CHAPTER 3 ELECTRICAL POWER SECTOR DEVELOPMENT PROJECTS

3.1 Purpose and Background of the Study

The Islamic Republic of Pakistan is now facing power shortage crisis which have not been experienced in the last decade by the Pakistani people as well as the power companies. The crisis rose up from various reasons such as rapid increase of oil prices, growth of electric demand, and huge amount of power losses which are not caused by simple structures. The government and other companies relating to power supply are currently struggling to find a solution on minimizing the problem.

On the other hand, consumers are obliged to be patient against routinely executed load-shedding, which is also causing water supply problems because water pumping facilities do not run regularly. The power shortage is now inducing social and political problems in the country.

The power company prioritizes industrial consumers at industrial zones in supplying power. Their feeders are not subjected to load-shedding since industrial customers are important revenue-generating clients to the power company while revenues from other consumer categories are not well collected.

Despite investors in industrial zones being prioritized when supplying power, they are still having troubles with the power quality, such as power-outage, voltage fluctuation, high tariff, and high cost of investment on back-up generation facilities. The major point is that investors cannot sweep away the anxiety that the load-shedding may eventually be applied to their respective zones in the near future. No specific solution has yet been taken to fill the gap of the supply-demand of electricity.

The above circumstances as well as political and social instability will discourage foreign direct investment (FDI).

This section provides the investigation and analysis of the Study Team on the present status of the electric power supply. Finally, the section will propose possible projects which will improve the investment climate of the Karachi Processing Zone and Bin Qasim Industrial Area.

3.2 Methodology of the Study

The study was done in four steps, namely: (1) Study on existing system, (2) Study on power supply status, (3) Study on future plan, (4) Select possible projects.

(1) Study on existing system

- Administrative structure of power supply to the whole of Pakistan

The administrative structure of power supply in Pakistan is divided into two systems. One system is the Karachi Electricity Supply Company (KESC) who supplies power to Karachi City. The other system is the Water Power Development Authority (WAPDA) group which consists of many companies covering different areas, and having different roles such as power generation, transmission, distribution, and administration. Both KESC and WAPDA group networks are connected, forming the total power network of Pakistan. The demarcation of the two companies and their mutual relation will be studied.

- Administrative status of KESC

KESC is an integrated power utility which handles the generation, transmission, and distribution of power sectors, and having a monopoly of power supply in Karachi. Although KESC is a privatized company, the power supply status will not improve unless KESC is aided in the upgrading or expanding of their supply facilities.

- Power network system

The grid system diagram of KESC which is shown on a map is not obtainable. The diagram helps in visualizing the company's system scale, topographical relation to the industrial areas, and also to know the mutual relation among electrical facilities.

The Study Team surveyed the location of major facilities of KESC such as power stations, grid substations, and major transmission lines using GPS.

(2) Study on power supply status

The Study Team conducted interviews with people from different sectors, such as KESC employees, industrial consumers, commercial consumers, residential consumers, and factories with self-supporting power generation systems (not receiving power from KESC), to study the actual status of KESC power supply.

(3) Study on future plan by KESC

The Study Team requested KESC to prepare the future plan for this project, wherein, KESC has prepared the list of possible projects of the company. Strategic plan by the Karachi Metropolitan Corporation (KMC), which was named the City District Government of Karachi (CDGK) when the strategic plan was prepared, is also referred to finalize the future plan.

(4) Select recommendable projects

The Study Team prioritized the above projects by carefully examining the ones that will help the Pakistani people, as well as the ones that will contribute to the development of investment climate.

The Study Team prioritized the projects with respect to the points whether the project will contribute to the reduction of power shortage, as well as whether the project will contribute to the development of investment climate in the Karachi Processing Zone and Bin Qasim Industrial Area.

3.3 Administrative Structure and Present Facilities of Power Supply

3.3.1 Countrywide Structure

(1) Administrative structure of the power sector

The electric power sector of Pakistan is roughly divided into two parts, KESC which supplies power to Karachi City and its suburbs and WAPDA group which supplies the whole country except the areas supplied by KESC.

WAPDA was the largest electric power utility in Pakistan before being unbundled. After the unbundling of WAPDA , the company specialized in hydro-power plants. However, the WAPDA is so known to the Pakistani people that the name WAPDA is still used as a group of companies.

KESC is an integrated utility with generation, transmission, and distribution, while WAPDA group consists of many independent companies, sharing their business of specialty. The National Electric Power Regulatory Authority (NEPRA) is controlling power producing businesses in Pakistan by regulatory bases. Administrative structure of power supply in Pakistan is shown in **Figure 3.3.1**.

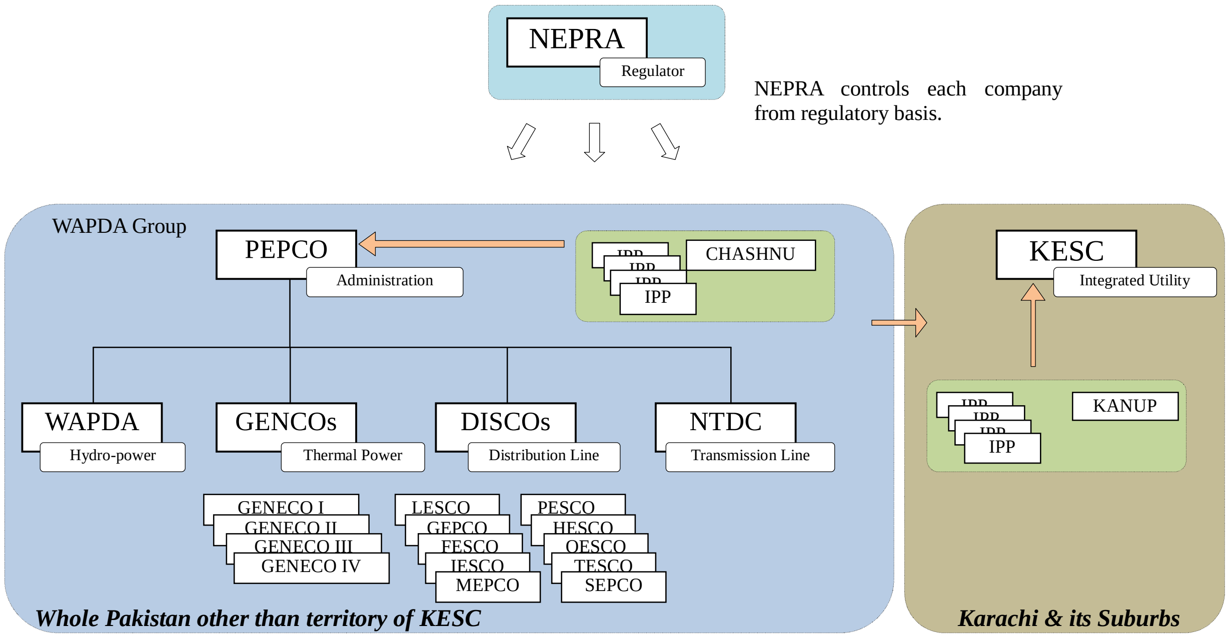
The Pakistan Electric Company (PEPCO) is the company specialized for administration work in the WAPDA group. PEPCO also summarizes data of group and publishes the total information. The name of PEPCO is also used in representing the WAPDA group. In this report, both the WAPDA group and PEPCO are used. However, PEPCO is used in case the data is obviously made by them or during cases where the company is clearly named in the agreements with other parties.

(2) General Information on Power System

As mentioned above, power supply to consumers is operated by two groups, KESC and WAPDA group with the former supplying power to Karachi City and the latter supplying to all of Pakistan. The total installed capacity of generators in Pakistan, including IPPs, is 19,437 MW as of 2010. Out of the total installed capacity, KESC shares 2158 MW of power. The system scale of KESC is about 11% of the total system.

As seen in **Figure 3.3.2**, most of the hydro-generating plants are located in the mountainous area of the northern regions, while the southern region relies on thermal power. Pakistan has two nuclear plants. The first is the Chashuma Nuclear Power Plant (CHASHUP) located near Chashma City of Punjab with two units generating 300 MW of power. Another plant is the Karachi Nuclear Power Plant (KANUPP) located at around 30 km west from the city center of Karachi City with a single unit generating 137 MW.

The power generation facilities of PEPCO and KESC are as shown in **Tables 3.3.1** and **3.4.2**.



NEPRA	National Electric Power Regulatory Authority	LESCO	Lahore Electric Supply company
PEPCO	Pakistan Electric Power Company	GEPCO	Gujranwala Electric Power company
KESC	Karachi Electricity Supply Company	FESCO	Faisalabad Electric Supply company
WAPDA	Water and Power Development Authority	IESCO	Islamabad Electric Supply company
GENCOs	Generation Companies	MEPCO	Mutan Electric Power Company
DISCOs	Distribution Companies	PESCO	Peshawar Electric Supply company
NTDC	National Transmission and Dispatch Company	HESCO	Hyderabad Electric Supply company
IPPs	Independent Power Producers	QESCO	Quetta Electric Supply company
GENECO I	Jamshoro TPS, Kotri TPS	TESCO	Tribal Electric Supply company
GENECO II	Guddu TPS, Quetta TPS	SEPCO	Sukkur Electric Power company
GENECO III	Muzaffargarh TPS, Faisalabad TPS, Multan TPS, Shahadara PP	KANUP	Karachi Nuclear Power Plant
GENECO IV	Lakhra Coal Power Plant	CHASHNUP	Chashuma Nuclear Power Plant

Source: JICA Study Team prepared through interview to KESC

Figure 3.3.1 Administrative Structure of Power Supply in Pakistan

(3) Transmission Line System

Pakistan has voltage levels of 500 kV, 220 kV, 132 kV and 66 kV high voltage transmission line systems. Currently, 5,078 cct-km of 500 kV and 7,325 cct-km of 220 kV transmission lines are in operation. **Figure 3.3.2** shows the power system diagram of the existing 220 kV and 500 kV transmission lines.

Pakistan has a 500 kV trunk line in its vertical axis, which passes the nation from Peshawar Substation in the north to HUBCO Power Station in the south. The trunk line has an approximate distance of 1000 km. The line has a substation in the KESC area, which enables power trade between WAPDA group and KESC. The name of the 500 kV substation is the NK1 Substation, which belongs to the WAPDA group.

The system has other interconnection points with 220 kV at KDA on a 220 kV ring transmission line of Karachi. The 220 kV transmission line connects to Jamoshoro Substation of WAPDA group.

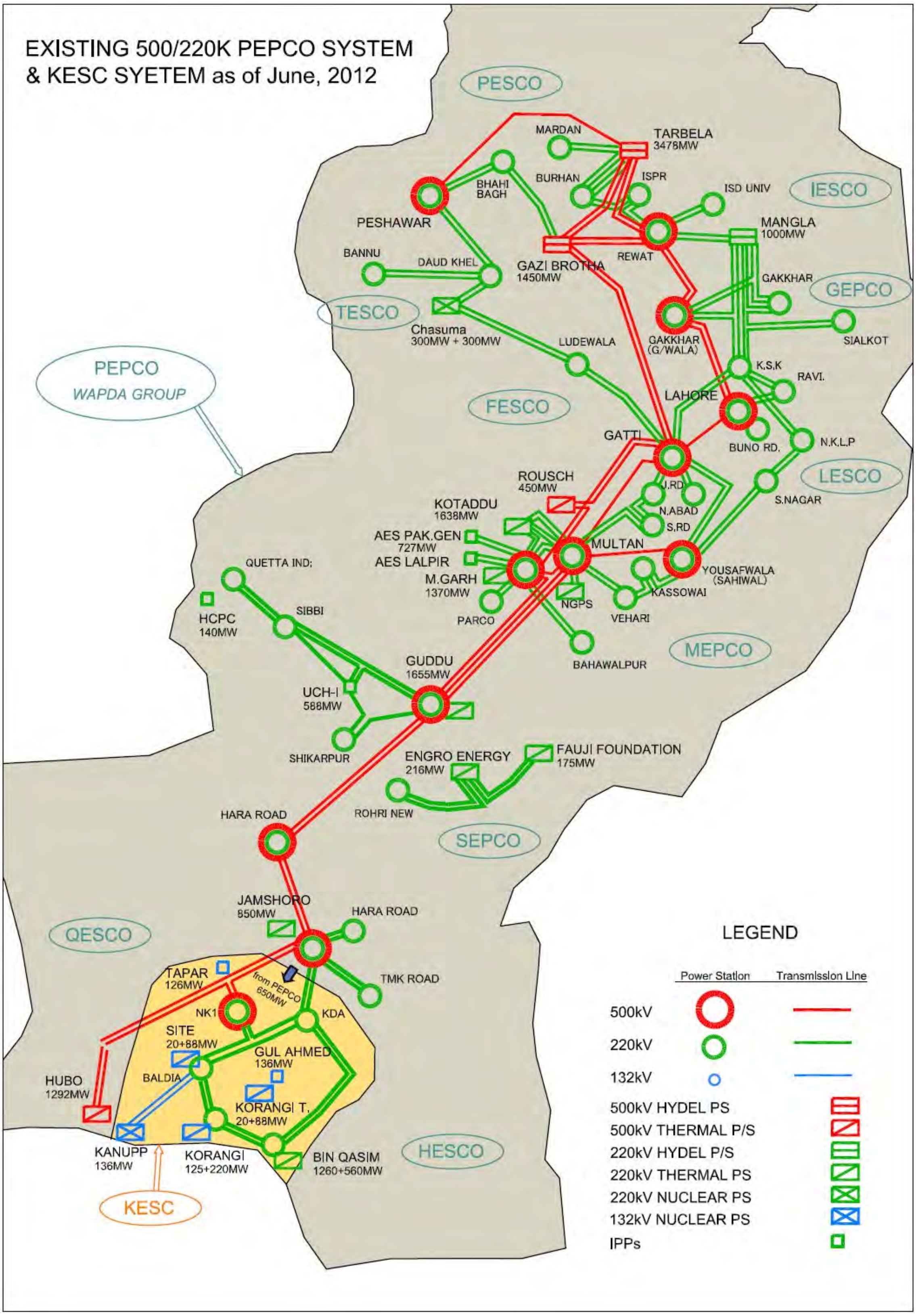
Table 5.3.1 shows the list of power generating plants of PEPCO. The power generating plant of KESC is shown **Table 5.3.2**.

Table 3.3.1 Power Generating Plant of PEPCO

NAME OF POWER STATION			FUEL	INSTALL CAPACITY (MW)	GENERATION CAPACITY (MW)	
PUBLIC SECTOR						
HYDRO					Summer	Winter
	1	Tarbela	Hydro	3,478	3,521	1,101
	2	Mangla	Hydro	1,000	1,014	409
	3	Ghazi_Barotha	Hydro	1,450	1,405	580
	4	Warsak	Hydro	243	171	145
	5	Chashma_Low_Head	Hydro	184	91	48
	6	Small Hydro	Hydro	89	64	20
THERMAL						
	7	TPS_Jamshoro_#1-4	Gas/FO	850	700	
	8	GTPS_Kolri_#1-7	Gas	174	140	
	9	TPSGiddiSteam #1-4	FO	640	270	
	10	TPS_Guddu_C.C._#5-13	Gas	1,015	885	
	11	TPS_Quetta	Gas	35	25	
	12	TPS_Muzaffargarh_#1-6	Gas/FO	1,350	1,130	
	13	NGPS_Multan_#1 and 2	Gas/FO	195	60	
	14	GTPS_Faisalabad_#1-9	Gas/HSD	244	210	
	15	SPS_Faisalabad_#1 and 2	FO	132	100	
	16	Shahdra_G.T.	Gas	44	30	
	17	FBC_Lakhra	Coal	150	30	
NUCLEAR						
	18	Chashma(PAEC)	Nuclear	325	300	
TOTAL				11,598	10,146	6,183
PRIVATE SECTOR						
HYDORO						
	19	Jagran	Hydro	30	30	
	20	Malakand-III	Hydro	81	81	
THERMAL						
	21	KAPCO	Gas/FO	1,638	1,386	
	22	Hub_Power_Project_(HUBCO)	FO	1,292	1,200	
	23	Kohinoor_Energy_Ltd._(KEL)	FO	131	124	
	24	AES_Lalpir_Ltd.	FO	362	350	
	25	AES_Pak_Gen_(Pvt)_Ltd.	FO	365	350	
	26	Southern_Electric_Power_Co._Ltd.(SEPCOL)	FO	135	119	
	27	Habibullah_Energy_Ltd._(11C PC)	Gas	140	129	
	28	Uch_Power_Project	Gas	586	551	
	29	Rouch_(Pak)_Power Ltd.	FO	450	395	
	30	Fauji_Kabirwala_(FKPCL)	Gas	157	151	
	31	Saba_Power_Company	FO	134	125	
	32	Japan_Power_Generation_Ltd.	FO	135	120	
	33	Liberty_Power_Project	Gas	235	211	
	34	Altern_Energy_Ltd.(AEL)	Gas	31	31	
	35	Attock Generation PP	FO	163	156	
	36	ATLAS_Power	Gas	219	219	
	37	Engro_P.P_Sixth	Gas	227	217	
	38	Saif_P.P.Shalwal, Punjab	RFO/Gas	225	225	

NAME OF POWER STATION			FUEL	INSTALL CAPACITY (MW)	GENERATION CAPACITY (MW)	
	39	Orient_P.P.Balloki, Punjab	RFO/Gas	225	225	
	40	Nishat_P.P.Near Lahore, Punjab	RFO	200	200	
	41	Nishat Chunian Proj Near Lahore	RFO	200	200	
	42	Sapphire_P.P.Muridke, Punjab	RFO/Gas	225	225	
	43	Gulf Rental RP, Gjranwala, Punj	RFO	62	62	
	44	Wallers Naudero Sindh	Gas	51	51	
				7,699	7,133	
				19,297	17,279	13,316

Source: The National Power System Expansion Plan 2011-2030 by NTDC



Source: JICA Study Team added from the updated data of the National Power System Expansion Plan 2011-2030 by NTDC

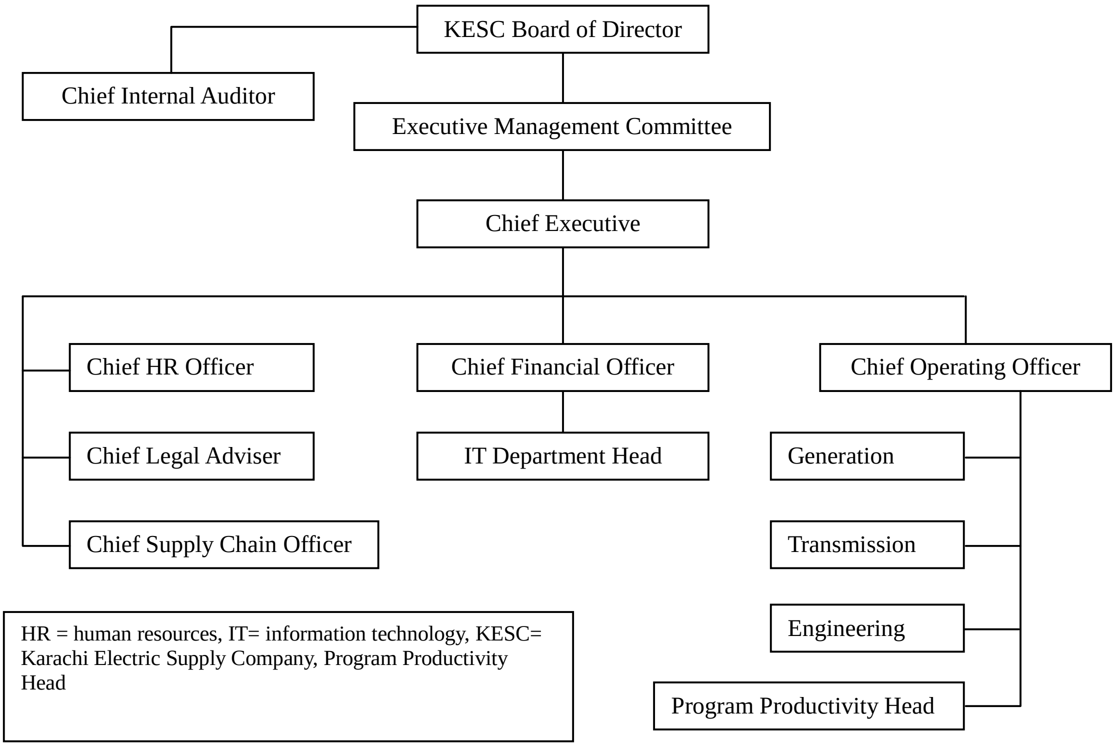
Figure 3.3.2 Major Existing Power System in Pakistan and its Relation with KESC System

3.3.2 Power Supply System in Karachi City

(1) Organization

KESC was established in 1913, having almost 100 years of history as a power producer. In 2003, the government decided to privatize KESC through transparent competitive bidding supported by ADB. The government transferred 73% of KESC's share to a consortium in 2005 led by KES Power Limited (KES Power). Of the consortium's share, 60% is owned by Al-Jomaih Holding (Al-Jomaih), a Saudi industrial group and the remaining 40% is owned by the National Industries Holding, a subsidiary of one of the largest Kuwaiti industrial and financial conglomerates.

Figure 3.3.3 below shows the organization of KESC as follows:



Source: "Post Privatization Rehabilitation, Upgrade, and Expansion", by ADB

Figure 3.3.3 Organization of KESC

(2) Existing Power Supply Facilities of KESC

KESC has their own power stations in four locations in Karachi City. Total installed capacity is 2341 MW as of June 2012. The power grid diagram in Karachi City and the single line diagram of the power grid of KESC is shown in **Figures 3.4.10** and **3.4.11**.

The installed capacity of KESC and other available power sources supplying KESC as of June 2012 are shown in **Table 3.3.2**. KESC generates power from its own plants, from IPP plants, nuclear plants, and from the WAPDA group.

Table 3.3.2 Installed Capacity of KESC and Other Available Capacity in KESC as of June 2012

Power Sources	Capacity Rate (MW)
1.Power plants of KESC(*1)	
(1) Bin Qasim –I	1,260
(2) Bin Qasim –II	560
(3) KTPS	125
(4) KGTPS-II	88
(5) KCCPP	220
(6) SGTPS	88
Sub-total	2,341
2.Power plants of IPPs	
(1) Gul Ahmed PS	127.5
(2) Tapal Energy PS	123.5
(3) Other	40
Sub-total	291
3.Nuclear Power Plants of KANUPP	
(1) KANUPP	80
Sub-total	80
4.Power from PEPCO	
(1) from PEPCO	650
Sub-total	650
Total	3,362

Source: KESC Website as of June 20, 2012

1) Bin Qasim Power Station (BQPS)

The Bin Qasim Power Station is located in the eastern part of Karachi City. The power station has two plants, the Bin Qasim Power Station I (BQPS-I) and the Bin Qasim Power Station II (BQPS-II).

BQPS-I started its operation in 1983 while BQPS-II has just begun its commission in 2012. Two power stations are located side-by-side in the same yard.

Bin Qasim Power Station I (BQPS-I)

BQPS-I is the biggest power plant in KESC with a total capacity of 1260 MW. The BQPS-I has six units of steam turbine generators, each with a capacity of 210 MW. Units 1, 2, 5, and 6 are manufactured by Hitachi (Japan) and Units 3 and 4 are by Ansaldo (Italy). Units 1 to 6 started its commission in 1983, 1984, 1989, 1990, 1991 and 1997 respectively. All units are operable using mixed fuel of heavy furnace oil (HFO), and natural gas. Units 1, 2, 5, and 6 are operable by 100% natural gas, while Units 3 and 4 become inoperable when HFO is mixed by natural gas of more than 50%.

Source: Planning Commission of GoP website
http://www.pc.gov.pk/hot%20links/PSR/5th%20OCT/2-KESC%20Presentation.pdf

Figure 3.3.4 Bin Qasim Power Station- I

Bin Qasim Power Station II (BQPS-II)

BQPS-II is a newly built combined cycle power plant located within the yard of BQPS-I. The last unit of BQPS-II has been commissioned in March 2012. The total capacity of the BQPS-II is 560 MW. The plant has three units of gas turbine made by General Electric (GE France) and one unit of steam turbine made by Harbin Power Engineering (China).

2) Korangi Thermal Power Station (KTPS)

The Korangi Thermal Power Station is located at Bin Qasim Town in Karachi City. The power station started its operation with four units of steam turbine generators. Rated capacities of Units 1 to 4 are 66 MW, 66 MW, 125 MW and 125 MW, and with manufacturing years of 1965, 1965, 1970, and 1977, respectively. Unit-1 and Unit-2 have already been dismantled and only Unit-4 is in operation. The turbine is operable by mixed fuel of HFO and natural gas.

3) Korangi Town Gas Turbine Power Station-I (KGTPS-I)

Korangi Town Gas Turbine Power Station-I is located in the Korangi inductrial area. The power station started operation with four units of 20 MW gas turbine generator, but only one unit is currently operable. Due to its low reliability, this station is not listed in **Table 3.3.2**.

Korangi Town Gas Turbine Power Station – II (KGTPS-II)

Korangi Town Gas Turbine Power Station-II is located in the Korangi industrial area. The plant consists of 32 reciprocating engine generators, unit capacity of which is 2.739 MW and 88 MW in total. The engine generators are made by GE Jenbacher.

