VOLTAGE PROFILE IMPROVEMENT IN A HYBRID DISTRIBUTION SYSTEM USING ETAP

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Abstract:

To design and analyse the integration of high PV and wind penetration into the Distribution system.This integration have been carried out on 33kv and 14 bus node test in the distribution feeder .To show the load flow analysis and impact of adding DG in the medium voltage distribution network using ETAP software.Renewable energy resources are present a high potential to fulfill the global increasing power demands. In distribution side ,high absorbs the reactive power so it must be equalize by renewable energy to improve the voltage level in the distribution network. Additionally, in order to examine the grid performance during this conditions.In etap software ,Adaptive Newton-Raphson method was used in the distribution network.

Keywords- Electrical Transient Analysis Program(ETAP),DistributedGeneration(DG), Photovoltaic(PV),Renewable Energy,Load Flow Analysis.

I. INTRODUCTION

Power consumption is one of the daily resources without which we can't imagine our modern life.The demand of consumer is much higher then supply generation and imbalanced.So in 2020 ,20% of renewable energy integration to the grid.The combination of two energy source is known as hybrid energy source.Nowadays the conventional energy sources are limited and cause pollution to the environment.So the government now move to the renewable energy sources such as solar,wind,fuel cells,biomass,hydro etc.But main drawback in the renewable source is depending upon the nature.While comparing to other renewable source wind and solar sources are generate high MW power[1].In conventional energy sources are generated the power in very long distance so it have high transmission losses to reach at consumers but in renewable energy sources are generated the power in short distance. Renewable energy sources like wind and solar power form a Distributed Generation (DG). The major problem today in power sector is losses in distribution network. Wind energy is the fastest growing and the most promising renewable energy source because it is plentiful, cheap, inexhaustible, widely distributed, clean and climate benign. The weak buses are the buses where the transmission line parameters namely voltage, current and power factor are not maintained efficiently, which results in poor voltage regulation[2].

Now a days the home appliances are inductive load so it absorbs more reactive power from the generation source.Therefore voltage drop occurs in the distribution networks and also in distribution network have several branches to separate the power for consumers ,it also make a cause for voltage drop[1].The impact of PV penetration at a large scale into the electricity distribution networks, at severe network conditions and location of fault occurrence remains uncertain. This leads to the importance of

examining the short circuit level to assure the validity of connecting such DG to ensure smooth network operation and reliability[3]. There may be disadvantages of connecting distributed generation such as increasing the voltage profile and exceeding the network short circuit level, and in turn, this may limit the connection of the distributed generation to the network. This paper will examine the impact of Doubly Fed Induction Generator wind turbines on short circuit level in distribution test system using ETAP software[5]. This analysis are done by the ETAP software.This ETAP simulator which is the most excellent software to represent the real electrical power grid system and to study all the case studies of electrical power applications[4].Photovoltaic (PV) systems can be hugely advantageous for commercial as well as domestic institutions which use inverters, generators and other auxiliary sources to diminish energy costs and also guarantee power continuity in the event of faults/ outages.
The impacts are came while installing the hybrid energy in the distribution network and analysis which bus gets fault and voltage drop occurs in the network.According to that which place we kept the renewable energy sources and capacitors to improve the voltage in the distribution network[8].

II. HYBRID NETWORK

In this project ,the combination of the solar pv panel and wind turbine are used for hybrid renewable energy sources.Using this renewable energy sources to improve the voltage level in the distribution network.
In **Solar energy** is generating the electricity through the sun radient light and heat.The solar energy is divided into solar thermal and solar electricity.In solar thermal, the sun ass direct source of heat energy to supply hot water and domestic uses.In solar electricity, uses photovoltaic for suppling electricity.In pv is a process of converting the sun light directly into electricity.In this project uses pv panel only for generating the source.The pv panel is a semiconductor device that transforms solar light into electrical energy[3]. Typically, it is few inches in size and produces about 1 Watt of power. In order to generate high power, PV cells are grouped in series and parallel circuits to form a PV module. Hence, numbers of PV modules are electrically connected in a series-parallel configuration to generate the required current and voltage. The PV array output power is affected by the operating conditions and the site conditions such as geometric location, irradiance level, and ambient temperature[5].The process of solar panal is connect to grid was

