

A Review of an Essential Role of the Distributed Power Generation- Applications and Challenges

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Abstract

The installed capacity of the renewable energy resources has in increasing trend over the last few decades. Societies cannot only rely on the traditional sources of energy to meet the whole of the demand. The population and consumption patterns are increasing while the recently developed units work more efficiently. Renewable energy resources are the best currently available substitution for the traditional sources of energy. Wind turbine and solar PV panels have got a lot of attention to be installed in a hybrid power network. Wind turbine technology is more mature compared with the solar PV panels. Although, the negative effects of the renewable energy resources are negligible compared with traditional resources, a comprehensive study should be performed to clearly identify the possible challenges of the implication. This study focuses on the essential role of the distributed generators included wind turbines, solar PV panels, and energy storage devices as hybrid power network. The most important application and challenges of a hybrid power network will be discussed with respect to the smart environment.

Keywords: Wind turbine; Solar PV; Energy storage devices; Smart environment

Introduction

Renewable energy resources have got a lot of attentions over the last few decades due to their potentials to substitute the traditional sources of energy which highly depend on the natural gas, coal, petroleum, etc. renewable energy resources can be installed for either small or large-scale application [1,2]. The solar PV panels installed on the rooftop of the houses in the residential areas is the best example for the small-scale application. The renewable energy resources can be installed as a second primary source of energy called micro-grid to generate a part of the needed power by the customers [3]. The main purpose of the micro-grid is generating the cleaner energy which is closer to the consumption nodes. For this reason, in technical studies, distributed generators refer to the micro-grid as well. One of the advantages of bringing the generation and consumption points closer together, is increasing the whole efficiency of the hybrid network [4, 5]. A considerable part of the generated power could be lost due to the far distance between the generation and consumption points. Furthermore, from the asset management point of view, the risk of the failure is less in distributed generators [6]. Considering an electrical diagram as Figure 1, it is obvious that a lot of electrical devices should be installed in order to adjust the voltage and frequency for to be used by consumption. If any failure happens in any point of this traditional network, the upstream units and ultimately customers will be affected. Although the back-up generators reserve the power for these cases but, this scenario is not an optimal decision [7].

Figure 2 shows the role of the distributed generators in an electrical network. Distributed generators can be installed at any part of the network starting from the generation to the points toward the end stream which are mostly needed load by customers. Based on the scale, the proposed hybrid network is less relying on the generated power from the main grid. As a result, the shorage will probably less occur while the generated energy is cleaner.

From the environmental point of view, distributed generators have less negative effects compared with the traditional sources of energy [8]. The main concern regarding the large-scale implementation of the distributed generators is unbalancing the ecosystem in long term. For

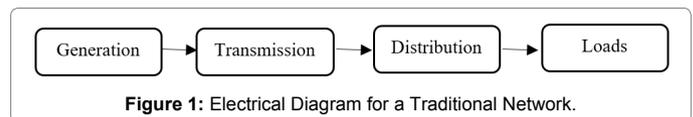


Figure 1: Electrical Diagram for a Traditional Network.

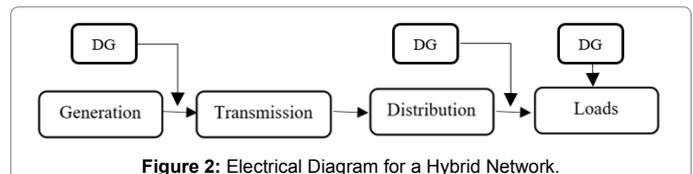


Figure 2: Electrical Diagram for a Hybrid Network.

instance, a wind farm might use large land area which can significantly affect the agriculture in the area [9,10]. Although, if the safety is considered, they still can use the land for agricultural purposes but, it somehow unbalances the natural environment. Shaded area due to the high wind turbine is an example of this scenario [11]. Wind turbine are also highly affecting the habitat and they considered as one of the menace for creatures such as birds [12]. From the economic point of view, the price of the generated electricity from the solar PV and wind turbine is less than the price offered by utilities. Statistics shows that the price of the generated electricity from the renewable energy resources has a decreasing pattern. From the technological point of view, modern methods of production using the advances materials with respect to some concepts such as self-healing, pros-media, and self-lubricating could significantly affect the components waste of the wind turbines and solar PV panels [13-16].

