POWER SYSTEM STUDIES TO IDENTIFY LOSSES AND EXISTING DIFFERENCES

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Abstract- Research paper presents simulation study of submitting technical losses of existing and renewable integrated real time network. All along with variations recorded in voltage profile at 400 KV levels are deliberately presented with test network modeling of existing system that is a part of Indian National grid synchronized at 765 KV and 400 KV voltage levels. Disturbances recorded for the financial year 2018-19 is being practiced to judge the increment of losses that are possibly to raise with the adherence of renewable energy system from 20 % to 70 % in a gap of ten percent. The paper discusses test network modeling basics, operations strategy in case of voltage issues are briefed. System deficiencies are represented with possible suggestions.

1. INTRODUCTION

Power System Network is the sum total of power generation, transmission and distribution to the infinitely connected load end termed as consumer. As the distance from generator increases the losses and differences in network keeps on multiplying. The present form of grid network is very much improved and advanced as compared to earlier versions. Bidirectional power flows, demand side management, utilization of smart meters have raised the role of consumers too in advancing the grid. System at present is working in its restructured stage, definitely the upcoming time will may provide wide changes in terms of source wise composition of power is concerned. Although obtaining huge power from coal at present, the level of power generation from renewable energy sources is continuously changing its digits from double to triple. As a result, it may change the old parameters soon. Concerning towards environment issues and pandemic situation have alarmed power system engineers to utilize and perform the grid operations in sustainable ways. Government of India are continuously modifying old rules and regulations to channelize the grid structure as per upcoming modifications and requirements.

Work carried in this paper is to identify the basic problems of network in operations with grid over huge area such as Rajasthan State Power System Network is utilized hereby for study. The respective test network could be termed as modern power system since it consists of demand side management as grid feature tool even all the arrangement are made on day ahead basis with proper planning from generation ends. Along with this state load dispatch centers took the responsibility of major operations and decisions if in case to be taken upon to maintain grid levels and limits when required upon. As per there instruction operator carries out exercises in the field.

Since from the last few years ratio of upcoming solar and wind integration to grid is changing. Government plans to raise renewable energy sources have led to the increase of renewable energy content for the present and upcoming time. Large sized solar plants are going to cover up the desert areas of Rajasthan State to collect and provide maximum solar penetration as much as they can drew from the barren lands spread over thousands of kilometers. Government has started Green energy corridor schemes to evacuate large amount of renewable energy over 765 KV corridors from the renewable rich states of India. So, raising the contribution of green energy that is reducing carbon foot prints over the areas as well as reducing the pollution issues attached with convention systems.

Many a times problem arises in grid network when conventional plants have to be managed with the intermittency issues related to renewable energy such as solar and wind because as solar starts from early morning 6 AM, rises peak at 11 to 12:00 PM in afternoon and last available till 6 :00 PM of evening and vice versa with Wind. So, intermittency is there contributing a large amount of system is reduced suddenly cause huge unbalancing of power flows. Since it is daily based issue so obviously utilities have already prepared some steps or we can say some arrangements such as opening of lightly loaded circuits, Switching off Shunt capacitors from night till morning and so on. But still these arrangements are not enough or up to the mark as such issues of voltage profile, burnouts of equipment’s, line outages at 400 and 220 KV voltage level, abrupt tripping’s etc. all such issues have been recorded regularly in past financial year. Thus, analysis over Rajasthan State power system is practiced with simulation studies. Basic idea of network along with modeling in software and issues recorded over past financial year 2018-19 will be discussed in the upcoming section. Targeted objectives of suggesting possible suggestions to the problems identified from the analytics of database will be also briefed.

2. PROBLEM IDENTIFICATION

Lacking in technology upgradation and non-availability of any schemes or methodology could be the major cause of unplanned work exercises. That may lead to over or under compensation of network at unnecessary areas in the network. As we see Rajasthan Power System has conventional thermal power plants in majority stack.

