ENTRO

EASTERN NILE POWER TRADE PROGRAM STUDY

AfDB

Analysis of the network expansion plan In the year 2015/2016

VOL 3.2 - ETHIOPIA

FINAL REPORT

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with participation of:

- EPS (Egypt)
- Tropics (Ethiopia)
- YAM (Sudan)

TABLE OF CONTENTS

PHYSICAL UNITS AND CONVERSION FACTORS

bbl	barrel (1t = 7.3 bbl)
cal	calorie (1 cal = 4.1868 J)
Gcal	Giga calorie
GWh	Gigawatt-hour
h	hour
km	kilometer
km^2	square kilometer
kW	kilo Watt
kWh	kilo Watt hour (1 kWh = 3.6 MJ)
MBtu	Million British Thermal Units (= 1 055 MJ = 252 kCal)
	One cubic foot of natural gas produces approximately 1,000 BTU
MJ	Million Joule (= $0{,}948.10^{-3}$ Mbtu = 238.8 kCal)
MW	Mega Watt
m	meter
m^3/d	cubic meter per day
mm	millimeter
mm^3	million cubic meter
Nm^3	Normal cubic meter, i.e. measured under normal conditions, i.e. 0℃ and 1013 mbar
	(1 Nm^3 = 1.057 m^3 measured under standard conditions, i.e. 15℃ and 1013 mbar)
t	ton
Toe	tons of oil equivalent
Tcf	ton cubic feet
℃	Degrees Celsius

General Conversion Factors for Energy

To:	TJ	Gcal	Mtoe	MBtu	GWh
From:	multiply by:				
TJ	1	238.8	2.388×10^{-5}	947.8	0.2778
Gcal	4.1868×10^{-3}	1	10^{-7}	3.968	1.163×10^{-3}
Mtoe	4.1868×10^{4}	10^{7}	1	3.968×10^{7}	11630
MBtu	1.0551×10^{-3}	0.252	2.52×10^{-8}	1	2.931×10^{-4}
GWh	3.6	860	8.6×10^{-5}	3412	1

ABBREVIATIONS AND ACRONYMS

ADB	African Development Bank
ADF	African Development Fund
CC	Combined Cycle
CCGT	Combined Cycle Gas Turbine
CIDA	Canadian International Development Agency
CT	Combustion Turbine
DANIDA	Danish Development Assistance
DFID	Department for International Development (UK)
DIDC	Department for International Development Cooperation (GoF)
DSA	Daily Subsistence Allowance
EEHC	Egyptian Electricity Holding Company
EEPCO	Ethiopian Electric Power Corporation
EHV	Extra High Voltage
EHVAC	Extra High Voltage Alternating Current
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EN	Eastern Nile
ENCOM	Eastern Nile Council of Ministers
ENSAP	Eastern Nile Subsidiary Action Program
ENSAPT	Eastern Nile Subsidiary Action Program Team
ENTRO	Eastern Nile Technical Regional Office
ENTRO PCU	Eastern Nile Technical Regional Office Power Coordination Unit
FIRR	Financial Internal Rate of Return
GEP	Generation Expansion Plan
GTZ	German Technical Co-operation
HPP	Hydro Power Plant
HFO	Heavy fuel oil
HV	High Voltage
HVDC	High Voltage Direct Current
ICCON	International Consortium for Cooperation on the Nile
ICS	Interconnected System
IDEN	Integrated Development of the Eastern Nile
IDO	Industrial Diesel Oil
IMF	International Monetary Fund
JICA	Japanese International Co-operation Agency
JMP	Joint Multipurpose Project
LNG	Liquefied Natural Gas
LOLP	Loss of Load Probability

LPG	Liquefied Petroleum Gas
LRFO	Light Residuel Fuel Oil
MENA	Middle East, North Africa Countries
MIWR	Ministry of Irrigation & Water Resources (Sudan)
MWR	Ministry of Water Resources (Ethiopia)
MWRI	Ministry of Water Resources and Irrigation (Egypt)
MSD	Medium Speed Diesel (TPP)
NBI	Nile Basin Initiative
NEC	National Electricity Corporation (Sudan)
NECC	National Electricity Control Centre (Egypt)
NELCOM	Nile Equatorial Lake Council of Ministers
NELSAP	Nile Equatorial Lake Subsidiary Action Program
NG	Natural Gas
NGO	Non Governmental Organization
NORAD	Norwegian Aid Development
NPV	Net Present Value
O&M	Operations and Maintenance
OCGT	Open Cycle Gas Turbine
OPEC	Organization of the Petroleum Exporting Countries
PBP	Pay Back Period
PHRD	Policy & Human Resource Development Fund
PIU	Project Implementation Unit
PRSP	Poverty Reduction Strategy Paper
RCC	Regional Electricity Control Centre (Egypt)
RE	Rural Electrification
SAPP	Southern Africa Power Pool
SIDA	Swedish International Development Agency
SSD	Slow speed diesel (TPP)
STPP	Steam Turbine Power Plant
STS	Senior Technical Specialist
TAF	Technical Assistant Fund
TPP	Thermal Power Plant
UA	Unit of Account
UNDP	United Nations Development Program
WB	World Bank

LIST OF TABLES

1. PRESENTATION

The purpose of this analysis was to assess the master plan proposed by EEPCO that is described in the report "Ethiopian Power System Expansion Master Plan Updated – June 2006"

The behaviour of the planned Ethiopian power system was examined for the year 2015/2016 to analyse in steady state the situation with the 220 kV interconnection between with Ethiopia and Sudan, planned for the year 2009, but without the interconnection between Egypt and Sudan. This analysis allowed pointing out the possible weak points of the future transmission system. Several load flow calculations were performed in normal and in contingency situations for the annual peak.

2. HYPOTHESIS

All data used in the simulations came from the report "Ethiopian Power System Expansion Master Plan Updated – June 2006".

2.1 LOAD DEMAND

The moderate scenario was selected; the corresponding annual energy is 10 917 GWh.

The simulations were performed for the annual peak day that appears in December. The total expected load in 2015/2016 is 2 186 MW and 1 059 MVAr. The corresponding power factor is equal to 0.9. This figure includes the transmission losses.

The sharing of the peak demand between the different substations was deduced from the load flow result attached to the Ethiopian Power System Expansion Master Plan.

