

Market Orient Wind Energy Regulation Model for Efficient Power Distribution in Power Grid Networks

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Abstract: The power regulation and distribution in smart cities has been well studied. There exists number of methods around the problem. Some of the method uses the voltage availability in the grids of power system and some of them use the cost of energy in the power grids. However, the methods suffer to achieve higher performance in power distribution and regulation. To handle this issue, an efficient Market Orient Wind Energy Regulation Model (MWERM) is presented in this article. The model monitors the production voltage in the power distribution system and market requirement at specific time. Based on that the method computes Market Requirement Factor (MRF) and Market Remuneration Factor (MReF) to compute the Market Energy Cost (MEC). The above factors are measured for various consumers and based on that the method identifies the energy distributor and perform regulation accordingly. The proposed method improves the performance of power distribution and regulation.

Index Terms: Power Distribution, Wind Energy, Power Regulation, MWERM, MEC.

1.Introduction:

The power distribution is the key challenge in any smart city considered where there exist number of consumers who purchase electricity from the grids to supply to the units and other consumers. As the electric energy is the most dominant source being used by the human society for their day to day life. However, it has been produced from limited sources and cost highly. So, the power producers spends huge amount in the production of electricity. The electricity being consumed by the consumers are charged according to the consumption and as per the unit of consumption. To support the power distribution systems, there are number of alternate power produces are available in the market. For example, there are organizations that produce electricity from solar power and supplies to the power distribution sector. Similarly, there is another form of electricity production which uses the wind energy.

The wind energy based power produces generates electricity from the wind and supplies to the power distribution sector. They spend huge amount in the installation and

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maintenance of wind towers. The electricity produced by the wind tower has been supplied to the transformer which boosts the incoming voltage and regulates to the power distribution systems.

The issue here is, the power distribution systems purchase the electricity and distribute to their customer. They are paying different amount for the producers who maintain the wind tower. They purchase in a fix cost as per the unit of consumption from the producers. This introduces poor performance in the side of wind tower management. On the other side, the power regulation has been performed in blind as the production units directly diverts the voltage produced to the distribution systems who earn a lot but no meaningful payment has been made to the producer. Similarly, power regulation is the process of diverting the electric energy to the specific consumer upon agreement. If the consumer is agreed with the cost of energy and volume of energy, then the producer can divert the energy produced and obtain good gain from the production.

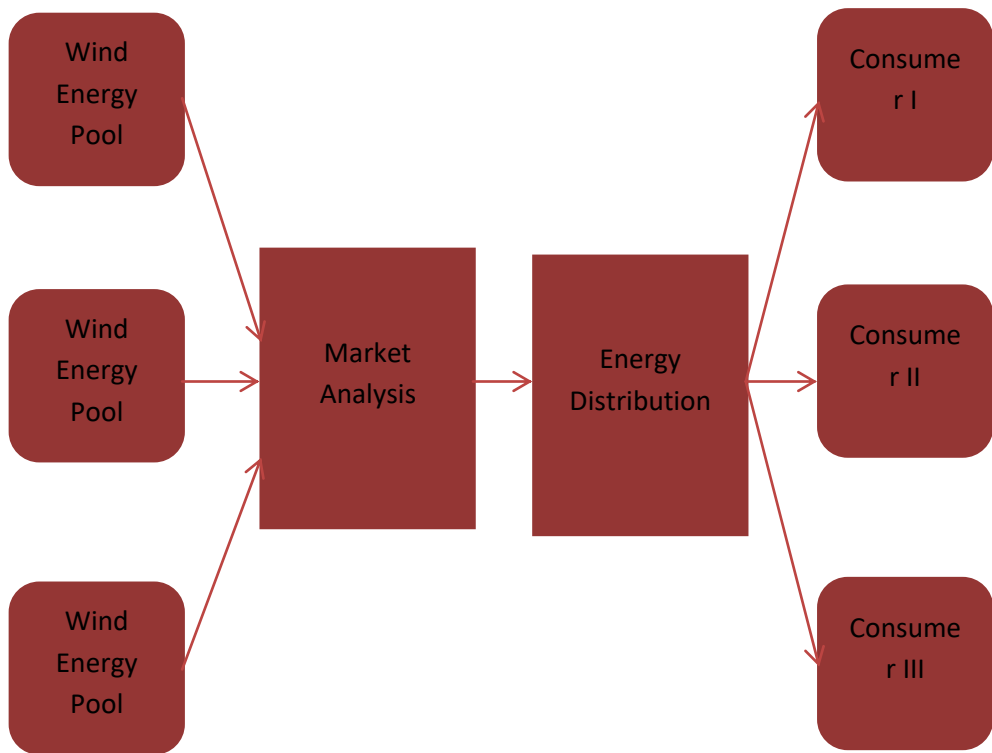


Figure 1: General working of Market Orient Power Distribution model

The general working of market orient power distribution model is presented in Figure 1.