- The sun shines on the solar panels generating DC electricity
- The DC electricity is fed into a solar inverter that converts it to 240V 50Hz AC electricity.
- The 240V AC electricity is used to power appliances in your home.
- Surplus electricity is fed back into the main grid.

Whenever the sun shines (and even in overcast weather), the solar cells generate electricity. The grid connect inverter converts the DC electricity produced by the solar panels into 240V AC electricity, which can then be used by the property/household[6].
If a grid connect system is producing more power than is being consumed, the surplus is fed into the mains power grid. Some electricity companies will meter the electricity fed into the grid by your system and provide a credit on your bill. How much you are paid is determined by the feed-in tariff.
When the solar cells are not producing power, for example at night, your power is supplied by the mains power grid as usual. The energy retailer charges the usual rate for the power used.
As all of the components in a grid connect system have no moving parts, you can expect a long and hassle free life from your solar power system! Generous government solar rebates and incentives mean you can also save thousands on a grid connect system for a limited time[8].

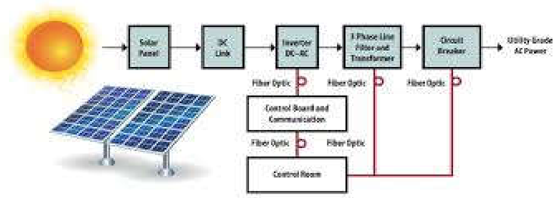

Fig.1.block diagram of pv panel.

In **wind turbine**, the process by which wind is used to generate electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. A generator can convert mechanical power into electricity. Mechanical power can also be utilized directly for specific tasks such as pumping water. The US DOE developed a short wind power animation that provides an overview of how a wind turbine works and describes the wind resources in the United States[4]. Wind is caused by the uneven heating of the atmosphere by the sun, variations in the earth's surface, and rotation of the earth. Mountains, bodies of water, and vegetation all influence wind flow patterns. Wind turbines convert the energy in wind to electricity by rotating propeller-like blades around a rotor. The rotor turns the drive shaft, which turns an electric generator. Three key factors affect the amount of energy a turbine can harness from the wind: wind speed, air density, and swept area[7].

Equation for Wind Power $\mathbf{P=1/2\ \rho AV^3}$

Wind speed

The amount of energy in the wind varies with the cube of the wind speed, in other words, if the wind speed doubles, there is eight times more energy in the wind (z^3=2x2x2=8). Small changes in wind speed have a large impact on the amount of power available in the wind.

Density of the air

The more dense the air, the more energy received by the turbine. Air density varies with elevation and temperature. Air is less dense at higher elevations than at sea level, and warm air is less dense than cold air. All else being equal, turbines will produce more power at lower elevations and in locations with cooler average temperatures

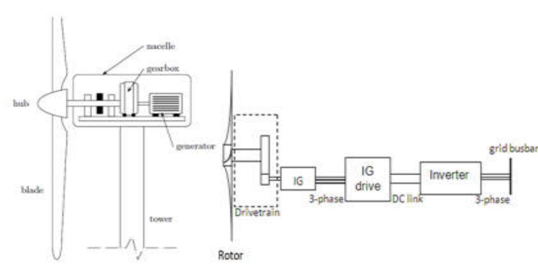

Fig.2. block diagram of wind turbine.

Due to wind the turbine start to rotate through kinetic energy ,the turbine was connected to generator through the shaft using gear box.The generator was generate electricity and connected to the grid network. The wind turbine generate reactive power and it is compensate the absorbs reactive power to the load in the distribution network.But it has main drawback was interference the security radian of milltary.[8].

