Intelligent Energy Management in Smart Grid using Heuristic Optimization Algorithm

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***Abstract*— Classical economic-emission dispatch considers only conventional generators. But the need of environment sustainability has promoted the penetration of renewable energy sources (RES). RES can help to provide clean energy at decreased generation cost. A major problem faced by generating plants is network reliability issues in power system arising from the peak hour's power demand. Application of demand side management (DSM) measures can help to ease the enormous peak hour's pressure in smart grid system. This paper presents a solution of peak hour's demand management with dynamic economic-emission dispatch (DEED). This paper provides a comparative analysis of the implications of deploying DSM strategies in smart grid system with/without integration of RES. The proposed system uses Grasshopper optimization algorithm to find the solutions. Optimal control of conventional generating units and energy storage system with application of DSM programs demonstrates the potential to diminish the peak overload and economic power dispatch with emission control.**

Keywords—Demand side management; Dynamic price; Energy management; Optimization

I. INTRODUCTION

Power systems have been built to accommodate varying demands for brief periods of time. However, increased supply-side fluctuation and uncertainty as a result of renewable energy sources may provide new issues for utilities. Variability in generation sources may need extra system-balancing procedures. Greater flexibility within the system may be required to accommodate supply-side variability as well as the link between generating levels and loads. "The availability of increased wind and solar power on electric grids can lead coal or natural gas-fired plants to turn on and off more often, or to adjust their output levels more frequently, to accommodate variations in variable generation [1-2]. This sort of cycling of fossil-fueled generators can increase wear and tear on the units and reduce efficiency". For coal plants, the effects of generator cycling might include higher boiler damage, lower efficiency from running a plant at part load, greater fuel usage from more starts, and issues sustaining a level of emissions [3]. All of these smart grid system challenges may be overcome by optimizing generating parameters and power demand [4]. Demand side management (DSM) is a smart grid technology solution that assists electrical utilities in managing demand for electricity [5]. Another approach to increase the adoption of DSM is the integration of different programs of DSM but for this the industry has limited experience to date [6]. Integrated demand side management at a conceptual level is a strategic approach to design and deliver a portfolio of DSM programs to customers. Most utility and 3rd party administrator programs currently identifies with the concept of IDSM as integration of only two DSM measures, namely energy efficiency (EE) and DR [7]. With the advancement of battery technologies, storage system is also utilized and a new energy management system (EMS) is developed. Some researchers have studied the implementation of DSM programs integrated with battery storage system with/without renewable energy sources in order to achieve different objectives [8]. In [9] incorporation of renewable energy sources (RES) is proposed in order to reduce peak hour's load. [10] proposed an energy management model based on GA to minimize the end customer's electricity bill using energy storage device. Later [11] also proposed the same optimization algorithm for load leveling and peak demand reduction using energy storage devices. [12] proposed the same integrated DSM scheme for load management with solar photovoltaic generation using average pricing. In this model EMS decides when to draw power from energy storage device and when to draw from the power grid.

II. PROBLEM FORMULATION

A. Dynamic Economic Emission Dispatch (DEED)

"DEED aims to minimize fuel cost and volume of greenhouse gases. This research work proposes solution of economic emission dispatch problem by incorporating renewable energy sources (RES). In this integrated system, operational costs for the renewable energy sources are also added with fuel cost of conventional generators". Objectives of DEED problem can be formulated mathematically and given by nonlinear equations (1) and (2) [10].

$$\textbf{Minimize}\ F_{cost} = \sum_{t=1}^{24} \{f_{(t)}^{cost} + C_{(t)}^{PV} + C_{(t)}^{WT} + C_{(t)}^{SS}\} \quad (1)$$

$$\textbf{Minimize}\ F_{Emission} = \sum_{t=1}^{24} \{f_{(t)}^{emission}\} + \{n_{ee} \left| P^{SS}{}_{t} \right|\} \quad (2)$$

Here, n_{ee} is quantity of pollutants emission in Kg/MWh from the energy storage system. $f_{(t)}^{cost}$ and $f_{(t)}^{emission}$ represent cost of power generation and emission dispatch at interval t by all conventional generating units, given by equations (3) and (4).

$$f_{(t)}^{cost} = \sum_{i=1}^{NG} (a_i Pg_{i,t}^2 + b_i Pg_{i,t} + c_i + \left| d_i * \sin\left\{ e_i * (Pg_i^{\min} - Pg_{i,t}) \right\} \right|) \quad (3)$$

$$f_{(t)}^{emission} = \sum_{i=1}^{NG} (\mathrm{p}_i Pg_{i,t}^2 + q_i Pg_{i,t} + r_i + s_i \exp(\mathrm{t}_i Pg_{i,t})) \quad (4)$$