By considering the above factors, this article present a novel market orient wind energy regulation model (MWERM) is presented in this article. This article denotes that the wind energy can be regulated according to the market constraints. The model allows the producer to choose the consumer according to the cost being afforded by the consumer for the unit of power. In this way, the consumer can bid the energy and consumer accordingly. On the other side, the producer can measure the market strategy according to the market requirement, the remuneration available and residual voltage. By considering all these factors, the producer can divert the energy with the consumer who got convinced. By doing

so, the performance of the power distribution and production units can be improved. This also supports the gain of producer and satisfies the requirement of the consumer. Accordingly, the method computes Market Requirement Factor (MRF) and Market Remuneration Factor (MReF) to compute the Market Energy Cost (MEC) for the selection of consumer. The selected consumer has been regulated with the wind energy. The detailed model has been briefed in this section.

2.Literature Review:

There are number of approaches available around the power regulation and distribution. This section briefs set of methods around the problem.

In [1], calculation of wind farm power curve distributions is presented which uses logistic function to represent a wind turbine power curve, and the Jensen model is used to simulate the wake effects. The wind turbine power curve has been used as the key in the selection of wind source and support the power distribution effectively.

In [2], they analyze wind characteristics and to assess wind power potential by selecting the best fit probability distribution function of Jhampir Sindh Pakistan. By analyzing the characteristics of wind the capability of the wind tower in regulating power for the Pakistan has been performed effectively.

A deloading power coordinated distribution scheme is presented in [3], towards frequency regulation of wind farms which consider the difference of wind speed to maximize power generation. The method use the regulation frequency as the key metric in regulating the power for various units of consumers.

A transient stability criterion based multi wind farm is presented in [4], which consider the variation in acceleration and deceleration power. A data driven approach is presented in [5], to handle wind power ramp events. The method monitor the events happening in the field and based on the historic data available the method performs power distribution.

A distributed active and reactive power control (DARPC) scheme is presented in [6], which works according to the alternating direction method of multipliers (ADMM). The proposed model uses the two mode power control which acts on both active and reactive conditions of the plant to support effective power distribution.

An EV based adaptive curtailment scheme is presented in [7], to improve the power flow accuracy in distributed networks. The model monitors the conditions of electric vehicle and based on the accuracy of electric flow the method performs power regulation in distributed networks.

An probabilistic power flow (PPF) scheme is presented in [8], to support wind sites which uses vine copulas and observes the dependency of wind power. The method consider the probabilistic value of electric flow and based on the value, the method handles the distribution problem.

A hybrid copula based wind power curve model (HCCM) is presented in [9], which model the independent distribution of wind speed to perform power distribution. The method monitor the wind speed and based on the speed available, the method performs power distribution to maintain stability.

A hybrid multiple linear permanent magnet generator (LPMG) based conversion model is presented in [10]. The method uses hybrid version of multiple linear magnet generator as the key towards maintaining power stability. A wind power probability prediction based Quantile regression model is presented in [11], towards power generation and regulation. The probabability value is measured according to the previous values and based on that the regression model identifies the power to be regulated. A stochastic model is presented in [12], to quantify the uncertainty of RES on the power system. A conditional

variational autoencoder is presented in [13], to perform wind power curve modeling. The auto encoder model is used to find the variation in the power flow and based on that the method performs power distribution.

All the above discussed methods suffer to achieve higher performance in power distribution and regulation performance.

Market Orient Wind Energy Regulation Model (MWERM):

The proposed MWERM model monitors the production voltage in the power distribution system and market requirement at specific time. Based on that the method computes Market Requirement Factor (MRF) and Market Remuneration Factor (MR_eF) to compute the Market Energy Cost (MEC). The above factors are measured for various consumers and based on that the method identifies the energy distributor and perform regulation accordingly. The market strategies must be considered towards maximizing the regulation performance as well as to maximize the gain of the power grids. This proposed model focused on the above and working of the model is detailed in this section.