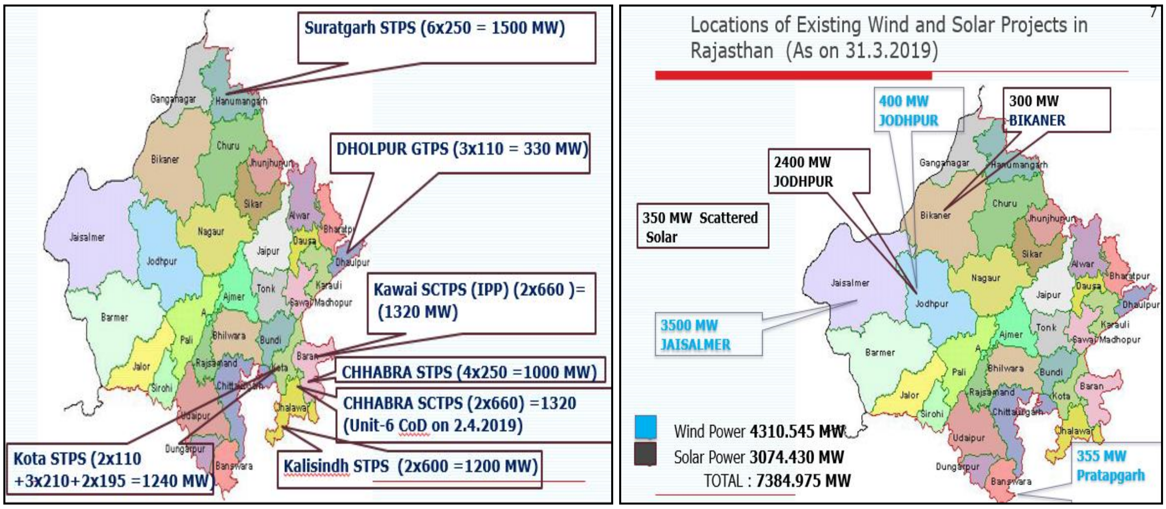

Fig. 2.1 Existing Coventional Plants and Renewable Generation of State Network

Also practicses performed since last ten years in raising the role of renewable energy in terms of solar and wind generation as shown in fig. 2.1. providing information about existing projects in renewable till 31:03:2019. Year wise progress in solar and wind generations is briefed in Plots of fig. 2.2 and 2.3 respectively.