2.2 GENERATION

On the basis of meeting the demand corresponding to the moderate scenario, the following new generating plants were implemented on the system:

Commissioning Year	New power plants	Number of units	Total installed capacity (MW)
2008	Gilgel Gibe II	4 x 105	420
2008	Tekeze	4 x 75	300
2009	Beles	4 x 115	460
2010	Yayu Coal	2 x 50	100
2011	Gibe III – Phase I	4 x 226	904
2012	Gibe III – Phase II	4 x 226	904
Total			3 048

Table 2.2-1- New generating plants

The new HPP Beles, Gilgel Gibe II and Gibe III are connected on the 400 kV system.

2.3 TRANSMISSION SYSTEM

2.3.1 TRANSMISSION LINES

The transmission system corresponds to the master plan network, including all the transmission expansion projects up to the year 2015/2016.

The new lines used to develop the 230 kV system after the year 2009, have the following characteristics:

- Short line (length inferior to 200 km): single conductor, cross section: 570 mm² - AAAC;
- Long line (length superior to 200 km): bundle conductors, cross section: 2 x 181 mm² - AAAC.

The 400 kV system is built using lines with bundle conductors, cross section 2 x 450 mm² - AAAC. It included:

- In the north west: single circuit line connecting Beles HPP, Bahir Dar, Debre Markos and Sululta 400/230 kV substations;
- In the south west: a single circuit line connecting Gibe III HPP, Gilgel Gibe II HPP and Sebeta 400/230 substation. A double circuit line connecting Gibe III HPP, W. Sodo 400/132 kV substation and Kaliti I 400/230 kV substation. Gilgel Gibe Old 400/230 kV substation is connected to Gilgel Gibe II HPP with a single circuit line.

2.3.2 TRANSFORMERS

To realise the simulations, the 400 kV and the 230 kV networks have been represented. The 230 kV substations Bedele, Metu, Gambela and Yayu coal HPP are connected to Gilgel Gibe I with the 132 kV lines. A 132 kV line connects Kaliti I to Dire Dawa, operating in parallel with a 230 kV single circuit line Koka - Dire Dawa III.

The Addis Ababa area is supplied by three 400/230 kV substations:

- Kaliti I, equipped with six 250 MVA autotransformers;
- Sebeta, equipped with two 250 MVA autotransformers;
- Sululta, equipped with two 250 MVA autotransformers;

The 400 kV and 230 kV systems are also interconnected in the substations:

- Debre Markos, equipped with one 250 MVA autotransformer;
- Bahir Dar III, equipped with one 250 MVA autotransformer;
- Gilgel Gibe II, equipped with two 250 MVA autotransformers.

The 400 kV and 132 kV systems are also interconnected at Wolaita Sodo substation, equipped with two 100 MVA 400/132 kV transformers.

2.3.3 REACTIVE COMPENSATIONS

Shunt reactors:

To control the voltage profile of the 400 kV and 230 kV systems, shunt reactors have been connected on the bus bars and at the end of the lines.

The total amounts to 285 MVAr:

- 45 MVAr equipped the 400 kV lines,
- 30 MVAr equipped the 230 kV lines,
- 210 MVAr are installed on the 230 kV bus bars.

Shunt Capacitors:

To improve the power factor of the system, a total amount of 715 MVAr shunt capacitors have been installed, among them, 80 MVAr are installed on the 400 kV Sebeta bus bar and 180 MVAr on 400 kV Kaliti I bus bar.

2.3.4 INTERNATIONAL INTERCONNECTIONS

The following interconnections between Djibouti, Sudan and Kenya have been taken into account.

Interconnection with Djibouti:

The Ethiopian system was connected to Djibouti system with a 230 kV single circuit line between Dire Dawa and PK 12. The length of the line is about 283 km, 201 km in Ethiopia and 82 km in the territory of Djibouti.

For the analysis of the transmission system, it has been assumed that Ethiopia exported 50 MW to Djibouti.

Interconnection with Sudan:

The Ethiopian system was connected to the Sudanese system with a 230 kV double circuit line. For the present study, Option C has been retained. It consists in a link between Gonder and Gedaref passing through Shehedi substation. The total length of the line is about 321 km, 171 km in Ethiopia and 150 km in Sudan. Compensation reactors have been installed to keep acceptable voltage profile.

For the analysis of the transmission system, it has been assumed that Ethiopia exported 100 MW to Sudan.

Interconnection with Kenya:

DC interconnection with Kenya is expected to be commissioning when Gibe III power station will be in operation.

For the analysis of the transmission system, it has been assumed:

- An AC/DC converter was installed at Gibe III 400 kV substation.
- A power exchange of 400 MW from Ethiopia to Kenya.

3. ANALYSIS OF THE TRANSMISSION SYSTEM, YEAR 2015/2016

Recall: The simulations were performed at the annual peak, which reaches 2 186 MW. Moreover, Ethiopia exported 400 MW to Kenya, 100 MW to Sudan and 50 MW to Djibouti.

The detailed results of the simulations are presented in Appendix M6 Vol3.2 attached at the report.

3.1 UNIT COMMITMENT

All the hydro power plants and the Yayu thermal power plant were in operation. The generation of each unit is displayed on the following table:

Name	Installed capacity (MW)			Generation (MW)
	Nber of units	Pmax	Total	
GILGEL GEBE III				
phase I	4	226	904	720
phase II	4	226	904	516
BELES	4	115	460	320
TEKEZE	4	75	300	240
GILGEL GEBE II	4	105	420	320
NESHE	2	21.5	43	30
AWASH II	2	16	32	24
AWASH III	2	16	32	24
KOKA	3	14.33	42.99	30
GILGEL GEBE I	3	65.7	197.1	165
FINCHAA	3	33.3	99.9	75
FINCHAA	1	38	38	25
MELKA WAKENA	4	38.25	153	100
TIS ABAY I	3	3.8	11.4	9
TIS ABAY II	2	34	68	50
SOR	2	2.5	5	4
YAYU COAL	2	50	100	80
	Total		3 810.39	2 732

Table 3.1-1 - Unit Commitment - ETHIOPIA peak 2015/2016

3.2 ANALYSIS OF THE VHV/132 KV TRANSFORMATION.

The 132 kV network was not modelized in the simulations. Only substations 400/132 kV and 230/132 kV are represented with their transformation. The loads supplied by the 132 kV are connected on these transformations.

The flows through the transformers in normal situation are displayed on Appendix M6 V3-2.

