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Paradigmatic Integration Of Wind Turbine Generators For A Real Time System

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Abstract

Smart grid aims at 20% renewable energy integration to the grid by 2020. Tamilnadu has already integrated more than 40% of wind into the grid. Since private entities are encouraged to setup wind on their own for the past two decades and no entity is to regulate the inter connection. This leads to unplanned growth which causes high losses, poor voltage profile, high equipment loading etc. It also reduces plant load factor of wind farms drastically due to unavailability of grid. Paper aims at not only reducing the losses, but also improving the voltage profiles and optimizing the equipment loading. Paper also deals with modelling of WTGs to study the impact in macro level.

Index Terms — Wind Integration, TANDISCO Real time system, ETAP, impact of wind on Voltage, Losses, Short Circuit Level

I. INTRODUCTION

The conventional energy sources are limited and cause pollutions to the environment. So, more attention is being paid to utilize the renewable energy sources such as wind, fuel cells, wave, biomass and solar. Wind energy is the fastest growing and most promising renewable energy sources among them because of its abundances, low cost, endless, widely distributed, uncluttered and benignant climate. The major challenge associated with the wind power generation is due to the intermittent nature of the wind. Challenges using wind energy includes that wind cannot be stored and all the energy in the wind cannot be completely harnessed during the time of light demand. There are quite lot of research works and papers are available in the integration of intermittent renewable resource. [1] Report a real time case study for 3.9MVA distribution system. Paper fails to address the variation in loads and change in intermittent renewable generation. Paper also does not address the impact ERG on equipment loading. Paper propose a Forward Reverse Algorithm for load flow analysis where as CymDist software is used to conduct the load flow analysis.

CymDist software does not have the Forward Reverse Algorithm which uses only conventional methods to solve the load analysis such as GS, NR & FDLF. This methods are not suitable for the given case study since the system considered is an ailing conditioned distribution system. Homer software is used to identify the generation of Solar and wind in this paper.

However this methodology of finding the average generation of renewable sources and using that value in static load flow studies is not proper way of way evaluating the performance. This results in unaccountable poor voltage profile during peak load or overvoltage, during light load etc. Suitable loss load factor should be applied which is impractical to find considering the fluctuation in renewable resources.

Paper [4] propose an algorithm for optimal placement Distributed Generation in distribution system. However the impact of the Distributed generation on short circuit level, Harmonics and power quality is not addressed. Without these the results are perfect since there is no additional cost considered for change in switchgear ratings or filters which needs to be installed in order to properly evacuate the power generated from the renewable. Papers also does not include the probability of re-conductoring and reconfiguration which is the major optimization part while integrating renewable resources.

Paper [11] discusses the benefits of the distributed generation. But the results shown in the report are over optimistic since the intermittent source will not always favour the reduction in loss or improving the voltage profile. Say during light load with peak distributed generation will results in higher losses and overvoltage problem. Variation in Load and renewable generation is not considered for studies. Proposed methodology in our paper overcomes all the drawbacks in aforesaid papers by means properly considering variations in renewable generation from time to time, Changes in the load from time to time and season to season.

II SYSTEM CONSIDERED

Tamilnadu 33 kV distribution network is considered with below details. Network consists of 32 buses out of which 29 buses are 33kV buses remaining three buses are of 690V (Bus27, Bus 31 & Bus 33) where the wind turbine generator is connected. Capacity of each wind turbine is 600kW. All the wind turbine generators are of Doubly fed induction generator with the power factor of 0.95 lag to 0.95 lead at its terminal and will be able to maintain the terminal voltage when it is operating under voltage control mode. Single circuit Dog conductor is used in 33kV system. 690V cable used is not considered and neglected. Loads are lumped at 33kV and modelled as constant power loads.

III. SYSTEM DATA AND MODELING

Single line diagram used for the system is given in figure1.