4) Korangi Combined Cycle Power Plant (KCCPP)

The Korangi Combined Cycle Power Plant is a dual fuel (NG + diesel) combined cycle plant with a total capacity of 220 MW. KCCPP consists of four 48.4 MW gas turbines of GE, two in open cycle mode, two in combined cycle mode, and one 26 MW steam turbine of Scoda Czech. The plant is located at Bin Qasim Town in Karachi City, and was commissioned in 2009.

5) Site Thermal Power Station (STPS)

STPS started its operation with five units of 20 MW gas turbine generators. Out of the five, only one unit is operable in the present. Site gas turbine power stations (SGTPS), shown in the next item, was built in the same yard. Switchyard and step-up transformers are commonly used by SGTPS. Due to its low reliability, this station is not listed in **Table 3.3.2**.

6) Site Gas Turbine Power Station (SGTPS)

SGTPS is a reciprocating engine-generator plant having a total capacity of 88 MW and was commissioned in 2009. The location of the plant is in Sindh Industrial Trading Estate in Karachi City. The plant consists of 32 gas engines having unit capacity of 2.739 MW, manufactured by GE Jenbacher.

(3) Nuclear Power Plant and IPPs

Nuclear plant and IPP plants are supplying power to KESC.

1) Karachi Nuclear Power Plant (KANUPP)

The Karachi Nuclear Power Plant (KANUPP) is a nuclear power plant with a single unit of

CANDU PHWR (Canadian deuterium uranium and pressurized heavy water reactor). It has a capacity of 137 MW and is located at Paradise Point on the arid Arabian sea coast, about 30 km west of Karachi City. The plant started its commercial use in 1972. KANUPP is part of Karachi Nuclear Power Complex (KNPC) and is owned and operated by Pakistan Atomic Energy Commission (PAEC).

2) IPP: Gul Ahmed PS

Gul Ahmed PS is a power plant IPP joint venture of Gul Ahmed Group (Pakistan) and Toyoda Tsusho Corporation (Japan). The plant is a 136.17 MW diesel engine generator manufactured by Wartsila Diesel Oy (Finland). The plant was commissioned in 1997.

3) IPP: Tapal Energy PS

Tapal Energy PS is a power plant IPP of Wartsila Diesel Development Asia Ltd., Marubeni Corporation (Japan), Sithe Energies Inc. (USA), and the principals from Ameejee Valeejee and Sons (Pvt) Ltd. (Pakistan). The plant is a 126 MW diesel engine manufactured by Wartsila and coupled with generator sets of ABB. The plant is designed for continuous operation on HFO with start-up and stops on LFO. The plant was commissioned in 1997.

(4) Existing Transmission Line and Distribution Line Facilities of KESC

KESC has 220 kV ring transmission lines, which encircles Karachi City. There are six 220 kV/132 kV substations on the 220 kV ring line. These substations are KDA, BQPS, KCR, Lalazar, Baldia, and NK1. The 132 kV lines are expanded from the substations, supplying the 132 kV/11 kV grid substation. In total, 61 grid substations are allocated within the city.

NK1 Substation, located northwest of Karachi on the 220 kV ring line, is a facility of WAPDA group and has 500 kV facilities connecting to a 500 kV trunk line of the WAPDA group network.

MDK Substation, which is also on the 220 kV ring line, also has an interconnection line with the WAPDA group network. The transmission line connecting MDK Substation to Jamshoro Substation is owned by the WAPDA group.

The Baldia Grid Substation on the 220 kV ring line has connection to the KANUPP Nuclear Power Station with 132 kV transmission line.

Most of the 220 kV transmission lines are supported by towers. Where lines pass through house-congested areas, poles are used. Transmission routes are selected within the right-of-way of roads. Where the route passes through densely populated areas, 220 kV underground cables are used. The length of overhead lines and underground lines are 16.8 cct-km and 321 cct-km, respectively.

Most 132 kV transmission lines are supported by towers and poles. The 132 kV line runs on the center-media or sides of roads, which is within the right-of-way of road. When the 132 kV passes through densely populated areas, underground cables are used. The length of overhead lines and underground lines are 29 cct-km and 604 cct-km respectively.

Tables 3.3.3, **3.3.4** and **3.3.5** show the list of 220 kV transmission lines, 132 kV transmission lines, and grid stations owned by KESC.

The 11 kV outgoing feeders from the grid substation are distributed directly to industrial customers, as well as to 15,200 numbers of 11 kV/400 V pole mounted substations which are allocated in the city. Most commercial and residential consumers are receiving power after the voltage was stepped down to 400 V by the pole mounted substations.

Table 3.3.3 220 kV Transmission Lines of KESC as of June 2012

S.NO	CIRCUIT	LENGTH-KM	
		Overhead	Underground
1	BQPS-KCR-I	35.000	0.5
2	BQPS-KCR-II	35.000	0.5
3	BQPS-PIPRI WEST-I	8.693	-
4	BQPS-PIPRI WEST-II	8.693	-
5	BQPS-PIPRI WEST-III	8.570	-
6	BQPS-ICI	0.360	-
7	ICI-PIPRI WEST	8.502	-
8	PIPRI WEST-KDA-I	30.708	-
9	PIPRI WEST-KDA-II	30.708	-
10	KDA-BALDIA	30.939	-
11	KDA-NKI	30.750	-
12	BALDIA-NKI	14.410	-
13	KCR-LALAZAR-I	8.120	1.35
14	KCR-LALAZAR-II	8.120	1.35
15	LALAZAR-MAURIPUR-I	2.887	4.1
16	LALAZAR-MAURIPUR-II	2.887	4.1
17	BALDIA-MAURIPUR-I	19.715	2.1
18	BALDIA-MAURIPUR-II	19.715	2.1
19	KCR/CCP-I	8.712	0.357
	TOTAL	321.201	16.814

Source: KESC

Table 3.3.4 132 kV Transmission Lines of KESC as of June 2012

S.NO	CIRCUIT	LENGTH-KM	
		Overhead	Underground
1	KTPS - LANDHI - I	13.300	-
2	KTPS - LANDHI - II	12.500	-
3	QAYYUMABAD - KORANGI EAST - I	10.800	0.075
4	QAYYUMABAD - KORANGI EAST - II	10.800	-
5	KTPS – PRL	1.471	1.005
6	PRL- KORANGI WEST	6.011	-
7	KORANGI TOWN - KORANGI WEST	7.281	-
8	KORANGI TOWN - BALOCH	8.613	0.042
9	KORANGI WEST- DEFENCE	1.244	4.744
10	DEFENCE - GIZRI	2.271	4.685
11	GIZRI - BALOCH - KORANGI WEST	8.409	-
12	GIZRI - CLIFTON	3.413	-
13	CLIFTON - QUEENS ROAD	5.723	-
14	GIZRI - QUEENS ROAD	4.856	-
15	PIPRI WEST - BOC	16.258	-
16	BOC - DHABEJI	18.586	-
17	DHABEJI - GHARO	12.502	-
18	PIPRI WEST - RECP	7.858	-
19	RECP – GHARO	33.344	-
20	PIPRI WEST - LANDHI	14.130	-
21	PIPRI WEST - PORT QASIM	4.190	-
22	PORT QASIM - LANDHI	9.950	-
23	PIPRI WEST - KORANGI TOWN	19.129	2.860
24	PIPRI WEST - KEPZ	12.104	-
25	KEPZ - LANDHI	1.653	5.732
26	LANDHI - GUL AHMED	7.460	-
27	KORANGI TOWN - GUL AHMED	0.350	-
28	GUL AHMED - AIRPORT - I	2.270	-
29	GUL AHMED - AIRPORT - II	2.270	-
30	LANDHI- CAA	13.500	1.600
31	CAA- MALIR	1.400	4.457
32	KDA - MEMON GOTH	14.200	-
33	MEMON GOTH - MALIR	3.800	2.875

S.NO	CIRCUIT	LENGTH-KM	
		Overhead	Underground
34	MALIR - GULISTAN-E JOHAR	7.560	-
35	LANDHI - GULISTAN-E-JOHAR – GULSHAN	26.792	-
36	KDA - GULISTAN-E-JOHAR	6.720	-
37	KDA - GULSHAN	11.360	-
38	KDA - GULSHAN-E-MAYMAR	5.800	-
39	GULSHAN-E-MAYMAR - SURJANI	5.200	0.271
40	VALIKA - SURJANI	6.900	0.271
41	KDA - FEDERAL B	14.700	-
42	FEDERAL B - VALIKA - FEDERAL A	10.700	-
43	NORTH KARACHI - VALIKA I	2.900	0.250
44	NORTH KARACHI - VALIKA II	2.900	0.250
45	BALDIA - VALIKA'	11.800	-
46	BALDIA - ORANGI	6.500	-
47	ORANGI - VALIKA (JAVEDEN CEMENT+ PS)	9.690	-
48	VALIKA - NORTH NAZIMABAD	6.430	-
49	NORTH NAZIMABAD - HAROONABAD	5.880	-
50	VALIKA - LIAQUATABAD	11.250	-
51	LIQUATABAD - HAROONABAD	10.280	-
52	MARIPUR - HAROONABAD - I	6.158	-
53	MARIPUR - HAROONABAD - II	6.158	-
54	BALDIA - SGT - II	4.300	-
55	BALDIA - SGT - SITE - I	4.970	-
56	SGT - SITE – II	0.670	-
57	BALDIA - KANNUP - I	21.078	-
58	BALDIA - KANNUP - II	21.078	-
59	BALDIA – HUB	16.000	-
60	BALDIA - TAPAL	8.480	-
61	TAPAL – HUB	8.480	-
62	HUB - VINDER	42.900	-
63	KORANGI EAST - AIRPORT II	2.312	-
64	KORANGI EAST - AIRPORT II	2.312	-
65	KORANGI SOUTH - KORANGI	4.500	-
	TOTAL	604.404	29.117

Source: KESC

Table 3.3.5 Grid Station of KESC as of June 2012

SL	Grid Station	SL	Grid Station	SL	Grid Station
1	AIRPORT	22	GULSHAN	43	MEMON GOTH (HIS)
2	AIRPORT-2 (HIS)	23	GULSHAN-E-MAYMAR (HIS)	44	NORTH KARACHI
3	AZIZABAD (HIS)	24	HAROON ABAD	45	NORTH NAZIMABD
4	BALDIA	25	HUB CHOWKI	46	OLD TOWN (132kV)
5	BALOCH COLONY	26	ICI	47	ORANGI TOWN
6	BELA	27	JACOBLINE	48	PIPRI EAST
7	BOC	28	JAIL ROAD (HIS)	49	PIPRI WEST
8	C A A	29	KDA SCHEME 33	50	PORT QASIM
9	CIVIC CENTER	30	KEPZ	51	PRL (HIS)
10	CLIFTON	31	KESC HOSPITAL (HIS)	52	QAYYUMABAD
11	CREEK CITY	32	KORANGI CREEK ROAD	53	QUEENS ROAD
12	DEFENCE	33	KORANGI EAST	54	RECP
13	DHABEJI	34	KORANGI SOUTH (HIS)	55	SITE
14	ELENDER ROAD	35	KORANGI TOWN	56	SURJANI TOWN
15	FEDERAL A	36	KORANGI WEST	57	UTHAL
16	FEDERAL B	37	LALAZAR GRID	58	VALIKA
17	GADAP	38	LANDHI	59	VINDER
18	GARDEN EAST	39	LIAQUATABAD	60	WEST WHARF (132kV)
19	GHARO	40	LYARI	61	DHA – 1
20	GIZRI	41	MALIR		

SL	Grid Station	SL	Grid Station	SL	Grid Station
21	GULISTAN E JOHAR	42	MAURIPUR (220/132 kv)		

Source: KESC

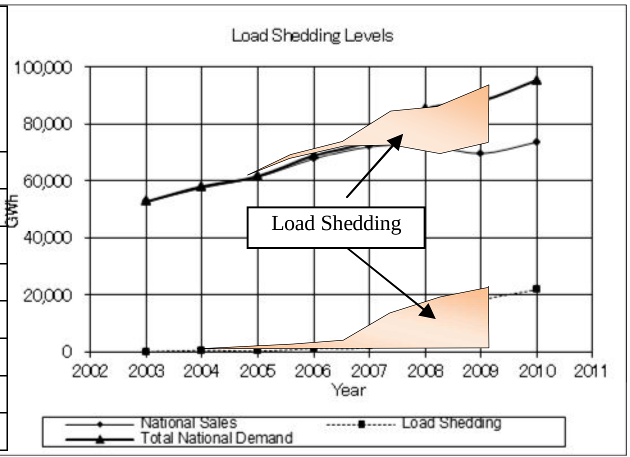
3.4 Status of Present Power Supply

3.4.1 Country-wide Status of Present Power Supply

(1) Power Generation

According to the latest report of NTDC in 2011, shortage of power in Pakistan started in 2003. Since then, the power shortage is increasing year by year. In 2009, the power shortage had exceeded 20% of the available capacity of the whole of Pakistan as shown in the **Figure 3.4.1**. The power shortage is derived from the balance of power demand and available generating capacity.

Year	National Sales (GWh)	National Load Shedding (GWh)	Total National Demand (GWh)	Shedding % of National Demand
2003	52,661	-	52,661	0.0%
2004	57,467	520	57,986	0.9%
2005	61,247	265	61,512	0.4%
2006	67,608	1,208	68,815	1.8%
2007	71,947	2,040	73,982	2.8%
2008	72,518	12,578	85,096	14.8%
2009	69,668	18,222	87,890	20.7%
2010	73,595	21,821	95,238	22.9%



Source: From the data of National Power System Expansion Plan 2011-2030 by NTDC

Figure 3.4.1 Supply–Demand Balance and Load-Shedding

Each power company supplying power to consumers has responded to the power shortage by conducting load-shedding. The load shedding is causing economic slowdown because of the cutback of production in industries, and interruption on commercial act and other businesses.

Recently, extreme load-shedding is creating serious social problems to people, since most of the life-line utilities such as potable water supply, sewage, medical treatment, welfare, and communication system are dependent on electricity.

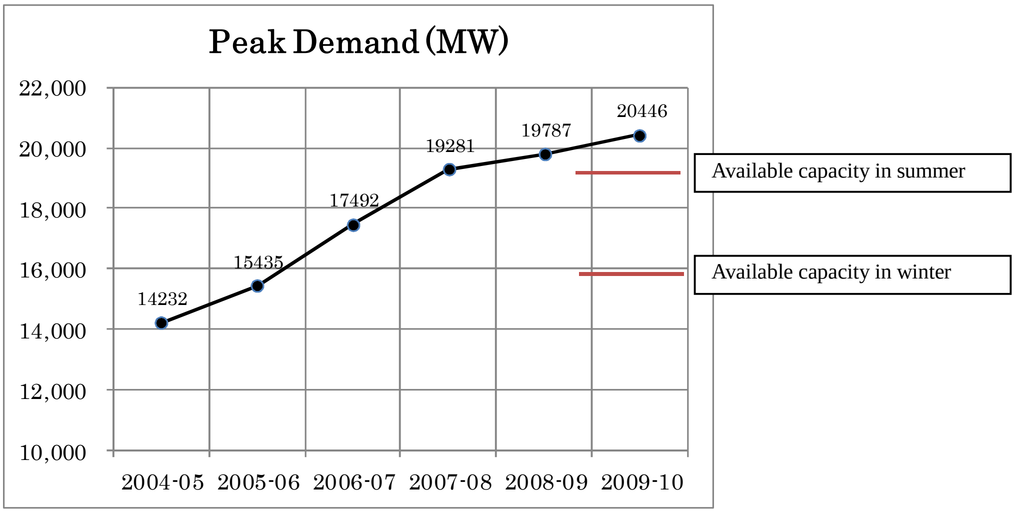
The total installed capacity and available capacity of PEPCO and KESC including IPPs and nuclear plants as of 2010 are as shown in **Table 3.4.1**.

Table 3.4.1 Installed Capacity and Available Capacity of PEPCO and KESC

Power Company	Installed (MW)	Available Capacity (MW)	
		Summer	Winter
PEPCO	19,297	17,279	13,316
KESC	2,158	1,938	
Total	21,455	19,227	15,254

Source: Figures are derived from Table 3.4.1 and Table 3.4.3

Against the above available capacity, electricity demand in Pakistan had been increased with an average rate of 8.5% between 2004 and 2010. **Figure 3.4.2** shows the peak demand of PEPCO and KESC with available capacities during summer and winter. The seasonal difference of generation capacity is also one of the difficulties of power supply operation in Pakistan. As shown in **Figure 3.4.2**, it is obvious that the available capacity is lower than the demand, especially in winter.

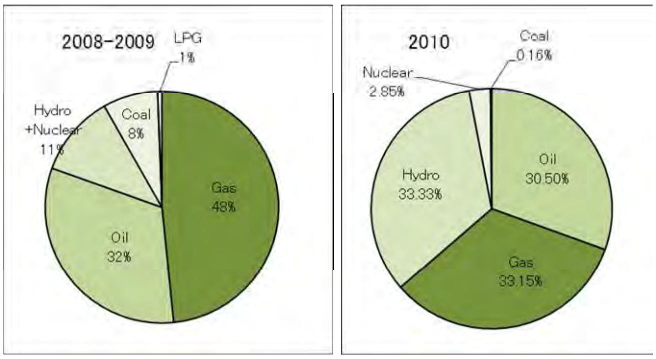


Source: From the data of National Power System Expansion Plan 2011-2030 by NTDC

Figure 3.4.2 Peak Demand & Available Capacity

As for gas supply, which is the key fuel for generation in 1970s and 80s even in 90s, the reserves of natural gas in Pakistan was redundant against the needs of increasing energy. However, the recent crisis of gas restriction emerged by the rapid demand increase and depletion of some of the major natural gas fields in Pakistan.

The government issued the "Natural Gas Allocation Management Policy" in 2005 which restricts natural gas allocation to power generation. Due to the restriction of use of natural gas for power generation, the source of power generation changed drastically after 2009 as shown in **Figure 3.4.3**. The share of natural gas is forced to be reduced from 48% to 33.15% and the dependency on hydropower is increased, even retaining the season dependence issue.



Source: Graphed the data of National Power System Expansion Plan 2011-2030 by NTDC

Figure 3.4.3 Energy Supply by Source in 2008-2009 and 2010

(2) Power Transmission and Distribution

The transmission lines of the WAPDA group are owned and maintained by the NTDC. In the KESC territory, KESC owns and maintains the transmission lines.

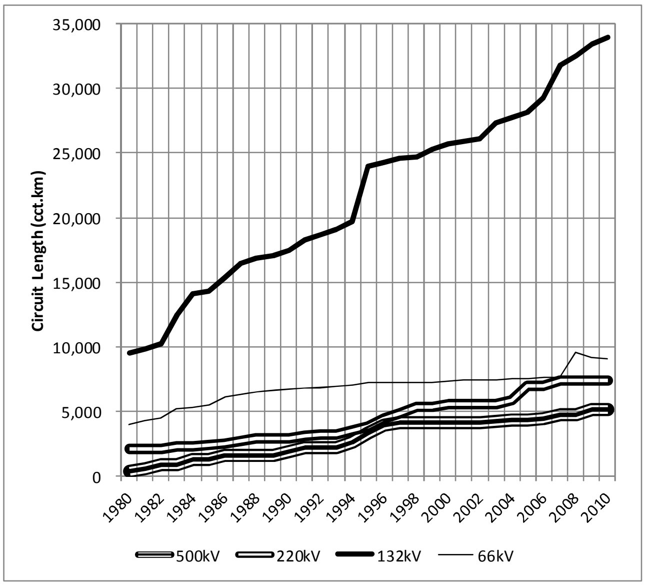
The voltage classes in Pakistan are 66 kV, 132 kV, 220 kV and 500 kV. The transmission lines have been constructed with an almost constant rate since 1980, as shown in **Figure 3.4.4**.

Length of the 132 kV transmission lines accounts to 60% of the total transmission lines. The 132 kV system is going to take over the position of 66 kV system.

The 132 kV/11 kV substation is called as the grid substation or GS, and is the connection point of the transmission line and distribution line. Most of the consumers are receiving power from the 11 kV or 400 V system.

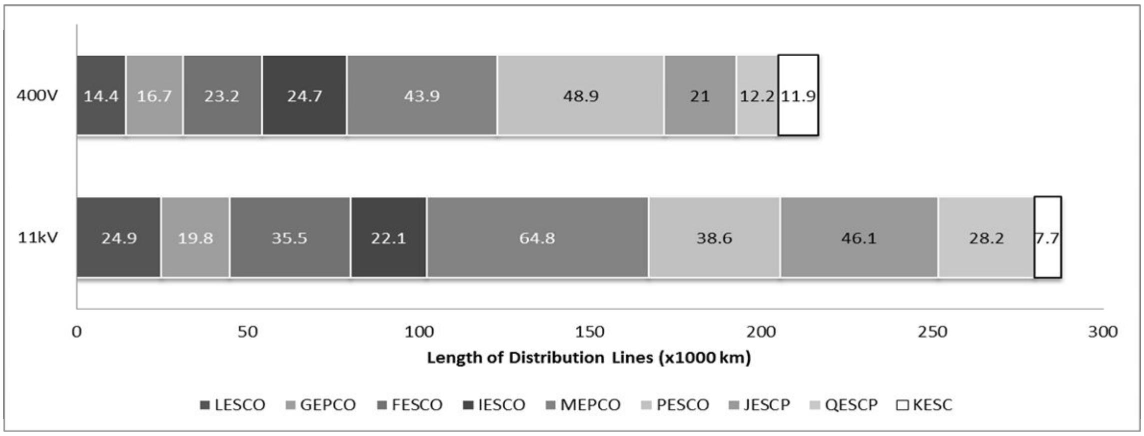
The lengths of the 11 kV and 400 V distribution lines are 287,672 km and 216,962 km respectively, in 2010.

Proportion of the length by each distribution company is shown in **Figure 3.4.5**.



Source: Power System Statistics by NTDC and Annual Report of KESC 2010-11

Figure 3.4.4 Length of Transmission Line



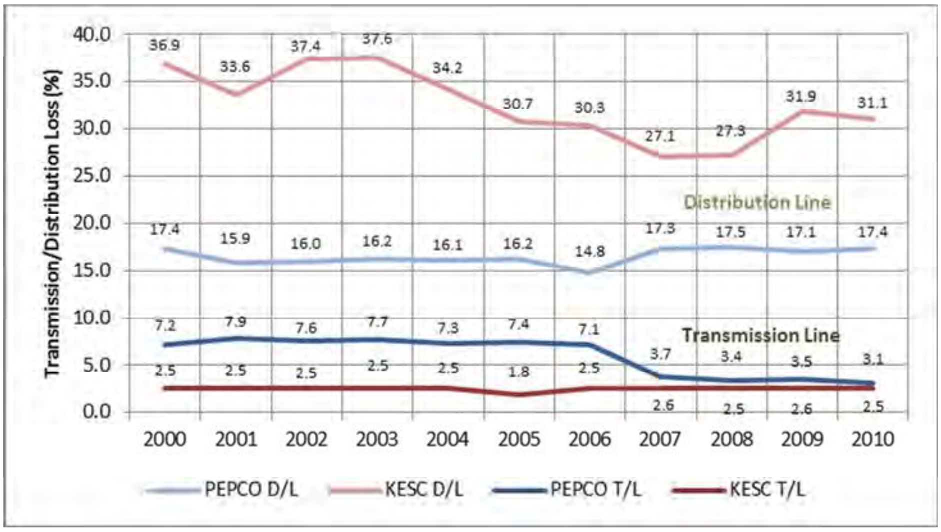
Source: Power System Statistics by NTDC and Annual Report of KESC 2010-11

Figure 3.4.5 Length of Distribution Line

Figure 3.4.6 shows the transmission and distribution losses.

PEPCO had maintained transmission losses between 7% and 8% up to 2006. Transmission losses lowered to 3.7% in 2007 which gradually lowered to 3.1%. The drop of transmission line losses in 2006 may be caused by the increase of 220 kV lines in the recent years. Transmission loss of KESC is almost kept at 2.5%, which is a reasonable value. PEPCO has relatively higher transmission losses than KESC which is caused by long transmission line distances. PEPCO has many long distance transmission lines, while KESC has shorter distance of the same.

Distribution losses are huge at around 17% for PEPCO and 31% for KESC. The distribution loss of PEPCO includes both the losses in rural and urban areas, while that of KESC includes only urban areas. The figures of losses include both technical and non-technical losses.



Source: Graphed the data of National Power System Expansion Plan 2011-2030 by NTDC

Figure 3.4.6 Transmission and Distribution Losses

(3) Problems to be solved

As mentioned in Sub-section 3.4.1, Pakistan is facing power shortage crisis since the last decade. The main reasons of power shortage are; 1) rapid growth of power demand, 2) fuel supply restriction, 3) high distribution losses, and 4) seasonal reduction of hydropower generation.

Although the power demand is increasing rapidly, new power generation plants has not been built. The price of oil rises drastically, while all dual-fuel generators go for gas-fired. However, the government restricted the quantity of gas for power generation. Therefore, generating plants produce power below its rated capacity, or implement a reduction in operating time.

