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Comparative Analysis of Different Micro Energy Resources Under Distributed Generation

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Abstract **- The renewable sources of energies are getting more attention due to limitations and gradual depletion of fossil fuels. Distributed generation which is a combination of both renewable and non-renewable sources of energies is becoming the prime attraction of researchers for its design and development. This paper attempts to present a brief comparative analysis of the different micro energy resources used in a typical stand- alone hybrid distributed generation. For proper selection of micro energy resources used in distributed generation reliability, cost and environmental degradation associated with the micro energy resources must be given due consideration for economic and efficient design and development.**
Keywords: **Wind turbine, solar PV, diesel generator, reliability and distributed generation.**

I. INTRODUCTION

The unsustainable nature of fossil fuels accompanied by the ever increasing energy demand has led scientists and researchers to investigate the alternate energy resources. And as a consequence of which distributed generations have emerged as superposition of renewable energy resources with conventional units. Some of the typical renewable resources utilized in distributed generation are wind turbine (WT), solar, biomass etc. Diesel generator (DG) is the most common conventional units which are superimposed with these non conventional sources of energy. Tidal and geothermal energy are the other two renewable energy resources whose capacity is not yet explored by scientists and researchers. The research in the field of tidal and geothermal energy is still in its nascent stage.

The reliability, cost and environmental degradation associated with these micro resources are different from each other. This paper attempts to present a brief comparative analysis of the different micro resources used in a typical stand- alone hybrid distributed generation. For proper selection of micro resources used in distributed generation reliability, cost and environmental degradation associated with the micro resources must be given due consideration. Costs include installation cost, maintenance cost and operating cost. The maintenance cost does not remain constant throughout the planning period. It obeys the well known bath-tub curve.

Considerable work has been performed in the field of distributed generation. Giacomoni et al [1] analysed a distributed generation with high penetration of renewable base on only reliability. Kale et al [2] presented the role of different micro sources within micro grid. They studied the role of wind turbines, diesel generator and fuel cells within a stand -alone hybrid distributed generation. Ramachandra et al [3] analysed the scope of renewable energy resources in entire South India. They provided a location based potential of wind and solar power in south India. T Nagarajan et al [4] presented reliability and cost analysis of different hybrid renewable energy systems.

II. BRIEF OVERVIEW OF DISTRIBUTED GENERATION MODELLING

For reliability assessment of these renewable sources only the major components of these intricate systems must be considered. A brief description of different resources used in distributed generation and their reliability modeling is presented below.

A. Diesel Generator (DG)

Diesel generator is one of the oldest source of energy which is developed around 100 years ago. It is becoming popular nowadays because of its low installation cost and high reliability. But the major drawback of DG is the high cost of fuel associated with it and the emissions which causes environmental degradation. Diesel generator is a multi component system. But for reliability analysis only some of the major components are considered. Some of the major components of diesel generator are:

i. Fuel Pump
ii. Cooling Radiator
iii. Alternator
iv. Automatic Voltage Regulator(AVR)

From reliability point of view all the components are connected in series. For the DG to be in ON state, all the components must be in up state. Failure of even a single component means failure of the entire system. Figure 1 represents the reliability block diagram of the DG. The DG can reside in two states ON state and OFF state. The binary two state model of reliability analysis can be directly applied for reliability analysis of DG.

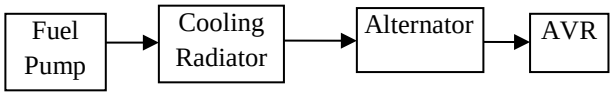

Fig. 1 Reliability block diagram of DG

B.Wind Turbine (WT)

The popularity of wind power as a source of distributed generation is increasing day by day. Wind power is becoming popular because of the sophisticated construction of modern wind turbines which are less prone to failures as well as low operational cost of wind turbine. Though the installment cost and maintenance cost of wind turbine is high but still it is gaining popularity because of its almost negligible operating cost. Wind turbine is an intricate system consisting of several mechanisms. The different components of wind turbine are

i. Generator,
ii. Gearbox,
iii. Convertor,
iv. Brake,
v. Yaw and
vi. Pitch.

Figure 2 shows the main components of Wind turbine. From reliability point of view all the components are connected in series.

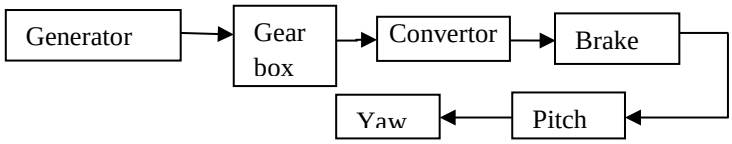

Fig. 2 Reliability Block Diagram of Wind Turbine

C.Solar PV cell

The low cost and easy availability of solar power has led scientists and researchers to explore this alternate source of energy. The main components of solar photovoltaic cell are:

i. Solar Panel
ii. Automatic charge controller
iii. Battery bank
iv. Convertor

Figure 3 shows the reliability block diagram of Solar PV cell.

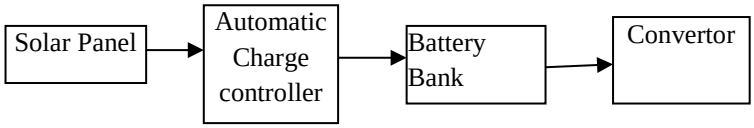

Fig. 3 Reliability Block Diagram of Solar photovoltaic cell

III.RESULTS AND DISCUSSION

From reliability point of view all the components are connected in series and the reliability is calculated for each component based on standard failure and repair rate. For cost analysis operating, installment as well as maintenance cost of the unit sources are considered. Maintenance and installment costs are considered to be constant for each type of unit sources. Operating cost of wind turbine and PV solar are considered to be negligible. The operating cost of DG unit is given by

$$\text{Operating cost} = \sum_{i=1}^{N} 10^{-2}(a_i + b_i P_i + c_i P_i^2)$$

Where a, b and c are the cost coefficients and P is the generation made by DG unit.

The emissions created by WT and PV solar are considered to be zero and the emissions associated with DG set is represented by

$$\text{Emission} = \sum_{i=1}^{N} 10^{-2}(\alpha + \beta P_i + \gamma P_i^2) + \varepsilon \exp^{\delta}$$

Where α, β and γ are the emission coefficients. Table 1 gives the system reliability and cost of each type of unit sources.

TABLE I RELIABILITY AND COST OF EACH TYPE OF UNITS

Unit Source	System Reliability	Cost($)
DG	0.98	300000
WTG	0.87	3214286
Solar	0.82	3214286

The system reliability of different unit sources is computed based on the reliability block diagram shown in the previous section. It is seen that the system reliability of DG is the highest and solar PV cell the least. The system reliability of the renewable sources is less than that of DG because of the random nature of these renewable sources. The system reliability of WTG is more than solar PV cell because of its sophisticated construction.

IV. CONCLUSION

Due to growing energy crisis and unsustainable nature of fossil fuels a paradigm shift has occurred from conventional fossil fuelled units to renewable non conventional units. And as a result of which the cost and reliability analysis of these units have gained importance. The system reliability calculation of these units is performed with the help of Reliability Block Diagram. The capacity of renewable energy resources in satisfying the ever increasing energy demand is also explored in this paper.

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