is also possible to sell excavated material to a third party in order to reduce the cost of construction.
However, it is not possible to confirm such ideas at this stage so there is no further discussion in this F/S.

4.7.4.2 **Environment and Measures for Neighbors**

Behavior of the earth support system is managed to provide early detection of abnormal phenomena and to prevent any accidents by installing a clinometer and displacement gauge.

The entrance of third parties into the site will be controlled by a fence of 2m. At the gate, traffic control is managed by a gate keeper/guard for the safety of pedestrians and for vehicular traffic at the time of importing/exporting material into/out of the site. At the time of export of materials from the site, measures are taken not to stain public roads. In addition, discharge of underground water and rainwater from the site is to existing drainage, keeping the predetermined quality of the water.

4.7.4.3 **Construction Methodology**

Construction with deep excavation has been based on local experience and local procurement of materials in principal.

This is from the point of view of leading construction to maintain the quality of structure at the required level, to keep to the planned schedule, and to keep to the planned cost. However, due to this being the first experience of special functions and performance in Dhaka, such as construction of an underground substation, where it is difficult to deal with existing methods in Dhaka, Japanese and third country techniques are introduced herewith in order to satisfy the appointed standard. Therefore, by spending sufficient time on local investigations and interviews in this study, collection and analysis of the local information are reflected in the construction plan too.

For the major construction method of the underground structure, (1) inverted lining wall method and (2) ordinal bottom up construction method are compared and examined herewith. Although an inverted lining wall may be accepted in the future, the ordinal method is proposed here. The following are the drivers of this decision. First, there is no experience of the inverted lining wall method. Secondly, there has been no experience of diaphragm walls, which are the core of an inverted lining wall, in Dhaka until now. A diaphragm wall may be used not only for temporary retaining walls but, as an advantage, can also become a permanent structure. The quality control of concrete walls is relatively difficult. Reliable external waterproofing is not feasible. Furthermore, in this way, the effective area of the structure becomes rather small due to the local regulations. The local regulations say that a permanent structure needs much more clearance from the boundary compared with a temporary structure. Finally, the inverted lining wall method is desirable as a method of construction to be examined again at a future stage because it will lead to a shortening of the term of work and a reduction in the cost of construction.

For waterproofing work, after completion of excavation, 10cm lean concrete will be cast as a protection for the membrane and to gain workability for laying work for the waterproofing membrane. Before starting the next process, 10 cm protection concrete will be cast so as not to break the membrane. At each edge of the bottom layer, the membrane will be standing in a wall to have space to join with the vertical membrane. Since the vertical waterproofing membrane is located in between the retaining wall (cast-in-situ bored pile) and permanent wall, it will be laid using the following procedure. First, the rough surface of the retaining wall shall be flattened by

casting filling concrete in between the wall and one side of form work. After flattening the vertical surface, the waterproofing membrane shall be installed. The permanent wall shall be constructed using this membrane as external form work. Every joint of the membrane shall be pasted by overlapping sheets with the standard heat and dissolve method. There is no particularly difficult technical problem, but we plan to use a Thai contractor to supply the material with on-site work because there was little experience among local companies. Regarding the penetration of the waterproofing membrane caused by the utility lines, such parts will be designed accordingly, complying with the other detailed designs. For the time being, ordinal processing, like that used in present subway facilities, is taken into account.

After construction completion, some underground water in between an alluvial layer and diluvium layer may flood into the excavated diluvium layer. There are concerns of pressured stagnant water outside of the underground structure. Therefore, during the backfilling stage, it is proposed to watch the neighboring underground water level and to take drainage measures for such stagnant water.

4.8 Design Coordination of Substation Buildings and the Superstructure

Regarding the two proposed sites for the plan, the drafted ideas for consideration based on the following design conditions and concerns are shown in a separate sheet.

4.8.1 Design Conditions

Design conditions in drafting of the ideas to be considered are as follows:

- Maintenance of functions for the underground substation facilities (Basement F1 – Basement F4)
- Making complex facilities with a 13-story office building
- Total floor area/construction area

  Gulshan: approximately 18,700m²/approximately 1,100m²

  Kawran Bazar: approximately 25,500m²/approximately 1,500m²
- Compliance with local, major relevant architectural regulations [building coverage ratio, floor-area ratio, and setback distance (Chapter 2.5.1)]

4.8.2 Considerations for Structures of Substation Buildings

4.8.2.1 Design Conditions for Substation Buildings

(1) Outline of Substation Buildings

The design considers the underground structures using both the floor and cross-sectional plan of the Gulshan district shown in a separate sheet, and the Architectural Institution of Japan (AIJ) Standards for Structural Calculation of Reinforced Concrete Structures and Steel Reinforced Concrete Structures.

