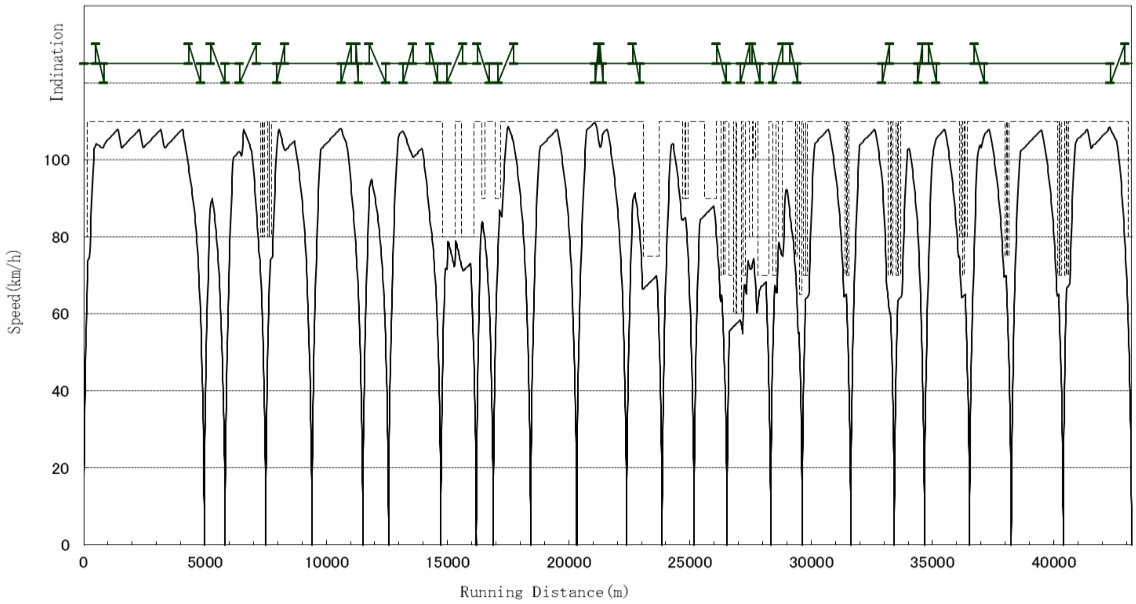
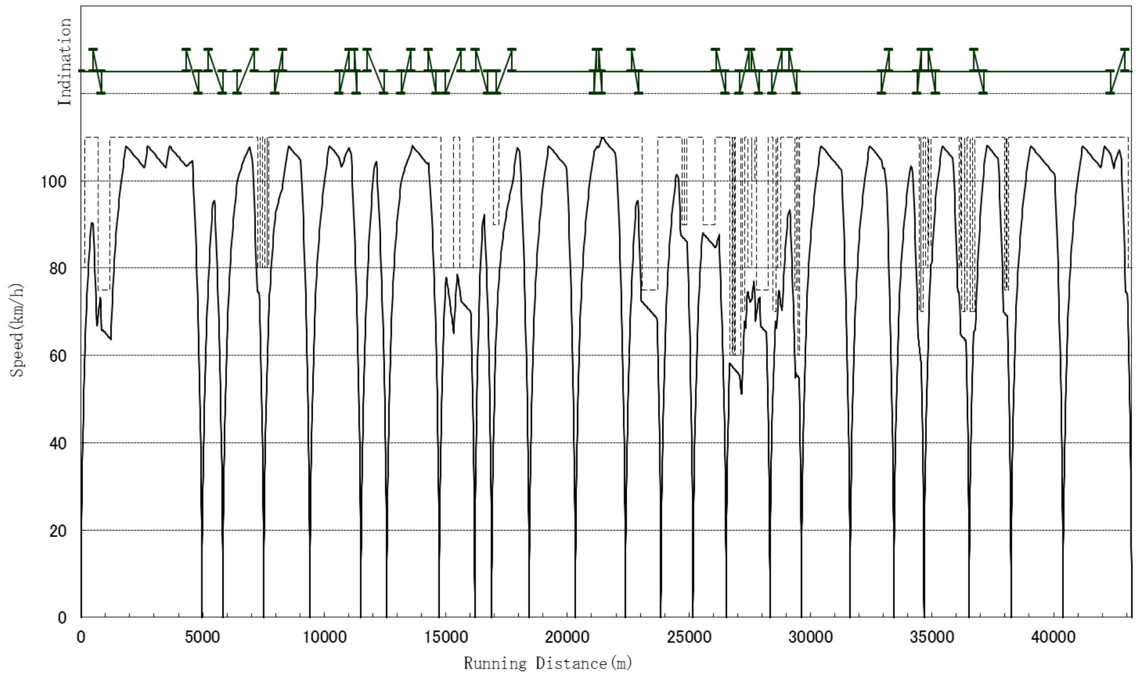
6) Train Movement Curve

Train movement curve of Circular Line (N-A1) is shown in Figure 5.3.29 for down line and Figure 5.3.30 for up line.



Source: JICA Study Team

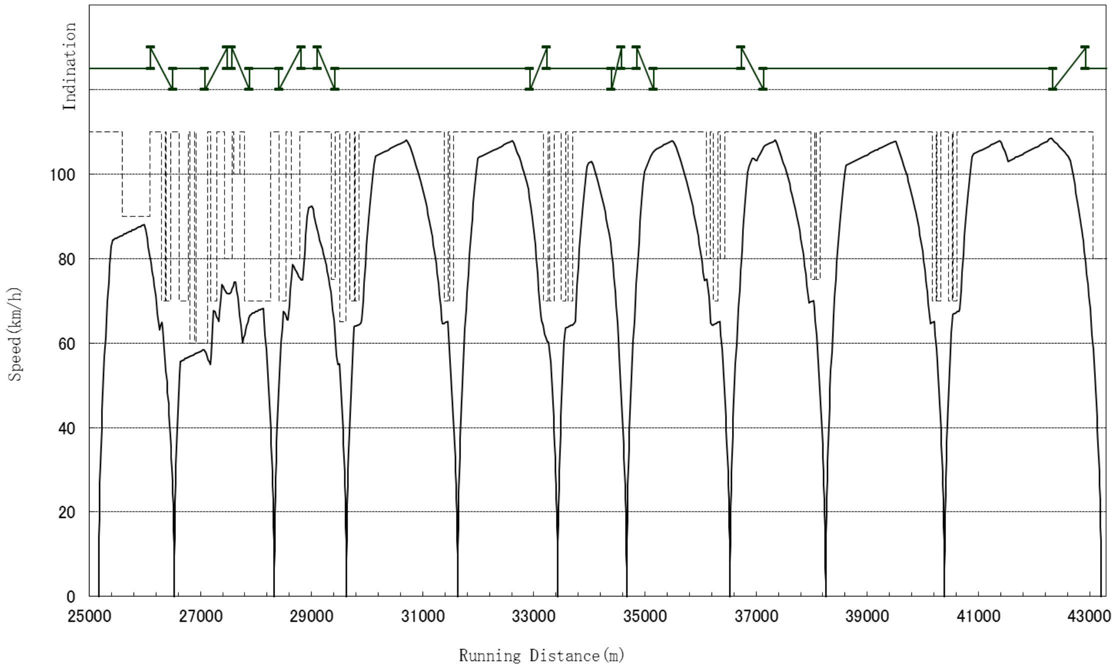
Figure 5.3.29 Train Movement Curve of Circular Line : Down Line (N-A1)



Source: JICA Study Team

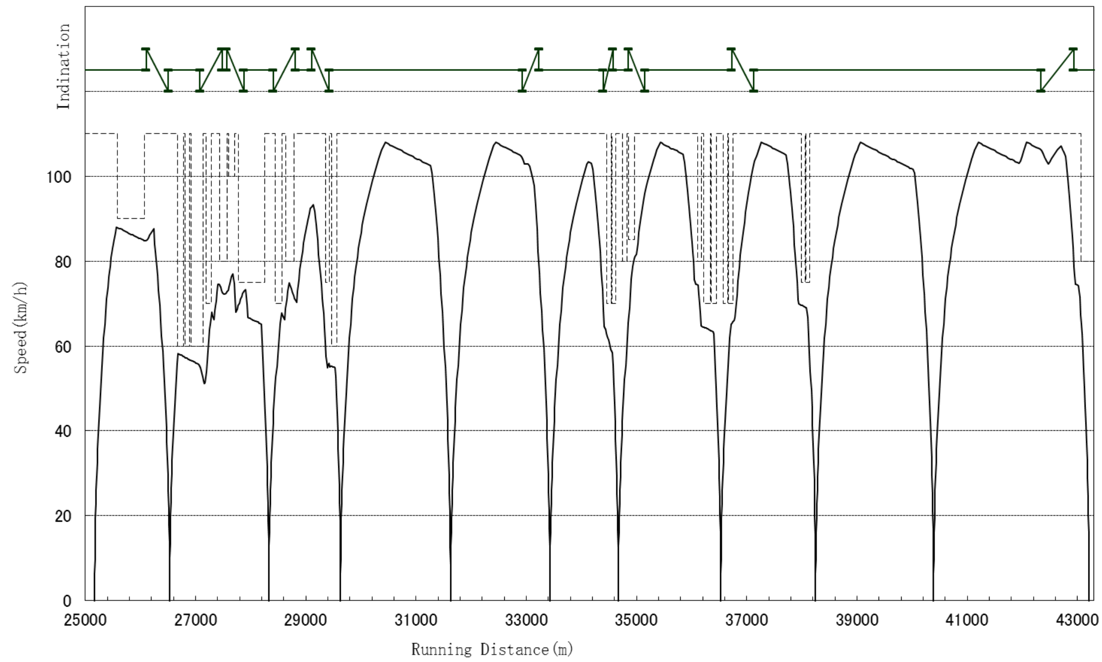
Figure 5.3.30 Train Movement Curve of Circular Line : Up Line (N-A1)

Train movement curve of Extension Line (N-A1) between Drigh Road and Liyari station is shown in Figure 5.3.31 for down line and Figure 5.3.32 for up line.



Source: JICA Study Team

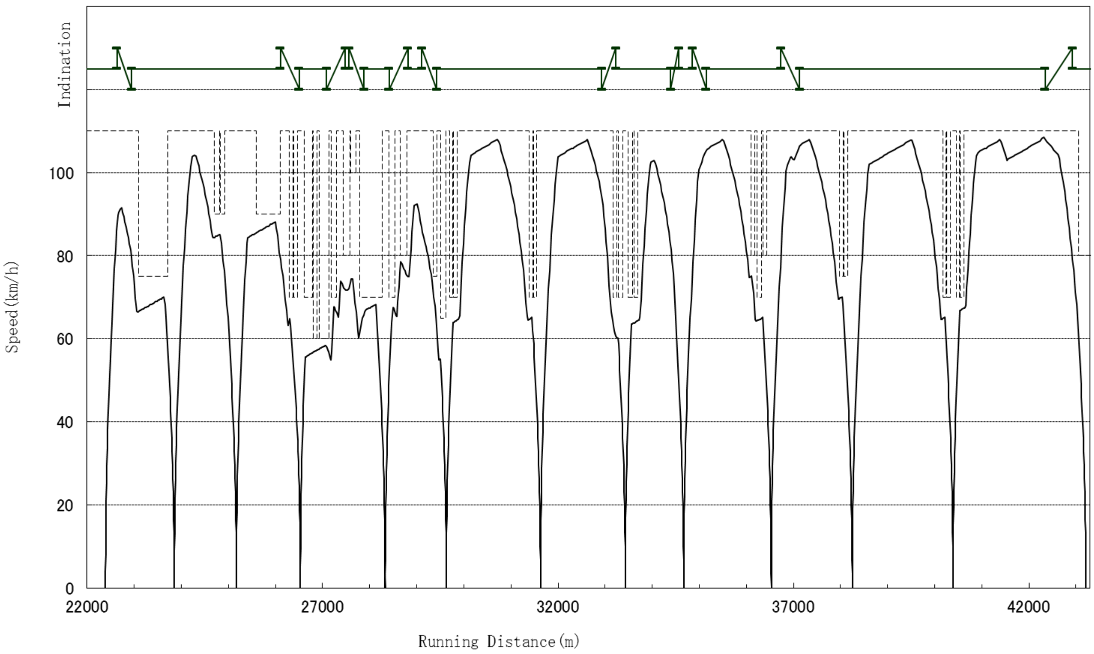
Figure 5.3.31 Train Movement Curve of Extension line : Down Line (N-A1)



Source: JICA Study Team

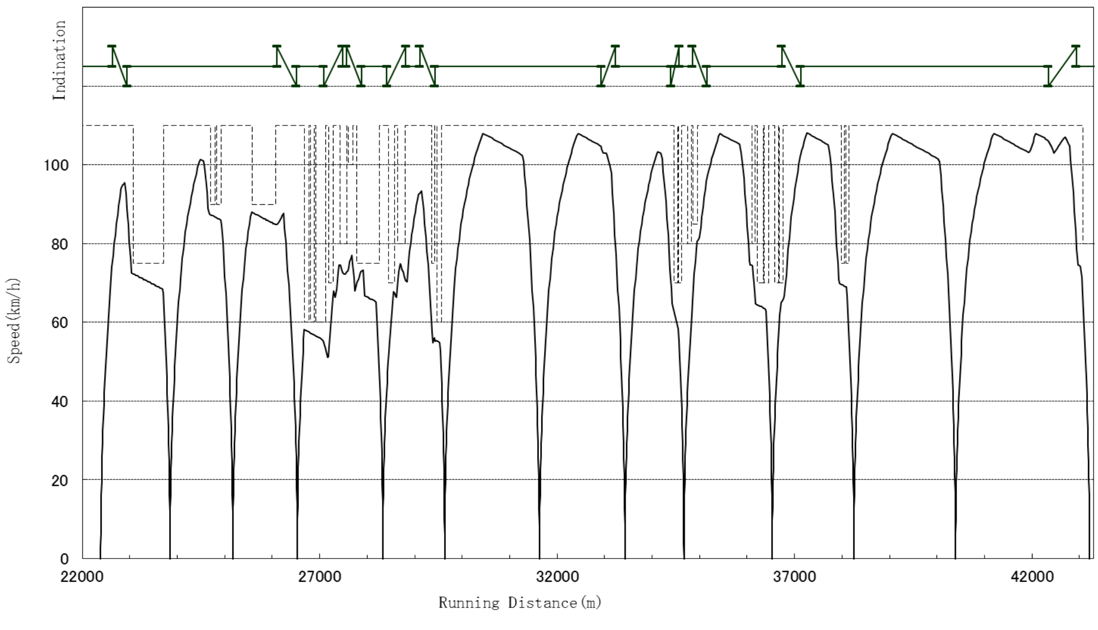
Figure 5.3.32 Train Movement Curve of Extension Line : Up Line (N-A1)

Train movement curve of Drigh Road - Shah Abdul Latif Line (N-B1) is shown in Figure 5.3.33 for down line and Figure 5.3.34 for up line.



Source: JICA Study Team

Figure 5.3.33 Train Movement Curve of Drigh Road - Shah Abdul Latif Line : Down Line (N-B1)



Source: JICA Study Team

Figure 5.3.34 Train Movement Curve of Drigh Road - Shah Abdul Latif Line : Up Line (N-B1)

(4) Details of Simulation Results

1) Alladin Park TSS (N-A1, Normal Feeding)

a) Voltage, Current and Power

i) Maximum & Minimum values of voltage and current

Maximum & Minimum values of voltage, current, power and time of occurrence at Alladin Park TSS and SP1&2 between 7:00 and 9:00 is shown in Table 5.3.27 below.

Table 5.3.27 Maximum & Minimum Values of Alladin Park TSS (N-A1, Normal Feeding)

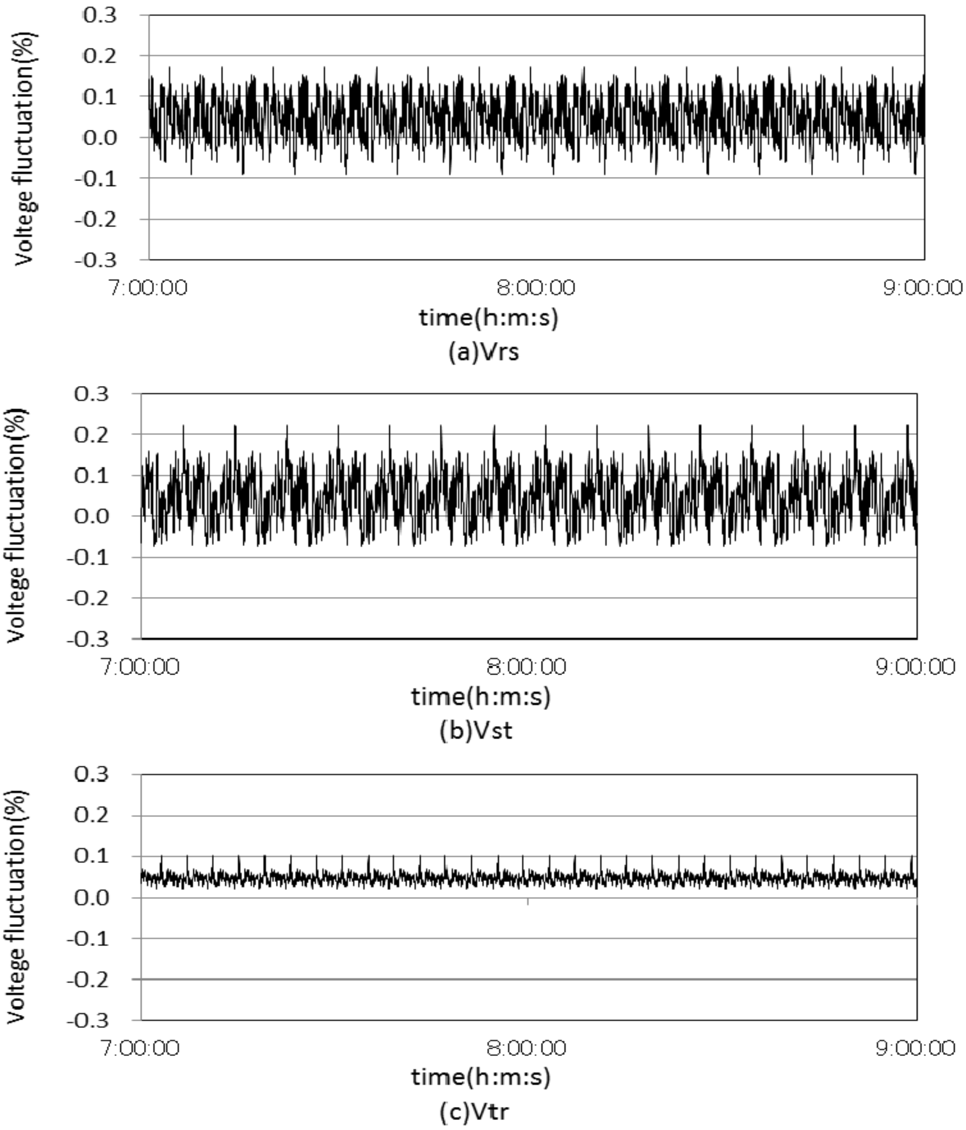
Item		ALLADIN PARK SS	
		Simulation Result	Occur Time
Incoming Voltage	minimum Vuv(kV)	131.772	7:03:11
	minimum Vvw(kV)	131.704	7:06:34
	minimum Vwu(kV)	131.862	7:03:11
	Max Effective Power(kW)	15438.8	7:01:00
	Average Voltage unbalance(%)	0.05	−
Teaser Feeding Bus	minimum Voltage(kV)	27.326	7:01:09
	Max Current(A)	330.9	7:00:14
	Max Effective Power(kW)	8847	7:00:14
	Max Reactive Power(kVar)	2436.5	7:08:22
	Electric Power Consumption(kWh)	5853.8	−
	Average Power Factor	0.93	−
Feeding circuit (SP1 end) Up track	Max Current(A)	188.3	7:07:17
	Max Effective Power(kW)	5023.5	7:07:17
	Max Reactive Power(kVar)	1174.5	7:05:53
	minimum Volltage at SP1(kV)	27.171	7:01:09
	Electric Power Consumption(kWh)	3349.8	−
	Average Power Factor	0.94	−
Feeding circuit (SP1 end) Down track	Max Current(A)	190.8	7:01:00
	Max Effective Power(kW)	5106.8	7:01:00
	Max Reactive Power(kVar)	1405.3	7:01:07
	minimum Volltage at SP1(kV)	27.171	7:01:09
	Electric Power Consumption(kWh)	2849.5	−
	Average Power Factor	0.92	−
Main Feeding Bus	minimum Voltage(kV)	27.302	7:03:11
	Max Current(A)	285.4	7:03:11
	Max Effective Power(kW)	7329.7	7:03:11
	Max Reactive Power(kVar)	2643.3	7:03:11
	Electric Power Consumption(kWh)	5403.6	−
	Average Power Factor	0.91	−
Feeding circuit (SP2 end) Up track	Max Current(A)	160.4	7:03:11
	Max Effective Power(kW)	4247.2	7:03:11
	Max Reactive Power(kVar)	1069.2	7:03:11
	minimum Volltage at SP2(kV)	27.185	7:03:11
	Electric Power Consumption(kWh)	2914.7	−
	Average Power Factor	0.92	−
Feeding circuit (SP2 end) Down track	Max Current(A)	146.8	7:03:05
	Max Effective Power(kW)	3937.7	7:03:05
	Max Reactive Power(kVar)	1574.2	7:03:11
	minimum Volltage at SP2(kV)	27.185	7:03:11
	Electric Power Consumption(kWh)	2682.8	−
	Average Power Factor	0.91	−

Source: JICA Study Team

ii) Unbalance and Fluctuation Rate of Receiving Voltage

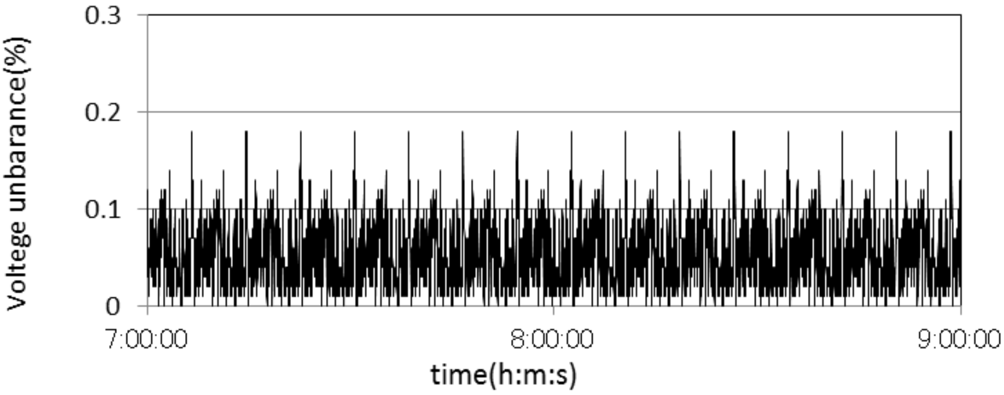
Figure 5.3.35 and Figure 5.3.36 show fluctuation rate and unbalance rate of receiving voltage of Alladin Park TSS. From these figures, maximum voltage fluctuation rate of Alladin Park TSS is Vrs:0.17%, Vst:0.22% & Vtr:0.10% and maximum voltage unbalance rate is 0.18%.