The high rate of distribution loss is consuming power without productive works and recovering generating cost. It also induces high tariff rates.

The reduction of dependency on imported oil and restriction of gas supply to power production urge power companies to develop hydro-plants. Pakistan has undeveloped hydropower sites in the north, but seasonal gaps in power generation is a problem for it to be an alternative source to thermal power.

The following are recent topics showing the severity of power shortage and tariff setting in the country.

1) Transfer of power from PEPCO to KESC

In the circumstance of a country-wide power shortage, the government instructed the WAPDA group to send up to 650 MW of power to KESC. As the KESC is a privatized company, there should be prioritization in power supply to the consumers who are paying revenue by reducing supply to the consumers who do not pay, in case of a power shortage. Therefore, residential consumers will have more difficulty in receiving power unless the government helps in supplying power to them.

The agreement was made between PEPCO, LTDC of the WAPDA group, and KESC in 2010 for a period of five years.

However, it is critical for the WAPDA group, to supply 650 MW to KESC when there are circumstances of restricted allocation of natural gas and extremely high rate of imported oil. At present, the duration of load-shedding to commercial and resident consumers in the PEPCO area is almost double of the KESC area.

Source: Google Earth

Figure 3.4.7 Rental Power of Ship-mounted Power Plant of 330 MW at Korangi

As an immediate effective solution for sending the agreed 650 MW power to KESC, PEPCO called for a rental of ship-mount power stations from Turkey in 2010. The power station is to provide 231.8 MW of power to PEPCO as part of the 650 MW agreement. The price of the rental power is 1.7 times the selling price to KESC.

The plant has already been anchored to the offshore near the Korangi Thermal Power Station, and connected to a tower at a bank, where it has been successfully tested. However, as of this moment (2012), the power has not yet been transmitted to the KESC grid because of unopened reasons between the rental power company and the government. The reason of which, deems to be payment trouble.

PEPCO is also planning a solution to supply 650 MW of power by directing a 220 kV line from HUBCO Thermal Power Station to the KESC grid. The capacity of the HUBCO Thermal Power Station is 1280 MW.

The power generation and receiving power on June 24, 2012 at 12:00 midnight is shown in **Table 3.4.2**. No load shedding was carried out at the time. Therefore, the real demand of Karachi City at midnight during low-demand time zone was obtained. Load-shedding usually starts from 6:00 in the morning to 11:30 in the evening in a day. Most generating power facilities of KESC runs at full capacity even during midnight, except when KTPS is not generating power and BQPS-I is running at half of its available capacity of 1150 MW. However KESC is receiving 645 MW from PEPCO, which is almost an upper limit of the 650 MW agreement.

Table 3.4.2 Receiving Power on June 24, 2012 at 12:00 Midnight

Power Station and Power Sent	Generation (MW)	Available Capacity (MW)	Percentage (%)
BQPS-I	605	1150*	53%

Power Station and Power Sent	Generation (MW)	Available Capacity (MW)	Percentage (%)
BQPS-II	508	560	91%
KCCPP	181	220	82%
GTPS-II	85	88	97%
KTPS	0	125	0%
SGTPS-II	88	88	100%
Total KEC	1467		
IPPs & KANUPP	249	371	67%
From PEPCO	645	650 limit	99%
Grand Total	2361		

Source: Control Center of Bin Qasim Power Station - I

People in the WAPDA group area are feeling a sense of unfairness, which is becoming one of the social and politic problems.

2) Tariff

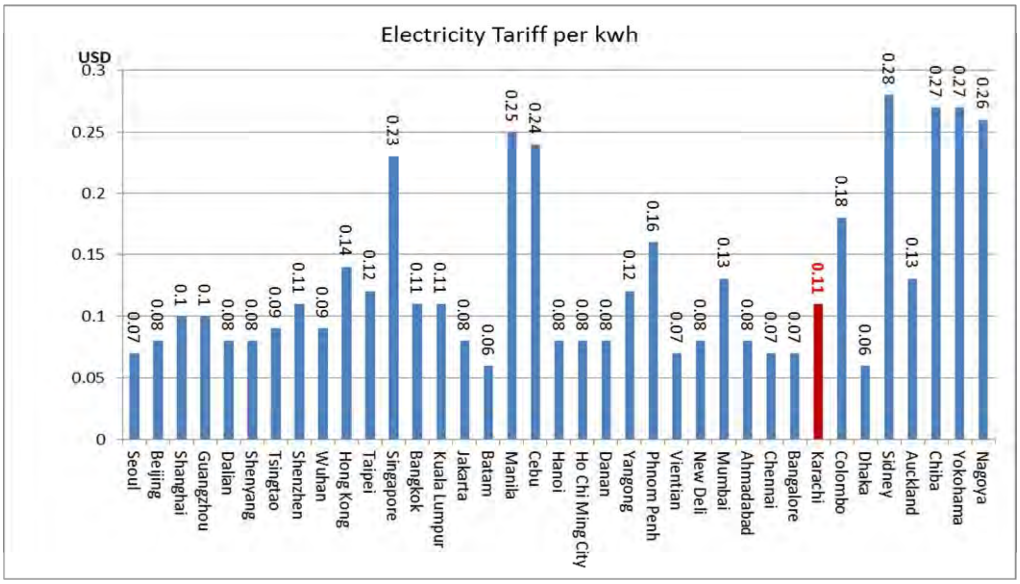
Electricity tariff was determined by NEPRA and the government. Power producers proposed the rate of tariff, taking into account the generation cost before NEPRA sets the proposal to the government. The final tariff is determined by the government taking account its affordability for the people. In 2010, the proposed rate by NEPRA and the government were determined for a final tariff rate of PKR 3.43.

Figure 3.4.8 shows the graph of tariff of various countries made by Japan External Trade Organization (JETRO) in 2012. The graph is made as a comparative study for Japanese investors who are seeking possible cities abroad with industrial areas. Compared to other cities, the tariff of Karachi is not extremely high, but the price is not attractive to the investors when compared to the other equivalent cities.

According to the interview with industrial consumers, the tariff paid to KESC varies from PKR11 to PKR13, which is equivalent to US$0.117 to US$.138 (US$1=PKR93.896, Jul 2012). The generation cost of diesel engine generator, which is used for emergency is around PKR35 (eq.US$0.372).

Some industrial consumers and hospitals have their own gas-turbine generators as a self-support routine. The generation cost (operation cost excluding initial investment) is PKR5 to PKR7.5, which are equivalent to US$0.053 to US$0.079 including all maintenance costs.

Generation cost using natural gas is less than the tariff for industrial consumers. Most factories in the city are studying the option of self-generation of electricity by gas. However, they worry about the increase in gas price, and future restrictions of gas supply to them.



Source: JETRO Cost Comparison Among Major Cities in Asia and Oceania, April 2012

Figure 3.4.8 Electricity Tariff of Industrial Area in the World

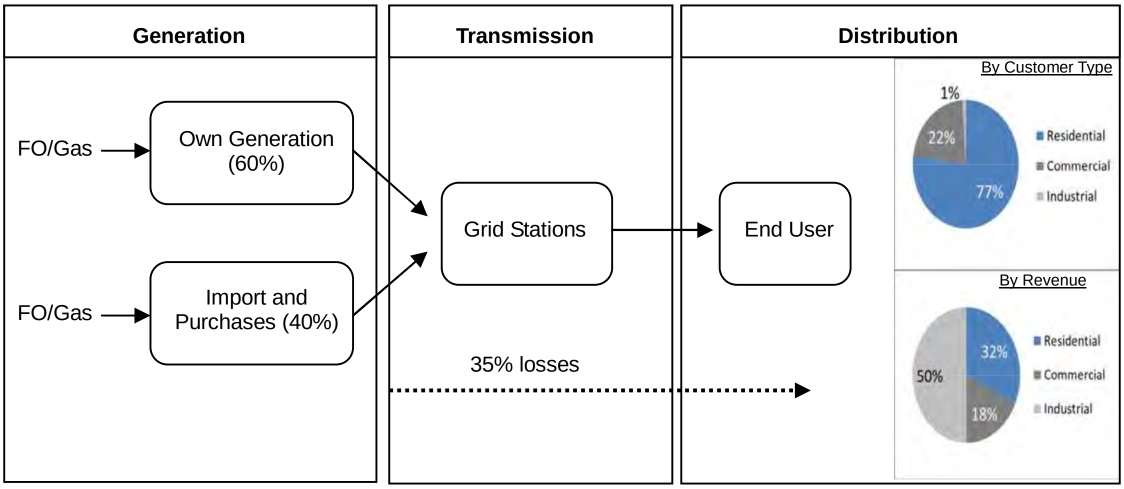
3.4.2 Status of Present Power Supply in Karachi

(1) Overview of Power Supply Status

Figure 3.4.9 shows the overview of power supply status of KESC. KESC is generating 60% of the total power by their own facilities while purchasing the remaining 40% to other power companies. About 35% of the sent power is lost due to transmission and distribution loss.

The number of consumers classified as residential, commercial, and industrial are 77%, 22%, and 1%, respectively. While the total revenue coming from residential, commercial, and industrial consumers are 32%, 18%, and 50%, respectively.

Thus, half of the total revenue is collected from industrial consumers which are only 1% of the total customers.



Source: by KESC from website of Planning Commission of GoP
http://www.pc.gov.pk/hot%20links/PSR/5th%20OCT/2-KESC%20Presentation.pdf

Figure 3.4.9 Overview of Power Supply Status of KESC

(2) Power Generation

Present status of power generation facilities of KESC are as follows:

1) Power plants of KESC

The largest plant of KESC is the BQPS. The plant is located neighboring the Bin Qasim Port Authority. Very recently in March 2012, a new combined cycle plant with a 560 MW power capacity has been added and is in operation. The natural gas consumption for the 560 MW output is 130 MMcfd (million cubic feet per day) and is guaranteed for continuous supply. The new plant is called the BQPS–II while the existing plant which is operating since 1983 is called the BQPS-I. BQPS-I has six units in which, all units have dual fuel specification of HFO and natural gas. However, four Hitachi units are operable by 100% natural gas, but two Ansaldo units are not operable using the mixed fuel beyond 50% of natural gas. A total of 220 MMcfd of natural gas is allocated for KESC, including the above 130 MMcfd for BQPS-II.

To reduce the dependency of imported oil, KESC is determined to modify the units of Ansaldo to coal-fired. The feasibility study is in process by the US consultant. KESC intends to perform fuel conversion to four other units when fuel-conversion of the two units is successfully done. According to KESC, the maximum output of BQPS-I is evaluated at 1150 MW as against its rated capacity of 1260 MW.

KTPS was the second largest power plant of KESC, located at the Karachi Port. Only one unit of 125 MW is currently operable. However, in 2009, the KCCPP was built next to the plant having 220 MW in total.

The Korangi Town GTPS is located in the Korangi industrial area. Only one unit with 20 MW power is operable, but KESC no longer considers this plant as a source of available power according to KESC’s latest website. New plant of reciprocating engine generator with a capacity of 88 MW (32 units x 2.739 MW) in total, have been built next to the plant in 2009. The 20 MW plant is called GTPS-I, and the new plant is called GTPS-II.

STPS is located at the eastern area of Karachi City. Only one unit with 20 MW capacity is operable, but KESC no longer considers this plant as a source of available power according on KESC’s latest website. However in 2009, a new plant of reciprocating engine generator with capacity of 88 MW (32 units x 2.739 MW) in total, have been built next to the plant.

2) Power plants of IPP

The Gul Ahmed Power Station with 137 MW and Tapal Energy Power Station with 126 MW of IPP plants are selling power to KESC. Other small IPPs are also available selling their surplus power to KESC.

Up to present, DHA Cogen Ltd. supplies 84 MW to KESC. The generation plant was constructed in 2008, as a co-generation of desalination plant. However, there were many technical problems and the plant ceased its power generation.

3) Nuclear power plants

KANUPP is located at Paradise Point, 30 km east from the center of Karachi City. The plant has a generating capacity of 137 MW. However, KESC corrected this capacity as 80 MW on their latest website.

The plant is connected to the Balidia Grid Substation of KESC with a 132 kV transmission line. The generated power by KANUPP is used for the demand of KESC.

4) Power from WAPDA group

As aforementioned, KESC is receiving power of up to 650 MW from the WAPDA group. The agreement was signed in January 2010, and the supply is for five years. The power received at NK1 Substation is through 500 kV, and at KDA Substation is through 220 kV.

5) Total power generation

Latest information on actual status of power generation of 2010-11 and the demand and generation forecast of 2011-12 and 2012-13 are shown in **Table 3.4.3**.

Table 3.4.3 Physical Targets and Achievements of KESC System

Item	2010 - 11 Actual	2011-12 Estimate	2012-13 Target
Additional Installed Capacity (MW)	-	560 (BQPS-II)	-
Total Installed Capacity (MW)	1821	2256 (*1)	2256
Growth Rate (%)		2.4%	0%
Maximum Demand (MW)	2565	2616	2668
Growth Rate (%)		2%	2%
Energy Generation (GWh)	14836	14676	15560
Growth Rate (%)		-1%	6%
Annual Energy Sales (GWh)	10059	10317	11281
Growth Rate (%)		3%	9%
Transmission and Distribution Losses (% of Net Generation)	32%	30%	28%
Consumers Cumulative (Million)	2.33	2.37	2.42
Consumers Added (Million)		0.05	0.05
Electrification of Villages/Abadies (Nos.)	510	580	650
Addition (Number)	67	70	70

Note. (*1): "Total Installed Capacity" in 2011-12 in this Table 3.4.3 is 85MW less estimated than 2341MW in Table 3.3.2, KESC's data. This may be caused by some old generating units which cannot be considered operable.

Source: "Annual Plan 2012-13" by Planning Commission, Government of Pakistan, June 2012

(3) Transmission Line and Distribution Line

Transmission lines of 220 kV and 132 kV are relatively well maintained. The capacity of the lines are sufficient, systems loss of 2.5% is reasonable.

However, distribution lines have much trouble as the loss in **Figure 3.4.6** shows 31%. Through the interview with the consumers, voltage of 11 kV lines drops 13.6% and 400 V drops 22%.

There are many aged lines which are causing a majority of line faults or trips by over-current, short circuit, phase grounding, and missing phase. Insufficient sizes of conductors, unorganized arrangement of conductors, and uninsulated conductors are major reason of faults.

The bare-conductor of 400 V line allows easy access to power thieves.

(4) Problems to Solve

Karachi City in the KESC territory has listed the following major problems on supplying power.

1) Shortage of gas and fuel conversion

Natural gas shortage is induced from the rapid increase of CNG (compressed natural gas) demand. Natural gas was mainly shared among generation, fertilizing industries, and steel mills. Recently, the demand of CNG increased because CNG is used as an alternative to expensive oil. Many vehicles, especially trucks, have converted their fuel system to CNG-use. To adjust the demand among gas-consumers, the government restricted the allocation of gas for generation.

KESC is receiving only 220 MMcfd on June 2012, against a total required quantity of 450 MMcfd. Therefore, KESC cannot produce sufficient power to meet the power demand even if the installed capacity of the plant is able to meet the power demand because of gas shortage and gas restrictions.

As the oil price is high, KESC is in the planning stage to convert fuel system to coal of two existing units in Bin Qasim Power Station-1, which are designed as dual fuel of HFO and natural gas. KESC estimated the cost at US$350 million for two units and seek coal import from Indonesia. KESC formed a joint-venture with Bright Eagle Enterprise of Hong Kong to form a joint-venture to execute the above work. Feasibility study was already done by Knight Piesold, a consultant from the United States.

KESC has the intention to convert all other units, and also to convert the units of the Korangi Thermal Power Station.

2) Power from WAPDA

KESC is now receiving power from the WAPDA group for up to 650 MW, but the shortage of power in WAPDA is more serious than in KESC. An agreement to provide power to KESC was signed in 2010 and is effective for five years. KESC is expecting the renewal of the said agreement, but KESC is also seeking methods for self-support by realizing fuel conversion.

3) Load shedding

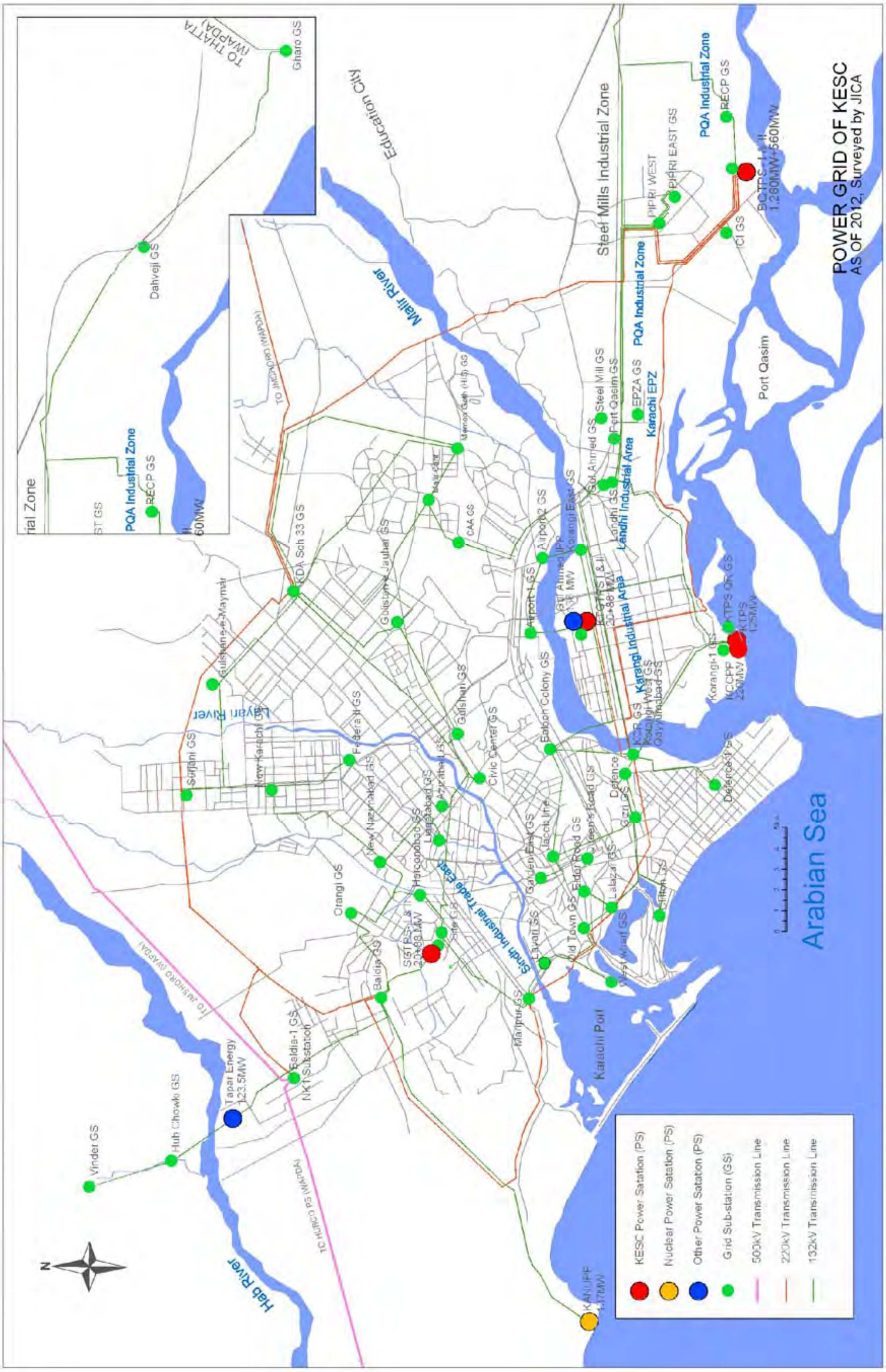
Pakistan, as a whole country, is currently facing power shortage crisis as explained in Sub-section 3.4.1. Electricity demand of Karachi City for 2011-2012 is estimated at 2616 MW, which is lower than the available capacity of 3362 MW as shown in **Table 3.3.2.** Even though the available capacity is higher, the actual limit of power production of KESC is 2256 MW only. To satisfy the shortage in power, the gap will be adjusted through load shedding.

According to KESC, no load-shedding has been done in industrial areas because the rate of tariff collection (recovery) is almost 100% in industrial areas. As KESC is a privatized company, the load shedding is done according to the recovery ratio. Therefore, load-shedding will not be done to feeders having a high recovery ratio, provided that there are no big changes in the power supply and demand balance in the future.

The 11 kV feeders are ranked by their revenue recovery ratios. The load shedding is done according to rank by manual. Feeders that are connected to important facilities, such as big hospitals, are exempted from load shedding. Applying an automated system, such as LFLS (low frequency load shedding), is difficult since the system is connected with the WAPDA group and the frequency is mostly governed by them.

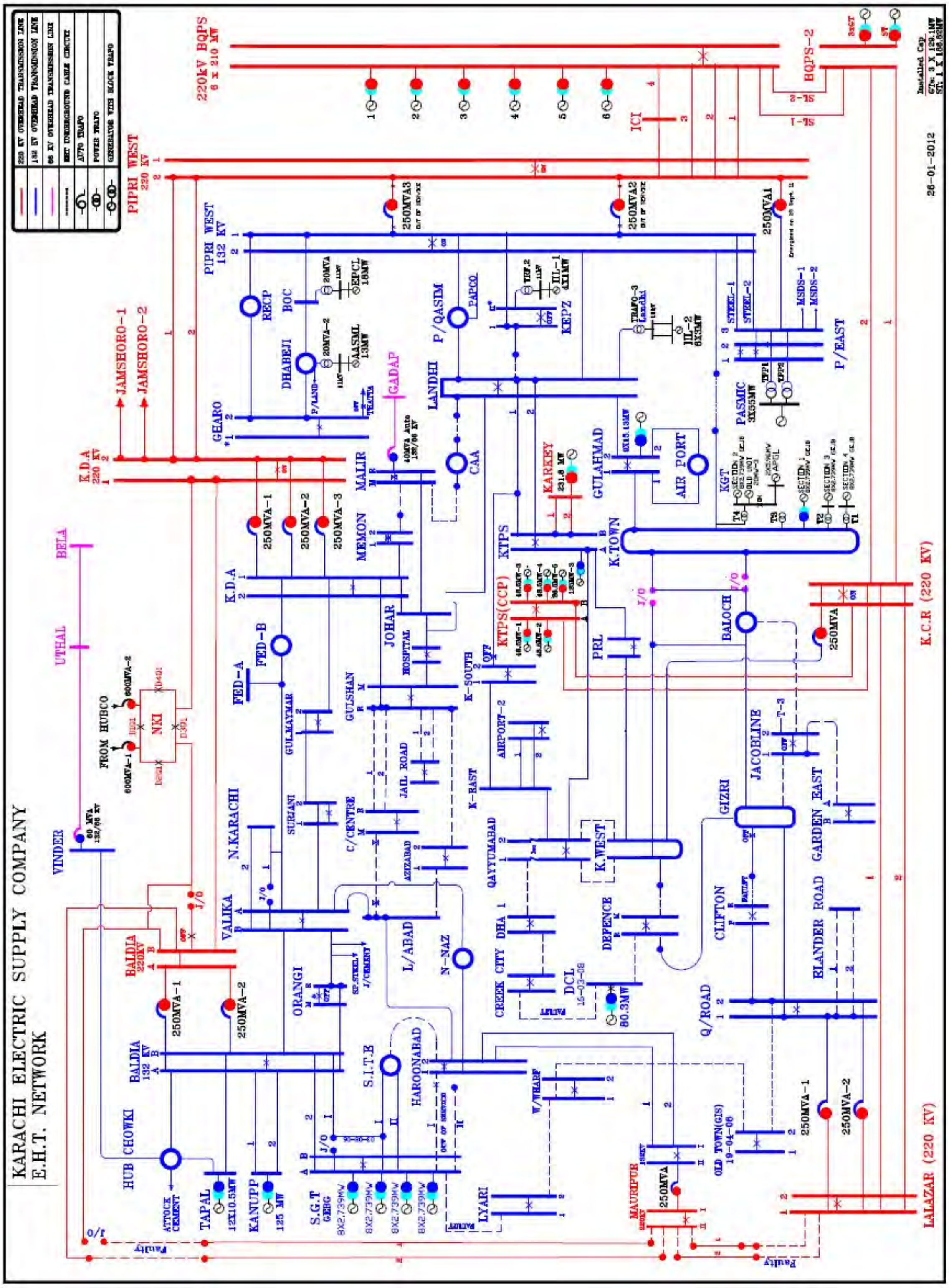
The lower ranked feeders have a huge amount of power losses due to power theft and unpaid electricity bills, which causes lower revenue recovery.

Industrial consumers are top-ranked, but most of the commercial and residential consumers are obliged to accept load-shedding day and night, for a total of six hours per day.



Source: JICA Study Team

Figure 3.4.10 Power Grid Diagram in Karachi



Source: From KESC

Figure 3.4.11 Single Line Diagram of Power Grid of KESC

4) Power outage due to system fault and power quality

Based on the interview with industrial consumers, it was confirmed that there is no load-shedding in industrial areas, but unannounced power outage occurs for almost 0 to 20 accumulated hours per month. The data of power outage are obtained from a towel factory owner near the Federal Grid Station and are shown in **Table 3.4.4**.