Section sizes of major segments on each floor are displayed in the following table.

Table 4-3: Section Sizes of Components of the Underground Structures

Story	Component	Section Size	Remarks
1F	Girder	600×1,200	Partially SRC construction
B1F	Column	1,000×1,500	Partially SRC construction
	Girder	800×1,200	Partially SRC construction
	Outer wall	t300	
B2F	Column	1,200×1,500	Partially SRC construction
	Girder	800×1,200	Partially SRC construction
	Outer wall	t600	
B3F	Column	600×1,200	Partially SRC construction
	Girder	1,500×1,500	Partially SRC construction
	Outer wall	t600	
B4F	Column	1,750×1,750	SRC construction
	Mat slab	t3000	RC construction
	Outer wall	t800	
	Inner wall (load-bearing wall)	t300	

(2) Types of Structures

Basically, structures are of reinforced concrete construction (RC construction). However, some structures are of steel reinforced concrete construction (SRC construction), considering the stress allowance.

(3) Materials Used

Materials to be considered are shown in the following table.

Table 4-4: Materials to Be Examined

Name of Material	Specifications
Concrete	Regular concrete Fc=40N/mm2
Reinforced concrete	≤ D16 SD345
	≥ D19 SD390
Steel	SM490

(4) Load of Superstructure

The load of the superstructure was simulated in a 13-story building of RC construction with a set load unit of 15kN/m2.

The load of the superstructure is placed as an axial force, corresponding to the load area position of each column on the first floor.

The placed axial forces of each column are shown in the following figure.

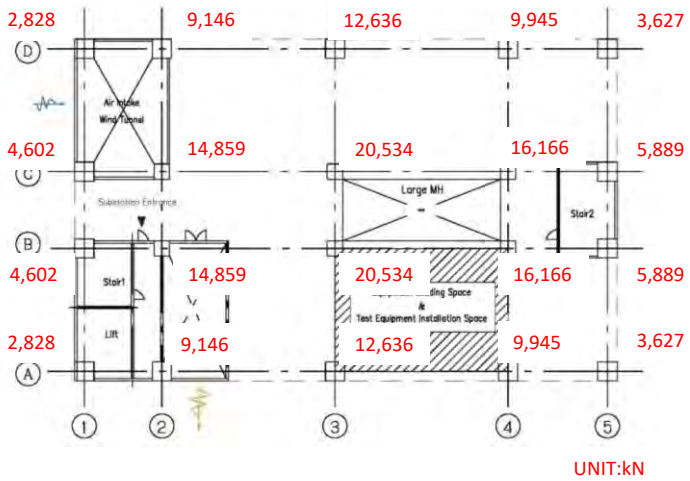


Figure 4-21 Axial Forces of the Superstructure

(5) Load Capacities of Substation Components

Load capacities of substation components to be considered are shown in the following table.

Table 4-5: Load Capacities of Substation Components to Be Considered

Story Level	Name of the room	Load capacity (N/m2)	
		Floor	Frame
1F	General	7,000	5,300
B1F	General	7,000	3,900
B2F	GIS	11,000	8,300
	General	6,000	4,500
B3F	General	3,000	2,300
B4F	General	7,000	5,000

(5) Soil and Water Pressure

Soil and water pressure were calculated from the data from the outcome of soil investigations.

The unit weight of soil was 19kN/m3; the underground water level was GL-3.3m.

For calculation of soil pressure and water pressure over a long period, the total of lateral pressure of the above-mounting load of soil and water pressure was added.

Values of loads for each floor are shown in the following figure.

