REVIEW ON DISTRIBUTED GENERATOR REPLACEMENT IN SMART GRID BUS SYSTEM

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Abstract: An outline of numerical and scientific demonstrating based dispersed age (DG) framework streamlining systems is exhibited in this survey paper. The goal is to look at changed parts of these two wide classes of DG advancement strategies, investigate their applications, and recognize potential research headings from explored thinks about. Starting portrayals of general electrical power framework and DG framework are first given, trailed by surveys on inexhaustible asset appraisal, stack request investigation, demonstrate plan, and advancement strategies. In sustainable asset appraisal display survey, indeterminate sun based and wind vitality assets are underscored though uses of gauging models have been featured dependent on their expectation skylines, computational power prerequisite, and preparing information force. For DG streamlining system, (sun based, wind and tidal) control generator, vitality stockpiling and vitality balance models are talked about; in advancement procedure area, both numerical and scientific displaying enhancement techniques are investigated, examined and scrutinized with suggestions for their upgrades.

*Index Terms- **DG, optimization, power, replacement***

I. INTRODUCTION

The use of renewable technologies is usually restricted to areas with low load and population densities. The distribution networks in such areas are constructed or designed to provide the increasing demands of the consumers that tend to decrease with transmission system distance. So, the use of such a network provides a great interest to the regulators of the industry and its utility [1]. This concept covers the additional benefits related to the distributed or dispersed types of compatible resources in the distinct locations of the network. These resources include small storage or modular based generation. Depending upon the changes done in the electrical industry, the use of such small portable or modular generation types provides a great interest. The rising issues of siting the big station plants, an increase in demand have made such modular resources as an additional benefit attracting the consumers based on the methods or the ability to change the projecting conditions [2, 3]. This basically provides dispersed forms of small modular installations very close to point-of-end use. Hence, the dispersed or distributed network has become a major electrical energy driven source in the present as well as the future-based generation. So, the main reason to use such dispersed systems relies on the following fact:

(a) The deregulation of power has encouraged the public investment in order to continue the power demand. This has resulted in breaking investments for the power development.
(b) The emergence of new technologies with large profitability, benefits, and smaller ratings.
(c) The rising demands and the saturation of the networks that already exist.

The distributed resources should be located optimally to minimize the line loadings, reactive power need, and the losses of the network [4]. The whole process of optimization should actively work on land costs, availability of the site, maintenance costs, plant operations conditions, etc.

1.1 DG: Deregulated Environment

The process of distributed generation in a deregulated environment plays a significant role in fulfilling the energy demands of future providing the free environment and the flexibility to its users in developing and planning the type of installation required as per the load critical conditions. It has the capability to serve as an alternate possible solution with a great potential. The continuous improvement in DG technology helps in providing electricity to its consumers in a very cost effective nature. In case of competitive (wholesale) deregulated environment, the users owing their DG's responds to very high price swings in order to decrease the price volatility. The DG's operated on utility are considered as the most suitable option for the process of planning. In emergency conditions, some part of the whole load is shifted on an isolated type of generator which provides some relief to the burden faced by utility [5]. If a small unit of DG fails, it does not affect the reliability of the working operation.

1.2 Dispersed Generation: Types

The process of dispersed generation is defined as a decentralized type of power plant that helps in feeding the power grid at the distribution level sized from 10 to 150 MW. It represents a concept of building a highly efficient (small) power plants along the grids that are already existing [6]. There are various advantages of using dispersed generation as these are small as compared to the centrally-stationed plants that are typically built, it can be used in emergency conditions, and as they depend on renewable or natural gas resources, the generators used are very less noisy and low-polluting which makes the use of such generation suitable for generating onsite at the location of the consumer [7]. Some of the most commonly used DG units have been listed as follows:

Table.1 DG Types based on size and efficiency

Type of DG units	Size (kW)	Electrical Efficiency (%)
Small Fuel Cell	1-300	30-50
Micro Turbines	30-300	25-30

Micro CHP	1-10	30+
Hydro Fuel Cell	400-20,000	65-70
Automotive Fuel Cell	30-60	50-80

1.3 DG Installation: Benefits

The installation of DG has become an interesting and attractive area of research providing a large number of benefits in the electrical engineering technology. Some of the major benefits of installing a DG are as follows:

(a) It can help to meet the power needs at the peak time.

(b) It reduces the need for building new distribution/transmission lines.

(c) It helps in reducing the distribution and the transmission losses with the help of a convenient form of local positioning. This local positioning provides benefit to use the generation (single or three phase).

(d) The process of a generation that is adjacent to the load allows the tremendous use of energy in the form of heat, for, example combined heat and power (CHP) applications.

(e) These types of units can be installed easily near the user/consumer end thereby, matching the requirements of the load.