In normal situation, the following 230/132 kV transformers were overloaded:

- Gefersa: 181 %
- Kaliti I: 128 %
- Melka Wakena: 160 %
- Addis North: 118 %
- Cotebe: 158 %

Moreover, the six 100 MVA transformers of Kaliti I were loaded by 96 %.

In N-1 situation, the following transformers were overloaded, taking into account the emergency limit:

- Woleita Sodo (400/132 kV): 155 %
- Sebeta: 105 %
- Kombolcha: 205 %
- Gilgel Gibe I: 121 %

However, following the tripping of one transformer at Kaliti I, the five remaining transformers were loaded under their emergency limit (115 MVA for 120 MVA).

To eliminate the constraints in normal and in N-1 situations and recover a system satisfying the N-1 criterion, the following reinforcement of the VHV/132 kV transformation is proposed:

- Gefersa: Replacement of the four existing 24 MVA transformers by one new 100 MVA transformer (Total installed capacity: 4 x 100 MVA).
- Kaliti I: Replacement of the three existing 45 MVA transformers by two new 100 MVA transformers (Total installed capacity: 6 x 100 MVA).
- Two of these 45 MVA transformers could be installed at Melka Wakena and one at Gilgel Gibe.
- Woleita Sodo: Addition of a third 100 MVA 400/132 kV transformer (Total installed capacity: 3 x 100 MVA).
- Melka Wakena: Replacement the existing 22 MVA transformer by two new 45 MVA transformers (Total installed capacity: 2 x 45 MVA).
- Addis North: Addition of one new 63 MVA transformer (Total installed capacity: 3 x 63 MVA).
- Cotebe: Addition of one 63 MVA transformer (Total installed capacity: 2 x 63 MVA).
- Kombolcha: Addition of one 63 MVA transformer (Total installed capacity: 2 x 63 MVA).
- Gilgel Gibe I: Addition of one 45 MVA transformer (Total installed capacity: 2 x 45 MVA).
- Sebeta: Addition of one 100 MVA transformer (Total installed capacity: 3 x 63 MVA and 2 x 100 MVA).

3.3 ANALYSIS OF THE 400 AND 230 KV NETWORKS

3.3.1 NORMAL SITUATION (SEE APPENDIX M6 VOL3.2 §1)

The whole transmission system was in operation. Ethiopia exported 100 MW to Sudan, 400 MW to Kenya and 50 MW to Djibouti. The behaviour of the system was satisfactory. The flows over the circuits were below their thermal rating. They are displayed on Appendix M6 V3-2.

The most loaded 400 kV lines were the two circuits Gibe 3 - W. Sodo that were 51.8 % loaded.

The most loaded 230 kV lines were the single circuit line Koka - Dire Dawa, that was 60.8 % loaded, the double-circuit line Sebeta I - Sebeta II, that was 58% loaded, the line A. North - A. Tap and the line Kaliti I - Sebeta, that were 54.5 % and 53.2 % loaded.

The loading of the other 400 and 230 kV lines was below 50 %.

The flows through the 400/230 kV transformers are displayed on Appendix M6 Vol3.2.

The most loaded transformers are the following:

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Tap position (%)
B.DARY761	250	142.37	-12.36	142.91	57.2	100
SEBETY762	250	154.1	29.52	156.9	62.8	100
SEBETY761	250	154.1	29.52	156.9	62.8	100
SULULY761	500	181.79	73.71	196.17	39.2	100

Table 3.3-1 - Transformers

The other transformers were loaded below 30 %.

The voltage profile was satisfactory, it was within 105 % and 102 % on the 400 kV system and within 105.7 % and 95.6 % on the 230 kV system. On the 230 kV system, the highest voltage appeared in the north west of the system, the lowest voltage appeared in the east of the system.

The voltage profile is displayed on Appendix M6 V3-2.

The tap positions of the 400/230 kV transformers were at the nominal value (100 %), except the tap position of Debre Markos transformer, which was set at 99 %.

The generators operated within their reactive limits, except the generators of Awash II and Awash III that produced their maximum reactive output.

The Tekeze, Beles, Finchaa and Neche HPP absorbed reactive power to keep the voltage profile below 105 %.

The active and reactive outputs of generators are displayed on Appendix M6 Vol3.2.

The total active losses amounted to 83.6 MW that represents about 3.9 % of the total demand. The losses are relatively large due to the length of the line and the localisation of the generation at Gibe III and Gilgel Gibe II and Beles far from the main load centre Addis Ababa. The losses on the 400 kV system amount to about 30 % of the total losses.

The losses of the interconnection between Ethiopia and Sudan reached 1.2 MW (1 % of the total exchange).

The transmission system generated 1 290 MVAr.

3.3.2 N-1 SITUATIONS (SEE APPENDIX M6 VOL3.2 § 2)

3.3.2.1 Analysis of the 400/230 kV transformation

Several load flow calculations were performed to simulate the tripping of one transformer substation by substation. In each case; the behaviour of the system was satisfactory.

3.3.2.2 Analysis of the 400 kV and 230 kV lines

Several load flow calculations were performed to simulate the tripping of 400 kV and 230 kV lines. Only one N-1 situation induced constraints on the system: tripping of the 400 kV Bahir Dar - Debre Markos line. Following the tripping of the line, the generation of Beles HPP, 320 MW in the simulation, was evacuated through the 250 MVA 400/230 kV Bahir Dar transformer that would be overloaded (106 % of its emergency rating).

To overcome this problem, it is proposed to install a second 250 MVA 400/230 kV transformer at Bahir Dar.

3.4 SHORT-CIRCUIT CALCULATIONS (SEE APPENDIX M6-VOL3.2 §3)

Three-phase to ground and one-phase to ground short-circuit calculations were performed taking into account the following assumptions:

- V = Vn
- Impedance of generator = X"d (sub transient reactance)

The short-circuit power of the Ethiopian system was not very high, it did not exceed 10 000 MVA at Gibe III HPP on the 400 kV network and 5 000 MVA at Kaliti I on the 230 kV network. The highest values are displayed on the following table:

Bus	Un (kV)	Tri-phases		Single-phase	
		kA	MVA	kA	MVA
1GIBE3S71	400	14.26	9 879	17.06	11 819
1KALITIS61	230	12.17	4 846	10.96	4 367
1SEBET1S61	230	11.24	4 475	9.32	3 711
1GEFERS61	230	10.02	3 993	7.95	3 168

Table 3.4-1 - Short Circuit

The results for all substations are displayed on the Appendix M6 Vol3.2 §3.

