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Impact of Wind Integration on Power Market: A Review

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Abstract---Wind energy generation increases rapidly all over the world. The increase of wind energy generation in European countries is due to the policy objectives set by EU to ensure energy security, environmental change and to increase competitiveness. Due to increasing awareness of climatic conditions all the Europe is moving towards the Renewable energy. Introduction of Wind energy in power systems introduces the technical, commercial, security and government Complexity. Wind generation is highly variable, uncertain and unpredictable thus produces the challenging implications of wind integration for balancing generation and demand. This paper reviews the designs of electricity market of Australia, Spain, Ireland, Denmark, Portugal, New Zealand, Austria and Netherland. This paper also investigates the techniques used for wind integration. This paper analyses the economic impacts of wind integration on power system of different countries. This paper also shows the different techniques and guidelines for balancing electricity power market. Demand response is important solution for integrating renewable energy. Different model for simulation and validation of electricity power market to integrate wind generation are discussed.

Index Terms— wind energy, security and government Complexity, challenging implications, wind integration, balancing electricity, power market, Demand response, integrating renewable energy**.**

1 Introduction

Wind generation is variable and random according to the time scale therefore for system stability and reliability, energy balancing of system is required. The increase of wind generation in European countries is due to the policy objectives set by EU to ensure energy security, environmental change and to increase competitiveness. In 1999, National-Electricity-Market (NEM) of Australia was established. In 2001 one of the world's first target of renewable energy was implemented by Australia. NEM modifies the rules of the electricity market for the incorporation of wind generation and introduces a system of centralized wind forecasting. In RES directives Portugal must complete renewable energy production of 39% by 2010. The demand of electricity in New Zealand is 6920 MW. There are 8 wind power plants having the combined capacity of 322 MW. 12 wind power plant of 1700 MW is to be installed. Wind generation operating capacity of Electric reliability council of Texas (ERCOT) 10000 MW.

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In summer peak demand of ERCOT is 65000 MW and penetration capacity of wind generation is 25%. Danish electrical power system consists of 50% wind generation. In 2025 Land wind generation is 3500 MW and off shore wind generation is 2900 MW. Wind generators have a contribution of 4% of total electricity generation in NZ. But when wind generation increases to 20%, an average daily saving of $3518 is expected for 6 months period. ERCOT has successfully incorporated 10000MW of wind energy into its power system. Australian NEM includes 4000 km from north to south have a power generation capacity of up to 40000 MW where the peak demand is 33000 MW. European and Nordic Electricity markets depends upon day ahead markets which includes high demands balancing and trading of high wind penetration. In Spain the stochastic behavior of electrical system increases due to increase penetration of renewable energy resources thus behavior of power system is discussed. Intraday, Day ahead market design of different countrie's are reiewed. A DR model is formulated through which wind power is integrated. Bellmore electricity market model is also discussed for economic and cost analysis for the integration of wind power.

2. Market Design and Wind Power Integration in Different Countries

2.1 Australian Electricity Market

In 1999 [1], National-Electricity-Market (NEM) of Australia was established. In 2001 one of the world's first target of renewable energy was implemented by Australia. With the increasing growth of wind energy Australia adopts different approaches of power market for the facilitation of wind integration. A market price shows daily, weekly and seasonal patterns and significant uncertainty. Income of wind farm depends up on this uncertain time. NEM modifies the rules of the Power market for the incorporation of wind energy and introduce the system of centralized wind forecasting. Electricity market operation includes a mix of decentralized and centralized decision-making however over the last two decades many countries tries to move towards

2.2 Ireland Electricity Market:

Wind generation is variable and random according to the time scale therefore for system stability and reliability balancing of system is required. The increase of wind generation in European countries is due to the policy objectives set by EU to ensure energy security, environmental change and to increase competitiveness. All Island Grid (AIG) faced many challenges from integrating wind energy into power system. AIG is nine times smaller than Great Britain Power System however penetration of wind energy in AIG is larger than the GB Power System. In 2005, Preliminary consultation paper 2020 vision issued by Ireland energy ministers. Another AIG study was published in 2008 which states that portion of energy generated by Renewable energy resources is to be increased from 12% to 40% till 2020 [2].

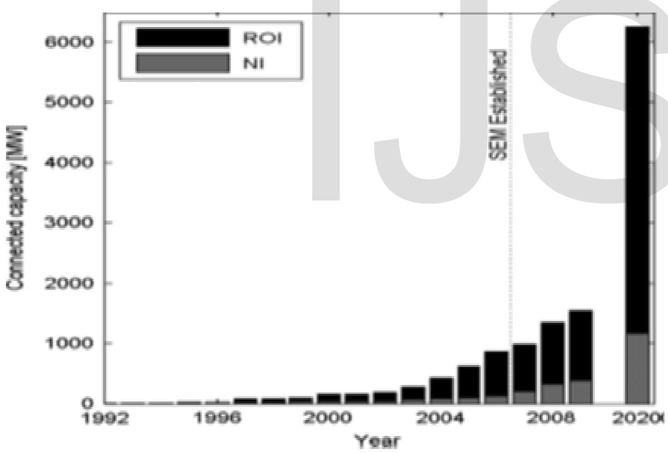


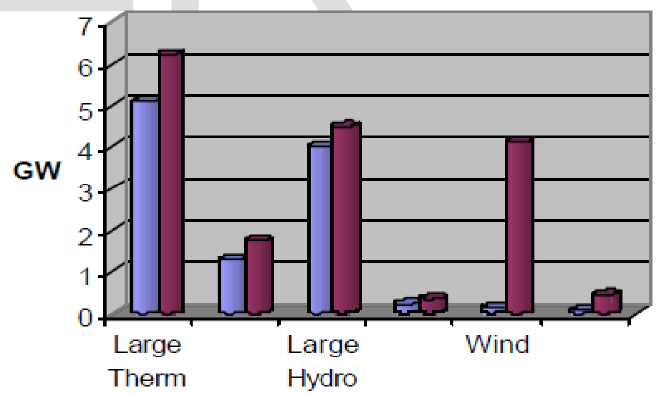
Fig. 1. Installed Power capacity of AIG is 9742 MW and 5842 MW is gas fired

2.3 Spain Electricity market:

In [3], The stochastic behavior of electrical system increases due to increased penetration of renewable energy resources. Actual wind energy is deviated from forecasted schedule thus balancing is required within a day. In order to cope this reserve market and short-term adjustments are traded for flexibility. The flexibility is modeled by stochastic approach in which the first step is to know the forecast uncertainty. In this study, the wind energy forecast errors are determined during the time between the day ahead closure and intraday first opening session. The method used the analysis of time series for the years 2010- 2013 to understand the wind error explanatory variables by using cluster techniques to decrease the uncertainty range. To forecast the probability density function regressive techniques are applied. This method is the tested for different system scenarios displaying the suitability. This method helps the wind energy producers to increase their benefits by optimally bid in the intraday market. This study shows that the intraday price fluctuations influenced by WPFE variability. This approach provides the building block for wind power market value. Some accurate scenarios are generated for system model which also helps in unit commitment and economic dispatch model thus on hourly basis system is optimized. The fluctuations of wind power in intraday market is the probabilistic unit-commitment model. In order to assess the storage and flexibility options this method is combined with the forecast model for reserve market and day ahead market prices. This method can also be improved by studding further explanatory variables.

2.4 Portugal Electricity Market:

In [4], RES directives Portugal have to complete renewable energy production of 39% by 2010. There are also hydroelectric projects which shares this percentage and the missing share should be completed by introducing wind energy of more than 4000 MW by 2010. Spain also focused on increasing the wind energy of more than 13 MW by 2010. There is challenge for both Portuguese and Spain power system is the electricity market. Thus, wind power integration can also be tackled by technically and commercially. The total load demand forecast is 62 TWh in 2010 out of which 24 TWh is to be produced by renewable energy resources. In 2007 wind power capacity is 500 MW. By 2010, 4000-Megawatt capacity of wind



farms is to be installed.

Fig. 2. Iberian Peninsula facing the wind power integration challenge of 17000 MW of the installed capacity of 50 GW.

2.5 New Zealand Electricity market:

In [5], The wind generation effects on the New Zealand Electrcity system is observed and quantified. The effects of outputs of wind generation variability and wind turbines capability are observed. The most challenging issue of wind integration are wind generation variability, wind generation forecast, Management of wind generation output changes. The demand of electricity in New Zealand is 6920 MW. There are 8 wind power plants having the combined capacity of 322 MW. 12 wind power plant of 1700 MW is to be installed. New Zealand ministry of economic development and Energy conservation agency published report that wind generation of New Zealand would be from 2% to 20 % whereas renewable energy generation of New Zealand is 65%. System operator has two objectives. First system operator (SO) has to balance the demand and supply so that voltage and frequency doesn't exceed its limits. Secondly system operator has to maximize the economic revenues. The investigations carried by Transpower for finding the impact of wind generation on power market. Result shows that wind generation technology effects are very minimum, but the wind generation output variability shows considerable effects on electricity market and power system. Thus, the accurate forecast of wind generation is very important and very critical for electricity market.