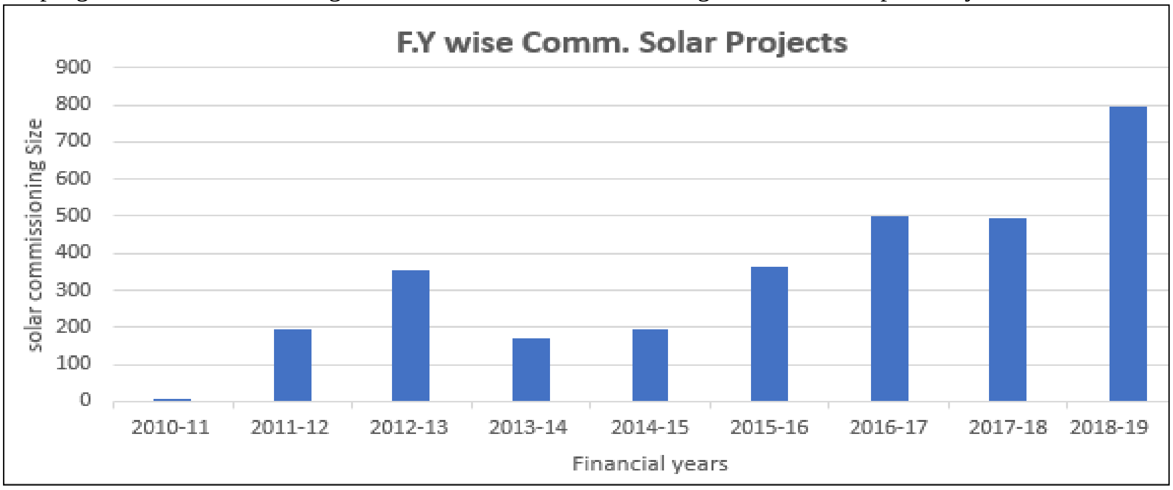

Fig. 2.2 Solar Projects Year wise Commisioning

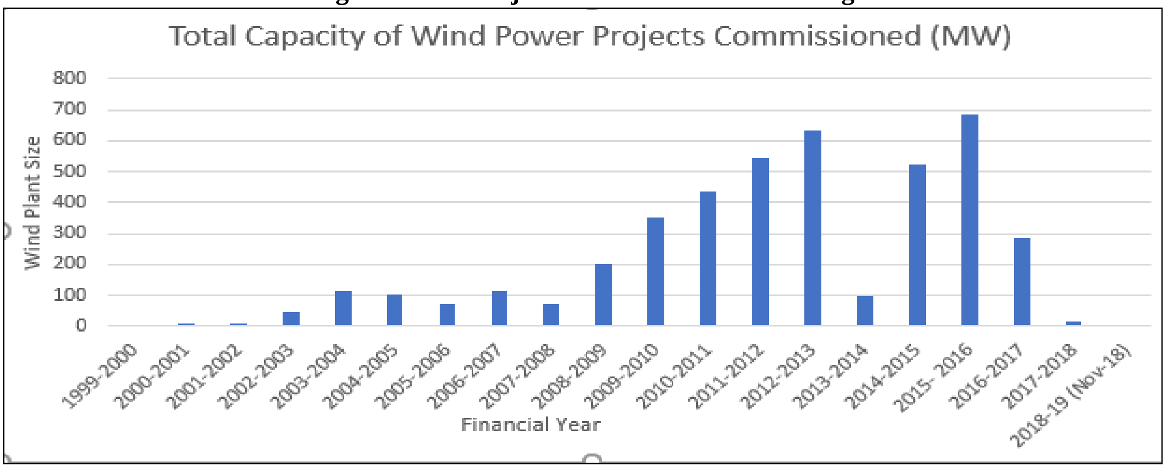

Fig. 2.3 Wind Projects Year wise Commisioning

Year 2018-19 shows progressive rise in solar addition during these years. Wind projects commissioning during year 2015-16 and 2012-13 is on higher scale, but afterwards it is down. Now following the available literature various technical issues prevailing in the power system are raised such as:

- Practically implementing techniques/methods available at DISCOMS to maintain the Voltage variations happening at transmission level is missing.
- No provisions are there at grid level to record the voltage variations and to keep deep study on them. Renewable integration misses the functionality of Ramp in/Out feature of conventional power plants thus resulting in low plant factors.
- No contingency plan action is there to handle dynamic behaviors of grid in case when solar or wind stops supplying their supply in grid.

All the above queries are on the base of research operations carried in past. Handling the grid from SCADA view or from a dispatch center or generating center is totally different from literature material angle. Recorded database of peak voltages at 400 KV GSS is provided in Table 2.1.

Table-2.1 Recorded Peak Voltages Of 400 KV GSS

MONTH WISE RECORDED MAXIMUM 400 KV BUS VOLTAGE AT 400 KV GSS					
Month	**BIKANER GSS**	**BARMER GSS**	**ANTA GSS**	**HINDAUN GSS**	**HIRAPURA GSS**
Apr-18	429	429	419	430	425
May-18	425	422	419	435	425
Jun-18	429	427	416	437	424
Jul-18	425	428	417	429	425
Aug-18	425	426	417	425	423
Sep-18	425	427	415	427	425
Oct-18	422	420	414	425	423
Nov-18	425	417	417	428	424
Dec-18	425	420	416	430	424
Jan-19	425	425	416	435	426
Feb-19	425	428	414	429	427
Month	**PHAGI GSS**	**AJMER GSS**	**BABAI GSS**	**BHILWARA GSS**	**MERTA CITY GSS**
Apr-18	424	428	436	420	426
May-18	423	425	434	421	428
Jun-18	424	425	433	420	427
Jul-18	423	425	428	422	426
Aug-18	426	425	425	419	424
Sep-18	426	425	428	421	426
Oct-18	423	423	430	417	425
Nov-18	425	425	431	419	423
Dec-18	426	426	432	421	425
Jan-19	425	425	433	420	424
Feb-19	425	425	430	421	424

As per voltage limit of operation is concerned various National/International obligations have already defined a fix limit under which operations should be there. But practical recordings violate the defined ones as provided in Table 2.2.

Table-2.2 Max/Min. Voltage Limit As Per IEGC/CEA

S. No.	**Nominal System Voltage (KV rms)**	**Maximum (KV rms)**	**Minimum (KV rms)**
1	765	800	728
2	400	420	380
3	220	245	198
4	132	145	122
5	110	121	99
6	66	72	60
7	33	36	30

Huge differences in peak values could be easily observed in the graph. It should be reduced otherwise it indirectly effects the equipment's of network. The upcoming section will detail the basic outlining of test network along with creation of simulation model in mipower software is briefed.

3. MODELING DESCRIPTION OF TEST NETWORK

Rajasthan State is connected with Northern Power Division and connected synchronously at all available higher voltage levels. Test network is the biggest part of India size wise with huge population as consumer more than 8 Crores. Source based data suggests that 57 % is upcoming from coal based thermal plants. More than 600 Plus grid substation network is currently involved in transmission and distribution of electricity to consumer. Table 2.3. states that test system is having more than 0.39588 lakh circuit KM area covered till date 31st of March 2019, database locked till this date.