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Discussion

As it has been mentioned above, the application of the distributed generators has a growing trend. One of the most important decisions which should be optimally make is about the managing these facilities [17]. Statistics show that the installed capacity of the renewable energy resources has an increasing pattern. Relying only on these resources, it may not be possible to meet the whole demands for that a few weeks or months [18,19]. The intermittent nature of the sources of energy such as wind and sun irradiance bold the role of the energy storage devices. Without installing the energy storage devices, the hybrid network is not reliable enough. Energy storage devices store the energy for future uses when the energy is needed [20,21]. The future periods could be the peak periods which the consumption is more than generation of the distributed generators or the prices of the electricity offered by grid is high [22]. An efficient management process is needed to reach to an optimal scheduling of the devices [23]. For instance, based on the predication of the weather, a day ahead scheduling of the solar PV and wind turbine generation can be easily predicted with an acceptable amount of uncertainty [24]. Based on the prediction, the schedule of the energy storage units will be determined to reach to an optimal scheduling of the units called unit commitment. For this manner, smart devices are playing an important role. Using the advanced smart devices leads to a real-time view of the power generation by the grid and distributed generators in large or small-scale as well as the demand behavior of the customers. It can be narrow down to each of the units in a house [25]. It should be considered that the nature of the environment is stochastic and predictions should gradually be updated as getting closer to the real-time. Using the smart devices, close to real-time analysis is possible but, some of the inputs are still based on the forecasting algorithms which bring the uncertainty to the system [26,27].

When the customers have an idea about their energy consumption behaviors, they might improve their consumption habits by offering some incentive by utilities. Furthermore, the houses which generate the energy of their own are able to sell their excessive energy back to the grid [28]. In most of the time, the excessive sold energy will be used for the consumption of the houses in a neighborhood to prevent the loss of the power over the transmission and distribution lines. Without the smart devices, proposing an efficient managing procedure is not possible. Another application of the smart devices is for charging the electric vehicles (EVs) [29]. The car can be attached to the plug in and criteria been set to be fully charged over the next few hours [30]. A smart system, charges the EV when the prices of electricity make sense or when the demand is not in the peak periods. In addition to that, smart house management system is not possible without the application of the smart devices. Another application of the Distributed Generators is in the mobile stations and camping areas. For instance, in the case of the natural disaster, societies still need electricity to survive. The interruption in the power transmission and distribution network has been possibly occurred and a local power station should be able to meet the demand. Integrating the solar PV panels and energy storage devices make this possible to respond to the local loads using the solar energy.

Solar and wind energy resources are considered as clean sources of energy. Most parts of the negative effect to the environment happen during the construction phases [31]. For instances, the logistic of the large blades of the wind turbine needs road construction. Or preparing sufficient area for solar PV panels to be installed might affect the habitant. During the operation periods, both of these sources

can be considered as green resources due to the zero emission. The noise generated by the wind turbines or the excessive land usage of the solar PV panels are still concerning for the researchers and policy makers [32,33]. Large-scale implementation of these resources is not permitted in the areas close to the residential houses due to generating high voltage electricity, noises, and safety concerns. Statistics show that the prices of the generated electricity from the solar PV panels and wind turbines have a decreasing trend [34]. Part of this is related to the technological development which have been achieved for the manufacturing processes. Manufacturers are able to produce more efficient components by spending lower amount of money [35,36]. As a result, less, capital investment is needed to install a hybrid network [37,38].

Conclusion

Renewable energy resources are the best available substitution for the traditional sources of energy. Wind turbine and solar PV panels have got a lot of attention during the last few decades. The negative effects of the distributed generators are less than traditional sources of energy but, a comprehensive analysis should be performed before any large-scale implementation. A part of the researchers, policy makers, and environmental scientist are strongly believed on the negative effects of the distributed generators on the environment. This study focused on the essential role of the distributed generators included wind turbines, solar PV panels, and energy storage devices as hybrid power network. The most important application and challenges of a hybrid power network have been discussed with respect to the smart devices. Smart devices caused to emerge a new era of the management. To reach to an efficient management system through the whole parts of the electrical network supply chain, smart devices should be optimally installed and utilized.

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