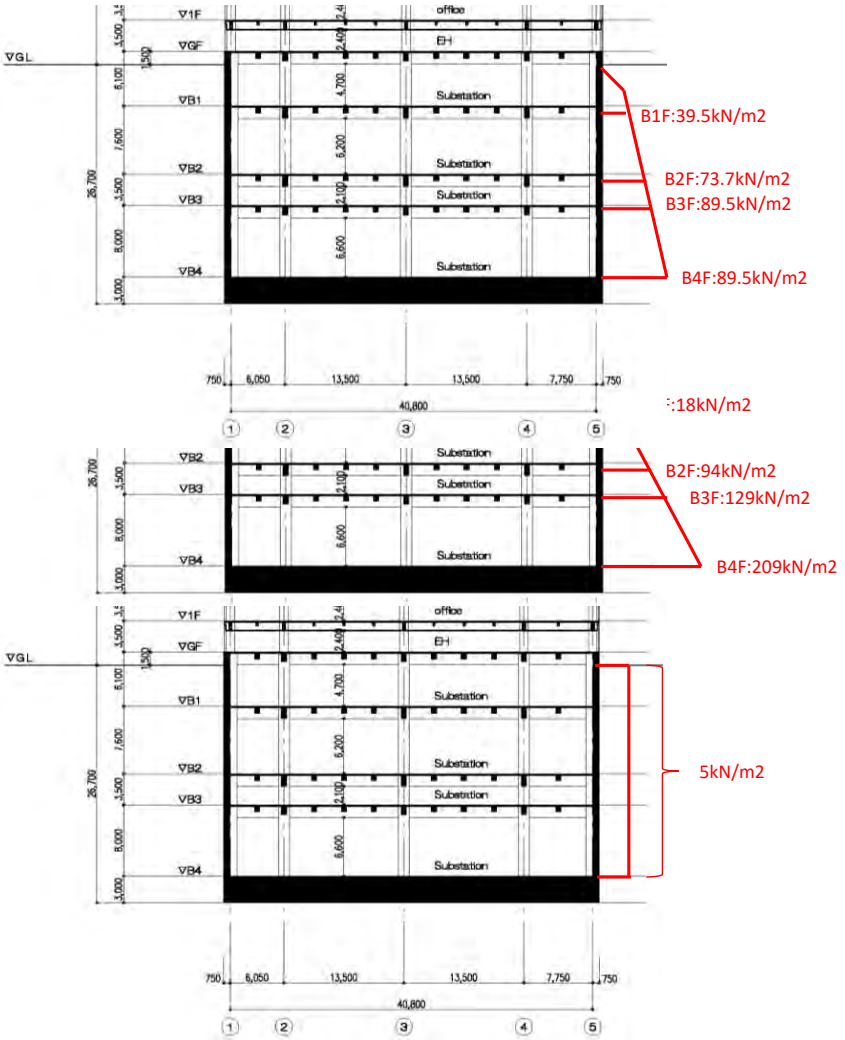


Figure 4-22 Soil and Water Pressure Affected on Each Floor

4.8.2.2 **Results of the Outline of the Plan to Be Considered**

Feasibility of the buildings was examined at the two sites in accordance with the local standards for structures. Based on the examination, the results of the deployment plans for each candidate site are shown.

(1) Gulshan

The site shape is long and thin in the south and east. Half of the south part of the site has more room available in the east and west. Around the center of the site, there will be outdoor substation equipment in operation at the time of the construction. For this reason, it is difficult to secure the necessary space within the north section of the site, so the building needs to be placed at the edge of the south portion of the site. Moreover, the above-mentioned displacement will be able to meet the conditions of setback distance, building coverage ratio, and floor area ratio that would restrict the placement and scale of the building. Three sides of the site face roads with a side-walk, which makes it highly and freely accessible to both pedestrians and vehicles. Also, placing the buildings so they are concentrated on the south edge will create more space for other flexible use. In consideration of this point, placement of the buildings on the south side would be advised.

(2) Kawaranbazar

One side of the site faces a road and the site forms a diamond shape. Also, in the north-east area of the site, there will be outdoor substation equipment in operation during construction. Considering the securing of the construction yard during the construction period and the convenience of having a square space after construction, it would be advisable to place a building on the south edge.

4.8.3 Concerns regarding Design

4.8.3.1 Flood Control Measures

Heavy rain and leakage from the superstructures (including water for fire-fighting) would be a cause of flooding. The following measures would be desirable.

- As a measure preventing leakage and flooding outside of the substation building, the entrance and exit, doors, and ceilings of the substation will be water-proof.
- Junctions to cable tunnels are to be water prevention structures (waterproof tubes), which will not affect the substation building if the tunnels are flooded.
- As a measure to prevent water leakage from the superstructures of the complex, make the floor slabs between the underground substation and the superstructures double slab structures. Make the lower slab waterproof.
- As a preventative measure for heavy rain, make the ground floor raised or construct storm surge barriers.

4.8.3.2 Security Measures

The gate to the substation site should be locked (electrical locks) and kept for authorized personnel only.

Concerns regarding Multi-usage Complex Buildings

As the substation building will be a complex for the office building of the superstructure (partial commercial use), the following would be desirable.

