Chapter 6

Transmission System Analysis

Chapter 6. Transmission System Analysis

6.1. Purpose of the System Analysis

The capacity of a power system to transmit electricity has limitations depending on the design of equipment and system condition. If the implementation of an electrification project, with the maximum power load at local level exceeds the system capacity of that area, then reinforcement of transmission system is inevitable and its cost should be added to the cost of the electrification project. This is why the analysis of the capacity of local network systems, i.e. the capacity of each substation, needs to be carried out for an electrification study.

In this section, the capacity of the transmission system and possible bottlenecks are studied.

6.2. Current Status of the Power Transmission System in Zambia

The main characteristics of ZESCO's power transmission system are as follows.

- ZESCO's transmission system has various voltage levels, namely 330kV, 220kV, 132kV, 88kV and 66kV. These voltage levels are stepped-down to 33kV and 11kV for distribution at substations.
- ZESCO's power system is interconnected to that of neighbouring countries as part of the Southern African Power Pool (SAPP). SAPP consists of power systems in southern African countries, namely Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Namibia, Republic of South Africa, Swaziland, Tanzania, Zambia and Zimbabwe, though actually some of these countries are not interconnected yet.
- The main 330kV transmission lines are running north to south in the middle of the country because the copper mines, the largest load centre, are located in the north and the main generation stations are located in the south. The electricity generation mostly comes from three hydro power plants located in southern area of Zambia, thus the main power flow is streaming from south to north.
- Copperbelt Energy Corporation (CEC) has some transmission lines, substations and generators to supply electricity to the copper mines. CEC's transmission system also has interconnection with DR Congo to wheel power export from DR Congo to Zimbabwe and South Africa.
- 66kV transmission lines are used for local supply. In North-Eastern and Western areas, the span of 66kV lines is in general very long.

Figure 6-1 illustrates the diagram of transmission system in Zambia as of 2006, most of which is owned and operated by ZESCO. The list of 330kV – 88kV transmission lines and that of 66kV line are shown in Table 6-1 and Table 6-2 respectively. According to the statistic data of ZESCO, total circuit length of 330kV transmission lines is 2,241km, total 220kV lines 348km, total 132kV lines 202km, total 88kV lines 754km and total 66kV lines 3,033km as at the end of March 2006. In addition, CEC also has transmission lines whose total length is 808km. Transmission system of ZESCO, as part of SAPP, has interconnection with DR Congo, Zimbabwe and Namibia in the south, and is also used for international power trade.

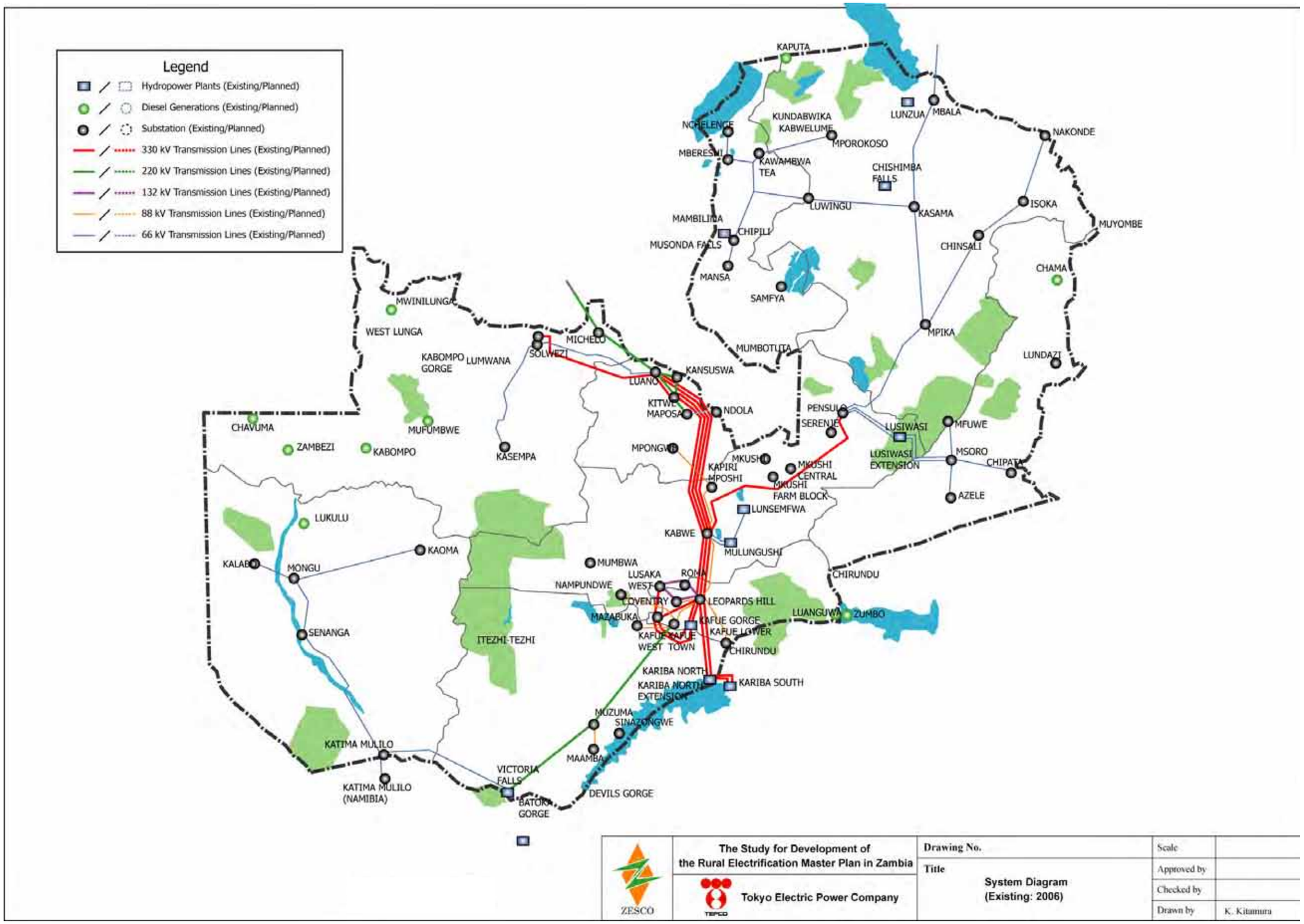


Figure 6-1 Transmission System Diagram of Zambia as of 2006

Table 6-1 Transmission Lines of ZESCO as of June 2006 (330kV – 88kV)

Voltage (kV)	Line (from – to)	Conductor	No. of Circuits	Route Length (km)
330	Kabwe – Pensulo	2xACSR381, Bison	1	300
	Kabwe – Luano	2xACSR381, Bison	2	252
	Kabwe – Kitwe	2xACSR381, Bison	2	212
	Kariba North – Leopards Hill	2xACSR381, Bison	2	123
	Leopards Hill – Kabwe	2xACSR381, Bison	3	97
	Kafue West – Lusaka West	2xACSR381, Bison	1	42
	Leopards Hill – Kafue West	2xACSR381, Bison	1	53
	Kafue Gorge – Leopards Hill	2xACSR381, Bison	2	47
	Kafue Gorge – Kafue West	2xACSR381, Bison	1	42
	Kitwe – Luano	2xACSR381, Bison	1	40
	Kafue Town – Kafue West	2xACSR381, Bison	1	3
	Kariba North – Zimbabwe Border	2xACSR381, Bison	2	1
220	Muzuma – Kafue Town	1xACSR381, Bison	1	189
	Victoria Falls – Muzuma	1xACSR381, Bison	1	159
132	Lusiwasi – Msoro	1xACSR158, Wolf	1	115
	Leopards Hill – Coventry	1xACSR100, Dog	1	29
	Lusaka West – Roma	1xACSR158, Wolf	1	20
	Roma – Leopards Hill	1xACSR158, Wolf	1	26
	Lusaka West – Coventry	1xACSR158, Wolf	1	11
88	Leopards Hill – Kafue Town	1xACSR158, Wolf	1	62
	Kapiri – Mpongwe	1xACSR158, Wolf	1	96
	Figtree – Kabwe	1xACSR158, Wolf	1	56
	Leopards Hill – Figtree	1xACSR158, Wolf	1	55
	Leopards Hill – Chirundu	1xACSR100, Dog	1	80
	Napundwe – Mumbwa	1xACSR100, Dog	1	90
	Kafue Town – Napundwe	1xACSR100, Dog	1	46
	Leopards Hill – Water Works	1xACSR100, Dog	1	22
	Kafue Town – Mazabuka	1xACSR100, Dog	1	40
	Muzuma – Maamba	1xACSR100, Dog	1	30
	Kabwe Step Down – Kapiri Mposhi	1xACSR100, Dog	1	98
	Leopards Hill – Mapepe	1xACSR158, Wolf	1	29
	Leopards Hill – Coventry	1xACSR100, Dog	1	28
	Kabwe Step Down – Kabwe Town	1xACSR100, Dog	1	24
	Kafue Town – Mapepe	1xACSR158, Wolf	1	33

Source: ZESCO Statistic Data 2005/06

Table 6-2 Transmission lines of ZESCO as of June 2006 (66kV)

Voltage (kV)	Line (from – to)	Conductor	No. of Circuits	Route Length (km)
66	Katima Mulilo – Senanga	1xACSR100, Dog	1	212
	Kasama – Mpika	1xACSR158, Wolf	1	211
	Luano – Solwezi	1xACSR131, Tiger	1	189
	Chinsali – Mpika	1xACSR158, Wolf	1	179
	Kasama – Mbala	1xACSR158, Wolf	1	161
	Kawambwa – Mporokoso	1xACSR158, Wolf	1	142
	Chabasitu tee – Luwingu	1xACSR158, Wolf	1	123
	Lusiwasi – Msoro	1xACSR158, Wolf	1	115
	Kazungula – Sesheke	1xACSR100, Dog	1	108
	Isoka – Nakonde	1xACSR158, Wolf	1	107
	Mongu – Senanga	1xACSR100, Dog	1	105
	Lubushi – Luwingu	1xACSR158, Wolf	1	100
	Chilonga – Mununga	1xACSR158, Wolf	1	100
	Lusiwasi – Pensulo	1xACSR158, Wolf	1	90
	Chinsali – Isoka	1xACSR158, Wolf	1	82
	Chipata – Msoro	1xACSR100, Dog	1	80
	Victoria Falls – Kazungula	1xACSR100, Dog	1	80
	Pensulo – Mununga	1xACSR158, Wolf	1	75
	Chambasitu Tee – Kawambwa	1xACSR158, Wolf	1	71
	Kasama – Lubushi	1xACSR158, Wolf	1	70
	Kalabo – Mongu	1xACSR100, Dog	1	66
	Msoro – Mfuwe	1xACSR100, Dog	1	65
	Msoro – Azele	1xACSR100, Dog	1	55
	Lusiwasi – Kaombe	1xACSR158, Wolf	1	50
	Pensulo – Serenje	1xACSR158, Wolf	1	43
	Musonda Falls – Chambasitu Tee	1xACSR158, Wolf	1	40
	Chishimba Falls – Kasama	1xACSR100, Dog	1	30
	Mpika – Chilonga	1xACSR158, Wolf	1	22
	Kanona – Kaombe	1xACSR158, Wolf	1	21
	Kanona – Chinese Rd	1xACSR158, Wolf	1	19
	Sesheke – Katima Mulilo	1xACSR100, Dog	1	8
	Pensulo – Chinese Rd	1xACSR158, Wolf	1	1
	Mongu – Kaoma	1xACSR158, Wolf	1	195

Source: ZESCO Statistics data 2005/06

Table 6-3 Transformers of ZESCO Substations as of 2006

Substation	Transformer Capacity [MVA]	Voltages [kV]
Leopards Hill	2 x125	330/132
	2 x 90	330/ 88
Kafue Town	1 x 60	330/ 88
	2 x 60	220/ 88
Kabwe	2 x 60	330/ 88
Kitwe	6 x120	330/220
	6 x 60	220/ 66
Luano	4 x120	330/220
Pensulo	2 x 60	330/ 66

Source: ZESCO Statistics Data 2005/06

6.3. Reinforcement Plan of Transmission System in Zambia

Transmission System Development Plan, which was provided by the Transmission System Planning Department of ZESCO, is listed in Table 6-4 . Diagrams of projected transmission system in 2010, 2015, 2020 and 2030 respectively are shown in Figures from Figure 6-2 to Figure 6-5

Table 6-4 ZESCO's Existing Transmission Development Plan

Voltage	From-To	Commissioning year	No. of circuits	Notes
330	Kansanshi – Lumwana	2007	1	New installation
	Pensulo – Kasama	2009	2	New installation
	Kasama – (Tanzania)	2009	2	New installation
	Kafue Town – Muzuma	2010	1	Upgrade
	Muzuma – Victoria Falls	2010	1	Upgrade
	Victoria Falls – Katimamulilo	2010	1	Upgrade
	Katimamulilo – (Namibia)	2010	1	Upgrade
	Muzuma – Itezhi-Tezhi	2010	1	Upgrade
	Victoria Falls – (Zimbabwe)	2010	1	New installation
	Lumwana – (DR Congo)	2010	1	New installation
	Kabwe – Pensulo	2011	1	2nd circuit
	Pensulo – Lusiwasi	2020	1	New installation
	Lusiwasi – Msoro	2020	1	New installation
	Msoro – (Malawi)	2030	1	New installation
220	Victoria Falls – Katima Mulilo	2006	1	New installation
	Katima Mulilo – (Namibia)	2006	1	New installation
	Luano – Michelo	2008	1	2nd circuit
	Michelo – (DR Congo)	2008	1	2nd circuit
	Muzuma – Itezhi-Tezhi	2009	1	New installation
132	Katima Mulilo – Senanga	2008	1	Upgrade
	Senanga – Mongu	2008	1	Upgrade
	Leopards Hill – Chirundu	2030	1	New installation
66	Serenje – Mkushi	2007	1	New installation
	Kasempa – Mufumbwe	2008	1	New installation
	Mongu – Lukulu	2020	1	New installation
	Lukulu – Kabonpo	2020	1	New installation
	Lukulu – Zambezi	2020	1	New installation
	Zambezi – Chavuma	2020	1	New installation
	Lumwana - Mwinilunga	2030	1	New installation

Source: ZESCO

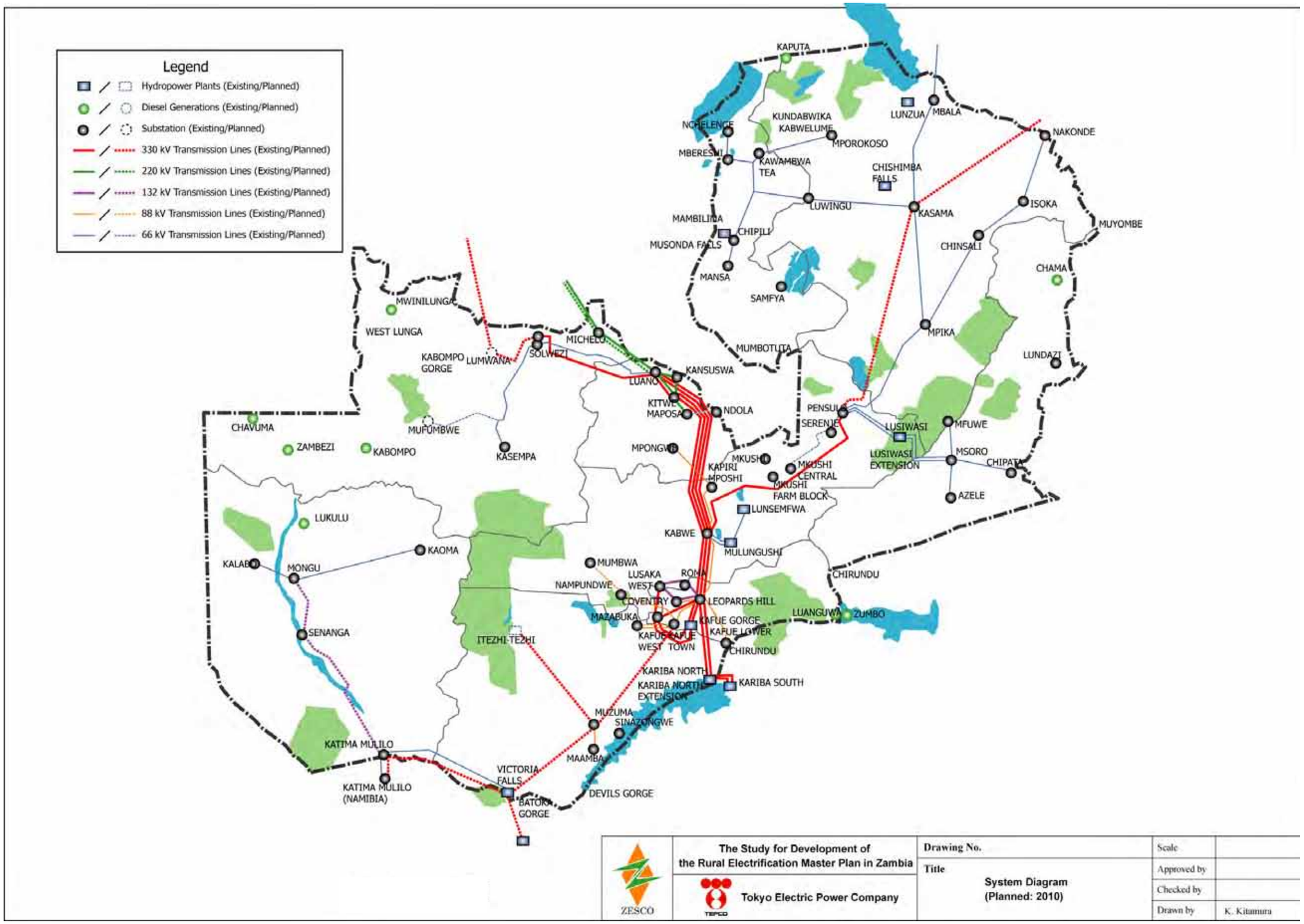


Figure 6-2 Transmission System Diagram of Zambia as of 2010

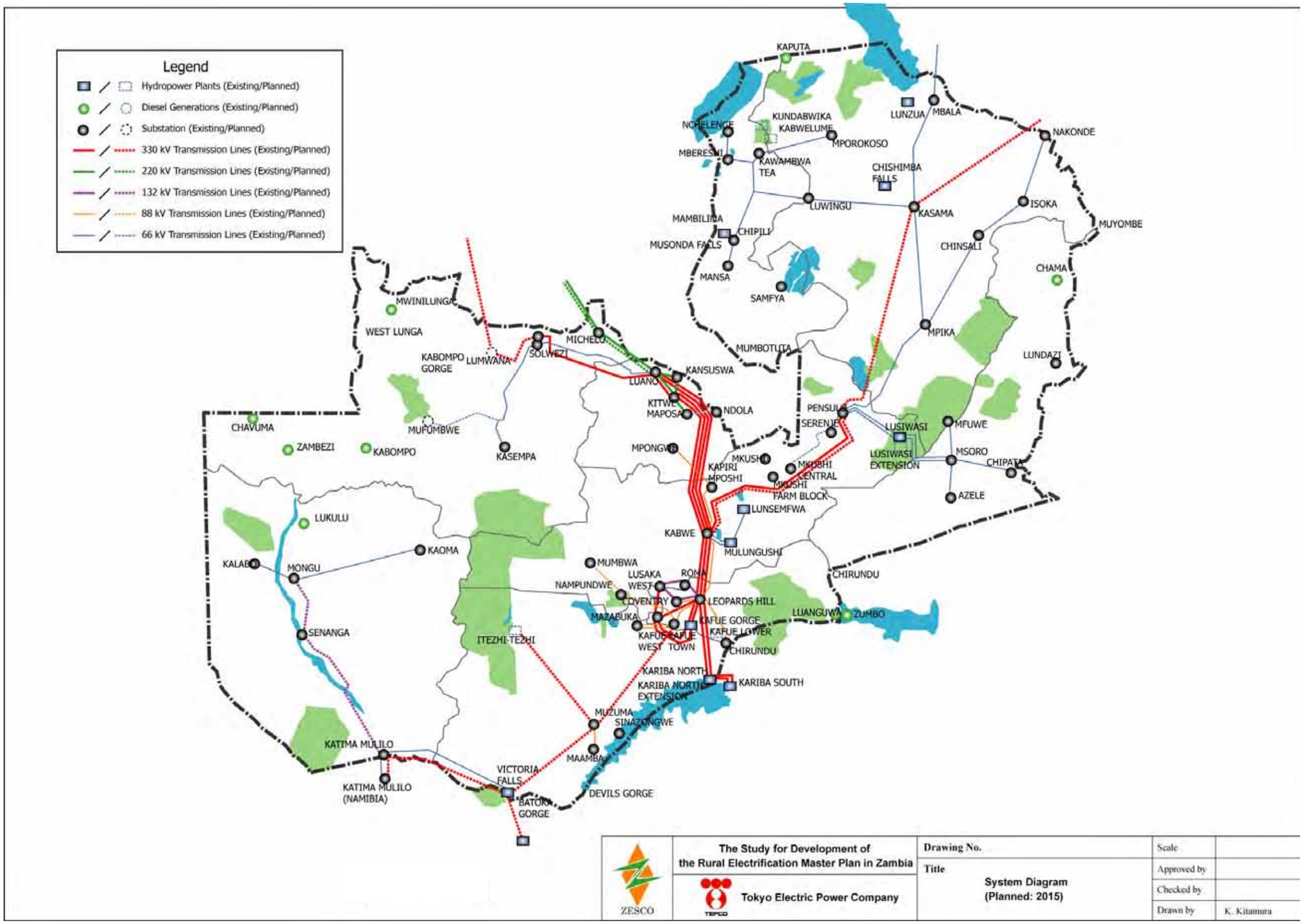


Figure 6-3 Transmission System Diagram of Zambia as of 2015

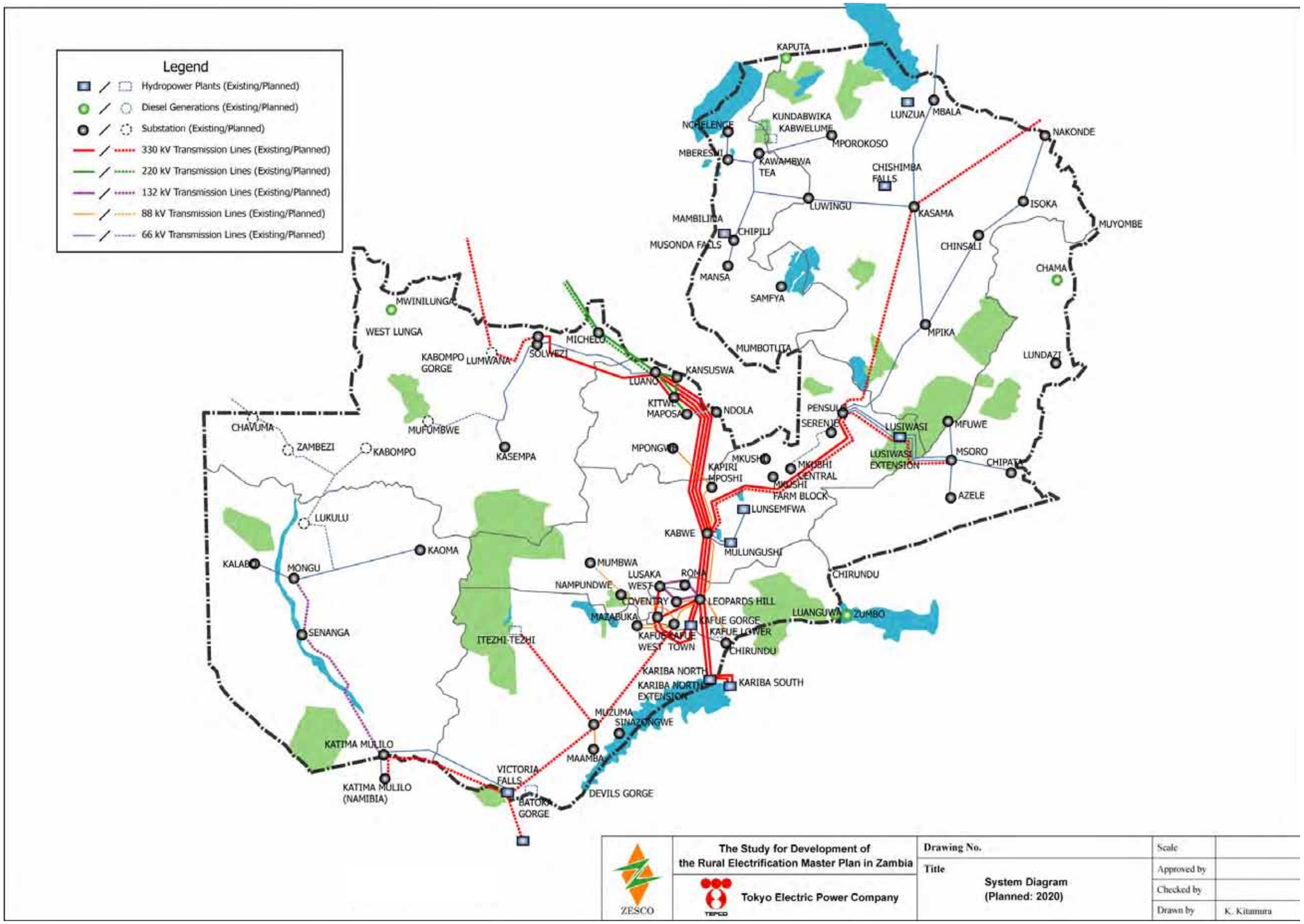


Figure 6-4 Transmission System Diagram of Zambia as of 2020

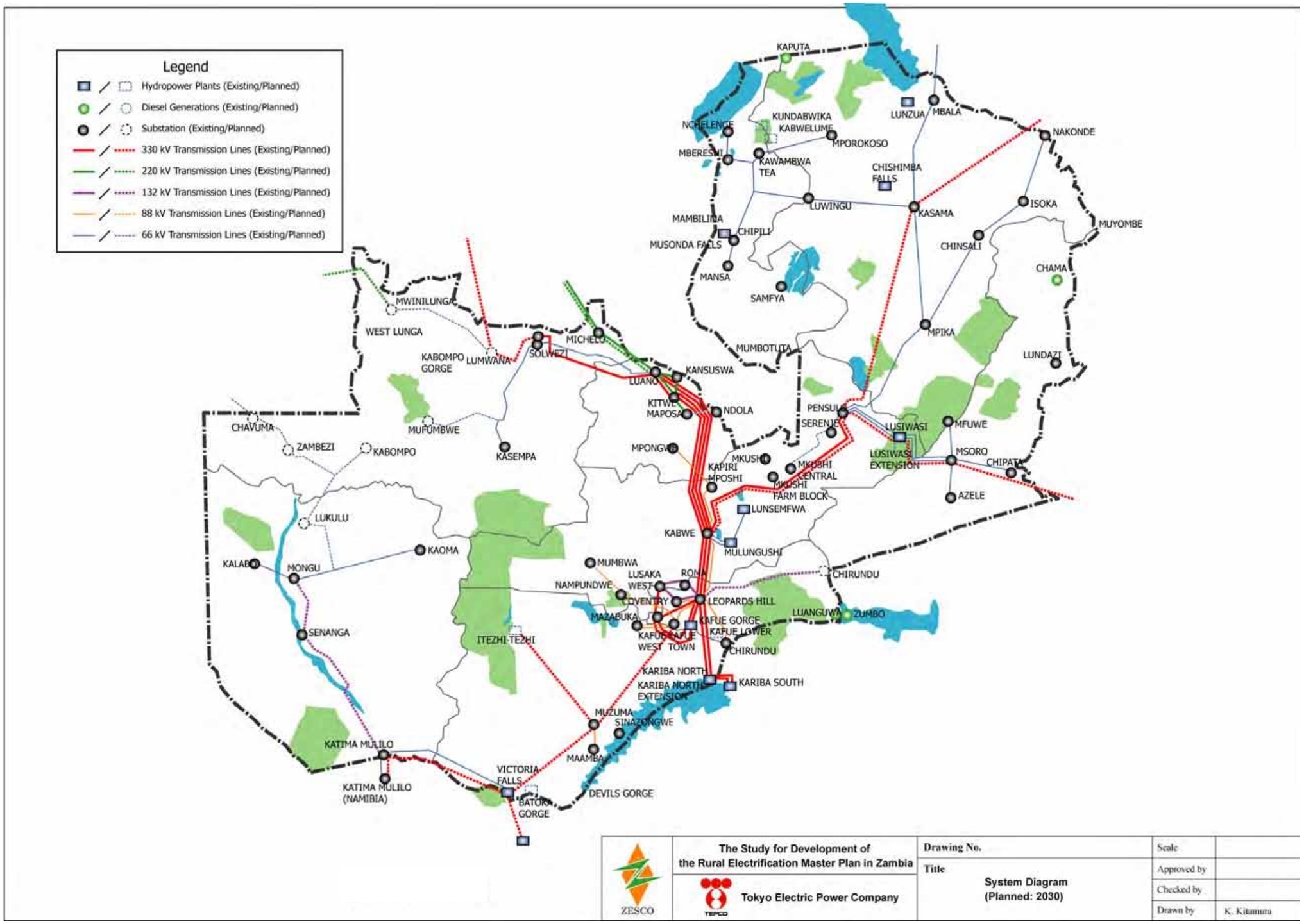


Figure 6-5 Transmission System Diagram of Zambia as of 2030

6.4. Analysis of the Capacity of Transmission System

There are two options of rural electrification, i.e. national grid extension and off-grid electrification, and regarding the first option, which is the topic of this section, it is necessary to take into account the effect of an electrification project on the capacity of power system such as substations and transmission lines. As already explained in Section 6.1. , if the maximum power load at local level is expected to exceed the facilities' capacity, reinforcement of the system should be considered as a part of the electrification project.