4. CONCLUSION

The behaviour of the transmission system planned for the year 2015/2016, which is described on the Ethiopian Power System Expansion Master Plan, was analysed.

Load Flow calculations were performed in normal and in N-1 situations for the peak demand.

The VHV/132 kV transformation was examined. Some reinforcements of this transformation were necessary to satisfy the N-1 criterion. The proposed reinforcements are listed hereafter:

- Gefersa: Replacement of the four existing 24 MVA transformers by one new 100 MVA transformer (Total installed capacity: 4 x 100 MVA).
- Kaliti I: Replacement of the three existing 45 MVA transformers by two new 100 MVA transformers (Total installed capacity: 6 x 100 MVA).
- Two of these 45 MVA transformers could be installed at Melka Wakena and one at Gilgel Gibe.
- Woleita Sodo: Addition of a third 100 MVA 400/132 kV transformer (Total installed capacity: 3 x 100 MVA).
- Melka Wakena: Replacement the existing 22 MVA transformer by two new 45 MVA transformers (Total installed capacity: 2 x 45 MVA).
- Addis North: Addition of one new 63 MVA transformer (Total installed capacity: 3 x 63 MVA).
- Cotebe: Addition of one 63 MVA transformer (Total installed capacity: 2 x 63 MVA).
- Kombolcha: Addition of one 63 MVA transformer (Total installed capacity: 2 x 63 MVA).
- Gilgel Gibe I: Addition of one 45 MVA transformer (Total installed capacity: 2 x 45 MVA).
- Sebeta: Addition of one 100 MVA transformer (Total installed capacity: 3 x 63 MVA and 2 x 100 MVA).

In Normal situation, taking into account the previous reinforcement of the VHV/132 kV transformation, the behaviour of the system was satisfactory. The flows over the lines and through the transformers were below the rating of the equipment. The voltage profile was within the limits.

In N-1 situations:

- Over voltage occurred following the tripping of the 400/230 kV transformer at Sululta.
- the 400/230 kV transformer at Bahir Dar was overloaded following the tripping of the 400 kV Debre Markos - Bahir Dar line.

To overcome this problem, it is proposed to install a second 400/230 kV transformer at Sululta and at Bahir Dar.

Whatever the other N-1 situations, there are no constraint on the system.

The proposed reinforcements described above will be included in the Ethiopian transmission system for the study of the interconnection between Ethiopia, Egypt and Sudan.

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EASTERN NILE POWER TRADE PROGRAM STUDY

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with participation of:

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Analysis of the network expansion plan In the year 2015/2016

VOL 3.2 - ETHIOPIA

APPENDIX

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LIST OF APPENDICES

LIST OF TABLES

1 LOAD FLOW RESULTS PEAK 2015/2016 – NORMAL SITUATION

1.1 POWER FLOW ON THE 400 KV AND 230 KV LINES

Lines	From Bus	To Bus	Un (kV)	P (MW)	Q (MVAr)	S (MVA)	I (kA)	Active losses (MW)	Reactive losses (MVAr)	Rating (kA)	Loading (%)
B.DAR72BELES	1B.DAR3S71	1BELESS71	400	-159.11	40.07	164.08	0.23	0.44	-36.56	1.01	22.5
B.DAR71BELES	1B.DAR3S71	1BELESS71	400	-159.11	40.07	164.08	0.23	0.44	-36.56	1.01	22.5
B.DAR71D.MAR	1B.DAR3S71	1D.MARS71	400	175.85	-84.03	194.9	0.27	1.49	-112.34	1.01	26.8
D.MAR71SULUL	1D.MARS71	1SULULS71	400	183.65	-52.6	191.04	0.26	1.85	-126.31	1.01	26.2
GG271GG3	1GG2S71	1GIBE3S71	400	-73.88	-49.88	89.14	0.12	0.19	-92.35	1.01	12.2
GGO71GG2	1GGOS71	1GG2S71	400	-79.98	-61.25	100.74	0.14	0.08	-24.8	1.01	13.8
GG372W.SOD	1GIBE3S71	1W.SODS71	400	378.07	-42.93	380.5	0.52	2.67	-29.9	1.01	51.8
GG371W.SOD	1GIBE3S71	1W.SODS71	400	378.07	-42.93	380.5	0.52	2.67	-29.9	1.01	51.8
GG271SEBET	1SEBETS71	1GG2S71	400	-308.22	-59.03	313.82	0.44	4.88	-91.26	1.01	43.8
KALIT72W.SOD	1W.SODS71	1KALITS71	400	292.13	-49.86	296.36	0.41	5.47	-122.9	1.01	40.5
KALIT71W.SOD	1W.SODS71	1KALITS71	400	292.13	-49.86	296.36	0.41	5.47	-122.9	1.01	40.5
A.TAP61COTEB	1A.TAPS61	1COTEBS61	230	-11.77	-20.79	23.89	0.06	0.01	-2.2	0.67	8.9
A.NOR61A.TAP	1A.TAPS61	1A.NORS61	230	138.53	44.95	145.64	0.36	0.13	0.07	0.67	54.5
ALAMA61KOMBO	1ALAMAS61	1KOMBOS61	230	104.29	-28.5	108.11	0.27	2.35	-15.66	0.69	38.7
ALAMA61GESHE	1ALAMAS61	1GASHES61	230	-17.93	-42.78	46.39	0.11	0.24	-18.56	0.69	16.6
ALAMA61MEKEL	1ALAMAS61	1MEKELS61	230	-52.67	7.99	53.28	0.13	0.8	-24.79	0.69	19.1
ALAMA62MEKEL	1ALAMAS61	1MEKELS61	230	-52.67	7.99	53.28	0.13	0.8	-24.79	0.69	19.1
B.DAR261MOTT	1B.DAR2S61	1MOTAS61	230	9.92	-12.76	16.17	0.04	0.01	-13.02	0.67	5.8
B.DAR61N.MEW	1B.DAR2S61	1N.MEWS61	230	18.37	-25.92	31.77	0.08	0.11	-30.2	0.69	11.1
BEDEL61METU	1BEDELS61	1METUS61	230	-12.33	-10.22	16.01	0.04	0.02	-12.25	0.67	6.3
BEDEL61YAYU	1BEDELS61	1YAYUS61	230	-49.43	-19.83	53.26	0.14	0.18	-5.54	0.67	20.9
COTEB61KALIT	1COTEBS61	1KALITIS61	230	-37.81	8.82	38.83	0.1	0.07	-4.61	0.69	14
D.MAR61FINCH	1D.MARS61	1FINCHS61	230	0.37	17.15	17.15	0.04	0.07	-14.44	0.67	6.2
E.SEL61TEKEZ	1E.SELS61	1TEKEZS61	230	-29.41	7.57	30.37	0.07	0.81	-47.93	0.69	10.5
FINCH61GHEDO	1FINCHS61	1GHEDOS61	230	45.87	-13.3	47.76	0.12	0.17	-9.24	0.67	17.7
FINCH62GHEDO	1FINCHS61	1GHEDOS61	230	45.87	-13.3	47.76	0.12	0.17	-9.24	0.67	17.7
GEFER61SEBE1	1GEFERS61	1SEBET1S61	230	-68.93	-24.16	73.04	0.18	0.07	-1.15	0.67	27.5
GG162GG0	1GGOS61	1GG1S61	230	-71.16	29.13	76.89	0.19	0.03	-0.45	0.67	28.2
GG161GG0	1GGOS61	1GG1S61	230	-71.16	29.13	76.89	0.19	0.03	-0.45	0.67	28.2
GEFER61GHEDO	1GHEDOS61	1GEFERS61	230	85.8	-2.7	85.84	0.21	1.18	-12.71	0.67	31.7
GEFER62GHEDO	1GHEDOS61	1GEFERS61	230	85.8	-2.7	85.84	0.21	1.18	-12.71	0.67	31.7
GGO61GHEDO	1GHEDOS61	1GGOS61	230	-95.37	0.3	95.37	0.23	1.44	-11.28	0.67	35.3
B.DAR61GOND	1GONDES61	1B.DAR2S61	230	-140.89	30.87	144.23	0.35	2.61	-48.16	1.38	25
GONDE61HUMER	1GONDES61	1HUMERS61	230	-21.45	-31.28	37.93	0.09	0.25	-67.02	0.69	13.2
GONDE62SHEHE	1GONDES61	1SHEHES61	230	51.09	-30.25	59.38	0.14	0.63	-26.07	0.69	20.6
GONDE61METEM	1GONDES61	1SHEHES61	230	51.09	-30.25	59.38	0.14	0.63	-26.07	0.69	20.6
E.SEL61HUMER	1HUMERS61	1E.SELS61	230	-28.81	-17.76	33.85	0.08	0.45	-58.56	0.69	11.6
KALIT62KOKA	1KALITIS61	1KOKAS61	230	54.06	-39.53	66.97	0.17	0.37	-8.02	0.55	30.1
KALIT61KOKA	1KALITIS61	1KOKAS61	230	54.06	-39.53	66.97	0.17	0.37	-8.02	0.55	30.1
KOKA61M.WAK	1KOKAS61	1M.WAKS61	230	-14.26	-23.3	27.31	0.07	0.07	-25.3	0.55	12.1
KOKA62M.WAK	1KOKAS61	1M.WAKS61	230	-14.26	-23.3	27.31	0.07	0.07	-25.3	0.55	12.1

