International Journal of Advanced Engineering and Nano Technology (IJAENT)
ISSN: 2347-6389 (Online), Volume-9 Issue-5, May 2022

Voltage Stability Assessment of Sudanese National Network within Re-Evaluation of the SVC Projects

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***Abstract:** In the last ten years Sudan National Grid suffering from a steady increase in loads, with a shortage of generation and congestion in transmission substations and lines. This caused many cases of blackouts. As a solution to this situation, the Static Var Compensators (SVC) project was recommended to improve the voltage in the National Grid (NG) by providing adequate reactive power support at the specified nine locations to solve voltage instability problems. This study re-evaluates the project, especially after the delay in implementation and the major change that occurred in the NG the evaluation will cover all nine proposed substations (Port-Sudan (POR), Hag-Abdallah (HAG), Farooq (FAR), Mahadiya (MHD), Kuku (KUK), Local market (LOM), New Hasahisa (NHAS), Bagair (BAG), and Gamueia (GAM).) and show its effect on the overall National Grid voltage.*

***Keywords:** National Grid (NG), Voltage Stability Analysis (VSA), Static Var Compensator (SVC), Bus Participation Factor (BPF), Eigen Values (EV).*

I. INTRODUCTION

Modern electric power utilities are facing many challenges due to ever increasing complexity in their operation and structure. One problem that received wide attention is voltage instability. One of the major causes of voltage instability in the power system is with its reactive power limit. Voltage instability is the cause of the system voltage collapse, in which the power system voltage decays to a level, from which point, it is unable to recover. Voltage collapse may lead to partial or full power interruption in the system. Providing adequate reactive power support at the appropriate location solves voltage instability problems [1].

Voltage instability has been given much attention by power system researchers and planners in recent years, and is being regarded as one of the major sources of power system insecurity. Voltage instability phenomena are the ones in which the receiving end voltage decreases well below its normal value and does not come back even after setting restoring mechanisms such as VAR compensators, or continues to oscillate for lack of damping against the disturbances [2]. Voltage collapse is the process by which the voltage falls to a low, unacceptable value as a result of an avalanche of events accompanying voltage instability [3]. The Static Var Compensation (SVC) is used to improve voltage stability and power system oscillation damping because of its role to adjust the reactive power on the transmission lines. Hence, it used for this function at the research to assist the whole voltage stability at the network.

II. SCOPE OF WORK

The scope of this study is to:

- Evaluate the performance of the SVC devices which already had been installed at (POR, LOM, and MHD) substations.
- Re-evaluate the capacity (if able) for those SVCs which the civil works had been completed at (KUK, GAM).
- Analyze the installation of proposed SVCs at (FAR, HAG, BAG, and NHAS) substations and the ability to relocate them to improve the whole performance of the Grid.

III. ASSUMPTIONS

Total Generation on the study case about 4564.023 MW,

- Total load is 4376.07MW.
- The 150 MW Floating Power Plant will be totally disconnected in all Scenarios.
- The two gas turbine units with capacity of (2×150 MW) at Klanaib are in-service.
- The three gas turbine units with capacity of (3×150 MW) at Garri-3 are installed.

IV. METHODOLOGY

In this study, two scenarios will be investigated in terms of load flow analysis and voltage stability analysis (VSA), to find out whether there is a need or necessity to change or maintain the capacities and proposed locations of the SVCs used in the SVC project. Voltage Stability Analysis will be done for the Southern Khartoum area and Gazira area to determine the weakest nodes (Optimal Location for SVC's) and the perfect reactive power which must be injected to reach system voltage stability. Neplan software packages are used in this study for the load flow analysis and voltage stability analysis of Sudan National Grid. In voltage stability analysis three approaches of static voltage stability analysis of power systems had been used (Q-V Eigenvalue Analysis (Modal Analysis),

Manuscript received on 19 April 2022.
Revised Manuscript received on 23 April 2022.
Manuscript published on 30 May 2022.