2.6 Brazil Electricity Market:

Integration of wind power plays a very prominent role in modern electric power system. The Brazilian Electric power system has major share of hydro energy and this centralized dispatch causes a highly volatile behavior of short-term prices of energy. Due to stochastic nature of backup reserves such as Wind and small hydro's, GENCOs are exposed to Price-Quantity risk. The objective of this study is to present a practical and commercial model to integrate the WPP into Free Brazilian Trading Environment while reducing this price-quantity risk. We put forward a novel model for a WPP acting jointly in coordination with a small hydro generation. The results show that proposed model is able to counter the exposure to short-term energy prices and foster the incorporation of wind energy in power system. The presented technique is currently being implemented in Brazilian market by DESCOs and trading organizations [6].

2.7 Texas Electricity market:

In [7], Market design of integrating wind energy of Texas. Wind generation operating capacity of Electric reliability council of Texas (ERCOT) 10000 MW. In summer peak demand of ERCOT is 65000 MW and penetration capacity of wind generation is 25%. In this work, market rules and designs are discussed to cope the penetration of wind generation variability while maintaining reliability of system and proper wind energy market price. Penetration of wind generation is done in both nodal and zonal market including the operation of real time and day ahead market and discusses the market outputs of increasing wind energy penetration. From 2001 wind generation of 10000 MW is implemented by improving market rules and continuous advancements. Stakeholders and regulators continuous review market modifications. Variable wind generation penetration is increased by using modified tools and advanced operational procedures.

2.8 Denmark Electricity Market:

In [8], Danish electrical power system consists of 50% wind generation. This work shows the results for maximum benefits and economical costs to incorporate wind power in system. Bellmore electricity market model is used for economic and cost analysis for the integration of wind power. This paper shows the scenario of two analysis. First scenario includes all the investments of production capacity. Second scenario consists of investments to achieve 50% wind generation by 2025 in Denmark. In 2025 Land wind generation is 3500 MW and off shore wind generation is 2900 MW. A "visionary Danish energy policy published by Danish Government in 2007. This policy states that wind power is to be doubled from 3000 MW to 6000 MW. Wind generation would be 50% of total generation. This paper determines the economical, benefits and costs of 50% of wind integration and then compare with 30% and 40% wind integration. This paper shows the technical feasibility of 50% wind integration with out decreasing the security. Wind power capacity must ensure the electrical system flexibility.

2.9 ERCOT Electricity Market:

[9] At Present, Renewable Energy Resources contribute a major share of electricity to ERCOT. In which, Wind resources are the primary source of electricity generation. As a result, the impact of wind resources has become more prominent on the market. Energy prices and Ancillary Services (AS) cost are the two main parameters affected by increased penetration of wind resources into the system. A unique characteristic of wind energy resources as compared to others is that they have zero fuel cost. So, it will tend to lower the Power market prices. But they have variable power output due sudden changes in weather and uncertain due to less dependability on fuel. This increase in uncertainty and variability will require more reserves in form of AS. This rise in requirement of AS Reserves will result in increase in overall total cost. This study employed ERCOT's market model to explore the impacts of Wind resources on Energy prices and AS prices. First, Energy offers and trend in market prices is observed. Then methodology used by ERCOT for determining the AS reserves requirements is modified by adjusting its inputs to observe what the AS requirement will be if the Wind Resources variability and uncertainty does not influence it.

2.10 Netherland Electricity Market:

Wind power generation increases rapidly. Wind generation is variable, uncertain and unpredictable. Therefore, for supply and demand balancing, wind power is to be forecast before. Design of Dutch electricity market facilitates the participants to take part in electricity market. This helps the system operator for wind power balancing. However, for generation and demand balancing, the main authority is system operator. This paper shows the design of Netherlands electricity market implications. Opportunities and threats of wind power balancing are discussed. EU wind power is 34 GW and Dutch wind power capacity is 1.5 GW. For power system operation balancing of generation and demand is required. Variability and unpredictability produce a great challenge to system operator for wind integration. In Netherland, transmission system operator is responsible for balancing market. In Dutch there is penalty for wind output variability and uncertainty and responsible parties required to forecast wind generation in advance and reserves are required for prediction errors. Thus by technical and economical wind generation capacity is determined[10].

2.11 Europe Electricity Market:

The purpose of this paper is to analyze the high penetration of wind generation in Europe electricity market. Design of electricity market of European countries like France, Germany, UK, and Spain are modified according to liquidity in intraday and spot market. This also provide the importance of wind power short term adjustments and liquidity in spot and intraday markets. For example, in Germany the lack of compatibility between the needs of Short-term adjustments and intraday market is analyzed this provides the importance of increasing liquidity on the short-term electricity market and the value of continuous spot market in UK. European and Nordic Electricity markets depends upon day ahead markets which includes high demands balancing and trading of high wind penetration. This provides the challenge how the design of electricity market is modified to cope the high wind penetration. In intraday market this gives the importance of role of liquidity to increase the efficiency of design of electricity market this decrease the wind integration societal cost and benefits wind producers and 'Balancing responsible party 'the grid operators. Actual and schedule wind power deviations, wind power producers are not responsible for that. Grid operators are responsible for deviations and will get benefit from liquidity and hence efficiency improves. Continuous spot trading market is adopted instead of day ahead market. For the spot trading, the gate closure time is moved to 6:00 pm on day before. In intraday market liquidity bundling is introduced [11].

2.12 New Zealand Electricity Market:

Due to volatile nature of the wind, integration of wind power plant into the power system comes with an extra cost. Various methods were proposed in literature to reduce this loss, Stochastic power Market clearing Technique being one of them. However, implementation of such a system is also costly. Therefore, it is necessary to analyze the efficiency gain of implementing such mechanism. SPM Technique differ from conventional mechanism in the sense that it takes future values in current decisions. A distribution function is derived to incorporate the uncertain parameters. This study shows that for current NZEM, Stochastic power market clearing mechanism is not efficient. Currently wind generators have a share of 4% of total electricity generation in NZ. But when wind generation increases to 20%, an average daily saving of $3518 is expected for 6-month period. So, for large scale wind power integration, Conventional mechanism will no longer remain efficient and it is necessary to move towards a more efficient technique like stochastic power market clearing technique. This study also provides an approximate of values of SPM for different wind integration percentage [5].

2.13 ERCOT Power Market:

This study provides the analysis of rules developed, related to integration of wind energy, within ERCOT nodal and zonal markets. There is 10000MW of wind energy produced and operating in ERCOT market. This paper describes the various techniques put together to intelligently deal with uncertain wind power generation while keeping in check the system stability, reliability and economic market prices. Particularly it deals with the treatment of wind power in nodal and zonal markets, including real time dispatch, Day-Ahead markets and explains actual power market outcomes. Trough continuous improvement and intelligent modification of its power market rules, ERCOT has successfully incorporated 10000MW of wind energy into its power system. This success has been made possible by constant Inspection and emendation of market rules by regulators and stakeholder. New procedure and tools have been implemented in ERCOT to allow more efficient operation and management of the continuously increasing penetration of wind power. However, due to integration of wind, additional problems lie ahead [7].

2.14 Norwegian electricity market:

Best renewable wind energy is in the Norway. Norwegian government give the vision in which they must produce 3 TWh wind generation till 2010. But the production of onshore wind integration in 2010 is only 1 TWh. This paper shows the challenges and reason for not achieving this goal. Important figures are analyzed on tactical and strategic levels. This analyses also able to guess the time at which this goal would be achieved. Questions are also arising for the important factors and three level model is developed. The factors of this failure are uncertainty of politics and role of wind uncertainty and variability is the key factor. Wind power uncertainty is analyzed on strategic level. This shows that there are very lower level of uncertainty on the strategic level and wind power investors risk is not too high [12].

2.15 Spanish Electricity Market:

In this paper electricity power market and wind power interaction is analyzed. Policies for the balancing of electricity market price is also focused in this paper. A new scheme of balancing prices is proposed in this paper and results are tested. For the efficient market design, the proposed method shows the minimum ancillary services are used for compensation. In this paper Impacts of prices imbalance is also analyzed and discusses the imbalance price policies recommendation. Wind power producer's participation in electricity market of Spanish is analyzed by including two cases which uses stochastic approach. As the wind power and associated variables are highly uncertain which are forecasting of wind power, prices, intraday market. For the duration of 10 years the tests cases having exact data were run and results shows in this paper. An error drop occurs in the electricity market which shows that the imbalance price regulation is not suitable for electricity market of Spanish therefore a new imbalance price scheme is suggested in this paper which have additional constraints. At the end policy recommendations are proposed in this paper [13].