Lines	From Bus	To Bus	Un (kV)	P (MW)	Q (MVAr)	S (MVA)	I (kA)	Active losses (MW)	Reactive losses (MVAr)	Rating (kA)	Loading (%)
KOKA61X	1KOKAS61	X	230	135.87	-16.42	136.85	0.34	4.14	-2.56	0.55	60.8
COTEB61KOMBO	1KOMBOS61	1COTEBS61	230	15.97	-33.87	37.45	0.09	0.15	-55.07	0.69	13.5
KOMBO61SEMER	1KOMBOS61	1SEMERS61	230	31.88	-15.72	35.54	0.09	0.31	-31.38	0.69	12.8
M.WAK61RAMO	1M.WAKS61	1RAMOS61	230	0.13	-26.48	26.48	0.06	0	-58.65	0.69	9.3
GAMBE61METU	1METUS61	1GAMBES61	230	9.28	-2.29	9.56	0.02	0.03	-20.29	0.67	3.7
D.MAR61MOTTA	1MOTAS61	1D.MARS61	230	9.91	0.25	9.91	0.02	0.02	-17.8	0.67	3.6
GASHE61N.MEW	1N.MEWS61	1GASHES61	230	18.26	4.28	18.76	0.04	0.09	-19.94	0.69	6.5
KALI161SEBET	1SEBET1S61	1KALITIS61	230	126.17	-64.62	141.75	0.35	0.35	0.06	0.67	53.2
SEBE162SEBE2	1SEBET1S61	1SEBET2S61	230	-153.18	-20.4	154.53	0.39	0.59	0.68	0.67	58
SEBE161SEBE2	1SEBET1S61	1SEBET2S61	230	-153.18	-20.4	154.53	0.39	0.59	0.68	0.67	58
DICHA61SEMER	1SEMERS61	1DICHATS61	230	6.92	-15.67	17.12	0.04	0.02	-18.86	0.69	6.2
GEFER61SULUL	1SULULS61	1GEFERS61	230	-3.31	43.09	43.22	0.11	0.08	-4.03	0.67	16.1
COTE62SULUL	1SULULS61	1COTEBS61	230	57.76	0.24	57.76	0.14	0.12	-3.77	0.67	21.5
A.TAP61SULUL	1SULULS61	1A.TAPS61	230	127.07	23.82	129.28	0.32	0.31	-0.35	0.67	48.2
MEKEL61TEKEZ	1TEKEZS61	1MEKELS61	230	104.59	-8.66	104.95	0.26	0.86	-13.81	1.16	22.4
MEKEL62TEKEZ	1TEKEZS61	1MEKELS61	230	104.59	-8.66	104.95	0.26	0.86	-13.81	1.16	22.4
SEBET61WOLKI	1WOLKIS61	1SEBET1S61	230	109.43	-7.18	109.66	0.27	1.95	-8.41	0.67	40.5
GGO61WOLKI	1WOLKIS61	1GGOS61	230	-124.13	0.38	124.13	0.31	1.23	-2.63	0.67	45.9
METU61YAYU	1YAYUS61	1METUS61	230	30.17	7.96	31.2	0.08	0.06	-5.48	0.67	12.1

