Public Summary Report
”Simulation Model for Electricity Market Price”

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1 Executive Summary

The report describes the simulation model of electricity market price to improve the Energy Risk management process. The report includes the critical analysis of a simulation model build by client which requires an extensive understanding of current independent variables and their correlation with each other. This also requires an understanding of their significance with time frame and pattern in the data which is identified not only by using time series analysis method but also by applying various logics and arguments, in order to create simulation model. Further, the report also explains a new price simulation model using seasonal decomposition method and the reinforcement learning techniques.

2 Project Objective:

The client wants to create a simulation model of electricity market price to optimize and to improve the Energy Risk management process and to make it more efficient. This simulation model will generate market price the agent can understand and make decision based on them. The model should be flexible in term of inputs and can be applicable to other markets as well.

3 Data Set:

Past 9 year's price of electricity market has been used. The date of data set ranges from 2010 to 2019. The total number of observations in data set are 2306 and each observation represents the daily market price of electricity.

4 Methodology Used in Existing Model:

The current simulation model is divided into two parts. The first part converts the input data file into different breaks and generate a .csv file named "Dense Data description" file which have mean value, standard deviation, and length of price of each break. Second part uses the dense data generated file to generate simulation using some statistical properties of data, different business logic and industry's practices and other related variables or factors.

5 Review of Existing Model:

Positive points:

- The input data is very comprehensive and properly cleaned.
- The data is broken down into chunks to highlight abrupt change in the market price in order to reduce their effect on statistical properties of time series.
- The model is applied using the concept of reinforcement learning.

Shortcomings:

- The model includes many parameters which are selected subjectively with the assumption that there is no correlation among themselves.
- The parameters in the existing model also have very narrow range of selection. If a user selects something out of range, the benefits of reinforcement learning may disappear.

6 New Simulation Model:

Stationarity of Time Series:
First, a Dickey Fuller test is applied to check whether there is a unit root or not. In other words, this test is used to check whether there is a trend, seasonality, and other pattern in the given data. This test is applied on two time series generated from original one. The name of new time series are summer_data and winter_data In this test, the hypothesis is:

Null Hypothesis: $\mathbf{H}_0$ The data is not stationary.
Alternate Hypothesis: $\mathbf{H}_a$ The data series is stationary.

The result of this data shows p-value is greater than 0.05, so it fails to reject the null hypothesis. This concludes that the data is not stationary which indicates the presence of trends, seasonality, and other data patterns in historic data.

Time Series Analysis Techniques:
After testing the presence of stationarity of data, the next step is to analyze the time series to identify the patterns in data which can be used for generating simulated values.

Seasonal trend decomposition using LOESS (STL)
STL uses LOESS (locally estimated scatterplot smoothing) to extract smooths estimates of the three components i.e., trend, season and noise or residuals. This will be applied on both time series summer and winter to extract the patterns which can be used in simulating the future market price of electricity.

Simulation Model Parameter:
The new simulation model generates the electricity market price for the input number of days. The simulated values are based on volatility, mean, trend, seasonal and error components which are identified in the historic prices of last 9 years. In addition to this, the random factor is associated with independent variables to keep the randomness nature of all possible scenarios which can be expected in the future. With this, there are some limits introduce in the model to keep it align with the historic pattern as well and a normalization will introduce in place of random nature of factors, if the simulated price is close to any historic price or pattern.

Reinforcement Learning:
This type of learning assumes no prior knowledge of the process to the user. The user makes a random decision, watches the positive or negative impact on the environment, and based on that makes a better decision the subsequent time.

7 Learning Points:

- There are different time series analysis to identify pattern and trend, but the selection of a particular technique will depend on the nature of data and desired outcomes.
- When two time series have to be compared, first we have to remove the random variables and separately compared their seasonality factor and trend to establish the similarity between them.
- The concept of reinforcement learning is very important as it autocorrects the simulated outcome based on validity or accuracy of user decisions. It also allows the users who have no prior experience to make subsequently good decisions.
- The concept of back testing the simulated price with the historic data to find the matching small chunk of time series with the assumption that historical value can be repeated in future.

8 Conclusion:

Creating a simulation model for electricity market price will help the company to manage their Energy Risk management policies more efficient and allow the users or agent to learn and to make better informed decision. The simulation incorporates statistical properties of historic data and also includes lot of subjective independent variables which represents lot of market factors which can not be analyzed objectively using historic time series.