2.16 Liberalized electricity market:

In electric power system, having a large share of hydro power plants, meeting the consumer MW demand is not the main problem. The main problem is to meet the yearly load demand with as low in-flows as possible. Also, in such a system, market price is very dependent on energy availability from hydro. Dry year and wet year prices are significantly different from each other. In this study, wind energy impact on the reliability of power system having dominated share of hydro power plants is studied. Based on this indication, we can define the value of energy delivery for wind. It can be seen from the result of numerical example that this value is lower for hydro as compared to wind energy depending on mutual relationship between the two. In a liberalized market it is more advantageous to study the impact on the market prices. It can be concluded that prices are slightly greater for wind energy as compared to hydel energy. This study evaluates how wind energy can increase the reliability of power and economic analysis of this increase in reliability [14].

3 Trading of Wind Power and Its Impact on Competitive Electricity Market

3.1 Impact of Trading Wind Power:

Wind power is stochastic in nature and uncertain. A dynamic response is developed through closed loop interactions and frequency control. Combined market scheme is proposed which is compared with existing scheme of markets using optimal wind forecasts. The evaluation of different market schemes are carried out. Contingency study shows benefits of reserves from wind power. The simulations show that security of grid system increases with the proposed market scheme [15]. In USA sold of wind power in competitive market is allowed. In this paper two approaches are used for the optimum bidding. Three Stochastic model are developed to achieve the objective of optimum models for trading [16].

3.2 Wind energy trading in California:

Short-term electricity market consists of service market and energy market. In ancillary market the trade of wind power is not taken place however wind power is feasible technically. This paper discussed the electricity market of California where wind power trading has a high market potential. Wind power is highly uncertain same the price of wind power in electricity market is highly uncertain considering these aspects a model of wind power trade is developed in the day ahead market. An algorithm is developed which helps the wind power producers to trade wind power at optimum. Real data is used for testing the wind power trading in the electricity market. This paper also discusses the wind power impacts on market results and market control. The results of this paper show that current electricity market structure of California is such that by bidding in the Regulation market and Day ahead market profit of wind producers increases than the bidding in just Day ahead market. The results of this paper also show that in the regulation down market wind power producers' profit is much more than as compared to the regulation up market. When the control of electricity market is strict the price of penalty becomes double in the regulation up market but in the regulation down market wind producers can obtain a profit [17].

3.3 Effect of wind and solar volatility on trading value of VRE:

An extensive examination of the market value of renewable energy resources is presented here. The market value of the VRE generators is defined as that revenue which they can earn from markets exclusive of the earning from different subsidies. The intrinsic volatility and variability of solar radiation and wind affect the trade value of VRE sources. This study focusses on how the market value changes with change in penetration level and how prices and policies are interconnected. VRE prices reduces during sunny and windy weather. This drop in Per Megawatt hour VRE prices is more as the installed capacity gets larger. To gauge this drop-in price, a mathematical model for European electricity market is developed, and with the help of literature review and by performing the regression investigation of available market data, quantitative information is derived. It is found that as wind contribution increases from 0 to 30% of total power consumption, wind prices fall from 110% to 50-60% of average electricity price. Similarly, for solar penetration of up to 15% low value conditions are obtained. Hence, large scale integration of renewable energy resources in a competitive environment is much more difficult [18].

3.4 Wind power trading in liberalized power market:

Due to negative environmental impacts, disastrous nature of nuclear fuel, rapidly decreasing coal and oil reserves and their ever-increasing prices requires alternative energy resources for power generation to meet the load demand. Wind Energy is a strong candidate in the field of RES but their incorporation in power system poses many operational and planning complexities due to their non-predictable nature. Due to their uncertain, variable nature and high costs, wind generators are left out in competitive power market. The integration of RES in deregulated electricity market requires that they should be taken in market differently than dispatch able generators. Due to highly concentrated nature of market, there are chances of market abuse. A robust trading methodology is a basic requirement to increase market efficiency. Spanish electricity market is taken as test system to show forecast error impacts. This study evaluates and proposes a pricing methodology for wind generators keeping in view both the demand and supply side bidding. Other issues like Ancillary series, market power and market collusion are also discussed. Power system operators and policy makers can use this paper as a guideline to promote the wind energy while maintain system security and reliability [19].

3.5 Wind power trading in India:

Wind Farms are gaining immense attention in India because of their rapidly increasing contribution toward total installed power capacity. Unlike other conventional power generators, wind power output is volatile, variable, unpredictable, impulsive, uncontrollable and wild. It prevents wind power producer to bid into the competitive power market. A feasible mechanism for wind energy trading is proposed and the effect of Availability-based-Tariff (ABT) and Day-Ahead-Trading (DAT) rates on the wind generators are analyzed. Unscheduled interchange (UI) is actually a power balancing mechanism in ABT which is used to run the system efficiently and economically. The existing tariffs are compared with the tariffs that a wind generator may avail if it operates for unscheduled interchange (UI) rates or Day-Ahead rates to balance out the prediction errors and alleviate the market power. It is concluded that DAT/UI rates are more advantageous for wind generators. This study promotes the need to develop a suitable strategy for wind power trading so that market power can be reduced, and wind energy is promoted to feed more green energy in the system [20].

3.6 Wind Power trading using Game theory:

Wind power is gaining much attention and one of the rapidly growing renewable and clean energy resources. However due to intermittency and uncertainty of wind, it poses many challenges to the power system operators. Also, in a competitive power market, WPP's profit is highly affected by another conventional generators' behavior. WPPs can take more benefit from the bi-lateral markets. A probabilistic programming technique is used to generate optimal scheduling and bidding policies to simultaneously optimize the profit of WPP and conventional generators in both bi-lateral reserve power market and energy market. The reserve-price is compromised between conventional generators and WPP by employing the game theory and by using the Nash Equilibrium. Different case studies using Real-time data for the games in a power market with variety of participants are analyzed to prove the merits and effectiveness of proposed approach [21].

3.7 Short term wind trading

A short-term power market is usually consisting of ancillary service or regulation market and energy market. Wind power producer (WPP) is not allowed to take part in trading activities in regulation markets despite of the fact that they have proven to be technically feasible for the regulation facilities. This study explores the wind power trading in regulation power market in California power market. A wind power model in the DA power market, by considering the fluctuations in market prices and uncertainties in power output, is developed. An analytical approach is used to evaluate the optimal biding and scheduling. Real time data is used to test the wind power output trading in regulation power market. The results indicate that WPPs can maximize their profit if they take part in both regulation and DA energy-markets as compared to profit by bidding only in DA market. It can also be concluded from the results that profit for a WPP is larger if he takes part in bidding of regulation-down power market than by bidding in regulation-up power market [22].

In short-run, as the wind power contribution increases, the spot market prices are likely to decrease because of the merit-order impact. But in the long-run, this effect is not so clear as the capacity backing, or investments tends to change as the penetration of wind changes. The aim is to investigate the relationship between market power, capacity backing or investments and wind penetration level by using a computer-based model and least-cost power generation model. It is found that the ability of firms to exert market power depends crucially on the relationship between capacity and peak load demand. For the long-run, the market power tends to get stronger for some specific periods as the wind integration increases but the merit-order balances out this and costs remain effectively flat overall. Also, the revenue or returns to the peaked plants increases as wind power penetration gets larger. The use of market power thus results in the inefficient and uneconomical dispatch which aggravates more as the wind power generation increase [23].

3.8 Economic Analysis of wind plant integration:

Wind energy generation increases in the world. This integration of wind energy provides meaning ful impact on the price of energy, profit and profit components of market participants. The methods for different systems developed for modeling and no general model has been proposed yet. In this paper modeling of wind plant and simulation of energy market is formulated. The model of wind plant developed in this paper can also be used for determining the wind power output and forecasted power output. According to real time and day ahead energy markets these are granular and consistent in scope. Wind energy generation increases 32% from 2005 to 2006. This paper shows the application of model of market integrated wind plant. This study shows that developed model is used to determine the market-based outcomes such as generator revenues, energy prices, unit commitment and economic dispatch costs. Revenue components RT, OR charges can also be examined. This study can also be helpful for large networks including many wind plants. Next step for modeling of wind plant market integration is ancillary services markets. [24]

Wind power generation is increasing day by day thus many challenges occur by wind integration for system operators. Demand response is important solution for integrating renewable energy. In this paper, a DR model is formulated through which wind power is integrated. DR resources reduce the load in electricity market. The elements of the model reduce the load in the day ahead market. The proposed method is in the format of mixed integer linear programming, measures generation unit commitments also manages the spinning reserve and load reduction is scheduled. The results show that load reduction in energy market is efficient tool for integrating wind energy this provides technical and economic benefits. In this paper, a load response and demand response program is formulated. Load recovery effect is also included by the model. At the final the result shows technical and economic benefits for load reduction in market [25].