III. EXISTING SYSTEM

The load flow analysis is performed on the IEEE 14-bus distribution test system using the ETAP software as a simulation tool.In the single line existing system have a single generator and 14 bus system .Using this system to find load flow analysis and find the voltage regulation ,real ,reactive power and power factor.By using etap software analysis the load flow in the distribution network.In existing system ,the flow of volage regulation in the buses are very low ,the power factor has been reduced.So to find the solution to improve the volage regulation and power factor. The single line diagram of existing system is shown in fig.3.

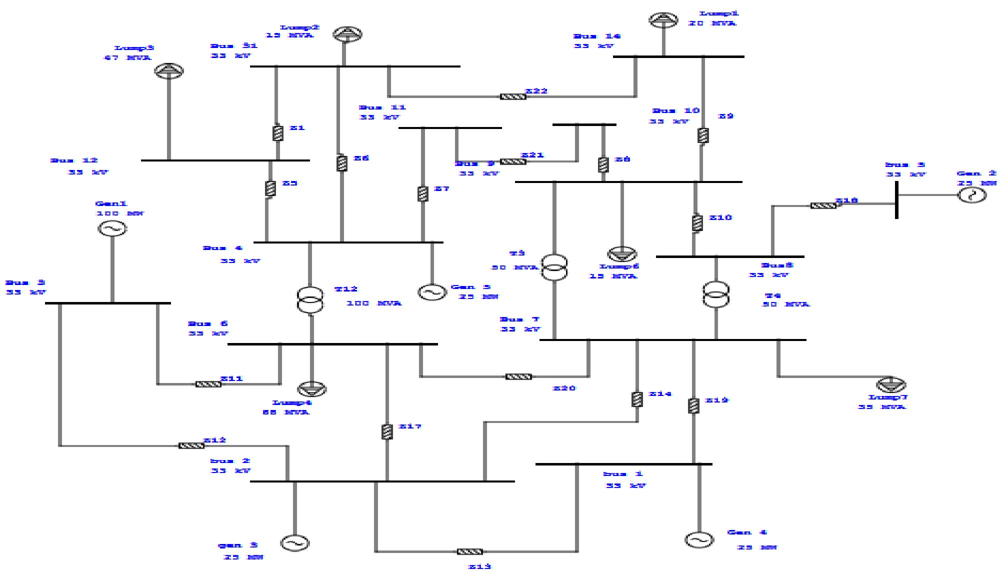

Fig.3. Existing Single Line Diagram of the IEEE 14-Bus Distribution Test System.

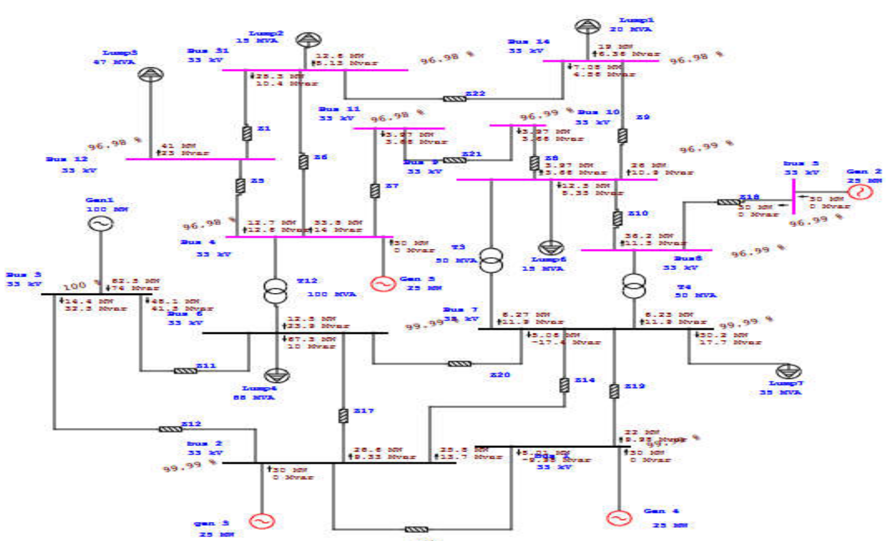

Fig.4. Simulation output for existing single line diagram of the IEEE 14-Bus system

