Solution to Renewable Economic Load Dispatch using Pattern Search Algorithm

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ABSTRACT: Economic load dispatch (ELD) is the process of calculating power generation of all the involved power generating units in the systems such that the total demand is met at the least possible cost. This research work proposes a framework that includes renewable energy sources into traditional power systems with the aim of decreasing production cost as well as decreasing CO_2 emissions. The framework is tested on IEEE 6 units test system by using Pattern search Algorithm. The results show that both production cost as well as CO_2 emissions can be decreased by adopting the proposed framework.

Keywords: *Economic load dispatch; renewable energy; sustainable energy systems*

1. INTRODUCTION

Paris agreement has been a highlight in recent times where about 153 nations around the globe agreed to adopt such policies which not only stop the effects of climate change but rather mitigate its effects [1]. Among the various sectors that use fossil fuels, power production sector has the majority share (35%). There is a growing demand for sustainable energy systems and most importantly, to work towards decreasing energy poverty and make this resource available to more parts of the world.

As a result, power generating systems all around the world are going through a transformation phase. Although inevitable due to economic and environmental factors, this transition is filled with uncertainties.

2. PROBLEM STATEMENT

The aim of Economic Load Dispatch (ELD) problem is to find such an optimal running configuration of all the involved units in power generating units, which produce the load demand at any given time with least possible cost.

Traditional ELD problem does not consider renewable energy sources due to their intermittent nature. Currently the major source for energy production are fossil fuels, which include coal, petroleum and natural gas. However burning of fossil fuels produce CO_2 as a by-product. This CO_2 is released into the atmosphere, which then stops the heat from escaping from the atmosphere. Such large scale release of carbon dioxide into the atmosphere has become the leading cause of global warming during last few decades.

In order to decrease the effects of carbon emissions, energy producers are looking towards alternate sources which are both renewable in nature as well as have lesser or negative carbon emissions. These renewable sources include solar, wind, hydro, tidal and geo-thermal sources. According to International Renewable Energy Agency (IRENA), energy transition is very crucial at this point and renewable sources of energy, energy efficiency and electrification are the three bases of this transition [2].

Apart from the various benefits of renewable energy, the volatile and intermittent nature of the sources make them quite difficult to be used, particularly wind and solar sources. The intermittent nature of such renewable sources sometimes result in excess generation whereas at other times they might produce less than required power.

With the integration of renewable energy, the optimal scheduling of economic dispatch has become the latest challenge faced by power system operators. In such hybrid power generating systems, the scheduling objective is to minimize the operating cost while increasing renewable energy penetration. This gives rise to the demand of a reliable scheduling technique which will, simultaneously, increase the reliance on renewable sources as well as ensure power system stability.

3. PROPOSED FRAMEWORK

This research work proposes a framework that accepts and adopts the uncertainties of several renewable energy sources and comes up with a direction towards a future sustainable power production system. This research work includes a wide array of technical constraints related to the problem which have not been discussed under a single framework ever before. Moreover, it is also proved that the new renewable sources based power systems will be scalable enough to meet the future demands while at the same time, work towards minimizing the cost of production.

This research work not only includes renewable sources into objective function for calculating the overall system cost, but also includes constraints related to each of the included power source. Therefore, total cost of the proposed system can be expressed as:

$$C_T = \sum_{i=1}^{N_A} \left[\sum_{j=1}^{N_t} f_{tj}(P_{tj}) + \sum_{j=1}^{N_w} f_{wj}(P_{wj}) + \sum_{j=1}^{N_s} f_{sj}(P_{sj}) + \sum_{j=1}^{N_s} f_{Hj}(P_{Hj})\right] \quad (1)$$

The first part of the total cost function CT represents the fuel cost of the thermal generator. The second part of the equation (1) represents the cost function for wind power generation. The third part of the equation (1) represents the cost function of solar PV plant. The fourth part of equation (1) represents power generation of

hydroelectric plants.

This proposed framework uses 11 constraints which are related to the included power sources in the problem formulation. It is believed that using a comprehensive number of constraints leads to adding authenticity to the proposed framework. A summary of all the constraints used in the proposed framework is given below in table 1:

Table 1 Summary of system constraints

Sr. No	Constraint	Source
1	System power balance	Overall system
2	Output capacity limitations	Overall system
3	Hydraulic network constraints	Hydro
4	AC load flow and power system security constraint	Overall system
5	Water release limit	Hydro
6	Initial and terminal reservoir storage limit	Hydro
7	Ramp rate limits	Thermal
8	Prohibited operating zone	Thermal
9	Prohibited discharge zone	Hydro
10	Spinning reserve for wind power	Hydro, solar, wind
11	Wind power uncertainty	Wind

4. Results and Discussion

To validate the proposed framework, Pattern search algorithm (PSA) was applied. This algorithm was selected mainly on the basis of its simplicity and the method for finding out minima of such functions which are not necessarily differentiable, stochastic or continuous.

Test system includes 6 thermal power generators, 4 wind power plants, 4 solar power plants and 3 hydro power plants. Data for wind and solar power plants have been adopted from [3]. The data for thermal units has been taken from [4]. Whereas data for hydro power plants has been taken from [5]. The load demand from the system in this case is 1000MW.

Pattern search algorithm is applied on the problem which runs for over 10000 iterations. In Fig 1, the graphs show the cost of power production by thermal, wind and solar power generation power sources respectively. The graph shows the reliance of system output on thermal power generation. It must be noted that cost of hydro power production is not included in figure as cost of hydro production cannot be quantified in terms of money rather it is determined on the basis of whether it has satisfied the constraints or not.

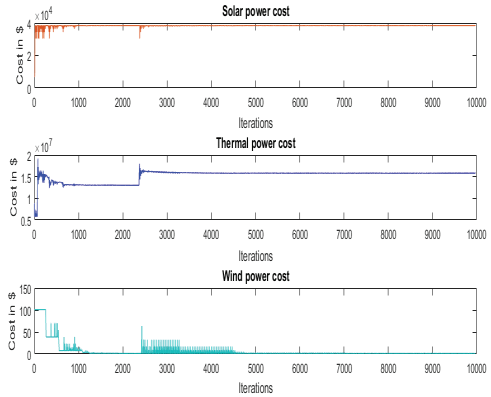

Figure 1 Cost of power generation

5. CONCLUSION

Optimization problems are an important part of our daily lives as we apply the optimization procedures in our daily chores even unintentionally. Optimization also holds an important role in the field on engineering and sciences. Electrical power systems, which acts as the oxygen for running day to day activities also performs optimization during its operation. It is quite a challenging task to ensure that electric power systems is maintained in terms of its security, reliability and around the clock availability. This research work aims to provide a framework that includes most abundantly available renewable energy sources into the conventional power generating systems with the aim of reducing the cost of power production while at the same time, reducing the carbonization of atmosphere. It is hoped that this research will provide a new direction to researchers and policy makers for achieving the climatic goals. Furthermore, while pattern search algorithm is fully capable of producing good results, other meta-heuristic algorithms and neural networks based approaches

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