In this section, the capacity of the transmission system is analysed by using a simulation model. The main objective of this analysis is to identify the capacity of transmission system, especially regarding substations, which can be specified as follows, and the bottlenecks in the system, taking into account the demand growth and the system development plan.

- Remaining capacity of source substations that can be used for the local supply system from bulk power transmission system (blue coloured circle in image diagram)
- Remaining capacity of end substation that can be used for local supply system (red coloured circle in image diagram)

Figure 6-6 is the image diagram of remaining availability for electrification projects.

6.4.1. Assumptions of the Analysis

(1) Methodology

The methodology to grasp the system's capacity takes the following steps. First, the base scenario of the power system in the future is considered based on the business as usual (BAU) case power demand projection (that is, additional rural electrification projects are not considered) and the system reinforcement already planned by ZESCO. Then, the power flow and the voltage in the system are simulated repeatedly by gradually increasing the local load of a particular area. And finally each substation's remaining availability for electrification projects is determined at the level just below the point where the calculation cannot be converged due to the system's overload or voltage instability. When we find that some system reinforcement is necessary even in the base scenario but that no information regarding the reinforcement has been given by ZESCO, we assume that an appropriate reinforcement shall be done, which is included additionally in the base scenario. This simulation model also assumes that the installation of capacitors, which is necessary for keeping the system voltage stable to meet the demand growth, shall be done properly. Although it is said that 88kV is not standard voltage level in Zambia, 88kV existing and planning facilities are took into consideration in system analysis. And the necessary reinforcement in the base scenario of each simulation period is the same as existing one even 88kV system, which is the simplest method. The details should be considered in transmission system master plan.

(2) Simulation periods

Year 2010, 2015, 2020, and 2030

(3) Power demand

The simulation model uses the projection of annual peak demand that is supposed to be possibly the highest so that the tight supply-demand balance is assumed even without electrification projects. The peak demand up to 2013 is based on ZESCO's forecast. Peak demand beyond 2013, i.e. between 2014 and 2030, is projected by the Study Team, assuming that 3% p.a. growth rate for the last five years in ZESCO's projection (from 2008 to 2013) continues. The annual peak demand used for this analysis is summarized in Table 6-5 . Generation development plan, shown in Table 6-6, is also included in the base scenario.

Table 6-5 Projection of Peak Demand in Zambia

Year	2006	2010	2015	2020	2030
Peak demand [MW]	1,404	1,818	2,108	2,448	3,295
Average annual growth rate	–	6.7%	3.0%	3.0%	3.0%

Table 6-6 Generation Development Plan of ZESCO

Power Station	Unit No.	Capacity [MW]	Commissioning Year	Notes
Kafue Gorge	1,2	150 → 165	2007	Rehabilitation
Kafue Gorge	3,4	150 → 165	2006	Rehabilitation
Kafue Gorge	5,6	150 → 165	2008	Rehabilitation
Kariba North	1,2	150 → 180	2006	Rehabilitation
Kariba North	3,4	150 → 180	2009	Rehabilitation
Itezhi-Tezhi	1	120	2009	New installation
Kariba North	5	360	2009	Extension
Kafue Gorge Lower	1	750	2011	New installation
Kalungwishi	1	220	2015	New installation
Lusiwasi	1,2,3,4	3 → 15.5	2015	Rehabilitation
Musonda Falls	1	5 → 7.5	2015	Rehabilitation
Chishimba Falls	1	6 → 9.6	2015	Rehabilitation
Lunzua	1	0.75 → 4.4	2015	Rehabilitation

Source: ZESCO

(4) Power trade with neighbouring countries through interconnection line

The following Table 6-7 is the assumption of power export/import through interconnection lines. These numbers are provided to the Study Team by ZESCO.

Table 6-7 Trading Power of Interconnection Line with Neighboring Countries

Country	Voltage	Substation in Zambia	Commissioning Year	Target Power Flow
D.R.Congo	220	Michelo	Existing (reinforced in 2008)	200MW inflow
D.R.Congo	330	Lumwana	2010	500MW inflow
Tanzania	330	Kasama	2009	200MW outflow
Zimbabwe	330	Kariba north	Existing	200MW outflow
Zimbabwe	330	Victoria Falls	2010	100MW outflow
Namibia	330 (220)	Katima Mulilo	2010 (2006)	200MW outflow
Malawi	330	Msoro	2030	100MW outflow

(5) Power system analysis software

PSS/E is employed for the study, which is also the software that ZESCO uses for system planning and analysis.

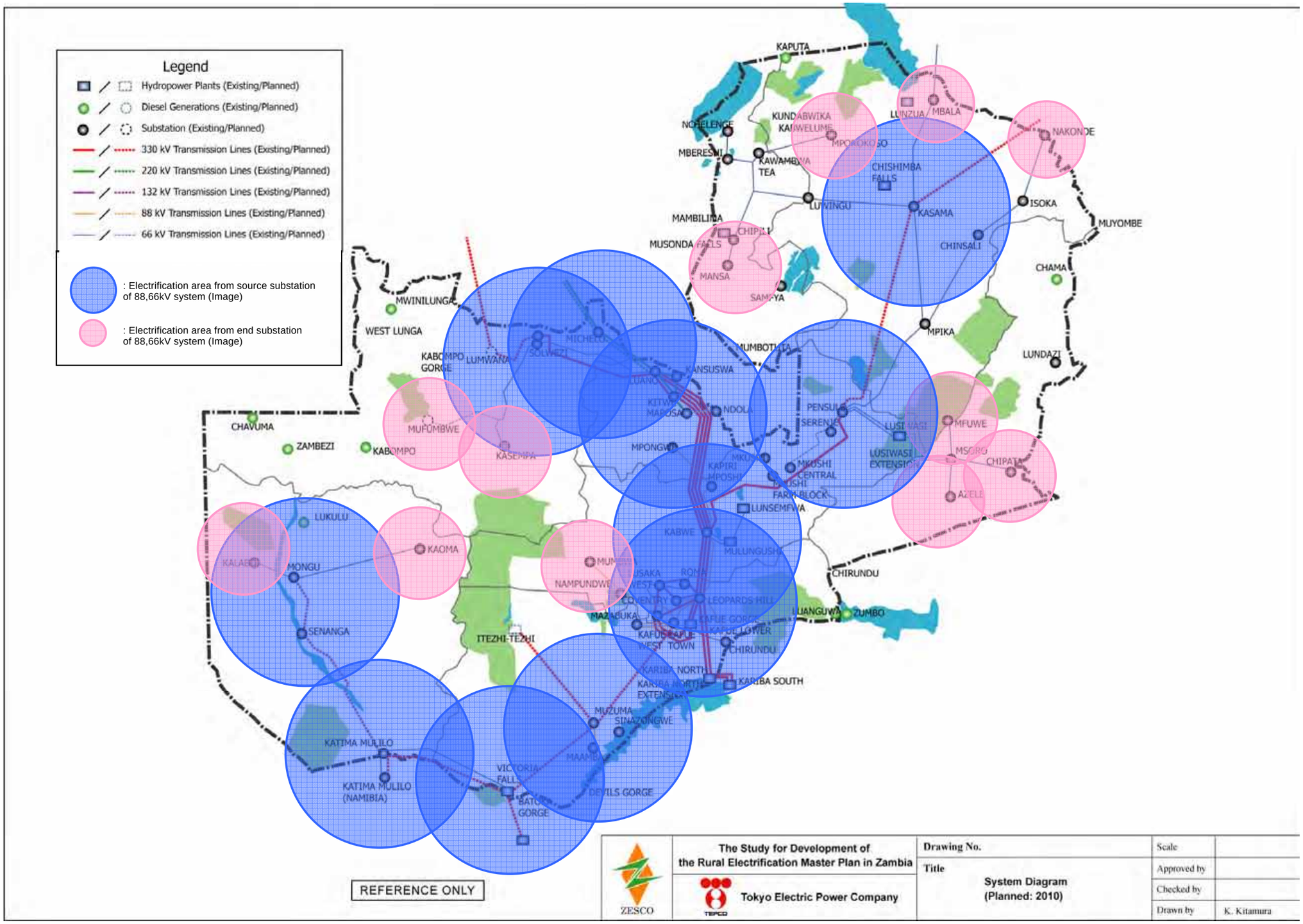


Figure 6-6 Image Diagram of Remaining Availability for Electrification Projects

6.4.2. Transmission System as of 2010

Transmission system diagram as of 2010 is shown in Figure 6-2 . The list of reinforcement of substations necessary to be done by 2010 is shown in Table 6-8 and that of transmission lines are shown in Table 6-9 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2010 are considered as explained in "(1) Assumptions of the Analysis". This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2010 is shown in Figure 6-7 Table 6-10 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-8 as image diagram.

Table 6-8 Additional Necessary Reinforcement of Substations by 2010

Substation	Reinforcement (Objective)
Lusaka West	Install one more unit of 330/132kV Transformer (Overload prevention)
Michelo	Install one more unit of 220/66kV Transformer (Overload prevention)
Kabwe	Install one more unit of 88/66kV Transformer (Overload prevention)

Table 6-9 Additional Necessary Reinforcement of Transmission Lines by 2010

Transmission Line	Reinforcement (Objective)
132kV Leopards Hill – Coventry (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
132kV Leopards Hill – Roma (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
88kV Leopards Hill – Waterworks (Leopards Hill 88kV system)	Install one more circuit (Overload prevention)
66kV Maposa - Dolahill (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Ndola - Dolahill (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Pensulo - Serenje (Pensulo 66kV system)	Install one more circuit (Overload prevention)

Table 6-10 Maximum Transmitting Capacity of each Substation as of 2010

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	16	65	81	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	58	60	118	Overload (Pensulo 330/66kV Tr)
Michelo 66kV	96	60	156	Overload (Michelo 220/66kV Tr)
Luano 66kV	245	40	285	Overload (66kV Michelo–Bancroft Line)
Kansuswa 66kV	177	45	222	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	229	25	254	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	248	50	298	Overload (Maposa 330/66kV Tr)
Kabwe 66kV	17	8	25	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	64	35	99	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	141	40	181	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	72	45	117	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	16	40	56	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	75	75	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	9	2	11	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	1	50 *	51	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	6	40 *	46	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	5	20	25	Overload (66kV Kasama-Mbala Line)
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	4	5	9	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	15	16	Voltage instability
Chipata 66kV	8	10	18	Voltage instability
Azele 66kV	2	15	17	Voltage instability
Mufumbwe 66kV	3	2	5	Voltage instability
Kasempa 66kV	4	1	5	Voltage instability
Mumbwa 88kV	0	25	25	Overload (88kV Nampundwe–Mumbwa Line)
Kaoma 66kV	3	10	13	Voltage instability
Kalabo 66kV	1	25 *	26	Overload (66kV Mongu–Kalabo Line)

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

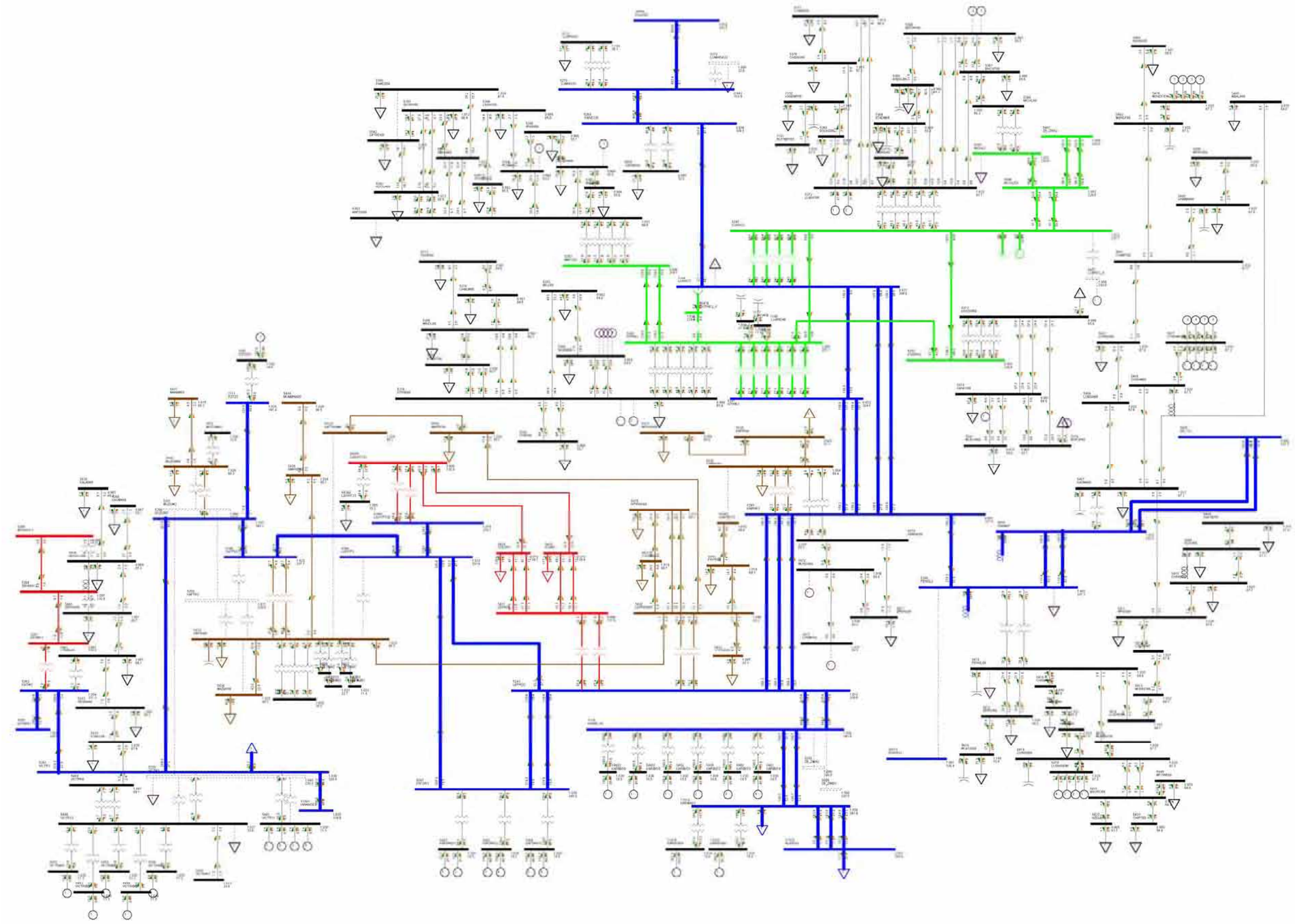


Figure 6-7 Power Flow Diagram of the Base Scenario as of 2010

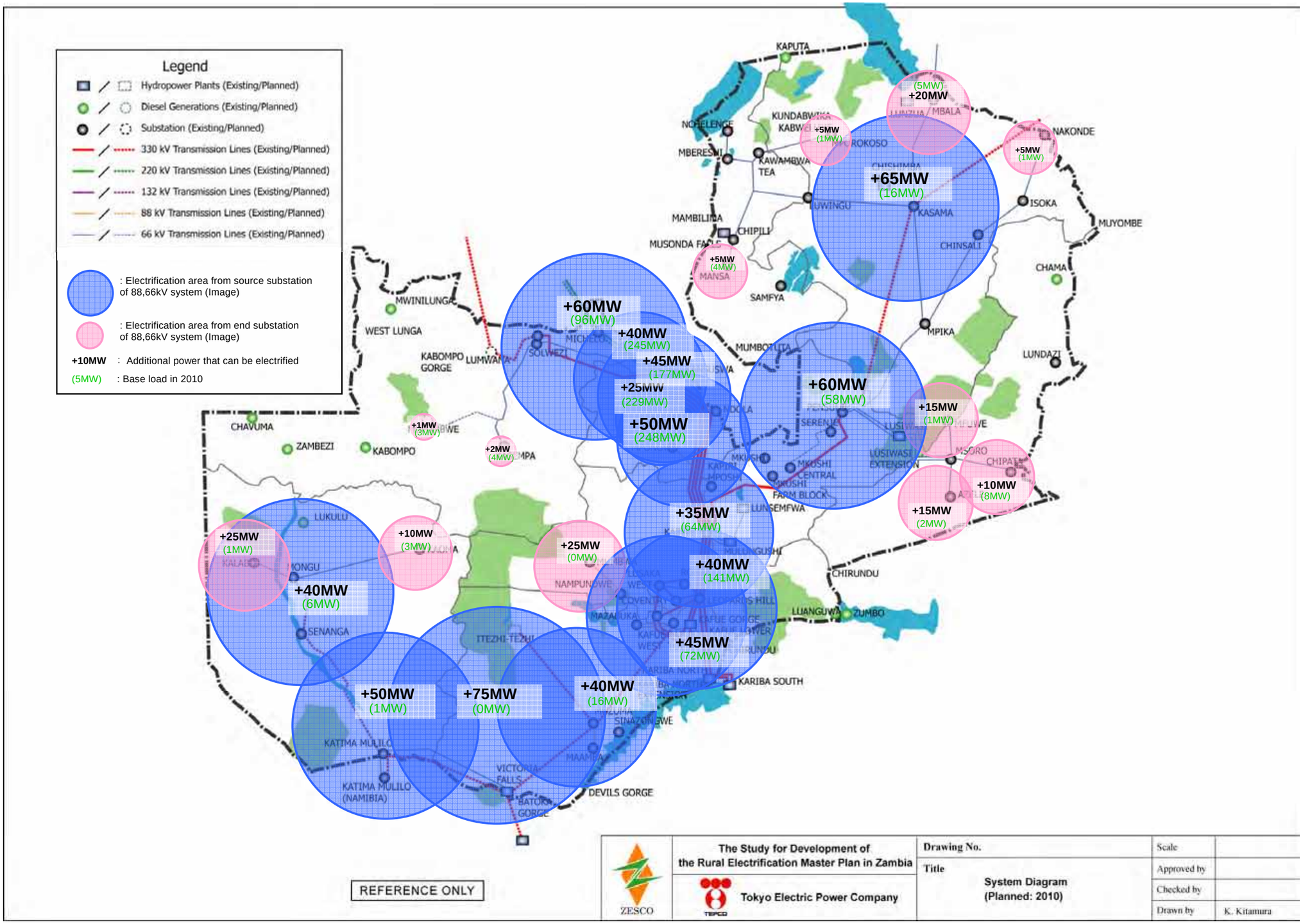


Figure 6-8 Image Diagram of Remaining Availability for Electrification Projects in 2010

6.4.3. Transmission System in 2015

Transmission system diagram in 2015 is shown in Figure 6-3 The list of reinforcement of substations necessary to be done by 2015 is shown in Table 6-11 and that of transmission lines are shown in Table 6-12 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2015 are considered as explained in "(1) Assumptions of the Analysis". This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2015 is shown in Figure 6-9 Table 6-13 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-10 as image diagram.

Table 6-11 Additional Necessary Reinforcement of Substations by 2015

Substation	Reinforcement (Objective)
Kitwe	Install one more unit of 220/66kV Transformer (Overload prevention)
Kansanshi	Install one more unit of 330/33kV Transformer (Overload prevention)
Luano	Install each one more unit of 330/33 & 220/66kV Transformers (Overload prevention)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)

Table 6-12 Additional Necessary Reinforcement of Transmission Lines by 2015

Transmission Line	Reinforcement (Objective)
66kV Maposa - Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Stadium – Kabundi (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV Michelo – Bancroft (Michelo 66kV system)	Install one more circuit (Overload prevention)

Table 6-13 Maximum Transmitting Capacity of each Substation in 2015

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	16	60	76	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	49	65	114	Overload (Pensulo 330/66kV Tr)
Michelo 66kV	109	30	139	Overload (Michelo 220/66kV Tr)
Luano 66kV	286	65	351	Overload (Luano 220/66kV Tr) [open BNCNT–BNCRF Line]
Kansuswa 66kV	206	35	241	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	308	30	338	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	414	60	474	Overload (Maposa 220/66kV Tr)
Kabwe 66kV	19	5	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	75	25	100	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	161	15	176	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	85	30	115	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	19	35	54	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	70	70	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	10	1	11	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	2	45 *	47	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	7	35 *	42	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	5	15	20	Voltage instability
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	4	5	9	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	15	16	Voltage instability
Chipata 66kV	9	10	19	Voltage instability
Azele 66kV	2	15	17	Voltage instability
Mufumbwe 66kV	3	0	3	Voltage instability
Kasempa 66kV	5	0	5	Voltage instability
Mumbwa 88kV	0	20	20	Overload (Kafue Town 330/88kV Tr)
Kaoma 66kV	3	5	8	Voltage instability
Kalabo 66kV	1	20 *	21	Voltage instability

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

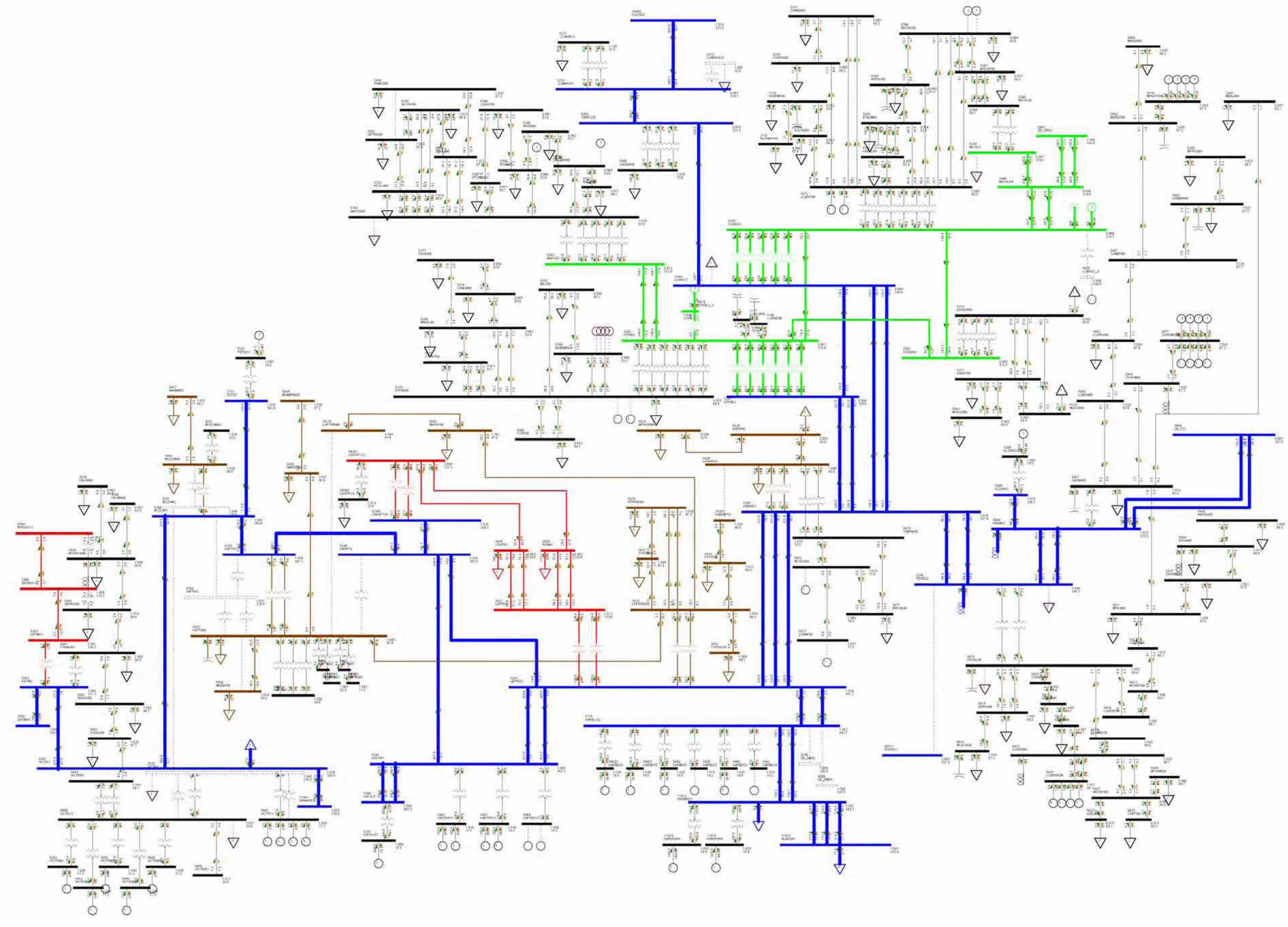


Figure 6-9 Power Flow Diagram of the Base Scenario in 2015

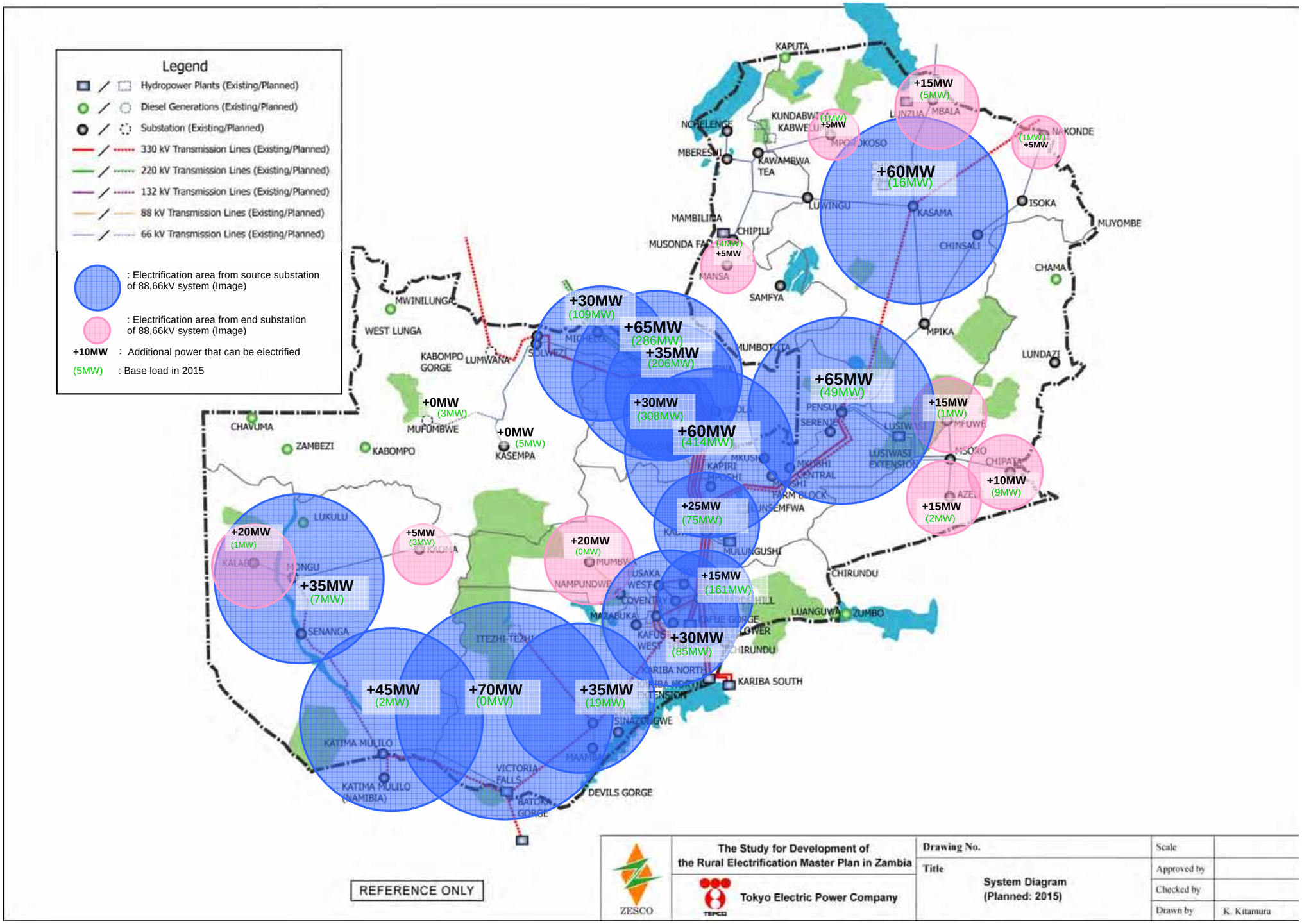


Figure 6-10 Image Diagram of Remaining Availability for Electrification Projects in 2015