1.4 DG Installations: Barriers

As a topic of great interest, the interconnection process of distribution network along with the distributed resources of power brings down some of the major challenges such as stability of the network, protocol protection, regulation of the voltage, unwanted losses, reliability, condition of power balancing, power quality issues, power outage and fluctuations [8][9][10]. The DG installation barriers are categorized into three parts described in the below *section.*

1.4.1 Economic Barriers: These represent a major type of barrier to the process of installing a DG. In the present scenario, the DG owner gets a large amount of profit from the power that is generated, whereas the operator of the DG (DGO) with whom the unit is connected to the grid faces the problems related to cost upgradation and unpredictable implications of the power supplied to the grid [11]. Therefore, the DGO considers it as a matter of nuisance rather than a benefit or opportunity. Moreover, it does not help the independent customers or householder to expect the working of such generation units on the daily basis.

1.4.2 Technical Barriers: This basically represents the barriers related to power quality (PQ) issues as the concept of PQ denotes a very powerful tool of the electrical engineering field. In relation to DG, the PQ issues include the flickering level, amplitude of the steady state voltage, and the presence of harmonics faced or experienced by the users [12]. The interconnection of distributed generation along with the distribution feeder helps in reducing the voltage drop at the upstream connection side that would automatically enhance the performance of the system, whereas, the use of tap-changing substation transformer with its compounded installation regulates the voltage at the down spot of the feeder measuring the transformer's total delivered power, which would lower the secondary voltage of the transformer as it experienced lower power consumption [12]. The dependency on the location site of DG may decrease the level of voltage on all or some of the feeders. On the other hand, the case of the feeder where the DG gets mainly connected to it would result in an excessive voltage rise on the feeder part. These discussed conditions show how DG installation put an impact (positive or negative) on the system performance.

1.4.3 Protection: Most of the applications of distribution are designed such that the power can be transferred vertically from a high to low level, without generation of power. Such type of distribution systems have to perform like a host to deal with a distributed form of generation and this poses various implication related to protection based on unwanted islanding, selectivity, reliability, and short-circuit (SC) levels. The time duration of a short circuit current ranges from 100-400% (inverters) to 500-1000% (rotating generator). The duration time of these short current depends upon the converter-based control settings. After, few turns or cycles, the SC current reduces to approximately about 200-400 % for the operation of the synchronous generator and to a negligible form of current for the case of induction type generators. The installation of DG units comprises of working under the limits that includes the distribution system (desired) short circuit level having the system's upper and lower limits, where the system gets damaged if exceeds its upper limit, and operational insufficiency in case of low limit, resulting in poor quality and non-operative behavior of the protection systems [13]. So, while implementing the DG's these upper and lower limits should be strictly kept in mind.

1.5 DG: Applications

Some of the important applications are given below:

1. Customer Generation: The applications based on continuous consumer generation produces power on regular basis, consisting of approximately 6,000 hours (per year). In such a capacity while evaluating or calculating the usage of technologies related to DG technologies, the consumers consider competence of grid price, as well as the cost of installation of the fuel and the units [14]. The other critical components of the grid power include maintaining the costs, the quality of the power and the reliability of the power grid.

2. Peak Shaving: The demand charges, peak shaving applications of the high power utility, also get affected by fuel prices, installed cost, and unit reliability, and fuel prices. These type of units operates less regularly than the applications of the continuous power, usually running annually for a few hundred.

3. Emergency Generation: The units of DG can operate for few hours a year, which means it lowers the devices that work critically and whose failure would result in property damage and threatening health of people based on safety measures. Some buyers like the institutions, airport authorities, hospitals, etc. required to maintain a power backup. So, they install DG units in emergency conditions. The selection of DG applications units is generally determined by starting time, operational cost, weight or size, and fuel storage or access.

4. Premium Power: The process of generating the power (onsite) improves both the reliability and the quality of the power especially when the back-up is provided for the continuous operation of the system via DG technology [14]. In the present scenario, power-outages and the rising demands of premium power creates a big problem for such applications to work. So, many of the business organizations adopt the idea of installing DG sets to cover the cost and the risk of power cuts or outages.

5. Net-Metering: Selling Power to the Grid: Some of the consumers or users are eligible got net metering process as it allows the users to sell excessive generation to the grids at same retail cost as they buy power from the grid. With such benefit, the market for both the residential and the commercial installations for DG, particularly, based on renewable energy technology, should rapidly increase [15].

6. Green Power: The increased use of green power based on fuel cells and renewable technologies provide very fewer emissions. The summation of such technologies emission-reducing technologies attracts the consumers to purchase the applications of DG even if they have to pay a little more premium for the use of green power.