Table 3.4.4 Example of Power Outage

Month	Power Outage in Hours
December 2011	0.2
January 2012	8.0
February 2012	1.15
March 2012	0.0
April 2012	19.5
May 2012	1.0

Source: JICA Study Team interviewed to a towel factory near Federal Grid Substation

The power outage may be caused by system fault of KESC. There are also problems on power quality. Industrial consumers near the power station are not facing problems on voltage fluctuation, but those who are far from the power station receive 9.5 kV power from 11 kV feeders. The missing phase on both 11 kV and 400 V induces a sudden voltage rise, and flickers are also observed.

Industry consumers also claim that there is instantaneous voltage drops. These are voltage drops, occurring in an instant. The instantaneous voltage drop stops manufacturing machines since most of the machines are controlled by electronics.

5) Circular debt

The power sector in Pakistan has fallen into a circular debt. Circular debt is created when power companies fail to pay their dues to the fuel suppliers. In return, fuel suppliers default on their payment to oil refineries or to international fuel suppliers. This is caused by inefficiency of revenue collection from public sectors, including provincial governments and power thieves.

From 2004 to 2007, as the government kept the tariff without a real increase, the power companies could not recover the costs from the revenue.

Following is the case of DISCOs of WAPDA Group. Power companies owe losses in more than unmanageable limits, as the tariffs allowed by the government were inadequate to cover their costs. When tariff is to be changed, the government reminds consumers that affordability is a key consideration, therefore the proposed tariff by NEPRA after 2007 was not passed and the government notified a lower price. In 2010, the gap between the NEPEA and the government was proposed and a notified price reached Rs 3.43.

Global economic meltdown and extraordinary high oil prices further compounded to the circular debt. NEPRA provided adjustment on a six-monthly basis reflecting to the fuel price. However, fluctuations in oil price are so rapid that the six-monthly adjustments could not support the day-to-day operation of DISCOs.

6) Rehabilitation of distribution lines

According to the information in 2012, the 11 kV and 400 kV distribution lines of KESC are 7096 km and 11,718 km in length, respectively. As illustrated in **Figure 3.4.6**, the loss of distribution line is 31.1% in 2010, while that of PEPCO is 17.4%. Losses include technical losses caused by improper conductor sizes, improper jointing methods, aged facilities, etc. Non-technical losses on the other hand, are caused by power theft, failure to collect revenue, etc. The renovation for upgrading conductor sizes and using insulated conductors are most urgently required for ensuring the revenue recovery.

Source: JICA Study Team

Figure 3.4.12 Power Thief at Korangi Town in Karachi City

Figure 3.4.12 shows the typical power theft, which was found at Korangi Town in Karachi City. The major reason of power theft is the lack of affordable electricity. However, according to the interviews with residential consumers, complicated and slow process of connection system may also induce power theft.

7) Reinforcement of transmission line

KESC has a 220 kV ring transmission line, which encircles the whole of Karachi City. It enables efficient power sharing among substations and limits the extent of line-fault impact. The 220 kV ring transmission lines have two or four bundled conductors made of copper with cross-sectional area of 250 mm^2 or ACSR with 400 mm^2 to 500 mm^2 area.

The sizes of the ring line are sufficient for the time being. However, the population and industrial load are growing in the north-east and east of Karachi City. Also, the conversion of residential buildings to commercial use, particularly at the south of the city, is increasing in power demand. Therefore, new grid substations in these areas and 132 kV transmission lines to connect among the grid substations are urgently needed.

3.5 Future Plan of KESC

3.5.1 Power Generation Plants to be Renovated

The generating facilities of KESC are its own plants, nuclear plant, and IPP, which are presently supplying power to Karachi City. These facilities will be replaced in future due to the life usage as shown in **Table 3.5.1**.

As for Unit 4 and Unit 5 of BQPS-I, KESC is now planning to convert fuel from dual-fuel HFO and natural gas to coal fired by changing their boilers. According to BQPS-I, prices of boilers are approximately 30% of the total plant. Hence, even if this conversion works is done, soon the remaining expenditure of 70% will become necessary because the lifetime of the remaining parts of the plant will be over.

Except for the above, there are no more generating facilities for KESC, while there will be many units which require replacement because of retirement.

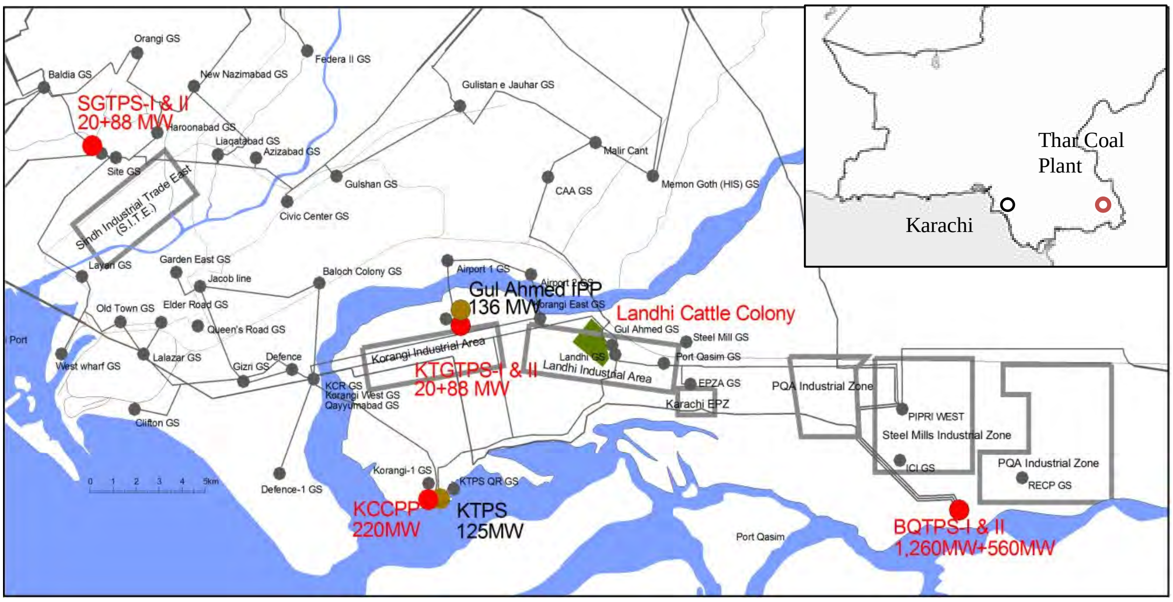
Table 3.5.1 Retirement Generation Facilities of KESC, KANNUP and IPP

Year	Power Station	Number of Units	Unit Capacity (MW)	Total Capacity (MW)
2019-2020	Gul Ahmed, all units	9	14	122
2019-2020	Tapal, all units	12	12	138
2020-2021	KANNUP	1	114	114
2023-2024	BQPS-I, #1	1	210	210
2024-2025	BQPS-I, #2	1	210	210
2027-2028	Anoud, #1,2,3	3	4	12
2028-2029	IIL, #1,2,3,4,5,6	6	19	113
2029-2030	SGTPS #1 to 32	32	2.739	88
2029-2030	KSGTPS #1 to 32	32	2.739	88
2029-2030	BQPS-I, #3	1	210	210
2030-2031	BQPS-I, #4	1	210	210
2031-2032	BQPS-I, #5	1	210	210
2037-2038	BQPS-I, #6	1	210	210

Source: JICA Study Team updated the data of National Power System Expansion Plan 2011 – 2030 by NTDC

3.5.2 Power Generation

KESC shows particular plans of power generation for the immediate future as shown in **Table 3.5.2**. KESC plans for the following: (1) Coal conversion plan, (2) Biogas plant, (3) Thar coal plant, (4) LNG import overseas and (5), (6), (7) for renovation (conversion to combined cycle system). Locations of the plants (1), (3), (5), (6), and (7) are shown in **Figure 3.5.1**.



Source: JICA Study Team

Figure 3.5.1 Projects Under Consideration by KESC

(1) Coal Conversion at Bin Qasim Power Station

Coal conversion for Units.3 and 4 of BQPS–I is the most progressing plan among all of the other plans. Feasibility study has already been done by the US Consultant, and land preparation for setting new boilers for the coal-fired generators has started. Preparation of the coal supply agreement with potential mines in Indonesia is now in process within KESC. The application to NEPRA for the conversion of fuel is also under process. KESC is currently in the process of finalizing the funding for the plan. KESC will propose the bids for the EPC contract as soon as the fund is finalized. At present, the fund seems to be a private company from China as described in Sub-section 3.4.2-(4)-1).

(2) Karachi Waste to Energy Project (Bio Gas Plant)

There is a stock farm named Landi Cattle Colony near the Bin Qasim Power Plant. KESC is planning to produce 22 MW of power and 300 t/day of fertilizers by converting 3000 to 3500 t/day of biodegradable waste from farms and 500 to 600 t/day of organic waste from municipality wastes.

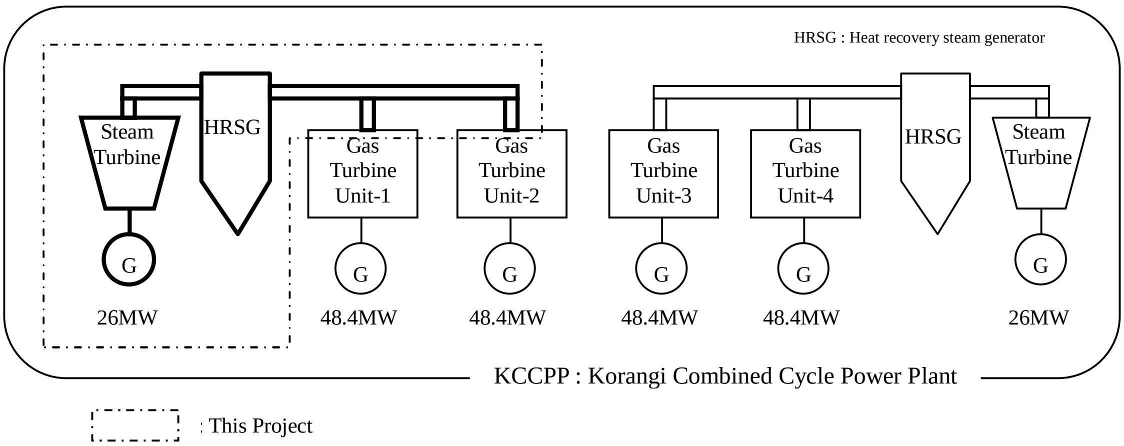
(3) Thar Coal Power Plant

The Thar Desert of Pakistan ranked 7th with the world’s largest coal reserves. Coal mine developer Oracle Coalfields has completed the Feasibility Study of Coal Mine Block VI, which is 380 km east of Karachi City. The lease of Block VI is granted to Oracle Coalfields, with subleasing option for the power supply. To diversify the source of electric power, KESC intends to develop a power plant with an initial capacity of 300 MW (overall 1200 MW) at the mouth of Block VI.

(4) Import Overseas LNG

Because of the increase of oil prices, KESC is reducing the consumption of imported oil and increase its domestic LNG consumption. However, government restricted the allocation of gas for power generation. Even if the capacity of KESC’s generating facility is able to meet the demand, load-shedding shall be done because of the restriction of gas allocation to power generation. To use the plant effectively, KESC is seeking possibilities of LNG supply from outside of Pakistan. KESC is seeking for investors who will provide facilities for unloading and stocking of LNG, before executing the importation. The construction of LNG storage facilities, etc. will be a big project.

(5) Phase II, Combined Cycle, KCCPP



Source: JICA Study Team

Figure 3.5.2 Schematic Drawing for the Renovation Plan of KCCPP

The KCCP has four 48.4 MW gas turbines with GE Unit-1 and Unit-2 in open cycle mode and Unit-3 and Unit-4 in combined cycle mode with one 26 MW steam turbine of Scoda Czech.

The plan is to renovate the Unit-1 and Unit-2 to the combined cycle mode, providing a heat recovery steam generator and a steam turbine generator of 26 MW. Except for the initial maintenance cost, KESC can increase the 26 MW without the additional fuel consumption by this renovation. Schematic drawing of this plan is shown in **Figure 3.5.2**.

Source: website of Planning Commission of GoP
http://www.pc.gov.pk/hot%20links/PSR/5th%20OCT/2-KESC%20Presentation.pdf

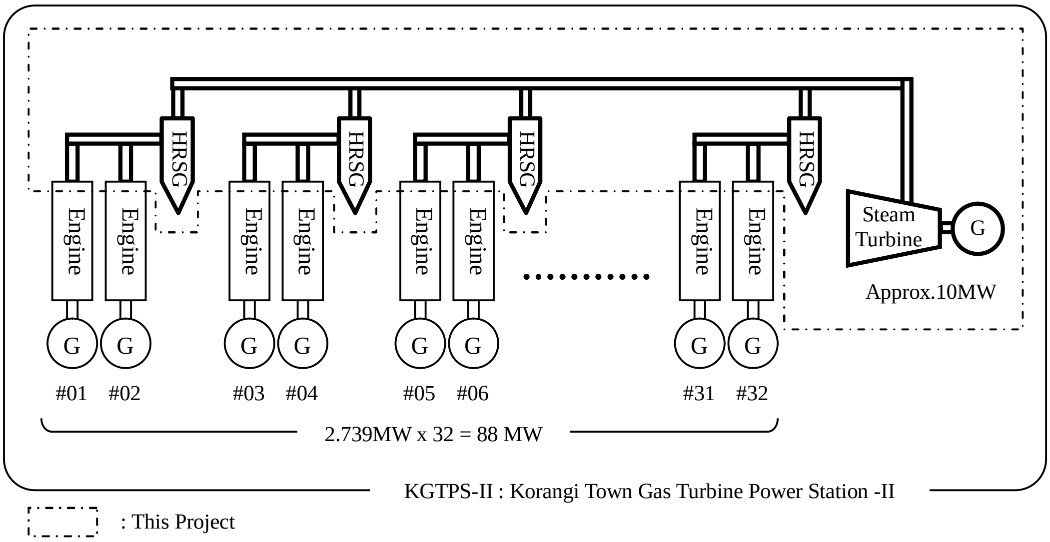
Figure 3.5.3 KCCPP

(6) Combined Cycle, KGTPS-II

The KGTPS-II has 32 reciprocating engine generators with unit capacity of 2.739 MW, for a total of 88 MW capacity. The plant was commissioned in 2009, which was made by GE Jenbacher. KESC is planning to equip heat recovery steam generators and a steam turbine on the plant to work as a combined cycle mode. Additional power to be obtained from this renovation is estimated at 10 MW. Except for the initial and maintenance cost, KESC can increase approximately 10 MW without additional fuel consumption by renovation. The schematic drawing of this plan is shown in **Figure 3.5.5**.

Source: website of Planning Commission of GoP
http://www.pc.gov.pk/hot%20links/PSR/5th%20OCT/2-KESC%20Presentation.pdf

Figure 3.5.4 Reciprocating Engines with 32 Units



Source: JICA Study Team

Figure 3.5.5 Schematic Drawing for Renovation Plan of KGTPS-II

(7) Combined Cycle, SGTPS-II

KGTPS-II reciprocates engine generators of 2.739 MW with 32 units made by GE Jenbacher were commissioned in the same year of 2009. KESC is planning to add the same facilities as KGTPS-II in order to obtain approximately 10 MW of power.

Table 3.5.2 Projects Under Consideration by KESC, as of June 2012

N	Project Name	Project Brief	Indicative Project Cost	Priority	Justification
1	Coal Conversion at Bin Qasim Power Plant	KESC plans to convert its 1,260 MWe (210 MW x 6) Bin Qasim Power Plant to Coal to diversify its fuel mix Conversion to be done in phases, starting with 420 MWe in the first phase . Master Plan of PQA land being offered to KESC was shared and is being analyzed internally. Internal work in progress on Coal Supply Agreement	USD250M	High	Replacing RFO based boilers with coal fired technology would help KESC in diversifying its existing fuel mix, attain fuel security, better utilization of existing fleet and reduce cost of generation; along with giving consumers a much needed relief in the tariff. The project will reduce the overall foreign exchange burden on the country, and will result in reducing tariff. This project is first of its kind and will create the capacity to develop similar projects by other power sector players in Pakistan.
2	Karachi Waste to Energy Project	KESC has embarked upon a venture that aims to generate power by converting 3,000-3,500 tpd cattle waste and around 500-600 tpd of organic food waste to upto generate 22 MW electrical energy along with organic fertilizer of around 300 tpd besides providing environmental and socio-economic benefits in Landhi Cattle Colony (project site) adjacent to Bin Qasim Industrial Area.	USD65–70M	High	This sustainable renewable energy project has the potential to rank as one of the largest bio-waste energy project of its kind. Collection and utilization of such waste will be a driver for effective and environmentally efficient cattle and municipal waste management in the city and will also make the project eligible for carbon financing and Gold Standard Certification from UNFCCC.
3	Thar Coal Power Plant	Thar Desert of Pakistan contains world's 7th largest coal reserves of around 175 Billion Ton of Lignite. KESC intends to develop power plant of initial capacity of 300 MW (Overall 1200 MW) at mine mouth of Block VI Thar Coalfield, Sindh in joint collaboration with Oracle Coalfields which is the Mine Developer. Coal mine feasibility study has been completed. KESC has recently signed JDA with Oracle and its subsidiary Sindh Coal Energy Limited. KESC has sought proposals for the feasibility study from leading international Consultants (Lahmeyer , Fichtner, Mott MacDonald, RWE, Knight Piesold, Harbin) that are being evaluated for selection of Consultant and commencement of feasibility study.	USD450M	High	This project is strategically important for KESC, as mine-mouth coal based power generation will allow readily available indigenous Thar coal reserves to be utilized. At the same time, KESC aims at not only bridging the prevailing power demand - supply gap, but also has an objective towards translating this benefit into a lower end user tariff. Generation through furnace oil is 3.7 times more expansive than coal generation.
4	LNG	KESC is looking to import 3.5 MTPA of Liquefied Natural Gas through an FSRU arrangement. KESC is expected to play the role of an off taker on take-or-pay basis. A consortium of local and international companies shall be	USD300-350M	Medium	This project will allow KESC to safeguard and utilize its investments made in gas-based power generation in recent years and to reduce load shedding caused by fuel supply shortages. Currently, there is an approximate 4 bcfd natural

N	Project Name	Project Brief	Indicative Project Cost	Priority	Justification
		formed for the development and operation of the terminal and purchase of LNG from molecule suppliers. KESC will also require an approximate SBLC of USD 250 million to be provided to suppliers.			gas deficit in Pakistan and KESC has seen a considerable reduction in natural gas supply over the years. Imported LNG can be used in KESC's existing power plants and the new 560 MW power plant going forward. This will result in enhanced efficiency of running gas based combined cycle plants also makes the import of natural gas a viable option.
5	Phase II, Combined Cycle CCPP	220MW CCPP at the KTC contains 04 GE LM6000 Gas Turbines. Of these, 02 are connected to an HRSG which drives a Steam Turbine. The remaining 02 GTs operate on Open Cycle. The Project is to install an HRSG and a Steam Turbine, downstream of the Open Cycle GTs. Hence the Plant shall have 02 Combined Cycle trains.	USD44M	High	This project will lead to increase in efficiency of KTC. 220MW CCPP will be generating approximately 26 MW more on the same volume of Natural Gas.
6	Combined Cycle, KGTPS2	32 GE Jenbacher gas engines are installed in the Plant which operate on Open Cycle and generate 88 MW. Project is to install 16 HRSGs (01 for every 02 gensets) and a suitable Steam Turbine which shall be driven by the steam from the HRSGs. This Plant will be converted to a combined cycle.	USD24M	High	This project will lead to increase in efficiency of KGTPS. The Plant will be generating approximately 10 MW more on the same volume of Natural Gas.
7	Combined Cycle, SGTPS2	32 GE Jenbacher gas engines are installed in the Plant which operate on Open Cycle and generate 88 MW. Project is to install 16 HRSGs (01 for every 02 gensets) and a suitable Steam Turbine which shall be driven by the steam from the HRSGs. This Plant will be converted to a combined cycle.	USD24M	Medium	This project will lead to increase in efficiency of SGTPS. The Plant will be generating approximately 10 MW more on the same volume of Natural Gas. However a major concern remains the availability of Natural Gas at the Plant; it sees frequent shut downs in both summers and winters.

Source: Prepared by KESC in June 2012.

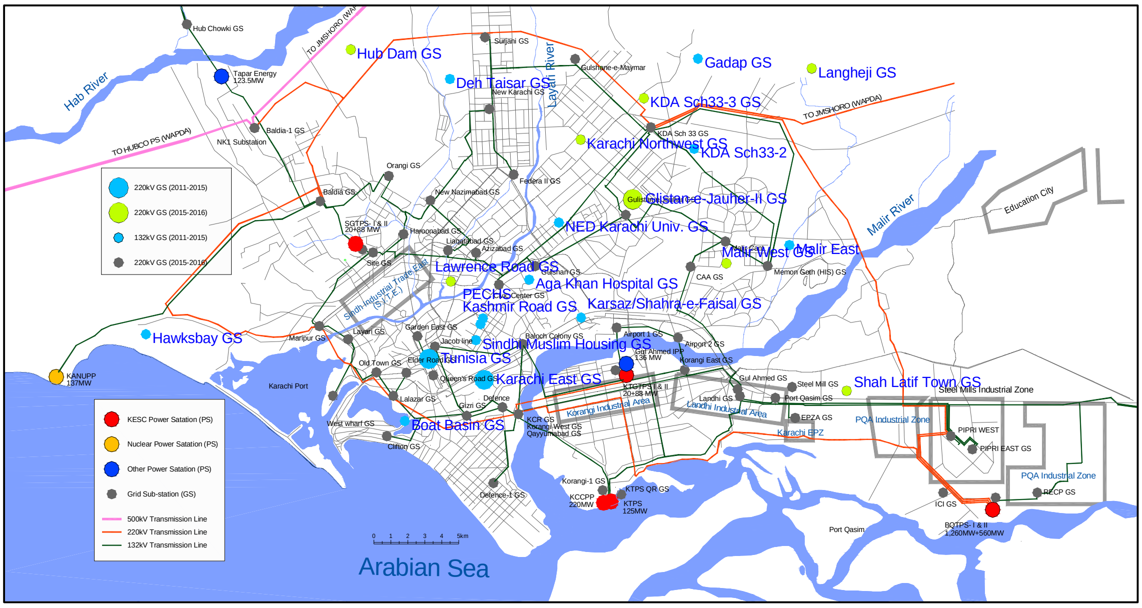
3.5.3 Transmission Lines and Distribution Lines

Detailed expansion plans for transmission lines and distribution lines were not obtained from KESC. However, various grid substations are planned to be constructed within the coming years from 2011 to 2020, according to Strategic Development Plan of the CDGK, the previous name of KMC.

Table 3.5.3 Expansion of Grid Substation and Transmission Lines from 2011 to 2020

	2011-2015	2016-2020
Transmission Lines and Substations	220 kV/132 kV Substation (1) Karachi East, (2) Tunisia Lines 132 kV Grid Substations (1)Deh Taisar, (2)Gadap, (3)Hawksbay, (4)Boat Basin, (5)Kashmir Road, (6)PECHS, (7)Sindhi Muslim Housing Society, (8)Malir east, (9)KDA Scheme 33, (10)NED Karachi University, (11)Karsaz, Shahra-e-Faisal, (12)Aga Khan Hospital.	220 kV/132 kV Substation Glistan-e-Jauher-II 132 kV Grid Substations (1) Shah Latif Town, (2) Lawrence Road, (3) Malir West, (4) KDA Scheme-33, (5) Karachi North East, (6) Deh Khar Kharo, (7) Hub-Dam, (8) Langheji, KHA
Distribution Lines and Substations	Increase of consumer : 100,000 people/year 11 kV Distribution feeders 700 to 800 feeders 11 kV Distribution substations 8000 units	

Source: "Karachi Strategic Develop Plan 2020" of Master Plan Group of Offices, City District Government Karachi



Source: JICA Study Team

Figure 3.5.6 Expansion of Grid Substation

For the purpose of formulating one substation project for recommendation, the Study Team proposed the project to install ten grid substations. The project is identified as "Project 9: Construction of Grid Substations and 132 kV Transmission Line" in **Table 3.5.4**. However, the scale of the project will be determined through the further feasibility study of this particular project.

Estimation of the quantitative benefit of the project is impossible at this stage. The frequency and duration of the power outages mentioned in Sub-section 3.4.2-(4)-4), however, will be drastically reduced by the completion of the project.

3.5.4 Projects Other than KESC

Other than KESC, the Port Qasim Authority (PQA) has a plan for the development of electricity circumstances.

(1) Co-generation with desalination plants by Port Qasim Authority

PQA is seeking developers for the desalination of plants by BOT basis. Desalinated sea water will be provided to the factories in the PQA industrial zones and other adjoining area. Estimated production of desalinated water is 25 MGD (Mega Gallon per Day). PQA is also planning to provide co-generation systems with the plant. The location of the plant is in the vicinity of the Bin Qasim Thermal Power Plant of KESC. The project is identified as "Project 8: Co-generation with Desalination Plant (25 MGD)" in **Table 3.5.4**.