Bus Data:

Bus details like nominal voltage, minimum voltage and maximum voltage, Short circuit rating are given in Table 1.1

Bus Name	Nominal Voltage in kV	Fault Current in kA	Minimum / Maximum Voltage in kV
Bus1	33	25	29.7/36.3
Bus2	33	25	29.7/36.4
Bus3	33	25	29.7/36.5
Bus4	33	25	29.7/36.6
Bus5	33	25	29.7/36.7
Bus6	33	25	29.7/36.8
Bus7	33	25	29.7/36.9
Bus8	33	25	29.7/36.10
Bus9	33	25	29.7/36.11
Bus10	33	25	29.7/36.12
Bus11	33	25	29.7/36.13
Bus12	33	25	29.7/36.14
Bus13	33	25	29.7/36.15
Bus14	33	25	29.7/36.16
Bus15	33	25	29.7/36.17
Bus16	33	25	29.7/36.18
Bus17	33	25	29.7/36.19
Bus18	33	25	29.7/36.20
Bus19	33	25	29.7/36.21
Bus20	33	25	29.7/36.22
Bus21	33	25	29.7/36.23
Bus22	33	25	29.7/36.24
Bus23	33	25	29.7/36.25
Bus24	33	25	29.7/36.26
Bus25	33	25	29.7/36.27
Bus26	33	25	29.7/36.28
Bus27	0.69	25	0.621/0.759
Bus30	33	25	29.7/36.28
Bus31	0.69	25	0.621/0.759
Bus32	33	25	29.7/36.28
Bus33	0.69	25	0.621/0.759

Table 1.1 Bus Data

Load data:

Load is modelled as lumped load at 33kV. Load is modelled constant power load for load flow analysis and as static load flow for short circuit studies which does not contribute for any fault current. Table 1.2 provides the load data.

Load	Apparent Power in kVA	Power Factor in percentage
Lump1	1917	85
Lump2	329	85
Lump3	1009	85
Lump4	3037	85
Lump5	1209	85
Lump6	2433	85
Lump7	1142	85
Lump8	2944	85
Lump9	868	85
Lump10	1528	85
Lump11	828	85
Lump12	1313	85
Lump13	413	85
Lump14	1254	85
Lump15	3213	85
Lump16	5081	85
Lump17	1426	85
Lump18	1877	85
Lump19	1142	85
Lump20	3328	85

Table 1.2 Load Data

Generator Data:

600kW,690V, Doubly Fed Induction Generator of Suzlon , make is considered for generator. Generator details are given in Table1.3

Table1.3 Wind Turbine Data

Generator Name	Nominal Voltage in V	Capacity in kW	Impedance in percentage
Gen 1	690	600	16
Gen 2	690	600	16
Gen 3	690	600	16

Transmission Line Data:

The table 1.4 gives the transmission line parameters.

CONDUCTOR TYPE	R_{75}	X	Y
Twin Moose (+Ve Seq)	0.1	0.4	0.00001

Table 1.4 Transmission Line Parameters

Transformer Data:
The table 1.5 gives the transformer data.

HV WDG.	LV WDG.	RATING IN kVA	% IMPEDANCE	X/R RATIO
33	0.69	750	5	4
33	0.69	750	5	4
33	0.69	750	5	4

Table 1.5 Tansformer Data

IV. Simulation Result

Load flow analysis for the real time system has been carried out under various conditions listed below.

a. Peak Wind Peak Load
b. Peak Wind Average Load
c. Peak Wind Light Load
d. Average Wind Peak Load
e. Average Wind Average Load
f. Average Wind Light Load
g. No/Light Wind Peak Load
h. No/Light Wind Average Load
i. No/Light Wind Light Load

Losses:

Load flow results shows that losses are reduced when there is peak wind generation during peak or average load. However peak wind increases the losses during light load. Table2.1 shows the losses of the system at various operating conditions. Figure 2.1 shows the graphical representation of various loading conditions.