Among the renewable energy resources, wind Farm is the most widely used resource because wind energy is environment friendly and cheap source of electricity. But there is a high level of uncertainty and variability associated with wind power plant because its power output changes with the strength level of the wind. Power system experiences some severe effect due to wind farm incorporation in the system. Typical effects are on optimum power dispatch, power system economics and power market prices. These also include deterioration of power quality and stability of the system. In this study, these issues are addressed by developing a model for single auction market. Genetic Algorithm is employed to analyze this power economics problem and find the best solution. The comparison between Wind farm and diesel generator shows that loads can experience a sudden increase in market prices at the instant when wind generation is disconnected form the grid. The high market price fluctuation occurs because wind power is highly variable and uncertain, and we have to rely on other expensive i.e. thermal units to meet the load demand. More the wind power generation, lower will the market prices. This will be more economical for supplier and customers. This study concludes that distributed resources installed near the distribution end will lower the electricity market prices [26].

Electricity Market is affected by the huge amount of solar and wind integration. Wind and solar generation are highly variable and uncertain. In this paper Nordic system example is used to show the impact on the producers of wind generation. Flexibility and capacity are the important considerations while designing Electricity market. Guidelines for designing the market are also presented in this paper. When wind power generation is high Price of day ahead market is low. When wind power generation is low, price of day ahead market is high. The experience from Germany, Spain, Denmark and Ireland Shows that wind generation decreases average market price. Forecasting of solar and wind generation is very important for balancing the intraday market. Operating time of generators which are running close to their marginal decreases by the increased amount of wind generation. Forecast errors are to be considered by the integration of wind generation these errors reduced to their half by shorter gate closure time. This reduces the imbalance of electricity market [27].

Due to the increasing integration of wind power in the power market and their deregulation results in severe effects on the flow pattern of transmission line. Also, TSOs faces many operational and technical challenges. Increasing the share of wind energy beyond certain points requires further research on following areas: grid codes and connection issues, infrastructure reinforcement due to dominated concentration of volatile infeed, Day-Ahead wind speed forecast implication in Electricity market, these implications coupling with TSOs and adjacent markets, impact of increasing wind generation on power system, increased technical and operational challenges for TSOs. This study shows the non-linear impacts on cross border flows and transmission line flows due to increased concentration of wind in synchronized power system. The results are explained through the impact of wind power on market behavior, due to incidental coupling of wind and conventional energy generation in adjoining control blocks.

Wind integration produces the effect on power system which is quite complex and can be understand by using feedback relationships. First the dynamics of integration of wind generation is analyzed. Dynamic model of integration of wind power is established using feedback relationships. Dynamic model includes the power price, cost, Supply and demand. At the end dynamic model is verified. In the recent few years the generation of wind power increased rapidly. In 2011 the wind capacity of china is 45000 MW. Large scale wind integration changes the operating conditions of power market. Wind power integration produces great effect on power market but don't produce great impact on power grid. By understanding the factors which effect wind integration develop feedback loops. These factors are power demand, power supply, and generated energy. Through these factors dynamic model of wind power is developed and verified in this paper by simulation. Simulation shows the economic importance of wind integration in china. Wind power also increases the thermal power operating cost [28].

Key factors involved in the development of renewable energy resources are independency of power market, release greenhouse gases and security of power supply. Wind energy source is the most advance among various other resources. But the development of wind power is accompanied by two important issues: wind projects are not so cost effective as compared to others and intermittency of wind. The first issue is being resolved by support mechanism configuration to encourage wind parks construction. The solution of second problem will require additional technical cost associated with immediate response and reserve capacities. The objective of this work is to describe how support mechanism can be of help to improve efficiency in managing the wind intermittency in power market balancing. This study describes the operation of support mechanism in EU countries and analyze the wind variability problem in balancing power market management. Finally, a comparison is done on how different countries deal with wind uncertainty and variability in balancing power market [29].

Baltic States are those whose major concentration of energy demand is met by large thermal power plants operated by fossil fuels. This study covers the strategies developed to analyze the effect of large-Scale wind integration on Baltic region's power market and electricity generation. The scope of this study is 2025. The method and model used in this study is unique in the sense that it takes into account the power plants of all the regions and their real time economic aspects. The proposed model provides a lot of information like utilization hour changes, changes in revenue collected and merit order dispatch curve shifts. This data helps to evaluate the feasibility of different generation sources economically. It also confirms that as the wind power capacity increases, the electricity market prices decrease. The biggest impact of wind power integration is the use of expensive fuel resources to fulfill the demand if wind capacity reduces. Finally, this paper describes the important effects of wind integration on economics of various power generation resources with and without the renewable energy contribution. This paper can serve as a guideline for regulatory/governmental bodies in Baltic States to develop new energy policies.

3.9 Economic analysis of small wind farms:

This study analyzes the production and economic viability of small wind farms on the electricity market. Along with the rated output, the power- curve shape is a very important parameter in determining the amount of electricity that can be produced with a wind turbine. Income and expenditures are the governing factors while performing the economic analysis of an investment. The wind turbine income mainly depends upon its electricity production and electricity price. While the wind turbine, converter and tower constitute the main expenditures. Operation and maintenance do not require significant costs. It is found that two factors, power curve shape and correspondence between rated output and area of rotor-swept, greatly influences the cost-effective viability of small wind turbines. These two factors should also be accounted for, besides the price and rated output of wind turbine, to reach a better economical and efficient decision on making investments [30].

4 Different ways and challenges for integrating wind energy in Market

Electricity Markets are broadly classified into two categories. One is wholesale (Day-Ahead or Forward) market in which all the trading occurs several hours before the actual operation. The other one is real time or spot market in which trading occurs on the spot to meet any deviations occurred in forecasted wholesale market trading. Wind power concentration is increasing very rapidly in power system. But wind energy only take part in whole sale market and due to volatility and variability of wind, it requires increased reserves and balancing. The objective of this paper is to analyze weather wind turbines can play a pro-active role and participate in real-time or spot market for balancing needs. The test system is a real time wind plant in west-Denmark. The results indicate that wind farms can play an important role in regulation and significantly increase other wind turbine's profit because it compensates high unbalancing costs [31].

4.1 Scheduling of Active and reactive power:

For the scheduling of active and reactive power the responsible authority is Distribution system operator. The purchase of reactive and active power is done from wholesale power market and Distribution energy resources. In this paper at distribution level an economical scheduling method is proposed which depends on day ahead reactive and active power markets. The proposed model shows that first day ahead active power market will be settled and then bid of reactive power market took place. Var market is developed at distribution level and reactive power from wind turbine could offer [32]
In the Region of west and east of great belt and Denmark the bidding of electricity prices done on hourly bases. Western Denmark increases the 25% wind generation. This produces great impact on the electricity market and electricity prices. Hourly bases market data is available on the website of Danish TSO. In this paper data is analyzed for the period 2004-2010. Hourly price variations occur in the electricity market and the responded by customers and generators. The important thing is the extreme values of consecutive hours. This paper also covers the some of the challenges occur by the project of EU respond. It shows that here were very few extreme values and the installed wind power can also be handled by the market organization. The results show that there are external constraints of transmission produced by wind power and this occur in the geographical bidding areas. The current infrastructure of western Denmark can handle the 25% wind integration. International transmission lines were the main important Part which handles the uncertainty and variability of wind generation. From the historical data from 2004 – 2010 shows that when wind power is minimum during high storms prices of electricity market were normal. The most important result form study is the external constraints caused by wind which effects bidding of wholesale market [33].
In the short run increasing wind integration in electricity market decreases the price of spot electricity market. The effect of long run is yet to be cleared because of the capacity investment changes. This paper discusses the wind integration, capacity investment and electricity market interaction by using the generation expansion model of least cost which simulates capacity investment with increasing wind generation and then another model is used in electricity prices of power market is forecasted by computer agent. The paper also analyzed dependence degree of electricity market power on the capacity to peak demand ratio. Generation scenario of long run shows that increases of wind integration increases the market power. This paper also shows that the increasing of wind integration increases the peaker return. Simulation also shows that large investment in wind generation ensures supply security and rate of return satisfaction [34].

4.2 Market flexibility between gas and win-integrated power markets:

Combined-cycle turbines (gas) (CCGTs) may serve as the back-up for the balancing needs that arises due to massive injections of wind energy in our electricity system. So, the study of market flexibility between gas and electricity market is useful. A model to study this inter-flexibility in Gas and power markets is developed. It is observed that intermittent nature of wind power output causes CCGTs output to change dynamically. By using a simple network for gas market, and simplified model for power generation and their application on a stylized example shows that Line-Pack flexibility provides us the best way to handle these variability's both in frequency and size. Although many improvements in the proposed model are needed but this study serves as a basis to develop a more advance model that can handle the complications involved in the current model [34].