Table 1.1-1 - Power flow on the 400 kV and 230 kV lines

1.2 FLOWS THROUGH THE 400/230 KV TRANSFORMERS

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Tap position (%)
B.DARY761	250	142.37	-12.36	142.91	57.2	100
D.MARY761	250	-9.29	48.32	49.2	19.7	99
GGOY762	250	39.99	30.63	50.37	20.1	100
GGOTR761	250	39.99	30.63	50.37	20.1	100
KALITY761	1500	573.3	146.09	591.62	39.4	100
SEBETY762	250	154.1	29.52	156.9	62.8	100
SEBETY761	250	154.1	29.52	156.9	62.8	100
SULULY761	500	181.79	73.71	196.17	39.2	100

Table 1.2-1 - Flows through the 400/230 kV transformers

1.3 400 KV AND 230 KV VOLTAGE PROFILE

Bus	Vn (kV)	Vsol (kV)	Vsol/Vn (%)
1B.DAR3S71	400	416.26	104.1
1BELESS71	400	414.45	103.6
1D.MARS71	400	416.98	104.2
1GG2S71	400	418.36	104.6
1GGOS71	400	416.55	104.1
1GIBE3S71	400	419.88	105.0
1KALITS71	400	408.06	102.0
1SEBETS71	400	409.58	102.4
1SULULS71	400	410.82	102.7
1W.SODS71	400	418.58	104.6
1A.NORS61	230	231.29	100.6
1A.TAPS61	230	231.89	100.8
1ALAMAS61	230	233.56	101.5
1B.DAR2S61	230	240.15	104.4
1BEDELS61	230	221.45	96.3
1COTEBS61	230	232.47	101.1
1D.DAW3S61	230	229.53	99.8
1D.MARS61	230	238.72	103.8
1DICHATS61	230	230.15	100.1
1E.SELS61	230	242.08	105.3
1FINCHS61	230	234.64	102.0
1GAMBES61	230	219.82	95.6
1GASHES61	230	238.62	103.7
1GEFERS61	230	230.68	100.3
1GG1S61	230	236.85	103.0
1GGOS61	230	236.98	103.0
1GHEDOS61	230	234.8	102.1
1GONDES61	230	241.24	104.9
1HUMERS61	230	243.15	105.7
1KALITIS61	230	232.48	101.1
1KOKAS61	230	235.5	102.4
1KOMBOS61	230	231.83	100.8
1M.WAKS61	230	239.32	104.1
1MEKELS61	230	232.71	101.2
1METUS61	230	222.47	96.7
1MOTAS61	230	240.81	104.7
1N.MEWS61	230	241.18	104.9
1RAMOS61	230	238.17	103.6
1SEBET1S61	230	231.34	100.6
1SEBET2S61	230	232.95	101.3
1SEMERS61	230	229.58	99.8
1SHEHE61	220	233.42	106.1
1SHEHES61	230	241.58	105.0
1SULULS61	230	233.07	101.3

Bus	Vn (kV)	Vsol (kV)	Vsol/Vn (%)
1TEKEZS61	230	234.39	101.9
1WOLKIS61	230	234.84	102.1
1YAYUS61	230	223.68	97.3

Table 1.3-1 - 400 kV and 230 kV voltage Profile

1.4 GENERATION

Generators	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Qmax (MVAr)	Qmin (MVAr)	Q/Qmax (%)
AWASH2-H1	40	24	24	33.94	24	24	100.0
AWASH3-H1	40	24	22	32.56	22	22	100.0
BELES-H1	540	320	-125.87	343.86	284	-168	74.9
FINCHA-H1	105	75	-13.7	76.24	32.76	-19.65	69.7
FINCHAA-H4	40	25	-7.17	26.01	24	-14.4	49.8
GG1-H1	146	110	-6.74	110.21	63.62	-38.2	17.6
GG1-H3	73	55	-3.37	55.1	31.81	-19.1	17.6
GG2-H1	375	240	-15.62	240.51	197.4	-118.5	13.2
GG2-H4	125	80	-5.21	80.17	65.8	-39.5	13.2
GG3-H1	798	540	13.92	540.18	420	-252	3.3
GG3-H2	266	180	4.64	180.06	140	-84	3.3
GG3-H5	1064	512.55	43.96	514.43	560	-336	7.9
KOKA_H1	36	20	5.18	20.66	21.6	-13	24.0
KOKA-H3	18	10	2.59	10.33	10.8	-6.5	24.0
M.WAKH1	142.5	75	10.04	75.67	85.5	-51.3	11.7
M.WAK-H4	47.5	25	3.35	25.22	28.5	-17.1	11.8
NECHE-H1	50	30	-10.45	31.77	26	-15.8	66.1
SOR-H1	620	4	2.34	4.63	370	-220	0.6
T.ABAY-H2	80	50	-9.46	50.89	34	-21	45.0
T.ABA-H1	14.4	9	-3.89	9.8	8.7	-5.1	76.3
TEKEZ-H1	360	240	-51.52	245.47	188	-113.6	45.4
YAYU-T	58	80	30.01	85.44	30	-18	100.0

Table 1.4-1 - Generation

2 **LOAD FLOW RESULTS** PEAK 2015/2016 - N-1 SITUATIONS

2.1 ANALYSIS OF THE 400/230 KV TRANSFORMATION

2.1.1 TRIPPING OF ONE OF THE TWO 250 MVA SULULTA TRANSFORMERS

Following the tripping, the behaviour of the system was satisfactory. The voltage profile remained below the acceptable limits. The voltage at Sululta reached 413.8 kV (1.03 p.u.).

The flows through the transformers were below their nominal rating; the maximum flow was 181.2 MVA at Sululta that corresponds to 72.5 % of its nominal rating.