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VQ Sensitivity Analysis, and V-Q Curves). The definitions of the four scenarios' as follows:

A. Scenario-I

Scenario-I or Base Case: This scenario considering the completion of all nine SVCs with their proposed values and location as in table -I below:

Table-I: Nine proposed SVCs

Substation Name	Qc (MVAR)	QL(MVAR)
Bagair	10	45
Port-Sudan	15	55
Mahdia	15	55
Local-Market	100	30
KUKU	40	45
Hasahisa	60	30
Hag-Abdlla	15	20
Gamoia	10	60
Farooq	10	60

B. Scenario-II

This scenario considering the completion of the planned 220KV transmission line (Gadarif – Fao – Marigan).

C. Scenario-III

In Scenario three the system analyzed at off-peak load condition

D. Scenario-IV

Assuming that the under-construction generation projects (2×150MW at Port-Sudan and 3×150MW at Garri-3) will be commissioned after year 2022.

V. RESULTS

A. Scenario-I

- **Load Flow Analysis:** When applying the load the system did *not converge* unless inserting additional Shunt capacitor:

Table -II: The Shunt capacitors inserted to enable the software to reach solution.

Substation Name	Capacitor size (Mvar)
KLX	30
JAS	60
MUG	30
IZB	30
SOB	60
SHG	30
MAN	80

- **Voltage Results:**

Table-III: shows voltage reading at 110KV bus bars related to focus area in Khartoum and Gazira.

Substation Name	Voltage	
	(KV)	(%)
AFR1	101.192	91.99
BAG1	103.11	93.74
BNT1	103.53	94.12
BSH1	112.831	102.57
FAR1	100.691	91.54
GAD1	103.159	93.78
GAM1	105.018	95.47
GND1	99.124	90.11
HAG1	104.918	95.38
IBA1	106.476	96.8
IZB1	109.151	99.23
IZG1	103.284	93.89
KHN	106.228	103.03
KLX1	102.751	93.41
KUK1	105.848	96.23
LOM1	102.498	93.18
MAR1	105.904	96.28
MHD1	101.718	92.47
NHAS1	100.599	91.45
OHAS1	100.495	91.36
OMD1	99.748	90.68
POR1	113.498	103.18
SHG 1	104.146	94.68
SNK1	111.498	101.36
SNP1	102.85	93.5
SWK1	111.272	101.16

Table-IV: voltage reading at 220KV bus bars related to focused area in Khartoum and Gazira.

Substation Name	Voltage	
	(kV)	(%)
GAD2	208.133	94.61
GAM2	207.79	94.45
IBA2	211.471	96.12
IZG2	210.068	95.49
JAS2	208.473	94.76
KLX2	209.423	95.19
KUK2	210.295	95.59
MAR2	205.844	93.57
MHD2	208.99	95.00
MUG2	206.153	93.71
NHAS2	205.11	93.23
POR2	239.077	108.67
SHG 2	205.00	93.20
SOB2	208.615	94.82

- **Voltage Stability Results**

There Different methods exist in the literature for carrying out a steady state voltage stability analysis.

The conventional methods can be broadly classified into the type Voltage Stability Results

There Different methods exist in the literature for carrying out a steady state voltage stability analysis. The conventional methods can be broadly classified into the types: (Modal Analysis, Sensitivity Analysis, PV-Curve Method, and V-Q Curve Method).

- **Modal Analysis:**

Voltage Stability of the system can be identified by computing the Eigen values and Eigen vectors of the reduced Jacobin matrix as defined as: (Modal Analysis, Sensitivity Analysis, PV-Curve Method, and V-Q Curve Method).

$$J_R=\Im\Lambda\eta \qquad (1)$$

Where:

$\Im$: Right eigenvector matrix of J_R.

Λ: Left eigenvector matrix of J_R.

η: Diagonal eigenvector matrix of J_R.