A similar desalination plant of 3 MGD with co-generation of 84 MW power was constructed and inaugurated in 2008 at the DHA Substation in Karachi with an approximate cost of US$115 million. The plant provides power to the KESC network and IPP. After a year, the plant ceased its power supply due to failure in generation equipment.

3.5.5 Other Conceivable Projects

(1) Rehabilitation of Distribution Lines

Distribution lines are to be repaired where the distribution loss is extreme. The project will include the upgrading of conductor sizes, conversion of bare conductors to insulated conductors, and addition of grid substations with transformers and capacitors. The project shall also include analysis of distribution line networks for an efficient system. Upgrading of conductor sizes contributes in the reduction of voltage drop and trip caused by overload. Changing conductors to insulated ones will reduce the trip caused by ground fault, short circuit, etc. as well as disabling power theft. The rehabilitation program was done by KESC twice in 2004-2005 and 2011-2012, but in a small limited area.

For the purpose of formulating one distribution line project for recommendation, the Study Team proposed the projects assuming the project scale are as follows. However, the scale of project will be determined through the further feasibility study of the particular project.

- Renovation of 400 V lines : 590 km (5% of existing total length)
- Renovation of 11 kV lines : 350 km (5% of existing total length)
- Renovation/installation of transformer : 300 sets
- Installation of capacitor : 300 sets

The project is identified as "Project 10: Renovation of Distribution Lines" in **Table 3.5.4**. The project is estimated to eliminate at least 0.5% among the 35% system loss shown in **Figure 3.4.9**.

Not like the "Project 9: Construction of Grid Substations and 132 kV Transmission Line" which will reduce accidental power outages and technical losses only, it is expected that this Project 10 may reduce the huge non-technical losses.

(2) Pakistan Textile City

The government has planned to establish a "Textile City" in the Bin Qasim Industrial Area exclusively for the textile industry. The owner of the textile city is the Pakistan Textile City Limited. More than 50% of its share is owned by the government. Considering the nature of the industries in the country, this is a promising project because textile manufacturing is one of the popular industries in Pakistan. The project was identified as "Project No.11: Construction of Pakistan Textile City" in **Table 3.5.4**.

The layout drawing of the city obtainable from the Pakistan Textile City website (http://www.textilecity.com.pk/) is shown in **Figure 3.5.7**. The city is located on the eastern corner of the Port Qasim Area Industrial Zone (Eastern Zone). From the information obtained through direct interview with the officials of the owner company and from the website, the total area of the Textile City, including roads, is 1250 acres (approximately 5 km^2).

According to the owner company, a 250 MW gas turbine generating plant on a build-own-operate (BOO) basis was planned. However, there is a difficulty in procuring natural gas. The use of coal as its fuel may raise argument regarding environmental considerations.

Moreover, in spite of the serious power shortage condition in Karachi, 250 MW generating plant in one industrial city for its exclusive use seems too large. Since the new power plant will be thermal plant, construction costs will be similar to "Project 3: Thar Coal Thermal Power Plant" listed in **Table 3.5.4** below (USD 450M for 300MW). It is recommended to prioritize the other generation projects, the power from which can be used for all the population in Karachi city.

According to the web site, parts of the civil work construction such as trunk roads and water supply tank etc. in the city has been almost finished. Booking of the plots of the city is already open.

The share holders of the Pakistan Textile City Limited and their shares are presented in the web site. 40% of the share is owned by "Ministry of Textile Industry, Government of Pakistan", and 16% by "Government of Sindh".

Investing this project may be attractive for private investors. However, this project does not seem to be suitable for international donors to invest. And the private funds are the shareholders of the owner company.

Source: Pakistan Textile City Limited

Figure 3.5.7 Plan of Pakistan Textile City (Layout of Textile City)

3.6 Recommendation

3.6.1 Priority Project

All the projects nominated by KSEC and other organizations including Study Team are listed in **Table 3.5.4**.

Table 3.5.4 List of Projects Relating to Power Supply

Project Number	Projects	Approximate Cost (USD million)	Planner
1	Bin Qasim Power Station -I (BQPS-I) Fuel conversion to coal-fired (420 MW)	250	KESC
2	Karachi Waste-to-Energy, Build and Operation (22 MW)	65-70	KESC
3	Thar Coal Thermal Power Plant (300 MW, overall 1,200 MW)	450	KESC
4	Import overseas LNG, build and operation (use for BQPS-II 560MW)	300-350	KESC
5	Korangi Combined Cycle Power Plant (KCCPP) Convert open mode unit to combined cycle mode	44	KESC
6	Korangi Gasturbine Power Station-II (KGTPS-II) Add combined mode	24	KESC
7	S.I.T.E Gasturbine Power Station-II(SGTPS-II) Add combined mode	24	KESC
8	Co-generation with desalination plant (25 MGD), by BOT	Unknown	PQA
9	Construction of grid substations and 132 kV transmission lines	130 (*1)	KMC
10	Renovation of Distribution Line	100 (*1)	Study Team
11	Construction of Pakistan Textile City including power plant with maximum 250 MW Power	Unknown	Study Team

Note: (*1) The cost of these projects are subject to their project scale.
Source: JICA Study Team

The projects No.9 is tentatively formulated from the concept of KMC's Strategic Development Plan. The project 10 is planned by the Study Team for study purpose. The project 11 is listed herein by the Study Team also for study purpose. However, it shall be noted that the owner of the facilities for the projects No.9 and No.10 is KESC. The owner of the project 11 is the Pakistan Textile City Limited.

The following projects were dropped from the list of possible projects.

1) Project 1: Coal Conversion at BQPS-I

The project is most urgent and a study by KESC is progressing in advance than other plans. Even through KESC suspended the final decision on determining the fund, the fund for this project has been almost finalized.

2) Project 2: Waste to Energy Project

The project will contribute both in waste management and power output increase by 22 MW.

However, the project includes the operation of total system of garbage collection, cow-dung management and power-generation. Therefore, the project may be difficult to realize under international funds.

3) Project 3: Thar Coal Power Plant

The project aims to use domestic coal in the generation plant. It is the best solution for the shortage of power generation in Pakistan.

However, the project cost is too high to prioritize under this Study considering the targeted industrial infrastructure in the whole Study Area. To include this project in the candidate projects, a separate feasibility study is necessary. Hence, it is not considered as a high priority project.

4) Project 4: Import Overseas LNG

This project includes the operation of importing oil. The project seems suitable for investors business and is not considered as a high priority project.

5) Project 8: Co-generation with Desalination Plant

Further preliminary study for the co-generation plan with desalination plant is necessary to realize the project. Analysis on similar plants of DHA, which has failed their operation, shall also be carried out.

6) Project 11: Construction of Pakistan Textile City including power plant with maximum 250 MW power

There are already shareholders investing the city. Construction of some civil works of the city has commenced already. Booking of the plots is now open. In addition, the project includes the construction of a power plant for its exclusive use. The construction of an exclusive power plant having huge capacity under international funds seems difficult while all other consumers in the country are suffering from power shortage.

Five projects, Projects 5, 6, 7, 9, and 10 are left for the final selection as possible projects for the improvement of investment climate in the Karachi Processing Zone and Bin Qasim Industrial Area.

Projects 5, 6 and 7 are to use a combined cycle by providing heat recovery steam generators (HRSG) and steam turbines to gas turbines, increasing generation capacity without additional fuel consumption. The expected increase of power generation is 26 MW, 10 MW and 10 MW for Projects 5, 6 and 7 respectively. Project 5 has four units of 48.4 MW gas turbines, two units of which are already working and operating as a combined cycle mode with a 26 MW steam turbine. The project is for the other two units. The success of this project is technically assured. Projects 6 and 7 have same reciprocated engine generators of 2.739 MW x 32 units. The project is to provide HRSG and steam turbine generator with an expected additional capacity of 10 MW. Those projects are for generation. Investors in industrial areas are feeling insecure on the cease of power supply from KESC as well as the restriction on the use of natural gas for power generation. The Study Team considered that the generation projects should be of highest priority, since reserving power generation capacity is the fundamental solution. Although additional capacity is not large, the power is obtained without additional fuel. The projects will contribute to the economy and environment of Pakistan.

Project 9 is to construct grid substations and to provide overhead or underground transmission lines to the grid station. It is not possible to determine particular points in popular dense areas without a detailed study, which includes land problem. However, this project will reduce the power outage by lightening the overload of the facilities and improve power quality by use of suitable materials.

Project 10 is the distribution project to increase the size of conductors, changing it to insulated conductors and adding transformers and capacitors. The project scale is adjustable. Its estimated cost is 5% of the total existing conductors of the 11 kV and 400 V. This project will reduce the power outage due to lightening, due to the overload of the facilities, and will improve power quality. Above all, this project will reduce power theft, and accordingly, reduce distribution loss.

Among the Projects 9 and 10, Project 10 for distribution was prioritized because the reduction of large distribution loss (about 35%) is almost equivalent to the effect with increasing generation.

Four high-priority projects are selected for recommendations and are listed below.

Projects 6 and 7 have the same priority because the existing gas turbines are of the same type that was installed in the same year.

Table 3.5.5 Four Projects Recommended for Final Selection

Project Number	Projects	Approximate Cost (US$ million)	Priority
5	Korangi Combined Cycle Power Plant (KCCPP) Convert Open mode unit to combined cycle mode (26 MW)	44	1
6	Korangi Gasturbine Power Station-II (KGTPS-II) Add combined cycle mode (10 MW)	24	2
7	S.I.T.E Gasturbine Power Station-II(SGTPS-II) Add combined cycle mode (10 MW)	24	2
10	Renovation of Distribution Line	100	3

Note: (*1) The cost of these projects is variable by changing project scale.
Source: JICA Study Team

Methodology of prioritizing the projects is as follows.

a) The project contributes in improving power supply circumstances to industrial areas.
b) The project increases the total power with minimum generation cost.
c) The project contributes in increasing revenue collection.
d) Assurance of operation.

The industrial zones are currently prioritized for power supply. No load-shedding is applied in this zone. However, power shortage is serious. Since the allocation of natural gas to generation is restricted, KESC is now seeking the use of coal as an alternative energy source. Increase in power output without fuel by adding combined cycle function is very efficient. KCCPP is prioritized than KGTPS-II and SGTPS-II, because of the assurance of operation. Unit-3 and Unit-4 of KCCPP were already in operation with combined cycle mode.

Main target areas for the rehabilitation of distribution lines are neither at the Karachi Processing Zone nor the Bin Qasim Industrial Area, but at the town center where old systems still exists, and power theft is common. Most line faults are happening in this area which is causing power quality problems. If the revenue in this area is recovered, the Project 10 will contribute in reducing circular debt.

Table 3.5.6 shows the summary of selecting and prioritizing the projects.

Table 3.5.6 Summary of Selection of Possible Projects for the Improvement of Investment Climate

Problems for Investors in Industrial Areas	Major Cause	Conceivable Projects and their Possibility	Priorities for Priority Projects	Advantage/Benefit for Pakistan
[Power Outage] The bulk consumers are prioritized for continuous power supply by KESC. No load-shedding was done in the industrial area. However, unannounced power outage occurs 0 to 20 hours a month. The power outage induces; (1) Production loss due to idle (2) Invest on back-up generator (3) Maintenance/fuel arrangement for the back-up generator	[Power Outage] Trips are caused by removing action of line fault, which even occurs outside of industrial area. Insufficient conductor size cause overcurrent and voltage drop, and un-insulated conductor causes grounding fault. To remove the power outages, improve of distribution system is necessary.	[Power Outage] Project **No.9** Expansion of Grid Substations and 132kV transmission lines Project **No.10** Rehabilitation of Distribution Lines	Projects are listed in order of priority for Priority Projects Project **No.5** Renovation for combined cycle mode of KCCPP Power of 26MW is additionally increased without additional fuel. Only initial cost for renovation is required. The project is fail-safe, since 2-units already run with combined cycle mode.	Project **No.5** Renovation for combined cycle mode of KCCPP - increase power output - decrease generation cost per kW - decrease oil/gas consumption
[Poor Power Quality] 11kV consumers far from power station are suffering from voltage fluctuation, almost 14% drop. Voltage drop, flickering is terrible for low-voltage consumers Instantaneous voltage drop occurs so frequently, and is causing machine stop. Occurrence of harmonics may also be causing the machine stop. Poor Power Quality induces (1) Manufacturing System down (2) Machine Failure	[Poor Power Quality] Voltage drop is caused by following reasons. Rehabilitation of distribution lines, changing conductor, installing step-up transformer and capacitor, is effective. (a) Distant distribution (b) Losing phase (c) Insufficient conductor size (d) Improper connection (e) Power thief on the line Rehabilitation of distribution lines, changing conductor, installing step-up transformer and capacitor, is effective. Instantaneous voltage is the surge from a distance induced by reclosing operation for removing line fault. Harmonics occurs by arc furnace, arc-welding, inverters, fluorescent lamp of consumers.	[Poor Power Quality] Project **No.9** Expansion of Grid Substations and 132kV transmission lines Project **No.10** Rehabilitation of Distribution Lines	Increase power out-put is basic requirement for KESC system, and will contribute; - reduction of possibility of future load-shedding due to power shortage - tariff reduction by lowering generation cost Project **No.6** Renovation for combined cycle mode of KGTPS-II Power of 10MW is additionally increased without additional fuel. Only initial cost for renovation is required. - reduction of possibility of future load-shedding due to power shortage - tariff reduction by lowering generation cost	Project **No.6** Renovation for combined cycle mode of KGTPS-II - increase power output - decrease generation cost per kW - decrease oil/gas consumption
[Reliability on Future Power Supply] Total installed capacity has redundancy to demand, but power generation is fuel-dependent. Bulk	[Reliability] 1. Generation (a) Increase of fuel cost	Project **No.5** Renovation for combined cycle mode of KCCPP Project **No.6**	Project **No.7** Renovation for combined cycle mode of SGTPS-II - same with (6)	Project **No.7** Renovation for combined cycle mode of SGTPS-II - increase power output - decrease generation cost per kW - decrease oil/gas consumption

Problems for Investors in Industrial Areas	Major Cause	Conceivable Projects and their Possibility	Priorities for Priority Projects	Advantage/Benefit for Pakistan
consumers have anxiety for future power supply, although they are prioritized in the present circumstance.	(b) Dependency to imported oil (c) Restriction of natural gas supply Demand Increase of CNG	Renovation for combined cycle mode of KGTPS-II Project **No.7** Renovation for combined cycle mode of SGTPS-II	Project **No.10** Rehabilitation of Distribution Lines This project contributes mainly low-voltage consumers. - reduction of fault trip - reduction of voltage drop - reduction of flicker	Project **No.10** Rehabilitation of Distribution Lines - decrease power thief - decrease technical loss - decrease voltage drop - decrease flickering - possibility for reducing tariff - Increase new consumer
1[High Tariff] Compared with possible industrial areas in other countries, electricity tariff is high for foreign investor. The cost of self-generation by gas is much lower the tariff, but afraid of stopping future supply of gas. KESC Tariff for Industries: USD0.117 – 0.138 Generation Cost by Diesel USD0.372 Generation Cost by Gas USD0.053 – 0.079	[High Tariff] 1. Rise up oil price 2. Restriction of gas supply 3. Distribution loss is 35%	Project **No.5** Renovation for combined cycle mode of KCCPP Project **No.6** Renovation for combined cycle mode of KGTPS-II Project **No.7** Renovation for combined cycle mode of SGTPS-II Project **No.9** Expansion of Grid Substations and 132kV transmission lines Project **No.10** Rehabilitation of Distribution Lines	Project **No.9** Expansion of Grid Substations and 132kV transmission lines This project reduces overload of existing grid substation and 132kV transmission lines by sharing it to new facility. - reduction of fault trip - reduction of voltage drop - reduction of flicker	Project **No.9** Expansion of Grid Substations and 132kV transmission lines - decrease power thief - decrease technical loss - decrease voltage drop - decrease flickering - possibility for reducing tariff - Increase new consumer

Source: JICA Study Team

3.6.2 Recommendation for GOP Action

In order to realize the smooth implementation of the priority projects recommended in the foregoing section, the government is recommended to carry out the following actions:

(1) Donor Selection for Recommended Projects

To realize the four projects recommended in **Table 3.5.5**, KESC is recommended to prepare and submit PC-1 urgently for approval. Then, the government is recommended to apply for loan to any possible donors.

Since all the four projects are the conversion/renovation of the existing system, or additional equipment be installed in the premises of the existing plant. Hence, land compensation or even EIA seem not necessary. KESC is recommended to confirm whether EIA for those four projects is necessary or not.

(2) Bin Qasim Power Station 1

Fuel conversion of BQPS-I to coal-fire, which is listed as Project 1 in **Table 3.5.4,** should be urgently implemented. Since the fund for the project is almost finalized, the goverment is recommended to urge its implementation so that the prevailing power shortage can be reduced before the priority projects are completed.

(3) Feasibility Study for the Renovation of Distribution Lines

Renovation of distribution lines is listed as Project 10 of the recommended four projects in **Table 3.5.5**. In case this project is selected for implementation under funding, a feasibility study including basic design should be conducted by the government or under any funding agency. A rough scope of the project and design of the project should be established for smooth implementation.

CHAPTER 4 TRAFFIC SURVEY IN THE STUDY AREA

4.1 Traffic Survey

4.1.1 Objectives of the Traffic Survey

The traffic survey, which includes the classified traffic count survey (12 hr and 24 hr), directional movement survey at intersections, travel speed survey, and on-road parking survey, was carried out to grasp the present traffic condition in the Study Area.

4.1.2 Outline and Schedule of the Traffic Survey

(1) Outline of the Traffic Survey

The outline of the traffic survey is summarized in **Table 4.1.1** below.

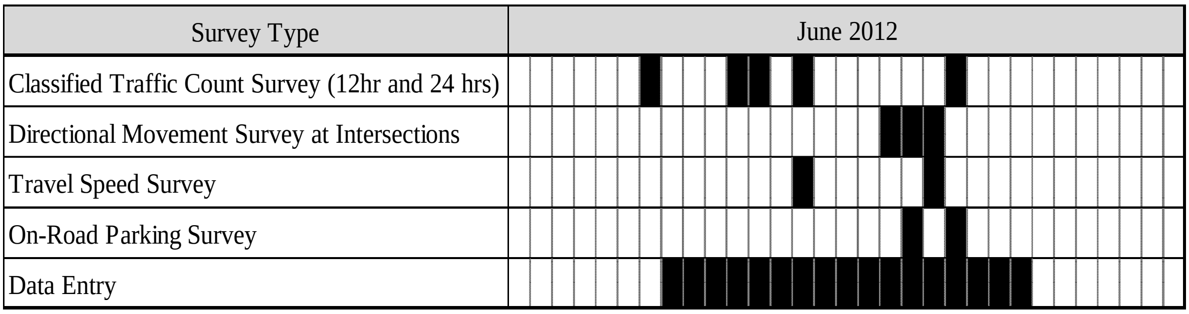
Table 4.1.1 Outline of the Traffic Survey

Survey	Objectives	Method	Coverage
1) Classified Traffic Count Survey	1) To grasp the existing road utilization situation. 2) To grasp the types of vehicle, direction, and points of bottleneck.	・Traffic count (vehicles)	2 locations (24 hr) 7 locations (12 hr)
2) Directional Movement Survey at Intersections	1) To grasp the directional movement at peak time at the bottleneck intersections, and identify problems.	・Traffic count (vehicles) in peak time.	3 locations (7:00-10:00, 16:00-19:00)
3) Travel Speed Survey	1) To grasp the average speed at peak time and off-peak time. 2) To grasp the traffic jam area, delay, and its cause.	・Actual driving survey by passenger car. ・3 round-trips every route by 3 time zones.	4 routes (7:00-10:00, 10:00-16:00, 16:00-19:00)
4) On-Road Parking Survey	1) To grasp the on-road parking situation. 2) To identify the characteristics of on-road parking user.	・Count on-road parking vehicles. ・Interviews of parking vehicle drivers.	4 sections

Source: JICA Study Team

(2) Schedule of the Traffic Survey

The schedule of the traffic survey is summarized below;

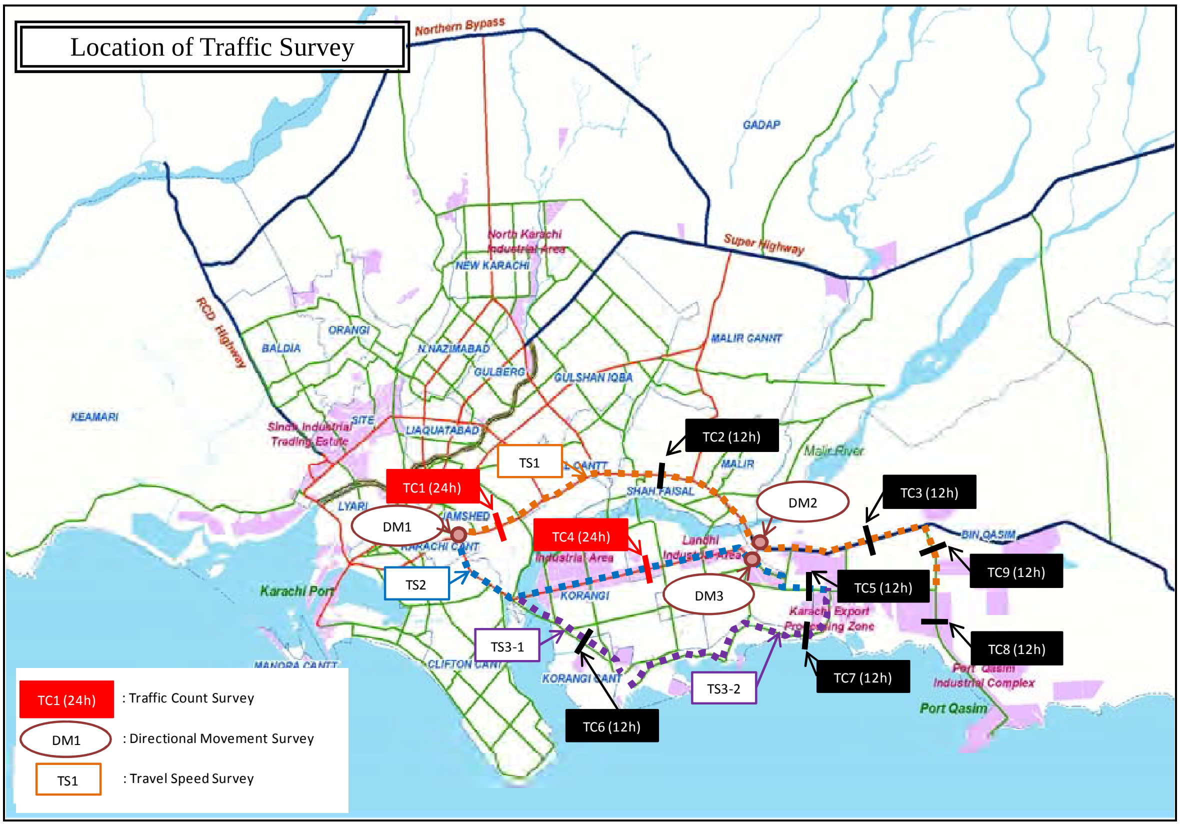


Source: JICA Study Team

Figure 4.1.1 Schedule of the Traffic Survey

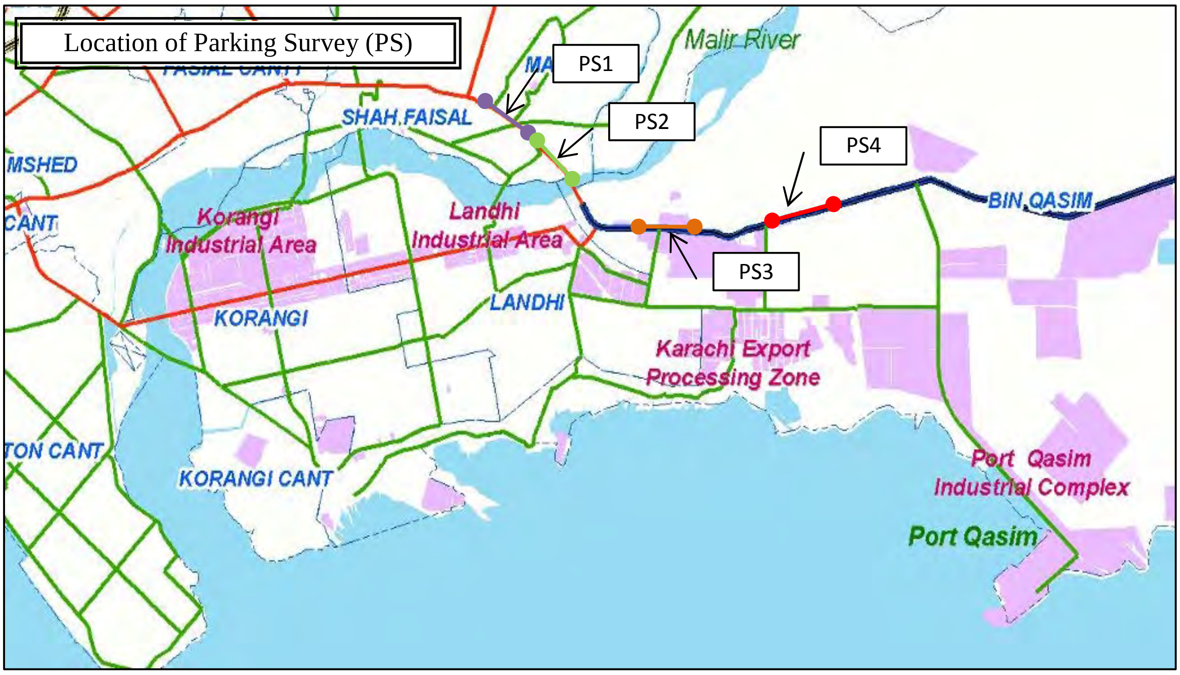
(3) Location for the Traffic Survey

The locations for the traffic survey are shown below;



Source: JICA Study Team

Figure 4.1.2 Locations for the Traffic Survey (Classified Traffic Count, Directional Movement Survey, and Travel Speed Survey Route)



Source: JICA Study Team

Figure 4.1.3 Location for the Traffic Survey (Section of On-Road Parking Survey)

4.1.3 Description of the Traffic Survey

(1) Classified Traffic Count Survey

The classified traffic count survey is done by counting the number of vehicles to obtain traffic volume on major roads. The contents of the classified traffic count survey are as follows:

Table 4.1.2 Contents of the Classified Traffic Count Survey

Survey Date	・ June 6, 2012: TC1 (24 hr), TC2 (12hrs), TC3 (12hrs), TC5 (12hrs), TC6 (12hrs) ・ June 12, 2012: TC4 (24 hr), TC7 (12hrs), TC8 (12hrs), TC9 (12hrs)
Survey Hour	・ 12 hours from 7:00AM – 7:00PM ・ 24 hours from 7:00AM – 7:00AM
Vehicle Type	・ Eleven categories as follows 1) Passenger cars 2) Taxis, Auto Rickshaws 3) Motorcycles & Scooters 4) Large Buses 5) Mini Buses, Coaches, Contract Carriages 6) Light Freight Vehicles 7) Trucks, 2 Axle 8) Trucks, 3 Axle 9) Trucks, 4 Axle 10) Trucks, 5 Axle 11) Trucks, 6 Axle and more
Survey Method	・ To count the number of vehicles by direction and by vehicle type continuously for 12 hr or 24 hr. ・ To record the number of vehicles on the survey sheet every thirty (30) minutes.