IV. PROPOSED SYSTEM

This proposed system is mainly focused to improve the voltage and power factor in the distribution network.Now a days consumers are using inductive loads only,so that the inductive loads are absorb the reactive power from the distribution system therefore the voltage becomes reduced .To improve the voltage means inject the reactive power in the network .Therefore to included the capacitor in the distribution system and added renewable energy to reduces the transmission loss in the system.Here pv panel and wind turbine are included in the distribution network.

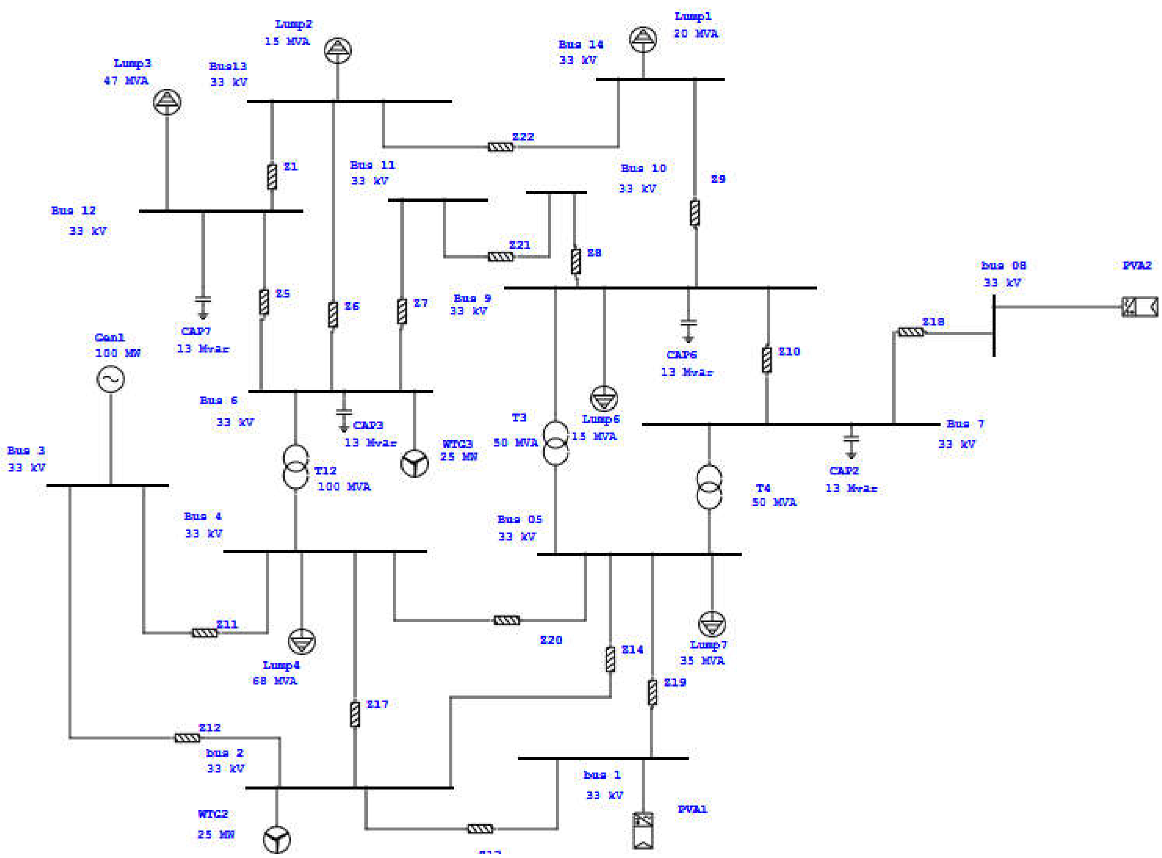

Fig.5 . Single line diagram of hybrid system using ETAP software.