As a result, both maximum fluctuation and unbalance rate of receiving voltage are not exceeding 5% which is limited by regulation.



Source: JICA Study Team

Figure 5.3.35 Fluctuation Rate of Receiving Voltage (Alladin Park TSS)



Source: JICA Study Team

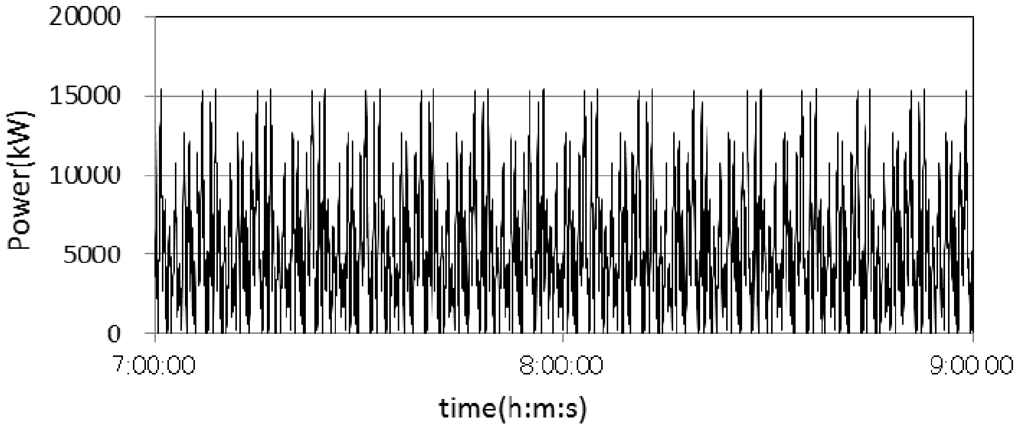
Figure 5.3.36 Unbalance Rate of Receiving Voltage (Alladin Park TSS)

iii) Receiving Power

Figure 5.3.37 and Figure 5.3.38 show receiving power transition and regenerative power transition of Alladin Park TSS respectively between 7:00 and 9:00.

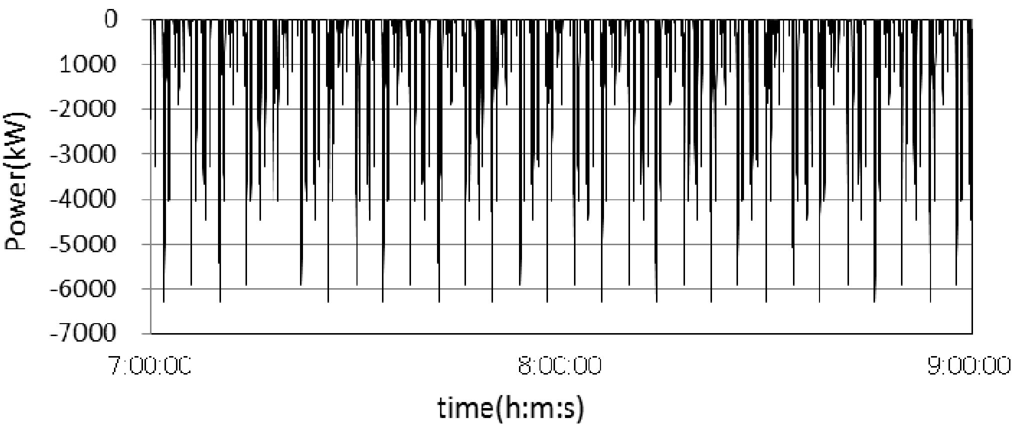
Maximum receiving power is 15,438kW at 7:01:00.

Power consumption for two hours is 11,256kWh, while regenerative power which is not consumed by accelerating cars but goes back to power company is -1,209kWh.



Source: JICA Study Team

Figure 5.3.37 Receiving Power Transition of Alladin Park TSS

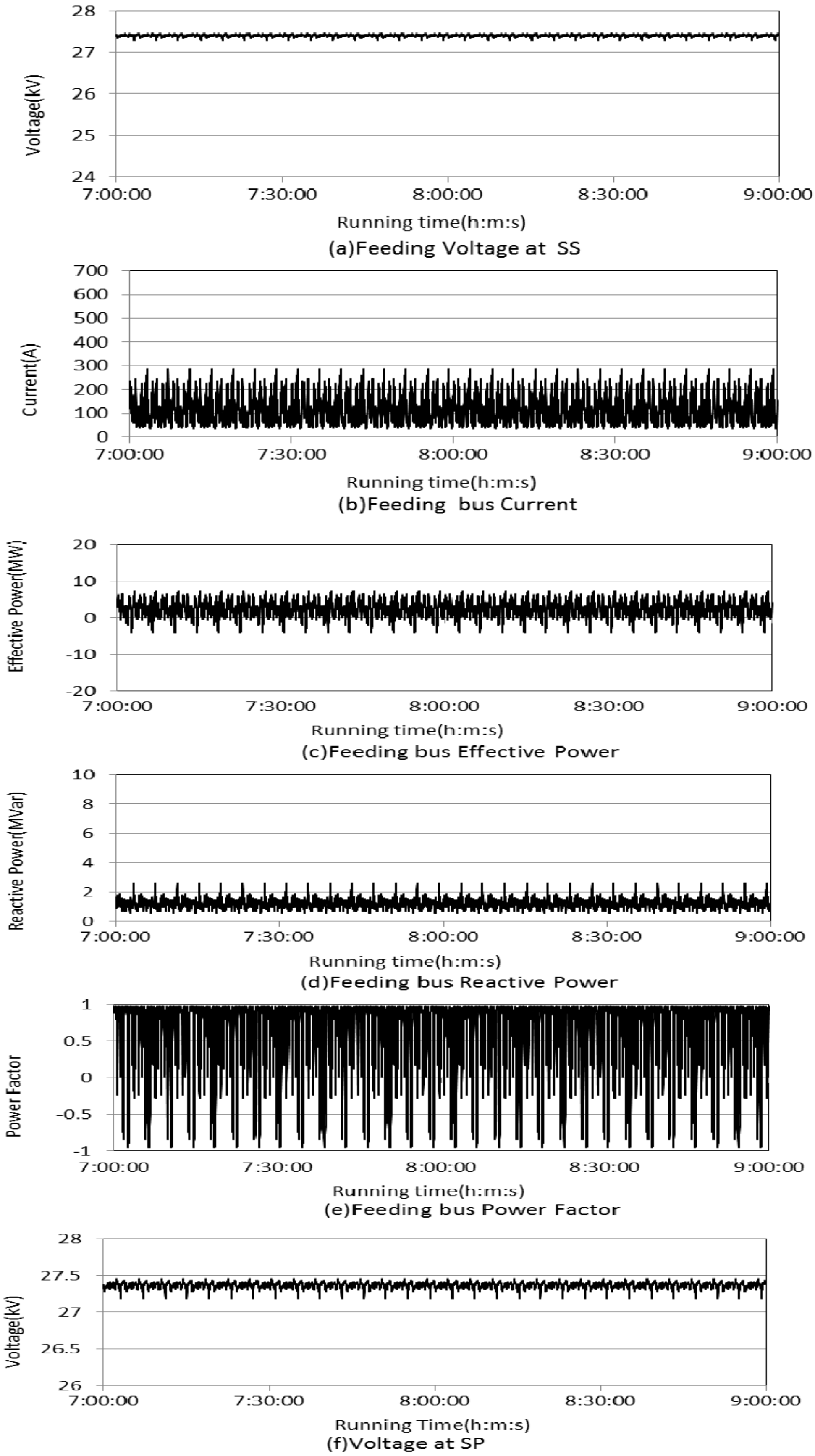


Source: JICA Study Team

Figure 5.3.38 Regenerative Power Transition of Alladin Park TSS

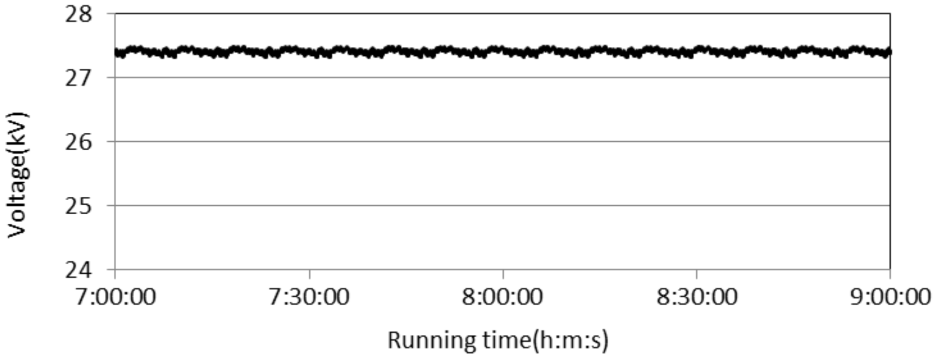
iv) Feeding Voltage, Current and Power

Figure 5.3.39 and Figure 5.3.40 show feeding voltage, current and power of Alladin Park TSS. Maximum feeding currents are 285A at Main phase bus and 331A at Teaser phase bus. Terminal voltage of feeding circuit at SP point is more than 27KV during 2 hours which is exceeding minimum feeding voltage of 20KV.

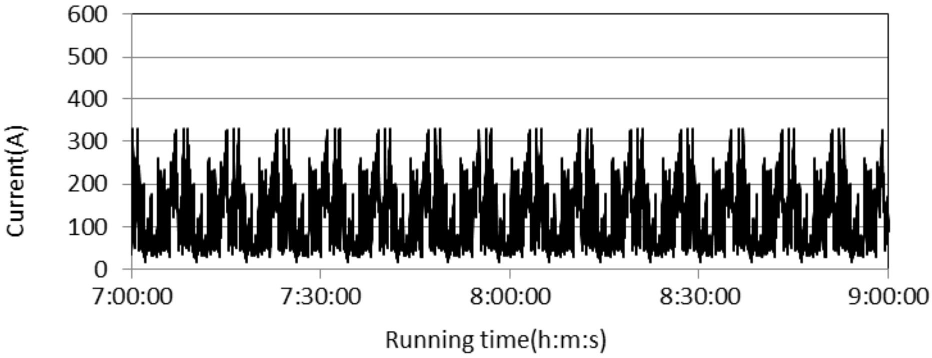


Source: JICA Study Team

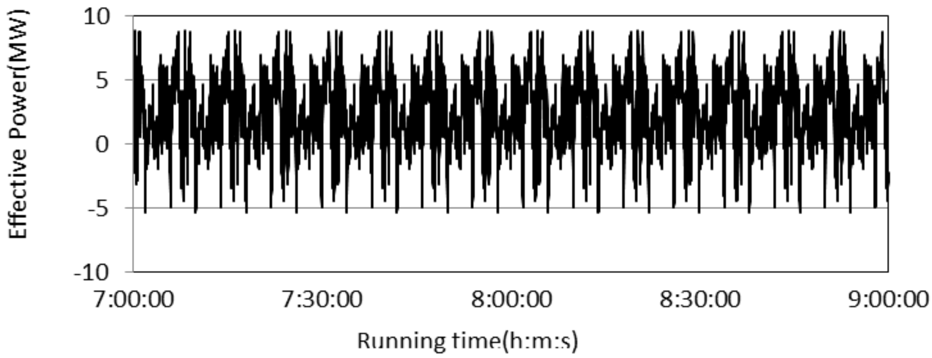
Figure 5.3.39 Feeding Voltage, Current & Power (Main Phase Bus) and Voltage at SP



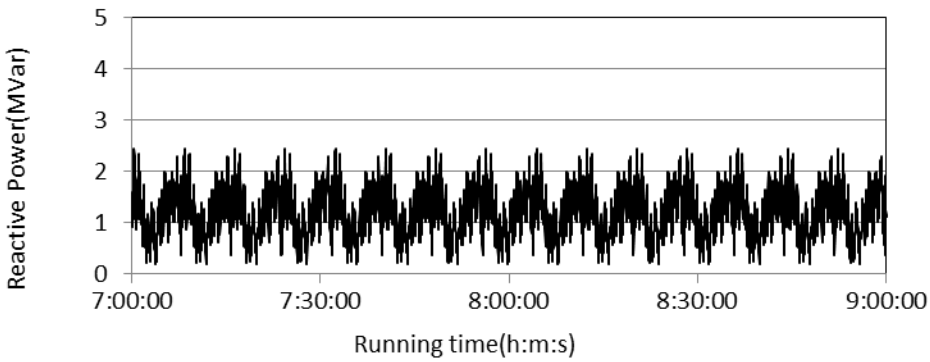
(a)Feeding Voltage at SS



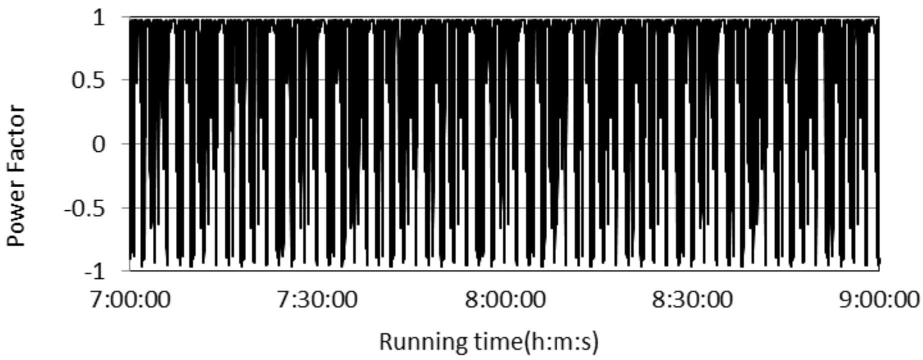
(b)Feeding bus Current



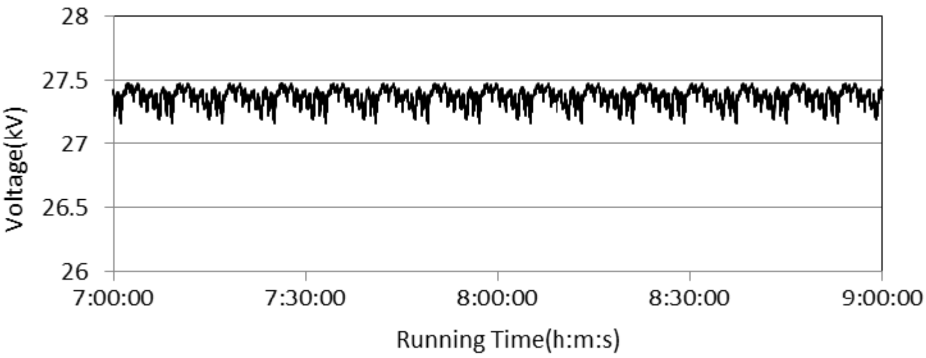
(c)Feeding bus Effective Power



(d)Feeding bus Reactive Power



(e)Feeding bus Power Factor



(f)Voltage at SP1

Source: JICA Study Team

Figure 5.3.40 Feeding Voltage, Current & Power (Teaser phase Bus) and Voltage at SP

b) **Capacity of Transformer**

i) Feeding Transformer

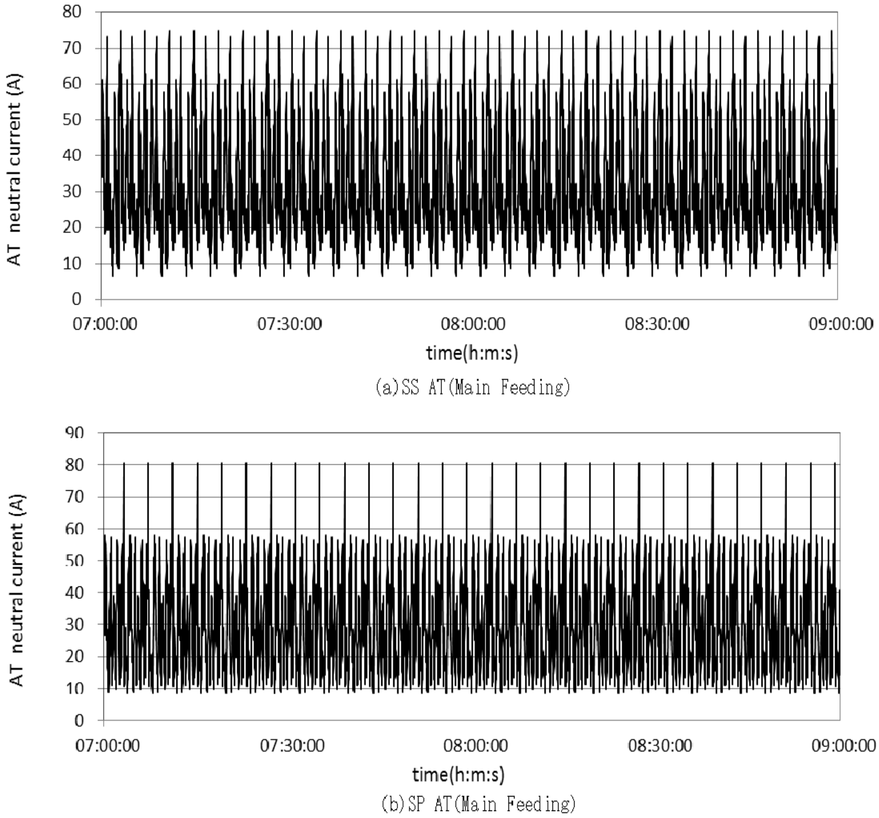
The maximum power of Main phase feeding bus of Alladin Park TSS is 8,847KW as shown in Table 5.3.27. Accordingly 17.6MVA (8.8MVA×2) is required for total capacity of Scott-Connected Transformer because total capacity is the sum of Main phase and Teaser phase capacity. However, taking 30% of safety factor into account, 23MVA will be appropriate capacity of feeding transformer in normal feeding case of N-A1.

ii) AT (Auto Transformer)

ii-1) AT Neutral Current

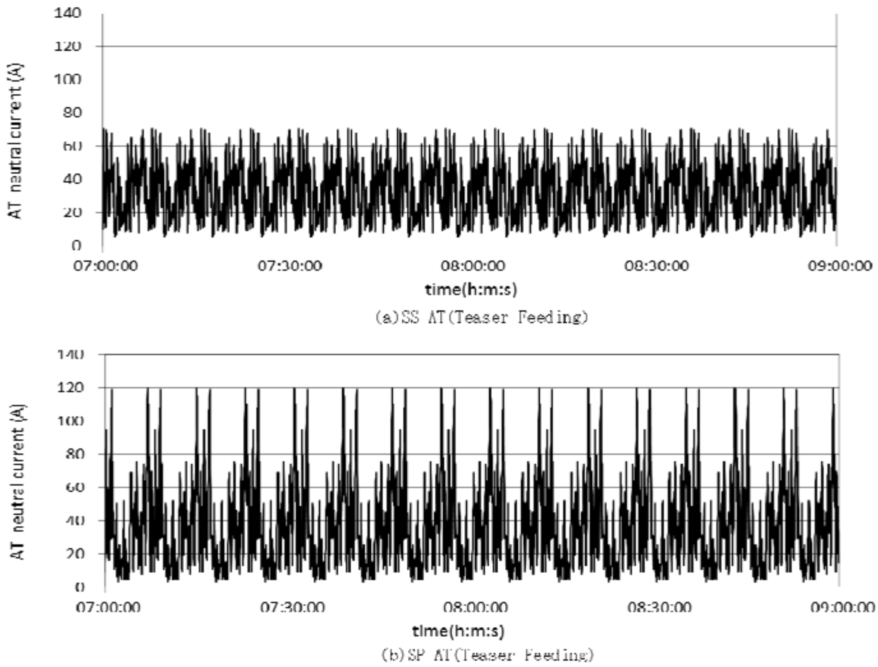
In case of Main phase, maximum AT neutral current at TSS is 75A and at SP is 81A as shown in Figure 5.3.41

In case of Teaser phase, maximum AT neutral current at TSS is 71A and at SP is 120A as shown in Figure 5.3.42.



