COMP 652: Project

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Presented to Dr. Doina Precup

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Introduction

The reliability of modern day energy markets is the responsibility of independent system operators (ISO) who are tasked with the governance of the energy network within a pre-definied geographic region. PJM Interconnection is such an organization. It is responsible for the proper functioning of the electric grid in Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

It ensures that loads on the system, such as cities, are serviced by a sufficient amount of generators, such as nuclear, natural gas or wind power plants at any given hour of the day. It does so by holding hourly auctions requesting that producers offer the quantity of megawhatts they are capable of producing and at what cost. Next, based on the demand for a given hour the ISO will request that the producers bring their generators online, prioritizing the most inexpensive power first while also ensuring that the grid operates at a sufficient level of reliability and redundancy.

The first priority of the ISO is the reliability of the system. If it does not provide a sufficient amount of power to satisfy the loads in the system it risks causing a brown out or a black out in the entire system. It also must ensure a certain level of redundancy as if a line or a power plant suddenly fails the energy grid must continue to operator as a whole. It's second priority is to provide loads with the most inexpensive power that it can find, nuclear is cheaper then natural gas, and natural gas cheaper then coal.

As such, the price of power through out the energy grid can be seen as being driven by three categories of variables: demand, supply and physical. With in the demand component variables will be ones that influence the amount of power being drawn from the grid. These will be things such as weather, season, day of the week, hour of the day, weather it's a holiday or normal work week. Supply will be made up of all factors influencing how generators are changing their bidding behavior. This will mostly be driven by fuel costs; uranium, natural gas, coal and the amount of wind. Physical variables will be the current status of the network; what outages and constraints there are on the system.

Congestion in the electricity grid will occur when the price of energy between two nodes is different. This will occur when different types of generation power different load zones. For example, take cities A and B both of which consume 100mwh and let's assume that city A is connected to generator E while city B is connected to F which also produces 200mwh. In a situation where E can produce 200mwh at 15$ and F at 20$ there will be no congestion so long as 100mwh can freely flow between city A and city B. However, if only 50mwh can flow from A to B then generator F will need to be turned on to produce the remaining 50mwh required by city B. This results in a cost of energy of 20$ in city B and a congestion of 5$ between the two cities.

In order to protect generators from unforseen congestion events a product called up to congestion (UTC) contracts were created. The holder of these contracts will receive payments when more congestion occurs then expected and have to make payments when less congestion the expected occurs.

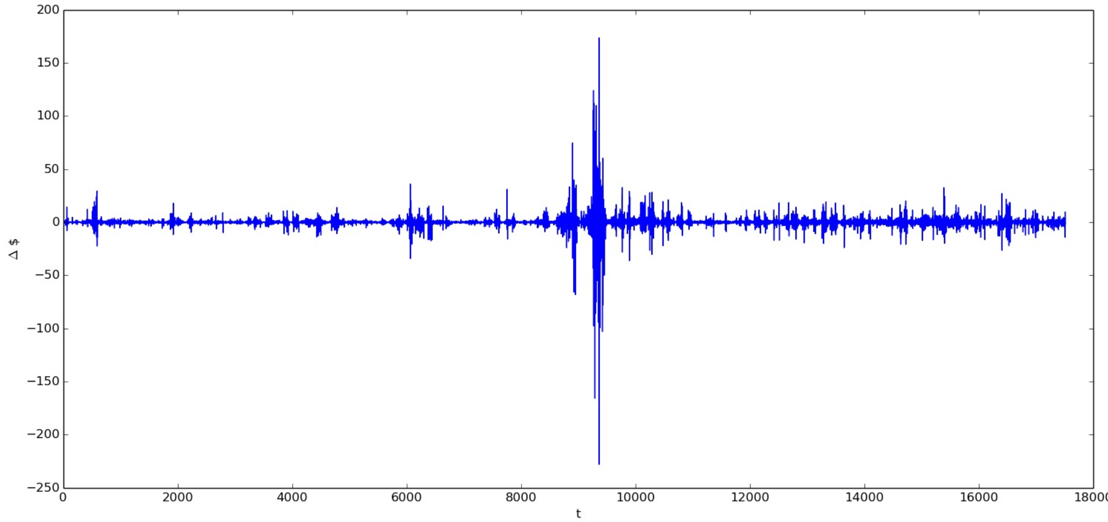
Which creates the problem of how to accurately evaluate the value of these contracts.