In this network there are five sources are used to reduces the losses in the network and four capacitors have been used to improve the voltage level in the distribution feeder.

Source	MW	KV
Synchronous Generator	100	33
PV panel 1	3	33
PV panel 2	3	33
Wind Turbine 1	25	33
Wind Turbine 2	25	33
Wind Turbine 3	25	33

There are six sources of power generation, one synchronous generator it must be used as slack bus,two pv panels and three wind turbines are used in this distribution system. There are three rating of transformers are used 100 MVA,50MVA,50MVA and the output is connected with the Loads.There are six different lumped loads are connected in the 14 bus test.

Load	Bus line	MVA
Lumped load 1	14	20
Lumped load 2	13	15
Lumped load 3	12	47
Lumped load 4	9	15
Lumped load 5	5	35
Lumped load 6	4	68

In the both solar panels are YINGLI manufacture ,YL 280 P-35b at 1000max Vdc,185 size(w),7.64 imp(A) and 8.27 Isc (A). Cells are 10 in series and 1265 in parallel. Synchronous Generator was used as a swing .ETAP is modern power system simulation software integrating standard and advanced models present for proper modeling and simulation of different power systems. ETAP is unique in providing wide variety of analysis including Load Flow, Short Circuit, Arc Flash,Transient stability etc.There are four capacitors are used in this network.

Capacitor	MVAR	Bus
Capacitor 1	13	6
Capacitor 2	13	7
Capacitor 3	13	9
Capacitor 4	13	12

EQUATIONS USED

NEWTON-RAPHSON METHOD (NR method) is used for solving the nonlinear algebraic equations. It provides fast response and sure convergence as compared to Gauss Seidel method. The procedure for load flow solution by the Newton-Raphson method,

Pi (Real Power) = $|V_i| \sum_{j=1}^{m}(|V_j||Y_{ij}|\cos(\emptyset_{ij} + \delta_j - \delta_i))$

Qi(Reactive Power)= $-|V_i| \sum_{j=1}^{m}(|V_j||Y_{ij}|\sin(\emptyset_{ij} + \delta j - \delta_i))$

Where,

V = voltage at i^{th} bus

V_{ij} = voltage at ^{jth} bus

Y_{ij} = admittance of i^{th} and j^{th} bus

$\emptyset_{ij}$= angle of the admittance

Δ_j = phase angle of the ^{jth} bus

Δ_i = phase angle of the i^{th} bus

J is the jacobian matrix which is used for solving the NR method.

$$J=\begin{bmatrix} dp/d\delta & dp/|V| \\ dQ/d\delta & dp/|V| \end{bmatrix}$$

$$\begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix}=\begin{bmatrix} J1 & J2 \\ J3 & J4 \end{bmatrix}\begin{bmatrix} \Delta\delta \\ \Delta|V| \end{bmatrix}$$

The terms $\Delta P_i^{(k)}$ and $\Delta Q_i^{(k)}$ are the difference between the scheduled and calculated values,known as the power residuals, given by

$$\Delta P_i^{(k)} = P_i^{sch} - P_i^{(k)}$$
$$\Delta Q_i^{(k)} = Q_i^{sch} - Q_i^{(k)}$$

The new estimates for bus voltage are

$$\delta_i^{(k+1)} = \delta_i^{(k)} + \Delta\delta_i^{(k)}$$
$$|V_i^{(k+1)}| = |V_i^{(k)}| + |\Delta|V_i^{(k)}|$$