Source: JICA Study Team

Figure 5.3.41 Neutral Current at Alladin Park TSS, Main Phase

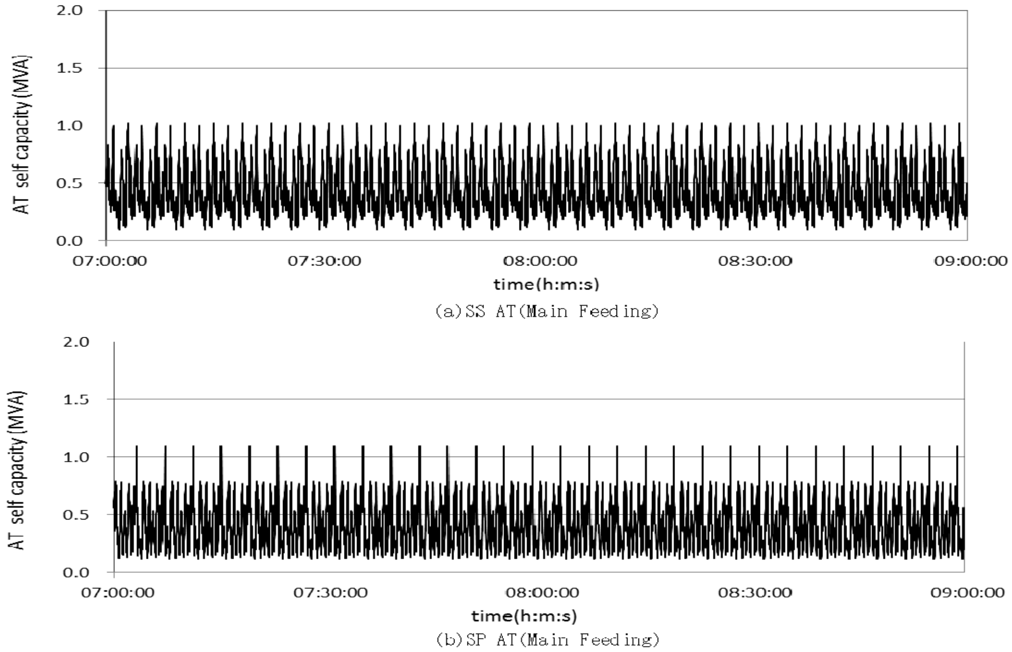


Source: JICA Study Team

Figure 5.3.42 AT Neutral Current at Alladin Park TSS, Teaser Phase

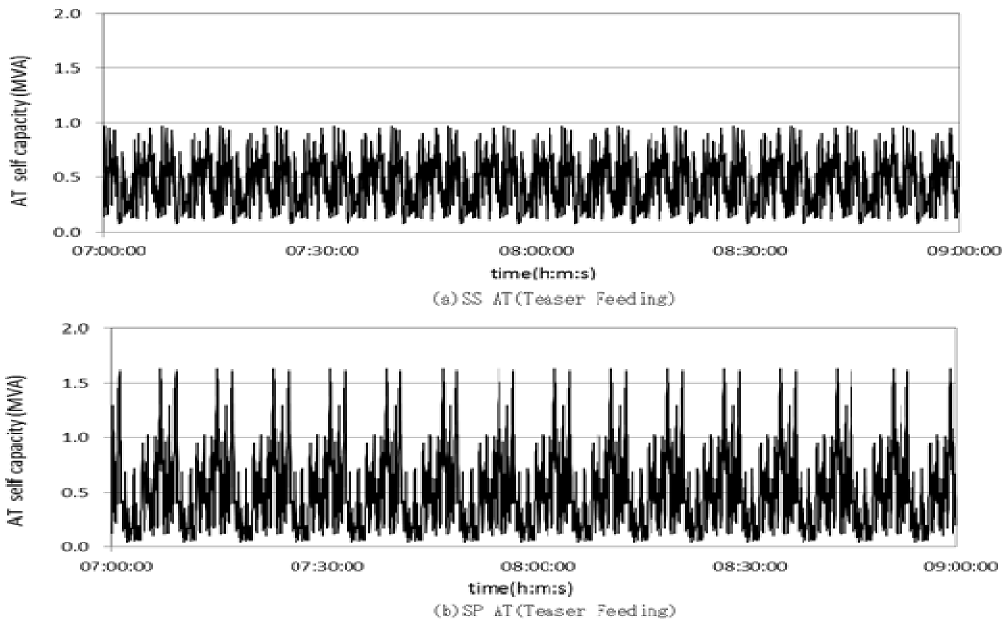
ii-2) AT Self Capacity

In case of Main phase, maximum AT self capacity at TSS is 1,024kVA and at SP is 1,097kVA as shown in Figure 5.3.43. In case of Teaser phase, maximum AT self capacity at TSS is 969kVA and at SP is 1,629kVA as shown in Figure 5.3.44.



Source: JICA Study Team

Figure 5.3.43 AT Self Capacity of Main Phase Feeder at Alladin Park TSS



Source: JICA Study Team

Figure 5.3.44 AT Self Capacity of Teaser Phase Feeder at Alladin Park TSS

Maximum AT neutral current and Maximum AT self capacity are summarized in Table 5.3.28 and Table 5.3.29 .

In case of Main phase of Alladin Park TSS, maximum AT capacity is 1.02MVA at TSS and 1.10MVA at SP.

While in case of Teaser phase, maximum AT capacity is 0.97MVA at TSS and 1.63MVA at SP.

Table 5.3.28 Maximum AT Neutral Current

substation	Max AT neutral current				mean-square value			
	Main feeding		Teaser Feeding		Main feeding		Teaser Feeding	
	SS	SP	SS	SP	SS	SP	SS	SP
	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
ALLADIN PARK	75	81	71	120	37	33	37	46

Source: JICA Study Team

Table 5.3.29 Maximum AT Capacity

substation	Max self capacity			
	Main feeding		Teaser Feeding	
	SS	SP	SS	SP
	(MVA)	(MVA)	(MVA)	(MVA)
ALLADIN PARK	1.02	1.10	0.97	1.63

Source: JICA Study Team

c) Temperature Rise of Trolley Wire

Basic characteristics used for simulation:

a. Trolley wire: PHC110mm^2, Messenger wire PH150mm^2
b. Diameter of trolley wire: 0.617 cm
c. Wind speed: 0.5m/s
d. Current shared ratio: Trolley wire 39%, Messenger wire 61%

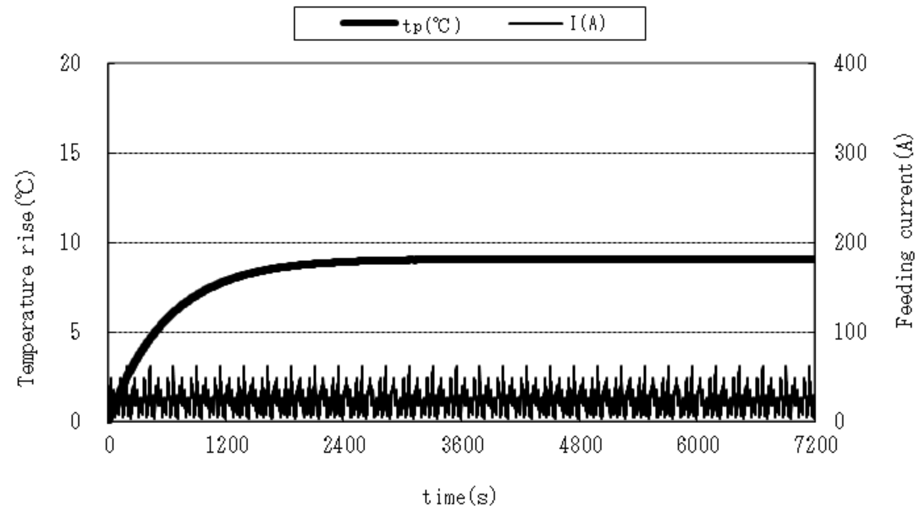
Table 5.3.30 Basic Characteristics for Simulation

No.	Item	Unit	Value
1	Diameter of electric wire d	cm	0.617
2	Resistance of electric wire (20℃) r0	Ω/cm	2.40E-06
3	Temperature coefficient of resistance (20℃) ar20	1/K	0.00381
4	Wind veloctiy v	m/s	0.5
5	Radiation coefficient η		0.9
6	Heat capacity of electric wire C	J/℃	3.7871
7	Solar radiation amount Ws	W/cm^2	0.10
8	Initial temprature tp0	℃	0.0
9	Time intervals dt	s	1.0

Source: JICA Study Team

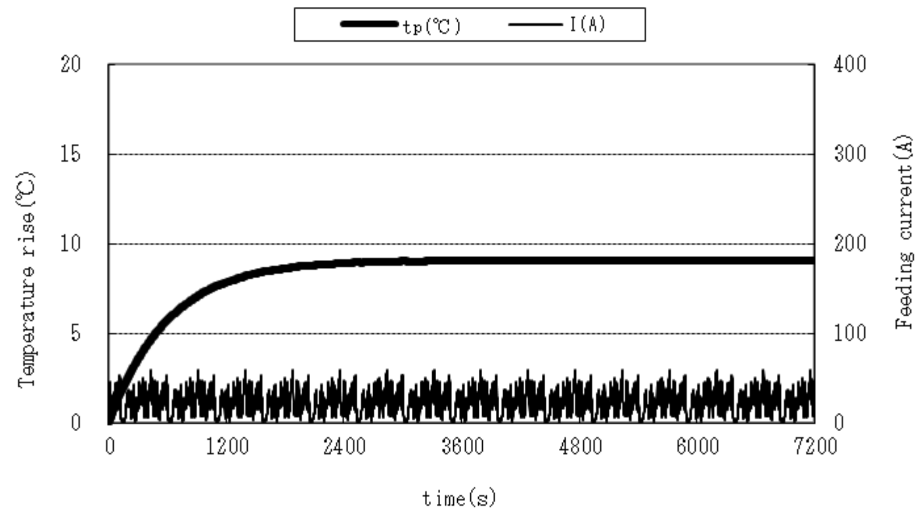
Result of Temperature rise is shown in following figures below and maximum temperature rise is 9.1ºC.

By adding 50ºC of air temperature, maximum temperature of trolley wire is 59.1ºC which is below permissible temperature of 90ºC.



Source: JICA Study Team

Figure 5.3.45 Temperature Rise (Alladin Park TSS, Teaser phase Feeder)



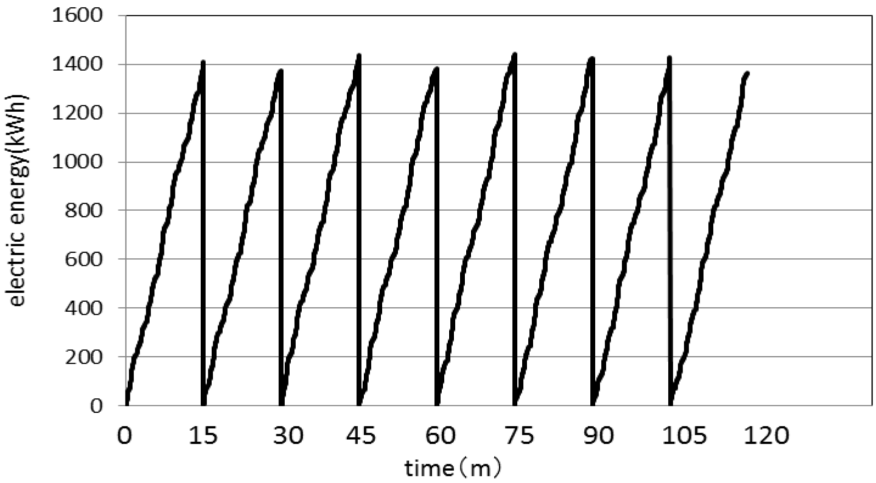
Source: JICA Study Team

Figure 5.3.46 Temperature Rise (Alladin Park TSS, Main phase Feeder)

d) **Power Consumption**

Figure 5.3.47 shows power consumption per 15 minutes of Alladin Park TSS.

Maximum power consumption per 15 minutes is 1,441kWh.



Source: JICA Study Team

Figure 5.3.47 Power Consumption per 15 Minutes of Alladin Park TSS

e) **Power Consumption With and Without Case of Regenerative System**

Regenerative power generated by regenerative brake system during decelerating the speed is normally supplied to other accelerating cars on KCR track. This system contributes to reducing energy consumption. The result of power simulation is showing that total power consumption of Alladin Park TSS between 7:00 and 9:00 is 17,751kWh without regenerative system and 11,257kWh with regenerative system. Difference of 6,493kWh is saved by regenerative system and saved efficiency is 36.6%. Furthermore, peak load (max effective power) of 1,428kW is saved by regenerative system with 8.5% efficiency as shown in Table 5.3.31.

Table 5.3.31 Power Consumption With and Without Regenerative Power System

Item	substation	ALLADIN PARK SS			
		regenerative brake		difference	efficiency
		off	on		(%)
Teaser Feeding Bus	Max Effective Power(kW)	9105.9	8847	258.9	-
	Max Reactive Power(kVar)	1925.6	2436.5	-510.9	-
	Electric Power Consumption(kWh)	8783.2	5853.8	2929.4	33.4
	Average Power Factor	0.98	0.93	0.0	-
Main Feeding Bus	Max Effective Power(kW)	10258.9	7329.7	2929.2	-
	Max Reactive Power(kVar)	2146.4	2643.3	-496.9	-
	Electric Power Consumption(kWh)	8967.8	5403.6	3564.2	39.7
	Average Power Factor	0.98	0.91	0.1	-
Incoming Bus	Max Effective Power(kW)	16867.0	15439.0	1428.0	8.5
	Electric Power Consumption(kWh)	17751.0	11257.4	6493.6	36.6

Note: Efficiency＝Difference / Regenerative brake off Source: JICA Study Team

2) Liyari TSS (N-A1, Normal Feeding)

a) **Voltage, Current and Power**

i) Maximum & Minimum values of voltage and current

Maximum & Minimum values of voltage, current, power and time of occurrence at Liyari TSS and SP1&2 between 7:00 and 9:00 is shown in Table 5.3.32 below.

Table 5.3.32 Maximum and Minimum Values of Liyari TSS (N-A1)

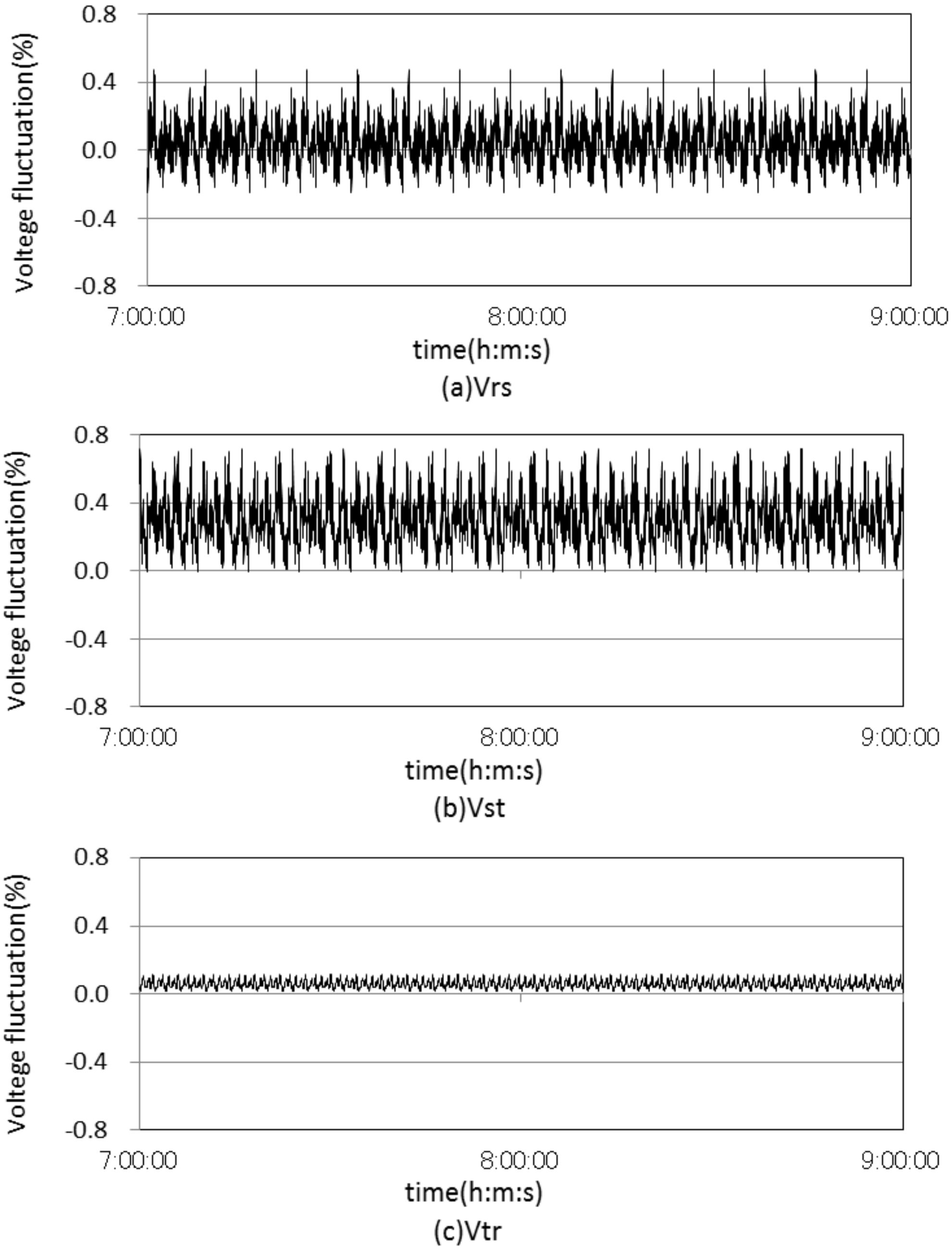
Item		LIYARI SS	
		Simulation Result	Occur Time
Incoming Voltage	minimum Vuv(kV)	218.965	7:01:06
	minimum Vvw(kV)	218.415	7:00:05
	minimum Vwu(kV)	219.747	7:02:04
	Max Effective Power(kW)	22873.8	7:00:06
	Average Voltage unbalance(%)	0.2	
Teaser Feeding Bus	minimum Voltage(kV)	27.005	7:03:59
	Max Current(A)	819.3	7:00:06
	Max Effective Power(kW)	21582.7	7:00:06
	Max Reactive Power(kVar)	6267.3	7:03:59
	Electric Power Consumption(kWh)	15302	
	Average Power Factor	0.9	
Feeding circuit (SP1 end) Up track	Max Current(A)	437	7:21:29
	Max Effective Power(kW)	11473.9	7:21:29
	Max Reactive Power(kVar)	3234.3	7:26:10
	minimum Volltage at SP1(kV)	26.704	7:03:59
	Electric Power Consumption(kWh)	7709.3	
	Average Power Factor	0.9	
Feeding circuit (SP1 end) Down track	Max Current(A)	451.2	7:06:02
	Max Effective Power(kW)	11856.8	7:06:02
	Max Reactive Power(kVar)	3587.1	7:01:06
	minimum Volltage at SP1(kV)	26.704	7:03:59
	Electric Power Consumption(kWh)	7875.6	
	Average Power Factor	0.9	
Main Feeding Bus	minimum Voltage(kV)	27.35	7:03:39
	Max Current(A)	216.9	7:00:26
	Max Effective Power(kW)	5820.6	7:00:26
	Max Reactive Power(kVar)	2094	7:02:04
	Electric Power Consumption(kWh)	4258.5	
	Average Power Factor	0.9	
Feeding circuit (SP2 end) Up track	Max Current(A)	148.4	7:01:57
	Max Effective Power(kW)	3982.4	7:01:57
	Max Reactive Power(kVar)	1183	7:02:04
	minimum Volltage at SP2(kV)	27.325	7:01:12
	Electric Power Consumption(kWh)	2213.2	
	Average Power Factor	0.9	
Feeding circuit (SP2 end) Down track	Max Current(A)	134.9	7:00:29
	Max Effective Power(kW)	3623	7:00:29
	Max Reactive Power(kVar)	1099.2	7:00:38
	minimum Volltage at SP2(kV)	27.325	7:01:12
	Electric Power Consumption(kWh)	2223.8	
	Average Power Factor	0.9	

Source: JICA Study Team

ii) Receiving Voltage Unbalance and Fluctuation Rate

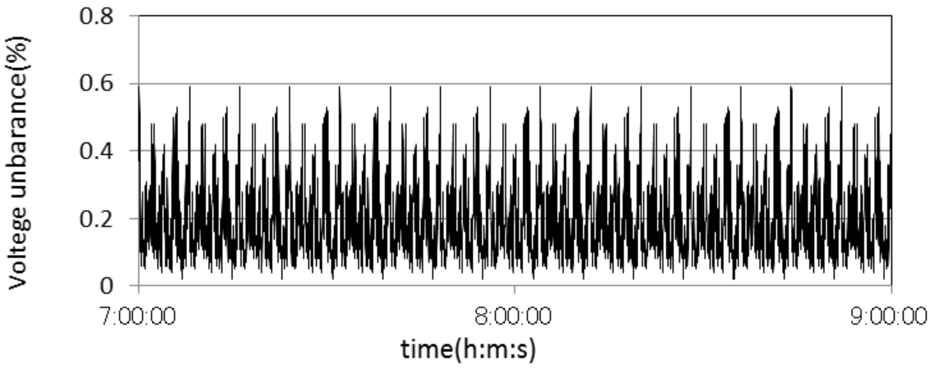
Figure 5.3.48 shows receiving voltage fluctuation rate and Figure 5.3.49 shows receiving voltage unbalance rate of Liyari TSS. From these figures, maximum voltage fluctuation rates are Vrs:0.47%, Vst:0.72% & Vtr:0.12% and maximum voltage unbalance rate is 0.59%.