4.3 Risk management and ED in wind-integrated power system:

With the ever-increasing demand of Electrical energy, Wind energy is gaining more and more attention because of the environmental concerns and energy saving. However, the interconnection of wind power output with the conventional generators induces many problems in the power system operation and reliability. The aim of this study is to present a literature review of different Economic Dispatch (ED) techniques and wind power risk management in power market. Its present different management techniques that can handle the unpredictability and intermittency characteristics very efficiently to protect the system stability. The main findings of this study are: 1) The complexity of ED problem depends upon the wind dispatch factors that we include in it. 2) The stability and security of the system very vital aspects so the risk management factors must be incorporated into the ED problem. 3) More precise the wind speed forecast is, more efficient & economical the wind power dispatch and risk management will be [35].

The research study shows that when wind integration increases the electricity prices decreases but the generalization of this pattern is unclear. This paper shows the inverse relation of wind integration and electricity market considering market conditions. For this a developed structure of electricity market is expanded which includes more flexibility while modeling electric industry framework and also considers the wind power producers diversification and market concentration. The results of this study show that Its not always necessary that increasing wind integration decreases electricity prices. The results also show that prices of electricity decrease when the wind integration is large enough and investment of which type of firm for increasing profit. This paper shows that in order to maximize profit wind owner able to produce energy from wind and conventional generators. Increasing large scale wind generation at about 60% increasing electricity price in one regime while decreases electricity price in another regime. Wind variability impacts on average wind price and average market price is examined. As the variance of wind generation increases price of wind energy decreases [28].

This literature review presents German, Spanish and Nordic countries' Electricity power market and points out the important effects of wind Energy integration in power system. While integrating the RES, two issues are in our interest center: Technical achievements along with robust market design for efficient deployment of RES. The integration of fluctuating RES is very complex challenge not only form technical view point but also for the market design parameters. Some design parameter will either lead to more efficient usage of resources or will counteract it. The objective of this study is to point out the key issues, either facilitating the integration or being regarded as critical. For this purpose, three electricity markets are taken to serve as an example and analysis is started from the price. Price is an important function which acts as a signal to all the players. A brief analysis of the factors that can distort the price is presented. This study concludes that an efficient incorporation of RES is encouraged by markets coupling, Effective allocation of transmission capacity, support schemes adaptation, competitive markets having unbiased prices [36].

4.4. Market Coupling based on load flow with wind power:

Electricity trading is being carried out on international level between the European countries which led to increased use of cross-border interconnectors. Considering the grid physical operation, an improved mechanism of trading between power markets called Load-Flow Based power Market coupling is proposed in this study. A zonal Electricity market model of European system is considered to carry out the analysis. Market coupling based on load flow has many advantages: Competition in the liberalized market is increased, congestion level on borders is decreased, costs of dispatch due to poor scheduling is reduced and capacities of cross border are used optimally. The comparison of market operation without load flow-based coupling shows that annual electricity prices, operation costs of power system are reduced substantially in case of market coupling based on load flow. Yet these impacts cannot be extended to generalize for other countries [37].

4.5 Coordination of wind Power plant and Energy storage devices under power market conditions:

In this paper virtual power plants are introduced in which wind farm operates in collaboration with energy storage device to reduce the stochastic nature of wind Farm. A state-of-the-art forecasting model is used realistic data from wind generator in Denmark and data from weather forecast is used as inputs to this model. By using the generator mix scheduling model energy storage is optimally used and bids are placed in market based on forecasted spot price and available wind energy. Energy storage devices are used to counteract any imbalances produced at injection spot due to errors in forecast. This study proposes a method for efficient operation and scheduling of virtual power plants having energy storage facility in the power market. This method is applied to a test system consisting of wind farm in cooperation with energy storage and a real time forecasting model for wind generation is used. Results show that important benefits can be obtained by using the proposed method. Virtual power plant Revenue is strongly influenced by forecasts of spot price and the uncertainties in the wind power [38].

4.6 Sensitivity of Wind Power Market Value:

Merit order effect is more prominent in European countries. It is the damping effect on the power market prices due to wind generation. When wind generation is high, average selling price of electricity is low. Literature work has studied this effect and concluded that wind power market value decreases as wind share increases relative to base load price. The aim of this paper is to investigate the impact of different system parameters on market value of wind power by using simulation. Power-price relation is modeled by a simple representation of CEPM. Then the sensitivity of market value of wind energy is analyzed by giving variations to different parameter [39].

The increased contribution of wind energy in power markets around the globe causes considerable imbalances in the markets at the time of gate closure due to non-predictable behavior of wind. This power imbalances must be balanced by using reserve capacity ramping generation units. As wind energy in system increases, market prices are reduced by about 5% but its effect on utilization of other types of units is unclear. In this work, a mathematical model is developed which takes into account the ramp-rate restriction and production costs and applies to Germen electricity market. It is concluded that the flexibility and incentives for investment in coal-fired natural

gas plants decreases considerably as well as the emission of CO2 is largely affected. Distributed generation like wind and solar contributes to the problem of reliability of power system. The coordination of Renewable energy resources (RES) and carbon-capture & Storage (CCS) in a carbon-constrained power market opens new areas in the field of reliability [40].
Green economy depends on renewable energy. Electricity market is not restructured for the integration of renewable energy, but suitable modifications are to be made for the fairness utilization of energy. In this paper a stackelberg model for wind power producer is produced. The results are verified on IEEE 18 bus system [41].
Due to increase demand of secure supply, increases of fossil fuel price wind power demand is increased. Due to this reason offshore wind generation is increased. Nature of wind is variable and stochastic and there is difficult in scheduling. Off shore wind forecast is more difficult than on shore. This paper is based on error in off shore wind forecasting of the Irish electricity market. In this paper a model is developed which is single energy model for the solution of unit commitment problem. Generation cost is also considered in this Paper. This paper also shows the greatest impact of error in forecasting of the British market [3].
Due to increasing concerns of pollutants from fossil fuels renewable energy increases. Wind and solar is notable. Main concerns about wind power is uncertainty and I initial costs. These concerns are solved in this paper through suitable sizing of wind power unit. In remote locations lower power system are used [42].

4.7 Energy strategy of future power systems:

In Future wind energy become important resource of generation. Major problem of wind integrations that its output is highly fluctuating. Another challenge of wind generation is optimum integration. European wind energy association CEO states that wind energy contributes to decrease energy tensions. This paper also presents the super grid advancement to tackle wind integration which include the balancing of variable wind generation. Wind generation take part in day ahead markets and very useful in balancing real time market. Cases of wind integration in India is also highlighted. Principal challenges of wind integration are discussed. Wind generation Importance in Bangladesh is also discussed where shows the importance of wind generation over oil generation [43].

5 Optimal Bidding Strategy of Wind Power

5.1 Bidding in day-ahead market:

In this paper decision of optimal bidding for the wind power producer who participate in day ahead market is studied and also studied the clearing of stochastic market and co-optimization of energy and reservoir. In this paper bi-level stochastic model is proposed. Wind power producer profit is maximized through upper level approach and lower level represents the clearing of market and then optimization of both reserve and energy. Kuhn tucker conditions for optimum are used for lower level problem and then the scheme of stochastic problem is used [44].

5.2 Optimal Bidding Strategy:

Wind energy is uncertain and clean renewable energy. Wind integration and penetration increases day by day thus bidding behavior in electricity market shows influence on market prices. Bi-level stochastic optimization model is proposed in this paper. The bi-level model optimizes the bidding strategy. Wind power producer profit is maximized by upper level approach and lower level represents the clearing of market [45].