LOADING CATEGORY	LOSSES IN kW
LL LW	32
LL MW	37
LL PW	39
ML LW	62
ML MW	63
ML PW	68
PL LW	128
PL MW	120
PL PW	97

Table 2.1 Losses Under Various Loading Conditions

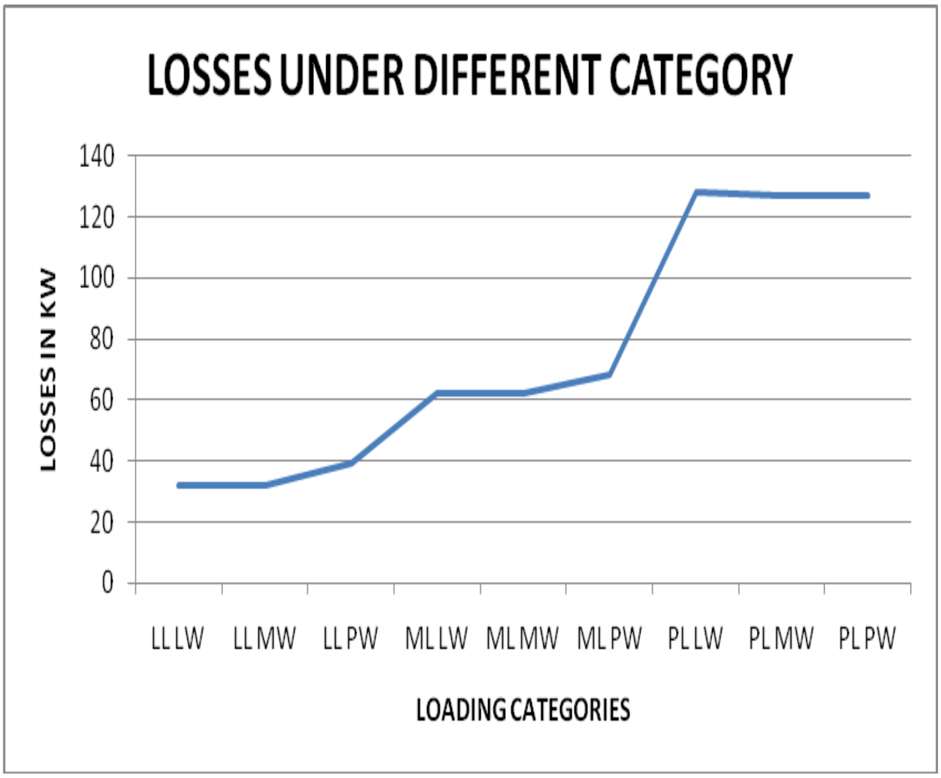

Fig 2.1 Losses Under Different Category

From the Table 2.1 and Figure 2.1 shows that during light load the losses are increased with increase in wind generation. This is due to the power flow reverse during the peak wind generation. This also increases the loading of component in the reverse direction. If the generator is operating at unity power factor then the power factor at the grid may be disturbed .In order to maintain power factor at the grid and to maintain a better voltage profile the generator is operated at lagging power factor. The figure 2.2 shows the losses under different loading categories.