Source: JICA Study Team

(2) Directional Movement Survey at Intersections

This survey is done to count the number of vehicles to obtain the traffic volume on major intersections. The contents of the directional movement survey are as follows:

Table 4.1.3 Contents of the Directional Movement Survey on Major Intersections

Survey Date	・ June 7, 2012: DM1 ・ June 13, 2012: DM2, DM3
Survey Hour	・ Peak hours from 7:00 to 10:00 in the morning and 16:00 to 19:00 in the evening
Vehicle Type	・ Seven categories as follows: 1) Passenger Cars 2) Taxis, Auto Rickshaws 3) Motorcycles & Scooters 4) Large Buses 5) Mini Buses, Coaches, Contract Carriages 6) Light Freight Vehicles 7) Trucks (2 Axle – 6 Axle and more)
Survey Method	・ To record the number of vehicles on the survey sheet every 15 minutes by vehicle type and by directions.

Source: JICA Study Team

(3) Travel Speed Survey

This survey is done to collect information about the average traffic speed in peak time and off-peak time. The contents of the travel speed survey are as follows:

Table 4.1.4 Contents of the Travel Speed Survey

Survey Date	・ June 7, 2012: TS1 ・ June 13, 2012: TS2 ・ June 14, 2012:TS3
Survey Hour	・ Morning and evening peak time on weekdays ・ Off-peak hours on weekday
Survey Method	・ To conduct by the "floating car method" ・ To record the travel time and length of measured section in each survey route ・ To calculate the travel speed (Travel speed =length/travel time)

Source: JICA Study Team

(4) On-Road Parking Survey

This survey is done to investigate the on-road parking situation in the Study Area and to identify the characteristics of on-road parking users in traffic bottleneck areas caused by curbside parking. The contents of the on-road parking survey are as follows:

Table 4.1.5 Contents of the On-Road Parking Survey

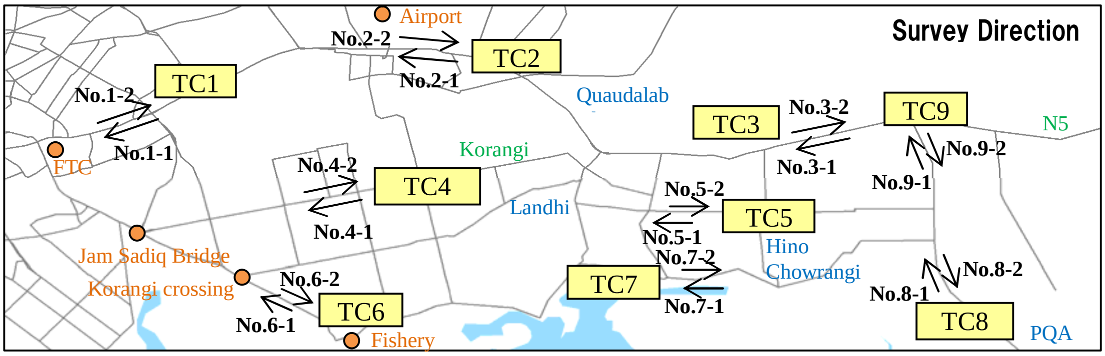
Survey Date	・ June 14, 2012: PS1, PS2 ・ June 18, 2012: PS3, PS4
Survey Hour	・ 12 hours from 7:00AM – 7:00PM
Vehicle Type	・ Seven categories as follows 1) Passenger Cars 2) Taxis, Auto Rickshaws 3) Motorcycles & Scooters 4) Large Buses 5) Mini Buses, Coaches, Contract Carriages 6) Light Freight Vehicles 7) Trucks (2 Axle – 6 Axle and more)
Survey Method	・ To count on-road parking at an interval of 30 minutes ・ To interview the parking vehicle drivers/owners to find out their trip purpose and parking duration.

Source: JICA Study Team

4.2 Present Traffic Condition

4.2.1 Traffic Volume and Vehicle Composition

The traffic count results were analyzed from various views such as traffic volume, vehicle type, and hourly variation to figure out the traffic trend in the Study Area.



Source: JICA Study Team

Figure 4.2.1 Location of Classified Traffic Count Survey

(1) Traffic Volume

The detailed data for the 24-hour and 12-hour traffic volumes is shown in **Table 4.2.1**. The 12-hour traffic volumes of over 50,000 vehicles were observed at TC1, TC2, TC4, and TC7. These stations are located in Shahrah-e Faisal Road and Korangi Road. The largest traffic volume was observed at TC1 with 169,962 vehicles per 12 hours and 232,840 vehicles per 24 hours.

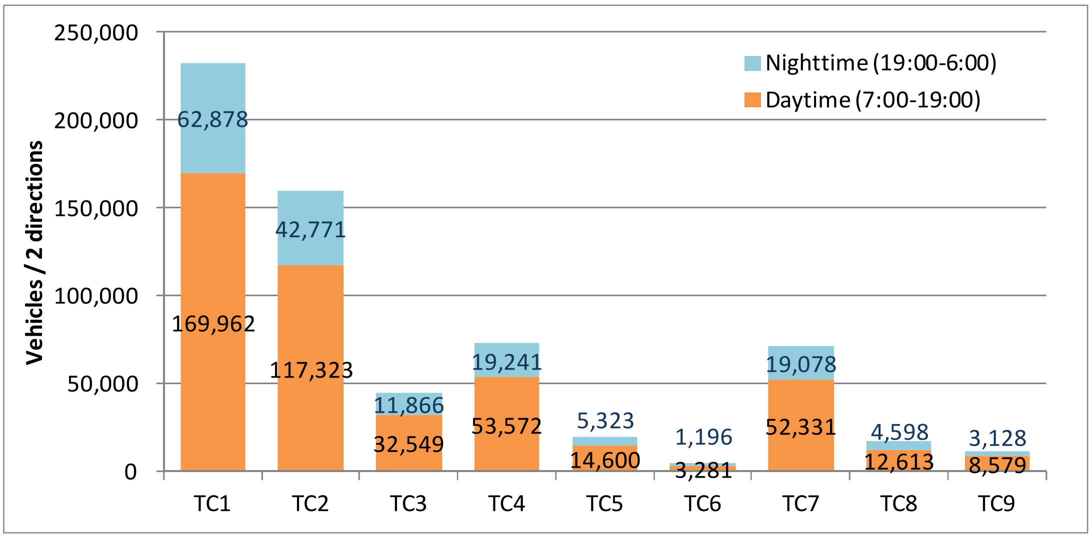
Both traffic volume ratios, i.e., for 24/12 hours at TC1 and TC4, are about 1.5 to the west direction. Proportion of night driving occupied about 27% and there was much westward traffic at night time.

Table 4.2.1 Results of the Classified Traffic Count Survey

Station	Direction			Traffic Volume (Vehicles)		
	No	From	To	12 hours (7:00 – 19:00)	24 hours (7:00 – 7:00)	24/12 hrs
TC1	1-1	Airport	FTC	87,735	112,921	1.29
	1-2	FTC	Airport	82,227	119,919	1.46
TC2	2-1	FTC	PQA	60,552	-	-
	2-2	PQA	FTC	56,771	-	-
TC3	3-1	PQA	Quaidabad	15,322	-	-
	3-2	Quaidabad	PQA	17,227	-	-
TC4	4-1	Landhi	Jam Sadiq Bridge	20,101	29,637	1.47
	4-2	Jam Sadiq Bridge	Landhi	33,471	43,176	1.29
TC5	5-1	PQA	Landhi	5,600	-	-
	5-2	Landhi	PQA	9,000	-	-
TC6	6-1	Fishery	Korangi Crossing	1,609	-	-
	6-2	Korangi crossing	Fishery	1,672	-	-
TC7	7-1	Hino Chowrangi	Korangi	21,222	-	-
	7-2	Korangi	Hino Chowrangi	31,109	-	-
TC8	8-1	PQA	N5	5,826	-	-
	8-2	N5	PQA	6,787	-	-
TC9	9-1	PQA	N5	4,142	-	-
	9-2	N5	PQA	4,437	-	-

Source: JICA Study Team

Figure 4.2.2 shows the daily data of each survey station. The 12-hour survey stations were converted into 24-hour traffic volumes based on the traffic volume ratios shown above.



Source: JICA Study Team

Figure 4.2.2 Traffic Volume (24 hours)

There were many large–size vehicles in these sections that traffics at TC3, TC4, TC8, and TC9 increased when converted to the above-mentioned traffic volumes into PCU. **Table 4.2.2** shows the result of traffic volume (PCU).

On the other hand, there are many motorcycles or scooters in these sections that traffic at TC1, TC2 TC5, TC6, and TC7 decreased.

Table 4.2.2 Traffic Volume by PCU

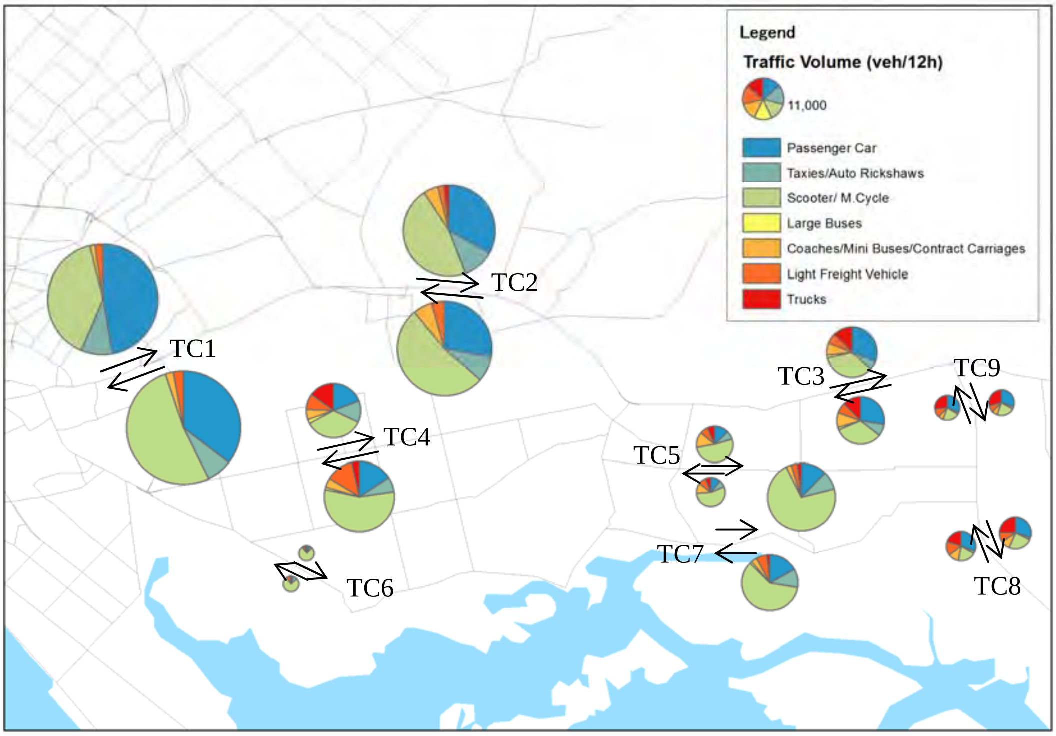
Station	Traffic Volume (PCU)		Traffic Volume (Vehicle)		Difference (PCU–Vehicle)	
	12 hours (7:00 – 19:00)	24 hours (7:00 – 7:00)	12 hours (7:00 – 19:00)	24 hours (7:00 – 7:00)	12 hrs	24 hrs
TC1	126,353	176,086	169,962	232,840	- 49,733	- 56,754
TC2	92,368	126,042	117,323	160,094	- 24,955	- 34,052
TC3	37,680	51,416	32,549	44,415	5,131	7,001
TC4	54,638	76,779	53,572	72,813	1,066	3,966
TC5	14,267	19,468	14,600	19,923	- 333	- 455
TC6	2,080	2,838	3,281	4,477	- 1,201	- 1,639
TC7	34,848	47,552	52,331	71,409	- 17,483	- 23,857
TC8	18,571	25,341	12,613	17,211	5,958	8,130
TC9	12,698	17,327	8,579	11,707	4,199	5,620

Note: 12-hour survey stations were converted into 24-hour traffic volumes by average traffic volume ratio
Source: JICA Study Team

(2) Vehicle Composition

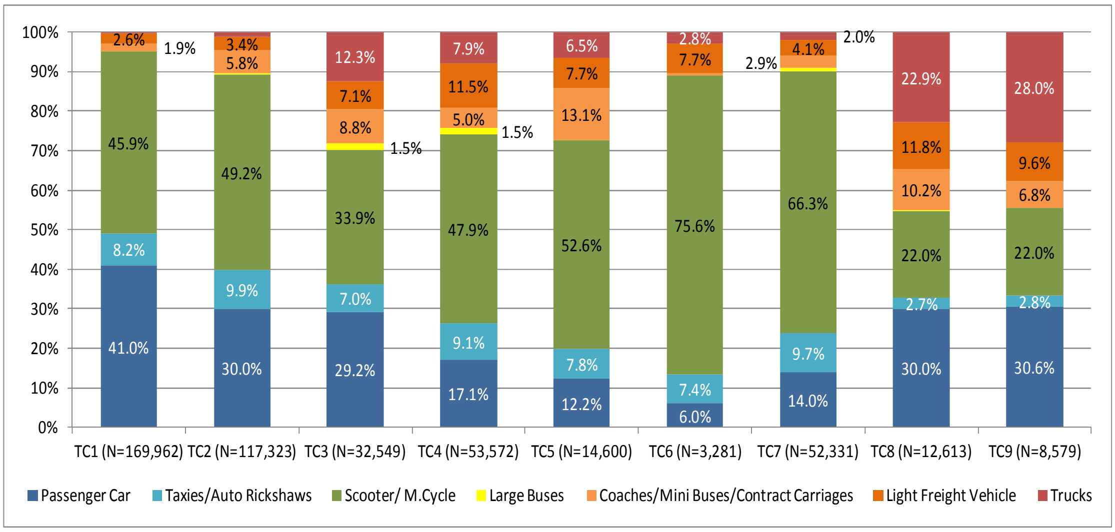
Figure 4.2.3 shows the traffic volume for each station by vehicle type and direction over the 12-hour period. **Figure 4.2.4** shows the vehicle composition by each cross-section.

As mentioned above, the highest traffic volumes were observed in Shahrah-e-Faisal Road. Passenger car and scooter/motorcycle were found to be the major type of vehicles in every station, but the proportion of trucks (2 Axle–6 Axle and more) was relatively higher at TC3, TC4, TC8, and TC9 (17.8%: average of four stations) than the others (2.6%: average of five stations).



Source: JICA Study Team

Figure 4.2.3 Distribution of Traffic Volume by Vehicle Type

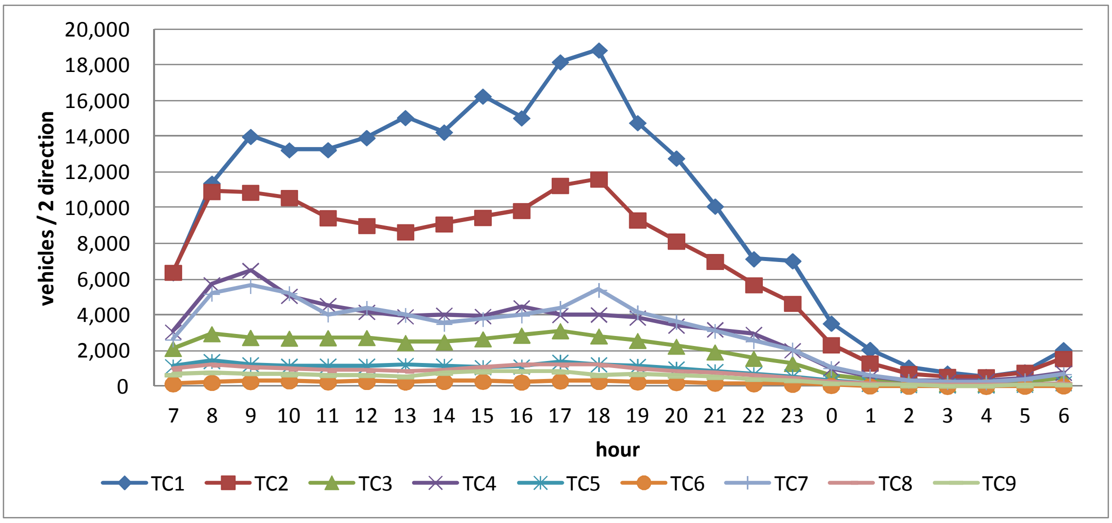


Source: JICA Study Team

Figure 4.2.4 Comparison of Vehicle Composition

(3) Hourly Fluctuation

Figure 4.2.5 shows the hourly fluctuations in every station. The traffic volume showed a strong peak in the evening between 18:00 and 19:00 hours. The tendency was seen especially at TC1 and TC2. The morning peak was between 9:00 and 10:00. TC5, TC6, TC8, and TC9 displayed relatively flat profiles and did not have the specific feature.



Source: JICA Study Team

Figure 4.2.5 Hourly Fluctuation

(4) Congestion Degree

Table 4.2.3 shows the congestion degree for each station. The Study for Karachi Transportation Improvement Project (Draft Final Report: JICA, May 2012) presents the capacity of each station as shown in **Table 4.2.3**. The congestion degree of Shahrah-e-Faisal Road is over 1.0, and it was assumed that serious traffic congestion occurs on this road, since the traffic volume exceeds the road capacity. Shahrah-e-Faisal Road is the main road in Karachi City and many vehicles use this road. Therefore, the concentration of traffic suppresses the road capacity and causes traffic jam due to decreased travel speed. Although at TC7, Coast Road, the congestion degree is also over 1.0, many of vehicle traffic are scooter/motorcycle, it was assumed that traffic congestion is relatively lower compared to TC1 and TC2. However, it was assumed that travel speed decreases because the width of this road is narrow.

Now, some bottlenecks and blockages of traffic (by parking, bus, etc) cause traffic congestion and contribute to the deterioration of traffic conditions. The population and traffic volume in the Study Area in the future will increase as mentioned in the Study for Karachi Transportation Improvement Project (Draft Final Report: JICA, May 2012). It is foreseen that traffic congestion will become more serious in the near future.

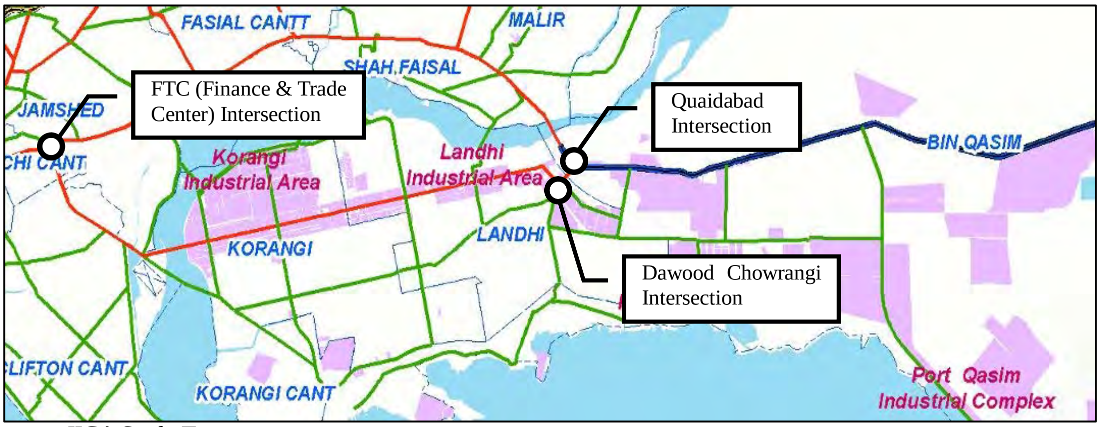
Table 4.2.3 Congestion Degree of Survey Stations

Station	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9
Traffic Volume (PCU)	176,086	126,042	51,416	76,779	19,468	2,838	47,552	25,341	17,327
Capacity	171,000	114,000	114,000	95,000	32,000	47,000	47,000	47,000	47,000
Congestion Degree	1.03	1.11	0.45	0.81	0.61	0.06	1.01	0.54	0.37

Source: Capacity: The Study for Karachi Transportation Improvement Project (Draft Final Report), JICA Study Team

4.2.2 Intersection Traffic

Traffic flows at three intersections were observed by using the directional movement survey. The intersection traffic results were analyzed using the traffic volume at each direction in the morning/evening and vehicle composition.



Source: JICA Study Team

Figure 4.2.6 Location of Directional Movement

(1) Traffic Volume at Each Direction

1) FTC (Finance & Trade Center) Intersection

Table 4.2.4 shows the traffic volume at each direction and **Figure 4.2.7** shows the traffic flow at the FTC Intersection in the morning (7:00-10:00) and evening (16:00-19:00).

It was observed that the major traffic flow is on the westward and eastward directions, and the traffic of northward and southward is relatively low. Traffic volume of this intersection in the evening is higher compared in the morning. Furthermore, traffic from west to east (Direction ⑦) increases especially in the evening.