The magnitude of Eigen values can be providing a relative measure of proximity instability. However, it does not provide an absolute measure because of the non-linearity of the problem. [1] The application of Modal Analysis is helps in determining how stable the system is and how much extra load or power transfer level should be added. Table V shows the amount of reactive power (Q) need to be insert for maintaining voltage magnitude within permissible limits at some buses at focused area in Khartoum and Gazira.

- **Result of Modal Analysis**

Table-V: The Required Reactive Power Q at Different Buses.

No.	Name	Voltage (%)	Reactive Q(MVAR)
1	FAO0	90	30.01843
		100	50.91088
		110	75.56358
2	MHD3	100	68.836
3	FAR3	100	48.7431
4	POR3	100	-33.2067
5	LOM3	100	61.96211
6	SHG3	90	18.01467
		100	123.5593
		110	243.701
7	OMD	90	-7.7474
		100	83.56829
		110	225.747
8	GAM3	100	68.836
9	BAG3	100	50.11485
10	GND1	90	-38.9926
		100	146.8901
		110	342.3439
11	MAR3	90	55.03927
		100	133.5739
		110	240.2674
12	MSH3	100	1.62788
13	MAN3	90	9.00837
		100	26.98802
		110	47.33124
14	HAG3	100	49.45844
15	MIN3	90	22.29648
		100	17.94263
		110	37.8403

*shaded cells for 100% voltage level of bus-bar.

- **The Bus Participation Factor**

Bus participation factor indicates the effectiveness of remedial actions applied at that bus in stabilizing the mode. Table -VI represents the participation factor of buses on the area for the six previously calculated Eigen values.

Table-VI: The Bus Participation Factor.

Eigenvalues	Name	Participation Factor
Mvar (%)		
0.2958	MAN3	0.1448
	FAO0	0.0902
	SNJ 3	0.0739
	SNP 0 N1	0.0728
	SNP 11 N2	0.0728
	MIN3	0.0632
	MAR3	0.0450
0.6461	WHL33	0.2847
	WAW3	0.2159
	DON3	0.1346
	SNP 0 N1	0.0838
	SNP 11 N2	0.0838
	DEB3	0.0814
0.8009	SNP 11 N2	0.2994
	SNP 0 N1	0.2994
	FAO0	0.0775
0.8277	SNP 0 N1	0.5000
	SNP 11 N2	0.5000
1.0428	FAO0	0.4577
1.4459	MIN3	0.2544
	FAO0	0.2456
	MAN3	0.1671
	SNJ 3	0.1391

*Table-VI above illustrate the bus participation factor which indicates the effectiveness of remedial actions applied at that bus in stabilizing the mode.

- **Result of Sensitivity Analysis**

It implies that if-Q sensitivity is positive for every bus the system is voltage stable and if V-Q sensitivity is negative for at least one bus, the system is voltage unstable.

Table-VII: The bus sensitivity

Substation	Sensitivity
FAO	1.0915
MAN3	1.0383
MIN3	0.7356
MAR3	0.2907
MSH3	0.2710
SHG3	0.1681
OMD	0.1506
NHAS3	0.1331

*The bus which has the largest sensitivity that means is the weakest bus and need compensation (Mvar).

- **Results of V-Q cure**

Voltage security of a bus is closely related to the available reactive power reserve, which can be easily found from the V-Q curve of the bus under consideration.

The reactive power margin is the MVAR distance between the operating point and either the nose point of the V-Q curve or the point where capacitor characteristics at the bus are tangent to the V-Q curve.

Stiffness of the bus can be qualitatively evaluated from the slope of the right portion of the V-Q curve. The greater the slope is, the less stiff is the bus, and therefore the more vulnerable to voltage collapse it is. Weak busses in the system can be determined from the slope of V-Q curve.

If the minimum point of the V-Q curve is above the horizontal axis, then the system is reactive power deficient Busses having V-Q curves below the horizontal axis have a positive reactive power margin. The system may still be called reactive power deficient, depending on the desired margin.