V. SIMULATION RESULT

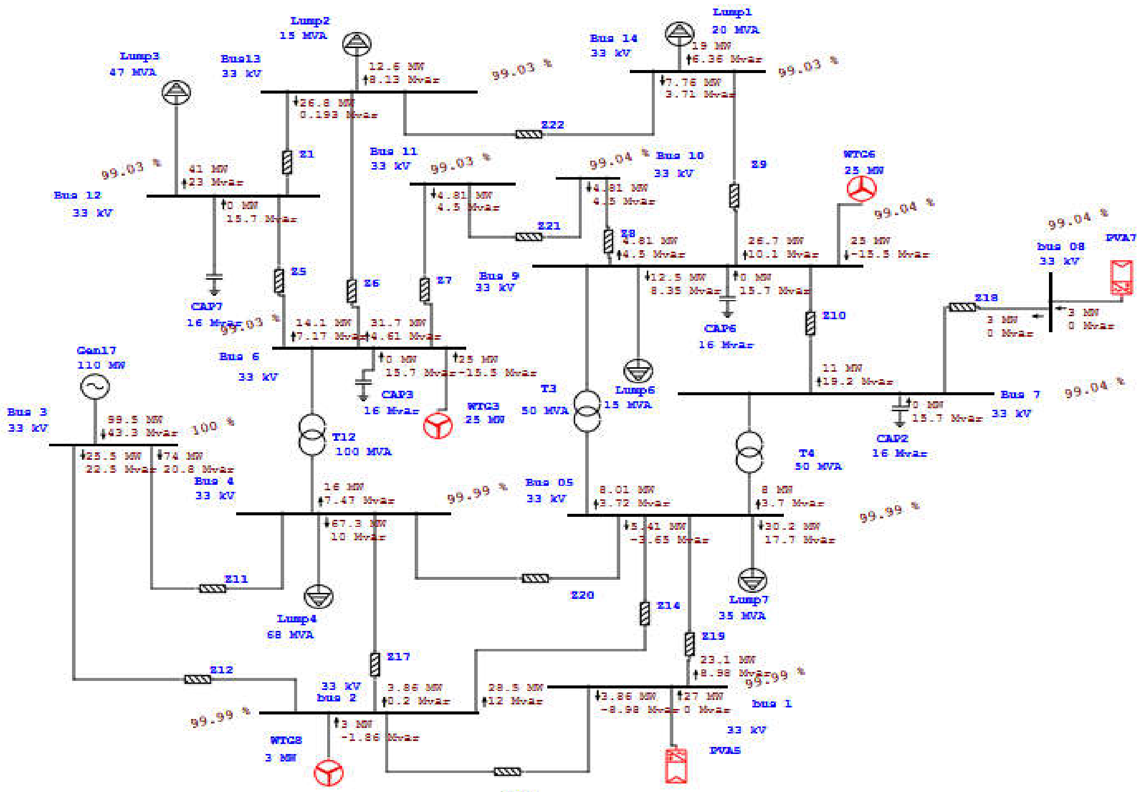

Fig.6. Load Flow Analysis of hybrid system using ETAP software.

In fig,6., the result of load flow analysis of hybrid system using ETAP software.In this, the voltages are improved in the distribution network by connecting the hybrid renewable energy sources with capacitor.In distribution network ,the reactive power are absorbs due to inductive load so, the wind energy and the capacitors are used to increases the reactive power in the distribution network using ETAP simulator software.