6.4.4. Transmission system in 2020

Transmission system diagram in 2020 is shown in Figure 6-4 The list of reinforcement of substations necessary to be done by 2020 is shown in Table 6-14 and that of transmission lines are shown in Table 6-15 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2020 are considered as explained in "(1) Assumptions of the Analysis". This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2020 is shown in Figure 6-11 Table 6-16 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-12 as image diagram.

Table 6-14 Additional Necessary Reinforcement of Substations by 2020

Substation	Reinforcement (Objective)
Kansanshi	Install one more unit of 330/66kV transformer to connect between Solwezi 66kV system and Kansanshi 66kV system (Voltage instability prevention)
Leopards Hill	Install one more unit of 330/132kV Transformer (Overload prevention)
Leopards Hill	Install one more unit of 330/88kV Transformer (Overload prevention)
Kansuswa	Install one more unit of 330/66kV Transformer (Overload prevention)

Table 6-15 Additional Necessary Reinforcement of Transmission Lines by 2020

Transmission Line	Reinforcement (Objective)
66kV Kansanshi - Solwezi (Kansanshi 66kV system)	Connection of Kansanshi 66kV system and Solwezi 66kV system (Voltage instability prevention)
66kV Luano - Stadium (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV Serenje – Mkushi (Pensulo 66kV system)	Install one more circuit (Voltage instability prevention)
66kV Kafue Town – Mazabuka (Kafue Town 88kV system)	Install one more circuit (Overload prevention)
66kV Kansuswa – Kankoyo (Kansuswa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)

Table 6-16 Maximum Transmitting Capacity of each Substation in 2020

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	21	55	76	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	50	75	125	Overload (Pensulo 330/66kV Tr)
Msoro 66kV **	4	50	54	Overload (Msoro 330/66kV Tr)
Michelo 66kV	122	15	137	Overload (Michelo 220/66kV Tr)
Luano 66kV	308	45	353	Overload (Luano 220/66kV Tr) [open BNCNT–BNCRF Line]
Kansuswa 66kV	238	65	303	Overload (Kanauswa 330/66kV Tr)
Kitwe 66kV	301	20	321	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	335	25	360	Overload (Maposa 220/66kV Tr)
Kansanshi 66kV **	25	35	60	Overload (Kansanshi 330/66kV Tr)
Kabwe 66kV	23	1	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	87	20	107	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	192	60	252	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	90	20	110	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	22	30	52	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	55	55	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	10	0	10	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	6	40 *	46	Overload (Katimamulilo 330/66kV Tr)
Mongu 66kV	15	30 *	45	Overload (Mongu 132/66kV Tr)
System end substations of 88kV and 66kV				
Mbala 66kV	6	15	21	Voltage instability
Mporokoso 66kV	1	5	6	Voltage instability
Mansa 66kV	5	5	10	Voltage instability
Nakonde 66kV	1	5	6	Voltage instability
Mfuwe 66kV	1	20	21	Overload (66kV Msoro–Mfuwe Line)
Chipata 66kV	11	10	21	Overload (66kV Msoro–Chipata Line)
Azele 66kV	2	20	22	Overload (66kV Msoro–Azele Line)
Mufumbwe 66kV	4	5	9	Voltage instability
Kasempa 66kV	5	10	15	Voltage instability
Mumbwa 88kV	0	15	15	Overload (Kafue Town 330/88kV Tr)
Kaoma 66kV	4	5	9	Voltage instability
Kalabo 66kV	1	15 *	16	Voltage instability
Kabompo 66kV	1	5	6	Voltage instability
Chavuma 66kV	1	5	6	Voltage instability

Note: * These are calculated based on the assumption that Victoria Falls 33/66kV transformers, which are apt to be overloaded as a result of loop power flow balancing when the system load at 66kV level becomes high, shall be isolated.

** Newly installed substations

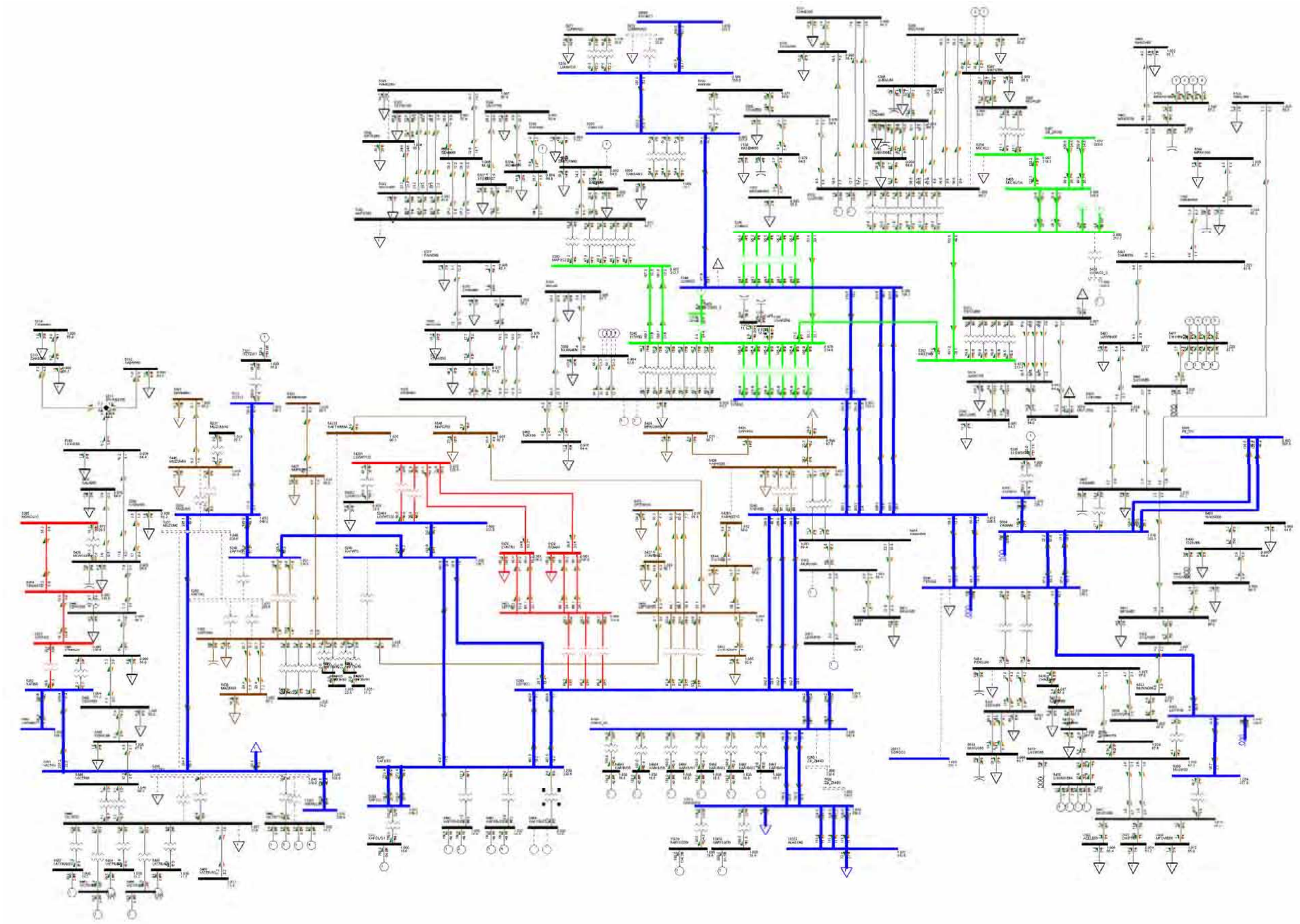


Figure 6-11 Power Flow Diagram of the Base Scenario in 2020

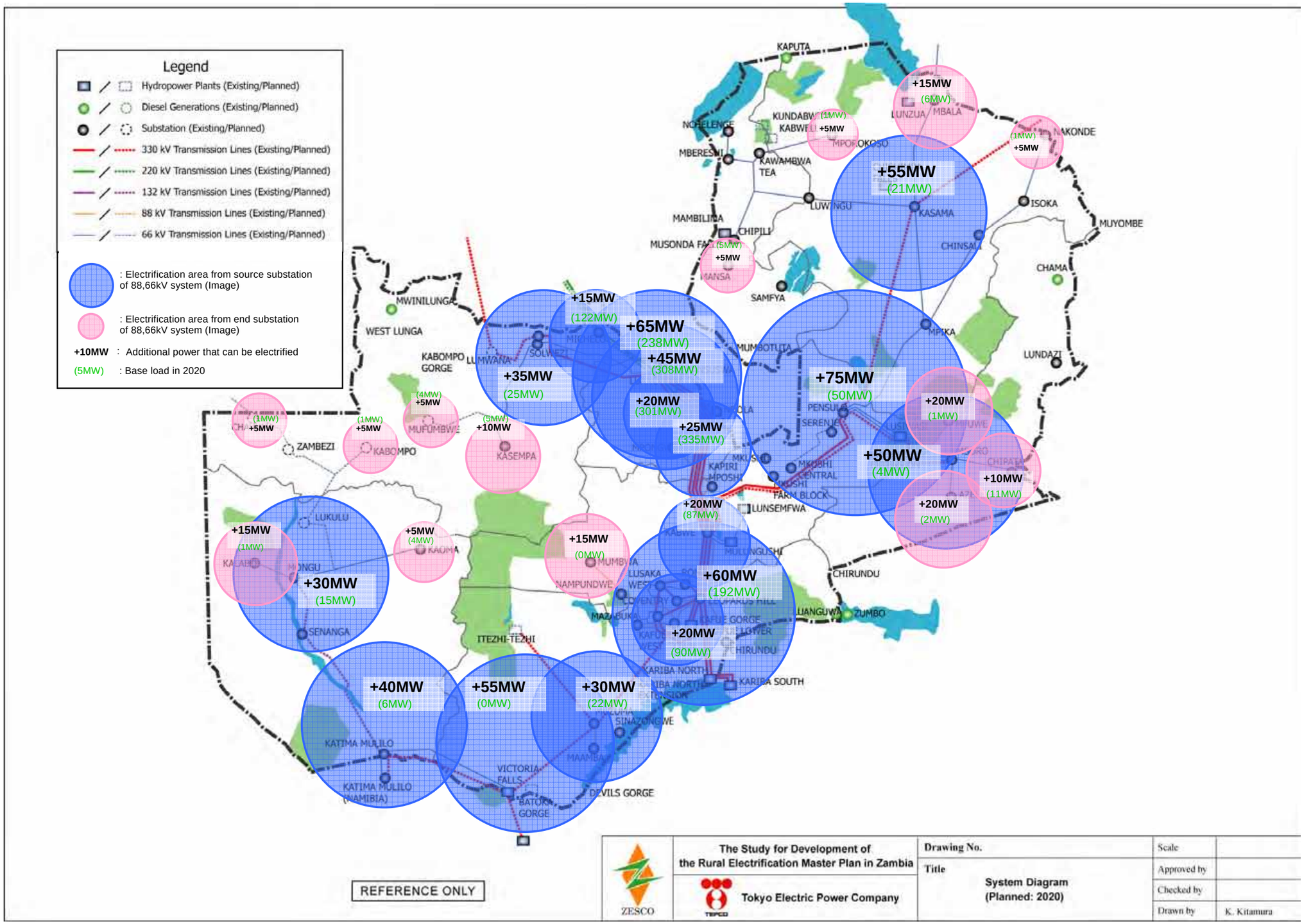


Figure 6-12 Image Diagram of Remaining Availability for Electrification Projects in 2020

6.4.5. Transmission System in 2030

Transmission system diagram in 2030 is shown in Figure 6-5 The list of reinforcement of substations necessary to be done by 2030 is shown in Table 6-17 and that of transmission lines are shown in Table 6-18 These reinforcements are considered in the base scenario in addition to the reinforcement projects already planned by ZESCO (refer to Table 6-4 The demand growth and power development plan up to 2030 are considered as explained in "(1) Assumptions of the Analysis". This simulation model assumes that the installation of capacitors is done properly to keep the system voltage stable.

Power flow diagram of the base scenario as of 2030 is shown in Figure 6-13 Table 6-19 shows the remaining availability that can be used for electrification projects, as well as the maximum capacity of each local substation in the base scenario, which is shown in Figure 6-14 as image diagram.

Table 6-17 Additional Necessary Reinforcement of Substations by 2030

Substation	Reinforcement (Objective)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)
Kitwe	Install three more units of 330/220kV Transformer (Overload prevention)
Kitwe	Install two more units of 220/66kV Transformer (Overload prevention)
Kabwe	Install one more unit of 330/88kV Transformer (Overload prevention)
Kabwe	Install one more unit of 88/66kV Transformer (Overload prevention)
Kansanshi	Install one more unit of 330/33kV Transformer (Overload prevention)
Luano	Install one more unit of 330/220kV Transformer (Overload prevention)
Luano	Install two more units of 220/66kV Transformer (Overload prevention)
Maposa	Install one more unit of 220/66kV Transformer (Overload prevention)
Michelo	Install one more unit of 220/66kV Transformer (Overload prevention)
Kansuswa	Install one more unit of 220/66kV Transformer (Overload prevention)
Leopards Hill	Install one more unit of 330/132kV Transformer (Overload prevention)

Table 6-18 Additional Necessary Reinforcement of Transmission Lines by 2030

Transmission line	Reinforcement
66kV Maposa – Roan (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Irwin – Maclaren (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Ndola (Maposa 66kV system)	Install two more circuits (Overload prevention)
66kV Skyways – Depot Road (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Dolahll – Pamodzi (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Maposa – Balub (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Skyways – Ndola (Maposa 66kV system)	Install one more circuit (Overload prevention)
66kV Kitwe – Scaw Mill (Kitwe 66kV system)	Install one more circuit (Overload prevention)
66kV Mindolo – Chibuluma (Kitwe 66kV system)	Install one more circuit (Overload prevention)
132kV Lusaka West – Coventry (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
132kV Leopards Hill – Roma (Leopards Hill 132kV system)	Install one more circuit (Overload prevention)
88kV Leopards Hill – Waterworks (Leopards Hill 88kV system)	Install one more circuit (Overload prevention)
66kV Luano – Kabundi (Luano 66kV system)	Install one more circuit (Overload prevention)
66kV BNCNT – BNCRF (Michelo 66kV system)	Install one more circuit (Overload prevention)
66kV Luano – Stadium (Luano Michelo 66kV system)	Install one more circuit (Overload prevention)
66kV Kansuswa – Kankoyo (Kansuswa 66kV system)	Install one more circuit (Overload prevention)
66kV Kankoyo – Mufulira (Kansuswa 66kV system)	Install one more circuit (Overload prevention)

Table 6-19 Maximum Transmitting Capacity of each Substation in 2030

Substation	Peak Demand [MW]	Remaining Availability [MW]	Maximum Capacity [MW]	Bottlenecks
System source substations of 88kV and 66kV				
Kasama 66kV	33	45	78	Overload (Kasama 330/66kV Tr)
Pensulo 66kV	67	60	127	Overload (Pensulo 330/66kV Tr)
Msoro 66kV **	8	55	63	Overload (Msoro 330/66kV Tr)
Michelo 66kV	174	30	204	Overload (Michelo 220/66kV Tr)
Luano 66kV	404	55	459	Overload (Luano 220/66kV Tr)
Kansuswa 66kV	320	65	385	Overload (Kansuswa 330/66kV Tr)
Kitwe 66kV	399	45	444	Overload (Kitwe 220/66kV Tr)
Maposa 66kV	449	60	509	Overload (Maposa 220/66kV Tr)
Kansanshi 66kV **	32	20	52	Overload (Kansanshi 330/66kV Tr)
Kabwe 66kV	20	4	24	Overload (Kabwe 88/66kV Tr)
Kabwe 88kV	119	35	154	Overload (Kabwe 330/88kV Tr)
Leopards Hill 88kV	243	20	263	Overload (Leopards Hill 330/88kV Tr)
Kafue Town 88kV	135	35	170	Overload (Kafue Town 330/88kV Tr)
Muzuma 88kV	29	20	49	Overload (Muzuma 330/88kV Tr)
Victoria Falls 33kV	0	40	40	Overload (330kV Muzuma–Victoria Falls Line)
Victoria Falls 66kV	12	4	16	Overload (Victoria Falls 33/66kV Tr)
Katimamulilo 66kV	8	35	43	Overload (330kV Muzuma–Victoria Falls Line)
Mongu 66kV	15	25	40	Overload (330kV Muzuma–Victoria Falls Line)
System end substations of 88kV and 66kV				
Mbala 66kV	8	15	23	Voltage instability
Mporokoso 66kV	1	3	4	Voltage instability
Mansa 66kV	6	5	11	Voltage instability
Nakonde 66kV	2	4	6	Voltage instability
Mfuwe 66kV	2	20	22	Overload (66kV Msoro–Mfuwe Line)
Chipata 66kV	15	5	20	Overload (66kV Msoro–Chipata Line)
Azele 66kV	3	20	23	Overload (66kV Msoro–Azele Line)
Mufumbwe 66kV	5	4	9	Voltage instability
Kasempa 66kV	7	5	12	Voltage instability
Mwinilunga 66kV **	0	15	15	Voltage instability
Mumbwa 88kV	0	25	25	Overload (Kafue Town 330/88kV Tr)
Chirundu 66kV **	0	70	70	Overload (132kV Leopards Hill–Chirundu Line)
Kaoma 66kV	5	5	10	Voltage instability
Kalabo 66kV	1	15	16	Voltage instability
Kabompo 66kV	1	5	6	Voltage instability
Chavuma 66kV	2	3	5	Voltage instability

Note: ** Newly installed substations

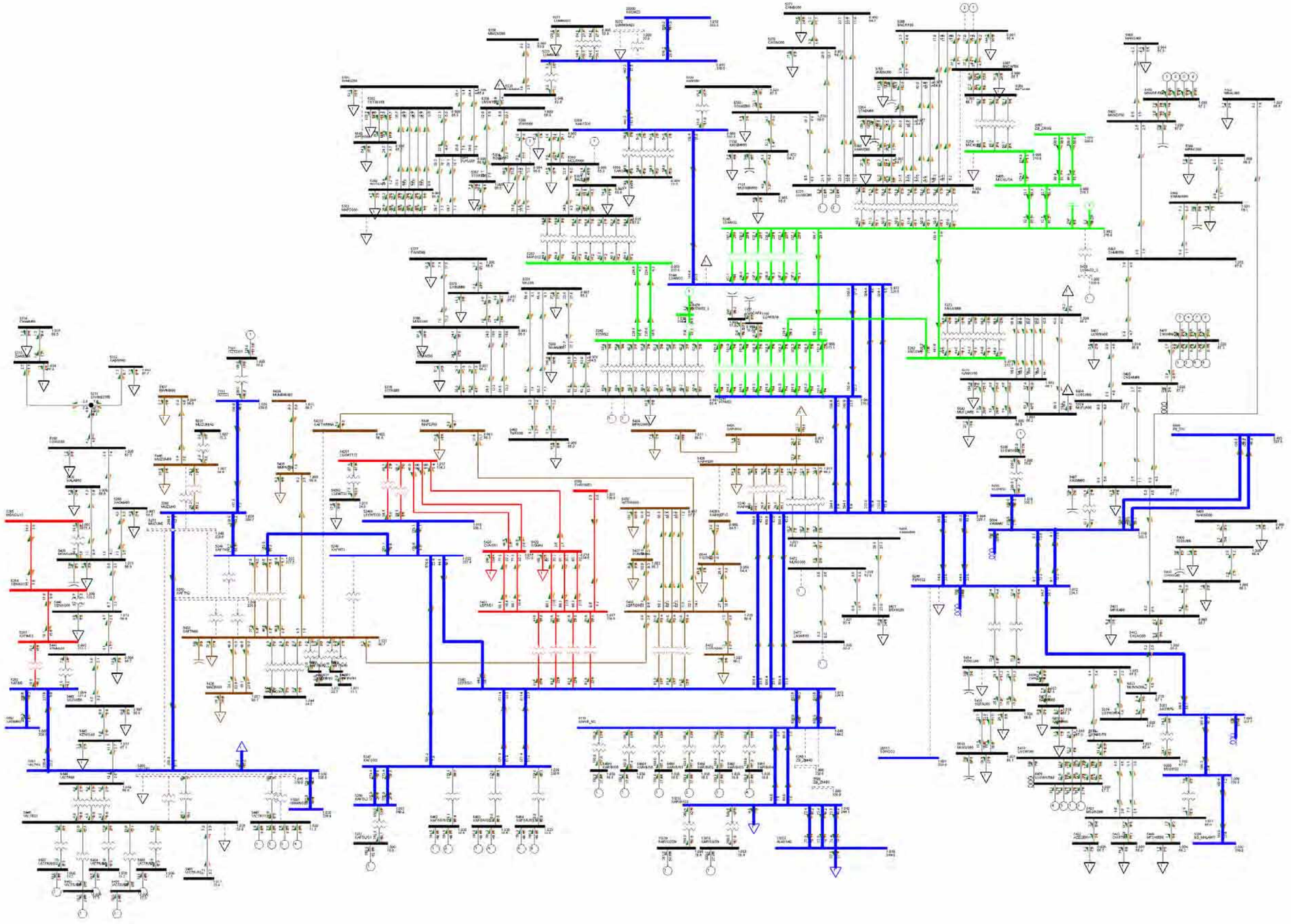


Figure 6-13 Power Flow Diagram of the Base Scenario in 2030

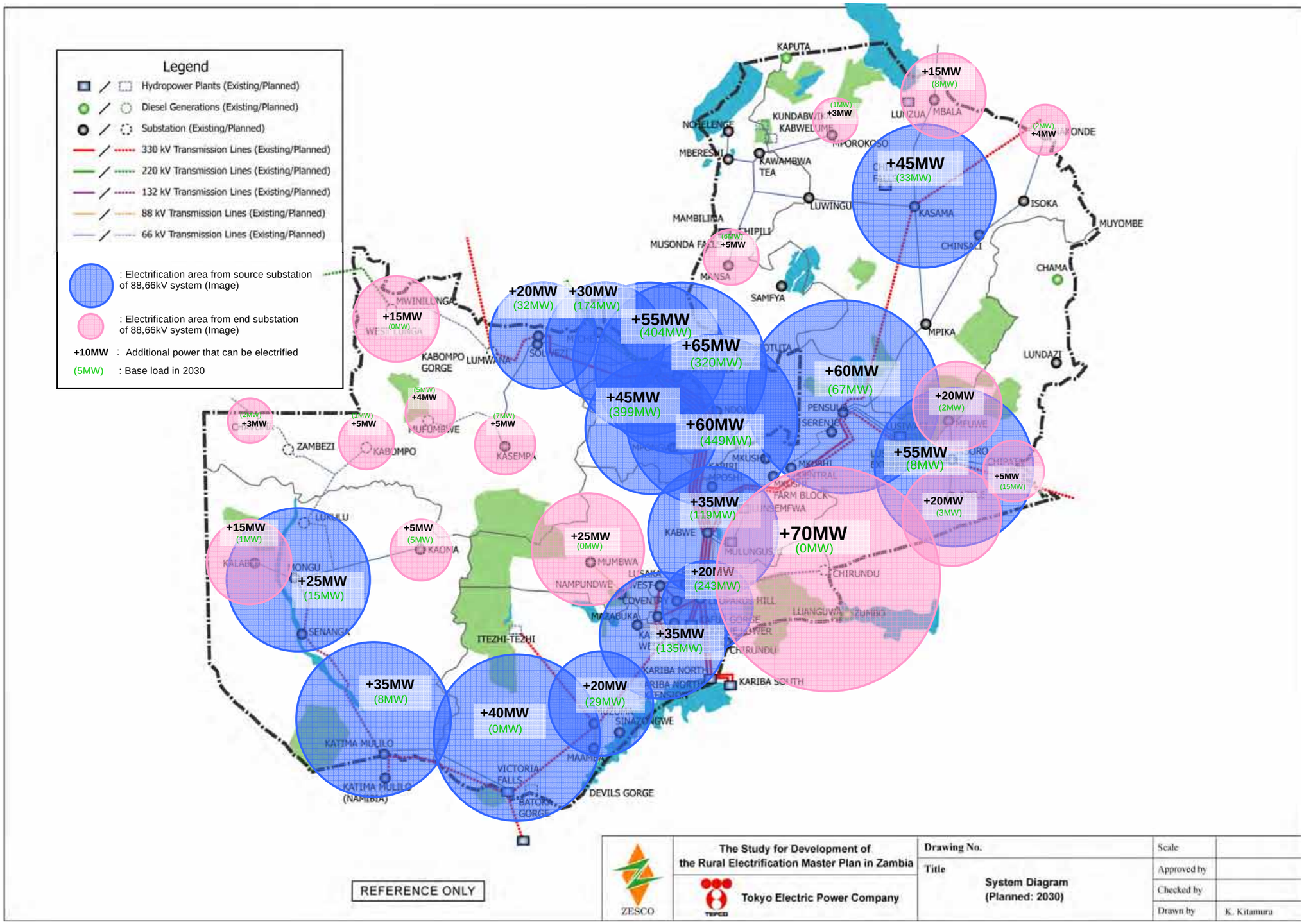


Figure 6-14 Image Diagram of Remaining Availability for Electrification Projects asof 2030

6.4.6. Observations on the Simulation Results

In this section, the capacity of source substations and end substations in local network system at 88kV and 66kV, which are the main source of local power supply, was analysed. The capacity of substations that are placed between a source substation and an end substation is estimated to come in-between. The system's remaining availability for electrification projects shall be referred to as basic data when considering electrification projects through grid extension.

