EVALUATION OF ATC FOR PERFORMANCE ENHANCEMENT OF HPS WITH RENEWABLE ENERGY SOURCES

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Abstract: *The non renewable energy sources can't be depleted, they pollute the environment which leads to global warming and forced to find an alternate named renewable sources such as wind, tide, solar, fuel cell, geothermal, etc. Hybrid power systems with wind and solar energy sources solve the problem of load demand of two areas system in the Distribution Network by evaluating Available Transfer capability. The main objective is to minimize the reactive power loss in the network by nullifies the power imbalance using a set of conventional generators through the specified sharing factors using the power flow model. the proposed model and the algorithm are validated by an analysis of the IEEE 30- bus system using the ETAP software.*

Key words: **Available Transfer capability(ATC), Distribution*Network*(D.N), Total Transfer Capability(TTC), Transmission Reliability Margin (TRM), Reactive Power Potential (RPP), Transmission Power System(TPS)**

1. Introduction

Recently, the demand for non renewable energy sources is increasing day by day in which the power can be generated and transmitted from anywhere but with more losses to reach the consumers. It can be overcome by the renewable energy sources. The commonly used renewable energy sources are wind, tide, solar, fuel cell, geothermal, etc. On the other hand, power grids in the modern power systems are continuously growing and concerning increase in economic, legal, and environmental factors. The transmission arcade may carry more power than their capacity which forces the modern power systems to be handled under highly exhausted conditions. In inter-connected transmission system, the concept of the Available Transfer Capability (ATC) assessment has recently transpired according to the North American Electric Reliability Council (NERC). Available transfer capability(ATC) is the measure of transfer capacity of the remaining part which is present in the physical transmission network for further reliable power transfer between the two areas in the power system. ATC assessment can be achieved through the number of iterations required for attaining convergence which is still highly demanding. This constitutes a burden for distributed Network and seeks an alternative method. Though the Grid extension is still preferred in rural electrification, the new technological solutions offered by hybrids generators, even they are very complex compared to current solutions however, they propose considerable interest with their flexible operation and minimize disturbances of the environment and attractive price. Hybrid Renewable Energy Systems (HRES) are composed of one or more renewable source with or without conventional energy sources, they can work in either stand-alone or grid connected mode. Different types of hybrid system combinations are feasible, depending on the need and resource availability at a particular location. In this paper, PV wind based hybrid systems as solar and wind sources are most promising power generating sources due to their complementary nature advantage is focused. With Wind Solar hybrid system, the benefit from both forms of energy source, each in different seasons of the year. This hybrid network balances the load demand of two areas system in the distribution network based on ATC calculation.

2. Analysis of wind and solar Generation in Tamilnadu:

The development of wind power in India began in 1990s, and has significantly increased in the last decade. India has the fifth largest installed wind power capacity in the world. As of 31 March 2019, the installed capacity of wind power in India was 23136.3 MW. Tamil Nadu

has become the leader in wind power in India and it is having the installed capacity of wind energy of around 8946.795MW and solar power of around 2724.552 MW which is almost 40% of total wind and solar power generation capacity developed in India.

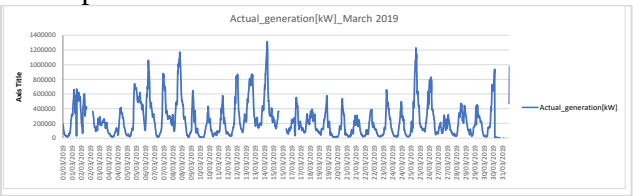

Figure 1 Actual generation in March 2019

Table 1: Power generation in Tamil Nadu state as on April 2019

Source	Installed Capacity(MW)
Hydro	2484.4
Thermal	4060
Gas	515.88
Central Generating Stations	3820
Private Sector	1154.16
External Assistance	50
Renewable energy sources(Windmill, solar, biomass ,co-generation plants)	12658.34
Others(CPP, Biomass)	265.594
TOTAL	25008.374

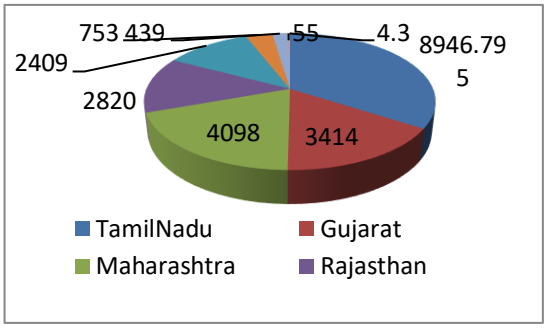

Figure 2 Renewable energy Generation in India.

