ANALYSIS OF OPTIMIZATION METHODS APPLIED FOR RENEWABLE ENERGY INTEGRATION

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Abstract. This work attempts to make a thorough study of prevailing optimization methods used in renewable energy application domain. This study takes simultaneously into account the meta-heuristics and heuristics methods as well as the classical methods. Through a pseudo-dynamic simulation, the paper investigates the effect of changes in resource power, load, and unplanned outages on renewable energy performance. In case of load changes, a comprehensive evaluation of a real network with and without renewable resources has been conducted. Simulation results show that renewable sources can be useful in terms of short circuits, losses, and voltage, however compensating measures should be taken to improve transient stability and power quality.

Keywords: Optimization methods, Pseudo-dynamic, Optimal operation, Renewable energy sources

چکیده: در این مقاله تلاش شده است تا یک مطالعه کامل از روش‌های بهینه‌سازی رایج مورد استفاده در حوزه کاربردهای انرژی‌های تجدیدپذیر انجام شود. این مطالعه به طور همزمان روش‌های فراابتکاری و ابتکاری و همچنین روش های کلاسیک را در نظر گرفته است. این مقاله از طریق یک شبیه‌سازی شبه دینامیک، تأثیر تغییرات در توان منبع، بار و قطع‌های برنامه‌ریزی نشده را بر عملکرد انرژی‌های تجدیدپذیر بررسی می‌کند. در صورت تغییر بار، ارزیابی جامعی از یک شبکه واقعی با و بدون منابع تجدیدپذیر انجام شده است. نتایج شبیه‌سازی نشان می‌دهد که منابع تجدیدپذیر می‌توانند از نظر اتصال کوتاه، تلفات و ولتاژ مفید باشند، با این حال اقدامات جبرانی باید برای بهبود پایداری گذرا و کیفیت توان انجام شود.

کلمات کلیدی: روش های بهینه‌سازی، شبه دینامیک، بهره‌برداری بهینه، منابع انرژی تجدیدپذیر

1- Introduction

Renewable energy sources (RES) have attracted attention because of their high energy consumption and environmental effects. Ref.[1] states that biological methods can provide good optimization despite the lack of climate information.

For detecting islanding modes, ref. [2] proposes a frequency response feedback method. This paper examines the performance of RES in island mode, short circuit current, and the feasibility of using a battery energy storage system (BESS) without or with wind power.

Almost all optimization methods are meta-heuristic or heuristic, and these methods can get stuck in local optimal points. DG optimization problems are best solved by genetic algorithms (GA) and particle swarm optimizations (PSOs) [3]. It has been shown that analytical methods are still useful and that dynamic models [4] can be used to solve these problems. The introduction of electric vehicles [5] and the uncertainties associated with solar and wind production should also be considered in all of these cases.

Ref.[6] provides an overview of environmental, building, and sustainable energy optimization methods. RES and Microgrids (MGs) are optimized using conventional methods and artificial intelligence in [7].

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With PSO, a method is presented in [8] for determining the optimal size of MGs and their optimal performance.

According to [9], flexible economic load flow is possible in the presence of electric vehicles using the Newton-Raphson method. Under boundary conditions, Newton-Raphson-Seidel offers a more accurate and faster solution of the load distribution equations [10].

In [11], mixed integer linear programming (MILP) is used to model economic stochastic distributions that incorporate thermal and pumped storage generators. Economic dispatch, optimal power flow, energy management strategy and unit commitment [12], can all contribute to achieving minimum energy costs. Hybrid RES and appropriate optimization techniques can effectively address environmental impact, cost, and reliability issues [13].

Using a pseudo-dynamic and renewable generation time pattern, we discuss the optimal operation of two systems (an IEEE standard network and Iranian real grid-connected RES). The conclusion and references are provided at the end of the article.

2- Pseudo-dynamic and RES time pattern

Fig. 1 depicts the IEEE 15-bus test system [14-15]. A RES is installed in the lowest voltage of each section of the test system, which is divided into commercial, industrial, and residential sections.

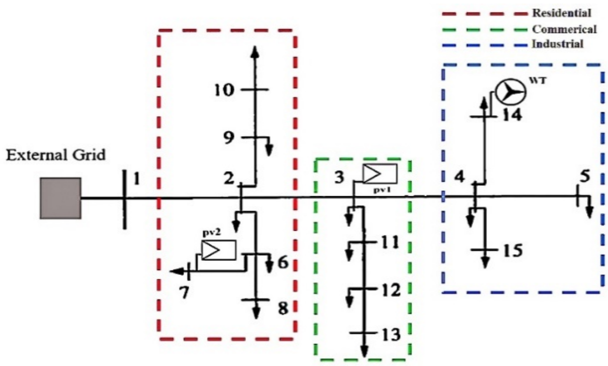

Fig. 1. 15-bus IEEE network

A power output pattern of RES is shown in Fig. 2, while a consumption pattern of customers is shown in Fig. 3.