The following features regarding Zambia's transmission system are observed through the analysis.

- Each source substation has in general around 20-70MW availability and each end substation has in general around 0-20MW availability for electrification projects.
- The capacity of source substations in the local network system is in general determined by the restriction deriving from equipment capacity whereas the capacity of end substations is determined by the restriction deriving voltage instability.
- Since the network system in the western region is underdeveloped and the transmission lines have a long span, the network system is vulnerable to voltage instability and its remaining availability is small. Implementation of large-scale electrification projects is not feasible without system reinforcement.
- Since the network system in the northern region is also underdeveloped and the transmission lines have a long, implementation of large-scale electrification projects is not feasible without system reinforcement.
- In general, the remaining availability for electrification projects becomes smaller as the power demand grows. However, this availability can be expanded with the implementation of the reinforcement of network system and the development of power stations. This possibility needs to be analysed in detail for each individual case.

Concerning the simulation model, the following issues should be paid attention to as important notice.

- Since the simulation was executed on each individual case, the results may not be the same as what would happen in reality, where many electrification projects are implemented in parallel. The simulation with comprehensive analysis should be carried out after the list of candidate sites for electrification is finalized and the schedule of implementing electrification projects is determined.
- If a candidate site for electrification is far from the existing grid, the availability of substations may be smaller than this simulation results due to the restriction of voltage instability. This effect should be analysed in detail after the list of candidate sites is finalized.

Chapter 7

Distribution System Planning

Chapter 7. Distribution System Planning

7.1. Current Status of Distribution System

The distribution system in Zambia comprises the "interconnected system", i.e. the main distribution network, which is connected to the national grid, and the "isolated system", which is fed from stand-alone power stations (diesel or hydro) and is often called "off-grid" system. All the distribution system is owned and operated by ZESCO with some exceptions[23]. The distribution network reaches all of the 9 Provincial Centres and most of the 72 District Centres (BOMAs) countrywide, but the network is still too underdeveloped to cover the villages countrywide.

Distribution network is operated at 33kV and 11kV middle voltages and 400V/230 V low voltage. Total length of 33kV and 11kV lines is 2,245 km and 7,000 km respectively, and detailed facility data (type of support, type of conductor, location of facilities, etc) and operation data is not maintained. In addition, the statistics of 400V/230V lines are not available. Almost all the distribution lines are overhead wires, whereas underground cables are installed in some parts of town centres.

ZESCO has segmented the whole country in four (4) areas called "Divisions", and Division Managers are responsible for the operation and maintenance of distribution lines in their respective area. Under the Divisions, there are 13 Regional Offices whose coverage area roughly corresponds to each Province[24], and under Regional Offices are District Offices that are in charge of forefront operation and maintenance activities.

Table 7-1 ZESCO's Operation and Maintenance Divisions

	Headquarters	Covering Area
Lusaka Division	Lusaka	• Lusaka province (except Luangwa District) • Mumbwa District of Central Province • Siavonga District of Southern Province
Copperbelt Division	Kitwe	• Luanshya, Kitwe, Kalulushi, Mufulira, Chingola & Chiliabombwe Districts of Copperbelt Province
Northern Division	Ndola	• Northern, Luapula & North-Western Provinces • Ndola, Lufwanyama, Masaiti & Mpongwe Districts[25] of Copperbelt Province
Southern Division	Lusaka	• Southern Province (except Siavonga District) • Central Province (except Mumbwa District) • Western & Eastern Provinces

ZESCO has developed distribution network maps, some electronically and some manually, but since not all of them are complete and frequently updated, the JICA Study Team has prepared a map that

[23] Small isolated power network with mini-hydro in remote area owned by private entities (refer to Section 3.3.2).

[24] There are 4 Regional Offices in Lusaka Province and Copperbelt Province has Regional Offices in Kitwe and Ndola, which turns out to be "13 Regional Offices in 9 Provinces". For technical reasons, the covering area of each Regional Office does not necessarily match the area of a Province (some Districts, where distribution lines are not extended from its Provincial centre but from another Province, are administrated by the Regional Office of that Province).

[25] Lufwanyama, Masaiti & Mpongwe Districts used be a part of Ndola District ("Ndola-rural"). Some ZESCO documents still define "Ndola District" as including these four Districts.

covers the complete distribution network countrywide at 11kV and above, based on the information collected from ZESCO's regional offices. GIS Software is used to compile the collected information electronically and to generate a map. The latest output of this GIS map is shown in Figure 13-2.

7.2. Data Collection

The following sections discuss the data that have been collected so far from DoE, REA and ZESCO.

7.2.1. Specification of distribution system

Design standard of transmission and distribution system were developed in 1997, and consists of following items.

- General Parameters
- Monitoring Trip Circuits
- Plant Control
- Multicore Cables in Substations
- System Earthing
- Instruments
- Control, & Relay Panel Wiring & Layout
- System Phasing & Switchgear Phase Marking
- Substation SLDs and Protection Schemes
- Design Philosophy
- Township Electrification

Allowable voltage and conductor sizes for overhead lines prescribed in this standard are as follows.

Table 7-2 ZESCO's Standard on Overhead Distribution Lines

Allowable voltage:	Between -5% to +5%
Conductor size:	ACSR 100mm^2, 200mm^2 and 300mm^2

7.2.2. Unit Cost of Equipment

The list of unit equipment cost provided by ZESCO was the one as of 2000 or 2003. For this Study, the Study Team shall adjust the costs taking into account the price escalation. The unit cost after adjustment is shown in Table 7-3.

Table 7-3 Unit Cost of Equipment

	Item	Unit	Unit Cost
Transmission Line	66 kV Transmission Line	US$/km	40,000
Distribution Line	33 kV Distribution Line (including pole and accessories)	US$/km	36,000
	33/0.4kV Transformer on the pole (100kVA)	US$/Unit	13,700
66/33kV Substation	New substation (2.5MVA)	US$/Unit	600,000
	New substation (5MVA)	US$/Unit	800,000
	New substation (10MVA)	US$/Unit	1,000,000
	New substation (15MVA)	US$/Unit	1,300,000
	33 kV bay	US$/Unit	99,300

7.2.3. Current Distribution Lines Extension Planning

The list of rural electrification projects to be executed in 2006 is shown in Table 3-2, which is publicized by Rural Electrification Authority (REA). All these projects, except for two micro-hydro projects in North-Western Province, deal with either distribution network extension or isolated network with diesel power plant, and are contracted ZESCO. The detailed scope of works of these projects is shown in Table 7-4.

Table 7-4 Rural Electrification Projects slated for 2006 and their Scope of Works

	Project	Scope of Works
Central Province	Mungule's Area-Mungule Clinic and Court and Mutakwa School, Chibombo (Phase I)	● Constructing 13km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 100kVA, 11/0.4kV pole mounted transformers substations. ● Installing 1 X 50kVA, 11/0.4kV pole mounted transformers substations. ● Constructing 1,630m of 50mm^2 ACSR medium voltage overhead line. ● Providing 23 x standard single phase overhead service connections as follows: a) One (1) for Chieftainess Mungule's palace main house b) Three (3) Chieftainess Mungule's palace, guest & families' houses. c) One (1) Chieftainess Mungule's Palace Courthouse. d) One (1) Chieftainess Mungule's Retainer house. e) One (1) for Mungule's court. f) Four (4) for Mungule's courthouse. g) One (1) for Mungule's clinic block. h) Six (6) for Mungule's staff houses. i) Five (5) for Mutakwa school staff houses. ● Providing 3 x standard single-phase underground service connections as follows. a) One (1) for Chieftainess Mungule's palace borehole b) One (1) for Mungule Clinic borehole c) One (1) for Mutakwa School classroom blocks. ● Carry out internal wiring of Chieftainess Mungule's Palace, Mutakwa School and staff houses, Mungule clinic and staff houses and Mungule court and staff houses.
	Mutombe Basic School, Mumbwa	● Constructing 5km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 50kVA, 11/0.4kV pole mounted transformers substations. ● Constructing 300m of 50mm^2 ACSR medium voltage overhead line. ● Providing 8 x standard single-phase overhead service connections to staff houses. ● Providing 2 x standard three phase underground service connections to the classroom block and to the school borehole.
	Nambala High School, Mumbwa	● Constructing 15km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 100kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 800m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 16 X standard single-phase overhead service connections to staff houses for the school and rural health centre. ● Providing 2 X standard three phase underground service connections for the school and rural health centre.
	Serenje's Area-Muzamene Basic School, Serenje	● Tee-off through 20m of 66kV overhead line. ● Establishing a 100kVA, 66/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 70mm^2 4core PVC medium voltage cable. ● Constructing 500m of medium voltage overhead line. ● Providing 1 x three-phase service connection to Chief Serenje's palace. ● Carrying out internal wiring of Chief Serenje's palace.
Copperbelt Province	Lubendo Basic School, Masaiti	● Constructing 4km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying & connecting 30m of 16mm^2 4core PVC medium voltage cable. ● Providing 1 X standard three-phase underground service connection to Lubendo School. ● Providing 4 X standard single-phase overhead service connections to Lubendo school staff houses.
	Mushili School, Masaiti	● Constructing 8.1km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer. ● Providing eight standard single-phase overhead service connections.

	Kabushi Township, Ndola (Phase I)	● Reinforcing existing feeder by constructing 6km of 100mm^2 ACSR 11kV overhead line from Mushili substation. ● Upgrading existing 1,110m of 25mm^2 ACSR 11kV overhead line to 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Upgrading existing 2 x 50kVA, 11/0.4kV and 3 X 100kVA to 200kVA, 11/0.4kV pole mounted transformer substations. ● Constructing 6.5km additional total route length of 50mm^2 ACSR three phase three-wire 11kV overhead line within the township. ● Installing 25 X 200kVA, 11/0.4kV pole mounted transformer substations. ● Constructing 14.5km of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Laying and connecting a total of 540m of 120mm^2 4-core PVC medium voltage cable. ● Providing 4500 X single-phase overhead services.
	Kankoyo/Chibolya, Mufulira	● Construction of 1.12km of 50mm^2 ACSR, 11kV overhead line. ● Installation of 7 X 200kVA, 11/0.4kV pole mounted transformer substations. ● Laying and connecting a total of 320m of 185mm^2 4-core PVC medium voltage cable. ● Construction of 7.6km of 100mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 820 X standard single-phase services.
Eastern Province	Mphamba Basic School, Lundazi	● Construction of 1.2km of 50mm^2 ACSR11kV overhead line. ● Installing a 50kVA, 11/0.4kV transformer. ● Constructing 600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Provision of 12 X single-phase overhead services. ● Laying and connecting a total of 320m of 185mm^2 4-core PVC medium voltage cable.
	Mtenguleni Areas-Katinta Basic School, Chipungu Rural Health Centre and Chankanga Basic School, Chipata	● Constructing 8km of 100mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing three sets of 11kV drop out fuses at the tee offs. ● Installing 2 X 100kVA, 11/0.4kV pole mounted transformers. ● Laying and connecting 120m of 70mm^2 4-core PVC medium voltage cable from the pole mounted transformers to the medium voltage lines (2 x 30m per transformer) ● Constructing a total of 2050m of 100mm^2 ACSR three phase four-wire MV overhead lines. ● Providing 9 X standard single-phase overhead services as follows: 01 to the main arena, 01 school block, 01 VCT building, 04 school staff houses and 02 Chief's structures.
	Ndake Area – Ndake Basic School, Ndake Court House and Ndake Rural Health Centre, Nyimba	● Constructing 7.4km of 100mm^2 ACSR three-phase, three wire, 11kV overhead line. ● Installing 100kVA, 11/0.4kV pole mounted transformer. ● Laying and connecting 30m of 70mm^2 4core PVC medium voltage cable. ● Constructing 1220m of 100mm^2 ACSR three-phase four-wire medium voltage overhead line. ● Providing 2 x standard underground services up to 15kVA to the palace and the school. ● Providing 13 x standard single-phase overhead services up to 15kVA to eleven (11) teachers' houses, court building and court clerk's house.
	Lumezi, Lundazi	● Survey and pole peg of 35km, 33kV overhead line wayleave. ● Bush clear 35km of 33kV overhead line wayleave. ● Construct 35km of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Install 3 X sets 33kV drop out fuses. ● Lay and terminate 2 X 30m of 95mm^2 3 core XLPE 33kV copper cables ● Install 2 X 500kVA, 33/0.4kV ground mounted transformers. ● Lay and terminate 2 X 40m of 185mm^2 4Core PVC medium voltage cable. ● Install 1 X 6Way, 1200A feeder Pillar complete with earthing. ● Install 1 X 1500A kWh metering.
Luapula Province	Lukwesa High School, Mwense	● Constructing 700m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. ● Constructing 450m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 10 X standard single-phase overhead service connections to staff houses. ● Providing 1 X standard three-phase underground service connections to classroom block.
	Bakashiwa Home Care, Kawambwa	● Constructing 1.7km of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 x 25kVA, 33/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 16mmsq 4-core PVC medium voltage cable. ● Providing 1 X standard single-phase underground service connection.
	Schools in Samfya (Nsengaila Basic School)	● Constructing 50m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 6 X standard single-phase overhead service connections.

	(Nshungu Basic School)	● Constructing 400m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. ● Constructing 600m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 5 X standard single-phase overhead service connections.
	(Mashitolo Basic School)	● Constructing 200m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer. ● Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 4 X standard single-phase overhead service connections.
	(Mambilima Mwange Basic School)	● Constructing 600m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer substation. ● Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 5 x standard single-phase overhead service connections. ● Constructing 200m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformer. ● Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 4 X standard single-phase overhead service connections.
	Schools in Kawambwa (Lubansa Basic School)	● Constructing 400m of 50mm^2 ACSR three phase three-wire 33kV overhead lines. ● Installing 1 X 25kVA, 33/0.4kV pole mounted transformers substations. ● Constructing 430m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Constructing 100m of 50mm^2 single-phase two-wire low voltage overhead line. ● Providing 5 x standard single-phase overhead service connections. ● Providing 5 x ready boards.
	(Kalasa Basic School)	● Constructing 400m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Constructing 150m of 50mm^2 single-phase two-wire low voltage overhead line. ● Providing 8 x standard single-phase overhead service connections.
	Chabilikila Middle Basic School, Nchelenge	● Constructing 100m of 50mm^2 ACSR three-phase three wire, 33kV overhead line. ● Installing 50kVA, 33/0.4kV pole mounted transformer. ● Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. ● Constructing 400m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing 2 x standard single-phase overhead services up to the school.
Lusaka Province	Palabana	● Reinforcement of 24km of 50mm^2 ACSR three phase three-wire 11kV line has been done in Palabana area. ● Material procurement is in progress for the remaining works.
	Mupelekesi Area-Schools and Rural Health Centres	● Constructing 48km of 50mm^2 ACSR 3phase 3wire 11kV overhead line. ● Installing 5 X 50kVA, 11/0.4kV pole mounted transformer substations. ● Constructing 1380m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Providing a total of 5 X standard three phase overhead services to Mulola, Mpango, Mwapula and Mupelekesi classroom blocks and Mpango clinic respectively. ● Providing a total of 24 x standard single-phase overhead services to Mulola, Mpango, Mwapula and Mupelekesi schools and Mpango clinic staff houses.
	Luangwa (Phase I)	● Reinforcement and stabilization of power supply in Luangwa.
North- Western Province	Schools in Solwezi (Kimiteto Primary School)	● Constructing 600m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Constructing 950m of 50mm^{2}2 ACSR three phase four-wire medium voltage overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. ● Providing 11 X standard single-phase overhead services. ● Providing 1 X standard three phase overhead service. ● Carrying out internal wiring for Kimiteto Primary School and eleven (11) staff houses.
	(Rodwell Mwepu Primary School)	● Constructing 800m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 3 X standard single-phase overhead services. ● Providing 1 X standard three phase underground service. ● Carrying out internal wiring for Rodwell Mwepu Primary School and three (3) staff houses.
	(Kisalala Basic School)	● Constructing 80m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Constructing 1150m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 60m of 35mm^2 4 core PVC medium voltage cable ● Providing 6 X standard single-phase overhead services. ● Providing 1 X standard three phase overhead service. ● Carrying out internal wiring for Kisalala School & six (6) staff houses.

	(Tumvwana'nai Basic School)	● Providing 1 standard single-phase overhead service. ● Carrying out internal wiring for Tumvwana'nai Basic School.
	(Kapijimpanga Basic School)	● Constructing 600m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Constructing 500m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Installing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. ● Providing 9 X standard single-phase overhead services. ● Providing 1 X standard three phase overhead service. ● Carrying out internal wiring for Kapijimpanga Basic School and nine (9) staff houses.
	(Kaimbwe School, Kasempa)	● Constructing 12km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 9 X single-phase overhead standard service connections. ● Providing 1 X three phase overhead standard service connection.
Northern Province	Chikwanda Basic School, Court House and Rural Health Centre, Mpika	● Constructing 100m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 350m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 2 X single-phase overhead standard service connections to Chikwanda courthouse and Rural Health Centre. ● Providing 2 X three phase underground standard service connection to Chikwanda's palace and Chikwanda Basic School. ● Carrying out internal wiring of the chief's palace.
	Luwingu High School Cooks Compound, Luwingu	● Establishing 1 X 100kVA, 11/0.4kV pole mounted transformer substation. ● Construction of 950m of 50mm^2 ACSR medium voltage overhead line. ● Providing 45 X single-phase service connections.
	Saili Basic School, Luwingu	● Construction of 600m of 50mm^2 ACSR 11kV overhead line. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Construction of 500m of 50mm^2 ACSR medium voltage overhead line. ● Providing 6 X single-phase service connections.
	Connection of Kaputa District to the Grid (Phase I)	● Construction of 125km of 100mm^2 ACSR three phase wire 33kV overhead line from Mununga to Kaputa. ● Establishment of a 2.5MVA, 33/11kV substation at Kaputa and connecting to the existing 11kV network.
	Waitwika's Area, Nakonde	● Constructing 8km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 6 X single-phase overhead standard service connections to Chieftainess Waitwika's palace. ● Providing 1 X three phase underground standard service connection to Chieftainess Waitwika's palace. ● Carrying out internal wiring of six structures at chief Waitwika's palace.
	Mpumba Basic School And Court House, Mpika	● Tee-off through 1.8km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 700m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 7 X single-phase overhead standard service connections to Chief Mpumba, Mpumba Basic School and courthouse. ● Carrying out internal wiring of six structures at Chief Mpumba's palace.
	Mulilansolo, Chinsali (Phase I)	● Construction of 45km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 500kVA, 11/0.4kV ground mounted transformer substation. ● Construction of 1600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 10 X single-phase service connections. ● Providing 1 X single-phase service connection.
	Chitimukulu Rural Health Centre, Police, Kapolyo Basic and Kanyanta Basic Schools, Kasama	● Constructing 11.4km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 400m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Laying and connecting 60m of 35mm^2 4-core PVC medium voltage cable. ● Providing 3 X single-phase overhead service connections to the Chiefs Chitimukulu's palace. ● Providing 2 X single-phase overhead service connections to clinic staff houses. ● Providing 1 X three phase overhead service connection to the Clinic. ● Carrying out internal wiring for Chief Chitimukulu's palace.

	Kafwimbi Basic School and Rural Health Centre, Isoka	● Constructing 15km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Laying and connecting 30m of 35mm^2 4core PVC medium voltage cable. ● Providing 6 X single-phase overhead service connections to Chief Kafwimbi's Palace, Basic school and Rural Health Centre. ● Providing 2 X three phase overhead service connections to the Clinic and school. ● Carrying out internal wiring of six structures at the Chief's palace.
Southern Province	Sianjalika Area– School and Rural Health Centre, Mazabuka	● Construct 4.3km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Install 1X 25kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 16m of 35mm^2 4core PVC medium voltage line. ● Providing 3 X three phase service connections to Chief Sianjalika's Palace, school and Rural Health Centre.
	Sikalongo Mission, Choma	● Construct 21km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Install 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Install 1 X 200kVA, 11/0.4kV pole mounted transformer substation. ● Construct 2450m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Lay and connect 30m of 185mm^2 PVC Medium voltage cable ● Lay and connect 60m of 35mm^2 PVC Medium voltage cable. ● Providing 47 X service connections.
	Mwanachingwala –School and Rural Health Centre, Mazabuka	● Install 1 X 50kVA, 11/0.4kV pole mounted transformer substation. ● Laying and connecting 35m of 35mm^2 4Core PVC medium voltage line. ● Constructing 430m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 3 X single-phase service connections to Chief Mwanachingwala's palace. ● Providing 1 X three phase service connection to Chief Mwanachingwala's Palace.
	Gwembe Tonga	(Supply to Sianyolo's Area, School and Rural Health Centre – Siavonga) ● Providing 16 X single-phase standard services & 1 X three phase standard service. (Supply to Simamba's Area and Rural Health Centre – Siavonga) ● Providing 12 X single-phase standard services. (Supply to Sikongo's Area and School – Siavonga) ● Providing 12 X single-phase standard services & 1 X three phase standard overhead service. (Supply to Chipepo's Area- Syakalyabanyama –Siavonga) ● Providing 16 X single-phase standard services & 1X three-phase standard overhead service. (Supply to Chikanta's Area And School – Kalomo) ● Providing 8 X standard single-phase overhead services& 1X three phase standard overhead service.
	Schools in Mazabuka (Nansenga Basic School)	● Constructing 100m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1X25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 250m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. ● Providing 5 X single-phase overhead standard service connections.
	(Mulawo Academic Production Unit (APU))	● Constructing 2km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 400m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. ● Providing 5 X single-phase overhead standard service connections. ● Providing 1 X three phase overhead standard service connection
	(Kaunga Basic School)	● Constructing 2km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1 X 25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 300m of 50mm^2 ACSR three phase three-wire medium voltage overhead lines. ● Providing 5X single-phase overhead standard service connections. ● Providing 1 X three phase overhead standard service connection
	(Malala Basic School)	● Constructing 900m of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Establishing 1X25kVA, 11/0.4kV pole mounted transformer substation. ● Constructing 600m of 50mm^2 ACSR three phase four-wire medium voltage overhead lines. ● Providing 9 X single-phase overhead standard service connections. ● Providing 1 X three phase overhead standard service connection
	Choongo's Area – Ntema Basic School, Monze	● Constructing 6.5 km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 1 X 25kVA 11/0.4 kV pole mounted transformer substation. ● Constructing 1200m of 50mm^2 three-phase four-wire medium voltage overhead line. ● Connecting 30m X 35mm^2 4core PVC Medium voltage cable. ● Providing 2 X three phase standard overhead service connections to Chief Choongo's area and Ntema Basic School.

Western Province	Shang'ombo District by Diesel Generators	● Construction of the powerhouse building. ● Installation of 2 X 400kVA, 400V diesel generators. ● Establishing 2 X 400kVA, 0.4/11kV ground-mounted transformer substations. ● Construction of 4.6km of 50mm^2 ACSR 3-phase 3-wire 11kV overhead line. ● Installing 2 X 100kVA, 11/0.4kV pole mounted transformer substations. ● Installing 3 X 50kVA, 11/0.4kV pole mounted transformer substations. ● Laying and connecting 4 X 30m of 70mm^2 4core PVC medium voltage cable. ● Laying and connecting 4 X 30m of 35mm^2 4core PVC medium voltage cable. ● Construction of 5,950m of 50mm^2 ACSR medium voltage line. ● Provision of 102 X single-phase service connections. ● Provision of 6 X three phase service connections.
	Luampa Mission	● Construction of part of 54km of 100mm^2 ACSR 33kV overhead line.
	Kalabo Basic School & Kalabo Training Centre, Kalabo	● Constructing 1.5km of 50mm^2 ACSR three phase three-wire 11kV overhead lines. ● Installing 2 X 25kVA, 11/0.4kV pole mounted transformer substations. ● Constructing 800m of 50mm^2 ACSR medium voltage overhead line. ● Providing 13 x standard single-phase overhead service connections to staff houses. ● Providing 2 X standard three phase underground service connections to classroom block at Kalabo Basic School and Kalabo Farm Training Centre.
	Mwandi Basic School, Royal Court and Market, Sesheke	● Installing 1 X 25kVA, 11/0.4kV pole mounted transformers substation. ● Constructing 700m of 50mm^2 medium voltage overhead line. ● Providing 10 x standard single-phase overhead service connections to staff houses for school and court. ● Providing 1 x standard three phase underground service connections to classroom block at Mwandi Basic School.
	Lukulu	● Refurbishment of generator set

7.3. Review of Existing Distribution Extension Plans

As observed in Table 7-4, most of the on-going rural electrification projects are relatively small-scaled ones that simply consist of the construction of short-span distribution lines and the installation of on-site transformers, and the projects' target of electrification is limited to public facilities such as schools, hospitals, as well as chief's palaces in some projects. On top of that, not all the projects in the list literally deal with "rural electrification", since two projects in Copperbelt Province, namely "Kabushi" and "Kankoyo", obviously have their objective rather strengthening electricity supply in urban area. In short, clear and long-term aspects in planning rural electrification projects don't appear to exist, though each individual project may have its reason to be implemented.

7.4. Preliminary Study for Planning Distribution Line Extension

This section explains how to proceed with the planning of distribution line extension projects as preliminary deskwork before the field study.