3. Existing System

In existing system, Distribution network consists of two areas, there are Area1 and Area2 respectively. Each area had one grid source with full load demand. This paper carried out lump load network, each load consists of 2.5kva, totally 20 lumped loads for the combination of both the areas. The cable connections for the two areas, overall 23 cables are separately connected and three cables only interconnected between the two areas and used to transfer the power from one area to another area according to load demand occurs in area. Table 1 shows the parameters and assumptions in the existing network. In the existing system large voltage drop occurs in Area2 at particularly Bus no 25, Bus no 26 and Bus no 27. Table 2 shows the details of connection in Area1 and Area2.

Table2: Shows the assumption and parameters of distribution networks

Parameters	**Assumptions**
System type	3 phase AC
Distribution line	Overhead line conductors
Line model	Lumped parameter
Load type	Lumped load
Nominal frequency	50hz
Nominal voltage	0.433kv
Percentage voltage limits	Critical under voltage<92%;critical over voltage>102% marginal under voltage<95%;marginal over voltage>100%
Grid connection	Reference or slack bus

Table3: Area parameters

PARAMETERS	AREA 1	AREA 2
Source	Grid	Grid
Source bus	1	5
Buses	13	11
Load buses	10	9
Branch connection	11	9

4. Proposed system

In the proposed system, penetrating the solar panel, wind turbine and hybrid renewable sources integrating in the distribution network using Adaptive Newton-Raphson method of power flow technique in the ETAP 16.0.0 software to determine the steady state condition. The power flow calculation was done successfully and converged within 99 iterations to increase the voltage profile and balance the distribution network through the ATC calculation. Area1 distribution network had low voltage generation source and creates load demand. So Cable no. 18, 19, 20 are the interconnection cables for two areas network. Solar panel, wind turbine and hybrid system are implemented in the same distribution network at different case studies shown below