II. RELATED WORK

Bhowmik, S., et.al [1] described a new planning method for the distribution system. In order to obtain an optimized solution, an algorithm has been developed by considering an objective function (non-linear) with both the linear and non-linear type of constraints for radial distribution system at a very large extent. Here, the objective function was optimized through the reduction in cost functioning operation. Further, a three-step iteration was performed. The first step includes the substation optimization process which determined the substation sites number with its exact location, the second step covered the feeder optimization which determined the feeder number with the actual original route and the final stage represented the reliability of system node. T. C. Green, et.al [2] presented a methodology for the sizing and the siting of the DG constraint system based on the security. The case of optimal siting was determined by analyzing the sensitivity of the power row equations. A method known as siring method was used for penetration level of generation, set of loading conditions, and power factor formulated such that it worked as a constraint problem of optimization based on security. The use of optimal generation site information was considered to optimize the reliability of the system via the indices obtained from the reliability calculations. In order to design such a method for solving the re-closing positions, a genetic algorithm was used. El-Khattam, et.al [3] presented a survey on DGs approaches which would change the working operation of electric power systems. This research was based on the important concepts, the definition of DGs, and their working constraints fair enough to help in understanding the regulations methodology of DGs. For the process of implementation, the economic and the operational benefits were also considered. Here, the researcher's main objective was to provide a comprehensive survey which would add new types and classifications related to DG technologies, types and the applications. Quezada, et.al [4] presented an approach in order to calculate the energy losses (annually) when different concentration and penetration levels of DG gets connected to the distribution type network. Additionally, various impacts have been calculated considering the wind power, combined heat and power, fuel cells, and photovoltaics. The results have shown that variation in energy losses that seemed to be a function of the penetration level of DG has presented the U-shape characteristics trajectory. Moreover, high loss reduction can be expected if the units of DG get more dispersed along the feeders of the network. In the context of technologies related to DG, it was noted that the wind power shows the worst type of behavior in curing the losses. In the end, the DG units along with reactive power control have provided the better network for controlling losses and the voltage profile. Piccolo, et.al [5] conducted a study to obtain or capture the postponed or deferral network investment effects on the expansion system of DG, several regulations for the operators of the distribution network and how they attracted optimized new generation combination with its existing forms. Here, the optimal power flow (multi-period), sizing and siting of DG installation are analyzed. Saint, Bob [6] proposed a study based on reviewing the languages in the Act that reviewed the characteristics and the value of Smart Grid defined by Department of Energy, discussed the unique characteristics that could be applied to rural-based utility systems, and described various technologies of smart grid that are in use today for the rural type distribution networks. Albu, et.al [7] conducted a study based on an algorithm establishing the best methods for the storing the system electrically for the virtual synchronous generator (VSG) that usually worked on its nominal power (desired) and the case of application. The resulting form of application helps in providing a wide description of the technologies that exist already depending upon the matching of characteristics with its required storage properties described accordingly from the user point of view. Falaghi, H., et.al [8] proposed a framework which has solved the issues related to the planning of distributed multi-stage system expansion where the distributed generation and feeder units along with substations installation has been considered as one of the best solutions for the expansion of the system's capacity. It further involved system's outage costs, investment, and its operation and the methodology of expansion was based on the procedure of pseudo-dynamic system. A joint study of optimal power flow (OPF) and genetic algorithm (GA) was developed as a tool for solving the problem of the system. The proposed strategical performance was illustrated and assessed by studies (numerical) on a complex distribution system. flow (OPF) Ochoa, et.al [9] conducted a research using a multi-period optimal power that was used to find the optimized form of accommodation of DG such that it minimized the losses occurring in the system. Additionally, the controlled schemes were expected to become a part of Smart grid technologies for extracting large benefits from the dispatchable DG power factor, coordinated type of voltage control. These are embedded in the formulation of OPF to grab the extra benefits with such types of technologies. The process of trade between the capacity of generation and losses of energy was also investigated. This strategy was applied to U.K based generic distribution network and further the results have shown the impacts while considering the characteristics (time-varying) in context of minimization of energy loss and highlighted the flexibility gain given by controlling strategies that can have both the generation capacity and the minimization of loss.

Table.1 Existing Scheduling Model.