7.4.1. Assumptions of Distribution System Expansion Planning

As existing distribution system is spreading dispersedly as observed in Figure 13-2, not many Rural Growth Centres (RGCs) in remote areas (e.g. Eastern, Northern, Luapula, North-Western and Western Provinces) are easily accessible from existing distribution lines while RGCs in Copperbelt, Lusaka, Central and Southern Provinces are relatively close to existing lines. Main scope of works of rural electrification projects is the extension of 33 kV and 11 kV overhead lines with 50 mm^2 or 100 mm^2 ACSR. Based on these preconditions, together with the information obtained through the interviews with ZESCO staff, the Study Team applies the following assumptions in planning distribution network expansion from existing substation including construction of bulky substation.

- Applying 33kV and ACSR100mm^2 lines shall be considered in this study, taking into account minimizing the voltage drop on long-span distribution lines.
- Because of the demand increase in electrified RGC and capacity limitation of existing lines, T-off and/or Extension from existing lines shall not be considered.
- In case the capacity of one circuit is not enough to cover the increasing power load, addition of one more circuit shall be constructed instead of increasing the conductor size of existing lines.
- Distribution routes shall be constructed alongside the public roads taking into account the easiness of construction works and maintenance.
- Step Voltage Regulator (SVR) shall not be applied in this study, because SVR has not been used so far in Zambia.
- Demand growth up to the year 2030 shall be considered.
- Transformer capacity of 100kVA shall be applied. In other words, the number of necessary transformers is calculated by dividing the demand of RGC by 100kVA. The 20% capacity margin shall be considered in determining transformer capacity.
- When electrifying a candidate RGC with high priority, RGCs with lower priority that are positioned between the target RGC and the existing distribution line (or substation) shall be electrified as well.

7.4.2. Flowchart of the Study

Figure 7-1 shows the flowchart of the study that visualized the above-mentioned assumptions.

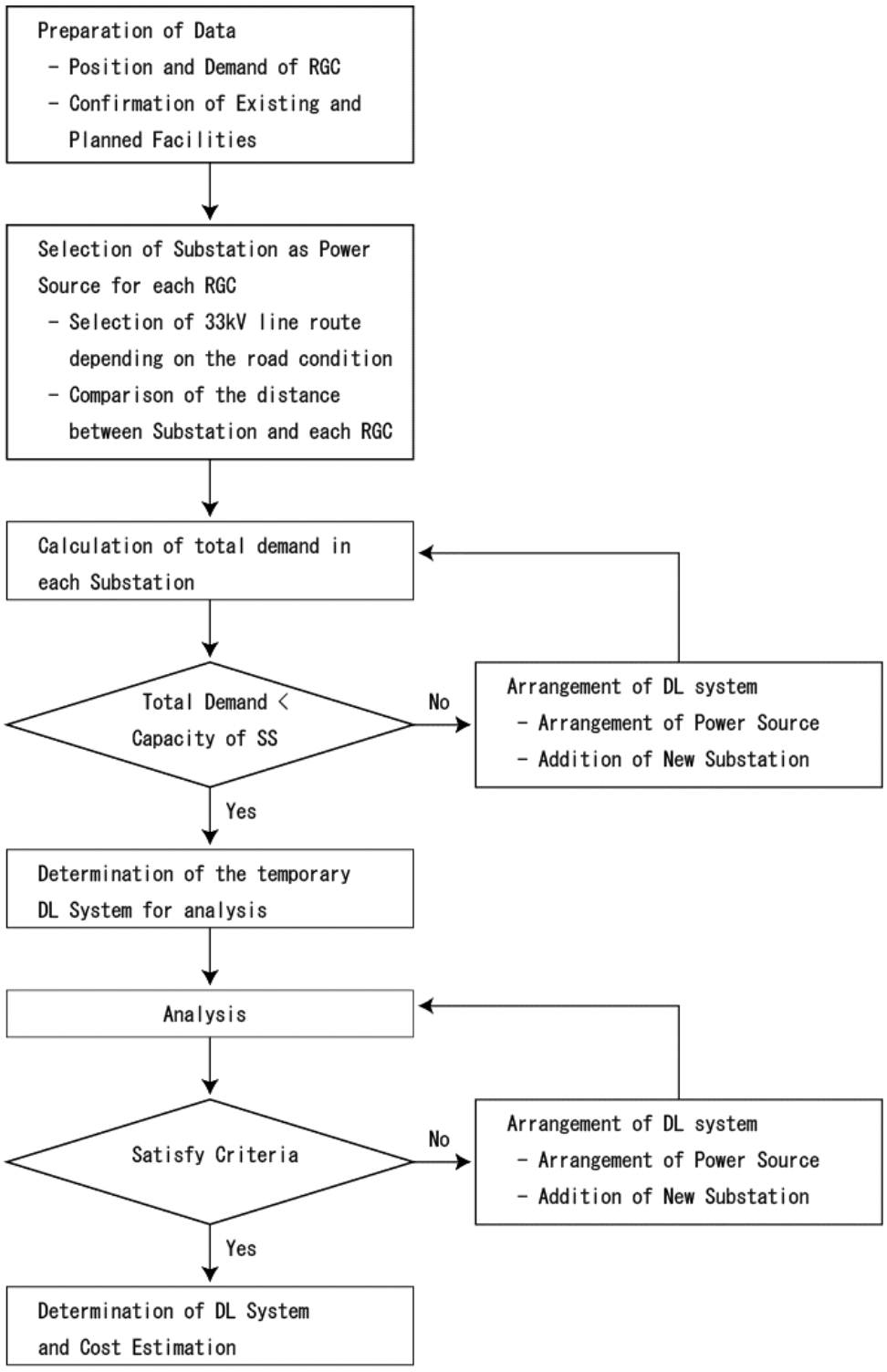


Figure 7-1 Flowchart of the Study

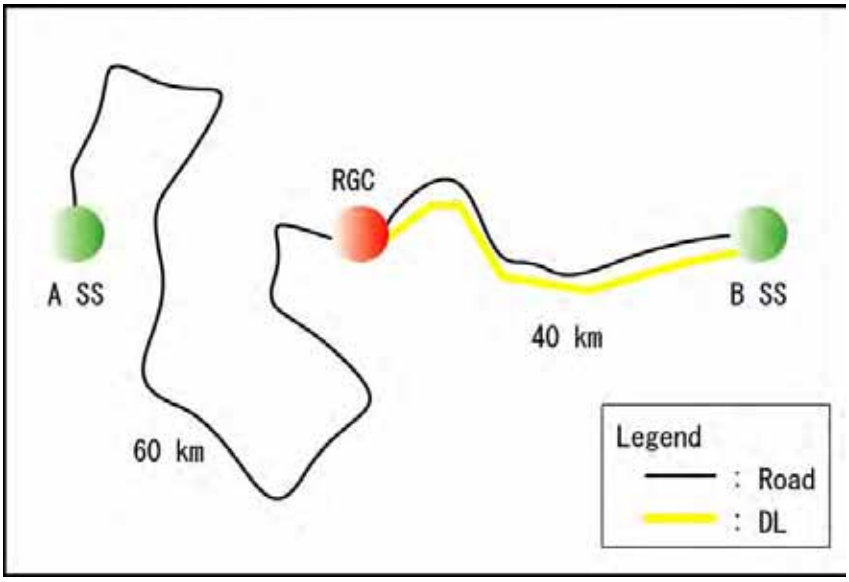
7.4.3. Result of the Study

(1) Data Collection

Demand and Priority of RGC is shown in Table 5-11. The position of RGC was input on the GIS map based on the data obtained from each district's representative and REA. In addition, existing distribution facility data was also input confirming with ZESCO.

(2) Selection of Power Source and Result of Analysis

Comparing with the distance between each RGC and near substations, the nearest substation was selected as a power source. Below figure is example. Although the direct distance between a substation and RGC is shorter than the direct distance between B substation and RGC, actual distance between B substation and RGC is shorter. Therefore, the electric power for this RGC should be supplied from B substation.



As a result of selection of power source based on the above-mentioned rule, the total demand of some substations became very large. Therefore, it was necessary to arrange the demand and/or add the new substation.

Based on the above distribution system, power flow and voltage analysis of each distribution line was carried out. The condition and model for analysis was shown in Table 7-5 and Figure 7-2 respectively.

Table 7-5 Condition for Analysis

Voltage		33 kV
Specification of Conductor	Conductor size	100 mm^2
	Capacity of conductor	313 A
	R	0.323
	X	0.349
	Y	$3.147x10^{-6}$
Power factor		0.85

$$\dot{V}s = Vr + \dot{Z}\left(\dot{I}r + \frac{\dot{Y}Vr}{2}\right)$$

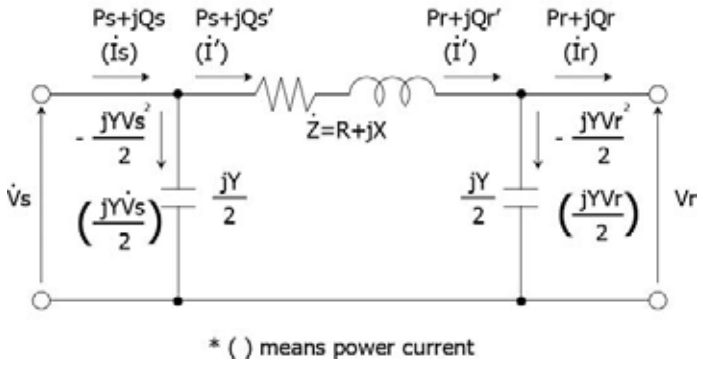


Figure 7-2 Model and Formula for Analysis

As a result of analysis, there were large voltage drop in some distribution lines, and it was necessary to add new substations. The total demand supplied from each substation, the number of RGC and the number of feeder is shown in Table 7-6-1 - 7-6-3.

The maps of each distribution line route are attached Appendix B, and the results of voltage analysis for each package of distribution line are attached Appendix C.

Table 7-6-1 Total Demand and Number of RGC (Existing SS)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Central	Kabwe	7,257	15	2
	Fig Tree	2,053	10	1
	Kapiri Mposhi	12,703	10	2
	Mkushi	3,502	12	1
	Mkushi Farm Block	3,234	12	1
	Mumbwa	8,583	18	3
	Pensulo	520	1	1
	Nampundwe	5,291	10	1
	Serenje	2,039	4	1
Copperbelt	Kansunswa	10,115	9	1
	Kitwe	8,555	28	3
	Luano	5,063	12	2
	Maposa	6,317	16	2
	Mpongwe	5,970	29	3
	Ndola	4,180	6	1
Eastern	Azele	10,573	4	2
	Chipata	10,097	15	2
	Lundazi	11,919	19	3
	Msoro	1,328	2	1
Luapula	Chipili	3,878	12	2
	Kawambwa Tea	3,702	9	1
	Mansa	1,572	19	2
	Mbereshi	6,835	13	2
	Nchelenge	7,877	18	2
	Samfya	1,251	3	1

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Lusaka	Coventry	1,678	8	1
	Kafwe Town	936	3	1
	Leopard's Hill	3,669	13	1
Northwestern	Kasempa	2,620	18	2
	Solwezi	6,947	14	3
Northern	Chinsali	3,462	28	3
	Isoka	8,837	11	3
	Kasama	6,843	22	2
	Luwingu	12,039	22	3
	Mbala	7,557	26	2
	Mfuwe	4,293	4	1
	Mpika	5,679	11	3
	Mporokoso	8,938	13	2
	Nakonde	3,848	10	1
Southern	Chilundu	3,384	17	2
	Maamba	2,021	14	1
	Mazabuka	1,756	7	1
	Muzuma	2,711	11	3
	Sinazongwe	2,548	22	1
	Victoria Falls	4,440	33	3
西部	Kalabo	11,894	37	3
	Kaoma	11,360	40	4
	Mongu	9,754	14	2
	Senanga	11,974	9	3
	Sesheke	3,808	6	1
Total		287,410	719	95

Table 7-6-2 Total Demand and Number of RGC (Proposed SS by ZESCO)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Eastern	New SS at Chama	4,707	11	2
	New SS at Nyimba	1,120	14	1
Lusaka	New SS at Chilundu	5,013	16	2
Northwestern	New SS at Chavuma	1,335	13	1
	New SS at Kabompo	7,116	14	2
	New SS at Mufumbwe	3,570	14	1
	New SS at Mumbezi	1,333	4	1
	New SS at Mwinilunga	6,323	16	3
	New SS at Zambezi	6,686	17	2
Western	New SS at Lukulu	7,631	17	2
Total		44,834	136	17

Table 7-6-3 Total Demand and Number of RGC (Proposed SS by Consultant)

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Central	Pensulo 1	6,522	10	2
	Pensulo 2	8,247	15	2
	Kabwe 1	4,226	3	1
	Kabwe 2	5,538	4	1
Copperbelt	Luano 1	3,457	16	2
	Luano 2	3,695	9	1
	Ndola 1	6,773	4	1
Eastern	Azele 1	12,201	10	2
	Azele 2	12,082	6	2
	Azele 3	10,217	3	2
	Azele 4	12,327	9	2
	Azele 5	11,154	4	1
	Azele 6	5,392	11	2
	Lundazi 1	2,728	3	1
	Mfuwe 1	3,172	7	1
Luapula	Mbereshi 1	9,933	17	2
	Nchelenge 1	6,954	12	2
	Samfya 1	5,742	10	2
	Samfya 2	6,110	8	2
Northwestern	Mwinilunga 1	3,530	5	1
	Zambezi 1	2,891	6	1

Province	Substation	Total Demand (kW)	# of RGC	# of feeder
Northern	Isoka 1	6,550	3	3
	Kasama 1	6,531	4	1
	Kasama 2	6,484	4	1
	Luwingu 1	5,791	5	1
	Luwingu 2	11,262	13	2
	Luwingu 3	7,391	12	2
	Mpika 1	7,201	8	2
	Mpika 2	3,126	3	1
Southern	Mazabuka 1	7,348	31	3
	Muzuma 1	8,996	19	3
	Muzuma 2	7,578	9	2
	Muzuma 3	6,250	10	2
Western	Mongu 1	11,888	20	2
	Mongu 2	13,149	10	2
	Senanga 1	6,156	5	1
	Senanga 2	4,038	6	2
	Senanga 3	10,275	10	2
	Sesheke 1	3,025	8	1
	Sesheke 2	3,010	9	1
Total		278,940	361	67

7.5. Cost Estimate for Distribution Line Extension

7.5.1. Condition

In case the distribution line is constructed from existing substation, following items should be considered to estimate the amount of equipment.

- Actual distance of distribution line between existing substation and RGC
- The number of transformer on the pole
- The number of bay

In case the distribution line is constructed from new substation, following items should be considered to estimate the amount of equipment.

- Distance of transmission line between existing substation and new substation
- Actual distance of distribution line between new substation and RGC
- The number of transformer on the pole
- New substation depending on the total demand of related RGCs

The capacity of substation should be selected following the below table. (e.g. If total demand of substation is 4.5MW, 10MVA capacity should be selected.)

Capacity of Substation (MVA)	Power Factor of Distribution Line	Capacity of Substation (MW)
2.5	0.85	2.125
5		4.25
10		8.5
15		12.75

Cost estimation shall be carried out depending on the above-mentioned amount and unit cost obtained from ZESCO. Cost shall be divided into foreign currency (material cost) and local currency (material cost, transport cost, overhead cost, labour cost) based on the following table obtained from ZESCO.

Item		Breakdown
F.C.	Material Cost	80.166747 %
L.C.	Material Cost, Transportation Cost, Overhead Cost	11.816629 %
	Skilled Labour	3.20667 %
	Unskilled Labour	4.810005 %

7.5.2. Result of Cost Estimation

Amount of facility and the result of cost estimation are shown in table 7-7-1 – 7-7-3. If all RGCs are electrified by distribution lines, total cost will be approximately 1,180 million USD.

Table 7-7-1 Result of Cost Estimation in each Package (Existing Substation)

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Azele	1	1 － 1	20	33	1	1,019,240	150,237	40,770	61,154	1,271,400
		1 － 2	23	41	1	1,193,683	175,950	47,747	71,621	1,489,000
	2	2 － 1	5	67	1	959,756	141,469	38,390	57,585	1,197,200
		2 － 2	13	87	1	1,410,293	207,878	56,412	84,618	1,759,200
Chilundu	1	1 － 1	34	9	1	1,159,692	170,939	46,388	69,582	1,446,600
		1 － 2	62	14	1	2,022,687	298,145	80,907	121,361	2,523,100
		1 － 3	76	20	1	2,492,625	367,414	99,705	149,557	3,109,300
		1 － 4	92	22	1	2,976,351	438,716	119,054	178,581	3,712,700
	2	2 － 1	85	8	1	2,620,571	386,274	104,823	157,234	3,268,900
		2 － 2	125	12	1	3,818,903	562,909	152,756	229,134	4,763,700
		2 － 3	155	16	1	4,728,636	697,004	189,145	283,718	5,898,500
		2 － 4	171	19	1	5,223,345	769,924	208,934	313,401	6,515,600
		2 － 5	188	22	1	5,746,914	847,099	229,877	344,815	7,168,700
		2 － 6	199	24	1	6,086,340	897,130	243,454	365,180	7,592,100
		2 － 7	204	25	1	6,241,623	920,019	249,665	374,497	7,785,800
		2 － 8	212	26	1	6,483,486	955,670	259,339	389,009	8,087,500
Chinsali	1	1 － 1	137	12	1	4,165,224	613,957	166,609	249,913	5,195,700
		1 － 2	198	16	1	5,969,617	879,925	238,785	358,177	7,446,500
		1 － 3	233	20	1	7,023,649	1,035,290	280,946	421,419	8,761,300
		1 － 4	239	22	1	7,218,775	1,064,052	288,751	433,127	9,004,700
	2	2 － 1	24	6	1	838,143	123,543	33,526	50,289	1,045,500
		2 － 2	58	14	1	1,907,247	281,129	76,290	114,435	2,379,100
		2 － 3	94	16	1	2,968,174	437,511	118,727	178,090	3,702,500
		2 － 4	99	18	1	3,134,440	462,018	125,378	188,066	3,909,900
		2 － 5	118	20	1	3,704,746	546,082	148,190	222,285	4,621,300
		2 － 6	139	21	1	4,321,789	637,034	172,872	259,307	5,391,000
	3	3 － 1	14	4	1	527,577	77,765	21,103	31,655	658,100
		3 － 2	77	7	1	2,378,708	350,623	95,148	142,722	2,967,200
		3 － 3	82	9	1	2,544,974	375,131	101,799	152,698	3,174,600
		3 － 4	89	10	1	2,757,977	406,527	110,319	165,479	3,440,300

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Chipata	1	1 - 1	72	11	1	2,278,339	335,829	91,134	136,700	2,842,000
		1 - 2	116	29	1	3,745,871	552,144	149,835	224,752	4,672,600
		1 - 3	122	34	1	3,973,946	585,762	158,958	238,437	4,957,100
		1 - 4	139	37	1	4,497,515	662,937	179,901	269,851	5,610,200
		1 - 5	186	39	1	5,875,902	866,112	235,036	352,554	7,329,600
		1 - 6	194	41	1	6,128,748	903,381	245,150	367,725	7,645,000
	2	2 - 1	62	81	1	2,758,538	406,610	110,342	165,512	3,441,000
		2 - 2	75	85	1	3,177,650	468,388	127,106	190,659	3,963,800
		2 - 3	92	88	1	3,701,219	545,562	148,049	222,073	4,616,900
Chipili	1	1 - 1	48	14	1	1,618,647	238,590	64,746	97,119	2,019,100
		1 - 2	57	19	1	1,933,301	284,970	77,332	115,998	2,411,600
		1 - 3	81	23	1	2,669,873	393,541	106,795	160,192	3,330,400
		1 - 4	99	26	1	3,222,302	474,969	128,892	193,338	4,019,500
		1 - 5	125	27	1	3,983,646	587,192	159,346	239,019	4,969,200
	2	2 - 1	184	21	1	5,620,491	828,464	224,820	337,229	7,011,000
		2 - 2	198	23	1	6,046,497	891,257	241,860	362,790	7,542,400
		2 - 3	211	24	1	6,432,660	948,178	257,306	385,960	8,024,100
		2 - 4	243	25	1	7,367,164	1,085,925	294,687	442,030	9,189,800
Coventry	1	1 - 1	39	6	1	1,271,044	187,353	50,842	76,263	1,585,500
		1 - 2	88	18	1	2,816,979	415,225	112,679	169,019	3,513,900
		1 - 3	124	21	1	3,888,889	573,225	155,556	233,333	4,851,000
		1 - 4	129	22	1	4,044,172	596,113	161,767	242,650	5,044,700
		1 - 5	141	23	1	4,401,475	648,780	176,059	264,089	5,490,400
Fig Tree	1	1 - 1	70	6	1	2,165,705	319,226	86,628	129,942	2,701,500
		1 - 2	95	12	1	2,953,102	435,289	118,124	177,186	3,683,700
		1 - 3	132	16	1	4,064,855	599,162	162,594	243,891	5,070,500
		1 - 4	151	21	1	4,668,110	688,082	186,724	280,087	5,823,000
		1 - 5	168	24	1	5,191,679	765,257	207,667	311,501	6,476,100
		1 - 6	175	26	1	5,415,665	798,272	216,627	324,940	6,755,500
		1 - 7	195	28	1	6,014,831	886,590	240,593	360,890	7,502,900
		1 - 8	206	29	1	6,343,274	935,003	253,731	380,596	7,912,600

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Isoka	1	1 - 1	2	33	1	499,760	73,665	19,990	29,986	623,400
		1 - 2	60	39	1	2,239,538	330,109	89,582	134,372	2,793,600
		1 - 3	73	40	1	2,625,701	387,030	105,028	157,542	3,275,300
	2	2 - 1	10	17	1	554,914	81,795	22,197	33,295	692,200
		2 - 2	34	20	1	1,280,503	188,747	51,220	76,830	1,597,300
		2 - 3	43	22	1	1,562,209	230,271	62,488	93,733	1,948,700
		2 - 4	113	26	1	3,626,343	534,525	145,054	217,581	4,523,500
		2 - 5	147	27	1	4,618,567	680,780	184,743	277,114	5,761,200
	3	3 - 1	39	29	1	1,523,649	224,587	60,946	91,419	1,900,600
		3 - 2	102	45	1	3,517,557	518,490	140,702	211,053	4,387,800
Kabwe	1	1 - 1	16	11	1	662,177	97,605	26,487	39,731	826,000
		1 - 2	91	18	1	2,903,559	427,986	116,142	174,214	3,621,900
		1 - 3	120	24	1	3,806,397	561,065	152,256	228,384	4,748,100
		1 - 4	126	28	1	4,023,489	593,065	160,940	241,409	5,018,900
		1 - 5	146	32	1	4,644,621	684,620	185,785	278,677	5,793,700
		1 - 6	150	35	1	4,793,009	706,493	191,720	287,581	5,978,800
		1 - 7	154	38	1	4,941,398	728,365	197,656	296,484	6,163,900
	2	2 - 1	26	16	1	1,005,692	148,240	40,228	60,342	1,254,500
		2 - 2	29	27	1	1,213,083	178,809	48,523	72,785	1,513,200
		2 - 3	48	38	1	1,882,235	277,443	75,289	112,934	2,347,900
		2 - 4	117	48	1	3,983,405	587,156	159,336	239,004	4,968,900
		2 - 5	137	54	1	4,626,503	681,949	185,060	277,590	5,771,100
		2 - 6	165	56	1	5,456,550	804,299	218,262	327,393	6,806,500
Kafwe Town	1	1 - 1	8	7	1	387,366	57,098	15,495	23,242	483,200
		1 - 2	25	10	1	910,935	134,272	36,437	54,656	1,136,300
		1 - 3	33	13	1	1,174,764	173,161	46,991	70,486	1,465,400