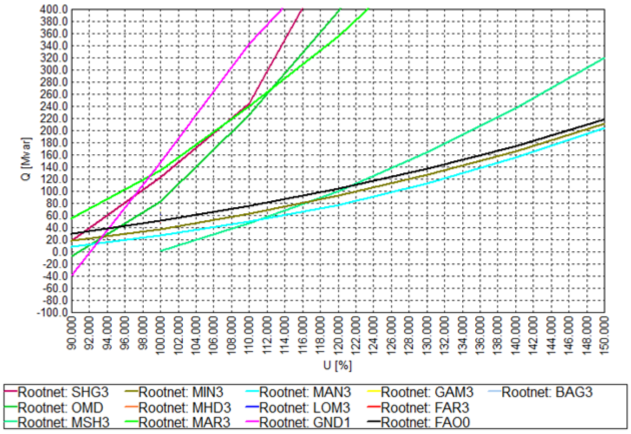

Fig1: The V-Q Curve for Substations Understudy at Scenario-I.

B. Scenario-II

- **Load Flow Analysis:** When applying the 2022 load forecast with that the SVCs at nine substations and the planned 220KV transmission line (Gadarif – Fao – Marigan), the system *did not converge* without the values of shunt capacitors that had been added on Scenario-I. (See table-II).
- **Voltage Stability Analysis:** On the other hand, the results of voltage stability represent that the required reactive power value at the area understudying had been reduced compared to values needed in Scenario-I. The Table-VIII below shows the new values

C. Scenario-III

- **Load Flow Analysis:** Both Load Flow and Voltage Stability Analysis in this Scenario had been done by considering the off-peak load for year 2022.
- **Voltage Stability Analysis:** The results of Voltage Stability Analysis at Off-Peak condition represent that the required reactive power value at the area understudy had been reduced compared to values needed in Peak condition. Table-IX below shows the new values.

Table-VIII: The Required Reactive Power Q at Different Buses for Scenario-II

NO	Name	U%	Q (Mvar)
1	OMD	100	158.60655
2	MHD3	100	115.3332
3	SHG3	100	99.3043
4	FAR3	100	77.20775
5	GND1	100	70.99871
6	GAM3	100	70.71256
7	BAG3	100	46.79399
8	LOM3	100	40.52688
9	FAO0	100	11.88843
10	MIN3	100	-1.26259
11	MSH3	100	-12.94208
12	MAN3	100	-16.334
13	POR3	100	-18.81858
14	MAR	100	-49.8068

Table-IX: The Required Reactive Power Q at Different Buses. (With Siemens Project)

NO	Name	Voltage (%)	Q Mvar
1	GAM3	100	68.836
2	OMD	100	68.612
3	GND1	100	65.534
4	MAR	100	63.538
5	SHG3	100	44.597
6	MHD3	100	39.481
7	FAR3	100	35.438
8	FAO0	100	25.590
9	BAG3	100	2.730
10	MAN3	100	-3.853
11	MIN3	100	-4.668
12	LOM3	100	-9.027
13	POR3	100	-11.450
14	MSH3	100	-27.520

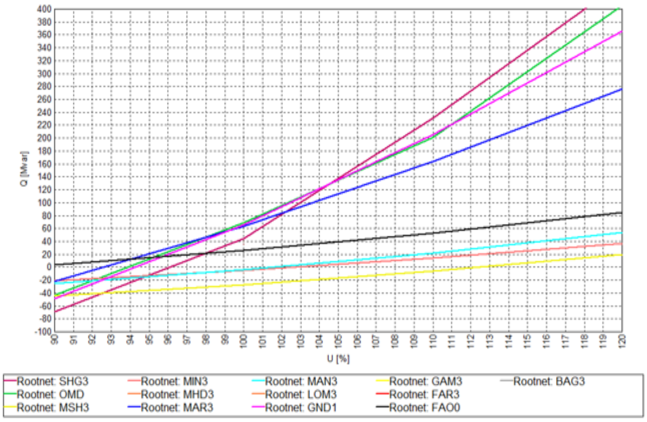

Fig2: The V-Q Curve for Substations Understudy at Scenario-III. (With Siemens Project).