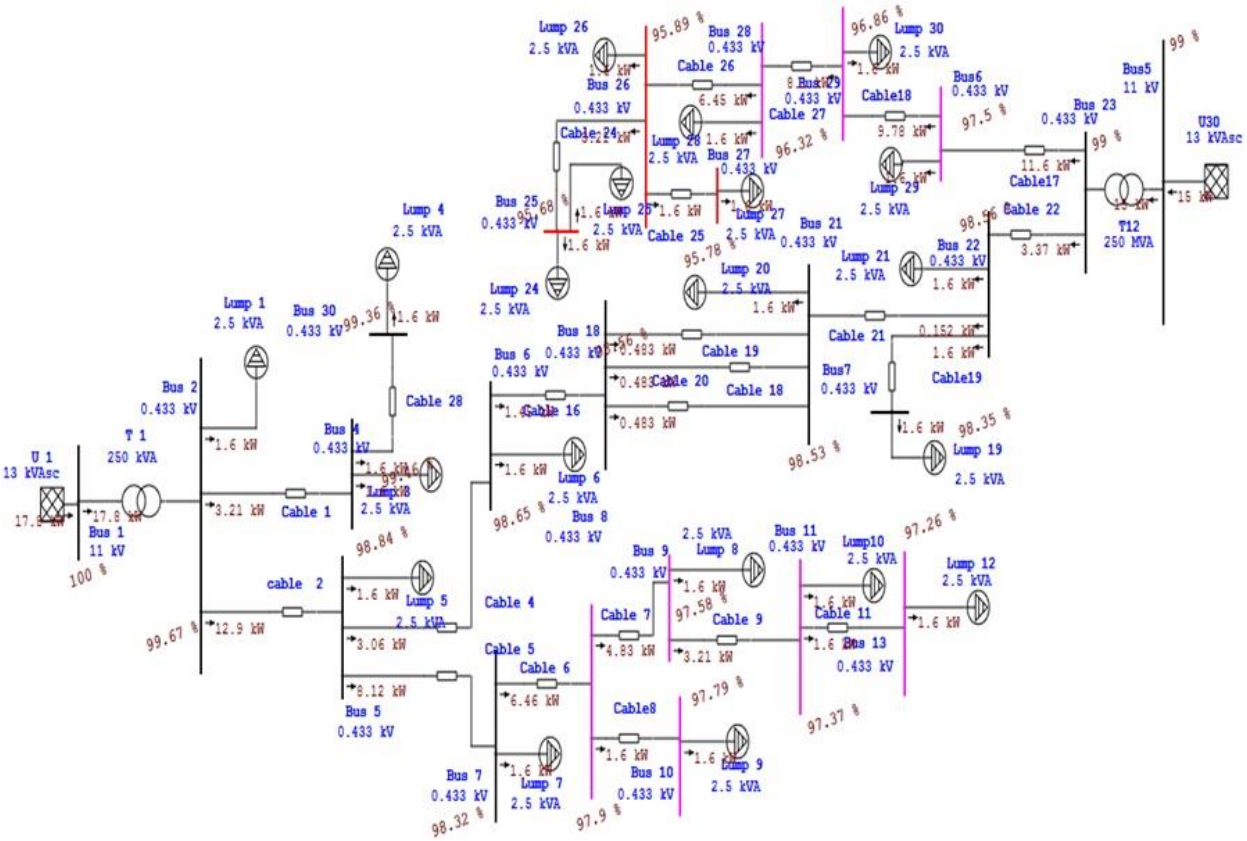

Figure 3 Existing system of two area distribution network

Case Study 1: Solar Panel and Wind Turbine

Nowadays peoples are moving to installing solar panels, it is a right time to changes from conventional source to Renewable Energy. In this case study solar panel installation has done in decentralized manner the ATC calculation at penetration of solar panel in the distribution network is determined. This two area system interconnected through three cables , cable 18, cable 19 and cable 20 respectively. There are four solar panels connected in this network to balance and increase the voltage profile in the distribution network. The same procedure is repeated once again with a change in the renewable source. That is solar panel is replaced by wind turbine.

Table 4: Details of Solar power generation in distribution Network

S.NO	BUS	AREA1	AREA2
PV1	2	10.7KW	
PV2	7	3.79KW	
PV3	23		10KW
PV4	28		7.58KW
Total Generates		14.49KW	17.68KW
Total Demand		16KW	00

Table5: WTG penetrated into distribution PARAMETERS

S.No	Bus	Area1	Area2
WTG	2	0.9KW	
WTG	7	10KW	
WTG	23		10KW
WTG	28		14KW
Total Generates		10.9KW	24KW
Total Demand		16KW	00

Case Study 2: Hybrid System

In this case study, both the solar panel and wind turbine are connected to the two areas distribution network. Both the renewable energies are penetrated into the same network and installed in decentralized manner and also ATC calculation had done for this network.

Table6: WTG penetrated into distribution Parameters

s.no	bus	area1	area2
WTG1	2	0.9KW	
PV1	7	10KW	
WTG2	23		10KW
PV2	28		14KW
Total Generates		10.9KW	24KW