Table-2.3 Rajasthan State Power System Detailing

Particulars GSS	**No. of GSS/MVA Capacity till 31-03-2019**
765 kV	4
400 kV	27
220 kV	122
132 kV	453
Total	**606**

As per the details briefed hereby the generation facility-based data is also shared in the upcoming Table where renewable and non-renewable sources both are classified as per there availability to the user. Large Sized network requires planning and operations at each level to work upon. State grid is maintained by grid operators as per the instruction received from the SLDC. Power map of Rajasthan power system provided hereby briefs the basic connectivity of complete network along with border tie line connections too provided in Fig. 2.4.

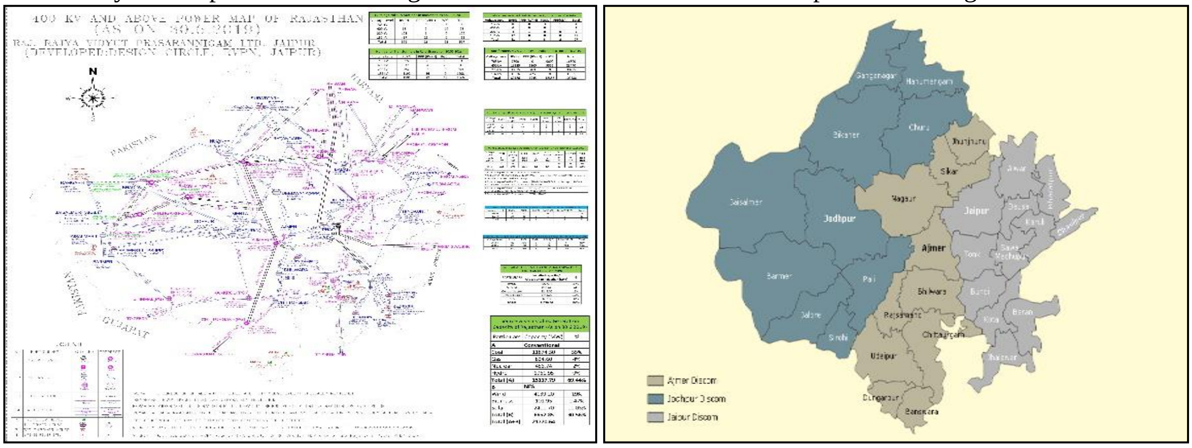

Fig. 2.4 Test Network Power Map & Distribution Network Division Map

As per fig. 2.4 model using mipower is practiced to prepare based on data recordings and collected an active load of 12874 MW as per the earlier electric power survey report and peak load recordings are concerned. Since area wise the test network is big so it has been divided into three different companies of distribution network as Ajmer, Jodhpur and Jaipur. Up to 10 to 11 districts in each division are divided All the three DISCOMs of Rajasthan were set up as per Companies Act,1956 by GOR, to completely distribute the roles and responsibilities over the wide area of state. So different zones are pertained to specific calculations are created as shown in Table 2.4.

Table-2.4 Load Based Zones Modeling

Zone No.	Defined Zones As per Test Network	Connected load		Load in 1A	
		Active	Reactive	Active	Reactive
		MW	MVAR	MW	MVAR
1	JAIPUR	7724	2640	3658	792
2	AJMER	4901	2051	2321	615
3	JODHPUR	5343	2319	2531	696
4	NTPC/PGCIL/ISTS	0	0	0	0
5	RVUN	0	0	0	0
6	IPP	27	0	13	0
7	SOLAR_PG	13038	0	2608	0
8	INDUSTRY	1012	190	479	57
9	RAILWAY	662	164	313	49
11	WIND_BANSWARA	76	42	36	13
12	WIND_JSLMR	63	22	30	6
13	WIND_JDP	282	136	134	41
14	WIND_OP	141	64	67	19
15	SOLAR_JSLMR	52	16	25	5
16	SOLAR_JDP	331	154	157	46
17	SOLAR_OP	536	162	254	49
18	SWING_BUS	0	0	0	0
19	REFINERY_LOAD	250	82	250	82
Total		**34438**	**8042**	**12875**	**2470**

The generation holds and operates the thermal, hydel and gas-based power generating stations located. Transmission company looks out operations from 765 to 132 KV lines of system in state and to its connecting's. Dis-coms look out the network lines operating below 132 kV voltage level. All power system equipment's wise modeling is carried out Graphical file as well as database in support to model the network is also created which is than solved using newton Raphson or gauss seidel method. During system creation various zones are created based on network topologies and their contribution to system. Bus Modeling: Initializing with the modeling of bus specific values related to buses organized in test network are created in mipower database as per the table 2.5 briefed hereby.