Request Handler:

The proposed market orient wind energy regulation model monitors the incoming power request from various consumers and power distribution systems. From the request received, the method extract the features like total unit of current required, mean voltage required at each time, cost afford for single unit and so on. Such features extracted are converted into feature vector and has been given to the MWERM power distribution function. The power distribution function computes the MEC value for different consumers and based on that a single consumer is selected and power regulation is performed for the selected user.

Algorithm:

Given: Regulation Request R_{req} , Wind Power Trace W_{pt} .

Obtain: Null

Start

Read R_{req} , W_{pt} .

While true

Extract Total current required $T_{cr} = T_{cr} \in R_{req}$

Extract mean voltage required $M_{vr} = M_{vr} \in R_{req}$

Extract Afford cost $A_c = AC \in R_{req}$

Generate feature vector $F_v = \{T_{cr}, M_{vr}, A_c\}$

$size(W_{pt})$

Identify wind grid set $W_{gs} = \sum(W_{pt}(i).wg \ni W_{gs})$

$i = 1$

Perform MWERM Power Distribution (w_{gs}, F_v).

Receive R_{req}

End

Stop

The request handler algorithm receives the power regulation request and extracts various features from the request. Further, the method identifies the set of wind grids available in the system and performs MWERM power distribution.

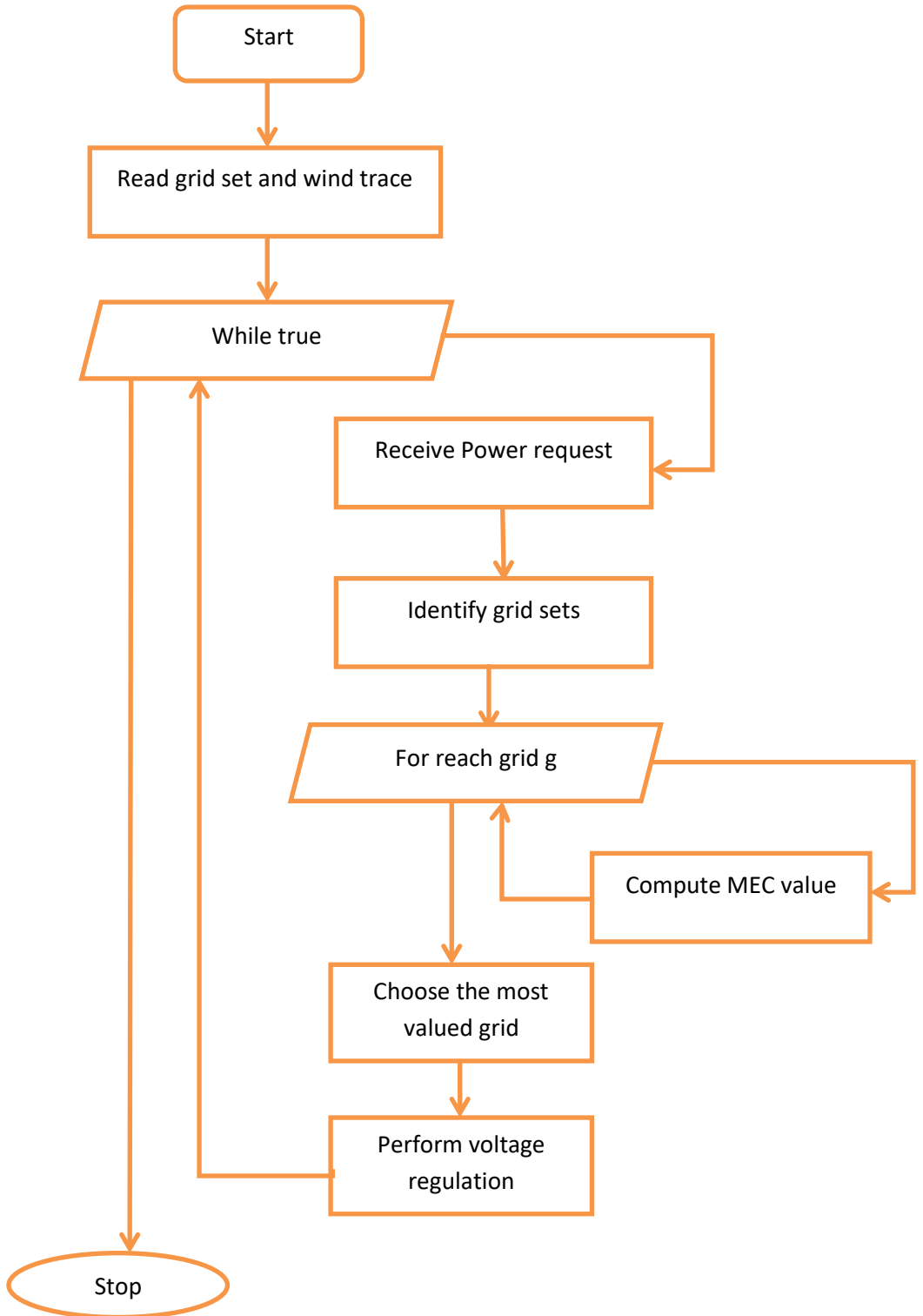


Figure 2: Architecture of proposed MWERM Model

The functional architecture of proposed MWERM model is presented in Figure 2, and its functional components are detailed in this part.

MEC Estimation:

The market energy cost is the measure which represents the suitability of any consumer quote for the wind grid according to market strategy. It has been measured based on Market Requirement Factor (MRF) and Market Remuneration Factor (MReF). The MRF value is measured based on the total voltage required and average volts required in each cycle and the residual voltage of wind source, average volts produced by the wind grid. Similarly, the MReF value is measured based on the average volts required by the consumer and the cost afford with the average voltage produced by the wind grid. Using both the measures, the method computes the value of Market Energy Cost (MEC). Estimated MEC value has been used to perform power distribution.