As a result, both maximum fluctuation and unbalance rates of receiving voltage are not exceeding 5% which is limited by regulation.



Source: JICA Study Team

Figure 5.3.48 Fluctuation Rate of Receiving Voltage (Liyari TSS)



Source: JICA Study Team

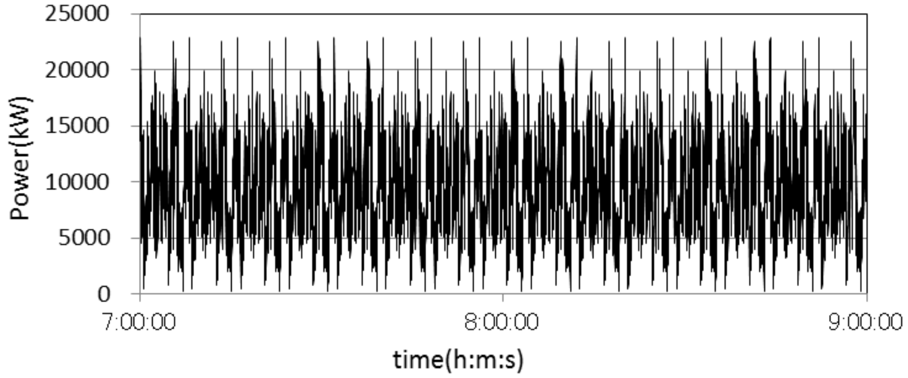
Figure 5.3.49 Unbalance Rate of Receiving Voltage (Liyari TSS)

iii) Receiving Power

Figure 5.3.50 shows receiving power transition between 7:00 and 9:00.

Maximum receiving power is 22,873kW at 7:00:06.

Power consumption for two hours is 19,551kW, while regenerative power which is not consumed by accelerating cars but goes back to power company network is -432kWh.



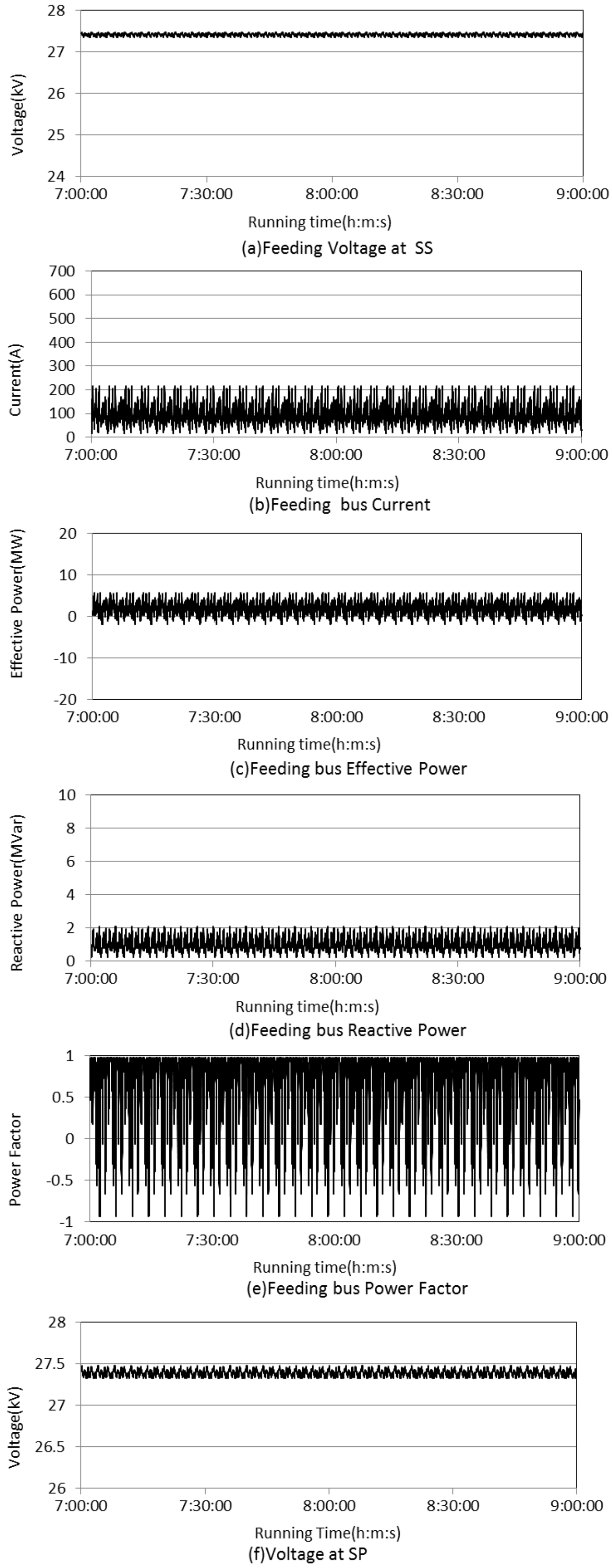
Source: JICA Study Team

Figure 5.3.50 Receiving Power Transition (Liyari TSS)

iv) Feeding Voltage, Current and Power

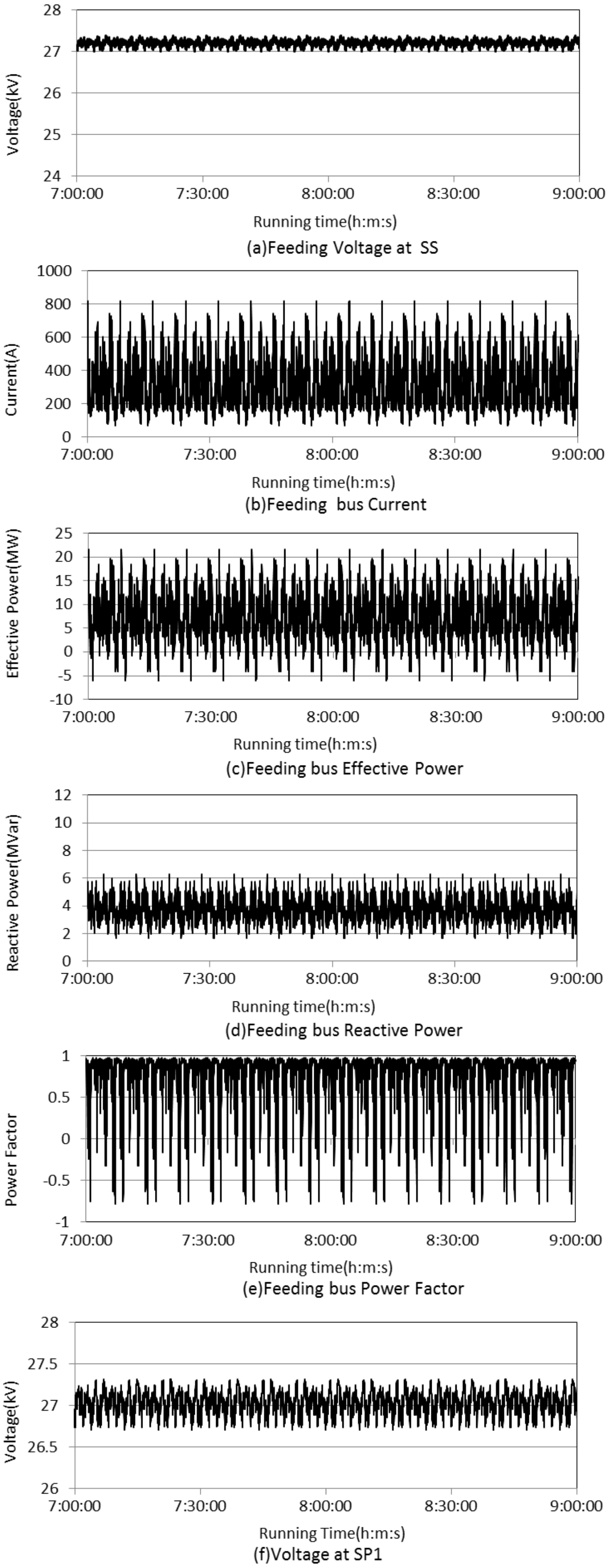
Figure 5.3.51 shows feeding voltage, current and power of Main phase feeding bus and Figure 5.3.52 shows that of Teaser phase.

Maximum feeding currents are 217A at Main phase and 819A at Teaser phase bus. Terminal voltage of feeding circuit at SP point is more than 26.7kV during 2 hours which is exceeding minimum feeding voltage of 20KV.



Source: JICA Study Team

Figure 5.3.51 Feeding Voltage, Current & Power (Main Phase Bus) and Voltage at SP



Source: JICA Study Team

Figure 5.3.52 Feeding Voltage, Current & Power (Teaser Phase Bus) and Voltage at SP

b) Capacity of Transformer

i) Feeding Transformer

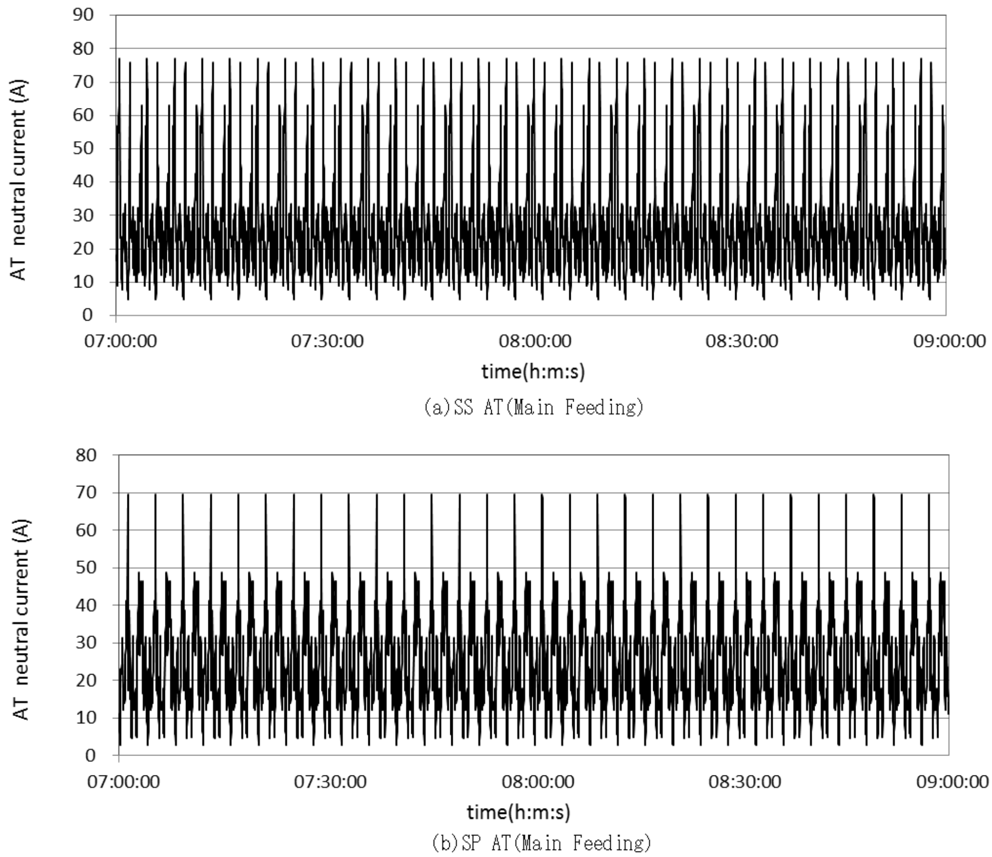
The maximum power of Teaser phase of Liyari TSS is 21,582kW as shown in Table 5.3.32. Accordingly 43.2MVA (21.6MVA×2) is required for total capacity of Scott-Connected transformer because total capacity is the sum of Main phase and Teaser phase capacity. However, taking 30% of safety factor into account, 56MVA will be appropriate capacity

ii) Capacity of AT

ii-1) AT neutral current

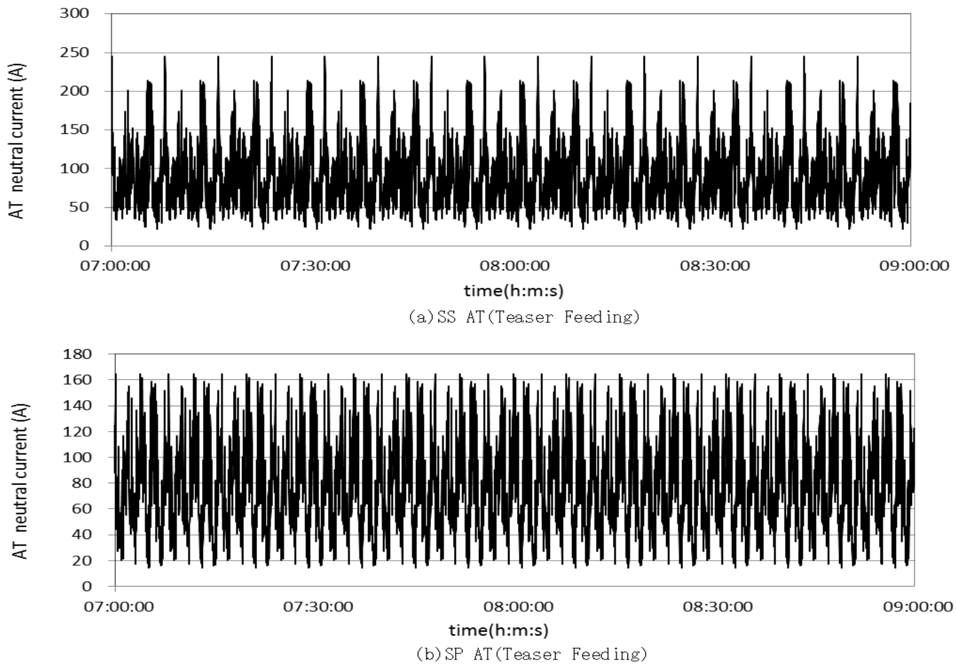
In case of Main phase, maximum AT neutral current is 77A at TSS and is 70A at SP as shown in Figure 5.3.53.

In Teaser phase, maximum AT neutral current is 246A at TSS and is 165A at SP as shown in Figure 5.3.54.



Source: JICA Study Team

Figure 5.3.53 Neutral Current at Liyari TSS, Main phase Feeder

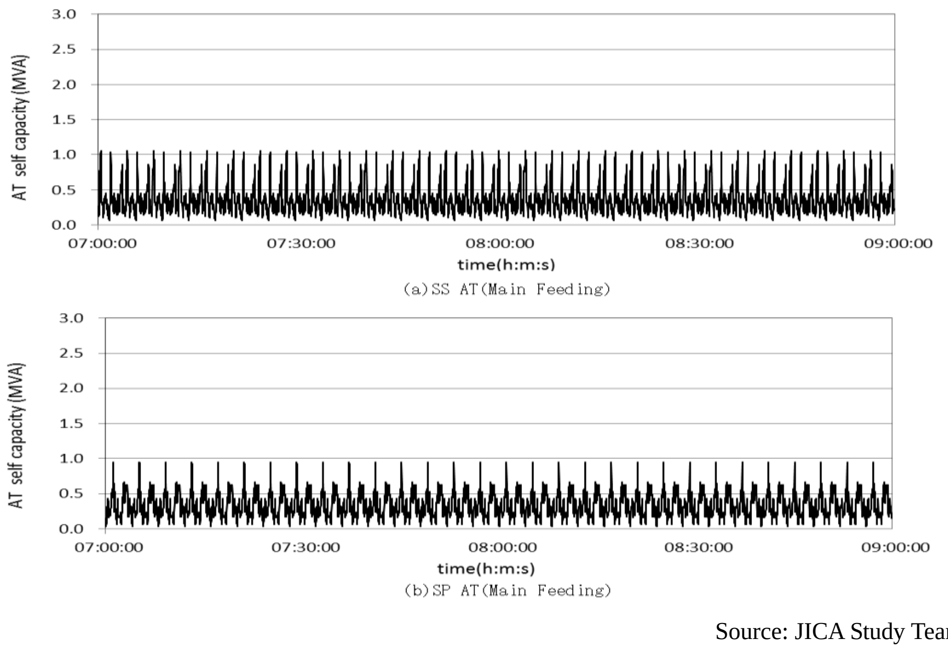


Source: JICA Study Team

Figure 5.3.54 AT Neutral Current at Liyari TSS, Teaser phase Feeder

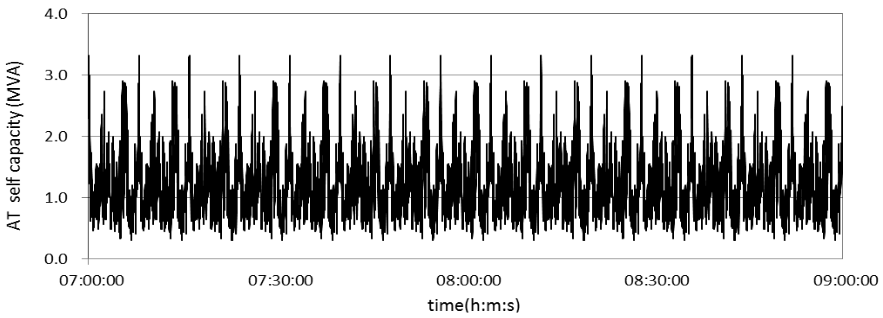
ii-2) AT self capacity

In case of Main phase feeder, maximum AT self capacity at TSS is 1,06MVA and at SP is 0.95MVA as shown in Figure 5.3.55. In case of Teaser phase feeder, maximum AT self capacity at TSS is 3.31MVA and at SP is 2.21MVA as shown in Figure 5.3.56.

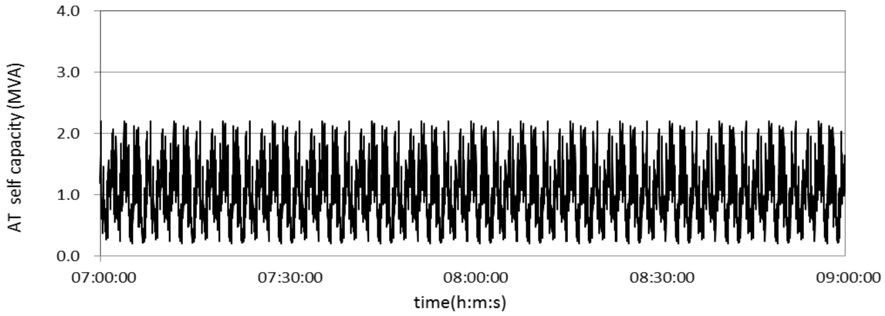


Source: JICA Study Team

Figure 5.3.55 AT Self Capacity of Main phase Feeder at Liyari TSS



(a)SS AT(Teaser Feeding)



(b)SP AT(Teaser Feeding)

Source: JICA Study Team

Figure 5.3.56 AT Self Capacity of Teaser phase Feeder at Liyari TSS

Maximum AT neutral current and Maximum AT capacity are summarized in Table 5.3.33 and Table 5.3.34 below.

In case of Main phase feeder of Liyari TSS, maximum AT capacity is 1.06MVA at TSS and 0.95MVA at SP. While in case of Teaser phase feeder, maximum AT capacity is 3.31MVA at TSS and 2.21MVA at SP.

Table 5.3.33 Maximum AT Neutral Current

substation	Max AT neutral current				mean-square value			
	Main feeding		Teaser Feeding		Main feeding		Teaser Feeding	
	SS	SP	SS	SP	SS	SP	SS	SP
	(A)	(A)	(A)	(A)	(A)	(A)	(A)	(A)
LIYARI	77	70	246	165	31	27	101	85

Source: JICA Study Team

Table 5.3.34 Maximum AT Capacity

substation	Max self capacity			
	Main feeding		Teaser Feeding	
	SS	SP	SS	SP
	(MVA)	(MVA)	(MVA)	(MVA)
LIYARI	1.06	0.95	3.31	2.21

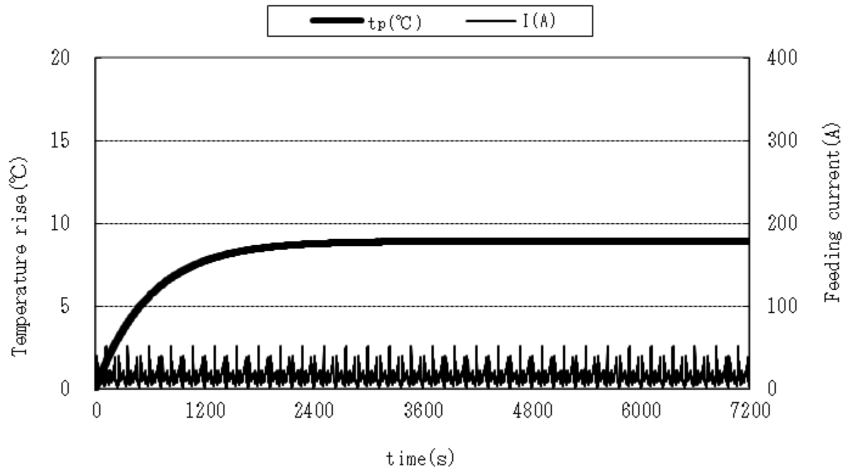
Source: JICA Study Team

c) **Temperature Rise of Trolley Wire**

Basic characteristics used for simulation:

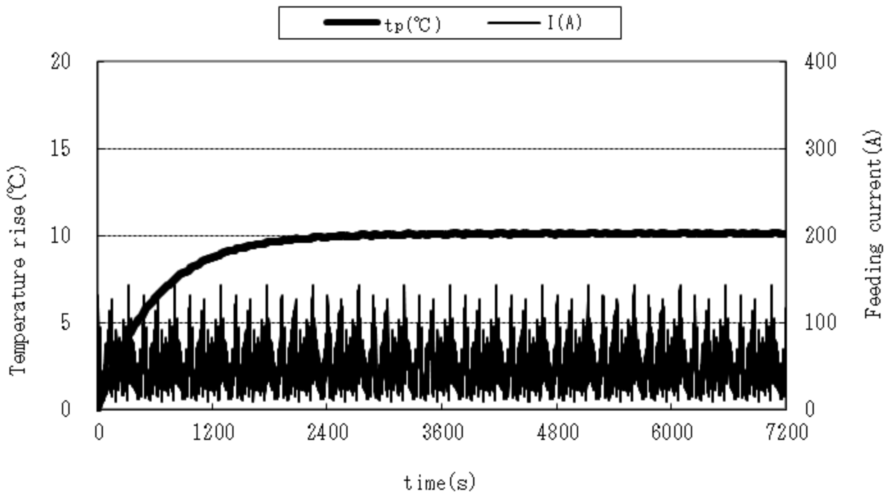
a. Trolley wire: PHC110mm^2, Messenger wire PH150mm^2
b. Diameter of trolley wire: 0.617 cm
c. Wind speed: 0.5m/s
d. Current shared ratio: Trolley wire 39%, Messenger wire 61%

Result of Temperature rise is shown in following figures and maximum temperature rise is 10.1ºC. By adding 50ºC of outdoor air temperature, maximum temperature of trolley wire is 60.1ºC which is below limited temperature of 90ºC.