- Adjust the building column span (distance between columns) so that the office building floor will be utilized flexibly.
- Establish shared architectural core (stairs, EV, bathrooms) joining the superstructure so that the inside of the buildings can be efficiently utilized.

・Secure sufficient floor area on the ground floor, as it has high added value for commercial use.
・Sort out the traffic on the ground floor as there are a mixture of substation operators, commercial facility users and office users.

4.8.3.3 Secure a gas cylinder room for gas fire extinguishing system

In this project, it was confirmed that an inert gas fire extinguishing system will be needed as in Japan. For this purpose, it is necessary to secure a gas cylinder chamber which has sufficient room to store gas. In Japan, as the size of a gas cylinder chamber depends on the number and volume of the release compartment, the number of the release compartment is determined in consultation with the relevant authorities and the size of the chamber needs to be evaluated.

4.8.3.4 Usage of Gas Flooding Extinguishers in Replacement of Water-based System

In Japan, a water-based extinguishing system (indoor fire hydrant and watering equipment with hose connector) is necessary depending on the size of the underground facilities. In light of the use of the underground substations, however, an exemption from installing a water-based extinguishing system is to be negotiated with the relevant authorities. In this project, the necessity of the system should be confirmed at the planning phase. If such a system is needed, consultations with the relevant authorities will be necessary to secure an exemption from installing the water-based extinguishing system.

4.8.3.5 Communication of Fire Information with the Superstructures

Underground substations and their superstructures are separately managed. Thus, each facility has its own management center. For this reason, it is essential to share fire information by exchanging fire signals with each other to secure the safety of both buildings. In Japan, equipment (a receiver) to collect fire information must be installed in a building. If more than two pieces of equipment are installed due to operational reasons, exchanging of fire signals is obligatory.

4.8.3.6 Securing of Ventilation Facilities for Releasing Heat within the Substations

In underground substations, there are several types of equipment which need to release heat (transformers, Gas Insulated Switchgears, cubicles, etc.) When an air-cooling system is used to cool transformers, instead of a water-cooling system, the amount of heat generated in the room and ventilation will be extremely large. For this, securing of space for an outdoor-air inlet and wind tunnel area will be an issue. Placing a transformer cooling system outside or at a dried area on the basement 1st floor where outside air comes in makes it possible to greatly decrease the amount of ventilation necessary for the entire building. Therefore, it is necessary to examine thoroughly where to place the transformer cooling system at the time of design. Regarding the ventilation system after the outside-air intake is introduced, as an increased amount of wind requires installing an air-intake filter and ventilation fan, and making the size of the duct for air-supply and exhaust larger, it is necessary to examine the duct runs as well during planning.

4.8.3.7 Prevention of Water Leakage from the Superstructures to the Underground Substations

There is a large amount of equipment which needs to be kept dry in underground substations. If there is no need to equip a water station within the substation, there may be possible water leakage from the water-supply and drainage pipe runs of the above building. In the planning of the building, plans and sections must ensure that the insides of underground substations are not affected by water leakage, making sure that the supply and drainage pipe runs placed above the substations are non-exposed pipe runs. The ground floor should be a double slab structure, just in case water leakage from the corresponding locations occurs. Regarding the drainage routes, including spring water

drainage in underground substations, placement of shaft ways needs to be examined so that leakage to a room with prioritized equipment can be prevented if leakage occurs.

4.9 Project Design

As discussed in the previous chapter, the proposed underground substation project consists of two major components: construction of an underground substation on-site and construction of a power grid supplying and distributing electricity through the underground substation. Thus, the project includes not only the two major components, the construction of the substation building and the installation of electric facilities, but also other important components (132kV feeder facility installation at the source substation in a PGCB substation, 132kV underground power cable and its underground enclosure (or direct-burial accessories), and sufficient vertical shaft and cable tunnel(s) around the underground substation) to be constructed.

In contrast to the addition of necessary networking components for the project, the project does not include any preparation work relating to load evacuation for the existing facility, installation of an interconnecting switch between distribution lines for load switching, or demolition of existing buildings and facilities on site, all of which must be done before UGSS substation construction based on DESCO and DPDC's working practices and workers' technical capabilities. Since this preparation work should be implemented by considering the existing networking configuration and its loading factor, site-specific operational constraints and customer-related activities, which should be closely administered by local power utilities with their own funding, the project only includes the cost for connecting existing distribution lines with newly installed power cables installed in the newly constructed tunnels or underground ducts near to the new UGSS.