Voltage Stability Analysis of the Off-Peak condition considering that both Garri-3 and Port-Sudan (Siemens Project) are out off-serves. Table-X below shows the values of reactive power needed at some buses.

Table -X: The Required Reactive Power Q at Different Buses. (Without Siemens Project).

NO	Name	Voltage (%)	Q (Mvar)
1	GAM3	100	68.836
2	SHG3	100	60.56908
3	OMD	100	48.86994
4	FAO0	100	30.9226
5	GND1	100	21.47692
6	HAG 3	100	14.08651
7	OHAS3	100	10.73859
8	BAG3	100	3.6835
9	MIN3	100	1.49129
10	MSH3	100	1.18182
11	MAN3	100	-14.9923

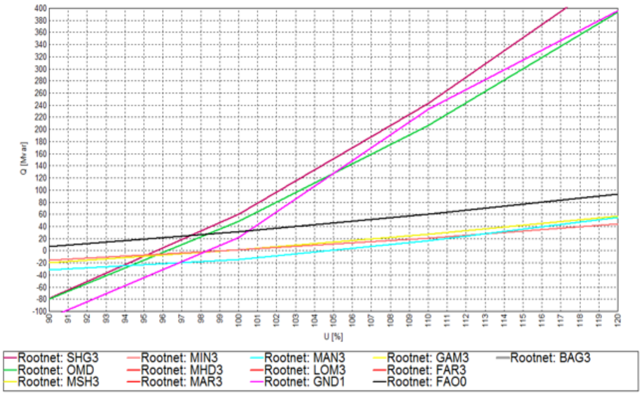

Fig3: The V-Q curve for Substations Understudy at scenario-III. (Without Siemens Project).

D. Scenario-IV

In this scenario we assuming that the under-construction generation projects (2×150MW at Port-Sudan and 3×150MW at Garri-3) will be commissioned after year 2022.

Table -XI: The Required Reactive Power Q at Different Buses.

No.	Name	Voltage (%)	Q Mvar
1	OMD	100	117.82
2	SHG3	100	116.7
3	GAM3	100	70.462
4	MHD3	100	68.836
5	GND1	100	39.376
6	BAG3	100	37.21
7	FAO0	100	31.482
8	OHAS3	100	13.336
9	HAG 3	100	9.209
10	POR3	100	8.4927
11	LOM3	100	7.738
12	MIN3	100	4.2715
13	MAR	100	2.0455
14	MAN3	100	-0.615
15	MSH3	100	-10.08

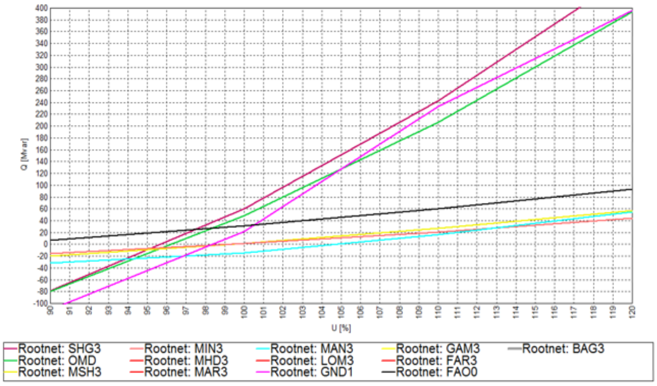

Fig4: The V-Q Curve for Substations Understudy at Scenario-IV.