Methodology

Ignoring potential variables such as fuel costs, weather and outages; as a first attempt in trying to evaluate the value of a UTC contract a Markov Chain Monte Carlo (MCMC) approach will be used. The objective will be to use the previous distribution of differences between UTC contract prices and the last known price to estimate the most likely value in the future. A similar method to the one used by Landauskas [2] to evaluate future stock prices will be used.

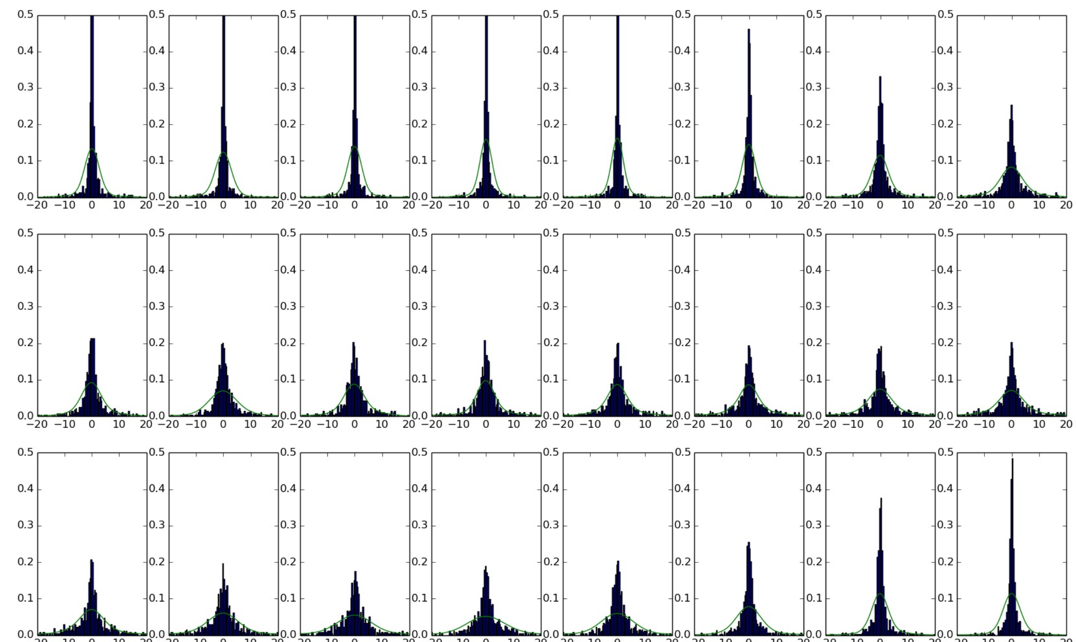
In order to attempt to reduce the effect of variables outside of normal seasonality aggregates of nodes were selected; Eastern Hub and Western Hub. These hubs are an average of a few hundred different pricing nodes within their regions.

Eastern Hub and Western Hub Price differences between January first 2013 and January first 2015 were consistent except for a period in January 2014. The differences in price from one hour to the next for this two year period can be seen in the following figure:



Because of the tendency of price differences to be within a rather tight range with the exception of a few outliers 10% of the top and bottom will be removed when evaluating their distributions.

The differences in price distributions between hours of the day is significant:



The figure above shows the price differences for hours ending 0 through 23. The x-axis is the difference in price and the y-axis is the probability 0 to 1 of that difference. Evening hours 22, 23 and 0 through 6 are much less volatile then the others. As such, the UTC contracts should be evaluated on an hourly basis given the price it was worth at the same hour the previous day.

Set-up

Results

Conclusions

Bibliography

[1] Eric Jones, Travis Oliphant, Pearu Peterson, et al. SciPy: Open source scientific tools for Python, 2001–. [Online; accessed 2015-04-20].

[2] Mantas Landauskas and Eimutis Valakevicius. Modelling of stock prices by the markov chain monte carlo method. *Intellectual Economics*, 5(2(10)):244–256, 2011.