Table-2.5 Bus Data for Modeling In Software

Name of Bus	Zone	Area	Owner	Voltage (in KV)	Voltage Limits (in PU)	
					Min.	Max.
AJMER_7	4	5	1	765	0.9	1.1
AJMER_4	2	3	1	400	0.9	1.05
BHIWADI2	1	2	1	220	0.95	1.03

Linking the above tabulated data to the model is carried by inserting from software interface as shown in Fig. 2.5.

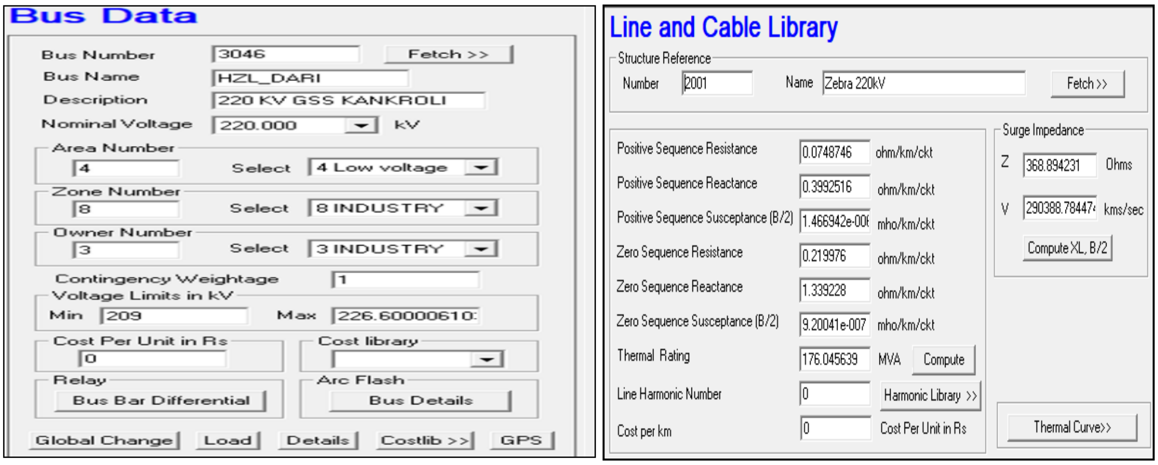

Fig. 2.5 Test Network Bus and line Conductor Modeling Snapshot

Transmission Line & Conductor Modeling: While modeling a line its sending end, receiving end both have to be signified and the conductor utilized as per the defined voltage level are provided and then model is created. Software snapshot providing details of line and cable library is shown hereby in fig. 2.5. Based on parameters collected such as resistance, reactance and susceptance values, positive and zero sequence values, as inserted into the software model is prepared

Table-2.6Transmission Line Paramters For 765 Kv Network

Cond. Parameters		Resistance	Reactance	Susceptance	Thermal Rating
Twin HTLS	+	1.47E-02	2.58E-01	2.29E-06	1.98E+03
	0	4.06E-01	1.62E+00	1.32E+00	
HTLS P	+	1.46E-01	3.86E-01	1.46E-06	1.86E+02
	0	4.06E-01	1.62E+00	1.32E+00	

Generator Modeling: It consist of inserting parameters to model a generator as such database contains library in which various values are fixed.

Table-2.7 Generator Paramters for Database Building In Simulation Application

BUS NAME	RATING- in MW	Q-MIN	Q-MAX	MVA Rating	P-RATE-MIN	P-RATE-MAX
STPS220G	500	-120	250	590	500	500
STPS400G	500	-120	250	590	500	500
STPS_G	1320	-230	660	1700	1320	1320

Load Modeling: Load is modeled by inserting values of power factor and active load participation for constant load type load.

Table-2.8 Load Modeling Paramters

S. No	Load Bus Name	Active Load in MW	Power Factor	Reactive Load in MVAr	No. Of SC's	Amount of Compensation
1	CHIT_7	270	1	3.287	0	0
2	PACHPD2	250	0.95	6.95	1 x 5.43	5.43
3	BHIWAD21	143.02	0.993	16.5	2 x 5.43	10.86

Till here all the elements are modeled and created in the document size of 4200 x 3270 inches area size as graphical layout. Now Load flow analysis of network is carried out using fast decoupled load flow method.

