Real Time Extra Economic Dispatch For Renewable Energy Uncertainty Over IEEE Bus Bar

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Abstract:
Load prediction and power generation uncertainties are biggest challenges to economic dispatch of power at minimum operational cost of different energy sources since decades. The economic dispatch (ED) in hybrid power system is becoming an exciting research topic courtesy to weather reservations. In this article major challenges of Economic Dispatch are briefly reviewed i.e. planning, evaluation of demand, weather forecasting and security constrains, existing algorithms, unit commitment and reduction in carbon emissions. The proposed methodology consists of renewable, price, security and conventional resource sections and for each section a Real Time Extra Economic Dispatch model is presented to tackle aforementioned parameters. The System will be verified over IEEE 30-bus bar and six generators along with wind and solar units considered as non-schedulable. Scheduling period is considered as 60 min (six intervals, each of 10-min duration) to show the effects of sequential and dynamic approaches. This 10-min interval is subdivided into ten 1-min subintervals.

Keywords *Economic Load Dispatch, Renewable Energy Resources.*

I. Introduction and Background

The economic dispatch is an extensively studied problem in power system research. A recent trend towards alternative energy resources may cause a serious problem economic dispatch in the upcoming electrical generation, where the reason is that the amount of controllable generators will decrease while disturbances increase. So, some new dynamic economic load dispatch (ELD) method are introduced to meet the general requirements for real-time use in a future power system, where load following capability is critically limited. A genetic algorithm has been tested over wind generation power plant by J.-C. Lee in 2011. He highlights the best solution to solve the economic dispatch (ED) issues regarding wind energy generation by creating a scenario to avoid the increment in cost by adding more wind generation Plants [1]. He discussed that mostly the droop schemes are focused on the power sharing in the control of distributed generations and other factors are ignored like cost, efficiency and also penalties on the emission as they are different for every type of distribution generation (DG). It will help in dropping the generation cost for micro-grids. Basically it was about the production of power sharing based on dropping the cost of generation and combining different factors. This scheme is enhanced by Inam Ullah Nutkani in 2014 where it is based on to linear expressions in which different variables are involved like quantity of DG units, active, reactive power, frequency, apparent power and terminal voltage. Different cost functions were also introduced. Experimental results have shown robustness. The contingencies and black outs are not considered here [2]. In 2014 keeping in mind the realistic variation of these wind plants, M. Zhou proposed an interval based optimal model by taking two worst case situations by demolishing all other situations. This method speeds up the solution so that the scheduling is in accordance with the security limitations and make the scheduling more cost effective [3]. To benefit from the speedy and fast regulation skills of the distributed generation while making the security and economics of power system more efficient idea of virtual power plant (VPP) is getting famous. Then J. Zhao introduced power systems with Multi-source scenarios. These became more renowned because of the large amalgamation of distribution energy units and dispatch-able loads [4].

One was the time when hydro-thermal unit commitment integrated with wind energy was gaining popularity. In this regard X. Li compared to other sources of energy with hydro power and found it more dependent on number of factors that can be easily united in time and space [5]. The problems related to win-thermal –hydro power becomes difficult to solve with the SO model because of its simplicity and no economically response at very high penetration. In 2014 A. L. Diniz and T. M. Souza introduced a short term model for scheduling developed to solve these problems [6]. Then a linear programming based model is separated into some time intervals but there was a sheer need to design uncertainty sets for robust optimization method carefully. A small set could not be able to cover the whole of the spectrum which could be a big problem. As compared to small if a set is big then it can compromise the robustness of the results and this become more cost effective procedure [7]. This issue was highlighted by Q. S. Xu where he suggests a multi scenario robust dispatch method for power grid integrated with wind farms. This model works at high penetration but integration of wind form and this become less reliable because of weather constrains of wind power. Then forecasting error for renewable energy resources becomes a problematic concern for ED. In 2014 H. Y. Wu with his team analyzed these forecasting issues a made some mathematical models for forecasting wind schedule and then developed a forecasting error scheduled system for the renewable energy generation plants that can be curtailed using day ahead scheduling and the probabilistic limitations was

the warrantee for this purpose [8]. The later on S. Chakrabarti and J.-C. Lee worked on day ahead scheduling in their separate articles where a robust optimization method in wind generation is introduced under extreme states. The unit commitment is solved with Ro method under some uncertainty. As compared with the linear programming based model, the robust model is much appreciated and it gives dependable ED processes [9]. The consensus algorithm needs transfer of information between all the nodal points, so It becomes really difficult for a very large power system as it has multiple node points and large number of devices which need to communicate with each other so it becomes a burden and very private data could be compromised. [10].