Algorithm:

Given: Feature Vector F_v , wind grid wg , wind trace W_{pt}

Obtain: MEC

Start

Read F_v , wg , w_{pt} .

Grid power trace set $gpts = \sum_{i=1}^{size(w_{pt})} w_{pt}(i).wg == wg$

Compute grid voltage average $Gva = \frac{\sum_{i=1}^{size(gpts)} gpts(i).volts\ produced}{size(gpts)}$

Compute MRF = $\frac{wg.residualvolts}{F_v.Tcr} \times \frac{Gva}{F_v.mvr}$

Compute MReF = $\frac{Gva}{F_v.Mvr} \times F_v.Ac$

Compute MEC = MRF×MReF

Stop

The MEC estimation algorithm computes the value of MRF and MReF measures for specific wind grid based on which power distribution is performed.

MWERM Power Distribution:

The proposed MWERM model receives the set of wind grids and the feature set extracted from the request. Using the wind grids, the method computes MEC value for different grids and based on that a suitable one is selected with higher MEC value. Selected grid will be allowed to regulate the voltage to support power distribution.

Algorithm:

Given: wind grid set Wgs , Feature vector F_v

Obtain: Null

Start

Read wgs and F_v .

For each wind grid wg

 Compute MEC = MEC Estimation (Feature Vector F_v , wind grid wg , wind trace W_{pt})

 End

$Wg =$ choose the wg with higher MEC value.

 Perform voltage regulation

Stop

The above algorithm shows how wind grid is selected for a request to perform voltage regulation.

3.Results and Discussion:

The performance of proposed MWERM model has been implemented using Simulink and its performance is measured and compared with the results of others. The results obtained are presented in this section.

Factor	Value
Tool Used	Simulink
Wind grids	100
Time	15 minutes

Table 1: Experimental setup

The experimental setup considered for the performance evaluation is presented in Table 1.