Table 4.2.4 Traffic Volume at FTC Intersection

Time		Direction										Total
		①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	
Morning	7:00-8:00	1,267	304	1,119	529	425	3,021	1,130	110	157	388	8,450
	8:00-9:00	3,198	888	2,063	746	725	6,790	2,646	133	420	677	18,286
	9:00-10:00	3,560	1,116	2,417	1,189	764	6,606	3,352	204	446	689	20,343
	3 Hours Total	8,025	2,308	5,599	2,464	1,914	16,417	7,128	447	1,023	1,754	47,079
Evening	16:00-17:00	4,017	408	3,727	1,251	743	4,958	6,874	311	732	1,076	24,097
	17:00-18:00	4,061	354	4,690	1,409	669	4,549	8,139	277	827	1,349	26,324
	18:00-19:00	4,790	388	5,766	1,524	559	4,333	8,642	449	855	1,282	28,588
	3 Hours Total	12,868	1,150	14,183	4,184	1,971	13,840	23,655	1,037	2,414	3,707	79,009

Source: JICA Study Team

Source: JICA Study Team

Figure 4.2.7 Traffic Flow of FTC Intersection (Morning and Evening)

2) Quaidabad Intersection

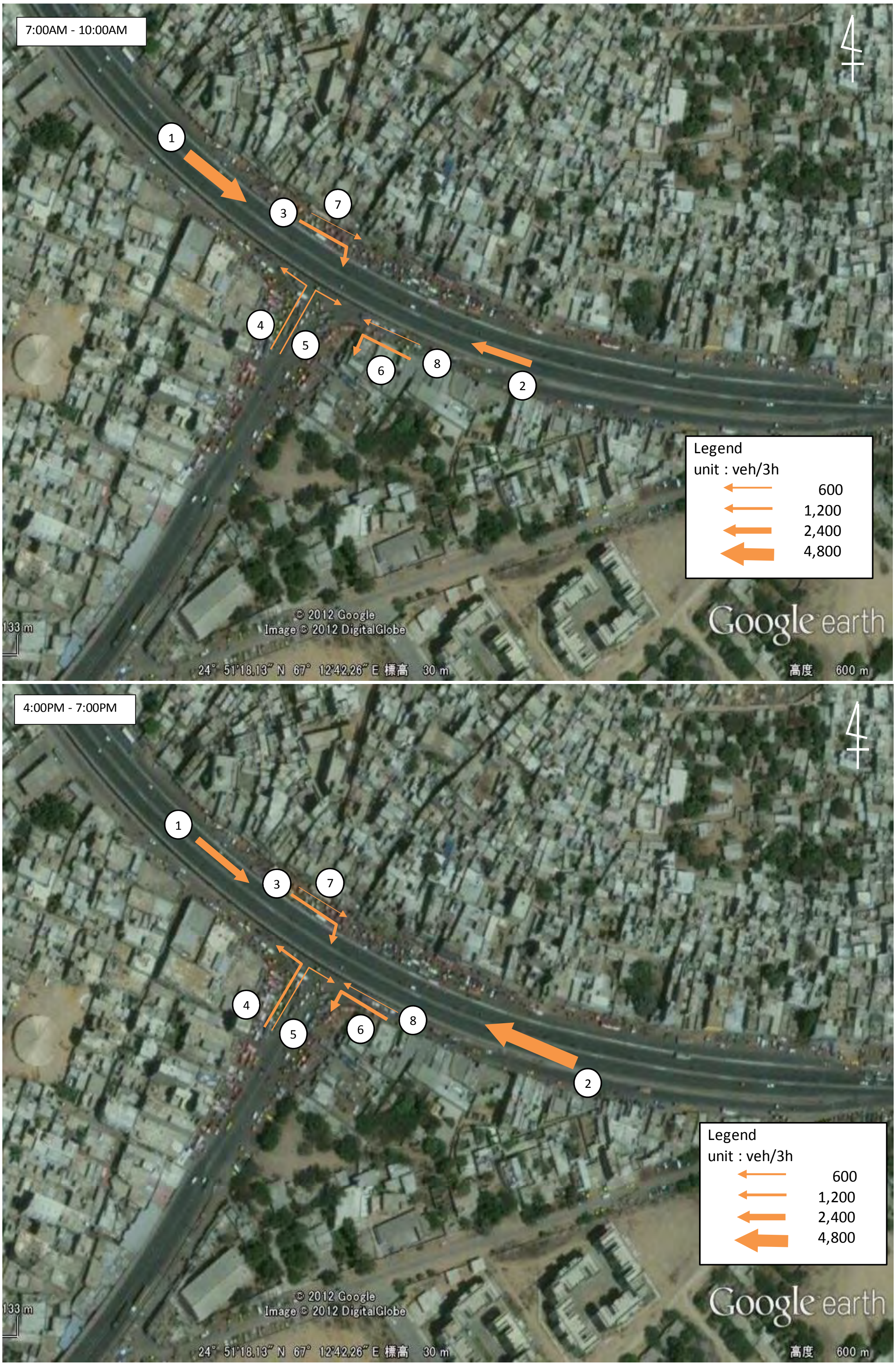
Table 4.2.5 shows the traffic volume at each direction and **Figure 4.2.8** shows the traffic flow at Quaidabad Intersection in the morning (7:00-10:00) and evening (16:00-19:00).

The major traffic flow was observed in the westward and eastward directions. But the traffic from the south directions ④ and ⑤ are relatively low.

Table 4.2.5 Traffic Volume at Quaidabad Intersection

Time		Direction								Total
		①	②	③	④	⑤	⑥	⑦	⑧	
Morning	7:00-8:00	1,644	938	462	266	221	480	79	98	4,188
	8:00-9:00	2,194	1,331	595	300	262	515	51	64	5.312
	9:00-10:00	2,064	1,197	534	217	239	501	66	57	4,875
	3 Hours Total	5,902	3,466	1,591	783	722	1,496	196	219	14,375
Evening	16:00-17:00	1,317	1,847	574	385	191	599	70	74	5,057
	17:00-18:00	1,056	2,729	457	451	188	682	64	72	5,699
	18:00-19:00	1,167	1,973	468	486	240	493	33	79	4,939
	3 Hours Total	3,540	6,549	1,499	1,322	619	1,774	167	225	15,695

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.8 Traffic Flow of Quaidabad Intersection (Morning and Evening)

3) Dawood Chowrangi Intersection

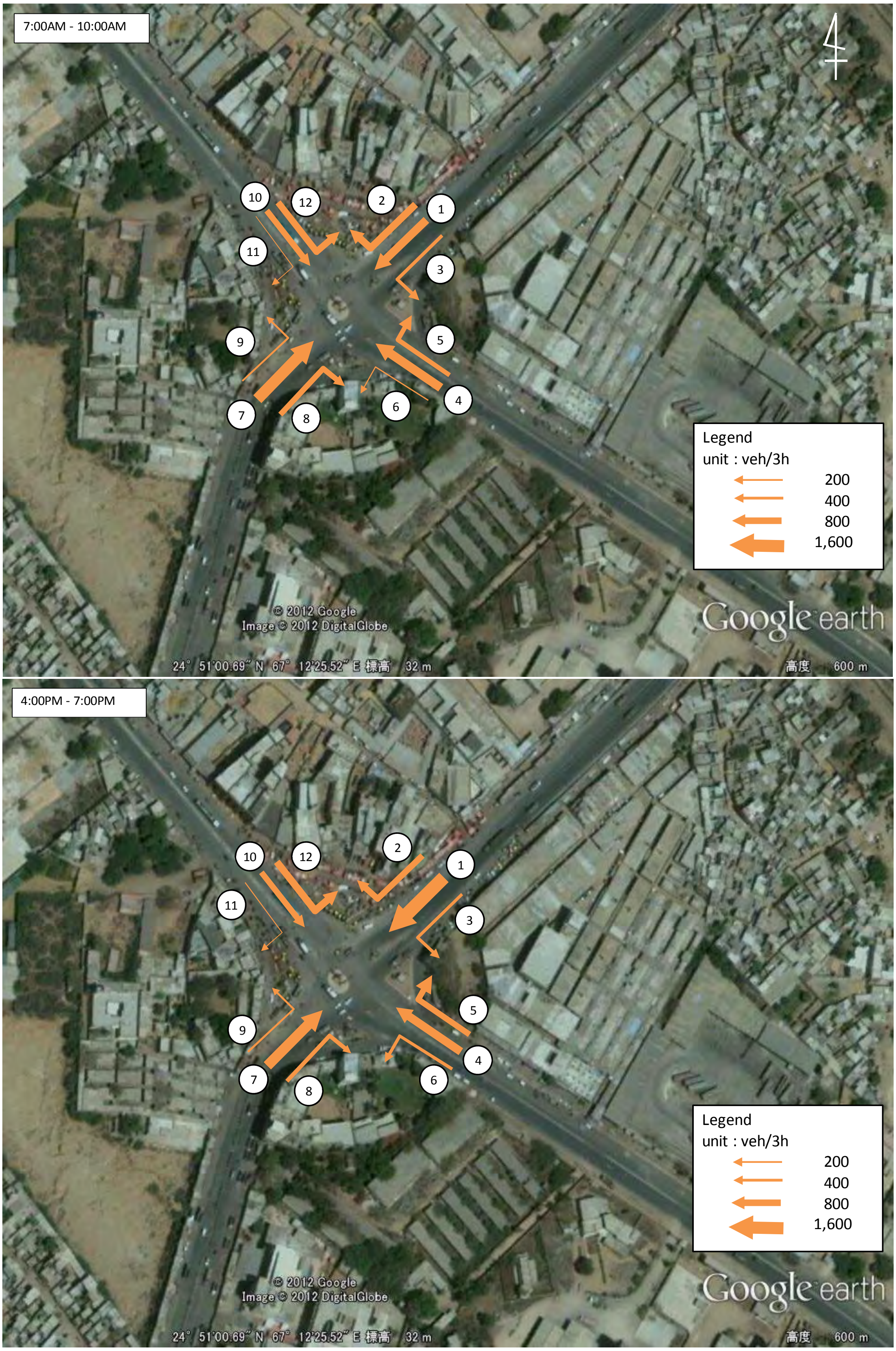
Table 4.2.6 shows the traffic volume at each direction and **Figure 4.2.9** shows the traffic flow at Dawood Chowrangi Intersection in the morning (7:00-10:00) and evening (16:00-19:00).

The major traffic flow was observed in the northward and southward directions. Also, the traffic toward south direction ⑦ and from north-direction ① are relatively high.

Table 4.2.6 Traffic Volume at Dawood Chowrangi Intersection

Time		Direction												Total
		①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	
Morning	7:00-8:00	376	343	103	409	227	52	509	260	76	145	22	269	2,791
	8:00-9:00	541	420	220	589	271	86	576	325	110	362	38	358	3,896
	9:00-10:00	446	377	227	489	266	62	694	304	106	405	61	433	3,870
	3 Hours Total	1,363	1,140	550	1,487	764	200	1,779	889	292	912	121	1,060	10,557
Evening	16:00-17:00	778	338	216	4540	262	125	551	229	141	350	31	359	3,830
	17:00-18:00	713	313	146	436	291	213	604	246	96	260	55	390	3,763
	18:00-19:00	620	308	144	370	379	173	559	182	76	362	53	402	3,628
	3 Hours Total	2,111	959	506	1,256	932	511	1,714	657	313	972	139	1,151	11,221

Source: JICA Study Team



Source: JICA Study Team

Figure 4.2.9 Traffic Flow of Dawood Chowrangi Intersection (Morning and Evening)

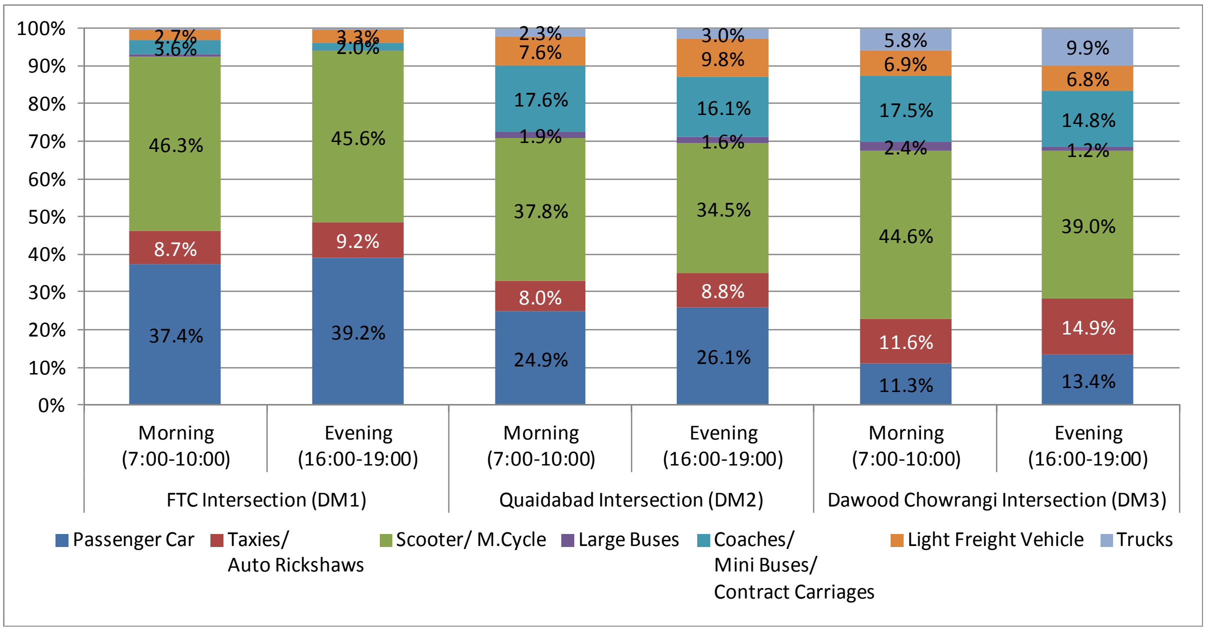
(2) Vehicle Composition

Table 4.2.7 and **Figure 4.2.10** show vehicle composition of each intersection. Scooter or motorcycle was found to be the major vehicle type present at every intersection. There are many passenger cars in DM1, but there are relatively many coaches/mini bus/contract carriages and light freight vehicle in DM2 and DM3. Also, there are relatively many taxis/auto rickshaws and trucks in DM3.

Table 4.2.7 Traffic Composition at the Three Intersections

Station		Passenger Car	Taxis/ Auto Rickshaws	Scooter/ Motorcycle	Large Buses	Coaches/ Mini Buses/ Contract Carriages	Light Freight Vehicle	Trucks
FTC Intersection (DM1)	Morning (7:00-10:00)	37.4%	8.7%	46.3%	0.7%	3.6%	2.7%	0.6%
	Evening (16:00-19:00)	39.2%	9.2%	45.6%	0.3%	2.0%	3.3%	0.5%
Quaidabad Intersection (DM2)	Morning (7:00-10:00)	24.9%	8.0%	37.8%	1.9%	17.6%	7.6%	2.3%
	Evening (16:00-19:00)	26.1%	8.8%	34.5%	1.6%	16.1%	9.8%	3.0%
Dawood Chowrangi Intersection (DM3)	Morning (7:00-10:00)	11.3%	11.6%	44.6%	2.4%	17.5%	6.9%	5.8%
	Evening (16:00-19:00)	13.4%	14.9%	39.0%	1.2%	14.8%	6.8%	9.9%

Source: JICA Study Team



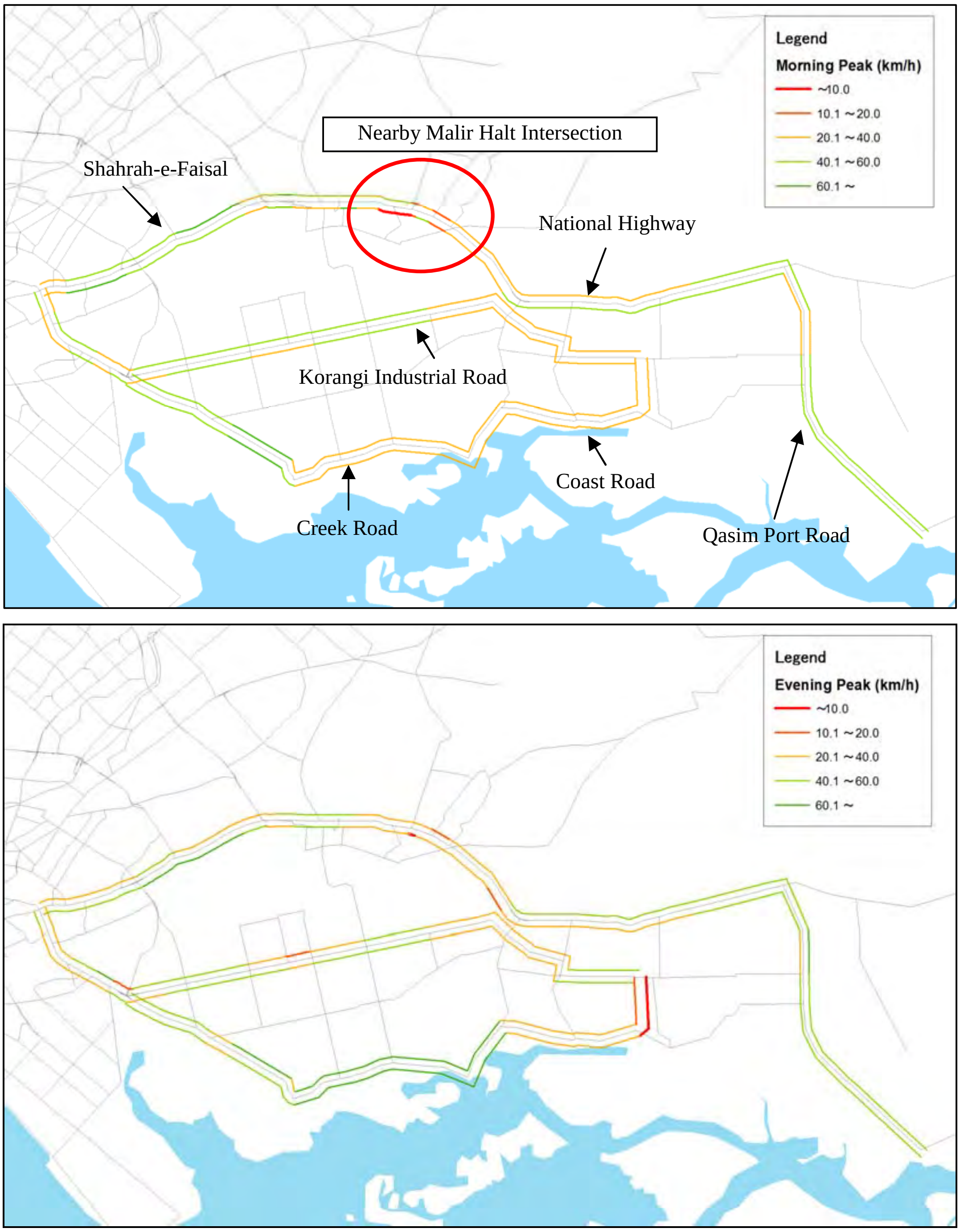
Source: JICA Study Team

Figure 4.2.10 Traffic Composition at Three Intersections (Morning and Evening)

4.2.3 Travel Speeds on Major Road

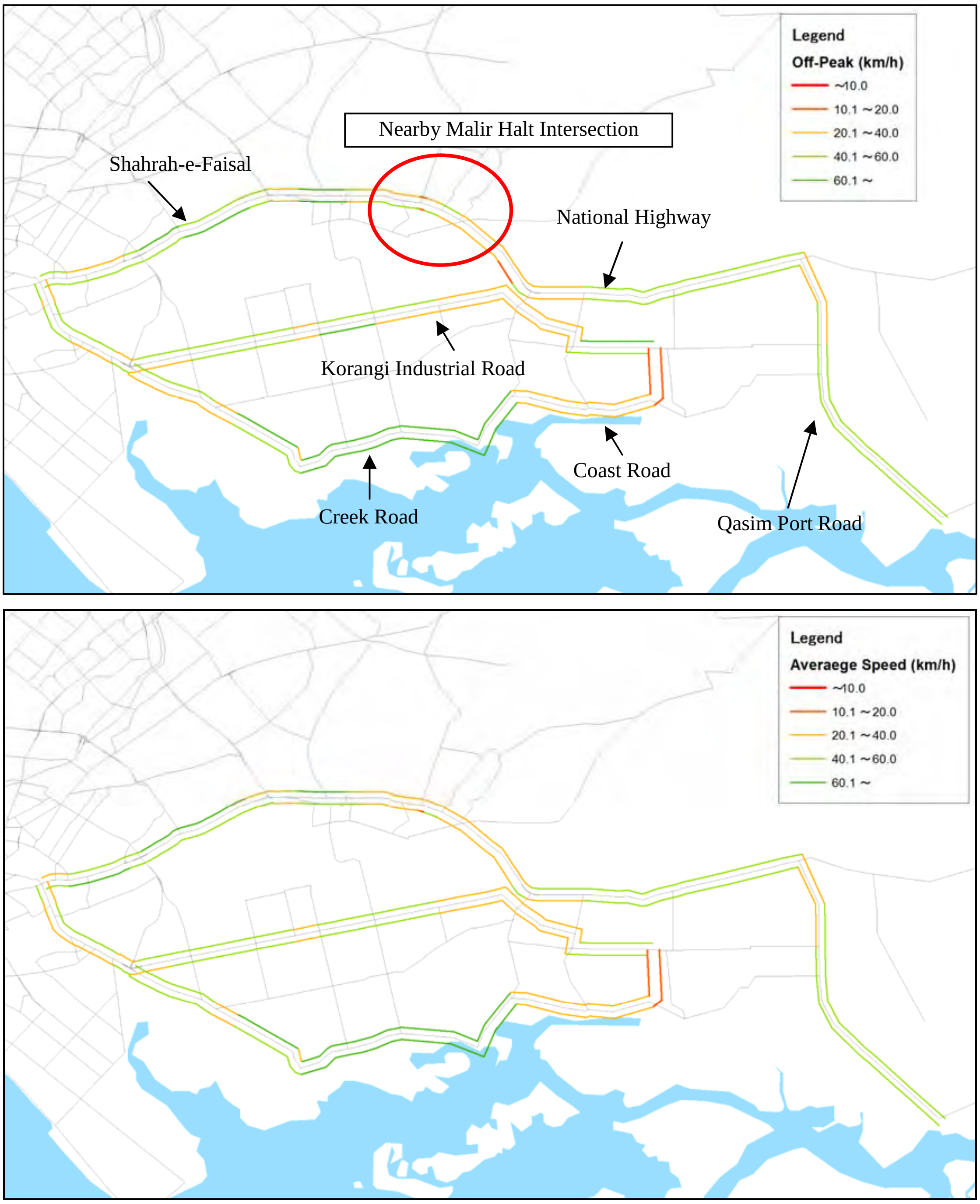
(1) Result of Travel Speed Survey

Figure 4.2.11 and **Figure 4.2.12** show the travel speed conditions by route and direction in the morning peak (7:00-10:00), off-peak (10:00-16:00), and evening peak (16:00-19:00). The congested sections appeared to be around Malir Halt Intersection and the surrounding sections. Traffic signal or concentration of traffic was found to be the cause of congestion.



Source: JICA Study Team

Figure 4.2.11 Result of Travel Speed Survey (Morning Peak and Evening Peak)

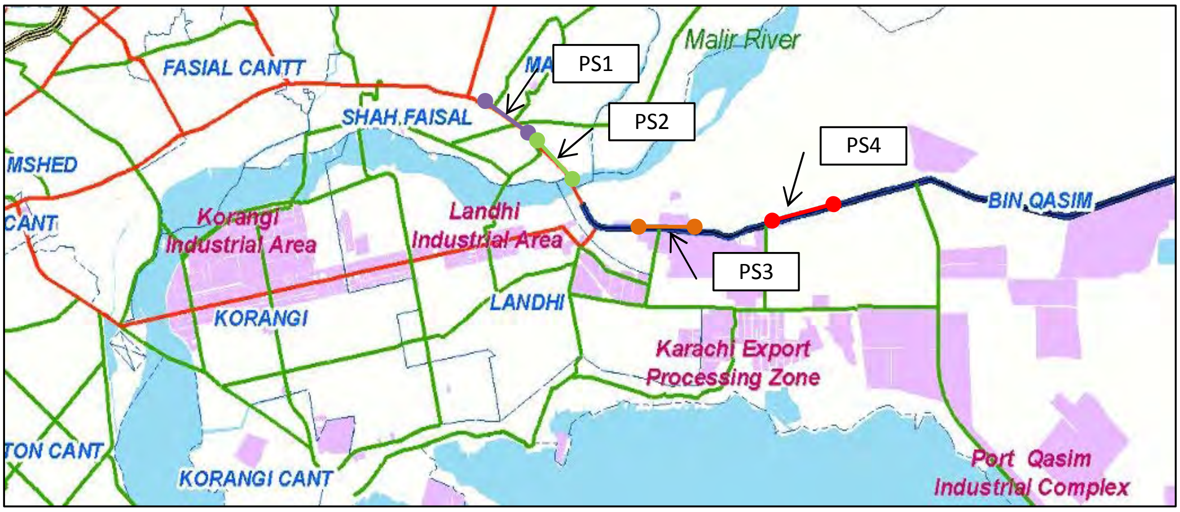


Source: JICA Study Team

Figure 4.2.12 Result of Travel Speed Survey (Evening Peak and Average Speed)

4.2.4 On-Road Parking

The on-road parking results were analyzed taking into consideration various views such as number of on-road parking, hourly fluctuation, purpose of parking and parking time, and parking frequency to figure out the parking situation in the Study Area.