II. Literature Review

In 2014, Hristiyan Kanchev proposed an idea of micro grid of renewable Energy resources (RES) is promoted by considering a photovoltaic (PV) model with conventional sources to minimize the carbon emissions as well as cost. This is also dynamic program based algorithms to solve the unit commitment problem and optimize the carbon emissions. A new concept of active generators (AG) is also the part of this work in which solar power is converted into desirable form it might be AC or DC. [14] In this article a new idea of AG proposed that is basically 3.6-kW PV generator, 106-Ah batteries, and a 160-F super capacitor bank. This is called generators because it operates at real scenario because DC load are connected with directly DC power, AC load connected with DC/AC converters and super capacitors are for back up. This model operates on three goals where first is no interruption of power supply, second is maximum utilization of AG at low per unit cost and last is minimum emission of CO_2. Some forecasting techniques are also considered for the availability of PV power according to load demand. Fuel consumption of generator can be assessed by using their partial load efficiency characteristics and calculated its mathematical model and then modeled an emissions of carbon with mathematical model. After getting this information there is approached a Scheme of the day-ahead optimal operational planning. It is like a flow chart of this planned scheme. [11] In literature, author is found that a huge work is done on maximum power point tracking (MPPT) of solar panels. Although it's very necessary to obtain maximum point (MP) but here he is focusing on active generators where PV generators are formed into AG [11]. In others proposed solution, there is focused on unit commitment (UC) but it facilitates not only the UC problem but also deal with smart grid application like provide a communication link between generation and consumption [12]. It has main focus on PV cells power but there is lightly focused on other conventional sources. Secondly no details are provided of communication link either its power line communication or wireless communication.

In 2015, Hao Xing reviewed in his study a distributed bisection algorithm is presented in the situation of smart grid to tackle the problem for economic dispatch. The major purpose of the study is to reduce the cost of total working of the generators with communication link, which supportively equip a specified volume of power within their discrete capacity restraints. The essence of this algorithm is that it is based on bisection rather than a having a sole decision maker. If the communication aspects are reasonable, the iterative solution becomes a global level optimal solution [13]. There is pair of stopping criteria which proposed for the real-world applications. Sign consensus for this is already fixed. There is no need for global information for the presented algorithm. There is no node which knows total demand. The proposed model is difficult to apply for overall convex functions. In the proposed algorithm the cost functions are not limited to the quadratic functions only. The future work could be done by extending this proposed algorithm to the line capacity limitations [15]. In a same year Haijun Xing enhanced this model by increase in the renewable energy sources has made the conventional grid to accommodate more reserves for power supply as well as demand balance. Demand Response DR strategy has become famous and it is used for cost effectiveness and to reduce emissions etc. The constraints considered like demand response (DR), maximum participating time and DR ramp rate are used to establish the cost effectiveness and for the economic dispatch [16]. After some time, H. Xing introduced a Sample average approximation method that is used as combinatorial optimization which has shown promising results in economic dispatch for power systems. The metal is cooled down in this procedure until the minimum value is reached by the total energy. The metal is recrystallized overall before the annealing [17]. This model raised issue of Unit commitment and it has been the talk in 2015 where it is used for day-ahead scheduling of the generators' regulations and wind curtailments. With the minimizing of the generator regulation and that of wind curtailment a problem of economic dispatch is framed keeping in mind several scenarios. The economic dispatch is based on several forecasted power generations rather than relying on single one. Generator regulation is presented as optimal variable in the model developed by Jinghua L [18]. After the unit commitment of these generation there was a need of multi area economic dispatch that that can merge the concept of decentralization in economically way [19]. So, Xiaowen Lai and W. Wei proposed the multi area economic dispatch and wind related study for decentralization respectively, where concept of decentralization lagrangian relaxation approach (dynamic multiplier based) can be used. During the iteration for the interchange of neighboring areas lagrangian multipliers sensitivity is examined to produce dynamic multipliers. These multipliers are different than those of conventional ones. Wind power related studies are mostly based on the stochastic optimization as well as robust optimization [20].