VI. EXISTING SYSTEM REPORT

FROM BUS	TO BUS	MW	MVAR	VOLTAGE REGULATION	AMP	POWER FACTOR(%)
Bus 1	Bus 2	3.622	-10.110	99.992	187.9	62.6
	Bus 5	21.378	10.110		413.8	90.4
Bus 2	Bus 3	-24.039	-33.478		721.1	58.3
	Bus 1	-3.622	9.823	99.993	183.2	63.7
	Bus 5	26.510	13.995		524.5	88.4
	Bus 4	26.150	9.660		487.8	93.8
Bus 3	Bus 4	58.470	41.168	100	1251.1	81.8
	Bus 2	24.040	33.242		717.7	58.6
Bus 4	Bus 3	-58.467	-41.349		1253.0	81.6
	Bus 2	-26.150	-9.862	99.990	489.0	93.6
	Bus 5	-0.180	17.088		299.0	68.7
	Bus 6	17.543	24.073		521.2	58.9
Bus 5	Bus 2	-26.510	-14.179		526.0	88.2
	Bus 1	-21.378	-10.377		415.8	90.0
	Bus4	0.180	-17.158	99.989	300.2	41.8
	Bus 9	8.767	12.023		260.4	58.9
	Bus 7	8.734	12.012		259.9	58.8
Bus 6	Bus 12	12.673	12.622		322.8	70.9
	Bus 13	33.817	13.998	96.956	660.4	92.4
	Bus 11	-3.971	-3.656		97.4	73.6
	Bus 4	-17.529	-22.964		521.2	60.7
Bus 7	Bus 9	33.722	11.459		642.6	94.7
	Bus 8	-25.000	0.001	96.961	541.1	100.0
	Bus 5	-8.722	-11.460		259.9	60.6
Bus 8	Bus 7	25.000	0.000	96.961	541.1	100.0
Bus 9	Bus 10	3.971	3.656		97.4	73.6
	Bus 14	26.042	10.923	96.959	509.6	92.2
	Bus 7	-33.722	-11.456		642.6	94.7
	Bus 5	-8.754	-11.469		260.4	60.7
Bus 10	Bus 9	-3.971	-3.656	96.958	97.4	73.6
	Bus 11	3.971	3.656		97.4	73.6
Bus 11	Bus 6	3.971	3.656	96.956	97.4	73.6
	Bus 10	-3.971	-3.656		97.4	73.6
Bus 12	Bus 13	-28.288	-10.428	96.949	544.1	93.8
	Bus 6	-12.673	-12.620		322.8	70.9
Bus 13	Bus 12	28.289	10.430	96.954	544.1	93.8
Bus 14	Bus 6	-33.817	-13.997		660.4	92.4
	Bus 14	-7.080	-4.559	96.956	152.0	84.1
	Bus 9	-26.041	-10.922		509.6	92.2
	Bus 13	7.081	4.559		152.0	84.1