As per the problem situation considered in the paper. When high voltages are recorded the possible strategies taken by utilities at their end without being inculcated are outlined hereby.

- The bus reactors will be switched in.
- The manually switchable shunt capacitor banks shall be taken out.
- The switchable line/ tertiary reactors be taken in.
- Synchronous condensers shall be operated for VAR absorption.
- Hydel generators shall be operated as synchronous condenser wherever feasible for VAR absorption, with the consent of SLDC.
- Lightly loaded EHV lines shall be opened keeping in view the security of the balance network with the consent of SLDC for 220 kV in NRLDC through SLDC for 400 kV.
- SLDC may resort to regulatory measures by opening of tie lines including those, feeding radial loads in the areas of defaulting Discoms. the same does not adversely affect the evacuation system from existing generation.

During grid disturbances SLDC generates flash report along with report to distribution companies as per the defined levels of issue. May be of Category A: Major, B: Moderate, C: Minor ones are classified. The reaction time of report also various with severity of disturbance. The previous sections till now submits basic information required to understand the complete Rajasthan Network. Based on this ideology network modelling will be presented in the next chapter four but before moving towards modelling part problem identification will be discussed in the upcoming section. Swing bus is operated as imaginary generator at the location shown in power map. Since majority of network of RSPS system is in synchronism with North Regional Grid division the swing bus point is model by keeping the same ideology.

The state tie line points will also be there near to swing bus. Since in real the test network is having connectivity to national grid at multiple voltage level, such as 765 KV, 400 KV 220 KV and 132 kV all are represented in our model. Simulation design of test network is carried on and analytics accomplished using MiPower software is shared hereby: -

- Test network of RSPS is drawn as per power map modeled and simulated up to 132 kV GSS with low renewable integration.
- Real time flow of power system elements as per grid sub stations schedule is studied with identification of the existing parameters and the values applied in power system.
- Real time simulator consists of total 1015 buses including 113 generator buses, 1256 transmission lines, 698 load buses, 180 shunt reactors, 449 shunt capacitors and one static var compensator installed at 400 kV Kankroli GSS.
- Load is represented at 132 kV bus of each 400 kV GSS. Total system load in simulation model is 12,874 MW & 2470 MVAR with 0.982 PF as load power factor.

Lastly Table is provided hereby providing losses and exact replica values obtained from multiple load flow studies.

Table-2.9 Load Based Result of Existing RSPS

Case Comparison	**1A_20**	**2A_30**	**3A_40**	**4A_50**	**5A_60**	**6A_70**
Real Losses in MW	270.86	341.79	460.54	632.22	868.67	1207.92
% Loss	2.010	2.28	2.79	3.51	4.45	5.75

Table-2.10 Load Based Result of Existing RSPS

Parameters		**RSPS LFS**
Load MF		**1.00**
Renewable Energy Integrated %		**20 %**
Tot. Real Power Load MW		12874.69
Tot. Reactive Power Load MVAr		2470.03
Generation P.F.		0.938
Renewable Gen.	Wind	1260.25
	Solar	4197.16
Tot. Shunt Reactor Injection MVAr (-)		25992.26
Tot. Real Power Loss MW		270.86
Percentage Real Loss		2.010

Load Flow results brief outs that with increase of renewable contribution from 20 to 70 % in step of 10 % as results.

CONCLUSION

The research work submits simulation study of State network electricity system. Existing voltage profile is obtained and problems of violating the voltage profile are identified. Deficiency of test system network in terms of inductive var support is obtained. Since if proper var support is there than it would work as utility function in maintaining voltage profile of network. The base load is having 20 % renewable integration. From the studies following conclusions can be drawn:

- Majority of GSS are submitting peak voltage due to not redressal of inductive system Var .
- Voltage variations must be recorded in terms of voltage variation index basis so that difference in voltage from bus-to-bus voltage could be known exactly.
- Necessary actions to maintain generator var drawls must be carry out.
- Instead of removing Capacitive VAR support during off solar period. Reactors could be penetrated in the same amount to handle the variations due to solar reduction.

As a future scope part apps could be design to maintain var calculations of network for maintaining voltage profile of network as renewable addition and removal may hinder the basic parameters of system.

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