In 2016 a new scheme of Unit Commitment Problem (UCP) introduced by Chongxin Huang that is optimal dispatch by on/off states of generating units in some time

intervals These units may be the steam power generators, renewable generation or any other conventional generation. These all generating units in operation have one common target that is the demand of that particular time interval [21]. In case of committing thermal generating unit, the emergency reserve is maintained to cover the loss of largest generating unit. So the extra constraints because of the combination of wind power make the UCP difficult to achieve the optimal solution. Using Fuzzy Optimization Technique this constrains is going to be solve out. [27]. Firstly, there is formed mathematical models of thermal plants as well as wind power plant. After setting the minimum up time and minimum down time there is approached to cost model which is main concern of UC. Where non zero like 1 is offered that the unit goes to ON state from OFF state [22]. After setting all parameters and physical constrains the author developed an optimal fuzzy model

There are servals techniques for UC but it is solved only by some dynamic approaches or algorithms. Previously there were done dynamic programming techniques that's provides more flexibility, it makes the problem complex and increases computation time with the increase of the dimension of the problem. [23]. This author introduced CPLEX as an optimization tool is used to solve our UCP by using fuzzy logic optimal technique because it creates flexibility in modeling and makes Mixed integer linear programming (MILP) based solution more practical. In future the mathematical model can be enhanced by considering all wind constrains like wind speed fluctuations, uncertain production, weather forecasting, by adding more wind turbine and perform parallel operation of different wind turbine. Then, there is definitely need to add more member function of fuzzy model and also enhanced our math model. At the first in this study all the constraint like ram rate, maintenance time, Power and the capacity were taken into account, combining it with the wind turbine output, open downtime and additional constraints. In 2016, A UC model of Ning Yan basically a steady state method for power. If a wind power is integrated in a grid the net economy of the grid is increased in virtual power plant (VPP) At the practical level the generation of wind power, load distribution and reduction of the cost of generation is examined. It is studied that the power distribution can be united for all day through energy storage system and also the wind turbine load distribution decreases the total cost of the large scale power system [24]. The Economic dispatch method presented is based on the interval mechanism. The ED method is used for both central power plant and virtual power plant. The interval based method for economic dispatch is converted into deterministic model. The optimization of the dispatch is done based on this model [25]. The work is done in three steps. In the first step ED model is established based on the interval pattern to design objective function as well as constraints taking in to account all the issues of the power systems and second step the obtained functions are converted into simulation to get the desired results. Third step is about the deterministic ED model. As mentioned in the literature the dispatch plan has not been worked on well for conventional power plants (CPPs) and virtual power plants (VPPs). The model basically uses interval as mean of elaborating uncertainties for VPP. Rather than going for PDFs and FMFs this interval based proposed solution of the uncertain variables is much more convenient for the engineers to apply. This proposed ED model of Chongxin Huang that is introduced in 2016, it can be easily explained by using quadratic programming. [26]. This proposed solution basically an interval-based ED model for a power system with conventional power plants CPPs and VPPs. It utilizes the interval to describe the uncertainty of load prediction and VPP power prediction. The probability degree in the interval optimization method is then employed to transform the interval-based ED model into a deterministic one. The optimal dispatch scheme of the power system with CPPs and VPPs is obtained by solving the deterministic ED model. Finally, the proposed interval-based ED scheme is applied to a 10-machine power system for simulation. [28]. First part the ED model is modeled in the interval scheme to establish objective functions and constraints according to the structural features and operational requirements of the power system. After taking these readings by two function of load and cost are developed on the basis of external characteristics of the VPP and try to minimize CPP importance. [29].

Recently Yue Chen modeled one more RES based ED by solar system integrated with thermal units is modeled. Then calculate its mathematically formulation into simulators. [31]. Dispatch prioritization and frequencies of distributed generation (DG) are acquired from number of factors involved quantity of the DGs. power rating and generation costs. The non-dispatch able DGs are also included, attributes of the droop are reserved. Generation cost of the combustion engine and renewable energy is used here. The presented economic dispatch scheme is an alternative for the cost-priority scheme Faults and life of the generation devices has not been taken into account [32].