Total demand		16KW	00

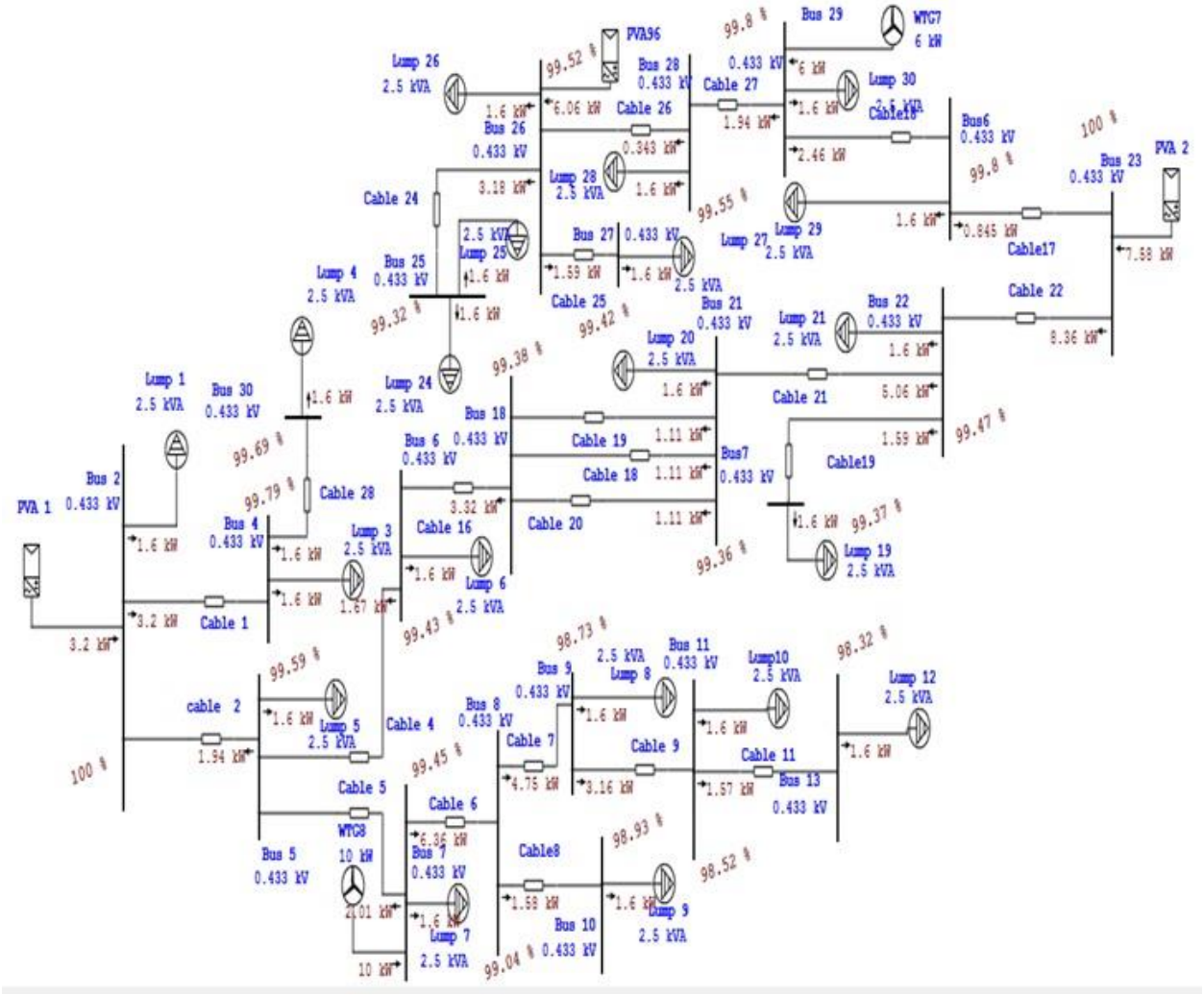

Figure 4 Hybrid system penetrated into distribution line

5. CALCULATION

In two area distribution network, two areas considering Area1 and Area2 connected by three transmission cables, Area1 generates 13.2kw but its load demand is 16kw. so Area1 becomes unbalance condition and Area2 generates 19.64kw but its load demand also same 16kw. Therefore Area1 requires 2.8kw to balance the power generation and customers demand. Area2 transfers the 2.8kw power to Area1 through the three interconnection transmission cables no 18, 19, and 20. To determine surge impedance load, TTC and TRM. The calculation of ATC shown below,

Input voltage = 0.433kv
Cable length = 1770.42 feet
Input conductor diameter (inch) = 0.28671
Input cable insulation thickness = 0.0272 inch
Input insulation dielectric constant = 2.3
Input sheath thickness = 0.0157 inch
Insulation type = XLPE
Cable operating current = 0.586amp
DC Resistance (Rdc) = 156.01µ
Surge impedance = 0.0563
Inductance = 0.1123mH
Reactance = 0.103 ohms
Surge impedance load = v^2/surge impedance
= $(0.433)^2/0.0563$
SIL = 3.3kw
Totally three cables are connecting the two Areas, each cable passes 1.11kw from Area2 to Area1.
TTC = 2.22kw
TRM = 2% of load demand Area1, because Area1 receive the power from Area2
Area1 total load demand = 16kw