VII. DISCUSSION

- From the results of this study, confirmed that Port-Sudan (POR) SVC already has been performed properly. Therefore, it no needs to be re-adjusted on a new value. Also, Kuku (KUK) SVC has been acting well with its proposed value (QC =40, QL=45 Mvar).
- Mahadiya`s (MHD) SVC required to upgrade the (QC) value for minimum (150 Mvar) otherwise, the system not converge due to the high amount of the voltage drop on this area which reach 87% at MHD bus-bar. The same mentioned above is occurred on Farooq (FAR) where the voltage drop reaches 80.7%, the capacity of the SVC required extension to minimum (QC =130 Mvar).
- The Local Market`s (LOM) SVC also must be upgrade to QC =130 Mvar.
- Also, from the voltage stability results the SHG substation required reactive power with QC=123.5593 Mvar.
- There is voltage drop about 89.9% at 33Kv of Gamoia (GAM) which lead to upgrade the **Q**C to minimum 20 Mvar instead of 10 Mvar.
- With the proposed value of Bageair (BAG) SVC still there is voltage drop at 110KV level reach 89.7% and this drop spread to the around area Hence, the **Q**C must be extended to 30 Mvar as minimum.
- The updating of the SVCs mentioned above lead to cancel the capacitors which have been inserted initially at (KLX, SOB, SHG, MUG, and IZB) to enable the software to converge and found a solution for the expected load of 2022. (see *table-II*)
- The situation at Haj-abd-Allah (HAG) substation is so different, that the system not converges within proposed value of SVC and voltage drop at the area is so high even if the **Q**C value of the SVC has been raised. Fig5 shows this amount of voltage drop when Q**C**= 200Mvar, this can be solved with keeping a shunt capacitor with high value at Maringan (MAR) or converting the SVC location from HAG to MAR.

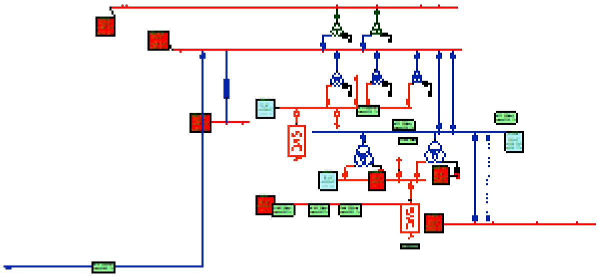

Fig5: Voltage drop at HAG and other substations around when SVC with (Q_C=200 Mvar)

- A similar case of HAG has occurred on Old Hasahisa (OHAS); the system did not converge even if the capacity of SVC increased to 300 Mvar. However, this can be achieved when a shunt compensator will be connected at Al- Gunned (GND). Fig6 at explains this conflict on OHAS. It also has been noticed that the substation transformers burden is not capable of bearing this high value of Mvar, hence the two transformers have been loaded.

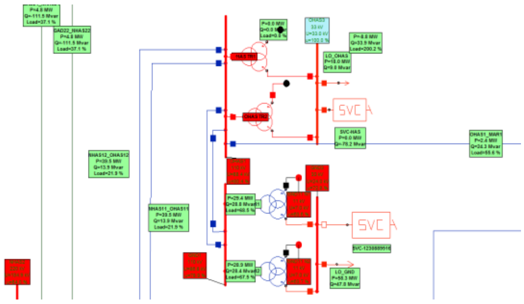

Fig6: Voltage drop at OHAS and the around substations when SVC with (Q_C=300 Mvar).

- From the Voltage Stability Analysis results presented in table-V, the substation that required the highest reactive power are (GND, MAR, SHG, OMD, MHD, GAM, LOM, FAO), positive reactive power margin at GND and negative reactive power margin at POR and this which match the result of V-Q Curve shown in Fig1.The point above clarifies the problem which had been mentioned previously at HAG and OHAS substations and endorses that (GND) and (MAR) substations are more reactive power deficient than OHAS and HAG and the SVC at these two substations will be more effective and therapeutic for solving the voltage drop in the area.

Retrieval Number: 100.1/ijaent.E0469059522
DOI:10.35940/ijaent.E0469.059522
Journal Website: www.ijaent.org

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- From table-V, the remedy can be achieved by installing the value of reactive power required for MAR and GND to reach the limit at normal state 100% which are (133.57 Mvar) for MAR substation and (146.89 Mvar) for GND. The effect of this installation is shown at Fig7 and Fig8 respectively.