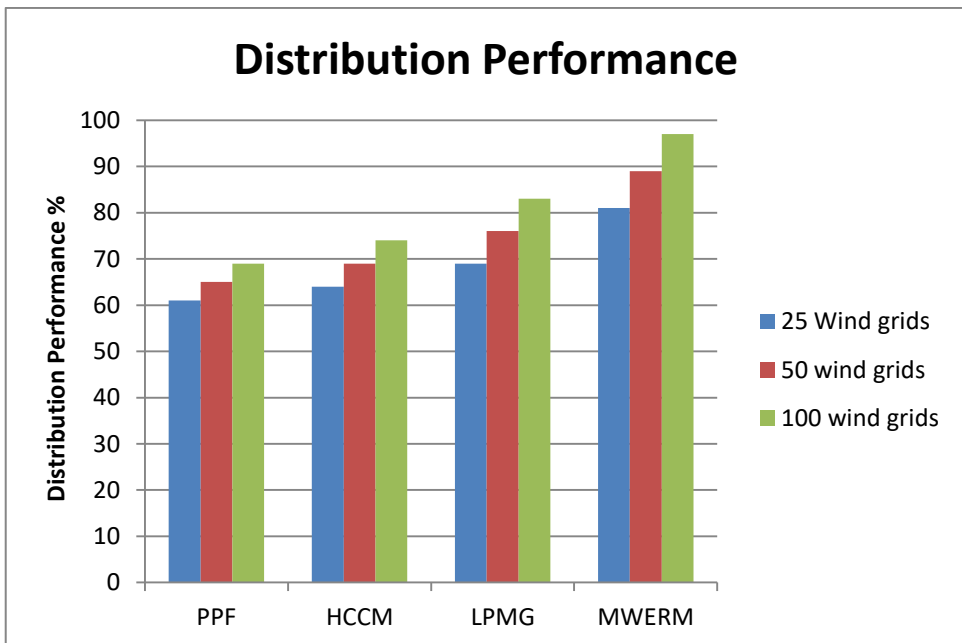


Figure 3: Distribution Performance

An insightful analysis of the performance of different approaches used in power distribution is shown in Figure 3, where the MWERM (Multi-Weighted Ensemble Regression Model) model is shown to have achieved a noteworthy feat. This comparison shows that the MWERM model performs better in terms of distribution than the other methods that were taken into consideration. The MWERM model's creative approach, which makes use of multi-weighted ensemble regression techniques, is responsible for its success. This model does a great job of combining data from various sources and accurately representing the complexities of power distribution dynamics. By using weighted ensemble methods, the MWERM model can be made more flexible and perform better in a range of operational scenarios by giving different factors influencing power distribution the proper amount of weight.

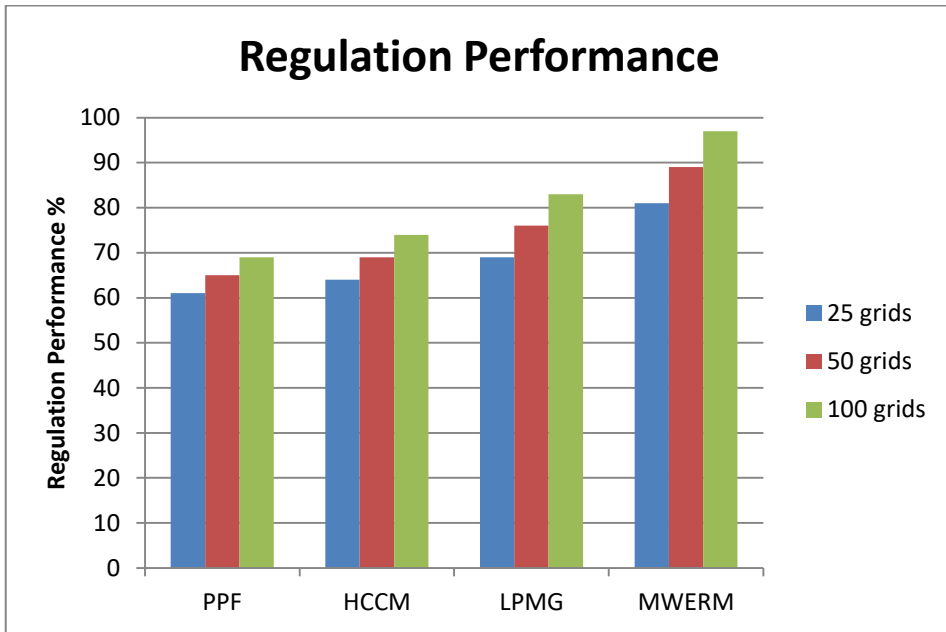


Figure 4: Regulation Performance

A thorough evaluation of the different techniques used in voltage regulation is shown in Figure 4, where the MWERM (Multi-Weighted Ensemble Regression Model) model's outstanding performance is highlighted. The comparative analysis presented in Figure 4 clearly demonstrates the superiority of the MWERM model over other methods in terms of voltage regulation performance. The MWERM model's creative and complex design is responsible for its effectiveness in voltage regulation. The model performs exceptionally well in capturing the complex dynamics of voltage regulation by utilizing multi-weighted ensemble regression techniques.

4. Conclusion:

This paper presented a novel Market Orient Wind Energy Regulation Model (MWERM) is presented in this article. The model monitors the production voltage in the power distribution system and market requirement at specific time. Based on that the method computes Market Requirement Factor (MRF) and Market Remuneration Factor (MReF) to compute the Market Energy Cost (MEC). The above factors are measured for various consumers and based on that the method identifies the energy distributor and perform regulation accordingly. The proposed method improves the performance of power distribution and regulation.

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