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kalabo	1	1 － 1	40	28	1	1,541,526	227,222	61,661	92,492	1,922,900
		1 － 2	79	48	1	2,886,724	425,505	115,469	173,203	3,600,900
		1 － 3	132	59	1	4,537,117	668,774	181,485	272,227	5,659,600
		1 － 4	167	62	1	5,580,167	822,520	223,207	334,810	6,960,700
		1 － 5	208	66	1	6,807,359	1,003,409	272,294	408,442	8,491,500
		1 － 6	219	67	1	7,135,802	1,051,822	285,432	428,148	8,901,200
		1 － 7	227	68	1	7,377,666	1,087,473	295,107	442,660	9,202,900
	2	2 － 1	59	24	1	2,045,936	301,572	81,837	122,756	2,552,100
		2 － 2	107	29	1	3,486,131	513,858	139,445	209,168	4,348,600
		2 － 3	111	30	1	3,612,554	532,493	144,502	216,753	4,506,300
	3	3 － 1	74	19	1	2,423,922	357,288	96,957	145,435	3,023,600
		3 － 2	279	38	1	8,548,902	1,260,113	341,956	512,934	10,663,900
		3 － 3	364	44	1	11,067,901	1,631,416	442,716	664,074	13,806,100
		3 － 4	383	50	1	11,682,139	1,721,955	467,286	700,928	14,572,300
		3 － 5	389	56	1	11,921,196	1,757,192	476,848	715,272	14,870,500
		3 － 6	470	60	1	14,302,790	2,108,240	572,112	858,167	17,841,300
		3 － 7	494	62	1	15,017,396	2,213,574	600,696	901,044	18,732,700
		3 － 8	512	63	1	15,547,860	2,291,764	621,914	932,872	19,394,400
Kansunswa	1	1 － 1	14	33	1	846,080	124,713	33,843	50,765	1,055,400
		1 － 2	25	66	1	1,525,974	224,930	61,039	91,558	1,903,500
		1 － 3	32	86	1	1,947,651	287,085	77,906	116,859	2,429,500
		1 － 4	39	99	1	2,292,448	337,908	91,698	137,547	2,859,600
		1 － 5	46	109	1	2,604,297	383,875	104,172	156,258	3,248,600
		1 － 6	48	119	1	2,771,845	408,572	110,874	166,311	3,457,600
		1 － 7	61	123	1	3,190,957	470,349	127,638	191,457	3,980,400
		1 － 8	66	125	1	3,357,223	494,857	134,289	201,433	4,187,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kaoma	1	1 - 1	55	21	1	1,897,547	279,700	75,902	113,853	2,367,000
		1 - 2	78	27	1	2,627,225	387,255	105,089	157,633	3,277,200
		1 - 3	136	30	1	4,334,055	638,842	173,362	260,043	5,406,300
		1 - 4	161	32	1	5,077,521	748,430	203,101	304,651	6,333,700
		1 - 5	166	34	1	5,243,787	772,938	209,751	314,627	6,541,100
		1 - 6	179	36	1	5,640,933	831,477	225,637	338,456	7,036,500
		1 - 7	201	38	1	6,297,819	928,303	251,913	377,869	7,855,900
		1 - 8	206	39	1	6,453,102	951,191	258,124	387,186	8,049,600
		1 - 9	210	40	1	6,579,525	969,826	263,181	394,772	8,207,300
	2	2 - 1	55	15	1	1,831,650	269,986	73,266	109,899	2,284,800
		2 - 2	144	28	1	4,542,969	669,637	181,719	272,578	5,666,900
		2 - 3	194	36	1	6,073,834	895,287	242,953	364,430	7,576,500
		2 - 4	245	40	1	7,589,626	1,118,716	303,585	455,378	9,467,300
		2 - 5	294	41	1	9,014,751	1,328,780	360,590	540,885	11,245,000
		2 - 6	305	42	1	9,343,194	1,377,193	373,728	560,592	11,654,700
		2 - 7	357	44	1	10,865,881	1,601,638	434,635	651,953	13,554,100
	3	3 - 1	177	24	1	5,451,419	803,543	218,057	327,085	6,800,100
		3 - 2	250	30	1	7,624,098	1,123,797	304,964	457,446	9,510,300
		3 - 3	260	32	1	7,934,664	1,169,574	317,387	476,080	9,897,700
	4	4 - 1	13	19	1	663,460	97,794	26,538	39,808	827,600
		4 - 2	71	34	1	2,502,084	368,809	100,083	150,125	3,121,100
		4 - 3	99	37	1	3,343,114	492,777	133,725	200,587	4,170,200
Kapiri Mposhi	1	1 - 1	51	13	1	1,694,244	249,733	67,770	101,655	2,113,400
		1 - 2	62	21	1	2,099,567	309,478	83,983	125,974	2,619,000
		1 - 3	98	28	1	3,215,408	473,953	128,616	192,924	4,010,900
		1 - 4	109	35	1	3,609,748	532,079	144,390	216,585	4,502,800
		1 - 5	113	42	1	3,802,068	560,427	152,083	228,124	4,742,700
		1 - 6	120	49	1	4,080,968	601,537	163,239	244,858	5,090,600
		1 - 7	145	52	1	4,835,418	712,744	193,417	290,125	6,031,700
	2	2 - 1	10	98	1	1,444,525	212,924	57,781	86,671	1,801,900
		2 - 2	26	107	1	2,005,131	295,558	80,205	120,308	2,501,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kasama	1	1 - 1	11	8	1	484,929	71,479	19,397	29,096	604,900
		1 - 2	45	15	1	1,543,050	227,446	61,722	92,583	1,924,800
		1 - 3	64	20	1	2,146,304	316,367	85,852	128,778	2,677,300
		1 - 4	129	23	1	4,055,155	597,732	162,206	243,309	5,058,400
		1 - 5	140	26	1	4,405,564	649,383	176,223	264,334	5,495,500
		1 - 6	223	34	1	6,888,809	1,015,415	275,552	413,329	8,593,100
		1 - 7	260	36	1	7,978,595	1,176,050	319,144	478,716	9,952,500
		1 - 8	271	38	1	8,318,022	1,226,082	332,721	499,081	10,375,900
		1 - 9	277	40	1	8,513,147	1,254,843	340,526	510,789	10,619,300
		1 - 10	305	41	1	9,332,211	1,375,574	373,288	559,933	11,641,000
		1 - 11	307	42	1	9,400,914	1,385,701	376,037	564,055	11,726,700
		1 - 12	320	43	1	9,787,077	1,442,621	391,483	587,225	12,208,400
	2	2 - 1	58	19	1	1,962,161	289,224	78,486	117,730	2,447,600
		2 - 2	74	28	1	2,522,767	371,857	100,911	151,366	3,146,900
		2 - 3	83	35	1	2,859,388	421,476	114,376	171,563	3,566,800
		2 - 4	148	44	1	4,834,135	712,555	193,365	290,048	6,030,100
		2 - 5	161	48	1	5,253,247	774,332	210,130	315,195	6,552,900
Kasempa	1	1 - 1	19	2	1	649,912	95,797	25,996	38,995	810,700
		1 - 2	34	4	1	1,104,778	162,845	44,191	66,287	1,378,100
		1 - 3	67	6	1	2,079,125	306,464	83,165	124,747	2,593,500
		1 - 4	76	8	1	2,360,831	347,988	94,433	141,650	2,944,900
		1 - 5	125	10	1	3,796,938	559,671	151,878	227,816	4,736,300
		1 - 6	130	12	1	3,963,203	584,179	158,528	237,792	4,943,700
		1 - 7	145	14	1	4,418,070	651,226	176,723	265,084	5,511,100
		1 - 8	199	16	1	5,998,477	884,179	239,939	359,909	7,482,500
	2	2 - 1	91	13	1	2,848,645	419,892	113,946	170,919	3,553,400
		2 - 2	133	16	1	4,093,715	603,416	163,749	245,623	5,106,500
		2 - 3	150	18	1	4,606,301	678,972	184,252	276,378	5,745,900
		2 - 4	159	20	1	4,888,007	720,495	195,520	293,280	6,097,300
		2 - 5	237	23	1	7,172,038	1,057,163	286,882	430,322	8,946,400

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Kawambwa Tea	1	1 － 1	34	22	1	1,302,469	191,985	52,099	78,148	1,624,700
		1 － 2	83	30	1	2,804,473	413,381	112,179	168,268	3,498,300
		1 － 3	85	36	1	2,928,090	431,602	117,124	175,685	3,652,500
		1 － 4	91	39	1	3,134,199	461,983	125,368	188,052	3,909,600
		1 － 5	99	42	1	3,398,028	500,871	135,921	203,882	4,238,700
		1 － 6	109	44	1	3,708,594	546,649	148,344	222,516	4,626,100
		1 － 7	128	46	1	4,278,900	630,713	171,156	256,734	5,337,500
		1 － 8	148	47	1	4,867,084	717,411	194,683	292,025	6,071,200
Kitwe	1	1 － 1	23	31	1	1,083,854	159,761	43,354	65,031	1,352,000
		1 － 2	29	36	1	1,311,929	193,379	52,477	78,716	1,636,500
		1 － 3	40	41	1	1,684,303	248,267	67,372	101,058	2,101,000
		1 － 4	54	44	1	2,121,292	312,680	84,852	127,278	2,646,100
	2	2 － 1	33	12	1	1,163,781	171,542	46,551	69,827	1,451,700
		2 － 2	56	26	1	1,981,321	292,048	79,253	118,879	2,471,500
		2 － 3	61	30	1	2,169,553	319,793	86,782	130,173	2,706,300
		2 － 4	69	32	1	2,422,399	357,063	96,896	145,344	3,021,700
		2 － 5	75	33	1	2,606,542	384,206	104,262	156,393	3,251,400
	3	3 － 1	75	13	1	2,386,885	351,828	95,475	143,213	2,977,400
		3 － 2	89	22	1	2,889,771	425,954	115,591	173,386	3,604,700
		3 － 3	91	27	1	3,002,405	442,556	120,096	180,144	3,745,200
		3 － 4	94	30	1	3,121,934	460,175	124,877	187,316	3,894,300
		3 － 5	120	33	1	3,905,243	575,635	156,210	234,315	4,871,400
		3 － 6	154	36	1	4,919,432	725,127	196,777	295,166	6,136,500
		3 － 7	156	38	1	4,999,118	736,873	199,965	299,947	6,235,900
		3 － 8	160	40	1	5,136,524	757,127	205,461	308,191	6,407,300
		3 － 9	178	42	1	5,677,970	836,936	227,119	340,678	7,082,700

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Leopard's Hill	1	1 - 1	66	14	1	2,138,127	315,161	85,525	128,288	2,667,100
		1 - 2	98	19	1	3,116,562	459,383	124,663	186,994	3,887,600
		1 - 3	118	24	1	3,748,677	552,557	149,947	224,921	4,676,100
		1 - 4	123	29	1	3,947,892	581,922	157,916	236,874	4,924,600
		1 - 5	179	33	1	5,607,985	826,620	224,319	336,479	6,995,400
		1 - 6	223	37	1	6,921,757	1,020,271	276,870	415,305	8,634,200
		1 - 7	233	41	1	7,254,289	1,069,287	290,172	435,257	9,049,000
		1 - 8	265	44	1	8,210,758	1,210,271	328,430	492,646	10,242,100
		1 - 9	284	46	1	8,781,065	1,294,334	351,243	526,864	10,953,500
		1 - 10	304	48	1	9,380,231	1,382,652	375,209	562,814	11,700,900
		1 - 11	309	50	1	9,546,497	1,407,160	381,860	572,790	11,908,300
Luano	1	1 - 1	22	13	1	857,303	126,367	34,292	51,438	1,069,400
		1 - 2	32	24	1	1,266,715	186,715	50,669	76,003	1,580,100
		1 - 3	48	28	1	1,772,407	261,254	70,896	106,344	2,210,900
		1 - 4	73	30	1	2,515,873	370,841	100,635	150,952	3,138,300
	2	2 - 1	13	15	1	619,529	91,319	24,781	37,172	772,800
		2 - 2	31	22	1	1,215,889	179,223	48,636	72,953	1,516,700
		2 - 3	42	25	1	1,566,298	230,873	62,652	93,978	1,953,800
		2 - 4	57	31	1	2,065,095	304,396	82,604	123,906	2,576,000
		2 - 5	83	33	1	2,837,422	418,238	113,497	170,245	3,539,400
		2 - 6	93	35	1	3,147,988	464,015	125,920	188,879	3,926,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Lundazi	1	1 － 1	55	19	1	1,875,581	276,462	75,023	112,535	2,339,600
		1 － 2	59	26	1	2,067,901	304,810	82,716	124,074	2,579,500
		1 － 3	116	30	1	3,756,854	553,763	150,274	225,411	4,686,300
		1 － 4	207	37	1	6,459,997	952,208	258,400	387,600	8,058,200
	2	2 － 1	46	17	1	1,593,875	234,938	63,755	95,633	1,988,200
		2 － 2	109	29	1	3,543,851	522,366	141,754	212,631	4,420,600
		2 － 3	124	38	1	4,075,597	600,746	163,024	244,536	5,083,900
		2 － 4	133	47	1	4,434,183	653,601	177,367	266,051	5,531,200
		2 － 5	177	53	1	5,769,921	850,490	230,797	346,195	7,197,400
		2 － 6	181	58	1	5,940,276	875,600	237,611	356,417	7,409,900
		2 － 7	186	62	1	6,128,507	903,346	245,140	367,710	7,644,700
	3	3 － 1	25	39	1	1,229,437	181,220	49,177	73,766	1,533,600
		3 － 2	47	54	1	2,029,101	299,091	81,164	121,746	2,531,100
Luwingu	1	1 － 1	122	50	1	4,149,671	611,664	165,987	248,980	5,176,300
		1 － 2	137	56	1	4,648,469	685,187	185,939	278,908	5,798,500
		1 － 3	142	62	1	4,858,666	716,170	194,347	291,520	6,060,700
		1 － 4	170	68	1	5,732,644	844,995	229,306	343,959	7,150,900
	2	2 － 1	66	25	1	2,258,939	332,969	90,358	135,536	2,817,800
		2 － 2	86	31	1	2,902,036	427,762	116,081	174,122	3,620,000
		2 － 3	118	37	1	3,891,454	573,603	155,658	233,487	4,854,200
		2 － 4	122	43	1	4,072,791	600,332	162,912	244,367	5,080,400
		2 － 5	152	49	1	5,004,489	737,665	200,180	300,269	6,242,600
		2 － 6	190	52	1	6,134,119	904,173	245,365	368,047	7,651,700
		2 － 7	204	54	1	6,560,125	966,967	262,405	393,608	8,183,100
	3	3 － 1	10	12	1	500,000	73,700	20,000	30,000	623,700
		3 － 2	17	18	1	767,917	113,191	30,717	46,075	957,900
		3 － 3	24	24	1	1,035,835	152,683	41,433	62,150	1,292,100

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Maamba	1	1 － 1	240	141	1	8,554,594	1,260,952	342,184	513,276	10,671,000
		1 － 2	271	143	1	9,471,220	1,396,064	378,849	568,273	11,814,400
		1 － 3	274	145	1	9,579,766	1,412,064	383,191	574,786	11,949,800
		1 － 4	296	147	1	10,236,652	1,508,889	409,466	614,199	12,769,200
		1 － 5	302	149	1	10,431,778	1,537,651	417,271	625,907	13,012,600
		1 － 6	308	151	1	10,626,904	1,566,412	425,076	637,614	13,256,000
		1 － 7	314	153	1	10,822,030	1,595,174	432,881	649,322	13,499,400
		1 － 8	327	154	1	11,208,193	1,652,095	448,328	672,492	13,981,100
		1 － 9	339	155	1	11,565,496	1,704,761	462,620	693,930	14,426,800
Mansa	1	1 － 1	81	5	1	2,472,182	364,401	98,887	148,331	3,083,800
		1 － 2	132	7	1	3,966,009	584,592	158,640	237,961	4,947,200
		1 － 3	144	9	1	4,334,295	638,878	173,372	260,058	5,406,600
		1 － 4	174	11	1	5,222,062	769,735	208,882	313,324	6,514,000
		1 － 5	186	13	1	5,590,348	824,021	223,614	335,421	6,973,400
		1 － 6	245	15	1	7,315,055	1,078,244	292,602	438,903	9,124,800
		1 － 7	283	16	1	8,422,719	1,241,514	336,909	505,363	10,506,500
		1 － 8	329	18	1	9,772,246	1,440,435	390,890	586,335	12,189,900
		1 － 9	350	19	1	10,389,290	1,531,388	415,572	623,357	12,959,600
	2	2 － 1	15	2	1	534,472	78,781	21,379	32,068	666,700
		2 － 2	26	3	1	862,915	127,194	34,517	51,775	1,076,400
		2 － 3	37	5	1	1,202,341	177,226	48,094	72,140	1,499,800
		2 － 4	67	6	1	2,079,125	306,464	83,165	124,747	2,593,500
		2 － 5	76	7	1	2,349,848	346,369	93,994	140,991	2,931,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Maposa	1	1 － 1	55	22	1	1,908,530	281,318	76,341	114,512	2,380,700
		1 － 2	126	35	1	4,100,369	604,397	164,015	246,022	5,114,800
		1 － 3	142	44	1	4,660,975	687,031	186,439	279,659	5,814,100
		1 － 4	186	52	1	6,018,679	887,157	240,747	361,121	7,507,700
		1 － 5	207	55	1	6,657,688	981,347	266,308	399,461	8,304,800
		1 － 6	211	57	1	6,795,094	1,001,601	271,804	407,706	8,476,200
		1 － 7	214	58	1	6,892,657	1,015,982	275,706	413,559	8,597,900
	2	2 － 1	41	13	1	1,405,644	207,193	56,226	84,339	1,753,400
		2 － 2	68	19	1	2,250,762	331,764	90,030	135,046	2,807,600
		2 － 3	72	22	1	2,399,150	353,636	95,966	143,949	2,992,700
		2 － 4	80	27	1	2,684,945	395,763	107,398	161,097	3,349,200
Mazabuka	1	1 － 1	44	9	1	1,448,292	213,479	57,932	86,898	1,806,600
		1 － 2	76	16	1	2,448,693	360,939	97,948	146,922	3,054,500
		1 － 3	86	19	1	2,770,242	408,335	110,810	166,215	3,455,600
		1 － 4	131	22	1	4,101,892	604,621	164,076	246,114	5,116,700
		1 － 5	163	25	1	5,058,361	745,606	202,334	303,502	6,309,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mbala	1	1 − 1	55	4	1	1,710,839	252,179	68,434	102,650	2,134,100
		1 − 2	146	14	1	4,446,930	655,480	177,877	266,816	5,547,100
		1 − 3	180	16	1	5,450,136	803,354	218,005	327,008	6,798,500
		1 − 4	216	18	1	6,511,063	959,735	260,443	390,664	8,121,900
		1 − 5	236	19	1	7,099,246	1,046,433	283,970	425,955	8,855,600
		1 − 6	272	20	1	8,149,190	1,201,196	325,968	488,951	10,165,300
		1 − 7	303	21	1	9,054,834	1,334,688	362,193	543,290	11,295,000
	2	2 − 1	37	27	1	1,443,963	212,841	57,759	86,638	1,801,200
		2 − 2	44	38	1	1,766,795	260,427	70,672	106,008	2,203,900
		2 − 3	95	55	1	3,425,365	504,901	137,015	205,522	4,272,800
		2 − 4	104	65	1	3,794,933	559,376	151,797	227,696	4,733,800
		2 − 5	150	69	1	5,166,426	761,534	206,657	309,986	6,444,600
		2 − 6	211	72	1	6,959,836	1,025,884	278,393	417,590	8,681,700
		2 − 7	265	78	1	8,584,175	1,265,313	343,367	515,051	10,707,900
		2 − 8	314	81	1	10,031,265	1,478,615	401,251	601,876	12,513,000
		2 − 9	321	84	1	10,266,234	1,513,249	410,649	615,974	12,806,100
		2 − 10	367	85	1	11,604,778	1,710,552	464,191	696,287	14,475,800
Mbereshi	1	1 − 1	19	29	1	946,449	139,507	37,858	56,787	1,180,600
		1 − 2	40	42	1	1,695,286	249,886	67,811	101,717	2,114,700
		1 − 3	46	49	1	1,945,326	286,742	77,813	116,720	2,426,600
		1 − 4	85	52	1	3,103,816	457,504	124,153	186,229	3,871,700
		1 − 5	93	54	1	3,356,662	494,774	134,266	201,400	4,187,100
	2	2 − 1	32	34	1	1,376,543	202,903	55,062	82,593	1,717,100
Mfuwe	1	1 − 1	160	28	1	5,004,730	737,700	200,189	300,284	6,242,900
		1 − 2	167	43	1	5,371,493	791,761	214,860	322,290	6,700,400
		1 − 3	170	54	1	5,578,884	822,331	223,155	334,733	6,959,100

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mkushi	1	1 - 1	23	11	1	864,198	127,383	34,568	51,852	1,078,000
		1 - 2	52	21	1	1,810,967	266,938	72,439	108,658	2,259,000
		1 - 3	88	26	1	2,904,842	428,176	116,194	174,291	3,623,500
		1 - 4	106	31	1	3,479,237	512,842	139,169	208,754	4,340,000
		1 - 5	115	35	1	3,782,908	557,603	151,316	226,975	4,718,800
		1 - 6	129	39	1	4,230,880	623,634	169,235	253,853	5,277,600
		1 - 7	135	42	1	4,436,989	654,015	177,480	266,219	5,534,700
		1 - 8	183	48	1	5,888,167	867,920	235,527	353,290	7,344,900
		1 - 9	187	50	1	6,025,573	888,173	241,023	361,534	7,516,300
Mkushi Farm Block	1	1 - 1	73	14	1	2,340,148	344,939	93,606	140,409	2,919,100
		1 - 2	107	20	1	3,387,286	499,288	135,491	203,237	4,225,300
		1 - 3	119	26	1	3,799,503	560,049	151,980	227,970	4,739,500
		1 - 4	156	35	1	4,966,170	732,017	198,647	297,970	6,194,800
		1 - 5	167	38	1	5,316,578	783,667	212,663	318,995	6,631,900
		1 - 6	250	42	1	7,755,892	1,143,223	310,236	465,354	9,674,700
		1 - 7	274	44	1	8,470,499	1,248,557	338,820	508,230	10,566,100
		1 - 8	301	45	1	9,260,702	1,365,033	370,428	555,642	11,551,800
Mongu	1	1 - 1	47	41	1	1,886,324	278,045	75,453	113,179	2,353,000
		1 - 2	55	48	1	2,194,084	323,409	87,763	131,645	2,736,900
		1 - 3	70	52	1	2,670,916	393,695	106,837	160,255	3,331,700
		1 - 4	76	56	1	2,888,007	425,694	115,520	173,280	3,602,500
	2	2 - 1	16	28	1	848,886	125,126	33,955	50,933	1,058,900
		2 - 2	136	52	1	4,575,677	674,458	183,027	274,541	5,707,700
		2 - 3	142	58	1	4,814,735	709,695	192,589	288,884	6,005,900
		2 - 4	147	64	1	5,024,932	740,678	200,997	301,496	6,268,100
		2 - 5	160	67	1	5,433,061	800,837	217,322	325,984	6,777,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mpika	1	1 － 1	26	9	1	928,812	136,907	37,152	55,729	1,158,600
		1 － 2	54	13	1	1,780,824	262,495	71,233	106,849	2,221,400
	2	2 － 1	51	9	1	1,650,313	243,257	66,013	99,019	2,058,600
		2 － 2	67	18	1	2,210,919	325,891	88,437	132,655	2,757,900
		2 － 3	86	25	1	2,836,139	418,049	113,446	170,168	3,537,800
		2 － 4	138	31	1	4,402,758	648,969	176,110	264,165	5,492,000
		2 － 5	156	34	1	4,955,187	730,398	198,207	297,311	6,181,100
	3	3 － 1	58	17	1	1,940,196	285,986	77,608	116,412	2,420,200
		3 － 2	154	24	1	4,787,638	705,701	191,506	287,258	5,972,100
		3 － 3	191	26	1	5,877,425	866,336	235,097	352,646	7,331,500
Mpongwe	1	1 － 1	27	6	1	924,723	136,305	36,989	55,483	1,153,500
		1 － 2	74	14	1	2,369,008	349,193	94,760	142,140	2,955,100
		1 － 3	179	24	1	5,509,139	812,051	220,366	330,548	6,872,100
		1 － 4	202	31	1	6,249,800	921,224	249,992	374,988	7,796,000
		1 － 5	206	32	1	6,376,223	939,859	255,049	382,573	7,953,700
		1 － 6	213	33	1	6,589,226	971,256	263,569	395,354	8,219,400
		1 － 7	224	34	1	6,917,669	1,019,669	276,707	415,060	8,629,100
		1 － 8	243	35	1	7,476,992	1,102,113	299,080	448,620	9,326,800
		1 － 9	245	36	1	7,545,695	1,112,240	301,828	452,742	9,412,500
		1 － 10	254	37	1	7,816,418	1,152,145	312,657	468,985	9,750,200
	2	2 － 1	38	9	1	1,275,132	187,955	51,005	76,508	1,590,600
		2 － 2	48	10	1	1,574,715	232,114	62,989	94,483	1,964,300
		2 － 3	66	11	1	2,105,179	310,305	84,207	126,311	2,626,000
	3	3 － 1	27	17	1	1,045,535	154,112	41,821	62,732	1,304,200
		3 － 2	37	34	1	1,520,843	224,173	60,834	91,251	1,897,100
		3 － 3	41	35	1	1,647,266	242,808	65,891	98,836	2,054,800
		3 － 4	57	36	1	2,120,010	312,491	84,800	127,201	2,644,500
		3 － 5	113	39	1	3,769,120	555,571	150,765	226,147	4,701,600
		3 － 6	122	40	1	4,039,843	595,475	161,594	242,391	5,039,300
		3 － 7	142	41	1	4,628,026	682,174	185,121	277,682	5,773,000

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mporokoso	1	1 － 1	15	8	1	600,369	88,495	24,015	36,022	748,900
		1 － 2	27	16	1	1,034,552	152,494	41,382	62,073	1,290,500
		1 － 3	40	22	1	1,475,629	217,509	59,025	88,538	1,840,700
		1 － 4	62	28	1	2,176,447	320,810	87,058	130,587	2,714,900
		1 － 5	90	33	1	3,039,442	448,016	121,578	182,367	3,791,400
	2	2 － 1	71	6	1	2,194,565	323,480	87,783	131,674	2,737,500
		2 － 2	74	32	1	2,566,699	378,333	102,668	154,002	3,201,700
		2 － 3	112	58	1	3,948,934	582,075	157,957	236,936	4,925,900
		2 － 4	114	66	1	4,094,517	603,534	163,781	245,671	5,107,500
		2 － 5	150	72	1	5,199,375	766,391	207,975	311,962	6,485,700
		2 － 6	158	78	1	5,496,152	810,136	219,846	329,769	6,855,900
Msoro	1	1 － 1	29	17	1	1,103,255	162,620	44,130	66,195	1,376,200
Mumbwa	1	1 － 1	11	12	1	528,860	77,954	21,154	31,732	659,700
		1 － 2	25	23	1	1,053,712	155,318	42,148	63,223	1,314,400
		1 － 3	37	33	1	1,509,861	222,554	60,394	90,592	1,883,400
		1 － 4	54	36	1	2,033,430	299,729	81,337	122,006	2,536,500
		1 － 5	98	37	1	3,314,254	488,523	132,570	198,855	4,134,200
		1 － 6	140	38	1	4,537,358	668,809	181,494	272,241	5,659,900
		1 － 7	194	39	1	6,106,782	900,144	244,271	366,407	7,617,600
	2	2 － 1	43	14	1	1,474,347	217,320	58,974	88,461	1,839,100
		2 － 2	98	22	1	3,149,511	464,240	125,980	188,971	3,928,700
		2 － 3	102	25	1	3,297,900	486,112	131,916	197,874	4,113,800
	3	3 － 1	30	20	1	1,165,063	171,731	46,603	69,904	1,453,300
		3 － 2	87	34	1	2,963,845	436,873	118,554	177,831	3,697,100
		3 － 3	125	43	1	4,159,372	613,094	166,375	249,562	5,188,400
		3 － 4	134	47	1	4,463,043	657,855	178,522	267,783	5,567,200

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Muzuma	1	1 － 1	84	7	1	2,580,728	380,401	103,229	154,844	3,219,200
		1 － 2	106	10	1	3,248,597	478,845	129,944	194,916	4,052,300
		1 － 3	118	12	1	3,616,883	533,131	144,675	217,013	4,511,700
		1 － 4	124	14	1	3,812,009	561,893	152,480	228,721	4,755,100
		1 － 5	127	16	1	3,920,555	577,892	156,822	235,233	4,890,500
	2	2 － 1	95	7	1	2,898,188	427,195	115,928	173,891	3,615,200
		2 － 2	98	14	1	3,061,648	451,289	122,466	183,699	3,819,100
	3	3 － 1	68	8	1	2,129,950	313,956	85,198	127,797	2,656,900
		3 － 2	92	10	1	2,844,557	419,289	113,782	170,673	3,548,300
Nakonde	1	1 － 1	19	10	1	737,775	108,748	29,511	44,266	920,300
		1 － 2	60	43	1	2,283,470	336,585	91,339	137,008	2,848,400
		1 － 3	156	47	1	5,097,964	751,443	203,919	305,878	6,359,200
		1 － 4	169	49	1	5,495,110	809,983	219,804	329,707	6,854,600
		1 － 5	211	51	1	6,729,197	991,888	269,168	403,752	8,394,000
		1 － 6	230	52	1	7,288,520	1,074,332	291,541	437,311	9,091,700
Nampundwe	1	1 － 1	27	38	1	1,276,174	188,109	51,047	76,570	1,591,900
		1 － 2	76	48	1	2,800,144	412,743	112,006	168,009	3,492,900
		1 － 3	101	55	1	3,598,525	530,425	143,941	215,912	4,488,800
		1 － 4	123	60	1	4,288,360	632,107	171,534	257,302	5,349,300
		1 － 5	136	63	1	4,696,489	692,265	187,860	281,789	5,858,400
		1 － 6	165	66	1	5,566,378	820,488	222,655	333,983	6,943,500
		1 － 7	196	68	1	6,483,005	955,599	259,320	388,980	8,086,900
Nchelenge	1	1 － 1	16	14	1	695,126	102,462	27,805	41,708	867,100
		1 － 2	19	20	1	847,603	124,937	33,904	50,856	1,057,300
		1 － 3	30	30	1	1,274,892	187,920	50,996	76,494	1,590,300
		1 － 4	38	34	1	1,549,703	228,427	61,988	92,982	1,933,100
		1 － 5	65	37	1	2,361,873	348,142	94,475	141,712	2,946,200
	2	2 － 1	13	19	1	663,460	97,794	26,538	39,808	827,600
		2 － 2	20	34	1	1,030,223	151,855	41,209	61,813	1,285,100
		2 － 3	66	59	1	2,632,355	388,011	105,294	157,941	3,283,600
		2 － 4	82	63	1	3,138,047	462,550	125,522	188,283	3,914,400
		2 － 5	121	65	1	4,285,554	631,693	171,422	257,133	5,345,800