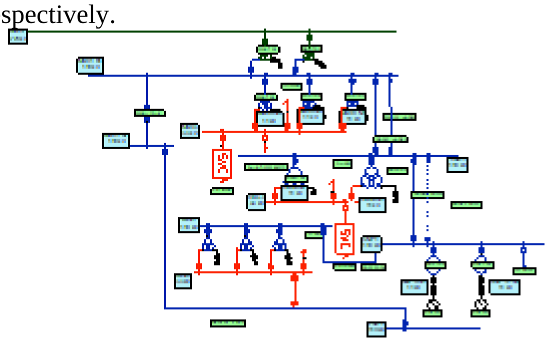

Fig7: The effect of exchange the SVC from HAG to MAR with Q_C value from table-V (Q_C = 133.5739Mvar).

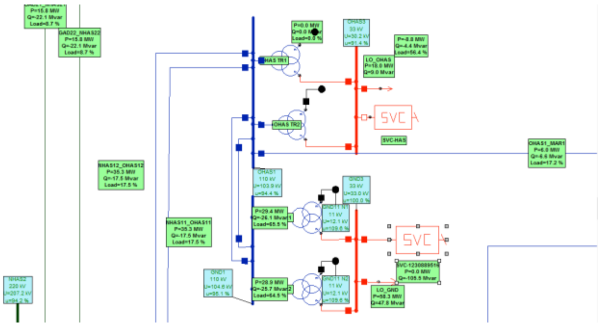

Fig8: The effect of exchange the SVC from OHAS to GND with Q_C value from table-V (Q_C = 146.8901Mvar).

- The Modal Analysis results shown on table-V that the participation factor for each Eigen Value had been considered (as taken six Eigen Values for calculating). It has been matched with the sensitivity result that voltage at FAO substation is instable, although of the remedy which had been done on the SVC limits.
- The Sensitivity Analysis results presented in table-VII it is clear that the system will be stable after installing the suggested SVC with suggested reactive power margin at table-5 that all the sensitivities are positive and the worst substation from the table is FAO substation with (1.0915) sensitivity and the best one in the table is NHAS substation.
- Scenario-II results presented in (*table-VIII*) shown that the negative reactive power margin had been appeared, at all of (MAR, MIN, MAN, MSH). And the total reactive power required was reduced from (892.54 Mvar) to (692.63 Mvar). Here, the importance of establishing the proposed 220KV transmission line, Gadarif- Fao-Maringan, appeared, as it improves the voltage in the Gazira area and consequence reduce the value of reactive power required.
- Scenario-III results presented in table-9 shown that the total reactive power required was reduced to 261.86 Mvar, due to reduction in total demand at Off-Peak condition. An over voltage had been appeared at OBD, TND, and UMR, at the western area and DEB, DON, WAW at Northern area hence, the following must be done:
- The existing reactors in DEB and DBT must be connect.
- Disconnect one unit form Kossti (1×125 MW).
- Scenario-IV results presented in table-XI, shown that when both g Power Plants at Port-Sudan and Garri-3 considered out of service the Software did *not converge* and no solution found unless doing the flowing steps:

1. Adding extra reactive power to enable the Software to find solution in case of disconnecting

(Garri-3 & Por-Sudan) power plants, as in table-XII below:

Table -XII: The Extra Reactive Power Injected Location Type QC (Mvar)

Location	Type	Q_C (Mvar)
GND	SVC	100
MAR	SVC	130
MHD	SVC	120
FAR	SVC	150
SHG	SVC	120
NHAS	Capacitor	60

*The other SVCs and Capacitor bank on the network remains it is.

2. Disconnecting the existing reactor at DEB substation.
3. Connecting the second circuit between WAW and DON.
4. Applying load shedding with 124 MW as:

Table-XIII: The load shedding required to reach a solution in case of no Garri-3 and Port-Sudan.