As discussed in METI's preliminary feasibility study, the project also excludes the construction of the UGSS's superstructure, which is usually designed for other business purposes, such as rented offices, residences, and warehouses, to utilize the UGSS plot and to improve the financial feasibility of the UGSS project. Although the JICA survey team evaluated the expected financial flow from the utilization of the superstructure to validate the project's financial stability preliminarily, the fund for the superstructure, which is not included in the UGSS project costs funded by JICA's ODA loan, must be arranged by DESCO and DPDC individually.

4.9.1 Project Components

The objective of underground substation construction is to improve distribution network reliability to achieve stable electricity supply and to initiate distribution network interconnection with remotely controllable switches and an automation system, thereby enhancing the country's economic growth. The proposed underground substation project consists of two major components: construction of an underground substation on-site and construction of a power grid supplying and distributing electricity through the underground substation. Thus, the project includes not only the two major components, the construction of the substation building and the installation of electric facilities, but also other important components (132kV feeder facility installation at the source substation in a PGCB substation, 132kV underground power cable and its underground enclosure (or direct-burial accessories), sufficient vertical shaft and cable tunnel(s) around the underground substation) to be constructed, which DESCO and DPDC requested to enable them to lay the increased number of incoming transmission and outgoing distribution line cables to the very deep cable cellar floor of the substation. In contrast to the addition of necessary networking components for the project, the project does not include any preparation work relating to load evacuation for the existing facility, installation of an interconnecting switch between distribution lines for load switching, or demolition of existing buildings and facilities on site, all of which must be done before UGSS substation construction based on DESCO and DPDC's working practices and workers' technical capabilities. Since this preparation work should be implemented by considering the existing networking configuration and its loading factor, site-specific operational constraints and customer-related activities, which should be closely administered by local power utilities with

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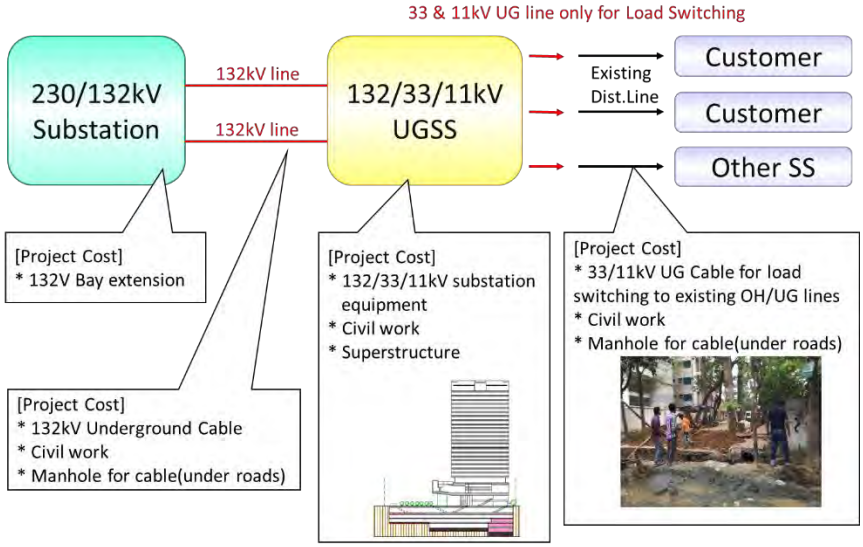