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Ndola	1	1 － 1	41	33	1	1,625,301	239,570	65,012	97,518	2,027,400
		1 － 2	89	44	1	3,131,393	461,569	125,256	187,884	3,906,100
		1 － 3	99	52	1	3,507,856	517,060	140,314	210,471	4,375,700
Pensulo	1	1 － 1	10	7	1	445,086	65,606	17,803	26,705	555,200
Samfya	1	1 － 1	25	14	1	954,866	140,748	38,195	57,292	1,191,100
		1 － 2	37	15	1	1,312,169	193,415	52,487	78,730	1,636,800
		1 － 3	47	16	1	1,611,752	237,573	64,470	96,705	2,010,500
Senanga	1	1 － 1	38	38	1	1,593,635	234,903	63,745	95,618	1,987,900
	2	2 － 1	26	26	1	1,115,520	164,428	44,621	66,931	1,391,500
		2 － 2	80	38	1	2,805,756	413,570	112,230	168,345	3,499,900
		2 － 3	202	58	1	6,546,336	964,934	261,853	392,780	8,165,900
	3	3 － 1	19	19	1	836,620	123,318	33,465	50,197	1,043,600
		3 － 2	37	38	1	1,564,775	230,649	62,591	93,886	1,951,900
		3 － 3	92	50	1	3,283,870	484,045	131,355	197,032	4,096,300
Serenje	1	1 － 1	61	7	1	1,916,947	282,559	76,678	115,017	2,391,200
		1 － 2	144	21	1	4,466,089	658,304	178,644	267,965	5,571,000
		1 － 3	175	28	1	5,437,630	801,510	217,505	326,258	6,782,900
Sesheke	1	1 － 1	154	26	1	4,809,604	708,939	192,384	288,576	5,999,500
		1 － 2	161	36	1	5,121,453	754,905	204,858	307,287	6,388,500
		1 － 3	174	43	1	5,573,513	821,539	222,941	334,411	6,952,400
		1 － 4	202	49	1	6,447,491	950,364	257,900	386,849	8,042,600

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Sinazongwe	1	1 － 1	83	16	1	2,650,713	390,717	106,029	159,043	3,306,500
		1 － 2	90	20	1	2,896,665	426,970	115,867	173,800	3,613,300
		1 － 3	100	24	1	3,229,197	475,986	129,168	193,752	4,028,100
		1 － 4	106	26	1	3,424,323	504,747	136,973	205,459	4,271,500
		1 － 5	108	28	1	3,504,008	516,493	140,160	210,241	4,370,900
		1 － 6	112	30	1	3,641,414	536,747	145,657	218,485	4,542,300
		1 － 7	115	32	1	3,749,960	552,746	149,998	224,998	4,677,700
		1 － 8	120	34	1	3,916,226	577,254	156,649	234,974	4,885,100
		1 － 9	143	36	1	4,601,972	678,334	184,079	276,118	5,740,500
		1 － 10	172	38	1	5,460,879	804,937	218,435	327,653	6,811,900
		1 － 11	204	39	1	6,395,382	942,683	255,815	383,723	7,977,600
		1 － 12	208	40	1	6,521,805	961,318	260,872	391,308	8,135,300
		1 － 13	221	41	1	6,907,969	1,018,239	276,319	414,478	8,617,000
Solwezi	1	1 － 1	65	38	1	2,372,856	349,760	94,914	142,371	2,959,900
	2	2 － 1	11	10	1	506,894	74,717	20,276	30,414	632,300
		2 － 2	32	15	1	1,167,869	172,145	46,715	70,072	1,456,800
		2 － 3	41	19	1	1,471,541	216,906	58,862	88,292	1,835,600
		2 － 4	57	23	1	1,977,233	291,445	79,089	118,634	2,466,400
	3	3 － 1	52	5	1	1,635,241	241,036	65,410	98,114	2,039,800
		3 － 2	127	17	1	3,931,538	579,511	157,262	235,892	4,904,200
		3 － 3	157	22	1	4,852,253	715,225	194,090	291,135	6,052,700
		3 － 4	234	26	1	7,118,406	1,049,258	284,736	427,104	8,879,500
		3 － 5	246	30	1	7,508,658	1,106,781	300,346	450,519	9,366,300

Substation	Feeder	Package	Unit Cost (US$) & Amount			FC (US$)	LC (US$)			Total (US$)
			33kV DL	33/0.4 Tr 100kVA	33kV Bay Extension	Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(13,700)	(99,300)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Victoria Falls	1	1 － 1	64	7	1	2,003,527	295,321	80,141	120,212	2,499,200
		1 － 2	72	9	1	2,256,373	332,591	90,255	135,382	2,814,600
		1 － 3	83	10	1	2,584,816	381,004	103,393	155,089	3,224,300
		1 － 4	87	11	1	2,711,239	399,638	108,450	162,674	3,382,000
		1 － 5	94	13	1	2,935,225	432,654	117,409	176,114	3,661,400
	2	2 － 1	58	10	1	1,863,316	274,654	74,533	111,799	2,324,300
		2 － 2	116	14	1	3,581,129	527,861	143,245	214,868	4,467,100
		2 － 3	122	16	1	3,776,255	556,622	151,050	226,575	4,710,500
		2 － 4	124	18	1	3,855,940	568,368	154,238	231,356	4,809,900
		2 － 5	151	20	1	4,657,127	686,463	186,285	279,428	5,809,300
		2 － 6	155	21	1	4,783,550	705,098	191,342	287,013	5,967,000
	3	3 － 1	32	21	1	1,233,766	181,858	49,351	74,026	1,539,000
		3 － 2	71	23	1	2,381,273	351,001	95,251	142,876	2,970,400
		3 － 3	109	26	1	3,510,903	517,509	140,436	210,654	4,379,500
		3 － 4	113	28	1	3,648,308	537,763	145,932	218,899	4,550,900
		3 － 5	147	30	1	4,651,515	685,636	186,061	279,091	5,802,300
		3 － 6	151	31	1	4,777,938	704,271	191,118	286,676	5,960,000
		3 － 7	155	32	1	4,904,361	722,906	196,174	294,262	6,117,700
		3 － 8	164	34	1	5,186,067	764,430	207,443	311,164	6,469,100

Table 7-7-2 Result of Cost Estimation in each Package (Proposed Substation by ZESCO)

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			100kVA	2.5MVA	5MVA	10MVA	15MVA							
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
New SS at Chama	1	1 － 1	230	70.5	21	0	0	0.5	0	9,529,982	1,404,725	381,199	571,799	11,887,700
		1 － 2	268	70.5	29	0	0	0.5	0	10,714,526	1,579,328	428,581	642,872	13,365,300
		1 － 3	278	70.5	32	0	0	0.5	0	11,036,075	1,626,724	441,443	662,165	13,766,400
	2	2 － 1	11	70.5	6	0	0	0.5	0	3,044,893	448,819	121,796	182,694	3,798,200
		2 － 2	84	70.5	16	0	0	0.5	0	5,261,504	775,549	210,460	315,690	6,563,200
		2 － 3	130	70.5	22	0	0	0.5	0	6,654,962	980,946	266,199	399,298	8,301,400
		2 － 4	171	70.5	26	0	0	0.5	0	7,882,155	1,161,835	315,286	472,929	9,832,200
		2 － 5	189	70.5	30	0	0	0.5	0	8,445,567	1,244,882	337,823	506,734	10,535,000
New SS at Chavuma	1	1 － 1	3	72	2	1	0	0	0	2,898,349	427,218	115,934	173,901	3,615,400
		1 － 2	12	72	4	1	0	0	0	3,180,055	468,742	127,202	190,803	3,966,800
		1 － 3	17	72	6	1	0	0	0	3,346,320	493,250	133,853	200,779	4,174,200
		1 － 4	40	72	10	1	0	0	0	4,054,032	597,567	162,161	243,242	5,057,000
		1 － 5	44	72	12	1	0	0	0	4,191,438	617,821	167,658	251,486	5,228,400
		1 － 6	49	72	14	1	0	0	0	4,357,704	642,328	174,308	261,462	5,435,800
		1 － 7	54	72	16	1	0	0	0	4,523,970	666,836	180,959	271,438	5,643,200
		1 － 8	61	72	19	1	0	0	0	4,758,939	701,471	190,358	285,536	5,936,300
		1 － 9	110	72	21	1	0	0	0	6,195,046	913,154	247,802	371,703	7,727,700
		1 － 10	122	72	22	1	0	0	0	6,552,349	965,820	262,094	393,141	8,173,400
New SS at Chilundu	1	1 － 1	22	90	12	0	0	0.5	0	4,053,551	597,496	162,142	243,213	5,056,400
		1 － 2	50	90	14	0	0	0.5	0	4,883,598	719,845	195,344	293,016	6,091,800
		1 － 3	95	90	15	0	0	0.5	0	6,193,282	912,894	247,731	371,597	7,725,500
	2	2 － 1	182	90	49	0	0	0.5	0	9,077,521	1,338,032	363,101	544,651	11,323,300
		2 － 2	216	90	51	0	0	0.5	0	10,080,728	1,485,906	403,229	604,844	12,574,700
New SS at Kabompo	1	1 － 1	42	68	10	0	0	0.5	0	3,903,319	575,352	156,133	234,199	4,869,000
		1 － 2	127	68	20	0	0	0.5	0	6,466,250	953,129	258,650	387,975	8,066,000
		1 － 3	162	68	23	0	0	0.5	0	7,509,299	1,106,875	300,372	450,558	9,367,100
		1 － 4	200	68	25	0	0	0.5	0	8,627,946	1,271,765	345,118	517,677	10,762,500
	2	2 － 1	36	68	32	0	0	0.5	0	3,971,781	585,443	158,871	238,307	4,954,400
		2 － 2	86	68	50	0	0	0.5	0	5,612,474	827,282	224,499	336,748	7,001,000
		2 － 3	150	68	60	0	0	0.5	0	7,569,344	1,115,726	302,774	454,161	9,442,000
		2 － 4	182	68	63	0	0	0.5	0	8,525,814	1,256,710	341,033	511,549	10,635,100
		2 － 5	186	68	65	0	0	0.5	0	8,663,220	1,276,964	346,529	519,793	10,806,500
New SS at Lukulu	1	1 － 1	3	47.5	31	0	0	0.5	0	2,351,050	346,546	94,042	141,063	2,932,700
		1 － 2	89	47.5	43	0	0	0.5	0	4,964,807	731,816	198,592	297,888	6,193,100
		1 － 3	114	47.5	50	0	0	0.5	0	5,763,187	849,497	230,528	345,791	7,189,000
		1 － 4	127	47.5	53	0	0	0.5	0	6,171,316	909,656	246,853	370,279	7,698,100
		1 － 5	130	47.5	56	0	0	0.5	0	6,290,845	927,275	251,634	377,451	7,847,200
	2	2 － 1	20	47.5	19	0	0	0.5	0	2,709,877	399,438	108,395	162,593	3,380,300
		2 － 2	57	47.5	29	0	0	0.5	0	3,887,526	573,024	155,501	233,252	4,849,300
		2 － 3	142	47.5	35	0	0	0.5	0	6,406,526	944,326	256,261	384,392	7,991,500
		2 － 4	261	47.5	38	0	0	0.5	0	9,873,818	1,455,407	394,953	592,429	12,316,600
		2 － 5	305	47.5	41	0	0	0.5	0	11,176,607	1,647,439	447,064	670,596	13,941,700

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
New SS at Mufumbwe	1	1 － 1	14	95	4	0	1	0	0	4,135,642	609,596	165,426	248,139	5,158,800
		1 － 2	59	95	15	0	1	0	0	5,555,155	818,833	222,206	333,309	6,929,500
		1 － 3	80	95	22	0	1	0	0	6,238,095	919,499	249,524	374,286	7,781,400
		1 － 4	95	95	26	0	1	0	0	6,714,927	989,784	268,597	402,896	8,376,200
		1 － 5	150	95	35	0	1	0	0	8,401,074	1,238,324	336,043	504,064	10,479,500
		1 － 6	198	95	38	0	1	0	0	9,819,304	1,447,372	392,772	589,158	12,248,600
		1 － 7	206	95	41	0	1	0	0	10,083,133	1,486,260	403,325	604,988	12,577,700
		1 － 8	232	95	44	0	1	0	0	10,866,442	1,601,720	434,658	651,987	13,554,800
New SS at Mumbezi	1	1 － 1	31	68	9	1	0	0	0	3,655,042	538,756	146,202	219,303	4,559,300
		1 － 2	72	68	17	1	0	0	0	4,926,166	726,120	197,047	295,570	6,144,900
New SS at Mwinilunga	1	1 － 1	132	52	17	0	0	0.33	0	5,928,251	873,828	237,130	355,695	7,394,900
		1 － 2	223	52	22	0	0	0.33	0	8,609,428	1,269,035	344,377	516,566	10,739,400
		1 － 3	334	52	31	0	0	0.33	0	11,911,736	1,755,797	476,469	714,704	14,858,700
		1 － 4	446	52	36	0	0	0.33	0	15,198,974	2,240,338	607,959	911,938	18,959,200
	2	2 － 1	44	52	17	0	0	0.33	0	3,388,568	499,477	135,543	203,314	4,226,900
		2 － 2	91	52	27	0	0	0.33	0	4,854,818	715,603	194,193	291,289	6,055,900
		2 － 3	123	52	33	0	0	0.33	0	5,844,236	861,444	233,769	350,654	7,290,100
		2 － 4	153	52	37	0	0	0.33	0	6,753,968	995,539	270,159	405,238	8,424,900
	3	3 － 1	12	52	7	0	0	0.33	0	2,355,219	347,161	94,209	141,313	2,937,900
		3 － 2	22	52	11	0	0	0.33	0	2,687,751	396,176	107,510	161,265	3,352,700
New SS at Nyimba	1	1 － 1	23	53	4	1	0	0	0	2,888,248	425,730	115,530	173,295	3,602,800
		1 － 2	32	53	6	1	0	0	0	3,169,954	467,253	126,798	190,197	3,954,200
		1 － 3	38	53	8	1	0	0	0	3,365,079	496,015	134,603	201,905	4,197,600
		1 － 4	55	53	11	1	0	0	0	3,888,648	573,189	155,546	233,319	4,850,700
		1 － 5	76	53	13	1	0	0	0	4,516,675	665,761	180,667	271,000	5,634,100
		1 － 6	85	53	14	1	0	0	0	4,787,398	705,665	191,496	287,244	5,971,800
		1 － 7	147	53	17	1	0	0	0	6,609,668	974,269	264,387	396,580	8,244,900
		1 － 8	173	53	18	1	0	0	0	7,371,012	1,086,492	294,840	442,261	9,194,600
		1 － 9	190	53	19	1	0	0	0	7,872,615	1,160,428	314,905	472,357	9,820,300
New SS at Zambezi	1	1 － 1	30	47.5	11	0	0	0.5	0	2,910,614	429,026	116,425	174,637	3,630,700
		1 － 2	79	47.5	27	0	0	0.5	0	4,500,481	663,374	180,019	270,029	5,613,900
		1 － 3	81	47.5	33	0	0	0.5	0	4,624,098	681,595	184,964	277,446	5,768,100
		1 － 4	126	47.5	39	0	0	0.5	0	5,988,697	882,738	239,548	359,322	7,470,300
		1 － 5	156	47.5	44	0	0	0.5	0	6,909,412	1,018,452	276,376	414,565	8,618,800
		1 － 6	172	47.5	49	0	0	0.5	0	7,426,086	1,094,610	297,043	445,565	9,263,300
		1 － 7	221	47.5	52	0	0	0.5	0	8,873,176	1,307,912	354,927	532,391	11,068,400
		1 － 8	230	47.5	55	0	0	0.5	0	9,165,865	1,351,054	366,635	549,952	11,433,500
		1 － 9	251	47.5	56	0	0	0.5	0	9,782,908	1,442,007	391,316	586,975	12,203,200
		1 － 10	270	47.5	57	0	0	0.5	0	10,342,232	1,524,451	413,689	620,534	12,900,900
	2	2 － 1	27	47.5	18	0	0	0.5	0	2,900,914	427,597	116,037	174,055	3,618,600
		2 － 2	60	47.5	30	0	0	0.5	0	3,985,089	587,405	159,404	239,105	4,971,000
		2 － 3	83	47.5	33	0	0	0.5	0	4,681,818	690,103	187,273	280,909	5,840,100

Table 7-7-3 Result of Cost Estimation in each Package (Proposed Substation by Consultant)

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
			(36,000)	(40,000)	100kVA (13,700)	2.5MVA (600,000)	5MVA (800,000)	10MVA (1,000,000)	15MVA (1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Azele 1	1	1 － 1	6	13	32	0	0	0	0.5	1,462,562	215,583	58,502	87,754	1,824,400
		1 － 2	10	13	59	0	0	0	0.5	1,874,539	276,308	74,982	112,472	2,338,300
		1 － 3	14	13	73	0	0	0	0.5	2,143,739	315,988	85,750	128,624	2,674,100
		1 － 4	15	13	80	0	0	0	0.5	2,249,479	331,575	89,979	134,969	2,806,000
		1 － 5	27	13	87	0	0	0	0.5	2,672,679	393,955	106,907	160,361	3,333,900
	2	2 － 1	17	13	40	0	0	0	0.5	1,867,885	275,327	74,715	112,073	2,330,000
		2 － 2	37	13	57	0	0	0	0.5	2,631,794	387,928	105,272	157,908	3,282,900
		2 － 3	74	13	60	0	0	0	0.5	3,732,564	550,182	149,303	223,954	4,656,000
		2 － 4	78	13	63	0	0	0	0.5	3,880,952	572,055	155,238	232,857	4,841,100
		2 － 5	85	13	65	0	0	0	0.5	4,104,938	605,070	164,198	246,296	5,120,500
Azele 2	1	1 － 1	9	11	53	0	0	0	0.5	1,715,649	252,888	68,626	102,939	2,140,100
		1 － 2	22	11	71	0	0	0	0.5	2,288,520	337,329	91,541	137,311	2,854,700
		1 － 3	56	11	80	0	0	0	0.5	3,368,607	496,535	134,744	202,116	4,202,000
	2	2 － 1	11	11	67	0	0	0	0.5	1,927,128	284,060	77,085	115,628	2,403,900
Azele 3	1	1 － 1	4	21.5	41	0	0	0	0.5	1,776,255	261,821	71,050	106,575	2,215,700
		1 － 2	14	21.5	82	0	0	0	0.5	2,515,152	370,735	100,606	150,909	3,137,400
	2	2 － 1	7	21.5	41	0	0	0	0.5	1,862,835	274,583	74,513	111,770	2,323,700
Azele 4	1	1 － 1	46	22.5	27	0	0	0	0.5	2,866,683	422,551	114,667	172,001	3,575,900
		1 － 2	107	22.5	49	0	0	0	0.5	4,868,767	717,659	194,751	292,126	6,073,300
		1 － 3	205	22.5	71	0	0	0	0.5	7,938,672	1,170,165	317,547	476,320	9,902,700
		1 － 4	220	22.5	86	0	0	0	0.5	8,536,316	1,258,258	341,453	512,179	10,648,200
	2	2 － 1	23	22.5	22	0	0	0	0.5	2,147,988	316,615	85,920	128,879	2,679,400
		2 － 2	31	22.5	44	0	0	0	0.5	2,620,491	386,262	104,820	157,229	3,268,800
		2 － 3	71	22.5	63	0	0	0	0.5	3,983,566	587,180	159,343	239,014	4,969,100
		2 － 4	101	22.5	65	0	0	0	0.5	4,871,332	718,037	194,853	292,280	6,076,500
		2 － 5	129	22.5	66	0	0	0	0.5	5,690,396	838,768	227,616	341,424	7,098,200
Azele 5	1	1 － 1	23	33	75	0	0	0	1	3,587,863	528,853	143,515	215,272	4,475,500
		1 － 2	43	33	110	0	0	0	1	4,549,463	670,594	181,979	272,968	5,675,000
		1 － 3	60	33	137	0	0	0	1	5,336,620	786,621	213,465	320,197	6,656,900
Azele 6	1	1 － 1	12	20	10	0	0	0.5	0	1,498,317	220,853	59,933	89,899	1,869,000
		1 － 2	99	20	36	0	0	0.5	0	4,294,693	633,040	171,788	257,682	5,357,200
		1 － 3	131	20	42	0	0	0.5	0	5,284,111	778,881	211,364	317,047	6,591,400
		1 － 4	145	20	43	0	0	0.5	0	5,699,134	840,056	227,965	341,948	7,109,100
	2	2 － 1	16	20	14	0	0	0.5	0	1,657,688	244,344	66,308	99,461	2,067,800
		2 － 2	51	20	25	0	0	0.5	0	2,788,600	411,041	111,544	167,316	3,478,500

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Isoka 1	1	1 － 1	14	75	33	0	0	0.33	0	3,436,027	506,473	137,441	206,162	4,286,100
	2	2 － 1	9	75	32	0	0	0.33	0	3,280,744	483,584	131,230	196,845	4,092,400
	3	3 － 1	50	75	15	0	0	0.33	0	4,277,297	630,476	171,092	256,638	5,335,500
Kabwe 1	1	1 － 1	8	26	42	0	1	0	0	2,167,228	319,451	86,689	130,034	2,703,400
		1 － 2	27	26	49	0	1	0	0	2,792,448	411,609	111,698	167,547	3,483,300
		1 － 3	43	26	53	0	1	0	0	3,298,140	486,148	131,926	197,888	4,114,100
Kabwe 2	1	1 － 1	1	38	47	0	0	1	0	2,565,256	378,120	102,610	153,915	3,199,900
		1 － 2	56	38	68	0	0	1	0	4,383,197	646,086	175,328	262,992	5,467,600
Kasama 1	1	1 － 1	1	12	67	0	0	1	0	1,951,178	287,605	78,047	117,071	2,433,900
		1 － 2	36	12	77	0	0	1	0	3,071,108	452,683	122,844	184,266	3,830,900
		1 － 3	55	12	80	0	0	1	0	3,652,397	538,366	146,096	219,144	4,556,000
Kasama 2	1	1 － 1	1	66	49	0	0	1	0	3,485,089	513,704	139,404	209,105	4,347,300
		1 － 2	6	66	66	0	0	1	0	3,816,097	562,495	152,644	228,966	4,760,200
		1 － 3	40	66	74	0	0	1	0	4,885,201	720,082	195,408	293,112	6,093,800
		1 － 4	66	66	80	0	0	1	0	5,701,459	840,399	228,058	342,088	7,112,000
Luano 1	1	1 － 1	33	41.5	11	0	0.5	0	0	2,724,627	401,612	108,985	163,478	3,398,700
		1 － 2	39	41.5	16	0	0.5	0	0	2,952,702	435,230	118,108	177,162	3,683,200
		1 － 3	45	41.5	19	0	0.5	0	0	3,158,810	465,611	126,352	189,529	3,940,300
		1 － 4	50	41.5	21	0	0.5	0	0	3,325,076	490,118	133,003	199,505	4,147,700
		1 － 5	60	41.5	22	0	0.5	0	0	3,624,659	534,277	144,986	217,480	4,521,400
	2	2 － 1	34	41.5	13	0	0.5	0	0	2,775,453	409,104	111,018	166,527	3,462,100
		2 － 2	57	41.5	21	0	0.5	0	0	3,527,096	519,896	141,084	211,626	4,399,700
		2 － 3	84	41.5	26	0	0.5	0	0	4,361,231	642,848	174,449	261,674	5,440,200
		2 － 4	94	41.5	28	0	0.5	0	0	4,671,797	688,626	186,872	280,308	5,827,600
Luano 2	1	1 － 1	20	44	21	0	1	0	0	2,860,109	421,582	114,404	171,607	3,567,700
		1 － 2	38	44	33	0	1	0	0	3,511,384	517,580	140,455	210,683	4,380,100
		1 － 3	55	44	39	0	1	0	0	4,067,901	599,611	162,716	244,074	5,074,300
		1 － 4	62	44	42	0	1	0	0	4,302,870	634,246	172,115	258,172	5,367,400
		1 － 5	77	44	48	0	1	0	0	4,801,667	707,769	192,067	288,100	5,989,600
		1 － 6	85	44	49	0	1	0	0	5,043,531	743,420	201,741	302,612	6,291,300
Lundazi 1	1	1 － 1	2	46	25	0	1	0	0	2,448,693	360,939	97,948	146,922	3,054,500
		1 － 2	8	46	32	0	1	0	0	2,698,733	397,795	107,949	161,924	3,366,400
		1 － 3	19	46	35	0	1	0	0	3,128,748	461,179	125,150	187,725	3,902,800