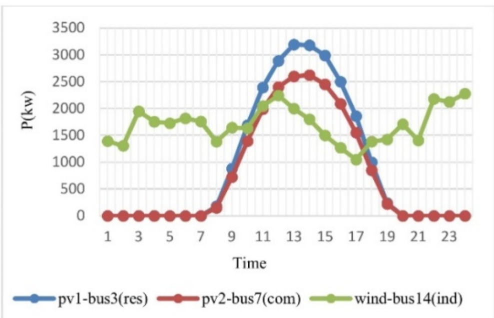

Fig. 2. Power output pattern of RES

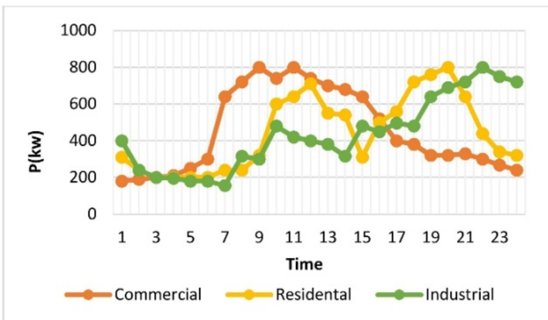

Fig. 3. The consumption patterns of customers

Using pseudo-dynamic simulation, the desired output is determined with continuous load flow at specific intervals. A maximum load of 9.42 MW occurred on the test network at 10 AM, while the maximum loss was 2.997 MW (Fig. 4). A total loss of 32.269 MW is shown in Fig. 5 without RES, while a loss of 18.308 MW is shown with RES.

When renewable energy is available, there is a reduction in line loading as shown in Fig. 6.

A comparison of voltage levels for different bus loads in Fig. 7 shows that weak buses get stronger with the addition of RES. Based on the previous figures, the optimal operation of the network can be summarized as follows. It is the operator's responsibility to keep the system within predetermined limits at all times.