Source: JICA Study Team

Figure 5.3.57 Temperature Rise (Liyari TSS, Main phase Feeder)



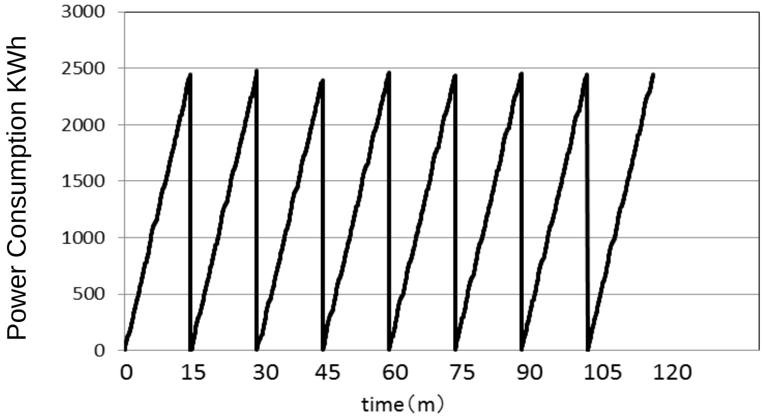
Source: JICA Study Team

Figure 5.3.58 Temperature Rise (Liyari TSS, Teaser phase Feeder)

d) **Power Consumption of TSS**

i) Power Consumption

Maximum power consumption per 15 minutes is 2,477kWh of Liyari TSS as shown below.



Source: JICA Study Team

Figure 5.3.59 Power Consumption per 15 Minutes of Liyari TSS

ii) Power Consumption With and Without Case of Regenerative System

Regenerative power generated by electric cars with regenerative brake system while cars are decelerating the speed is normally supplied to other accelerating cars on KCR track. This system contributes to realizing lower energy consumption. The result of power simulation is showing that total power consumption of Liyari TSS without using regenerative system between two hours is 34,015Wh and power consumption with using regenerative system is 19,560kWh. Difference of 14,454kWh is saved by regenerative system and efficiency is 42.5%.

Table 5.3.35 Power Consumption With and Without Regenerative Power System

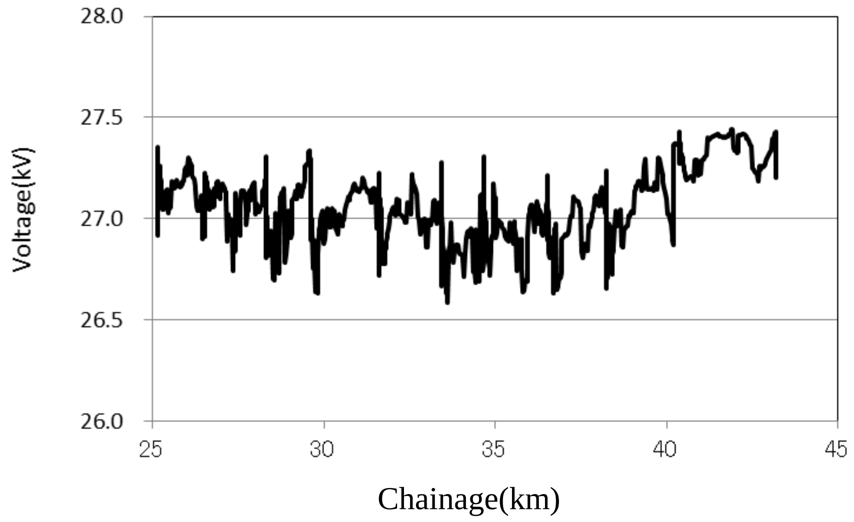
Item	substation	LIYARI SS			
		regenerative brake		difference	efficiency
		off	on		(%)
Teaser Feeding Bus	Max Effective Power(kW)	22383	21582.7	800.3	-
	Max Reactive Power(kVar)	5084.5	6267.3	-1182.8	-
	Electric Power Consumption(kWh)	26423.5	15302	11121.5	42.1
	Average Power Factor	0.98	0.9	0.1	-
Main Feeding Bus	Max Effective Power(kW)	6569.8	5820.6	749.2	-
	Max Reactive Power(kVar)	1357.8	2094	-736.2	-
	Electric Power Consumption(kWh)	7591.7	4258.5	3333.2	43.9
	Average Power Factor	0.98	0.9	0.1	-
Incoming Bus	Max Effective Power(kW)	26868.0	22874.0	3994.0	14.9
	Electric Power Consumption(kWh)	34015.2	19560.5	14454.7	42.5

Note: Efficiency＝Difference / Regenerative brake off

Source: JICA Study Team

3) Voltage at Pantograph of Electric Car

Minimum voltage at pantograph point is around 26.6kV which is exceeding minimum feeding voltage of 20KV as shown in following figure.

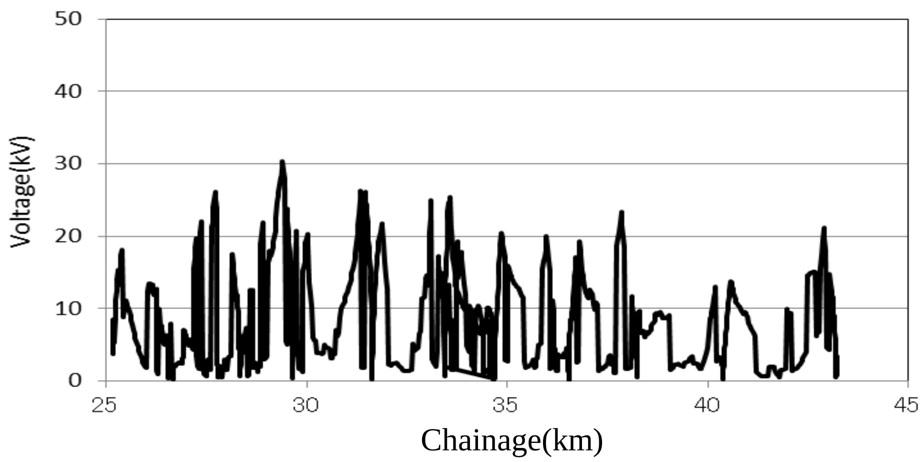


Source: JICA Study Team

Figure 5.3.60 Voltage at Pantograph of Electric Car between Liyari SS and SP

4) Rail Voltage in Normal Train Operation With Protective Wire (PW) Earthing

Figure 5.3.61 shows rail voltage with PW earthing case. Maximum rail voltage is 30.4V which is not exceeding 120V limited by regulation.



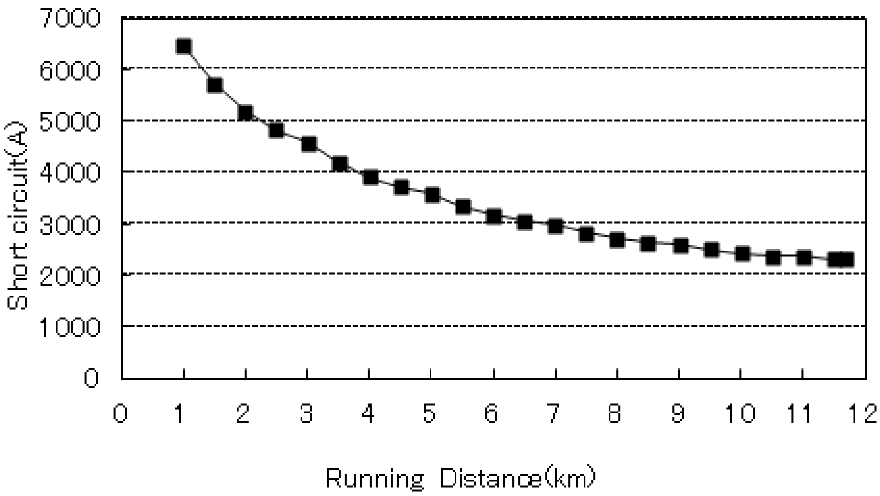
Source: JICA Study Team

Figure 5.3.61 Rail Voltage between TSS and SP in Case of PW Earthing

5) Case of Short Circuit Fault

a) Fault Current

Figure 5.3.62 shows fault current in case of short circuit failure between Trolley wire and Rail. Maximum and minimum fault current are 6,452A and 2,321A respectively.

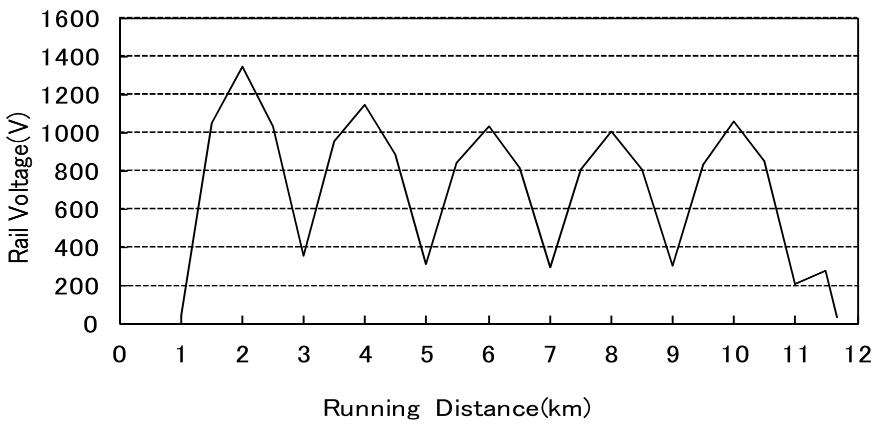


Source: JICA Study Team

Figure 5.3.62 Fault Current (Short Circuit between Trolley and Rail)

b) **Rail Voltage with PW Earthing Case**

Figure 5.3.63 shows rail voltage with PW earthing case when short circuit failure occurs between Trolley wire and Rail. Maximum rail voltage is 1,342V and fault current is 5,202A (Figure 5.3.62) in case that short circuit fault occurs at 2kM from TSS.

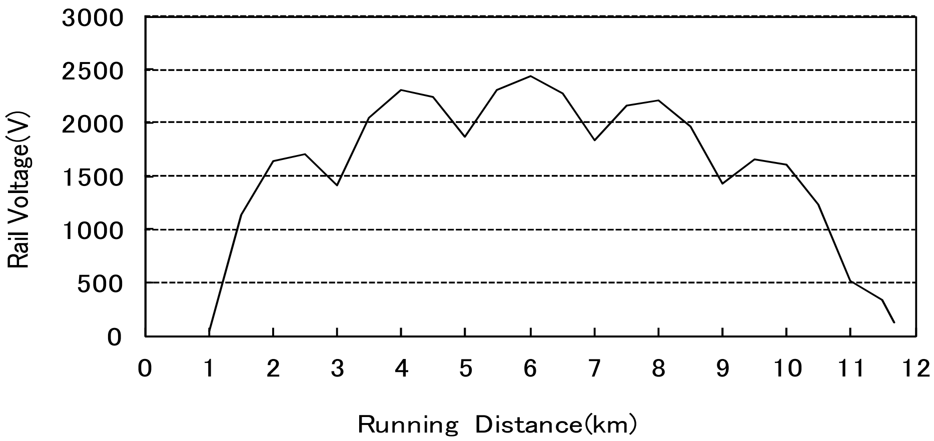


Source: JICA Study Team

Figure 5.3.63 Rail Voltage in Case of Short Circuit Fault (With PW Earthing Case)

c) **Rail Voltage without PW Earthing Case**

Figure 5.3.64 shows rail voltage without PW earthing case when short circuit failure occurs between Trolley wire and Rail. Maximum rail voltage is 2,438V and fault current is 3,176A (Figure 5.3.62) in case that short circuit fault occurs at 6KM from TSS.



Source: JICA Study Team

Figure 5.3.64 Rail Voltage in Case of Short Circuit Fault (Without PW Earthing Case)

d) **PW Earthing and Buried Earth Conductor**

From the result of Rail Voltage simulation in case short circuit fault occurs, PW has to be connected to earthing to reduce the rail voltage which does not exceed permissible level.

However, at detailed design stage, in order to install PW Earthing properly, earthing methods should be further reviewed and examined by measuring actual earthing resistance along KCR route. Besides, it is also required to clarify the necessity of Buried Earth Conductor based on the results of earthing resistance. If earthing resistance can't meet the minimum requirement, Buried Earth Conductor might be necessary to reduce the rail voltage for safety reason.

6) Liyari TSS (N-A1, Extended Feeding)

a) **Voltage, Current and Power**

i) Maximum and Minimum Values of Voltage, Current and Power

Maximum & minimum voltage, current, power and time of occurrence of Liyari TSS and SPs between 7:00 and 9:00 at peak hour is shown in Table 5.3.36.

Table 5.3.36 Maximum and Minimum Values of Liyari TSS in Extended Feeding (N-A1)

Item		LIYARI SS	
		Simulation Result	Occur Time
Incoming Voltage	minimum Vuv(kV)	218.805	7:01:06
	minimum Vvw(kV)	218.312	7:05:29
	minimum Vwu(kV)	219.495	7:03:11
	Max Effective Power(kW)	28679	7:08:06
	Average Voltage unbalance(%)	0.2	–
Teaser Feeding Bus	minimum Voltage(kV)	26.873	7:08:09
	Max Current(A)	906.1	7:08:06
	Max Effective Power(kW)	23660.6	7:08:06
	Max Reactive Power(kVar)	7845.5	7:01:06
	Electric Power Consumption(kWh)	20014.5	–
	Average Power Factor	0.90	–
Feeding circuit (SP1 end) Up track	Max Current(A)	491.9	7:21:29
	Max Effective Power(kW)	12774.7	7:21:29
	Max Reactive Power(kVar)	4116	7:21:35
	minimum Volltage at SP1(kV)	26.392	7:30:18
	Electric Power Consumption(kWh)	9944.5	–
	Average Power Factor	0.9	–
Feeding circuit (SP1 end) Down track	Max Current(A)	487.9	7:06:02
	Max Effective Power(kW)	12745.3	7:06:02
	Max Reactive Power(kVar)	4427.5	7:01:06
	minimum Volltage at SP1(kV)	26.392	7:30:18
	Electric Power Consumption(kWh)	10223.2	–
	Average Power Factor	0.9	–
Main Feeding Bus	minimum Voltage(kV)	27.182	7:03:11
	Max Current(A)	393.3	7:03:11
	Max Effective Power(kW)	10307	7:00:12
	Max Reactive Power(kVar)	3979.7	7:03:11
	Electric Power Consumption(kWh)	9182.5	–
	Average Power Factor	0.89	–
Feeding circuit (SP2 end) Up track	Max Current(A)	219.5	7:00:12
	Max Effective Power(kW)	5794	7:00:12
	Max Reactive Power(kVar)	2122.8	7:03:09
	minimum Volltage at SP2(kV)	26.92	7:03:11
	Electric Power Consumption(kWh)	4623.2	–
	Average Power Factor	0.9	–
Feeding circuit (SP2 end) Down track	Max Current(A)	218.9	7:01:05
	Max Effective Power(kW)	5854.6	7:01:05
	Max Reactive Power(kVar)	1930	7:00:37
	minimum Volltage at SP2(kV)	26.92	7:03:11
	Electric Power Consumption(kWh)	4693.8	–
	Average Power Factor	0.9	–

Source: JICA Study Team

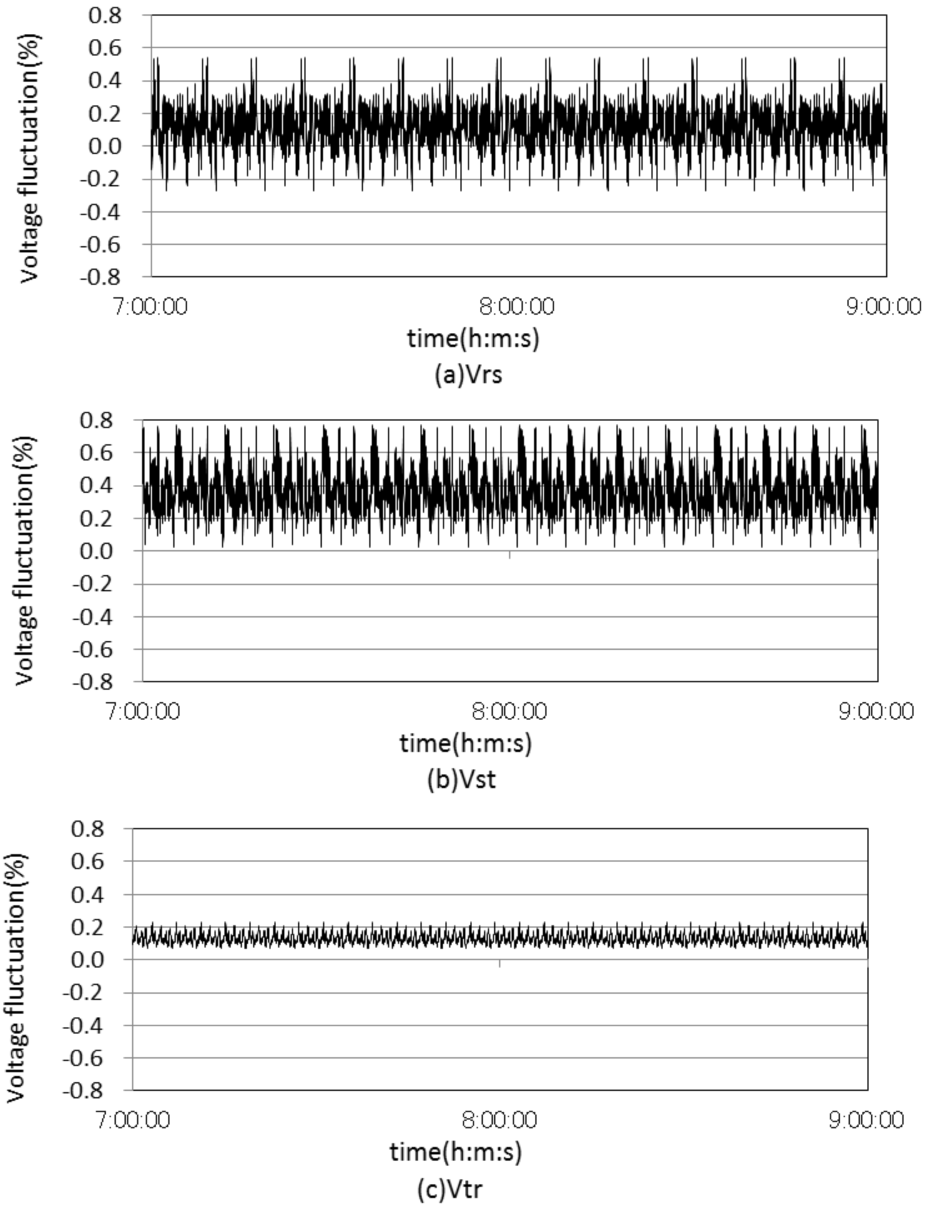
Maximum receiving power of Liyari TSS is 28,679kW at 7:08:06.

Power consumption for two hours is 29,186kW, while regenerative power which is not consumed by power running cars but goes back to power company network is -196kWh.

ii) Receiving Voltage Unbalance and Fluctuation Rate

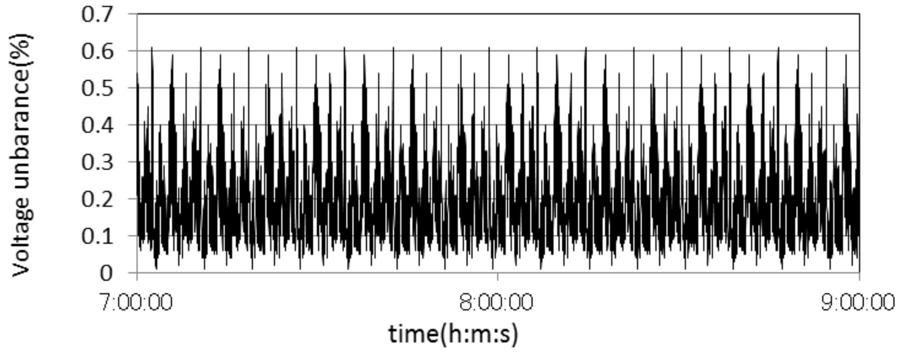
Figure 5.3.65 shows receiving voltage fluctuation rate and Figure 5.3.66 shows receiving voltage unbalance rate of Alladin Park TSS. The maximum voltage fluctuation rate of Alladin Park TSS are Vrs:0.54%, Vst:0.77% & Vtr:0.23% and the maximum voltage unbalance rate is 0.61%.

As a result, both maximum receiving voltage fluctuation and unbalance rate do not exceed 5% which is limited by regulation.