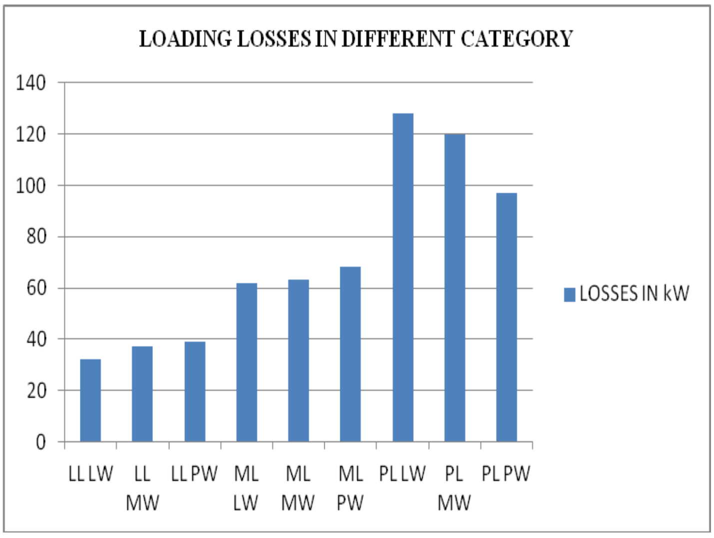

Fig 2.2 Loading Under Different Category

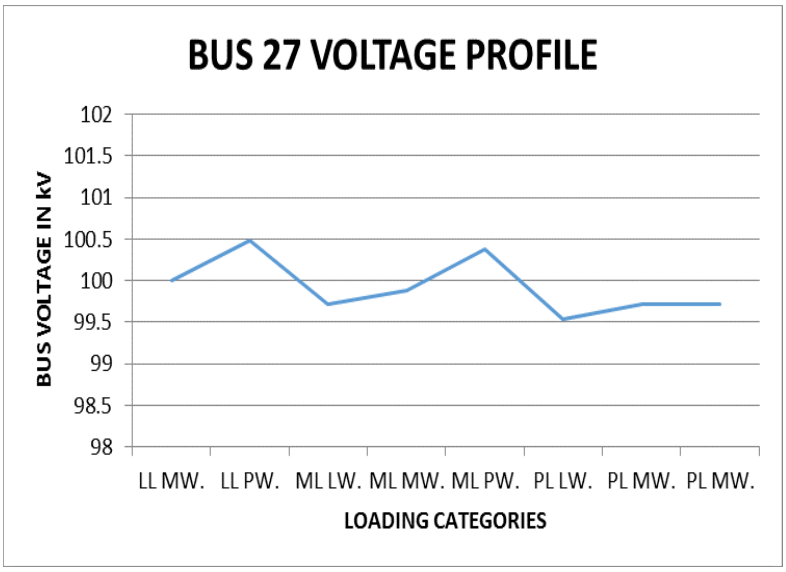

Fig 2.3(A) Voltage Profile Of WTG Connected Bus

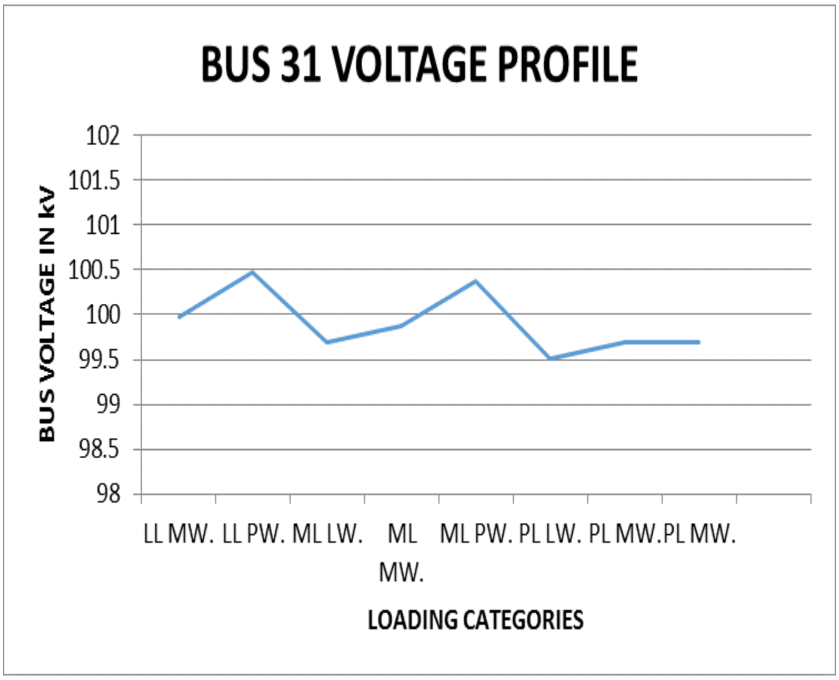

Fig 2.3(B) Voltage Profile Of WTG Connected Bus

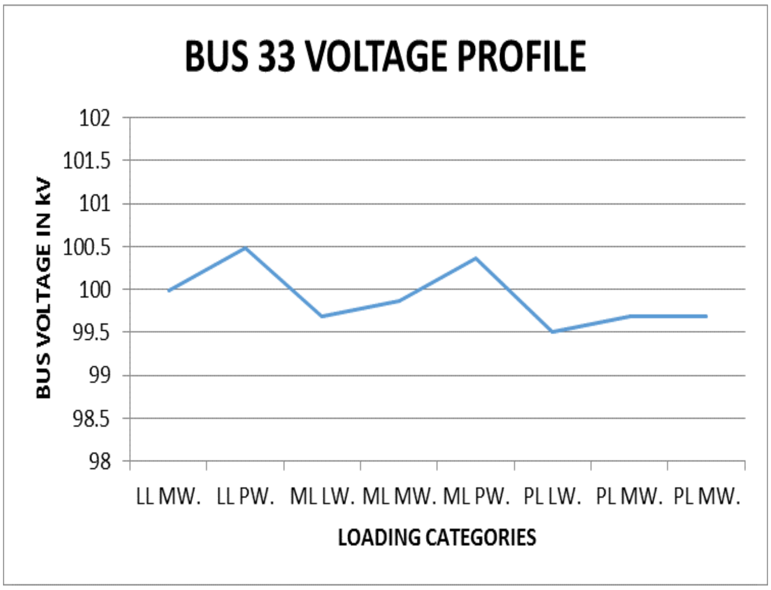

Fig 2.3(C) Voltage Profile Of WTG Connected Bus

The voltage profiles of the buses to which the wind turbine generators are connected are shown in Figure 2.3(A) to 2.3(C)

V.CONCLUSION

The proposed work increases the plant load factor by strengthening the network for existing wind farms and also provides necessary guidelines for upcoming wind farms. This Paper concentrated in modelling of WTGs to study the impact on macro level.