5.3 ding in soft penalty power market:

Due to economic and environmental advantages of wind generation, its share in power market has grown rapidly. But at the same time, distribution and transmission network operators are facing severe problems due to uncertain and variable nature of wind. They have to back up the power system by means of expensive reserve capacities to meet the demand. Penalties are applied whenever there is an imbalance between demand and delivered power beyond a certain tolerance level. The aim of this paper is to develop bidding strategy so that producers may offer the precise amount of power and avoid heavy penalties. The objective is to maximize the profit of wind generator owner by driving a model for finding optimal strategy of bidding in power market and using the database of historic wind power knowledge. Other contribution of this study is to predict day ahead bids by using the wind speed forecast given by meteorological service. Although wind speed forecasts are not so precise, but they can give a rough idea about the next day wind conditions. A comparison is made between different bidding strategies on an Italian wind farm data [46].
Lengthy wind speed and power production forecast are necessary for wind power to participate in current electricity market. In this study, a new bidding methodology is prosed for minimizing the imbalance costs of wind Farm. Nordic Electricity market is taken as a test system in which all the electricity trading must be carried out by a balance player. A wind power producer has three options: either become a balance responsible actor or sell all its energy to balance player or have a settlement with balance responsible actor to balance any differences. To minimize the imbalance cost, balance responsible actor assumes a strategy in which wind power production is modeled by using statistical data analysis based upon historically observed data and Energy bands and probability tables are formulated. The drawback of this method is that a significant historical data is required to produce smooth and continuous probability curves and wind speed behavior depends largely upon season, so probability tables will differ between years and season. In this study, this strategy is further improved by modelling the wind power production by day-ahead wind speed forecast and forecast error by statistical data. Bidding methodology is framed as stochastic optimization problem and to obtain a solution for large number of wind power situations, mixed integer programming is used. This bidding methodology is implemented on Nordic Electricity system but it with slight changes, it can be applied to any other market. Further improvements that can be made are to sto-

chastic price model and stochastic model for spot market prices. Also, here the WPP is assumed to be a price-taker generator but it may lead to substantial price imbalances. This effect can be considered in the future [22].

5.4 Wind energy bidding using fuzzy optimization:

Despite no gas emissions and zero fuel cost, wind power is still non-dispatch able due to the uncertain and difficult to predict nature of wind. Its integration in short-term power market causes generation uncertainty and increased reserves. Also, wind power producer face penalties due to scheduling imbalance and therefore reduced net income. Previous literatures have adopted a single objective function and focuses on maximizing the profit without considering operator side. This can result in gaming bids or multiple solutions whenever spot price and imbalance price will be equal. Keeping in view this point, here a bidding strategy of multiple objective is modeled using mixed integer linear programming (MILP) and solved by using fuzzy optimization techniques. Stochastic forecast are used and bidder's response toward risk is also incorporated depending upon his knowledge and confidence over his forecast. This work can be further improved by using Piece-wise or S-shaped linear function and by considering real time field data [47].
In this paper soft penalties are considered while offering wind power in market. These penalties are applied when forecasted load and actual bids mismatched. Wind power historical statics helps for optimal bidding. Meteorological services are also used for estimating the wind speed. Predetermined classes are made based on wind speed forecast. This paper also compared the results of optimal bidding with or without classification [46].

6 DIFFERENT MECHANISM AND TECHNIQUES FOR WIND INTEGRATION

In the European Union, due to increasing awareness of climatic conditions all the Europe is moving towards the Renewable energy. In Portugal feed in tariffs are used for the project duration normally 15-20 years after which the remuneration method established based on electricity market. This paper examines the wind generation operation from economical and technical perspective. A market splitting model is used to implement a day ahead market simulator and wind generation is assessed by economic perspective using different strategies. The result shows accuracy of forecast production, balancing of prices, and volatility of market prices, frequency and liquidity of intraday markets. The Iberian electricity market (MIBEL) main features are, the management of MIBEL is depend upon the interconnected bipolar structure where the Spanish division OMEL operated the intraday and day ahead markets and Portuguese division OMIP operates derivatives market. A market simulator was also developed to include the producer. The algorithm is used for the computation of market simulator depends based on market splitting mechanism. In the electricity market the methodology used to include the wind producer had the goal to increase the economic output of the wind producer through day ahead intraday and system operation balancing. In 2008, the revenue generation by the wind farms were higher than the revenue generation through all portrayed scenarios. Further concluded that average energy price is unpredictable and wind producer will not know the price at which they will sell electricity. Wind producer's revenue generation is high unpredictable. Further this paper shows that production forecast accuracy and features of market design. Finally, In the electricity market the economic importance of renewable integration are models of balancing mechanism and intraday market.
Uncertainty and variability of wind generation needs more attention for the integration. There may be difference arises between the actual forecasted wind speeds thus there is penalty on the generating companies for this imbalance by the independent system operator. In this paper a method is developed for the forecasting of wind speed and reduces the error between the forecasting and actual values. The proposed approached is to be applied in the 12 spots in India which are chosen randomly, and results of the proposed approach is verified. In this approach the forecasted data and actual data of wind speed are considered. There also be a misbalance between the forecasted and actual value and misbalance cost occur which is evaluated by surplus and deficit charge rate. The effectiveness of the proposed scheme is analyzed by IEEE 30 Bus and IEEE 14 Bus system. This approach also helps to obtain the maximum profit by reducing the misbalance. The approach presented in this paper is in generalized from can also be applied in large, small and highly deregulated system [48].
This paper investigates the wind power and plugin electric vehicles economic and technological relationship. The impact of charging infrastructure of level 1 and level 2 on electric power market of New York is considered. 7560 scenario of plugin electric vehicle, wind dispatch and level 2 charging are constructed and finds the challenges of PEVs, wind power and infrastructure of charging. Market data history which includes load ramps is used for econometric model and that model is used to study resource integration. The results of paper show that curtailment policy is required for wind power and PEV charging correlation this paper further shows that PEV charging with over estimate of wind triples the reduction rate as compared to under forecast of wind. PEV integration with level 2 charging and wind power economically penetrate in the energy market [49].

6.1 Multi objective strategies:

In this paper mechanism for market clearing of spinning reserve and electrical energy is proposed which include the effect of wind power uncertainty and variability. The effect of variability of wind power and volatility of load demand on the electricity market is considered. In this paper the thermal generation reserves are also considered. Weibull pdf is used for representing wind speed stochastic behavior and Normal pdf represents uncertainty of load demand. Two objectives are considered in this paper cost minimization of energy and spinning reserves and minimization of emissions. The first objective considers the thermal generation cost, wind genera-

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tion cost and spinning reserves cost. The cost of error between the forecast and real valued is also considered. Pareto evolutionary algorithm is proposed for the optimize solution of both objectives. IEEE 30 bus system is used in this paper. In this paper mechanism of (ESRMC) is developed which includes the effect of wind uncertainty and forecasting of load. As the uncertainty increases total cost increases, total reserves increases [50].

In Power system the main important thing is the quality and reliability of electricity in this paper optimum operating reserve is determined and optimum reserve cost is allocated. This paper also considers the wind power, load and network uncertainty. Stochastic programming is used for modeling the uncertainty. Operating reserves are determined by considering the customer choice. Demand factor for customer and system is used to determine the exact allocation of reserve between customer and Genco's. In addition, the reliable requirement is also considered with flexible value of load loss. There are different reliability level customers which are to be classified. Finally, the results of proposed method are tested using IEEE-RTS test system, Roy Billiton Test system and three buses test system. The propose method performance is validated using results of simulation. Wind power generation impacts on reserves are determined and the result shows when wind power uncertainty increases, the cost and operating reserve increases. More operating reserves are required if wind power forecast accuracy is decreased. When wind power integration increases the operating cost of system deceases [23].

6.2 Optimum conditions for wind generation in power market.

The main problem of wind generation is uncertainty. This problem can be solved by stochastic programming in this paper. Variability also occur in wind availability, balancing market and market price. Optimum conditions are derived for wind energy producers in this paper such that forecast and expected profit would be minimum. Forecasting of wind and prices of electricity are predicted by ARIMA techniques. Probability density function is also used to increase accuracy. In this paper multistage stochastic programming is used to make optimum strategies which helps wind producers to take part in power market. For more reliable and accurate prediction weibull distribution is used and probability function is derived from the error between the real and forecasted value and different scenario are generated which are used to derive optimum strategies for wind power producers thus the profit increases. Imbalance of prices are also reduced by these strategies and profit of wind power producers are increases from 220% to 550%.

6.3 Using moth flame algorithm:

In deregulated Power Market, one of the most crucial problem encountered is contingency. To alleviate this problem, techniques like rescheduling of generators or incorporation of FACTS devices are used. In modern Electricity network, renewable energy generation from Solar or Wind Farm are getting closer attention because of their excellent ability to reduce emission of green house. But incorporation of these resources makes the transmission system planning a very complicated task. In this study, renewable energy generation in the form of Wind Farm is emphasized because it results in not only profit maximization but also alleviate the contingency situation along with Fuel cost minimization and reduction of losses of the system. To find the most crucial line in the system, Line Outage Contingency Index technique (LOCI) is used. Moth Flame Algorithm (MFO) in collaboration with Contingency Constraint Optimal Power Flow (CCOPF) technique is used. This technique has been applied to the 30 bus IEEE system. Results depict that renewable energy generation is very helpful for LOCI value minimization and profit maximization in restructured power market after a line outage occurs. It is also observed that social welfare greatly improves with the integration of wind farm in restructured power network [51].