Source: JICA Study Team

Figure 5.3.65 Fluctuation Rate of Receiving Voltage in Extended Feeding (Liyari TSS)



Source: JICA Study Team

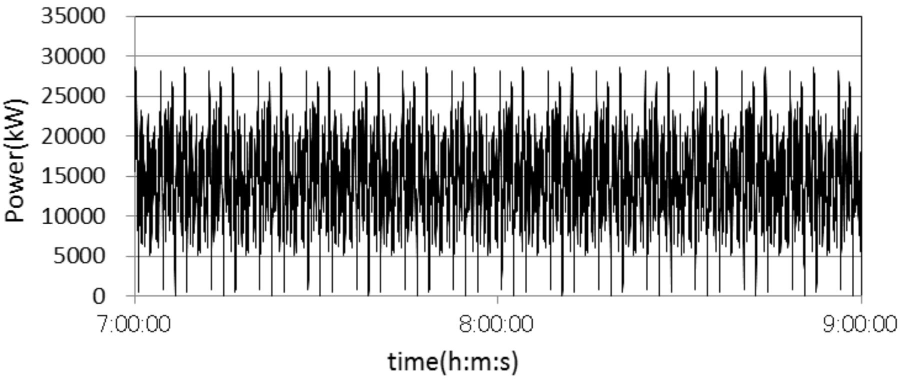
Figure 5.3.66 Unbalance Rate of Receiving Voltage in Extended Feeding (Liyari TSS)

iii) Receiving Power

Figure 5.3.67 shows receiving power transition between 7:00 and 9:00.

Maximum receiving power is 28,679kW at 7:08:06.

Power consumption for two hours is 29,816kWh, while regenerative power which is not consumed by power running cars but goes back to power company network is -196kWh.



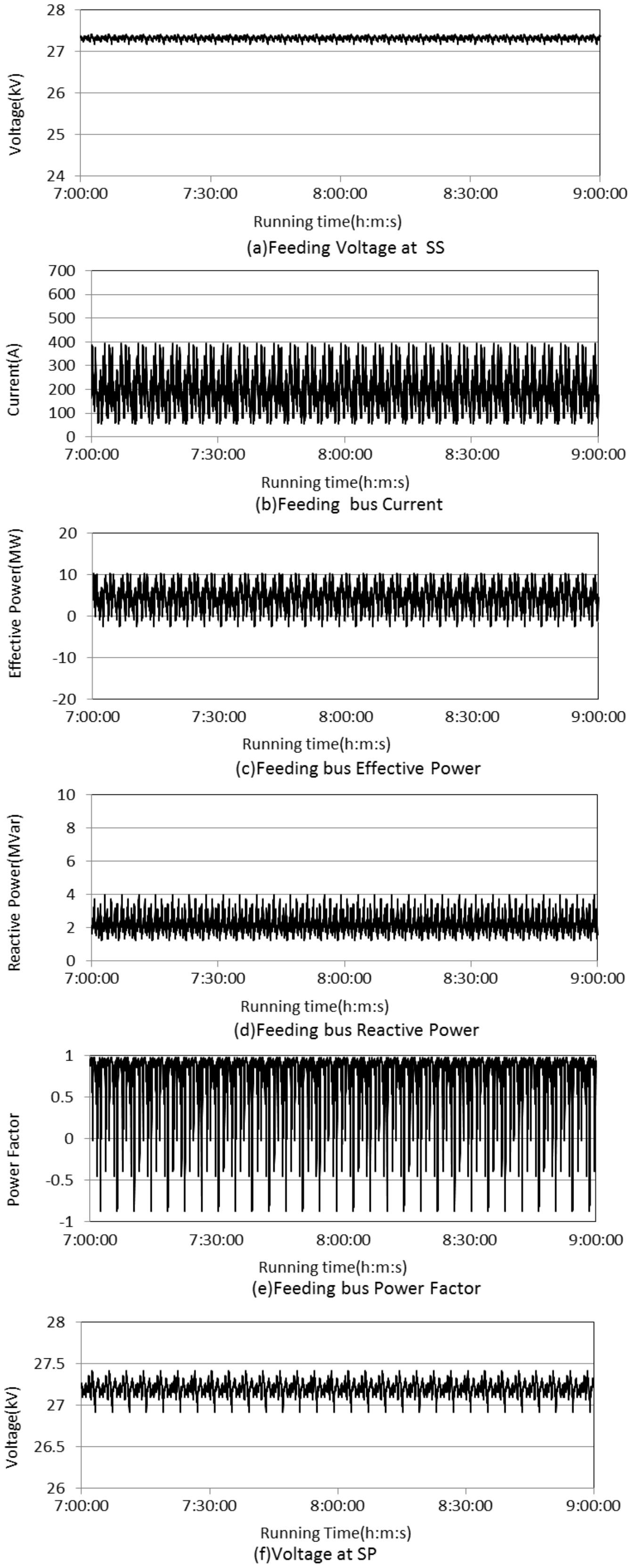
Source: JICA Study Team

Figure 5.3.67 Receiving Power Transition (Liyari TSS)

iv) Feeding Voltage, Current and Power

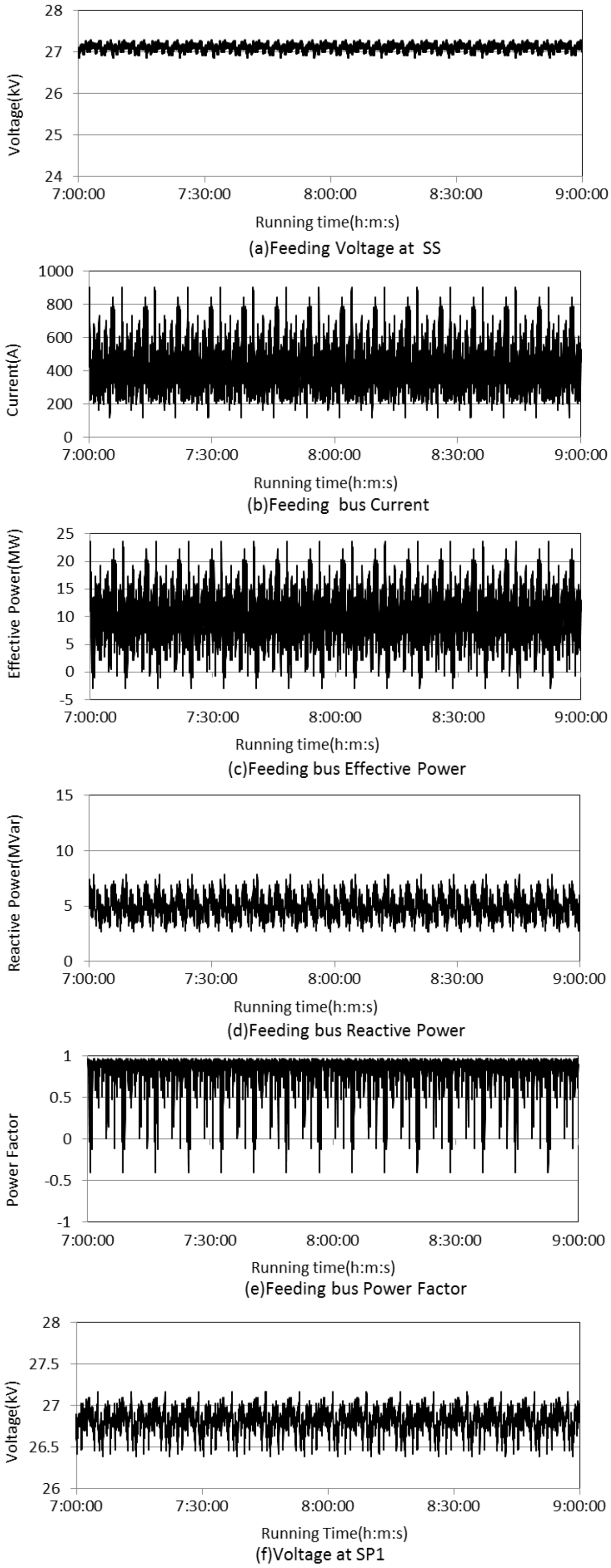
Figure 5.3.68 and Figure 5.3.69 show feeding voltage, current and power of Main phase and Teaser phase feeding bus.

Maximum feeding currents are 393A at Main phase and 906A at Teaser phase. Terminal voltage of feeding circuit at SP point is 26.9KV at Main phase feeding circuit and 26.4KV at Teaser phase feeding circuit throughout 2 hours. Both of them are exceeding minimum feeding voltage of 20KV.



Source: JICA Study Team

Figure 5.3.68 Feeding Voltage, Current & Power (Main Phase Bus) and Voltage at SP



Source: JICA Study Team

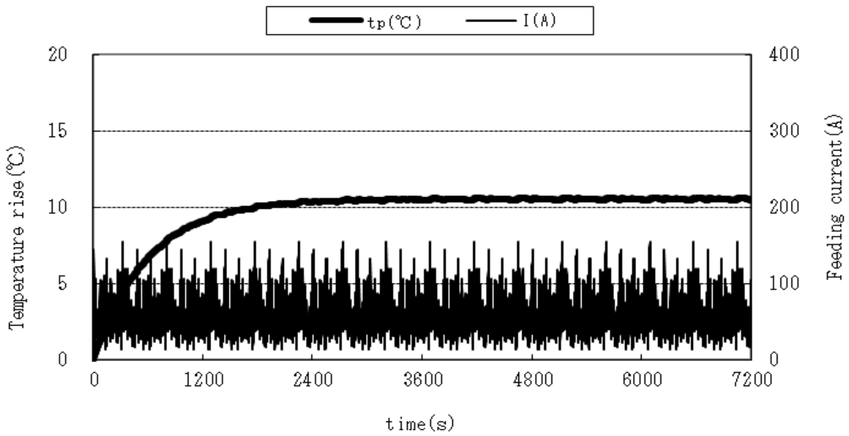
Figure 5.3.69 Feeding Voltage, Current & Power (Teaser Phase Bus) and Voltage at SP

b) **Capacity of Feeding Transformer**

The maximum power of Teaser phase feeding bus is 23,661KW as shown in Table 5.3.36. Accordingly 47.3MVA (23.66MVA×2) is required for total capacity of Scott-connected Transformer because total capacity is the sum of Main phase feeding and Teaser phase feeding circuit capacity. Taking 30% of safety factor into account, 62MVA will be appropriate capacity of feeding transformer.

c) **Temperature Rise of Trolley Wire**

Result of Temperature rise is shown in following figures and maximum temperature rise is 10.6ºC. By adding 50ºC of outdoor air temperature, maximum temperature of trolley wire is 60.6ºC which is below limited temperature of 90ºC.

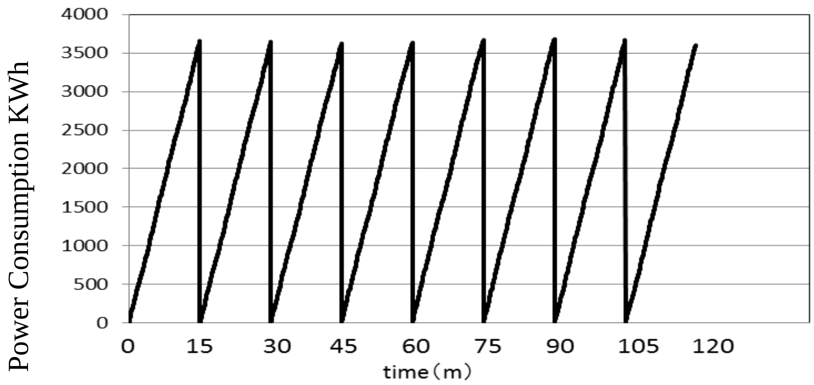


Source: JICA Study Team

Figure 5.3.70 Temperature Rise (Teaser phase Feeder)

d) **Power Consumption of TSS**

Maximum power consumption per 15 minutes is 3,678kWh.

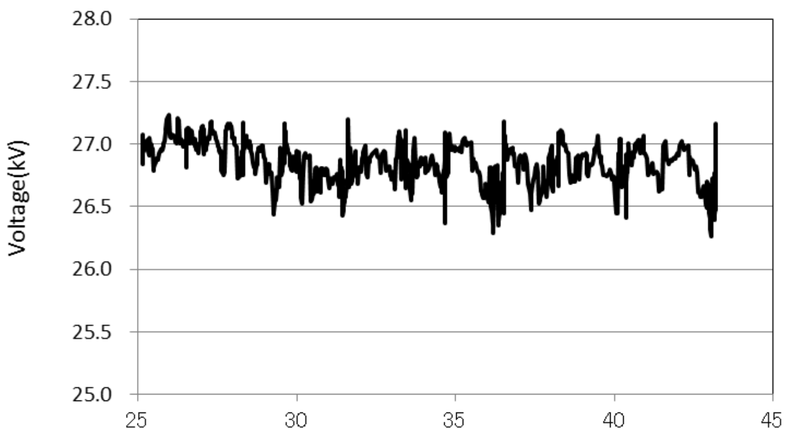


Source: JICA Study Team

Figure 5.3.71 Power Consumption per 15 Minutes of Liyari TSS (Extended Feeding)

e) **Voltage at Pantograph of Electric Car**

Minimum voltage at pantograph is around 26.3kV which is exceeding minimum feeding voltage of 20kV .



Source: JICA Study Team

Figure 5.3.72 Voltage at Pantograph of Electric Car

f) **Power Consumption With and Without Case of Regenerative System**

The result of power simulation is showing that total power consumption of Liyari TSS between 7:00 and 9:00 is 51,446kWh without using regenerative power system and 29,197kWh with using regenerative power. Difference of 22,249kWh is saved by regenerative system and efficiency is 43.2 %.

Table 5.3.37 Power Consumption With and Without Regenerative Power System

Item \ Substation		LIYARI SS			
		regenerative brake		difference	efficiency
		off	on		(%)
Teaser Feeding Bus	Max Effective Power(kW)	28724	23660.6	5063.4	-
	Max Reactive Power(kVar)	7222	7845.5	-623.5	-
	Electric Power Consumption(kWh)	34946.6	20014.5	14932.1	42.7
	Average Power Factor	0.97	0.9	0.1	-
Main Feeding Bus	Max Effective Power(kW)	15068.3	10307	4761.3	-
	Max Reactive Power(kVar)	3224.9	3979.7	-754.8	-
	Electric Power Consumption(kWh)	16499.8	9182.5	7317.3	44.3
	Average Power Factor	0.98	0.89	0.1	-
Incoming Bus	Max Effective Power(kW)	38407.0	28679.0	9728.0	25.3
	Electric Power Consumption(kWh)	51446.4	29197.0	22249.4	43.2

Note: Efficiency＝Difference / Regenerative brake off Source: JICA Study Team

7) Liyari TSS (N-B1:Supply for Shah Abdul Latif - Drigh Road Line)

In this train operation, single TSS system is applied since power consumption is smaller than circular line. Liyari TSS is selected as single traction substation for KCR due to its location. Simulation was conducted between 7:00 and 8:00 because of short distance.

a) Voltage, Current and Power

i) Maximum and Minimum Values of Voltage, Current and Power

Maximum & minimum voltage, current, power and time of occurrence of Liyari TSS and ATP between 7:00 and 8:00 at peak hour is shown in Table 5.3.38.

Maximum receiving power of Liyari TSS is 29,674kW at 7:16:09.

Table 5.3.38 Maximum and Minimum Values of Liyari TSS (N-B1)

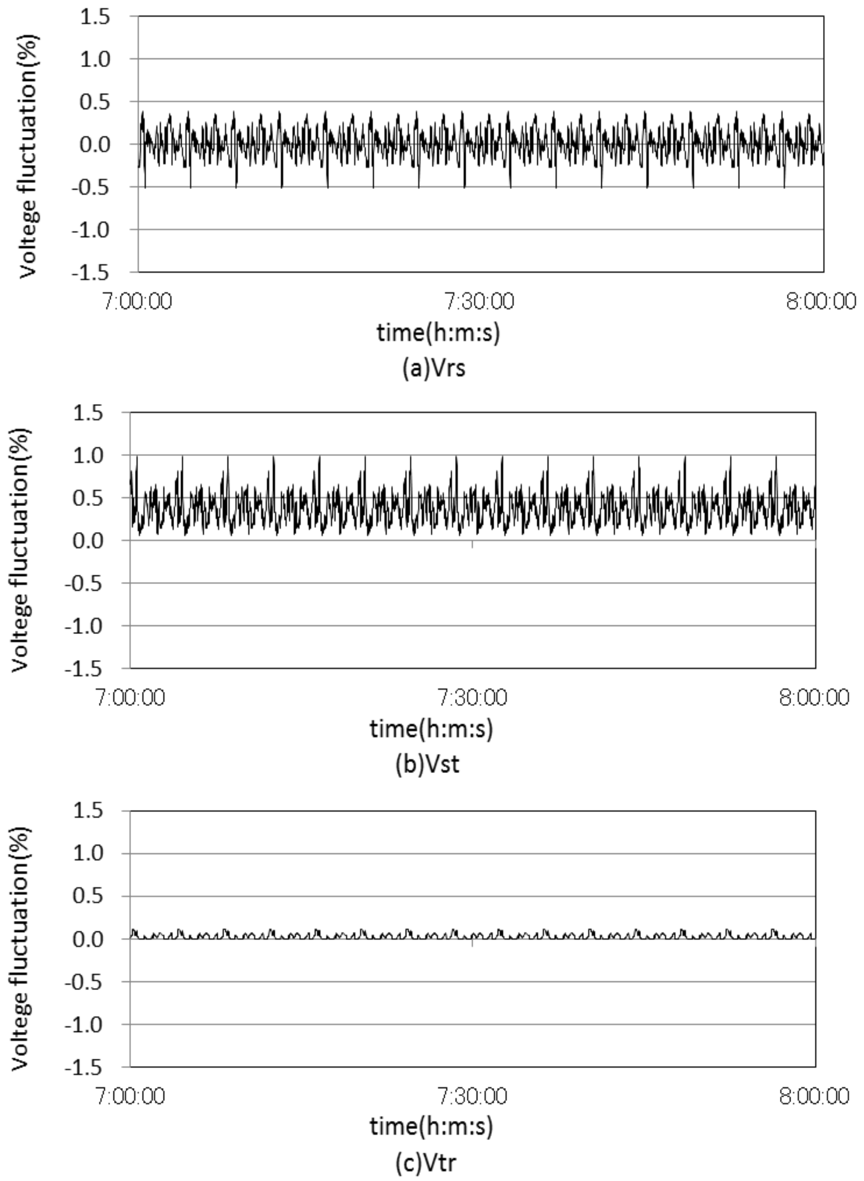
Item		LIYARI SS	
		Simulation Result	Occur Time
Incoming Voltage	minimum Vuv(kV)	219.152	7:00:22
	minimum Vvw(kV)	217.838	7:16:35
	minimum Vwu(kV)	219.734	7:00:19
	Max Effective Power(kW)	29674.9	7:16:09
	Average Voltage unbalance(%)	0.26	–
Teaser Feeding Bus	minimum Voltage(kV)	26.905	7:00:20
	Max Current(A)	997.1	7:16:09
	Max Effective Power(kW)	26236.6	7:16:09
	Max Reactive Power(kVar)	7758	7:00:20
	Electric Power Consumption(kWh)	8989.3	–
	Average Power Factor	0.9	–
Feeding circuit (SP1 end) Up track	Max Current(A)	498.7	7:16:09
	Max Effective Power(kW)	13118.2	7:16:09
	Max Reactive Power(kVar)	3760.2	7:48:20
	minimum Volltage at SP1(kV)	26.401	7:00:19
	Electric Power Consumption(kWh)	4728.7	–
	Average Power Factor	0.91	–
Feeding circuit (SP1 end) Down track	Max Current(A)	498.4	7:00:09
	Max Effective Power(kW)	13118.4	7:00:09
	Max Reactive Power(kVar)	3997.7	7:00:20
	minimum Volltage at SP1(kV)	26.401	7:00:19
	Electric Power Consumption(kWh)	4389.2	–
	Average Power Factor	0.89	–
Main Feeding Bus	minimum Voltage(kV)	27.323	7:00:19
	Max Current(A)	372.5	7:00:35
	Max Effective Power(kW)	9736	7:00:19
	Max Reactive Power(kVar)	2075.9	7:00:35
	Electric Power Consumption(kWh)	2053.3	–
	Average Power Factor	0.96	–
Feeding circuit (SP2 end) Up track	Max Current(A)	214.9	7:00:12
	Max Effective Power(kW)	5750.3	7:00:12
	Max Reactive Power(kVar)	1192.1	7:00:12
	minimum Volltage at SP2(kV)	27.273	7:00:19
	Electric Power Consumption(kWh)	945.4	–
	Average Power Factor	0.95	–
Feeding circuit (SP2 end) Down track	Max Current(A)	211.6	7:00:35
	Max Effective Power(kW)	5550.1	7:02:39
	Max Reactive Power(kVar)	1179.6	7:00:35
	minimum Volltage at SP2(kV)	27.273	7:00:19
	Electric Power Consumption(kWh)	1130.2	–
	Average Power Factor	0.96	–

Source: JICA Study Team

ii) Receiving Voltage Unbalance and Fluctuation Rate

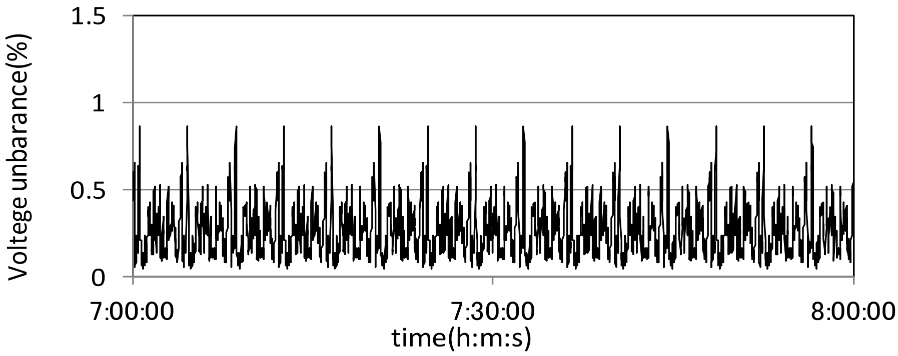
Figure 5.3.73 shows receiving voltage fluctuation rate and Figure 5.3.74 shows receiving voltage unbalance rate of Liyari TSS. The maximum voltage fluctuation rates are Vrs:0.39%, Vst:0.98% & Vtr:0.12% and the maximum voltage unbalance rate is 0.87%.