In e 2017, the work is going on to reduce the cost of active power generated. Fixing Chen presented a cost based droop scheme without making any changes in the droop control decentralized nature and plainness. In this scheme the distributed generators' incremental costs are merged in to the droop schemes, basically this incremental cost is found by taking derivative of the DG cost function to the power output. A lone frequency is shared in steady state by DGs, incremental cost is computed by cost base droop scheme, hence reducing total generation cost for active power, in the form of incremental cost. The major issue for the cost based droop process was to compute the total cost of generation because all the generators are regulated for their individual generation cost. To resolve this problem incremental cost is merged in to this scheme. The main attributes of this model is that they do not have complex mathematic model, do not require communication network and have plug and play capability [33]. In 2017, Yingzhong Gu model offers the system to evaluate between stochastic and deterministic

strategies. Stochastic LAED is developed and criteria is developed to see that if stochastic approach is more effective it is totally dependent on the uncertainty response. This Horizon division method is used to divide the look ahead prospect in to two potions stochastic and deterministic. For the solution of the LAED-S a computer program is constructed which influences L-shaped model and algorithm. This technique is not necessarily applied on all the LAED-S but however in intervals with higher economic risk this could be applied. Future recommendations are theoretical digging of the approach [34]. The solution of these uncertainness is an economic dispatch model which can consider steady-state secure region for variable wind power. The base-case operation cost and the wind power integration are balanced via the introduction of secure regions. Before model the proposed solution, author illustrates the secure region for wind power and actual region for wind power and then formulates the proposed model and later on provides the algorithm for this proposed model [35]. In the short-term grid operation, the base-case schedule plays an important role but if apply to mid/long term grid operation the planning problems are accrued. So there is need to enhance the capability of the model for long term grid operation.

III. Economic Dispatch Security Constrains For RES

Recent development in renewable energy that penetrated electrical power system then economic dispatch with conventional power system has become the challenging task to manage different security constrains, Followings are concerns that are mainly discussed:

A. Study State Security Constrains

Yanfeng Ma [36] (2017) highlights the security constrains foe economic dispatch by considering the wind power integration with conventional power plant where he found over current issues, probability of outage for transmission and voltage protection failure. A numeric comparison based system is developed to validate these security concerns.

Hong chen [37] (2017) provides an schedule system that can control demand of power, meet the security constrains of over current and voltage protection. This hourly based scheme also satisfies the unexpected changes in power system of renewables.

B. Voltage Security Constrains

Xiaowen Lai [38] (2017) compared two technique that contains voltage security constrains where one has voltage fluctuation of wind power and second have missing of voltage in night time foe solar. These both techniques have fixed algorithms at rated values of power system. Then minimize the generation cost and approve the voltage security by adding voltage collapse points in singular value ten take its derivative.

Yousef Pipelzadeh [39] (2017) indicates assessment on transmission line voltage security constrains which used the real coded variable that contains natural variables with floating point. At the end proposed a transient controlled assistive measurement for correction.

C. Decentralization Constrains

Brijesh Sing and his team [40] (2011) suggests an optimal power flow decentralized system with solar power. He used IEEE-30 bus bar system for decentralization, so need was an AC power conversion of solar power to make independent optimal flow where he tries to approach the profit but cannot succeed. In 2016, authors highlight the decentralized constrains in details and on same 30 bus bar system, he approaches a centralized power system [30].

Ibrahim F [41] (2014) worked on decentralization of renewable resources and realized a control action and also compensates the Brijesh Singh constrains for decentralization. His simulation results have shown two switching constrains that is big reason to down the overall efficiency of whole power system. Then researches are shown their interest on only centralization.

D. Dynamic Security Constrains

Haicheng Zhang[42] (2016) work on issued that mentioned in literature where he implemented and designed a technical historical system integrated with Data Transfer Rate (DTR) technology which can forecast thermal ratting as well as predict environmental situations for renewable sources. This system is capable to enhance power system security but exploited the potential transfer capability at dynamic environment changes. Hong Chen [43] (2017) improve economic efficiency while dynamic constrains remains because his focus on power system operational functionality. Market analysis on real time data software is made that is design to increase efficiency and made a center of electricity generation.

E. Contingency Selection Constrains

Yunfeng Wen [44] (2016) indicates a two stages programming issues that has combination of integer where a composition is also developed to solve Contingency selection problems. He demonstrates the two case studies on RTS-79 as well as RTS-96.

Pablo Ledesma[45] (2017) describes the transient stability issues in optimal power flow to find Contingency selection problem of power source either it be renewable or thermal. This model automatically read the data from standard files that are programmed in software. This schemes also facilitates the different application of power integration expect thermal and renewable.