Substation	From (loading MW)	Reduction to (loading MW)
IZG	181.51	100.51
FRZ	49.3	39.3
FAR	133.16	100.16

- The Voltage Stability results are shown at table-XII and the V-Q Curve at fig3. It can be noticed that when disconnecting Garri-3 and Port-Sudan, the total reactive power required to save system stability will be (**1196.2837 Mvar**). (*Table-XI and table -XII*).

VIII. CONCLUSION AND RECOMMENDATIONS

From the results of this study, we recommend increasing the capacitances (QC Mvar) of seven SVC static compensators from the proposed nine, and transferring two SVCs (from HAG to MAR and from OHAS to GND) with the addition of a new SVC in SHG. (*Table-XIV*)

The two SVCs proposed at Hag-Abdallah (HAG) and Old Hasahisa (OHAS) should be converted to Maringan (MAR) and Al- Gunned (GND) respectively.

Also, the execution of the proposed 220 KV transmission line Maringan, Al-Fao, and Gadarif with the expansion of Fao substation it's highly recommended.

In case of GER3 and POR generation projects not completed by the year 2022, the total reactive power required to save system stability at peak load will become (1196.2837 MVAR) with increasing POR QC to (**23.5** MVAR) and acting load shedding with (124 MW) as in table-XIV.

At off- peak load with considering GER3 and POR generation projects not completed by the year 2022, the total reactive power required to save system stability load will become (**261.8563 MVAR**) with increasing POR QC to (**23.5** MVAR) at peak load and adding DEB and DBT reactors.

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Table-XIV: the total reactive power required to save system stability at peak load.

No.	SVC Location	Qc (Mvar)		Comments
		Old Value	New Value	
1	Gamoia (GAM)	10	20	Same Site & Upgrade the Capacity
2	Farouq (FAR)	10	130	Same Site & Upgrade the Capacity
3	Mahdiya (MHD)	15	150	Same Site & Upgrade the Capacity
4	Local Market (LOM)	100	130	Same Site & Upgrade the Capacity
5	Bagair (BAG)	10	30	Same Site & Upgrade the Capacity
6	Hag-Abdallah (HAG)	15	133.57	Relocated to MAR
7	Maringan (MAR)	60	146.98	Relocated to GND
8	Al-Shagarah(SHG)	-	123.6	New SVC

ACKNOWLEDGMENT

We are grateful to all of those with whom we have had the pleasure to work during this project first of them: Eng. Ali Habib-Allah the head manager of the general Directorate of operation and maintenance at Sudanese Electricity Transmission Company Co. Ltd (SETCO). This work would not have been possible without the scientific support, especially indebted to Dr. Mohammed Osman Hassan, and Eng. Amna Rahama Babiker the head manager of the General Directorate of Planning and Projects at Sudanese electricity transmission company co. Ltd (SETCO), who have been supportive and who worked actively to provide time to pursue those goals. We would like to express the great appreciation to Dr. Shiv Kumar, for the valuable and constructive suggestions and the willingness to give his time so generously.

REFERENCES

1. *Prabha Kundur , "Power System Stability and Control",McGraw-Hill, Inc*
2. S. Chakrabarti, Dept. of EE, IIT, Kanpur, "*Notes on Power System Voltage Stability*".
3. IEEE/CIGRE Joint Task Force on Stability Terms and Definitions, "*Definition and Classification of Power System Stability*", IEEE Transactions on Power Systems, Vol. 5, No. 2, May 2004, pp. 1387–1401.
4. Badrul H. Chowdhury, Student Member, IEEE and Carson W. Taylor, Fellow, IEEE "*Voltage Stability Analysis: V –Q Power Flow Simulation Versus Dynamic Simulation*".
5. D-P-Kothari, I-J-Nagrath, *"Modern-Power-Systems-Analysis"*, McGraw-Hill, New Delhi.

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