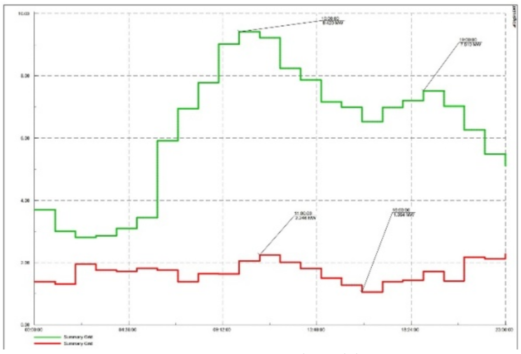

Fig. 4. Demand and loss

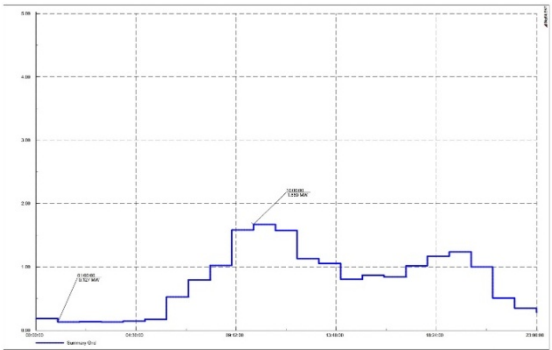

Fig. 5A. The losses without RES

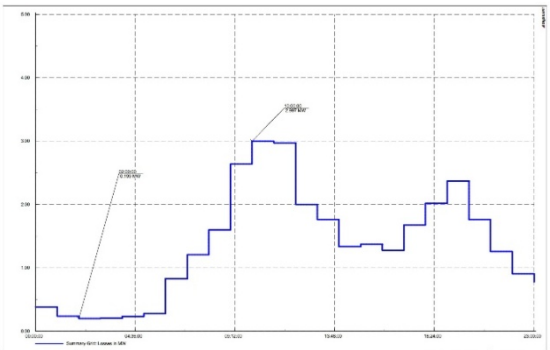

Fig. 5B. The losses with RES

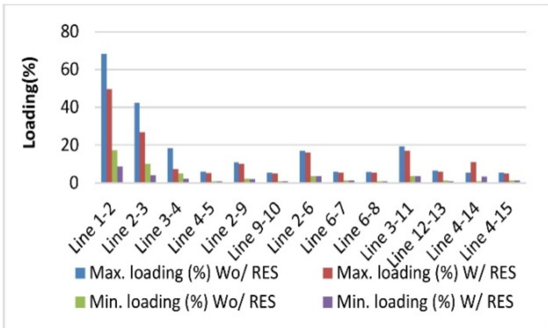

Fig. 6. Max/Min line loading with/without (W/Wo/) RES

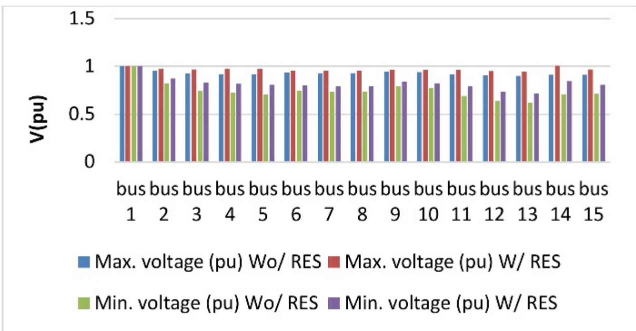

Fig. 7. Bus voltage with/without (W/Wo/) RES

In order to determine possible changes in operational indicators, a pseudo-dynamic simulation is used. The design, number, and production capacity of renewable sources, installation points, and production time pattern should be changed if the network is not in the optimal state after the pseudo-dynamic simulation.

3- RES optimization of a practical network

An example of a real network can be seen in Fig. 8. Three scenarios of low, medium, and high load have been investigated for this real network without and with RES. This study examined four wind and photovoltaic power plants connected to the grid with a total capacity of 20 megawatts.