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Emergency rating (MVA)	Loading in emergency (%)	Tap position (%)
B.DARY761	250	146.23	-10.72	146.62	58.6	300	48.9	100
D.MARY761	250	1.52	51.6	51.62	20.6	300	17.2	98.969
GGOTR761	250	38.87	30.83	49.61	19.8	300	16.5	100
GGOY762	250	38.87	30.83	49.61	19.8	300	16.5	100
KALITY761	1500	574.94	148.74	593.87	39.6	1800	33	100
SEBETY761	250	154.56	30.49	157.54	63	300	52.5	100
SEBETY762	250	154.56	30.49	157.54	63	300	52.5	100
SULULY761	250	167.49	69.02	181.16	72.5	300	60.4	100

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Emergency rating (MVA)	Loading in emergency (%)	Tap position (%)
B.DARY761	250	194.28	28.47	196.35	78.5	300	65.5	100
SEBETY762	250	161.24	46.22	167.74	67.1	300	55.9	100
SEBETY761	250	161.24	46.22	167.74	67.1	300	55.9	100
D.MARY761	250	122.27	72.55	142.17	56.9	300	47.4	102.128
KALITY761	1 500	601.35	197.63	632.99	42.2	1 800	35.2	100
GGOY762	250	27.89	33.88	43.89	17.6	300	14.6	100
GGOTR761	250	27.89	33.88	43.89	17.6	300	14.6	100

Table 2.1-1 - Transformers 400/230 kV

The flows over the transmission lines were below their nominal rating. The 230 kV lines Ghedo - Gefersa and Sebeta - Gefersa were respectively loaded at 33.3 % and 27.9 %.

The generators operated within their reactive capabilities.

2.1.2 TRIPPING OF THE BAHIR DAR TRANSFORMER

Following the tripping, the behaviour of the system was satisfactory. The voltage profile remained below the acceptable limits. The voltage at Bahir Dar reached 412.1 kV (1.03 p.u.).

The flows through the transformers were below their nominal rating; the maximum flow was 157.5 MVA at Sebeta that corresponds to 63 % of its nominal rating.

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Emergency rating (MVA)	Loading in emergency (%)	Tap position (%)
D.MARY761	250	94.31	58.82	111.15	44.5	300	37	96
GGOY762	250	40.68	30.59	50.9	20.4	300	17	100
GGOTR761	250	40.68	30.59	50.9	20.4	300	17	100
KALITY761	1500	577.19	150.47	596.48	39.8	1800	33.1	100
SEBETY762	250	154.38	31.23	157.5	63	300	52.5	100
SEBETY761	250	154.38	31.23	157.5	63	300	52.5	100
SULULY761	500	216.41	44.75	220.98	44.2	600	36.8	100

Transformers	Sn (MVA)	P (MW)	Q (MVAr)	S (MVA)	Loading (%)	Emergency rating (MVA)	Loading in emergency (%)	Tap position (%)
SULULY761	250	201	42.6	205.5	82.2	300	68.5	100
SEBETY762	250	155.2	33.6	158.8	63.5	300	52.9	100
SEBETY761	250	155.2	33.6	158.8	63.5	300	52.9	100
D.MARY761	250	110	66.3	128.5	51.4	300	42.8	96
KALITY761	1 500	580.7	157.7	601.8	40.1	1800	33.4	100
GGOY762	250	39.5	30.5	49.9	20	300	16.6	100
GGOTR761	250	39.5	30.5	49.9	20	300	16.6	100

Table 2.1-2 - Transformers 400/230 kV

The flows over the transmission lines were below their nominal rating. About 100 MW flowed from Debre Markos to Motta.

The generators operated within their reactive capabilities.

2.1.3 TRIPPING OF ONE OF THE TWO SEBETA TRANSFORMERS

Following the tripping of the transformer, the behaviour of the system was acceptable. The remaining transformer was loaded at 273.5 MVA that corresponds to 109.4 % of it nominal rating, but the flow remained below the emergency rating. It reached 91.2 % of this rating.

The flows over the transmission lines were below their nominal rating. About 135 MW flowed from Gilgel Gibe old to Wolkite.

The voltage profile was not significantly affected.

2.2 ANALYSIS OF THE TRIPPING OF THE 400 KV AND 230 KV LINES

2.2.1 TRIPPING OF ONE CIRCUIT OF THE 400 KV DOUBLE CIRCUIT LINE GIBE III - W.SODO

In normal situation, about 760 MW (52 % of rating) flowed over the two circuits from Gibe III to W. Sodo.

Following the tripping, the behaviour of the transmission system was acceptable.

About 94 % of the initial flow was transferred on the second circuit that corresponded to 98% of its nominal rating (714 MW).

The voltage profile was not significantly affected.

The voltage at Kaliti I slipped from 406 kV to 402 kV.

2.2.2 TRIPPING OF ONE CIRCUIT OF THE 400 KV DOUBLE CIRCUIT LINE KALITI I - W.SODO

In normal situation, about 590 MW (41 % of rating) flowed over the two circuits from W. Sodo to Kaliti I.

Following the tripping, the behaviour of the transmission system was acceptable.

81 % of the initial flow was transferred on the second circuit that corresponded to 71 % of its nominal rating (479 MW).

The voltage profile was significantly affected.

The voltage at Kaliti I dropped from 406 kV to 361 kV, which is just acceptable in N-1 situation.

Thanks to tap changer of the 400/230 kV transformers (Tap position: 91 %), the voltage reached 225.6 kV on the 230 kV Kaliti I bus bar.

2.2.3 TRIPPING OF THE 400 KV LINE GILGEL GIBE II - SEBETA

In normal situation, about 310 MW (44 % of rating) flowed over the line from Gilgel Gibe II to Sebeta.

The tripping of the line induced the disconnection of the two transformers of Sebeta.

Following this tripping, the behaviour of the transmission system was acceptable.

The voltage profiled was significantly affected. The voltages dropped at Sebeta from 408 kV to 377 kV and at Kaliti I from 406 kV to 376 kV.

On the 230 kV level, the voltage reached 223.7 kV at Sebeta I and 226.9 kV at Kaliti I.

About 55 % of the initial flow was transferred on the 400 kV double-circuit line Gibe III - W.Sodo - Kaliti and about 45 % on the 400 kV Gilgel Gibe Old-Gilgel Gibe II.

2.2.4 TRIPPING OF THE 400 KV LINE GILGEL GIBE II - GILGEL GIBE OLD

In normal situation, about 80 MW (13 % of rating) flowed over the line from Gilgel Gibe II to Gilgel Gibe Old.

The tripping of the line induced the disconnection of the two transformers of Gilgel Gibe Old. Following this tripping, the behaviour of the transmission system was satisfactory.

The voltage at Gilgel Gibe Old was slightly affected, the voltage slipped from 416 kV to 403 kV (3 %)

2.2.5 TRIPPING OF THE 400 KV LINE BAHIR DAR - DEBRE MARKOS

Following the tripping of the line, the generation of Beles HPP, 320 MW in the simulation, was evacuated through the 250 MVA 400/230 kV Bahir Dar transformer that would be overloaded (106 % of its emergency rating).