As a result, both maximum receiving voltage fluctuation and unbalance rate do not exceed 5% which is limited by regulation.



Source: JICA Study Team

Figure 5.3.73 Fluctuation Rate of Receiving Voltage (Liyari TSS)



Source: JICA Study Team

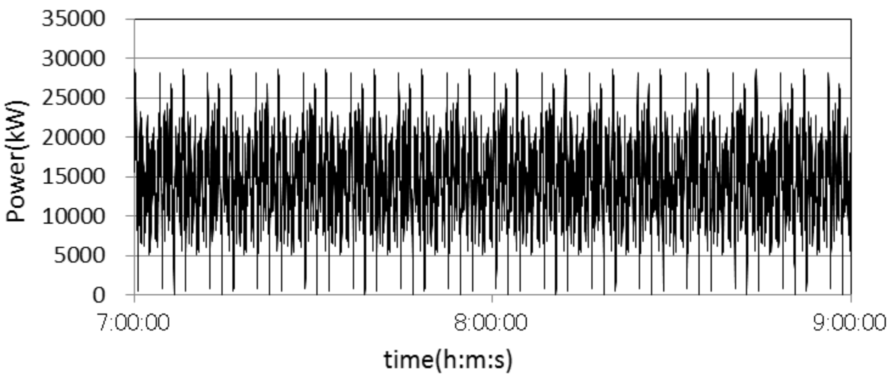
Figure 5.3.74 Unbalance Rate of Receiving Voltage (Liyari TSS)

iii) Receiving Power

Figure 5.3.75 shows receiving power transition of Liyari TSS between 7:00 and 8:00.

Maximum receiving power is 29,674kW at 7:16:09.

Power consumption for one hour is 11,029kWh, while regenerative power which is not consumed by accelerating cars but goes back to power company network is -679kWh.



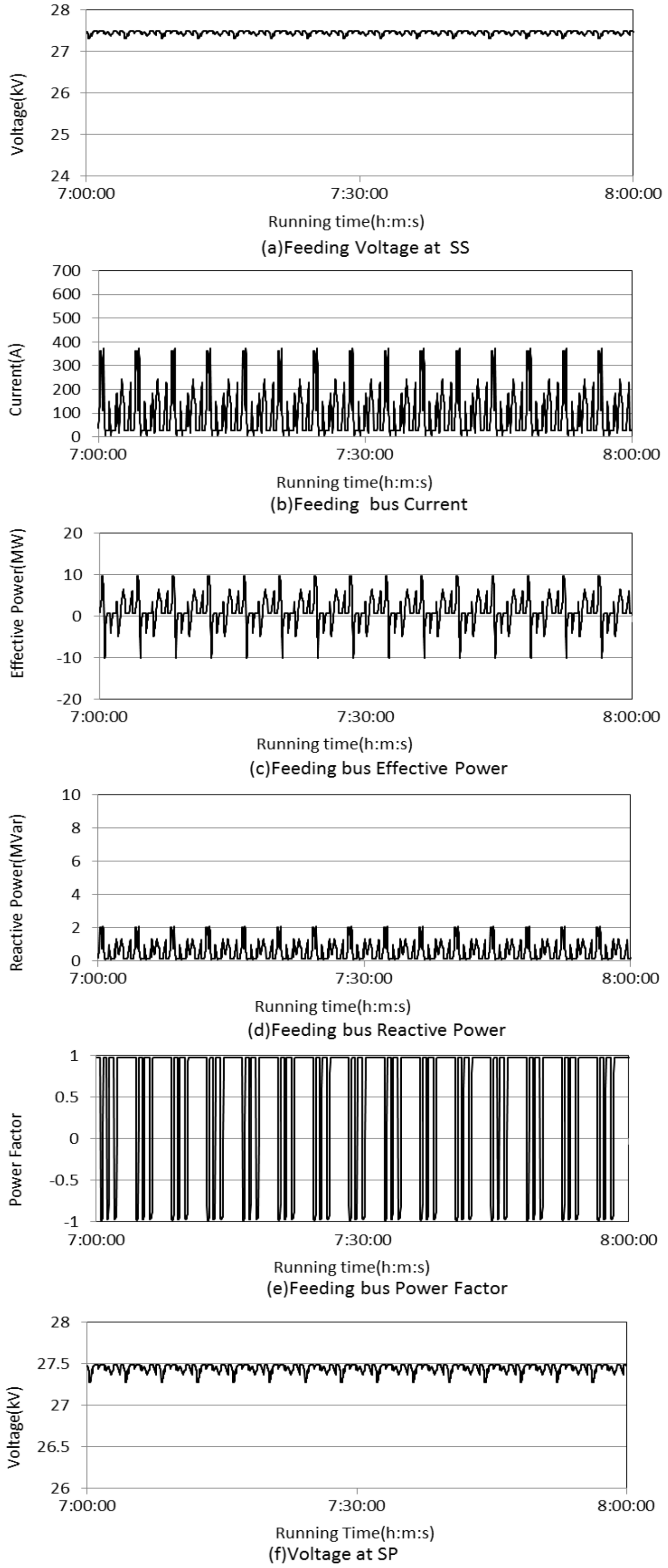
Source: JICA Study Team

Figure 5.3.75 Receiving Power Transition (Liyari TSS)

iv) Feeding Voltage, Current and Power

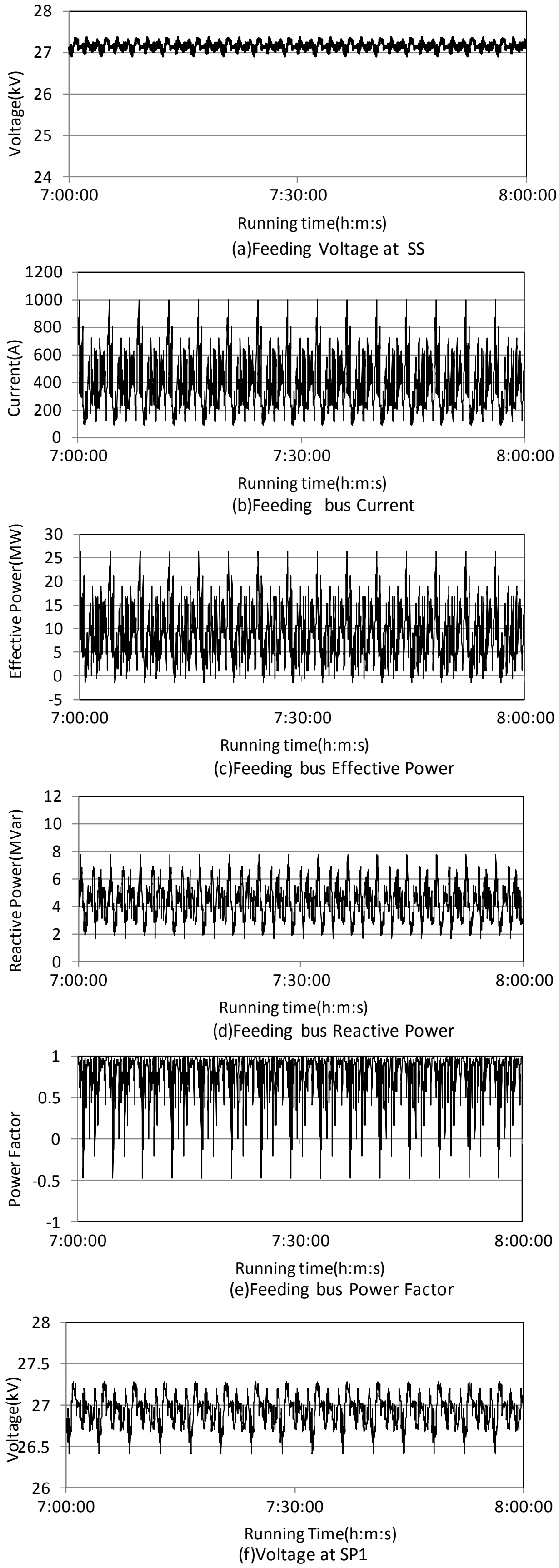
Figure 5.3.76 and Figure 5.3.77 show feeding voltage, current and power of Main phase and Teaser phase feeding bus of Liyari TSS.

Maximum feeding currents are 373A at Main phase bus and 997A at Teaser phase bus. Minimum terminal voltage of feeding circuit at SP point is 26.4kV which is exceeding minimum feeding voltage of 20kV.



Source: JICA Study Team

Figure 5.3.76 Feeding Voltage, Current & Power (Main Phase Bus) and Voltage at ATP



Source: JICA Study Team

Figure 5.3.77 Feeding Voltage, Current & Power (Teaser Phase Bus) and Voltage at ATP

b) **Capacity of Transformer**

i) Feeding Transformer

The maximum power of Teaser phase feeding bus is 26,236KW as shown in Table 5.3.38. Accordingly 52.4MVA (26.2MVA×2) is required for total capacity of Scott-connected transformer because total capacity is the sum of Main phase feeding and Teaser phase feeding circuit capacity. Taking 30% of safety factor into account, 68MVA will be appropriate capacity of feeding transformer.

ii) Auto Transformer (AT)

Maximum AT neutral current is shown in Table 5.3.39 and Maximum AT capacity is shown Table 5.3.40. In case of Teaser phase feeder of Liyari TSS, maximum AT capacity is 2.77MVA at TSS 2.95MVA at SSP and 1.76MVA at ATP. While in case of Main phase feeder, maximum AT capacity is 1.08MVA at TSS and 1.49 MVA at ATP.

Table 5.3.39 Maximum and Mean-Square Value of AT Neutral Current

substation	Max AT neutral current				
	Teaser Feeding			Main feeding	
	SS	SSP	ATP	SS	ATP
	(A)	(A)	(A)	(A)	(A)
LIYARI	206	222	133	79	109

Source: JICA Study Team

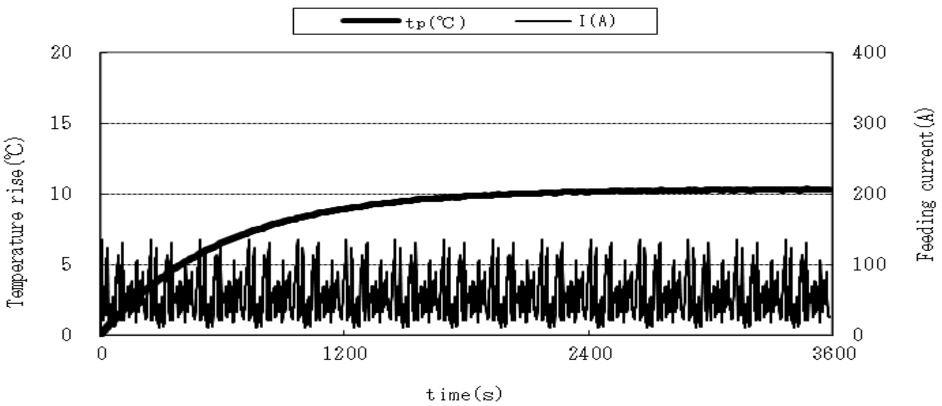
Table 5.3.40 Maximum AT Capacity

substation	Max self capacity				
	Teaser Feeding			Main feeding	
	SS	SSP	ATP	SS	ATP
	(MVA)	(MVA)	(MVA)	(MVA)	(MVA)
LIYARI	2.77	2.95	1.76	1.08	1.49

Source: JICA Study Team

c) **Temperature Rise of Trolley Wire**

Result of Temperature rise is shown in following figures and maximum temperature rise is 10.4ºC. By adding 50ºC of outdoor air temperature, maximum temperature of trolley wire is 60.4ºC which is below limited temperature of 90ºC.

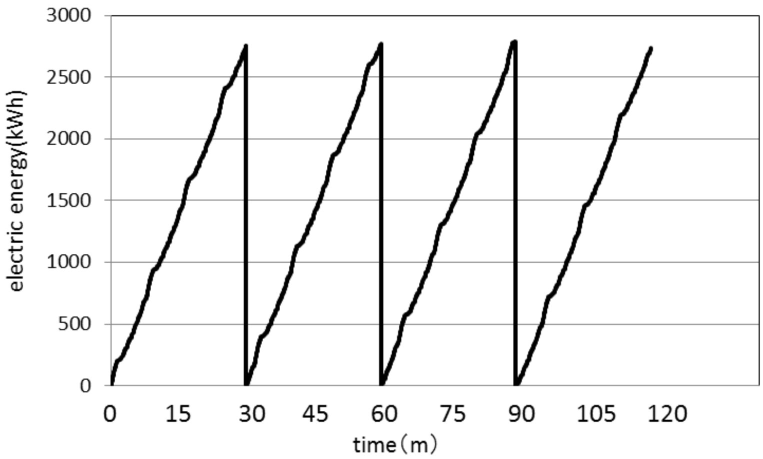


Source: JICA Study Team

Figure 5.3.78 Temperature Rise (Teaser Phase Feeder)

d) **Power Consumption of TSS**

Figure 5.3.79 shows power consumption per 30 minutes of Liyari TSS. Maximum power consumption per 30 minutes is 2,790kWh.

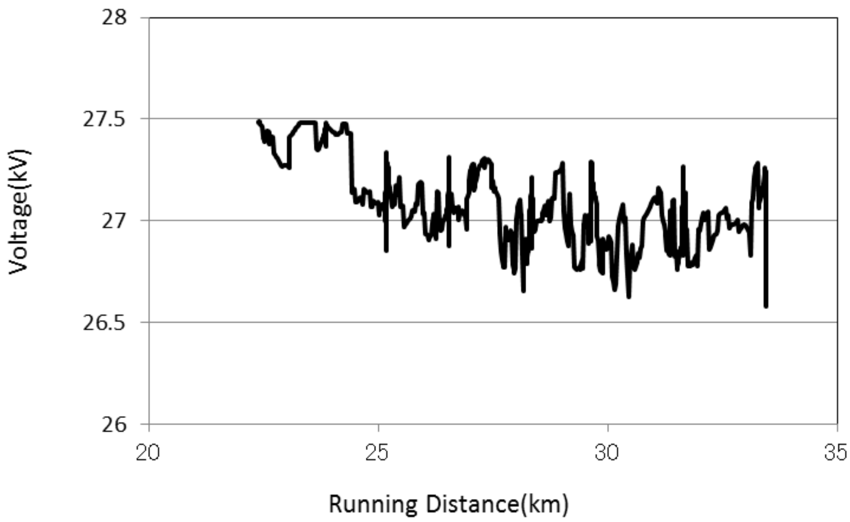


Source: JICA Study Team

Figure 5.3.79 Power Consumption per 30 Minutes of Liyari TSS (Extended Feeding)

e) **Voltage at Pantograph Point of Electric Car**

Minimum voltage at pantograph point is around 26.6kV which is exceeding minimum feeding voltage of 20kV .

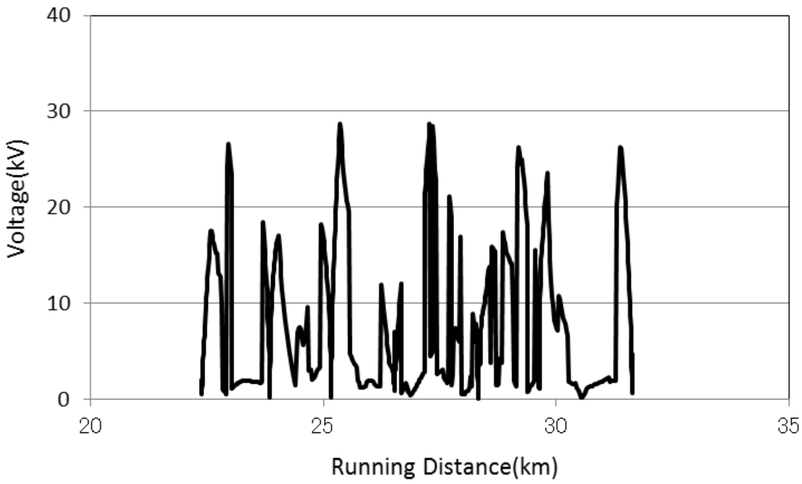


Source: JICA Study Team

Figure 5.3.80 Voltage at Pantograph Point of Electric Car

i) Rail Voltage With PW (Protective Wire) Earthing”

Figure 5.3.81 shows rail voltage with PW earthing case. Maximum rail voltage is 28.7kV which is not exceeding 120kV limited by regulation.



Source: JICA Study Team

Figure 5.3.81 Rail Voltage with PW Earthing

f) Power Consumption With and Without Case of Regenerative System

The result of power simulation is showing that total power consumption of Liyari TSS between 7:00 and 8:00 is 17,985kWh without using regenerative power system and 11,042kWh with using regenerative power. Difference of 6,942kWh is saved by regenerative system and efficiency is 38.6 %.

Table 5.3.41 Power Consumption With and Without Regenerative Power System

Item		LIYARI SS			
	substation	regenerative brake off	regenerative brake on	difference	efficiency (%)
Teaser Feeding Bus	Max Effective Power(kW)	26236.6	26236.6	0.0	-
	Max Reactive Power(kVar)	6016.5	7758	-1741.5	-
	Electric Power Consumption(kWh)	15704.6	8989.3	6715.3	42.8
	Average Power Factor	0.98	0.9	0.1	-
Main Feeding Bus	Max Effective Power(kW)	9736	9736	0.0	-
	Max Reactive Power(kVar)	2017.4	2075.9	-58.5	-
	Electric Power Consumption(kWh)	2280.6	2053.3	227.3	10.0
	Average Power Factor	0.98	0.96	0.0	-
Incoming Bus	Max Effective Power(kW)	35602.0	29675.0	5927.0	16.6
	Electric Power Consumption(kWh)	17985.2	11042.6	6942.6	38.6

Note: Efficiency＝Difference / Regenerative brake off Source: JICA Study Team

5.3.5 Power Distribution Facility

(1) Current Conditions

1) Distribution Facility of KESC

In KESC grid stations, most current distribution equipment such as transformers, distribution apparatus, and control panels are from abroad. Sizes are a bit bigger compared to Japanese.

2) Distribution Facility of the Currently Inactive KCR

According to the result of the site survey, there are no distribution facilities in the currently inactive circular line.

3) Local Procurement of Distribution Equipment, Electric Wire, and Power Cable

Since 11kV power cables are commonly used for distribution equipment and manufactured locally, procurement is expected to be easy. Many other types of wires are expected to be procured locally, as well. However, technical specifications need to be carefully checked in accordance with Japanese standards.

(2) Planning of the Distribution Facility

Normally, distribution systems consist of the following:

- High Voltage Distribution Lines
- Switching Rooms
- Power Distribution Facilities for the Stations, the OCC, and the Rolling Stock Workshop
- Lighting Facilities for the Two Depots
- Power Distribution Facilities along the Railway Tracks

Designing policies for each distribution facility are as follows:

1) High Voltage Distribution Lines

a) Power Supply

Electric power to high voltage distribution lines will be supplied from Liyari and Alladin Park traction substations (TSS) through three-phase 11kV distribution cable (double circuit) installed between substations. Two 11kV distribution transformers will be installed in TSS.

Three-phase 11kV distribution cable for rolling stock depot is installed dedicatedly from the Liyari TSS.

b) Technical Standards for Laying Cable

Elevated and Underground Sections: in- duct

On-ground Sections: underground

For laying cables, Pakistan Technical Standards will be applied.

c) Types of Power Cables

Cross Linked Polyethylene (XLPE) cable common in Pakistan will be used, taking into consideration ease of future maintenance work.

Fire prevention cable will be used for the U-Shaped retaining wall section.

2) Switching Rooms

31 switching rooms will be constructed at each station, maintenance depots, the OCC, and the rolling stock depot.

a) Power Supply for Switching Rooms

Power will be supplied through double circuit (No1 and No2) 11kV high voltage distribution lines installed between TSS.

An emergency diesel generator will be installed at underground stations and the Wazir Mansion rolling stock depot.

Alladin Park and Johar are underground stations where an emergency diesel generator will be installed in case of emergency with no power supply from TSS. Because important machinery and equipment for safety measures such as fire extinguishing, smoke extraction equipment, tunnel lighting and drainage pumping machine are installed at underground stations.

Alladin Park rolling Stock Depot is also where an emergency diesel generator will be installed in case of emergency with no power supply from TSS. Electric power for the maintenance depot, OCC, and rolling stock workshop is supplied from Liyari TSS through double circuit 11kV high voltage distribution lines. To handle an emergency situation with no power supply from TSS, an emergency diesel generator is installed in the OCC. Because the OCC has various important facilities for safe train operation control and the OCC must be kept in operating condition at anytime.

b) Distribution Panels in Switching Rooms

Distribution panels in switching room consist of

- high voltage distribution panel
- low voltage distribution panel

3) Power Distribution Facility for Stations, the OCC and the Rolling Stock Workshop

A distribution system for stations, the OCC, and the rolling stock workshop will be installed based on each of their requirements.

4) Lighting Facilities for the Two Depots

Mercury lamps on beams will be used for the lighting system to illuminate entire tracks in depot. In addition, bracket and pole lights will also be used for lighting in depot.