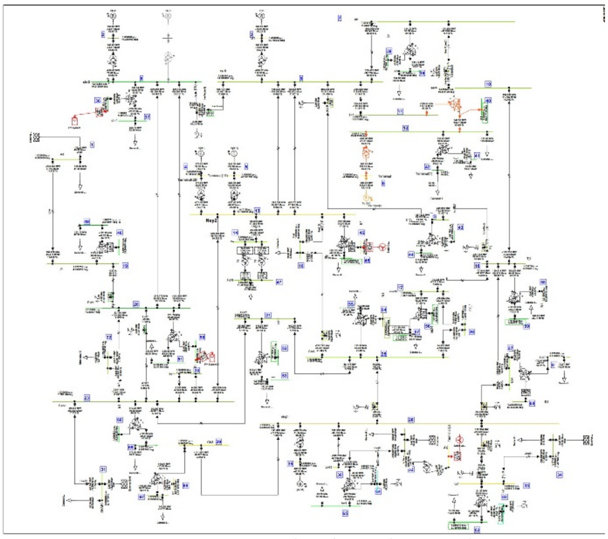

Fig. 8. An example of a real network

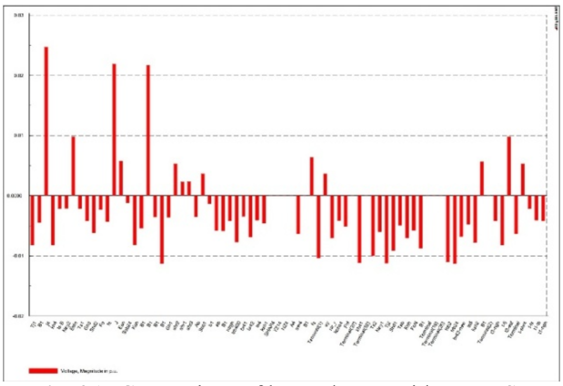

Fig. 9A. Comparison of bus voltages without RES

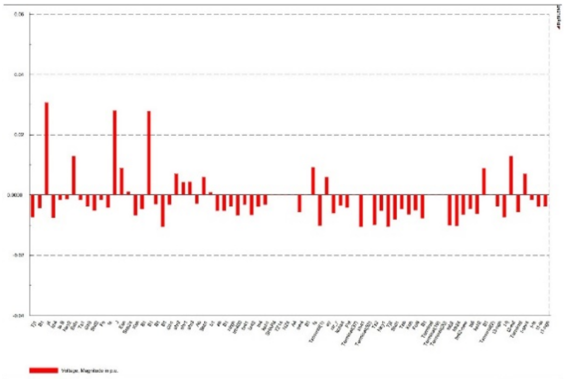

Fig. 9B. Comparison of bus voltages with RES

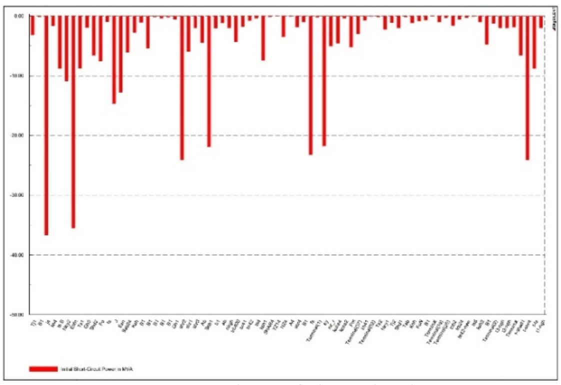

Fig. 10A. Comparison of short circuit power with/without RES in low load

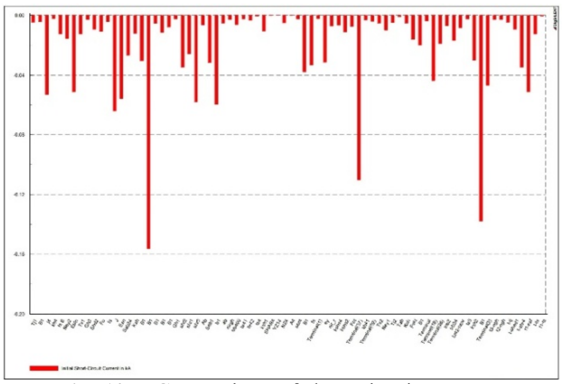

Fig. 10B. Comparison of short circuit current with/without RES in low load

The following results were obtained after load flow. It is possible to transfer power to nearby networks in low loads, in medium loads, there is no problem supplying power, and in peak loads, losses are minimized. Based on a comparison of bus voltages without and with RES (Fig. 9), it is evident that RES have been able to increase voltage stability and decrease voltage fluctuations.

Without and with RES, Fig. 10 illustrates the differences in short-circuit current and power levels. Most buses have increased their short-circuit current in maximum load. Short-circuit power and current have decreased after the RES is connected to the network.

As harmonic producers, RES can be modeled. THD values in two modes without and with RES are shown in Fig. 11. RES have increased the THD on the network, and filtering should be considered when they are added to the network.

This part investigates the system's transient stability. A synchronous generator with a short circuit in one line is shown in Fig. 12. A light colored curve indicates the presence of RES, while a bold colored curve indicates the absence of RES. Fig. 12 shows how operators can improve the stability of their networks by properly protecting the network during peak loads.

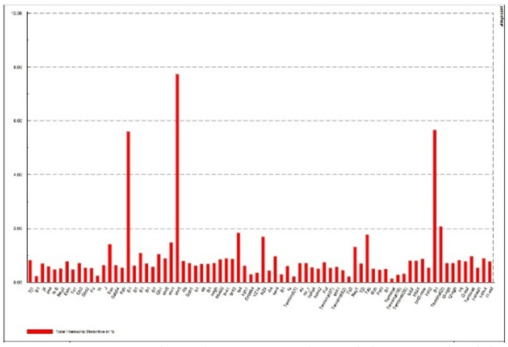

Fig. 11. THD values in two modes without and with RES

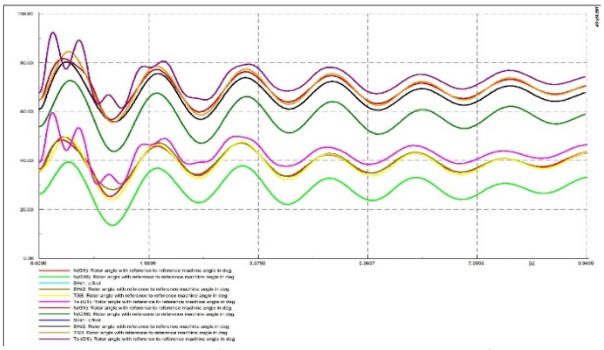

Fig. 12. Synchronous generator rotor angles

4-Conclusion

Computer simulations are required to study various aspects of RES plugging into the grid. Based on the results found, the optimal Integration of renewable energy in all loading modes improves the overall system performance in terms of load flow and short circuits. The quality of network power quality of the system, however, requires corrective actions such as filtering. Moreover, RES improves transient stability of the system at light loads and decreases it at heavy loads. As a result, it is necessary for operators to increase their secondary alternatives for the system operation and to provide advanced protection.

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