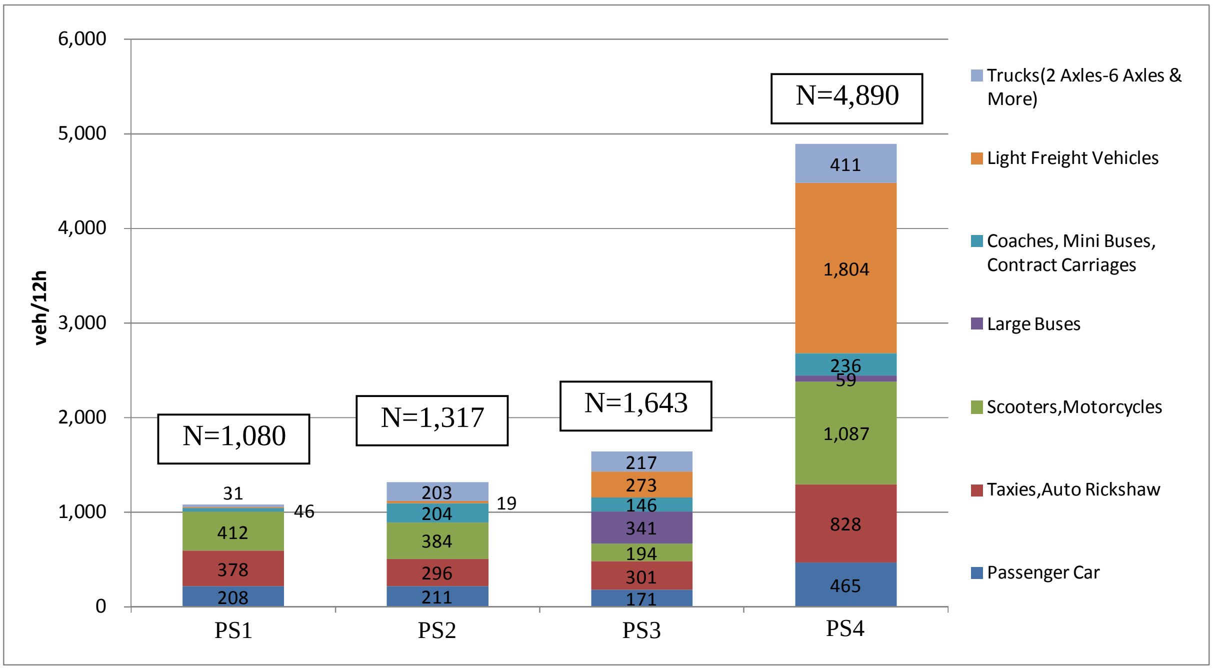
Source: JICA Study Team

Figure 4.2.13 Location of On-Road Parking Survey

(1) Number of On-Road Parking at Each Section and Parking Vehicles Composition

1) Number of On-Road Parking by Vehicle Type

Figure 4.2.14 shows the number of on-road parking by vehicle type and survey sections. PS 4 has the highest number of parking (4890 veh/12 h), and there were many light freight vehicles observed.

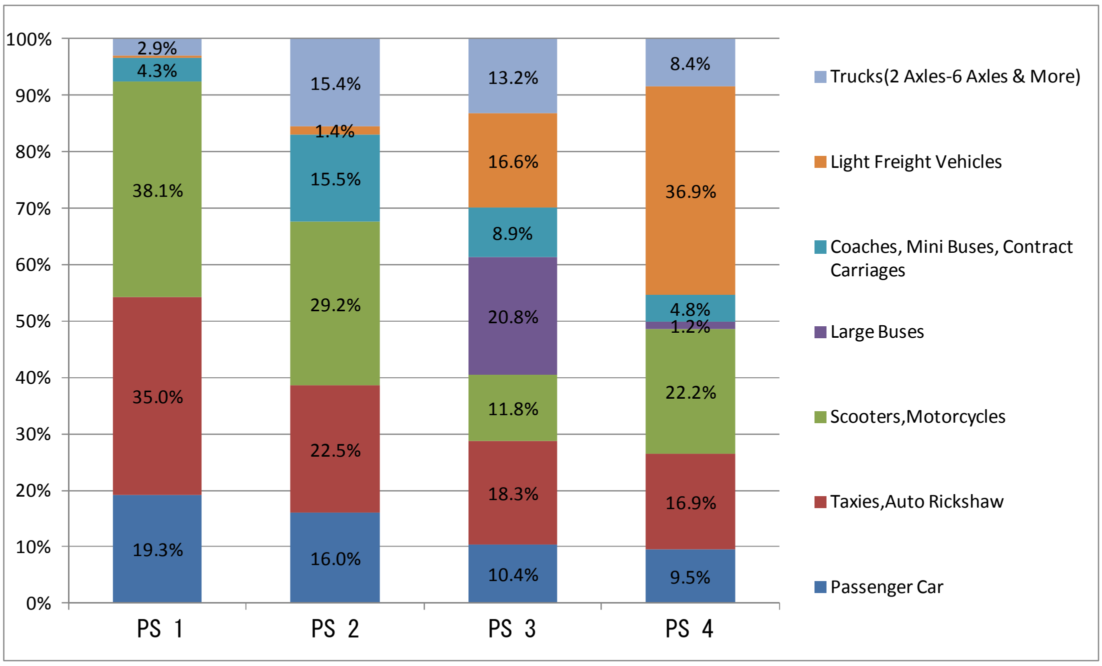


Source: JICA Study Team

Figure 4.2.14 Number of On-Road Parking by Vehicle Type and Section

2) Parking Vehicle Composition

Figure 4.2.15 shows the vehicle composition by survey section. PS 1 and PS 2 obtained the highest ratio of motorcycles (38.1%) and scooters (29.2%), PS 3 has the highest ratio of large buses (20.8%), and PS 4 has the highest ratio of light freight vehicles (36.9%).

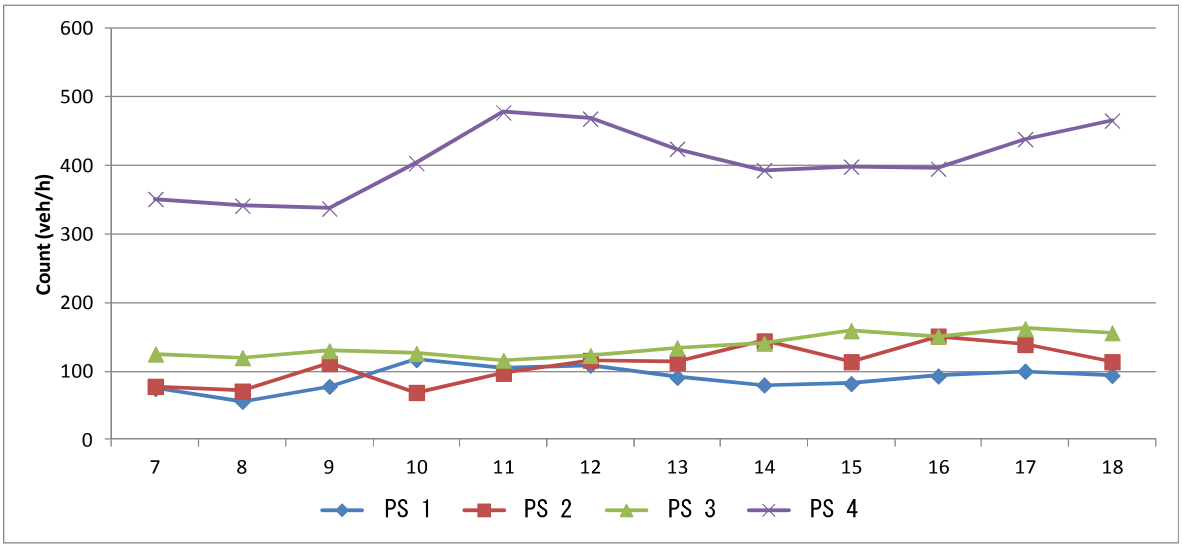


Source: JICA Study Team

Figure 4.2.15 Vehicle Composition by Section

(2) Hourly Fluctuation

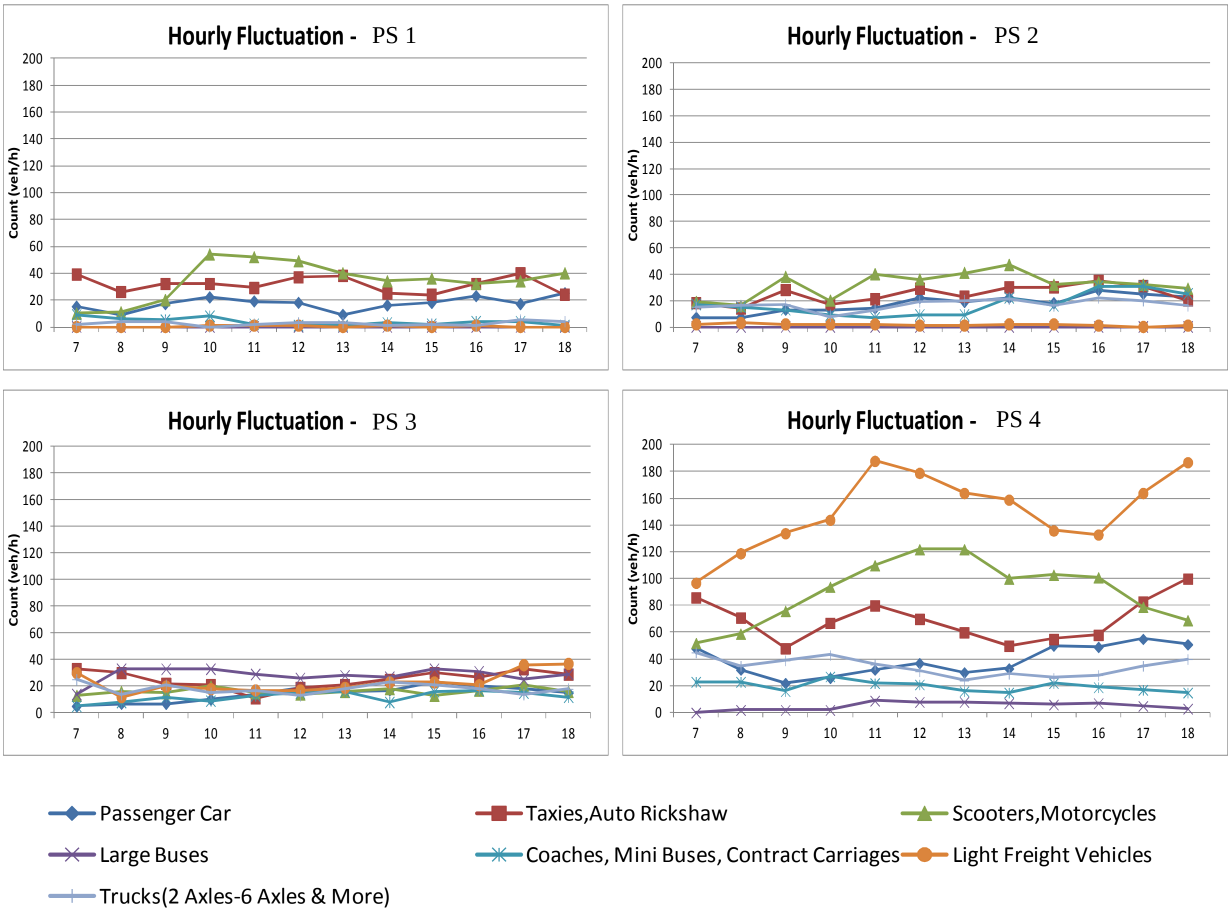
Figure 4.2.16 shows the hourly fluctuation by sections. The number of parking in PS 4 showed a strong peak between 11:00 and 12:00 in the morning, but the other sections displayed relatively flat profiles over the 12-hour day and did not have specific feature.



Source: JICA Study Team

Figure 4.2.16 Hourly Fluctuation by Section

Secondly, as observed in the hourly fluctuation of vehicle composition by sections, the light freight vehicles contributed more than 100 parks at each hour in PS 4. It was accounted that every vehicle parked generally less than 60 minutes' time in other sections. **Figure 4.2.17** shows hourly fluctuation of vehicle composition by sections.



Source: JICA Study Team

Figure 4.2.17 Hourly Fluctuation by Vehicle Composition and Section

(3) Purpose of Parking

Table 4.2.8 shows the parking purpose by section and **Figure 4.2.18** shows the proportion of parking purpose by vehicle composition and section. Shopping got the highest number of parking purpose at PS 1. On the other hand, delivery of goods has the highest number of parking purpose at other sections.

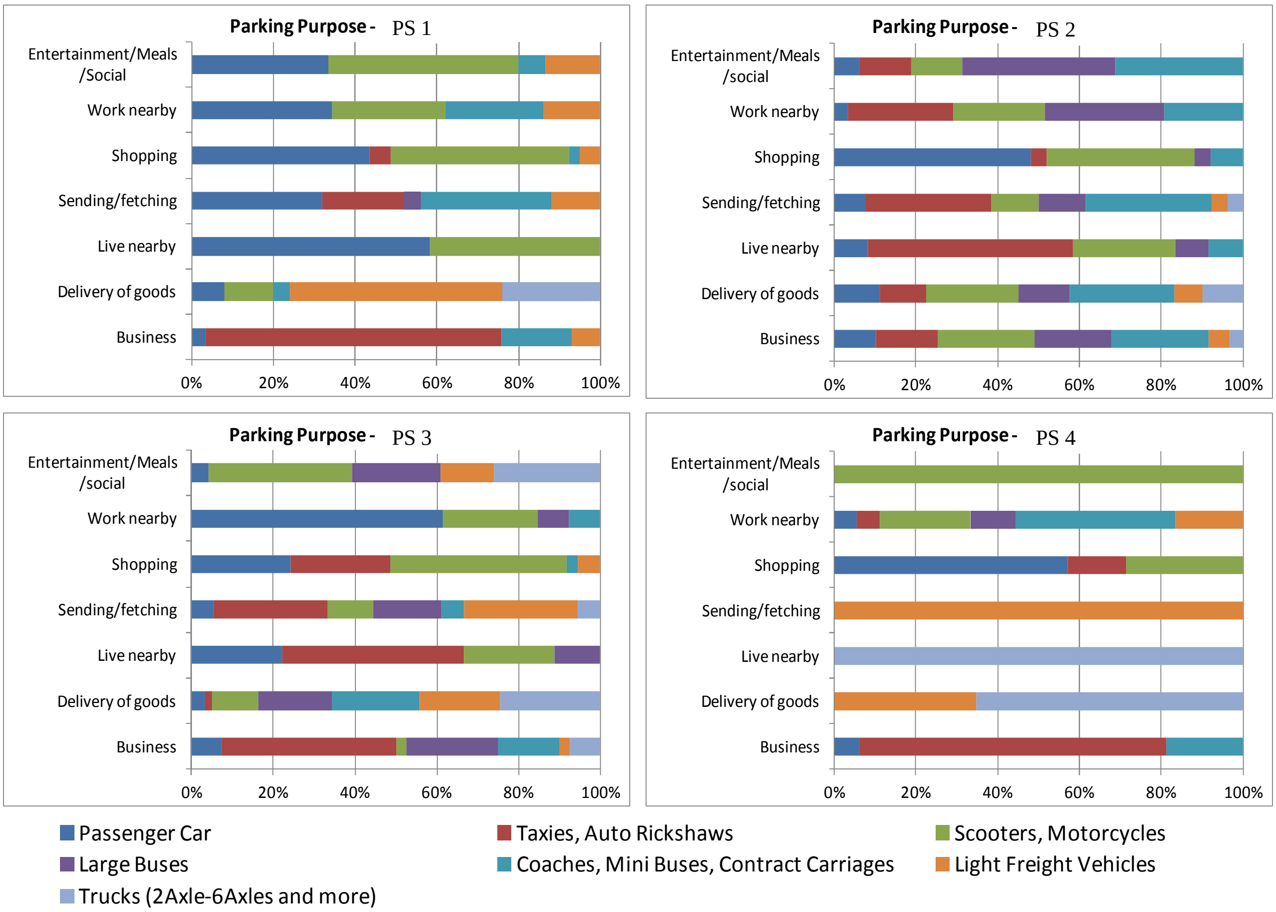
Many road users with business purpose used taxi or auto rickshaw, while road user who used car or scooter/motorcycle for shopping purpose was relatively high. Generally, large-size vehicle such as light freight vehicle and truck were used for the purpose of delivering goods.

Table 4.2.8 Parking Purpose

Parking Purpose	PS 1	PS 2	PS 3	PS 4	Total
Business	29	59	40	32	160
Delivery of goods	25	71	61	72	229
Live nearby	12	12	9	1	34

Parking Purpose	PS 1	PS 2	PS 3	PS 4	Total
Sending/fetching	25	26	18	1	70
Shopping	39	25	37	35	136
Work nearby	29	31	13	18	91
Entertainment/meals/social	15	16	23	9	63

Source: JICA Study Team

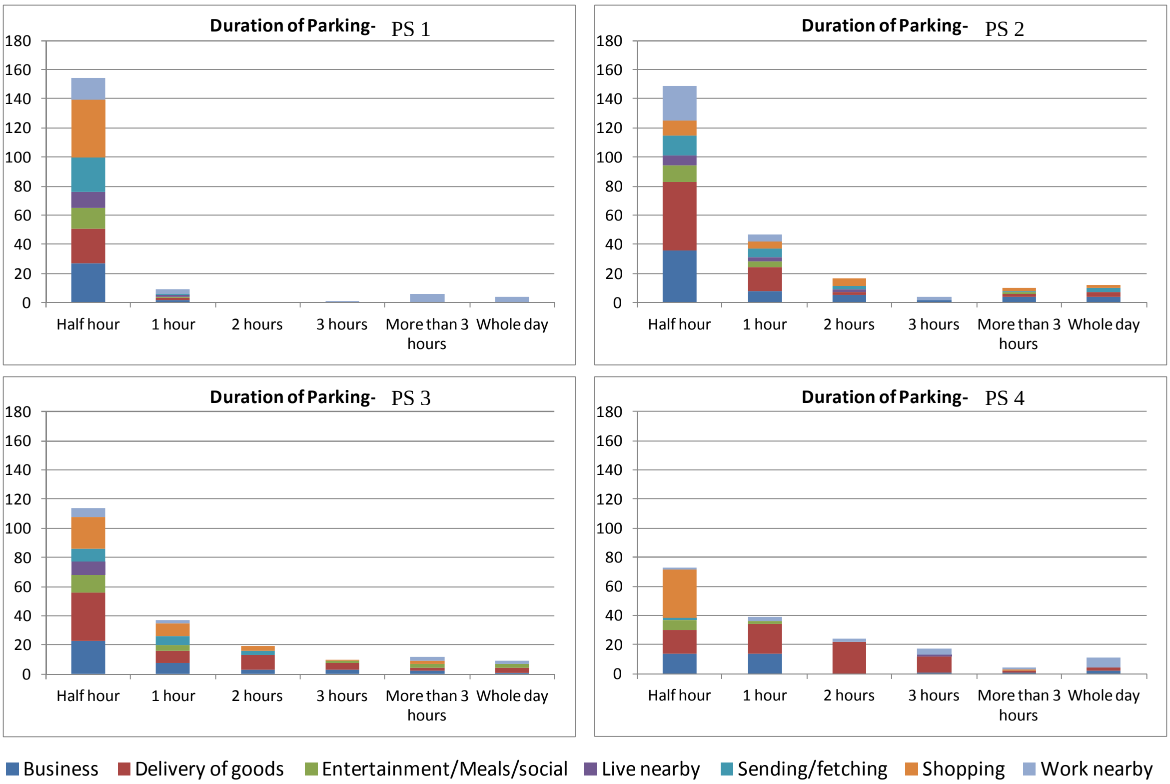


Source: JICA Study Team

Figure 4.2.18 Parking Purpose by Vehicle Composition and Section

(4) Duration of Parking

Figure 4.2.19 shows the duration of parking by purpose and section. Half-hour obtained the highest number of parking duration in every section, and accounted for most at PS 1, in particular. The purposes of shopping, living nearby or entertainment/meals/social got shorter parking time than other purposes, but delivery of goods has relatively long parking time of two to three hours or more.

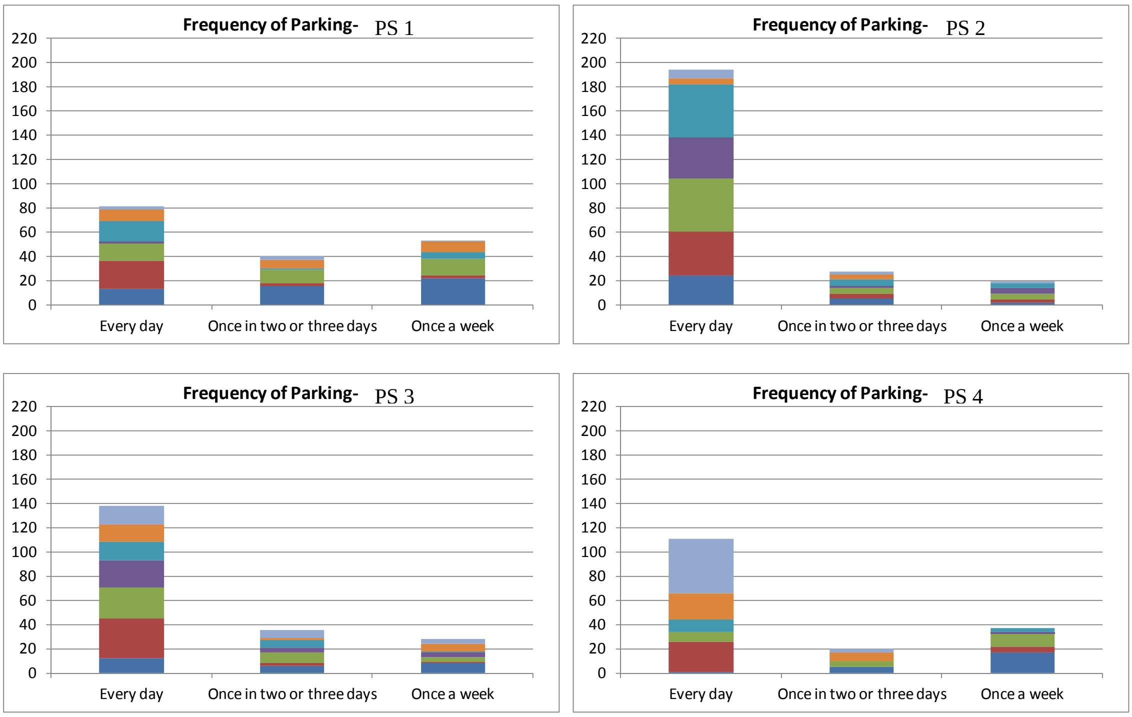


Source: JICA Study Team

Figure 4.2.19 Duration of Parking by Purpose and Sections

(5) Parking Frequency

Figure 4.2.20 shows the frequency of parking by vehicle composition and sections. Everyday has the highest number of parking frequency in every section, but there was a fewer proportion of everyday at PS 1 compared to other sections. At PS 4, the proportion that trucks parks everyday was high.



Source: JICA Study Team

Figure 4.2.20 Frequency of Parking by Vehicle Composition and Sections

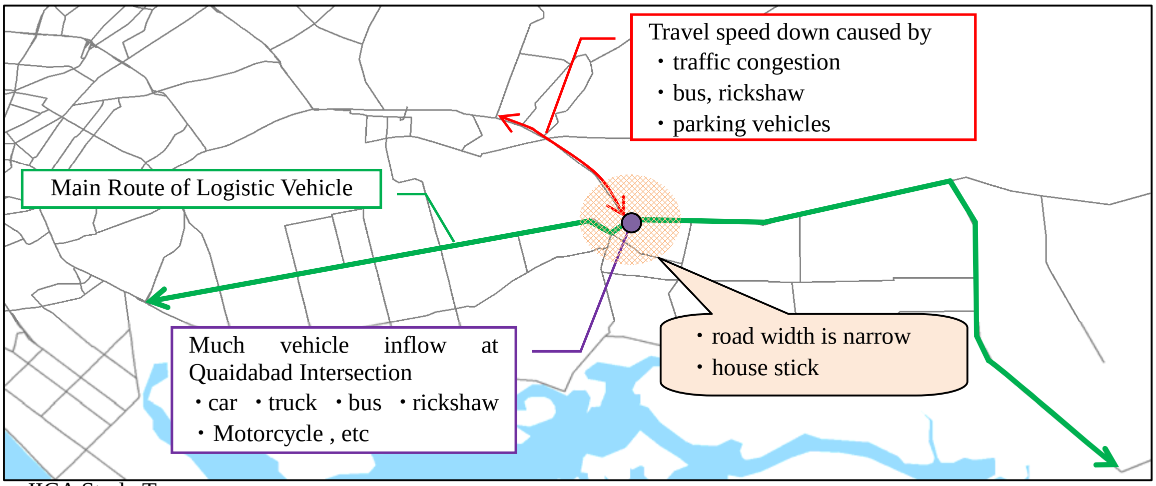
4.2.5 Summary of Present Traffic Condition

Based on the above-mentioned traffic conditions, Shahrah-e Faisal Road and Korangi Road have much traffic since these roads are considered major routes. The proportion of large-size vehicle increases on Shahrah-e Faisal Road around Qasim Port. Shahrah-e Faisal Road is an important route for logistics.

Vehicle speed of Shahrah-e Faisal Road decreases by the inflow from the crossway, and obstruction of traffic by getting on and off of bus passengers, and on-road parking around Malir Halt Intersection, which then becomes the bottleneck. Speed degradation occurs on the crossings of Shahrah-e Faisal Road and Korangi Road.

Although the traffic of large-size vehicles is regulated on Shahrah-e Faisal Road, traffic volume of large-size vehicles increases from Dawood Chowrangi Intersection without regulation. The inflows of bus or rickshaw and parking of vehicles obstruct traffic and contribute to the decrease in vehicle speed. In particular, vehicle composition changes on Quaidabad Intersection becoming the node, then the inflows of various traffic accelerate speed degradation, traffic congestion, and pressure on the road capacity. Because there is much inflow of traffic in these bottleneck spots, and the existence of house stakes makes the road width narrower, it is necessary to alleviate the obstruction of traffic and construct an alternative road.

Although there is little traffic on the Coast Road, vehicle speed is decreased in some sections due to the road width being narrow and the concentration of large-size vehicles and scooters/ motorcycles.



Source: JICA Study Team

Figure 4.2.21 Present Traffic Condition in this study area