Using the Renewable energy resources has become a complementary for us due to rapid exhaustion of fossil fuels. Wind energy has very large potential but incorporation of wind turbine in the power distribution system must not deteriorate its stability and reliability while keeping the tariff economical. A model for a single auction power market is developed to evaluate the effects of wind farm integration on the electricity power market prices and on the total costs of generation for different wind speed levels and wind power project locations. In this study, to analyze the integration of wind resources on social welfare, a probabilistic model is developed. Monte Carlo Technique is used to model the uncertainties produced due to chaotic nature of wind. By taking into account the variations of demand side and by varying the wind speed stochastically, an optimal power flow has been obtained for light, regular and heavy load. MATLAB and some of the features of MATPOWER are used to implement this work. Wind power traders can use this approach as a guideline to remain in competition in the day ahead of wholesale power market. The proposed method can be applied on large scale network to illustrate its applicability and scalability. Further, Gaussian distribution can be used to model the load demand and marginal prices for different locations can be obtained [52].

6.4 Stochastic model

The incorporation of large amounts of wind power in restructured electricity power market will have some adverse effects on the market i.e. changes in Market prices and transmission bottlenecks will occur. Also, there will be a need for frequency responding reserve and non-spinning reserve. For the evaluation of wind power integration cost, it is crucial to model the stochastic nature of wind power and to consider the prediction error. In this study, to efficiently operate the power market, a stochastic LP model is developed by using the rolling planning principle on hourly basis. This model is composed of four markets: i) A Day-Ahead Market ii) a market for process heating and district heating iii) a day-ahead market for automatically activated reserve power iv) Intraday market. This model (3 stage) is implemented on German Market consisting of 3 different regions and 40 different units. Results indicate that transmission and distribution bottlenecks occur due to continuously changing wind electricity production. Also, whenever there will be a difference between wind speed forecast and actual wind speed, price fluctuation between intraday market and Day-Ahead market will come. This technique can be further improved to evaluate efficient strategies for incorporation of renewable resources [53].

Wind power producers, in competitive markets participate strategically. In this paper a model is proposed for the optimal bidding strategy of wind power producers. Wind power producer's strategic behavior is modeled through bi model approach that is Mathematical Model with Equilibrium Constraints. Profit maximization represents upper model and market clearing is represented by lower model. The results of this paper shows that profit of wind power producer increases significantly [54].

6.5 Real Time and Forward Market:

Excessive integration of wind energy in power system introduces complex problems in operation & control. It also affects adversely the running power system market design. To embed the stochastic property of wind in power system, market now-a-days are designed as multi stage stochastic optimization problem, simultaneously optimizing the forward and real time economic dispatch. The objective of this paper is to find the optimal bid of Price-Maker wind power producer in both forward and real time cases. The proposed methodology is a multi-stage MPEC technique which is then converted to a single stage Mixed-Integer LP Problem. MILP problem can be solved easily. Analysis shows that by acting on strategic behavior results in increased expected profit as wind power share increases in grid. However, this incentive reduces in a power system where power market operation is highly efficient. This setup can be further studied by incorporating the competition between different price maker wind producers and market equilibrium can be determined by using the EPEC technique. We can remove the assumption related to the constraint on number of producers acting as price maker [55].

6.6 Optimal wind investment:

To determine the optimal level of investment for a wind Farm investor for a constant transmission capacity and working in an electricity grid network, this paper proposes a probabilistic two-level model. This bi-level modelling allows to develop efficient interaction between power market and wind power investor. The lower level deals with the market clearing and upper level deals with the wind operation and investment. The methodology proposed is first a probabilistic MPEC which is then re-modeled into MILP problem which facilitates us to use it in larger power system if number of scenarios is kept under a certain limit. The required number of scenarios to efficiently demonstrate the load variability and volatile nature of wind depends upon the depth of our study. In this case these are between 18 and 16. Future work includes the integration of dynamic management framework and representation of strategic market players other than producers [56].

6.7 Agent based approach:

This study centers on the electricity markets and trading mechanism currently in operation in UK. It presents an agent-based model and a learning paradigm for agents to improve their bidding procedure. Now-a-days utilities are showing a clear towards low emission, intermittent distributed generations. T the time of GC, the imbalance in electricity is more volatile as the contribution of wind generation increases. Here agent-based model is presented which consists of two dependent parts, a model for Electricity Exchange and a model for balancing mechanism and settlement procedure. To analyze the impacts of variety of generation mechanisms on the balancing prices, generating units are modeled with respect to type and size of fuel used. This model also includes the operational decisions by System Operator and involvement of market participants. Future work include the inclusion of a reserve market that operates few hours before gate closure (GC), a real time representation of Power Exchange (PXs) and location of balancing mechanism unit (BMU) [57].

6.8 Strategy for WPP:

Extra Power Market policies have been devised to allow the trading of renewable energy in markets, but they are efficient only when contribution of wind is very low. As the wind energy penetration increases, these policies become unjustified. A wind power producer faces extreme competition in liberalized power market and has to offer the economic strategy. WPP also faces the fluctuation in wind energy and market prices. These fluctuations have to be handled very carefully otherwise financial instability is expected. A probabilistic programming technique Mixed-integer linear-Programming (MILP) is proposed to suitably handle these fluctuations and derive an offering technique. The proposed methodology is applied to the data from Iberian power market to validate the efficacy of this approach. Since bids in day-ahead power market are made 1 day before, the proposed methodology is helpful for the System Operator in taking decisions to fulfill the balancing needs [58].

6.9 Complete Wind Farm interconnection strategy:

Wind farms are facing the problem of remaining undeveloped and stranded because of the complexity of their interconnection with the Grid due to the absence of transmission network up gradation. To avoid the transmission congestion complication, and by keeping in view the inter-connection costs and variable equipment costs, a very detailed assessment and guidance for the interconnection of large wind farms with a power grid is presented. Keeping in view the unpredictable nature of wind and probable risk of outage of thermal power generators, Monte-Carlo Simulation Technique is used to analyze the behavior of different power generating units under variety of situations and a methodology for economical interconnection of large wind projects with Grid is devised. A complete cost analysis is also performed for comparing with other interconnection alternatives. This technique has advantage over other interconnection method in the sense that it close to realistic wind farms and benefit the whole Power system by reducing the congestion costs, electricity generation as well as increasing the wind Farm revenue [59].

6.10 Secondary control mechanism:

Unlike other conventional power generators, wind power output is volatile, variable, unpredictable, impulsive, uncontrollable and wild. It arises many complex challenges in the balancing of load and generation which requires the use of reserve capacity generation. Using Netherlands as a case study, it is shown that wind power output variations can be efficiently handled by the power market parties if it is incorporated in unit commitment (UC) and Economic dispatch (ED). As compared to wind energy variable output, outage of large Power generation unit affects Area control error more critically. Variation in wind power requires other conventional generators to operate more dynamically because additional unit commitment decisions by system operator for balancing needs affects ACE. Also, the market party's strategic involvement temporarily sends ACE increasing, followed by the triggering of control actions from the transmission system operator. Finally, it was shown that after outage of large generation unit, Actions of secondary controls are enough to recover the ACE back to zero in one program-unit-time (PTU)/ within fifteen minutes [60].

6.11 Strategic Market ramp rates:

Increased contribution of wind power in system calls for generation units having fast ramp rates. These generators are used in the reserve capacity for economical and efficient balancing of any outages or prediction errors. However, in practice, by suppressing their ramp-rates, these generating units exercise market power and refuse to operate strategically. A gaming model is developed for ramp-rates behavior. A market operator runs a ramp-rate constrained ED keeping in view the forecasted demand, contingency situations and bids. A multi-level optimization problem is set up. The lower level comprises of ramp-rate constrained ED and the upper level is profit maximization problem. The whole model is developed as Equilibrium-Problem with equilibrium-constraints (EPEC). This model results in set Nash Equilibrium. To solve this, the concept of External-Nash-Equilibrium is presented which is modeled a single-level Mixed-integer-Linear-Programming (MILP). This mathematical model is applied to a realist case study and obtain amenable results [61].

6.12 Multi- level optimization:

This paper presents Energy output and Spinning-Reserves Market-clearing (ESRMC) technique for structure of thermal and wind generators by talking into account the uncertainties in load forecast and wind power output. The effect of load variability and wind output volatility on the spinning reserves and energy is also investigated. The probabilistic nature of wind power output is represented by Weibull distribution (PDF) and uncertainties in the load demand forecast is characterized by Normal PDF. The objective is to minimize the emission and optimization of energy production and spinning-reserves costs. The later one includes the cost of reserves and energy production by thermal generating units. It also considers the costs associated with error in forecasting the load demand wind output. The presented market clearing model simultaneously minimizes both objectives by employing multi-objective Strength-Pareto-Evolutionary-Algorithm 2+ (SPEA 2+).IEEE 30-bus system is considered as a case study to validate the effectiveness of proposed approach [50].