Figure 4-23: Overall Picture of the Project

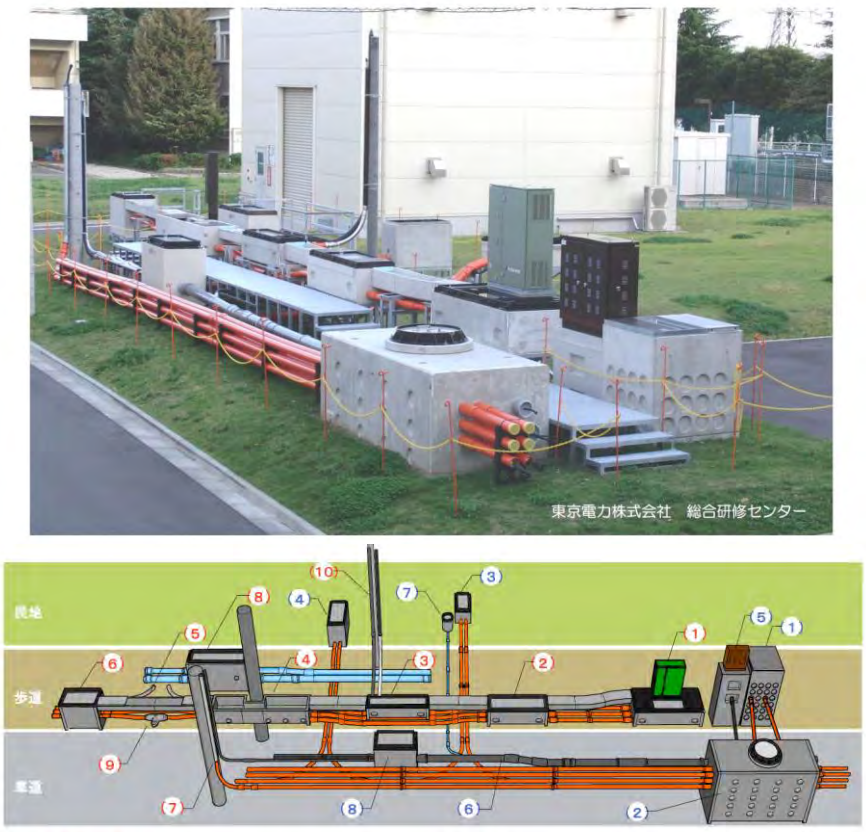

Figure 4-24: Underground Distribution Facility Model

4.9.2 Project Packaging

In terms of the project package arrangement, DESCO and DPDC requested the formation of a full-turn-key project package for individual project sites, and the full-turn-key project consists of the underground substation's building construction, substation equipment installation, 132kV transmission line installation along with underground tunnel around the site, and distribution line from source to the first pole. This full-turn-key project arrangement enables DESCO and DPDC 1) to minimize overall project costs by streamlining the underground substation's building based on the dimensions of procured equipment, 2) to co-ordinate the entire building design to secure the necessary UGSS operational spaces for equipment expansion and repair, and 3) to synchronize each subcomponent's construction schedule for minimum project duration.

However, if a full-turn-key package is selected for the project, the number of capable bidders for the project may be limited and contract prices may be quite expensive. Hence, the JICA Survey team and DESCO/DPDC tentatively agreed on two packages.

If DESCO/DPDC and JICA can forecast that some bidders will come to the bidding, they confirmed that they would change it to one package under agreement. The below table shows the tentative bidding summary list.

Table 4-6 Package List (Draft)

Package	Item	Procurement	Construction Contract
DESCO-1	Gulshan S/S: Civil and Structure Construction for UGSS and Surrounding Underground tunnel	International Competitive Bidding (ICB)	Design Build
DESCO-2	Gulshan S/S: Installation of electrical facilities and underground transmission and distribution cables	International Competitive Bidding (ICB)	Design Build
DPDC-1	Kawran Bazar S/S: Civil and Structure Construction for UGSS and Surrounding Underground tunnel	International Competitive Bidding (ICB)	Design Build
DPDC-2	Kawran Bazar S/S: Installation of electrical facilities and underground transmission and distribution cables	International Competitive Bidding (ICB)	Design Build

(Source: JICA Survey Team)

For the procurement of necessary equipment, materials for building construction, human resources, and technical assistance, the consultant divided items into a foreign portion and domestic portion depending on their availability and the necessary quality assurance in Bangladesh. Most of the substation equipment must be imported - in particular, Gas Insulated Transformers are assumed to be imported from Japanese manufacturers - so substation design, equipment manufacturing, testing and shipment, and technical supervision are categorized as being in the foreign portion, while transportation and on-site installation are included in the domestic portion. For other substation equipment and fixtures, special cable sealing devices and ventilation systems for equipment and the UGSS building are imported to ensure long-term UGSS operability by minimizing water-inundation risk and for ventilation termination with higher product quality. Most of the building materials can be procured domestically, except the core steel used for the SRC structure to ensure the product's quality considering the project's designed pillar size, although some steel products have now become available domestically according to DESCO and the sub-consultant's information.

The procurement of underground transmission line, underground distribution line, and consultancy for underground substation design is done internationally to ensure products' quality, and proper design for the UGSS's long lifecycle in consideration of the anticipated operational activities, and design co-ordination between superstructures and the underground portion. All of these technical studies must be done by international consultants who are skilled in underground facility design because of the scarcity of such technical experience in Bangladesh. Also, the education program for UGSS operation, including GIT maintenance and emergency drills for SF6 gas leakage in UGSS, must be sought internationally.