Author's Name	Year	Method/Algorithm Used	Proposed Work
Falaghi, H., et.al	2011	A joint study of optimal power flow (OPF) and genetic algorithm (GA)	Proposed a framework which has solved the issues related to the planning of distributed multi-stage system expansion.
Wen-Shan, et.a al	2013	Optimal Power Flow, Mixed-Integer Non-linear Programming 2/3 Rule, Analytical Methods, Hybrid Intelligent System	Presented reviews on renewable distributed generation locating methods that include the Optimal Power Flow, Mixed-Integer Non-linear Programming 2/3 Rule, Analytical Methods, Hybrid Intelligent System, and various intelligent optimization techniques.
Saint, Bob	2009	Smart Grid Technologies	Proposed a study based on reviewing the languages in the Act that reviewed the characteristics and the value of Smart Grid defined by Department of Energy
T. C. Green, et.al	2003	Siring method	Presented a methodology for the sizing and the siting of the DG constraint system based on the security.
Edward J., et.al	2011	Grid planning methods	Addressed several types of possibilities which handled issues on grid planning processes.
Albu, et.al	2009	Virtual Synchronous Generator (VSG)	Conducted a study based on an algorithm establishing the best methods for the storing the system electrically for the virtual synchronous generator (VSG) that usually worked on its nominal power (desired) and the case of application.
Abapour, et.al	2015	33-bus system based on a radial distribution network	Proposed a model that determined the location, investment of time, and optimal size for DG units.
Muñoz-Delgado, et.al	2015	Linear program mixed-integer method	Proposed a study based on planning problem with the multi-stage expansion of distribution system where the financial investment in distributed generation and distribution network have been considered jointly.

Edward J., et.al [10] addressed several types of possibilities which handled issues on grid planning processes. Effects on voltage control, grid protection, and fault levels are investigated and described. Such aspects were illustrated in addition of simulation techniques on the already existed grid distribution. The study demonstrated that in the case of a compact form of grid distribution, the problem of voltage control does not occur likely but the issues related to fault levels and the false tripping needs a special care. Wen-Shan, et.a al [11] presented reviews on some of the populous renewably based distributed generation locating methods that include the Optimal Power Flow, Mixed-Integer Non-linear Programming 2/3 Rule, Analytical Methods, Hybrid Intelligent System, and various intelligent optimization techniques. Each and every method represented its exceptional potential and feature for the promotion of distributed generation in accordance with renewable energy systems. Abapour, et.al [12] proposed a model that determined the location, investment of time, and optimal size for DG units. A modeling approach based on the present scenario has been used for determining the uncertainty of load growth rate and the energy price. In order to demonstrate the merits of DG planning, the result of the process was compared with the static models along with a comparison of active network DG planning with that of a mode based on a passive operation. Additionally, a technical comparison and evaluation were done between passive, active and conventional networks. The model has been proposed was applied 33-bus system based on a radial distribution network. The study indicates that the use of AM results in minimizing the losses and the cost function effectively as compared to the passive type management. Sravanthi, S., et.al [13] conducted a research study on renewable and load generation of DG following a probabilistic nature. This methodology was started with the help of selecting the candidate busses that were sensitive to the voltage for the DG unit installation processes. Here, DG level of penetration, the capacity of the feeders, and system voltage limits represent the constraints for the proposed study. Georgilakis, et.al [14] conducted a study on the planning of power distribution systems used to design or model the systems in order to meet the demand growth with the best possible methods based on reliable, safe, and economic conditions. The process of gradual transforming from passive to active type of distribution grid imposed the need to consider certain effects of DG, the demand (active) during the planning process, and the benefits of control. This study presented an overview of the methods and the models that were applied to modern PDP-based analyzation and classification of the current and future trends in the field of technology. Muñoz-Delgado, et.al [15] proposed a study based on planning problem with the multi-stage expansion of distribution system where the financial investment in distributed generation and distribution network have been considered jointly. The expansion of the network was comprised of various alternatives for the transformers and the feeders. Similarly, the DG installation was based on various alternatives for wind and other conventional type's generators. Here, the approach basically consists of different types of set-nodes for the installation of the generator. Therefore, the expansion plan that has been optimized helps in identifying the best suitable location, alternative, and installation time for the candidate's assets. Usually, this model was driven by minimizing total cost's present value (net-value) that included the cost linked to its maintenance, investment, unserved energy, production, and the losses. The energy losses cost was modeled by linear approximated method prices. Consisting of an additional feature which was based on radial conditions that uniquely tailored to entertain the distribution generation presence and the problems linked with transfer nodes. The results have shown the optimization issue enlightened a linear program mixed-integer method where the process of convergence (finite) relying on optimization process was guaranteed, with the availability of the software. This methodology out-performs the proposed approach.

III. CONCLUSION

Most of the applications of distribution are designed such that the power can be transferred vertically from a high to low level, without generation of power. Such type of distribution systems have to perform like a host to deal with a distributed form of generation and this poses various implication related to protection based on unwanted islanding, selectivity, reliability, and short-circuit (SC) levels.. Besides technological advancement, optimal ESS planning and scheduling is one of the effective ways to reduce the costs and justifying high investment costs by taking their benefits out as much as possible. During the past few years, various studies have been conducted by the researcher to address the problem of optimal ESS planning in distribution networks. In this context, various models, methods, and considerations have been proposed to enhance the functionality of optimal planning process. The aim of this paper is to review the problem.

IV. ACKNOWLEDGMENT

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