To overcome this problem:

- The generation of Beles HPP should be automatically reduced in N-1 situation,
- Or, a second 250 MVA 400/230 kV transformer should be installed at Bahir Dar. But Beles HPP is connected to the main system with a 400 kV double circuit line, to secure in N-1 situation the evacuation of Beles generation. So to be consistent with this choice, the second solution would have to be selected.

2.2.6 TRIPPING OF ONE CIRCUIT OF THE 230 KV DOUBLE CIRCUIT LINE SEBETA I - SEBETA II

In normal situation, about 308 MW (59 % of rating) flowed over the two circuits from Sebeta II to Sebeta I.

Following the tripping, the behaviour of the transmission system was acceptable.

About 94 % of the initial flow was transferred on the remaining circuit that was loaded by 110 % of its nominal rating that is acceptable in N-1 situation (92 % of the emergency rating).

The voltage profile was not significantly affected.

2.2.7 TRIPPING OF THE LINE 230 KV COTEBE-KOMBOLCHA

In normal situation, about 16 MW (13.5 % of rating) flowed from Kombolcha to Cotebe.

Following the tripping, the behaviour of the transmission system was satisfactory.

The voltage at Kombolcha and Dichato were affected: the voltage at Kombolcha dropped from 230.3 kV to 219 kV (%) and the voltage at Dichato dropped from 228.6 kV to 217 kV.

The voltage at Cotebe was slightly affected: the voltage decreased from 231 kV to 228.6 kV.

2.2.8 TRIPPING OF THE LINE 230 KV ALAMATA - KOMBOLCHA

In normal situation, about 105 MW (39 % of rating) flowed from Alamata to Kombolcha.

Following the tripping, the behaviour of the transmission system was satisfactory.

The voltage at Kombolcha and Dichato were affected: the voltage at Kombolcha dropped from 230.3 kV to 213.5 kV (-7.3 %) and the voltage at Dichato dropped from 228.6 kV to 210.8 kV.

The voltage at Cotebe was slightly affected: the voltage decreased from 231 kV to 226.8 kV.

2.2.9 TRIPPING OF ONE CIRCUIT OF THE DOUBLE CIRCUIT LINE KALITI I - KOKA

In normal situation, about 110 MW (30.6 % of rating) flowed over the two circuits from Kaliti I to Koka. The reactive power flowed from Koka to Kaliti I (80 MVAr).

Following the tripping, the behaviour of the transmission system was satisfactory. Almost the total flow was transferred on the remaining circuit that corresponds to 57% of its nominal rating.

The voltage at Kaliti I and Koka was slightly affected: the voltage at Koka increased from 234.4 kV to 235.4 kV and the voltage at Kaliti I decreased from 231.4 kV to 230.4 kV.

2.2.10 TRIPPING OF ONE CIRCUIT OF THE DOUBLE CIRCUIT LINE GONDER- SHEHEDI

In normal situation, about 51.2 MW (21 % of rating) flowed over the two circuits from Gonder to Shehedi.

Following the tripping, the behaviour of the transmission system was satisfactory.

The voltage at Gonder and Shehedi was slightly affected: the voltage at Gonder decreased from 237.2 kV to 232 kV and the voltage at Shehedi decreased from 237.8 kV to 232.3 kV.

3 SHORT-CIRCUIT RESULTS PEAK 2015/2016

Bus	Un (kV)	tri phases		single phase	
		kA	MVA	kA	MVA
1GIBE3S71	400	14.26	9879	17.06	11819
1W.SODS71	400	9.36	6482	8.17	5662
1GG2S71	400	8.35	5784	8.74	6055
1GGOS71	400	6.67	4618	6.32	4380
1KALITS71	400	6.65	4605	5.89	4079
1SEBETS71	400	4.68	3242	3.79	2628
1BELESS71	400	4.63	3207	5.21	3608
1B.DAR3S71	400	4.59	3177	4.66	3224
1D.MARS71	400	3.78	2619	3.07	2125
1SULULS71	400	3.37	2334	2.77	1915
1KALITIS61	230	12.17	4846	10.96	4367
1SEBET1S61	230	11.24	4475	9.32	3711
1GEFERS61	230	10.02	3993	7.95	3168
1GGOS61	230	9.56	3807	9.54	3801
1SEBET2S61	230	9.53	3795	7.54	3003
1COTEBS61	230	9.29	3701	7	2790
1GG1S61	230	9.26	3686	9.3	3704
1SULULS61	230	8.92	3554	6.8	2711
1A.TAPS61	230	8.06	3212	5.96	2374
1A.NORS61	230	7.15	2849	5.17	2060
1GHEDOS61	230	6.89	2743	5.56	2213
1FINCHS61	230	6.45	2568	6.53	2600
1KOKAS61	230	6.38	2539	4.96	1976
1B.DAR2S61	230	6.26	2495	6	2388
1D.MARS61	230	5.46	2176	4.51	1795
1WOLKIS61	230	4.66	1857	3.32	1323
1TEKEZS61	230	4.55	1814	5.27	2100
1M.WAKS61	230	3.88	1545	4.18	1665
1MEKELS61	230	3.71	1479	2.95	1174
1MOTAS61	230	3.7	1474	2.7	1077
1GONDES61	230	3.58	1424	2.4	957
1ALAMAS61	230	3.46	1379	2.31	918
1SHEHES61	230	3.31	1319	2.39	951
1N.MEWS61	230	2.92	1164	1.82	726
1GASHES61	230	2.8	1114	1.73	687
1KOMBOS61	230	2.64	1053	1.57	625
1YAYUS61	230	1.94	774	2.16	860
1BEDELS61	230	1.74	694	1.7	678
1METUS61	230	1.72	685	1.72	684
1E.SELS61	230	1.7	677	1.04	415
1HUMERS61	230	1.52	605	0.88	351
1SEMERS61	230	1.25	498	0.7	280
1D.DAW3S61	230	1.05	418	1.02	404
1RAMOS61	230	1.03	412	0.64	254
1DICHATS61	230	0.95	380	0.53	211
1GAMBES61	230	0.95	377	0.74	295
1SHEHE61	220	3.46	1319	2.51	954

Table 2.2-1 - Short circuit results