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Luwingu 1	1	1 － 1	24	50	27	0	0	1	0	3,394,180	500,304	135,767	203,651	4,233,900
		1 － 2	42	50	50	0	0	1	0	4,166,266	614,110	166,651	249,976	5,197,000
		1 － 3	47	50	59	0	0	1	0	4,409,412	649,950	176,376	264,565	5,500,300
		1 － 4	71	50	65	0	0	1	0	5,167,949	761,759	206,718	310,077	6,446,500
		1 － 5	80	50	71	0	0	1	0	5,493,587	809,758	219,743	329,615	6,852,700
Luwingu 2	1	1 － 1	11	37	25	0	0	0	0.5	2,299,583	338,960	91,983	137,975	2,868,500
		1 － 2	44	37	37	0	0	0	0.5	3,383,758	498,768	135,350	203,026	4,220,900
		1 － 3	63	37	47	0	0	0	0.5	4,041,927	595,783	161,677	242,516	5,041,900
		1 － 4	81	37	56	0	0	0	0.5	4,660,253	686,924	186,410	279,615	5,813,200
		1 － 5	113	37	63	0	0	0	0.5	5,660,654	834,384	226,426	339,639	7,061,100
	2	2 － 1	19	37	28	0	0	0	0.5	2,563,412	377,849	102,536	153,805	3,197,600
		2 － 2	37	37	47	0	0	0	0.5	3,291,566	485,179	131,663	197,494	4,105,900
		2 － 3	44	37	61	0	0	0	0.5	3,647,346	537,621	145,894	218,841	4,549,700
		2 － 4	72	37	72	0	0	0	0.5	4,576,239	674,540	183,050	274,574	5,708,400
		2 － 5	79	37	78	0	0	0	0.5	4,844,156	714,032	193,766	290,649	6,042,600
Luwingu 3	1	1 － 1	13	26	17	0	0	0.5	0	1,796,457	264,799	71,858	107,787	2,240,900
		1 － 2	19	26	25	0	0	0.5	0	2,057,480	303,274	82,299	123,449	2,566,500
		1 － 3	41	26	38	0	0	0.5	0	2,835,177	417,907	113,407	170,111	3,536,600
	2	2 － 1	8	26	27	0	0	0.5	0	1,761,985	259,718	70,479	105,719	2,197,900
		2 － 2	15	26	38	0	0	0.5	0	2,084,816	307,303	83,393	125,089	2,600,600
		2 － 3	20	26	46	0	0	0.5	0	2,316,979	341,524	92,679	139,019	2,890,200
		2 － 4	32	26	53	0	0	0.5	0	2,740,180	403,904	109,607	164,411	3,418,100
		2 － 5	44	26	56	0	0	0.5	0	3,119,448	459,809	124,778	187,167	3,891,200
Mazabuka 1	1	1 － 1	14	20	4	0	0	0.33	0	1,353,856	199,559	54,154	81,231	1,688,800
		1 － 2	42	20	14	0	0	0.33	0	2,271,765	334,860	90,871	136,306	2,833,800
		1 － 3	68	20	17	0	0	0.33	0	3,055,075	450,320	122,203	183,304	3,810,900
		1 － 4	80	20	19	0	0	0.33	0	3,423,361	504,606	136,934	205,402	4,270,300
	2	2 － 1	26	20	13	0	0	0.33	0	1,799,022	265,177	71,961	107,941	2,244,100
		2 － 2	38	20	23	0	0	0.33	0	2,255,171	332,414	90,207	135,310	2,813,100
		2 － 3	68	20	31	0	0	0.33	0	3,208,834	472,984	128,353	192,530	4,002,700
		2 － 4	73	20	35	0	0	0.33	0	3,397,066	500,730	135,883	203,824	4,237,500
		2 － 5	88	20	40	0	0	0.33	0	3,884,881	572,634	155,395	233,093	4,846,000
		2 － 6	108	20	43	0	0	0.33	0	4,495,030	662,570	179,801	269,702	5,607,100
	3	3 － 1	43	20	18	0	0	0.33	0	2,344,557	345,589	93,782	140,673	2,924,600
		3 － 2	58	20	21	0	0	0.33	0	2,810,406	414,256	112,416	168,624	3,505,700
		3 － 3	66	20	24	0	0	0.33	0	3,074,234	453,144	122,969	184,454	3,834,800
		3 － 4	71	20	26	0	0	0.33	0	3,240,500	477,652	129,620	194,430	4,042,200
		3 － 5	78	20	28	0	0	0.33	0	3,464,486	510,667	138,579	207,869	4,321,600
		3 － 6	86	20	30	0	0	0.33	0	3,717,332	547,937	148,693	223,040	4,637,000
		3 － 7	104	20	33	0	0	0.33	0	4,269,761	629,365	170,790	256,186	5,326,100
		3 － 8	114	20	36	0	0	0.33	0	4,591,310	676,762	183,652	275,479	5,727,200
		3 － 9	120	20	38	0	0	0.33	0	4,786,436	705,524	191,457	287,186	5,970,600

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mbereshi 1	1	1 － 1	17	25	31	0	0	0	0.5	2,153,840	317,477	86,154	129,230	2,686,700
		1 － 2	23	25	38	0	0	0	0.5	2,403,880	354,333	96,155	144,233	2,998,600
		1 － 3	53	25	44	0	0	0	0.5	3,335,578	491,666	133,423	200,135	4,160,800
		1 － 4	67	25	47	0	0	0	0.5	3,772,567	556,079	150,903	226,354	4,705,900
		1 － 5	75	25	48	0	0	0	0.5	4,014,430	591,730	160,577	240,866	5,007,600
	2	2 － 1	6	25	15	0	0	0	0.5	1,660,654	244,781	66,426	99,639	2,071,500
		2 － 2	25	25	42	0	0	0	0.5	2,505,532	369,317	100,221	150,332	3,125,400
		2 － 3	36	25	61	0	0	0	0.5	3,031,666	446,869	121,267	181,900	3,781,700
		2 － 4	75	25	69	0	0	0	0.5	4,245,070	625,726	169,803	254,704	5,295,300
		2 － 5	88	25	75	0	0	0	0.5	4,686,147	690,741	187,446	281,169	5,845,500
		2 － 6	111	25	79	0	0	0	0.5	5,393,859	795,058	215,754	323,632	6,728,300
Mfuwe 1	1	1 － 1	11	32	13	0	1	0	0	2,127,706	313,625	85,108	127,662	2,654,100
		1 － 2	28	32	24	0	1	0	0	2,739,137	403,751	109,566	164,348	3,416,800
		1 － 3	32	32	31	0	1	0	0	2,931,457	432,099	117,258	175,887	3,656,700
		1 － 4	48	32	36	0	1	0	0	3,448,132	508,257	137,925	206,888	4,301,200
		1 － 5	51	32	40	0	1	0	0	3,578,644	527,494	143,146	214,719	4,464,000
		1 － 6	80	32	42	0	1	0	0	4,437,550	654,098	177,502	266,253	5,535,400
Mongu 1	1	1 － 1	58	26	22	0	0	0	0.5	3,270,322	482,048	130,813	196,219	4,079,400
		1 － 2	86	26	38	0	0	0	0.5	4,254,129	627,061	170,165	255,248	5,306,600
		1 － 3	94	26	46	0	0	0	0.5	4,572,872	674,044	182,915	274,372	5,704,200
		1 － 4	97	26	53	0	0	0	0.5	4,736,332	698,138	189,453	284,180	5,908,100
		1 － 5	236	26	72	0	0	0	0.5	8,956,550	1,320,201	358,262	537,393	11,172,400
	2	2 － 1	60	26	25	0	0	0	0.5	3,360,991	495,412	134,440	201,659	4,192,500
		2 － 2	64	26	37	0	0	0	0.5	3,608,225	531,855	144,329	216,494	4,500,900
		2 － 3	77	26	46	0	0	0	0.5	4,082,251	601,726	163,290	244,935	5,092,200
		2 － 4	100	26	58	0	0	0	0.5	4,877,826	718,995	195,113	292,670	6,084,600
		2 － 5	136	26	65	0	0	0	0.5	5,993,667	883,470	239,747	359,620	7,476,500
		2 － 6	155	26	71	0	0	0	0.5	6,607,904	974,009	264,316	396,474	8,242,700
		2 － 7	161	26	76	0	0	0	0.5	6,835,979	1,007,628	273,439	410,159	8,527,200
		2 － 8	185	26	80	0	0	0	0.5	7,572,551	1,116,199	302,902	454,353	9,446,000
Mongu 2	1	1 － 1	3	19	22	0	0	0	0.5	1,458,554	214,992	58,342	87,513	1,819,400
		1 － 2	15	19	43	0	0	0	0.5	2,035,514	300,036	81,421	122,131	2,539,100
		1 － 3	42	19	64	0	0	0	0.5	3,045,374	448,890	121,815	182,722	3,798,800
		1 － 4	51	19	66	0	0	0	0.5	3,327,080	490,414	133,083	199,625	4,150,200
	2	2 － 1	31	19	48	0	0	0	0.5	2,552,189	376,194	102,088	153,131	3,183,600
		2 － 2	58	19	70	0	0	0	0.5	3,573,032	526,667	142,921	214,382	4,457,000
		2 － 3	71	19	92	0	0	0	0.5	4,189,835	617,584	167,593	251,390	5,226,400
		2 － 4	93	19	95	0	0	0	0.5	4,857,704	716,029	194,308	291,462	6,059,500

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Mpika 1	1	1 － 1	74	52.5	31	0	0	0.5	0	4,560,446	672,213	182,418	273,627	5,688,700
		1 － 2	108	52.5	45	0	0	0.5	0	5,695,447	839,512	227,818	341,727	7,104,500
	2	2 － 1	33	52.5	21	0	0	0.5	0	3,267,356	481,610	130,694	196,041	4,075,700
		2 － 2	168	52.5	39	0	0	0.5	0	7,361,151	1,085,038	294,446	441,669	9,182,300
		2 － 3	216	52.5	46	0	0	0.5	0	8,823,313	1,300,562	352,933	529,399	11,006,200
Mpika 2	1	1 － 1	57	78	15	0	1	0	0	4,952,301	729,972	198,092	297,138	6,177,500
		1 － 2	118	78	30	0	1	0	0	6,877,505	1,013,749	275,100	412,650	8,579,000
		1 － 3	124	78	39	0	1	0	0	7,149,511	1,053,842	285,980	428,971	8,918,300
Muzuma 1	1	1 － 1	39	11	16	0	0	0	0.33	1,997,916	294,494	79,917	119,875	2,492,200
		1 － 2	46	11	30	0	0	0	0.33	2,353,696	346,936	94,148	141,222	2,936,000
		1 － 3	100	11	42	0	0	0	0.33	4,043,931	596,078	161,757	242,636	5,044,400
		1 － 4	117	11	49	0	0	0	0.33	4,611,432	679,728	184,457	276,686	5,752,300
		1 － 5	168	11	56	0	0	0	0.33	6,160,173	908,013	246,407	369,610	7,684,200
		1 － 6	306	11	58	0	0	0	0.33	10,164,823	1,498,301	406,593	609,889	12,679,600
		1 － 7	319	11	59	0	0	0	0.33	10,550,986	1,555,222	422,039	633,059	13,161,300
	2	2 － 1	32	11	27	0	0	0	0.33	1,916,707	282,524	76,668	115,002	2,390,900
		2 － 2	118	11	35	0	0	0	0.33	4,486,532	661,318	179,461	269,192	5,596,500
		2 － 3	142	11	43	0	0	0	0.33	5,267,035	776,364	210,681	316,022	6,570,100
	3	3 － 1	40	11	12	0	0	0	0.33	1,982,844	292,273	79,314	118,971	2,473,400
		3 － 2	105	11	15	0	0	0	0.33	3,891,695	573,638	155,668	233,502	4,854,500
		3 － 3	120	11	16	0	0	0	0.33	4,335,578	639,067	173,423	260,135	5,408,200
Muzuma 2	1	1 － 1	66	46	20	0	0	0.5	0	4,000,321	589,650	160,013	240,019	4,990,000
		1 － 2	75	46	27	0	0	0.5	0	4,336,941	639,268	173,478	260,216	5,409,900
		1 － 3	95	46	41	0	0	0.5	0	5,067,901	747,012	202,716	304,074	6,321,700
		1 － 4	114	46	47	0	0	0.5	0	5,682,139	837,551	227,286	340,928	7,087,900
		1 － 5	145	46	49	0	0	0.5	0	6,598,765	972,662	263,951	395,926	8,231,300
	2	2 － 1	12	46	48	0	0	0.5	0	2,749,399	405,263	109,976	164,964	3,429,600
Muzuma 3	1	1 － 1	16	39	25	0	0	0.5	0	2,387,767	351,958	95,511	143,266	2,978,500
		1 － 2	26	39	36	0	0	0.5	0	2,797,178	412,306	111,887	167,831	3,489,200
		1 － 3	39	39	40	0	0	0.5	0	3,216,290	474,083	128,652	192,977	4,012,000
	2	2 － 1	8	39	17	0	0	0.5	0	2,069,024	304,975	82,761	124,141	2,580,900
		2 － 2	15	39	25	0	0	0.5	0	2,358,907	347,704	94,356	141,534	2,942,500
		2 － 3	41	39	29	0	0	0.5	0	3,153,199	464,783	126,128	189,192	3,933,300
		2 － 4	48	39	33	0	0	0.5	0	3,399,150	501,037	135,966	203,949	4,240,100
		2 － 5	54	39	36	0	0	0.5	0	3,605,259	531,417	144,210	216,316	4,497,200
		2 － 6	63	39	39	0	0	0.5	0	3,897,948	574,560	155,918	233,877	4,862,300
Nchelenge 1	1	1 － 1	4	44	9	0	0	0.5	0	2,026,054	298,642	81,042	121,563	2,527,300
		1 － 2	32	44	29	0	0	0.5	0	3,053,792	450,131	122,152	183,228	3,809,300
		1 － 3	46	44	40	0	0	0.5	0	3,578,644	527,494	143,146	214,719	4,464,000
	2	2 － 1	1	44	8	0	0	0.5	0	1,928,491	284,261	77,140	115,709	2,405,600
		2 － 2	49	44	18	0	0	0.5	0	3,423,601	504,641	136,944	205,416	4,270,600
		2 － 3	70	44	42	0	0	0.5	0	4,293,250	632,828	171,730	257,595	5,355,400
		2 － 4	103	44	48	0	0	0.5	0	5,311,528	782,923	212,461	318,692	6,625,600

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Ndola 1	1	1 － 1	4	14	45	0	0	1	0	1,860,269	274,205	74,411	111,616	2,320,500
		1 － 2	7	14	74	0	0	1	0	2,265,352	333,914	90,614	135,921	2,825,800
		1 － 3	16	14	81	0	0	1	0	2,601,972	383,532	104,079	156,118	3,245,700
		1 － 4	20	14	82	0	0	1	0	2,728,395	402,167	109,136	163,704	3,403,400
Mwinilunga 1	1	1 － 1	1	60	24	0	1	0	0	2,857,784	421,239	114,311	171,467	3,564,800
		1 － 2	28	60	36	0	1	0	0	3,768,799	555,523	150,752	226,128	4,701,200
		1 － 3	41	60	40	0	1	0	0	4,187,911	617,301	167,516	251,275	5,224,000
		1 － 4	60	60	43	0	1	0	0	4,769,200	702,983	190,768	286,152	5,949,100
Zambezi 1	1	1 － 1	35	53	12	0	1	0	0	3,482,764	513,362	139,311	208,966	4,344,400
		1 － 2	47	53	22	0	1	0	0	3,938,913	580,598	157,557	236,335	4,913,400
		1 － 3	63	53	29	0	1	0	0	4,477,553	659,994	179,102	268,653	5,585,300
		1 － 4	69	53	35	0	1	0	0	4,716,611	695,231	188,664	282,997	5,883,500
		1 － 5	86	53	37	0	1	0	0	5,229,197	770,787	209,168	313,752	6,522,900
		1 － 6	124	53	38	0	1	0	0	6,336,861	934,057	253,474	380,212	7,904,600
Pensulo 1	1	1 － 1	31	15.5	7	0	0	0.5	0	1,869,408	275,552	74,776	112,165	2,331,900
		1 － 2	40	15.5	14	0	0	0.5	0	2,206,029	325,170	88,241	132,362	2,751,800
		1 － 3	57	15.5	21	0	0	0.5	0	2,773,529	408,820	110,941	166,412	3,459,700
		1 － 4	94	15.5	35	0	0	0.5	0	3,995,110	588,882	159,804	239,707	4,983,500
	2	2 － 1	26	15.5	25	0	0	0.5	0	1,922,799	283,422	76,912	115,368	2,398,500
		2 － 2	34	15.5	32	0	0	0.5	0	2,230,560	328,786	89,222	133,834	2,782,400
		2 － 3	64	15.5	39	0	0	0.5	0	3,173,240	467,738	126,930	190,394	3,958,300
		2 － 4	71	15.5	45	0	0	0.5	0	3,441,158	507,229	137,646	206,469	4,292,500
		2 － 5	87	15.5	51	0	0	0.5	0	3,968,815	585,006	158,753	238,129	4,950,700
Pensulo 2	1	1 － 1	36	51.5	14	0	0	0.5	0	3,244,990	478,314	129,800	194,699	4,047,800
		1 － 2	77	51.5	28	0	0	0.5	0	4,582,011	675,391	183,280	274,921	5,715,600
		1 － 3	115	51.5	35	0	0	0.5	0	5,755,572	848,375	230,223	345,334	7,179,500
		1 － 4	122	51.5	42	0	0	0.5	0	6,034,472	889,485	241,379	362,068	7,527,400
		1 － 5	171	51.5	49	0	0	0.5	0	7,525,493	1,109,262	301,020	451,530	9,387,300
	2	2 － 1	214	51.5	52	0	0	0.5	0	8,799,423	1,297,040	351,977	527,965	10,976,400
		2 － 2	238	51.5	58	0	0	0.5	0	9,557,961	1,408,849	382,318	573,478	11,922,600
		2 － 3	250	51.5	59	0	0	0.5	0	9,915,264	1,461,516	396,611	594,916	12,368,300

Substation	Feeder	Package	Unit Cost (US$) & Amount							FC (US$)	LC (US$)			Total (US$)
			33kV DL	66kV TL	33/0.4 Tr	New SS				Foreign Costs	Domestic Costs	Skilled Labor	Unskilled Labor	
					100kVA	2.5MVA	5MVA	10MVA	15MVA					
			(36,000)	(40,000)	(13,700)	(600,000)	(800,000)	(1,000,000)	(1,300,000)	(0.80166747)	(0.11816629)	(0.0320667)	(0.04810005)	
Samfya 1	1	1 － 1	57	19.5	11	0	0	0.5	0	2,791,967	411,538	111,679	167,518	3,482,700
		1 － 2	77	19.5	17	0	0	0.5	0	3,435,065	506,331	137,403	206,104	4,284,900
		1 － 3	84	19.5	22	0	0	0.5	0	3,691,999	544,203	147,680	221,520	4,605,400
		1 － 4	108	19.5	26	0	0	0.5	0	4,428,571	652,774	177,143	265,714	5,524,200
		1 － 5	127	19.5	30	0	0	0.5	0	5,020,843	740,075	200,834	301,251	6,263,000
	2	2 － 1	1	19.5	13	0	0	0.5	0	1,197,771	176,552	47,911	71,866	1,494,100
		2 － 2	25	19.5	24	0	0	0.5	0	2,011,223	296,456	80,449	120,673	2,508,800
		2 － 3	57	19.5	43	0	0	0.5	0	3,143,418	463,342	125,737	188,605	3,921,100
Samfya 2	1	1 － 1	28	19	33	0	0	0.5	0	2,180,616	321,424	87,225	130,837	2,720,100
		1 － 2	66	19	39	0	0	0.5	0	3,343,194	492,789	133,728	200,592	4,170,300
		1 － 3	70	19	45	0	0	0.5	0	3,524,531	519,518	140,981	211,472	4,396,500
	2	2 － 1	16	19	21	0	0	0.5	0	1,702,501	250,950	68,100	102,150	2,123,700
		2 － 2	24	19	31	0	0	0.5	0	2,043,210	301,170	81,728	122,593	2,548,700
Senanga 1	1	1 － 1	1	118	16	0	0	1	0	4,790,123	706,067	191,605	287,407	5,975,200
		1 － 2	184	118	50	0	0	1	0	10,444,925	1,539,589	417,797	626,696	13,029,000
		1 － 3	232	118	68	0	0	1	0	12,027,898	1,772,920	481,116	721,674	15,003,600
		1 － 4	266	118	76	0	0	1	0	13,097,002	1,930,506	523,880	785,820	16,337,200
Senanga 2	1	1 － 1	8	11	12	0	0.5	0	0	1,036,075	152,718	41,443	62,165	1,292,400
		1 － 2	20	11	19	0	0.5	0	0	1,459,275	215,098	58,371	87,557	1,820,300
		1 － 3	52	11	27	0	0.5	0	0	2,470,659	364,177	98,826	148,240	3,081,900
	2	2 － 1	24	11	14	0	0.5	0	0	1,519,801	224,020	60,792	91,188	1,895,800
		2 － 2	38	11	24	0	0.5	0	0	2,033,670	299,764	81,347	122,020	2,536,800
Senanga 3	1	1 － 1	30	11.5	39	0	0	0	0.5	2,183,983	321,920	87,359	131,039	2,724,300
		1 － 2	87	11.5	63	0	0	0	0.5	4,092,593	603,251	163,704	245,556	5,105,100
	2	2 － 1	18	11.5	36	0	0	0	0.5	1,804,714	266,016	72,189	108,283	2,251,200
		2 － 2	46	11.5	50	0	0	0	0.5	2,766,554	407,792	110,662	165,993	3,451,000
		2 － 3	140	11.5	66	0	0	0	0.5	5,655,123	833,569	226,205	339,307	7,054,200
Sesheke 1	1	1 － 1	37	107	9	0	1	0	0	5,239,137	772,252	209,566	314,348	6,535,300
		1 － 2	62	107	16	0	1	0	0	6,037,518	889,934	241,501	362,251	7,531,200
		1 － 3	120	107	22	0	1	0	0	7,777,297	1,146,378	311,092	466,638	9,701,400
		1 － 4	154	107	28	0	1	0	0	8,824,435	1,300,727	352,977	529,466	11,007,600
		1 － 5	164	107	33	0	1	0	0	9,167,949	1,351,362	366,718	550,077	11,436,100
		1 － 6	253	107	36	0	1	0	0	11,769,440	1,734,823	470,778	706,166	14,681,200
		1 － 7	274	107	39	0	1	0	0	12,408,450	1,829,013	496,338	744,507	15,478,300
		1 － 8	293	107	41	0	1	0	0	12,978,756	1,913,077	519,150	778,725	16,189,700
Sesheke 2	1	1 － 1	95	45	17	0	1	0	0	5,012,747	738,882	200,510	300,765	6,252,900
		1 － 2	437	45	32	0	1	0	0	15,047,619	2,218,029	601,905	902,857	18,770,400
		1 － 3	450	45	35	0	1	0	0	15,455,748	2,278,187	618,230	927,345	19,279,500
		1 － 4	477	45	40	0	1	0	0	16,289,883	2,401,139	651,595	977,393	20,320,000

7.6. Discussion on Low Cost Electrification

7.6.1. Present Situation

We had a discussion with REA and ZESCO, and following contents were confirmed.

- Commission year's demand is used for distribution system design.
- As for the voltage calculation for distribution line, it is carried out by hand calculation by ordinary. In case more detailed calculation is needed, PSS/E (Power System Simulation for Engineers) is used.
- The design and construction of distribution line is carried out according to the ZESCO standard. This standard was established referring to British standard (BS).
- To reduce the distribution cost, SWER (Single Wire Earth Return) system is adopted in a part of distribution system.
- Some conductor disconnection accidents were occurred by the thunder.

7.6.2. Present Situation

Based on the result of present situation, following contents were proposed.

- If distribution system is designed by using the commission year's demand, it has a possibility to construct new distribution line shortly after new distribution line construction is finished. Therefore, it is necessary to make the distribution system reasonable in consideration of the future plan (future demand, distribution system planning around the target area), distribution system loss and so on.
- Distribution line route will be selected in consideration of distance, road condition, geographical condition, etc. In addition, distribution system will be expanded and constitute the complex network in the future, and some loads of substation may be shift to other substations or construct new substation. Depending on this situation, it is recommended to adopt the software that could carry out distribution analysis easily base on the map information system. The following table shows the comparison of some kinds of software.
- The facility cost of SWER is cheaper, but this it is easy to cause the unbalance of phase current by this system. Therefore, it is necessary to adjust the load on each phase to control the phase current.
- As the ground wire is not applied to 33kV distribution line, the conductor disconnection by the thunder is occurred in some area. Therefore, it is necessary to collect and analyse the accident data, and compare the total cost of facility cost and O&M cost in the case of with or without ground wire. If the total cost is reduced in the case of with ground wire, it is recommended to modify the existing facilities in that area.

	Software	SynerGEE Electric	CYMDIST	PSS/ADEPT	PSS/Engines
	Company	ADVANTICA (USA)	CYME (Canada)	Shaw Power Technologies International (USA)	Shaw Power Technologies International (USA)
	System Modeling	Stand-Alone	Stand-Alone	Stand-Alone	Enterprise-Wide (Application Programming Interface)
	PC Requirement	Windows NT/2000/XP Intel Pentium II or higher	Windows 95/98/ME/NT/2000/XP Pentium based CPU	Windows ME/2000/XP	-
	User Interface	Geographical Background	Geographical Background	One-Line Diagram	-
Loss Reduction	Load Flow Analysis	Basic Module	Basic Module	Basic Module	Basic Module
	Load Balancing	Basic Module	Basic Module	-	-
	Optimal Switching (System Reconfiguration)	Switching Module (Add-on Module)	Switching Optimization Module (Add-on Module)	Tie Open Point Optimization (Add-on Module)	Tie Open Point Optimization (Add-on Module)
	Optimal Capacitor Placement	Basic Module	Basic Module	Capacitor Placement Optimization (Add-on Module)	Capacitor Placement Optimization (Add-on Module)
	Re-Conductoring	-	Basic Module	Basic Module	Basic Module
	Re-Phasing	-	Basic Module	-	-
	Geographic Information System (GIS)	Middle Link(Add-on Module)	Geographic Map Overlay Module (Add-on Module)	-	Basic Module
Functions	Line Property Calculation	Basic Module	Basic Module	Line Properties Calculator(Add-on Module)	Line Properties Calculator(Add-on Module)
	Load Scaling	Basic Module	Basic Module	-	Load Scaling(Add-on Module)
	Load Growth Study	Basic Module	Basic Module	-	-
	RMS Fault Analysis	Basic Module	Basic Module	Basic Module	Basic Module
	Contingency Analysis (System Restoration)	Switching Module (Add-on Module)	Contingency Analysis Module (Add-on Module)	-	-
	Protection and Coordination	Protection Coordination (Add-on Module)	CYMTCC (Add-on Module)	Protection and Coordination (Add-on Module)	Protection and Coordination (Add-on Module)
	Reliability Analysis	Basic Module(Only Basic Analysis)/ Predictive Reliability(Add-on Module)	Reliability Assessment Module (Add-on Module)	Distribution Reliability Analysis (Add-on Module)	Distribution Reliability Analysis (Add-on Module)
	Motor Starting Analysis	Motor Start Analysis(Add-on Module)	Basic Module	Basic Module	Basic Module
	Harmonic Analysis	Additional Module	Harmonic Analysis Module(Add-on Module)	Harmonics(Add-on Module)	Harmonics(Add-on Module)
	Optimal Voltage Regulator Placement	-	-	-	Voltage Regulator Placement Optimization (Add-on Module)
	Time Based Load Modeling	Basic Module	-	-	-
	GIS Data Format	AutoDesk - AutoCAD(.dxf and .dwg) ESRI - ArcView(.shp) Bentley Systems - Microstation(.dgn) MapInfo - MapInfo(.mif) Raster file formats - .tiff / .jpg / .bmp	AutoDesk - AutoCAD(.dxf and .dwg) ESRI - ArcView(.shp) Bentley Systems - Microstation(.dgn) Intergraph - GeoMedia GE Energy - SmallWorld Raster file formats - .bmp	Raster file formats - .tiff / .jpg / .bmp	Several kinds of GIS data format (unidentified)
	Remarks	SynerGEE Electric has users around the world, particularly Philippines in Asia. This tool includes functions needed for Loss Reduction and GIS. ADVANTICA provides Gas distribution, Electric and Petroleum software. They are dominant position in the US Gas distribution software market.	CYMDIST is recommended as the most suitable tool for distribution analysis by Oak Ridge National Laboratory (USA) in their technical report. A utility has handled up to 250,000 sections and 3.4 million customers with CYMDIST. CGI-CYME totally develops Electrical Engineering tools.	PSS/ADEPT creates one-line diagram for distribution system analysis, which is commonly used for transmission system analysis. PTI totally develops Electrical Engineering tools.	PSS/Engines must be embedded in enterprise-wide system, which means that this tool is application programming interface (API) and does not have user interface. API prepares the tools for each analysis, so programmer is not needed to be experts in that field. However, user needs to built user interface themselves.