VII. PROPOSED SYSTEM REPORT

FROM BUS	TO BUS	MW	MVAR	VOLTAGE REGULATION	AMP	Power factor (%)
BUS 1	BUS 2	3.865	-8.976	99.994	171.0	95.5
	BUS 5	23.124	8.976		434.0	93.2
BUS 2	BUS 3	-25.492	-22.767		598.0	74.6
	BUS 1	-3.865	8.689	99.995	166.4	60.2
	BUS 5	28.492	12.019		541.1	92.1
	BUS 4	3.858	0.200		67.6	99.9
BUS 3	BUS 4	73.999	20.762	100	1344.6	96.3
	BUS 2	25.492	22.531		595.2	74.9
BUS 4	BUS 3	-73.995	-20.942		1345.5	96.2
	BUS 2	-3.858	-0.218	99.992	67.6	99.8
	BUS 5	-5.408	3.643		114.1	82.9
	BUS 6	16.008	7.467		309.1	90.6
BUS 5	BUS 2	-28.498	-12.203		542.4	91.9
	BUS 1	-23.123	-9.243	99.991	435.7	92.9
	BUS 4	5.408	-3.649		114.2	82.9
	BUS 9	8.008	3.717		154.5	90.7
	BUS 7	7.998	3.699		154.2	90.8
BUS 6	BUS 12	18.118	17.167		279.7	99.2
	BUS 13	31.693	4.612	99.034	565.8	99.0
	BUS 11	-4.811	-4.503		116.4	73.0
	BUS 4	-15.999	-7.077		309.1	91.5
BUS 7	BUS 9	10.992	19.200		390.8	49.7
	BUS 8	-2.999	0.000	99.042	53.0	100.0
	BUS 5	-7.993	-3.505		154.2	91.6
BUS 8	BUS 7	2.999	0.000	99.042	53.0	100
Bus 9	Bus 10	4.811	4.503		116..4	73.0
	Bus 14	26.721	10.072	99.038	504.5	93.6
	Bus 7	-10.992	-19.199		390.8	49.7
	Bus 5	-8.004	-3.522		154.5	91.5
Bus 10	Bus 9	-4.811	-4.503	99.036	116.4	73.0
	Bus 11	4.811	4.503		116.4	73.0
Bus 11	Bus 6	4.811	4.503	99.035	116.4	73.0
	Bus 10	-4.811	-4.503		116.4	73.0
Bus 12	Bus 13	-26.336	-0.192	99.031	474.2	100.0
	Bus 6	-14.625	-7.166		279.7	89.2
Bus 13	Bus 12	26.843	0.193	99.033	474.2	100.0
Bus 14	Bus 6	-31.692	-4.611		565.8	99.0
	Bus 14	-7.759	-3.708	99.035	151.9	90.2
	Bus 9	-26.720	-10.071		504.5	93.6
	Bus 13	7.759	3.708		151.9	90.2

VIII. CONCLUSION

This paper deals with a real-time Analysis of IEEE 14-bus distribution network.By comparing the network using single generator and connected with renewable energy sources. The network in its existing state under peak loading conditions experiences multiple problems of low voltage, high line losses, overloaded sections, and future expansion constraints. A methodology is developed in this paper for deciding the proper locations of pv panels and wind turbines with capacitor. Various case scenarios are analyzed for various combinations of the hybrid network. It is found that all the above discrepancies are solved by the combination of pv panel and wind turbine in the distribution network. By using five numbers of generating source connected at different location where standing load is present and different capacitors are kept to improve the reactive power, it was found that the proposed methodology , increased voltage profile, increased active power and improved power factor. The real power and reactive power losses have been reduced . the voltage profile improvement from bus 6 to bus 12 has been increased from 96.956 to 99.034,the real power increased from 12.673 to 18.118 and also the power factor can be improved from 70.9 to 99.2. Also, during future expansion,if additional load to be supplied it can be utilized from the reserve capacity of the network. In future, the current study can be expanded to all states in India using the above techniques to reduce line losses,increases the power factor and improve the power quality in the whole country for good Voltage Regulation. Distribution restoration plays a critical role in the future “Smart Grid” to enable the power network at the distribution level a self-healing capability. The loads in the out-of-service area should be restored as quickly as possible after the fault is isolated. The distribution restoration plan with minimized switching operations and an optimized switching sequence will reduce the impact of outages and enhance system reliability. The distribution system restoration problem is a multi-objective, non-linear, combinatorial optimization problem with numerous constraints, including topology constraints, electrical and operating constraints.

IX. SCOPE FOR FUTURE STUDY

Development of a self-healing power network that is able to anticipate and response to disturbances has been envisioned in to enhance system reliability and customer satisfaction in the future power grid.This study development of new tools and techniques in this area which should enable large national infrastructures to self-heal in response to threats, material failures, and other destabilizers. With the global focus on energy management and conservation, low power controllers – Internet of Things(IoT) will extend the connected benefits of the smart grid beyond the distribution, automation and monitoring being done by utility providers. Management systems for in-home and in-building use will help consumers monitor their own usage and adjust behaviours – Demand Side Management (DSM). These systems will eventually regulate automatically by operating during off-peak energy hours and connect the sensors to monitor occupancy, lighting conditions, and more. But it all starts with a smarter and more connected grid.

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