TRM = 0.32kw
ATC = TTC – TRM
ATC = 2.22 – 0.32
ATC = 1.9kw
Available Transfer Capability for the hybrid distribution network is **1.9kw**

6. RESULT DISCUSSION

This research paper gives solutions for the distribution network to balance and improve the voltage profile in the distribution network. In the first analysis, the distribution network of two areas with ATC calculation had done with an implementation of solar panel, wind turbine and hybrid in the same network with different case studies. In the existing system bus no 25, 26 and 27 have 95.68% 95.89%, 95.78% votage regulation. The solar panel have 98.537%, 98.744%, 98.641% voltage regulation. In the wind turbine it is 98.173%, 98.383%, 98.278% voltage regulation but in hybrid system more power generated compared to other sources, that is it generates 99.318%, 99.524%, 99.421% voltage profile. Graph1 shows the difference case studies of voltage regulation in percentage for existing system, various renewable energy sources. The hybrid system generates high supply and it minimizes the voltage drop and get balanced the two areas distribution network. The existing system has very low voltage percentage compared to other sources. The wind turbine source improves the voltage profile in the same network but not that much, The solar panel improves more voltage percentage compared to other two systems. Finally the hybrid system improves much voltage profile from other all sources.

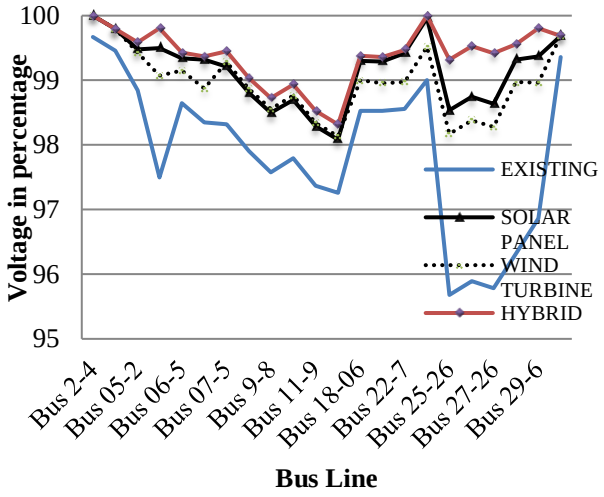

Figure 5 Voltage percentage for different case studies

Graph2 shows the comparison of existing system and hybrid system through voltage profile improvement in the two areas distribution network. In existing system, cable no 25 had 95.68% voltage flow but it should have minimum voltage as above 96% in the network, otherwise it is not recommended. In the same network integrated hybrid energy system, has voltage improvement from 95.68% to 99.318% which is very good condition to flow the voltage in the network.

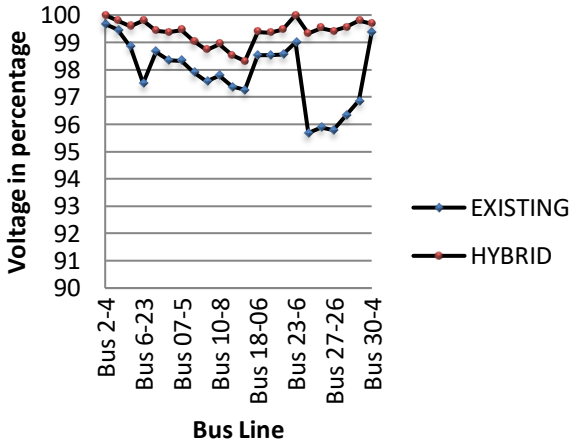

Figure 6 Compare between Existing system and Hybrid system

7. Conclusion

This research work investigates the unbalanced two areas distribution network problem and solved based on the ATC calculation with an aim of 100% voltage enhancement and reactive power loss reduction as shown in the simulated results. It had

done by the hybrid power system consisting of solar as well as wind energy sources. This hybrid network balances the load demand between two areas and energy sources in the distribution network based on ATC calculation. Table 7 shows that wind energy gives better voltage improvement compared to solar energy source. But the Hybrid energy source is the best system to reduce the loss as well as to enhance the performance of the Distribution Network. The Simulation had done by ETAP software.

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