6.13 Probabilistic variability of wind:

The intermittent and volatile nature of wind power output affects the power system operation in various ways. In this study, the effect of wind power variability on reactive power market is analyzed. This study presents a probabilistic method for market-clearing while talking into account the voltage security and variable nature of wind. An optimization technique is presented which uses a non-linear programing method to maximize the reliability and voltage security while simultaneously minimizing the market payment. A 3-stage probabilistic multi-objective numerical programming is used for modelling and solution of the algorithm. IEEE 14 bus system is taken as a test system for the scheduling of reactive electricity market. The Monte-Carlo technique is used to simulate the market for a specific time. The obtained results and analyses shows the validation of presented algorithm [62].

6.14 Probabilistic market-clearing:

Incorporation of renewable energy resources into the Power grid requires ED with risk management technique to include the effect of unpredictable nature of output. This study performs the day-ahead probabilistic power-market clearing using the DC OPF (Optimal Power Flow). The aim is to optimize the social-cost which consists of generation costs, disutility of end-user and the cost of re-dispatching because of underestimation or over-estimation of load demand. An esteemed method, Conditional Value at Risk (CVaR) is used to alleviate the high risk of balancing action resulting from wind power forecasting errors. The derived convex optimization problem is handled via sample based and distribution-free based approach to avoid the curse of dimensionality. Alternating-direction method-of-multipliers (ADMM) based technique is used for market clearing in a distributed manner. The results derived by the application of proposed approach on standard test systems authenticate the validation of approach [63].

6.15 Energy Market using MASCEM simulator:

For The increase of wind power integration different remuneration techniques are developed. Wind power is increasing every day and it effects the market equilibrium and price. In this paper wind power plants offering in competitive electricity market is evaluated through MASCEM Multi Agent System. Real data is employed for the case study [64].

Capability of available transfer is evaluated in a complicated process involving the total capability and commitments of existing transfer. Wind generation is renewable uncertain generation and will be challenging. In an existing liberated market independent system operator decided commitment of existing transfer. Total power commitment, optimal power flow, unit commitment all these are decided based on Economic Dispatch solutions. There are two problems in uncertainty and there is no accuracy in ATC. A bi-level optimization is proposed in this paper considering the uncertainty and variability of wind generation. This problem is solved in levels upper level is formulated for ATC computations and lower level is assigned to the economic dispatch. Equilibrium constraints are used for converting bi level model in to mathematical program and then Kuhn tucker and mixed integer programming is used for optimization [65].

6.16 Electricity Price Linkage Game:

In this paper electricity linkage game model for the optimum strategy of wind power producer. In this model two systems are proposed. One for the participation of wind power producers and other for the multi agent simulator. This model predicts the electricity price changes as well as load changes. The results of this paper shows that linkage system improves operational environment [66].
In this paper (UPFC) unified power flow control technique is developed for finding the optimal and best parameters of a competitive market. Social welfare is maximized, and generation cost is minimized by the optimization approach. With the help of proper usage of UPFC Nodal Price is also improved. UPFC also shows impacts on system voltage. IEEE 14 bus system is used in this paper for the effectiveness analysis of proposed technique [67].

7 WIND FORECASTING AND ERROR HANDLING TECHNIQUES

7.1 OWP forecast-error:

This study analyzes the impacts of forecast error in off-shore wind energy on the management and operation of electricity pool market in 2050 (which will be a carbon-constrained power market) from the perspective of operational hours, generation costs, system Marginal electricity price, emissions expenses and optimal dispatch of wind. The incorporation of variance in OWP forecasting error increases SMP because more reserve capacity generation should be utilized to balance the forecasted error. It also increases production cost and emissions because of the involvement of more coal fired power plants having high CO2 concentration. This effect emphasis on the need to predict OWP forecast as accurately as possible. Increased accuracy in OWP forecast results in more economical & efficient generators to be dispatched. The main conclusion of this study is that with each percentage point increase in OWP forecast-error there is an increase in SMP of about 1% irrespective of the sign of average wind forecast error. If OWP produces less than forecasted generation (-13%) then SMP and production costs increases by about 10%. And if OWP produces more than forecasted generation (4%), then production costs decrease but SMP still show an increase of about 3%. Form the System Operator's point of view, when participating in the Day-ahead market, it is more advantageous to predict the wind energy less than it will be actually generated [68].

7.2 Forecasting using MBA and RBF-Neural Network:

Among all distributed generations, wind energy is gaining much attention due to advancement in technology and increased MW capacity of WTG. However intermittent and unpredictable nature of wind presents very complex challenges in the power system operation & Control which emphasizes the need to forecast wind power with great accuracy. This study focusses on the short-term wind forecast of wind farms. For one hour ahead (short-term) forecast of wind speed and wind power, a new method based on the collaboration of data mining technique and Radial-Basis-Function (RBF) Neural Networks (ANN) is presented in this study. Market-basket analysis (MBA) is used as a data mining technique to evaluate the crucial parameters for inputs to RBF-NN. The RBF-NN uses a Gaussian activation model as neurons which is more general and vaster than traditional models. Three phases for training an RBF-NN are Unsupervised, supervised and fine tuning. It is concluded that wind power can be forecasted accurately with the help of wind speed data and parameters evaluated by MBA. The presented method was also verified by the simulation [69].

7.3 DEEPSO to Predict Wind Power:

As the wind integration increases day by day. The nature of wind integration is stochastic, uncertain and similarly the market price is fluctuating. In this study, particle swarm optimization technique is used to predict power market prices and wind power uncertainty [70].

7.4 Handling of forecast errors of wind power production in NORDIC countries:

Wind energy is distributed and renewable which is associated with high fluctuation in productions. These fluctuations can be forecasted to some extent by neural networks. Longer the time horizon, more difficult is to predict the power production by wind. All power producers having wind generators need a forecast of wind power based on which they can bid in market. The errors in forecast results in imbalance scheduling which causes extra cost. The accuracy of wind power production forecast depends upon the forecast of wind speed. Wind power cannot be predicted with as high accuracy as load forecast can be. Nord pool has a very long history and largest electricity market in Europe. Balance responsible actors have wind generators in their scheduling in all Nordic countries. This study illustrates examples based upon one-year data of wind power production and produced power. Wind power data from one wind farm of Norway and eastern and western parts of Denmark is obtained and calculations are made. It can be concluded that for a wind power producer, it will be more beneficial to sell energy as close to delivery hour as possible [71].

8 CONCLUSION

This paper describes the important effects of wind integration on economics of various power generation resources with and without the renewable energy contribution. It can serve as a guideline for regulatory/governmental bodies in Baltic States to develop new energy policies. It concludes that an efficient incorporation of RES is encouraged by markets coupling, Effective allocation of transmission capacity, support schemes adaptation, competitive markets having unbiased prices. It promotes the need to develop a suitable strategy for wind power trading so that use of market power can be countered, and wind energy is promoted to feed more clean, cheap and green energy in the system. This study evaluates and proposes a pricing methodology for wind generators keeping in view both the demand and supply side bidding. Other issues like Ancillary series, market power and market collusion are also discussed. Its present different management techniques that can handle the unpredictability and intermittency characteristics very efficiently to protect the system stability. Guidelines for designing the market are also presented in this paper.

Findings:

- It is found that two factors, power curve shape and correspondence between rated output and area of rotor-swept, greatly influences the cost-effective viability of small wind turbines. Flexibility and capacity are the important considerations while designing Electricity market.

- Form the System Operator's point of view, when trading in the day-ahead power market, it is more advantageous to predict the wind power less than it will be generated.

- It is also observed that social welfare greatly improves with the integration of wind farm in restructured power network.

- For a wind power producer, it will be more beneficial to sell energy as close to delivery hour as possible. Profit for a WPP is larger if he takes part in bidding of regulation-down power market than by bidding in regulation-up power market.

- It is found that as wind contribution increases from 0 to 30% of total power consumption, wind prices fall from 110% to 50-60% of average electricity price. Similarly, for solar penetration of up to 15% low value conditions are obtained.

- The use of market power results in the inefficient and uneconomical dispatch which aggravates more as the wind power generation increase.

- Wind farms can play a principle role in regulation services and remarkably increase other wind turbine's profit because it compensates high unbalancing costs.

- It was shown that after outage of large generation unit, Actions of secondary controls are enough to recover the ACE back to zero in one program-unit-time (PTU)/ within fifteen minutes.

- Linkage system improves operational environment. Line-Pack flexibility provides us the best way to handle these variability's both in frequency and size. It is concluded that DAT/UI rates are more advantageous for wind generators.

Future work includes the inclusion of a reserve market that operates few hours before gate closure (GC), a real time representation of Power Exchange (PXs), location of balancing mechanism unit (BMU), the integration of dynamic management framework and representation of strategic market players other than producers. The coordination of Renewable energy resources (RES) and carbon-capture & Storage (CCS) in a carbon-constrained power market opens new areas in the field of reliability

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