IV. Study Of RES Economic Dispatch Methods

A. Linear Programming

Already existing power systems have control methods that can only tackle with single wind farm, single solar system and single thermal unit. These units operated independently but power losses are major drawback of these systems. So linear programming based system were launched to dispatch economically. Li Lin [48] (2013) approached an active power ED model by considering short term wind weather forecasting and power prediction. He uses a linear programming method

to resolve nonlinear constrains under algebraic calculations. Further on Beatice Lazzerini [49] (2015) made a model of emissions free, valuable distance and load balancing scheme from importing a function of linear programming which solves alternative configuration of system but no work on minimize the security constrains.

B. Optimal Power Flow Method

Smart grid techno\logies development also a one reasons of economic dispatch with power flow dispatchment. Denis V. Armeev [46] (2016) proposed an optimal power flow method of renewable resources where it consists of generation resources price, real power losses control and other climate condition, He work on in this method by combining multiple objects into single one. This method only can reduce the power losses in power flow not target the security constrains.

Anya Castillo[47] (2017) provides a solution to voltage fluctuations constrains for commercial users and did test on IEEE RTS-79, and the IEEE-118 in Matlab Simulink but not been able to overcome uncertainty of power flow.

C. Non-Linear Programming

Nonlinear programming only can deal power resources that have nonlinear nature like solar are wind mainly. So Shama Bansal[50] (2016) presented nonlinear programming based model that have ability to transferred security constrains but cannot resolve. Pablo Ledesma [51] (2017) also try to reduce or highlights the ED constraints but only can reduced in thermal power plant.

D. Artificial Intelligence Method

Now a day artificial intelligence models are developing in power system to control different scenarios. These methods are to be considered as not-deterministic. particle swarm optimization (PSO) based algorithm that is based on Eigen value analysis for the evaluation of system stability and normal operating conditions. [52], [53]. The relative analysis of power flow exposes that PSO based algorithm that is example of artificial intelligence models make optimal power flow without any constraint violations and the system is under stable operation conditions.

E. Quadratic Programming

Earlier mentioned methods are missing one security constrains or one optimal power dispatch term but this quadratic programming based dynamic model not only optimize the power from different energy resources wind and conventional but also evaluate fuel consumption, gas pollution emission fees, and electricity purchase costs as the optimized objective. [54], [55]. A little Drawback of this method is that it cannot easily tackle the barrier opposed by penetration of wind and solar in power system but comparatively best from others methods.

V. Proposed Methodology

In order to optimize costs, keep in knowledge the PF for the wind and solar power outputs, weather forecasting and load forecasting. So that there is proposed five Real-time extra economic dispatch (RTED) models:

1. To make Cost model of conventional sequential RTEED approach.
2. To establish a Model of Price for power and changeable costs using proposed sequential RTEED approach.
3. To apply the Cost model of conventional dynamic RTEED approach.
4. Model of Pricing energy and variability costs using proposed dynamic RTEED approach.
5. Model of Sequential RTEED with Variable Load and Renewable Power Generation units.

The System that have IEEE 30-bus with six generators located at buses 4, 7, 8, 9, 16, and 17. Here, the IEEE 30-bus system is proposed to tackle the wind and solar injections at buses 16 and 17. In this proposal, wind and solar units are considered as non-schedulable and they can supply the power up to the maximum available wind and solar irradiation. Scheduling period is considered as 60 min (six intervals, each of 10-min duration) to show the effects of sequential and dynamic approaches. This 10-min interval is subdivided into ten 1-min subintervals. These optimization models with equation and code insert in MATLAB and solve using a MATLAB Optimization Tool.

VI. Conclusion

This paper presents a detailed study of various option of renewable energy that can integrate with conventional power plant or independently run. After all option review it is suggested that any option which is avail according to situation can optimize for power dispatch but each method have to overcome security constrains. Different security constrains are discussed and which method overcome which constrains this is also a part of this research. All methods found a multiple solution but artificial intelligence models provide better performance than other conventional optimal techniques. Further in detail that PSO method of artificial intelligence can be used for complex and multiple unit's combination due to fast convergence speed. After summarization of this research a RTEED based ED model presents which ability to overcome all renewable security concerns by providing a separate model for renewable as well as price and other concerns.

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