5) Power Distribution Facilities along the Railway Track

- Tunnel Lighting
  In the tunnel section near Alladin Park and Liyari stations, tunnel lighting will be installed along railway tracks with intervals of 20m. Electric power will be supplied through distribution lines from each station.
- Drainage Pumping Facilities
  In underground stations, drainage pumps will be installed to drain ground and rain water.

(3) Issues to be solved

1) **Load Demand Estimation**

Accurate load demand estimation will be required for appropriate planning of distribution facility at basic design stage.

2) **Theft Prevention**

To prevent theft of distribution cables on the ground, proper countermeasures for theft will be required. A survey for theft prevention method applied to existing electric power company should be conducted to get useful information.

3) **Layout Plan for Switching Rooms**

A layout plan for switching rooms in stations, the OCC and rolling stock workshop should be carefully checked to avoid interference with signaling & telecommunication equipment and air-conditioning machinery.

4) **Space for Emergency Diesel Generator**

Since an emergency generator is installed at underground stations and the OCC, coordination is required to properly accommodate the generator considering the layout plan of other facilities.

5) **Fire Prevention Standard**

Fire prevention standard applied to KCR should be carefully reviewed and examined with KUTC.

5.3.6 Overhead Contact System

(1) Results of the On-Site Investigation

In the previous SAPROF (I) study, a comparison about Alternate-Current (AC) and Direct-Current (DC) electrification systems is mainly conducted, and description of the Overhead Contact System (OCS) facilities is hardly found. However, the composition of the overhead wires has been described that in case of an AC electrification system being used, SAPROF (I) recommends a simple catenary system which consists of contact wire for Cu110mm2 and messenger wire for Cu60mm2. In this study, based on the conclusion of the previous SAPROF (I) study, OCS facilities will be built on the assumption that an AC electrification system with an AT feeding system of 2x25 kV will be used. Although the feeding voltage is the same as that of a Shinkansen in Japan, KCR does not require such for high speed train operation due to urban railway systems operating at slower speeds. The OCS will be built by referring to "Tsukuba Express" which adequately accommodates these conditions and introduced the latest railway system in Japan.

1) **Data and Information Collected in the Field Study**

a) **Associated Data of Pakistan Railway**

The current status of electrified facilities of Pakistan Railway (PR) was investigated and resulted in acquiring PR design criteria and rules, which will be used in the coming basic design stage. The main collected data and information are as follows:

i) Construction Rule "SCHEDULE OF DEMENSIONS 1676mm GAUGE"

This includes the following information.

- construction gauge and vehicle gauge
- permitted electric clearance from nearby structures
- standard of rail track construction
- standard height of a contact wire

ii) Design and Construction Standard for PR

- Electric Traction Power Supplies Manual
- Electric Traction Overhead Line Manual

These manuals were enacted in 1973 and became the standard of electrification design and construction. Since then and despite being used until now, there has been no revision. Although the existing electrification system of Pakistan railway differs from our proposed system, the management methodology of facilities and the demarcation responsibilities will be consulted with an electric supply company.

iii) Related Data for Ongoing Electrification Line Plan

The following information covers the outline of future electrification and double-tracking currently planned by PR.

- feeding network (Karach City ~ Pana Akil)
- double-tracking plan route diagram

b) **Karachi Electric Supply Company (KESC)**

i) Karachi Electric Supply Company E.H.T. Network

This network indicates the transmission network and supply voltage level of the entire KESC jurisdiction. JICA Study Team assumed the optimal transmission line from KESC Grid Station (GS) to KCR traction power substation (TSS) based on this diagram.

ii) Grid Station Single Track Wire Connection Figure

This figure is a typical single line diagram of a dispatch center.

iii) Annual Report 2010-11 issued by Karachi Electric Supply Company

This book mainly explains financial and organization information, but the facilities track record of transmission line in this book will be useful for design.

c) **Climate Conditions in Karachi City**

To determine the basal condition of the overhead contact system, various meteorological data for the past ten years in the KCR project area was collected from the Meteorological Department of the Ministry of Defense.

The contents of collected data are as follows

a. minimum, maximum, and average temperature
b. average humidity
c. month-long precipitation
d. month-long average wind velocity
e. average wind direction
f. month-long thunderstorm days

This acquired data is shown in Table 5.3.42.

Table 5.3.42 Climate Conditions in Karachi City

Temperature (Mean)	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	19.4	22.3	26.4	29.2	31.6	32.3	29.6	29.4	29.5	36	26	23.1	27.9
	2002	19.9	21	26.4	29.6	31.3	31.6	29.5	28.3	28	29.4	25.1	21.4	26.8
	2003	20.1	22.7	26.1	30.3	30.6	31.4	30.9	29.7	28.9	28.9	23.7	20.1	26.9
	2004	19.7	22.2	27.7	30.2	32	32.1	30.6	29.5	29	28.1	24.3	22.4	27.3
	2005	18.6	20.8	25.9	29.1	30.9	32.3	30.3	29.4	30.4	29	26	20.7	27
	2006	18.9	24.7	25.7	29.4	31	32	31.1	28.7	30.5	30.4	26.4	20.1	27.4
	2007	19.9	23.4	25.5	30.3	31.8	32.5	31.3	30.1	30.6	28.6	26.2	20	27.5
	2008	17.2	19	27	29.2	30.6	32.1	30.7	29.4	30.7	29.6	25	21	26.8
	2009	20.5	23.1	26.9	29.9	32.2	32.2	31.3	30.3	29.6	29.3	25	21.3	27.6
	2010	19.9	22	27.7	30.5	32.3	31.5	31.5	30.2	30.2	29.9	25.1	19.6	27.5
	Monthly mean	**19.4**	**22.1**	**26.5**	**29.8**	**31.4**	**32.0**	**30.7**	**29.5**	**29.7**	**29.9**	**25.3**	**21.0**	**27.3**

Temperature (Max)	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	27.2	29.6	33.1	34.6	35.1	34.8	32.1	32.3	33.1	36	33.5	30.4	32.6
	2002	27	28.2	33.3	35.4	35.6	35.1	32.2	31	31.3	36.5	32.7	28.1	32.2
	2003	27.6	28.5	32.3	36.6	35.7	34.8	34.1	33.5	32.5	37	32.2	28.3	32.8
	2004	26.6	29.9	36.2	35.4	36.8	35.6	33.5	32.6	32.8	33.7	30.7	29.4	32.8
	2005	24.9	26.2	31.4	35.2	35.4	36.1	33.2	32.2	34.2	35.2	33.1	28.4	32.1
	2006	26	31.3	31.8	34.3	34.6	35.4	33.9	31	34.2	35	33.4	26.3	32.3
	2007	26.8	29.4	31.3	36	36	36.3	34.7	32.8	34.5	35.9	33.9	27.1	32.9
	2008	24.4	26.9	34.3	34.4	33.9	35.1	33.5	31.9	34.7	35.5	32.5	27.2	32
	2009	26.2	29.8	33	36	36.8	35.7	34.5	33	32.8	35.9	33	28.6	32.9
	2010	27.5	29.2	34	35.7	36.5	34.7	34.6	33.2	34.5	35.9	32.7	28	33
	Monthly mean	**26.4**	**28.9**	**33.1**	**35.4**	**35.6**	**35.4**	**33.6**	**32.4**	**33.5**	**35.7**	**32.8**	**28.2**	**32.6**

Temperature (Min)	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	11.5	14.9	19.7	23.8	28.1	29.8	27.1	26.5	25.9	24.4	18.5	15.9	22.2
	2002	12.8	13.8	19.5	23.9	27	28.1	26.9	25.6	24.7	22.2	17.6	14.8	21.4
	2003	12.7	16.9	19.8	24.1	25.6	28.1	27.6	26	25.3	20.9	15.2	12	21.2
	2004	12.9	14.5	19.1	24.8	27.3	28.7	27.7	26.3	25.3	22.4	17.9	15.4	21.9
	2005	12.3	15.4	20.3	22.9	26.4	28.4	27.4	26.6	26.6	22.9	18.9	13	21.8
	2006	11.7	18.1	19.6	24.5	27.5	28.5	28.3	26.3	26.8	25.7	19.4	14	22.5
	2007	13	17.4	19.7	24.7	27.5	28.7	29	27.5	26.9	21.3	18.4	12.8	22.2
	2008	10.1	11.1	19.6	24	27.3	29.1	27.9	26.8	26.6	23.8	17.6	14.9	21.6
	2009	14.7	16.5	20.8	23.8	27.6	28.7	28.1	27.5	26.5	22.6	17	13.9	22.3
	2010	12.2	14.7	21.3	25.2	28	28.2	28.3	27.2	25.8	23.9	17.4	11.1	21.9
	Monthly mean	**12.4**	**15.3**	**19.9**	**24.2**	**27.2**	**28.6**	**27.8**	**26.6**	**26.0**	**23.0**	**17.8**	**13.8**	**21.9**

Humidity (Mean) at 0000	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	57	68	68	78	79	77	82	80	82	83	65	67	73.8
	2002	56	59	72	71	79	81	80	81	81	80	72	66	73.2
	2003	67	67	68	63	75	81	83	81	78	73	67	67	72.5
	2004	67	72	69	74	79	79	81	83	81	74	68	56	73.6
	2005	59	66	75	67	77	79	79	80	79	72	69	60	71.8
	2006	61	73	70	78	79	79	81	88	83	78	78	73	76.8
	2007	59	80	77	80	82	81	80	84	80	74	80	64	76.8
	2008	57	64	72	77	82	79	78	82	75	77	62	71	73
	2009	65	74	76	67	78	81	83	83	83	81	62	59	74.3
	2010	71	68	79	76	81	82	82	84	80	78	61	61	75.3
	Monthly mean	**61.9**	**69.1**	**72.6**	**73.1**	**79.1**	**79.9**	**80.9**	**82.6**	**80.2**	**77.0**	**68.4**	**64.4**	**74.1**

Humidity (Mean) at 1200	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	26	32	35	47	59	63	71	65	59	47	30	39	47.8
	2002	27	27	33	43	57	62	66	65	63	39	34	33	45.8
	2003	31	35	37	35	53	63	71	67	57	34	31	34	45.7
	2004	34	33	26	47	55	62	64	66	59	43	32	25	45.5
	2005	29	41	45	37	55	59	65	65	60	37	36	30	46.6
	2006	31	37	38	49	62	59	68	76	61	54	38	40	51.1
	2007	31	44	43	47	57	64	66	72	59	35	41	31	49.2
	2008	28	30	36	48	66	62	63	68	58	48	31	47	48.8
	2009	37	40	46	35	55	63	69	71	67	46	31	32	49.3
	2010	35	32	42	49	59	64	67	70	59	47	33	28	48.8
	Monthly mean	**30.9**	**35.1**	**38.1**	**43.7**	**57.8**	**62.1**	**67.0**	**68.5**	**60.2**	**43.0**	**33.7**	**33.9**	**47.9**

Precipitation	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	0	0	0	0	0	10.6	73.6	16.2	0.1	0	0	0	100.4
	2002	0	2.4	0	0	0	0.1	0.3	52.2	0.1	0	0.5	0.4	55.8
	2003	6.4	21.8	0	0	0	16.3	270.4	9.8	0.1	0	0.2	0	324.9
	2004	13.7	0	0	0	0	0.1	3	5.6	0.1	39.3	0	4.3	65.9
	2005	10.8	12.8	0.1	0	0	0.1	1.3	0.3	54.9	0	0	17.1	97.2
	2006	0.1	0	0.1	0	0	0	66.2	148.6	21.9	0	3.1	61.3	301.1
	2007	0	13.2	33.4	0	0	110.2	41	250.4	0	0	0	17.4	465.6
	2008	8	0.1	1.1	0	0	0	54	37.5	0.1	0	0	21	121.6
	2009	3	0.1	0	0.1	0	2.6	159.9	44	68.9	0	0	1.5	279.9
	2010	0	0.5	0	0	0	97.4	120.4	111.5	42.7	0.4	0.1	0	372.9
	Monthly mean	**4.2**	**5.1**	**3.5**	**0.0**	**0.0**	**23.7**	**79.0**	**67.6**	**18.9**	**4.0**	**0.4**	**12.3**	**218.5**

Wind Speed at 0000	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	1.7	2.2	2.6	4.3	6.5	7.9	6.2	7.5	4.9	2	1.6	1	4
	2002	2.5	1.6	2.7	5.3	8	8	10.4	6	6.5	1.1	1.3	1.6	4.6
	2003	1.8	3.1	3.2	4.8	6	7.7	4.8	6.6	4.9	0.8	1.7	2.1	4
	2004	2.1	2.1	2.1	3.9	6	8	8.6	9.5	5.5	2.3	0.4	2.4	4.4
	2005	2.1	4	3.7	3.1	4.3	5.5	8.6	7.1	5.1	1.7	0.7	0.8	3.9
	2006	1.5	1.6	1.6	4.3	7.2	6.7	8.6	5.9	4	3	0.9	1.6	3.9
	2007	0.8	1.4	2.3	2.3	3.9	3.9	3.5	4.5	4.1	1.1	0.6	1.7	2.5
	2008	1.5	2.3	2.3	3.4	7.7	4.9	6.6	6.3	5.2	2.2	1.3	2.1	3.8
	2009	3.4	1.3	2.5	2.6	3.4	5	6.4	6.5	5.5	1.3	2.5	2.7	3.6
	2010	1.9	2.7	2.6	4.1	6.3	7.3	5.8	6	4.6	1.7	2	2.3	3.9
	Monthly mean	**1.9**	**2.2**	**2.6**	**3.8**	**5.9**	**6.5**	**7.0**	**6.6**	**5.0**	**1.7**	**1.3**	**1.8**	**3.9**

Wind Speed at 1200	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
	2001	4.5	5.7	7.9	9.5	12.2	12.3	8.5	9.8	8.2	5.7	4.2	4.3	7.7
	2002	6	7	8.6	10.9	12.6	9.1	14.1	9.7	11	5.8	5.8	5.2	8.8
	2003	7.1	8.3	9.2	10.1	11.2	10.5	7.9	9.6	7.3	6.2	4.7	4.1	8
	2004	6.3	7.2	7.2	10.1	11.9	12.2	12.5	11.9	9.4	6.7	3.8	4.9	8.7
	2005	4.5	6.9	7.8	9.5	10.1	9.9	11.2	10.7	8.1	5.9	4.4	4.5	7.8
	2006	4.7	6	7.8	8.9	10.5	10.8	11.2	8.9	6.5	7.9	4	4.8	7.7
	2007	4.1	7.5	6.8	7.8	10.2	10.5	8.6	9.4	8	5.8	6.2	3.3	7.4
	2008	4.3	7.6	8.2	10.5	12.6	7.6	11	9.3	8.7	6.6	5.1	3.9	7.9
	2009	7	7.2	7.9	9.3	9.8	9.7	9.5	9.3	9.1	6.1	5	3.9	7.8
	2010	5	6.8	7.7	8.2	9.8	9.3	8.8	7.2	1.5	6.2	4.9	5	6.7
	Monthly mean	**5.4**	**7.0**	**7.9**	**9.5**	**11.1**	**10.2**	**10.3**	**9.6**	**7.8**	**6.3**	**4.8**	**4.4**	**7.9**

Wind Direction at 0000	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
	2001	N43E	N16W	N76W	S73W	S62W	S49W	S67W	S62W	S53W	S82W	N18E	N22E
	2002	N16E	N07E	N79W	S87W	S67W	S45W	S68W	S66W	S51W	N68W	N17E	N29E
	2003	N40E	N45W	S81W	S72W	S57W	S54W	S68W	S95W	S66W	N06W	N45E	N55E
	2004	S	N06E	N77E	N56W	S32W	S51W	S46W	S56W	S56W	N51W	N	N32E
	2005	N38E	N14W	N79W	S73W	S57W	S54W	S55W	S57W	S79W	S89W	N	N45E
	2006	N27E	S74W	S84W	S73W	S77W	S72W	S75W	S88W	S72W	S74W	N22E	N32E
	2007	N45E	CALM	N88W	S69W	S61W	S45W	S55W	S71W	S71W	N37W	N37W	N29E
	2008	N30E	N14E	N87W	S71W	S61W	S52W	S57W	S57W	S75W	S75W	N17E	N35E
	2009	N55E	N3E	S66W	S72W	S72W	S55W	S65W	S51W	S75W	S76W	N30E	N45E
	2010	N40E	N24W	S68W	S80W	S88W	S72W	S77W	S84W	S83W	N75W	N43E	N34E

Wind Direction at 0300	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
	2001	N24E	N05E	N67W	S72W	S51W	S51W	S59W	S67W	S61W	S76W	N18E	N34E
	2002	N38E	N34E	N37W	S82W	S68W	S59W	S72W	S61W	S77W	N45W	N29E	N38E
	2003	N30E	N41E	S81W	S81W	S69W	S53W	S62W	S52W	S63W	N43E	N38E	N45E
	2004	N45E	N37E	N58E	S57W	S61W	S53W	S46W	S57W	S58W	N37W	N19E	N39E
	2005	N24E	N7W	N84W	S81W	S65W	S53W	S63W	S61W	S90W	N83W	N5E	N34E
	2006	N16E	N63W	N45W	S82W	S78W	S71W	S82W	S85W	S75W	S73W	N37E	N42E
	2007	N32E	N45E	N72W	S72W	S64W	S45W	S52W	S64W	S71W	N11W	N45E	N34E
	2008	N37E	N8E	S79W	S57W	S67W	S54W	S59W	S62W	S72W	S84W	N30E	N41E
	2009	N45E	N45E	S88W	S86W	S58W	S55W	S65W	S60W	S75W	N88W	N34E	N37E
	2010	N60E	N34E	S86W	S80W	S91W	S65W	S87W	W	S88W	N8W	N39E	N37E

Thander storm days	Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12	Amount
	2001	0	0	0	0	0	1	0	2	0	0	0	0	3
	2002	0	0	0	0	0	1	0	0	0	0	0	0	1
	2003	1	0	0	0	0	0	9	0	0	0	0	0	10
	2004	0	0	0	0	0	0	3	0	0	1	0	1	5
	2005	0	0	0	0	0	0	0	0	1	0	0	1	2
	2006	0	0	1	0	0	0	2	5	0	0	1	0	9
	2007	0	0	1	0	0	6	0	0	0	0	0	0	7
	2008	1	0	1	0	0	0	1	1	0	0	0	2	6
	2009	0	0	0	0	2	0	5	2	0	0	0	0	9
	2010	0	0	0	0	0	2	5	4	4	2	0	0	17

Source: the Meteorological Department of the Ministry of Defense

2) Site Situation of Proposed Stations and Surrounding Environments

The result of the on-site investigation is shown in Table 5.3.43.

Table 5.3.43 Site Situation of Proposed Stations

No	Station Name	Kilo Post	Site Situation
1	DRIGH ROAD	0+000	The road side of the direction of an airport has a vacant lot.It has posibility as a proposed site for SS.Check of transmission route is required.
2	JOHAR	4+970	The proposed station site is a stagnant water area currently.Around 1.5km interval from KESC Hospital Grid.
3	ALLADIN PARK	5+830	The proposed station site is surrounded by private houses.The amusement park is located in the opposite side of KCR track .
4	NIPA	7+510	Two road bridges crosses right-angled to KCR line , and the height from the ground to undersurface of bridge is 6.3m.
5	GILANI	9+410	There is a vacant land in which Stabling of 2 to 3 lines is possible in the direction of Yasinabad Station. Surroundings is a housing hight density area.
6	YASINABAD	11+510	The proposed station site adjoins a busy crossing and crowded with furniture shops.
7	LIAQUATABAD	12+570	The proposed station site adjoins a road bridge and the neighborhood is a residential area.Many KESC transmission lines run in the vicinity.
8	NORTH NAZIMABAD	14+730	An road bridge is adjoined and there is a close resemblance to land situation of LIAQUATABAD station.
9	ORANGI	16+190	A station square is large and the level crossing adjoins.Sufficient land for SP will be able to acquire.
10	HBL	16+890	Use of the employee of National Industrial Area is expected.
11	MANGHOPIR	18+430	Sewage are flowing into station yard from adjointed textile factory.Many factories(electronic manufacturer,textile company) are located.
12	SITE	20+330	KCR line cross right-angled to the road.The beverage plant is located in the neighborhood.
13	SHAH ABDUL LATIF	22+390	Proposed station will be newly constracted in the same location where is the existing station.There is an automoble factory along KCR line at the station.
14	BALDIA	23+850	A vacant land (ornered by PR) is located on the back side which is big intersection.PR land was made a studied for receiving Substation from KESC Mouripur grid station.
15	LIYARI	25+170	Proposed station faces on the south of the LIYARI river.New substation will be constructedt in the dry riverbed of the north side.
16	WAZIRMANSION	26+530	A new station is adjoined, Car depot of KCR is constructed next to proposed station.KESC transmission line tower exists in Car depot
17	TOWER	28+330	The vast vacant land spreads out.
18	KARACHI CITY	29+630	Pakistan Railways branch office is located in the station yard. Road bridges exist in DCOS side.
19	DCOS	31+630	PR Deputy Control Store is located in the neighborhood.Two road bridges exist in the Karachi Cantt side.
20	KARACHI CANTT.	33+430	Sufficient land for SSP at the time of Revised Option-B plan will be able to acquire.
21	NAVAL	34+670	The proposed station site is located between road bridges.
22	CHANESAR	36+530	The location is straight line section with double tracks of PR North side is residential areas.
23	SHAHEED-E-MILLAT	38+250	Just as Chanesar, so it is along PR double tracks.Railway side is partly occupied by illegal intruder.
24	KARSAZ HALT	40+390	Required land for SP will be able to acquire next to proposed station.

Source: JICA Study Team