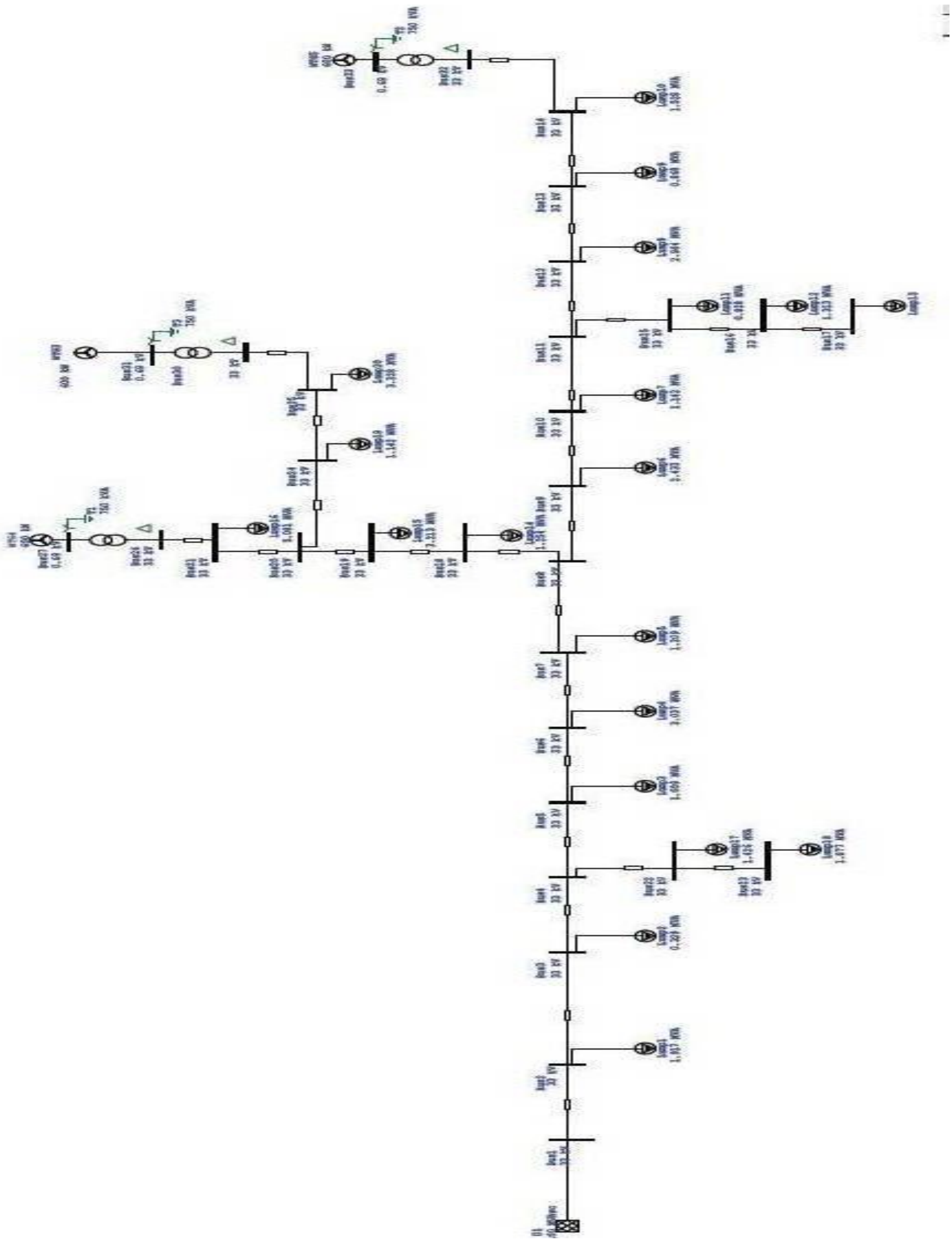

Fig.1.single diagram for 33kv distribution network

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