

## **Paper for the 2014 Conference**

### **Hedging Utility Risk**

Nandita Das

Delaware State University  
College of Business  
1200 N. Dupont Hwy  
Dover, DE 19901  
Phone: 302-857-6940  
Fax: Phone: 302-857-6924  
E-mail: [ndas@desu.edu](mailto:ndas@desu.edu)

## **Abstract**

People deal with extreme weather conditions by dressing up in layers and probably having a good weather-proof jacket. Companies facing weather challenges have much more at stake and simple dress-code change does not help wither the financial impact. Insurance companies have long offered cover against flooding, hurricanes and other catastrophes for the general public. What about the impact that such extreme and unpredictable weather have on the energy sector?

It is well-known that electric utility systems are affected by harsh weather due to the large scale exposure of their assets which are mostly outdoor and above ground. Protecting all assets from super-storms like Sandy is expensive and time-consuming. There are other weather patterns like tornados, microbursts etc. that are difficult to predict with a longer time-frame and can cause outages to utility systems. Utilities can take some actions by enhanced automated isolation and restoration plans which are also expensive and takes time to deploy. Most of the investments over the years were focused on transmission and generation systems while distribution system received less attention. With the focus on Smart Grid around the world, attention is paid to strengthen distribution systems. One of the challenges is to redesign the distribution systems for enhanced restoration capability which will also be expensive. Public utility commissions, in charge of maintaining rates of electricity in states, are reluctant to increase the electricity rates while demanding higher reliability numbers (like SAIFI, SAIDI, MAIFI etc.) from utilities. One of the options for utilities is to hedge the reliability indices affected by unpredicted weather. If more utilities around the country participate in the hedging program, it will spread the cost and the hedging option will become economically viable.

Our goal in the paper is to study the financial impact that extreme weather fluctuations have on utilities and if utilities can hedge the risk of not meeting the reliability standards using weather derivatives. Researchers have previously shown that weather derivatives can be effectively used to reduce the risk of game franchisers. The use of weather derivatives is not just limited to game franchisers or agriculture industry. In fact, energy companies can effectively use weather derivatives to hedge and transfer risk to market participants. Many-a-times it is difficult to find a direct correlation between weather and revenues. The interest in Smart Grids has created a renewed interest in hedging the risk that utilities face for not meeting the reliability standards.

## 1.0 Introduction

Risk management through hedging against losses due to adverse, unpredictable weather is gaining popularity with the use of weather derivatives. Main users of weather derivatives include energy companies, agricultural industry and firms arranging major sporting (outdoor) events (Baseball franchises). In contrast to other derivative products, the underlying asset, such as frost, rain, temperature and wind, has no direct value with respect to the price of the weather derivative. Most weather derivatives are based on Heating Degree Days (HDD) or Cooling Degree Days (CDD). The seller of the weather derivative bears this risk for a premium and gains should the weather remains relatively stable, predictable or normal, however should the weather turn unpredictable the purchaser of the derivative claims the agreed upon amount.

## 2.0 Overview and explanation of weather Derivatives

El Nino winter of 1997-98 jumps started the weather derivative market. Many companies facing a possibility of declined earnings decided to hedge their seasonal weather risk. In his article “Introduction to Weather Derivatives” Geoffrey Considine describes how a company can structure a weather deal by buying a cooling degree day option (CDD) in the case of summer, or a heating degree day option (HDD) for winter. He also suggests databases that provide monthly total CDDs and HDDs for all U.S. cities like the Midwestern Climate Center (MCC). A HDD is the number of degrees by which the day’s average temperature is below a base temperature, while a CDD is the number of degrees by which the day’s average temp is above the base temperature.

There are three commonly traded instruments: the call option, the put option and the swap. According to Don Ellithrope and Scott Putnam in their article “Weather Derivatives and

their implication for power Market”, the buyer for a call option, gets a linear payoff based upon the difference between the realized value and a predetermined, or strike level, upon paying a premium upfront. The put option is based upon the difference between a strike level and the realized index value. The swap is a combination of a long call and a short put struck at the same level.

Presently, most weather contracts are temperature related due to the abundance of historical temperature data and demand for weather products from end users with temperature exposure. With more end users exposed to diverse weather risk entering the market, we will see more trading in other weather indexes such as rainfall or snowpack. Contract sizes in the OTC market have a constant payout, or tick size of \$5000 per degree day with a limit of \$2 million. While contract traded on CME are smaller and have tick sizes of \$100 per degree day and no payout limit. (Don Ellithrope and Scott Putnam, 2000).

Below we list some CME weather futures contract specifications:-

### **CME weather futures contract specifications**

***Exchange*** CME (Chicago Mercantile Exchange)

***Trading units*** HDDs (Heating Degree Days)  
CDDs (Cooling Degree Days)

***Indices*** HDD Index [(average HDD/month)\_No. of days/month]  
CDD Index [(average CDD/month)\_No. of days/month]

***Index price*** \$100 x Index

***Tick size*** 1.0 (= \$100)

***Delivery months*** seven consecutive calendar months

***Settlement*** Month following contract month

In developing countries risk is persistent, especially in the rural areas and reliance on weather conditions for economic activities is inevitable. Frequent weather hazards such as such as drought, floods and windstorms are prevalent and households and companies have a low asset base and little access to well-developed insurance and credit markets, they are financially ill-equipped to deal with weather shocks. New weather risk management (WRM) insurance instruments, like area-based weather indices, provide a viable alternative to traditional insurance instruments, and offer real advantages to households, companies and governments in developing countries. (Ulrich Hess, Kaspar Richter, Andrea Stoppa)

## **2.1 Growing market**

According to Ulrich Hess, Kaspar Richter and Andrea Stopps in their paper titled “Weather Risk Management for Agri-Business in Developing countries” weather risk causes substantial inefficiencies in developing countries and agri-businesses are forced to rely on traditional weather risk management (WRM). This causes underinvestment and over diversification. Key success factors for new WRM in emerging markets include: good weather data in key locations, client profile as financial intermediary, facilitation by development organizations, a benign regulatory framework, and risk transfer mechanism into international weather markets. (Ulrich Hess, Kaspar Richter & Andrea Stopps)

Potential clients for weather insurance include micro finance institutions, input suppliers, contract farming companies and other lenders to agriculture and agri-business. Moroccan farmers pay a 9% premium of the maximum indemnity for traditional crop insurance. (Ulrich Hess, Kaspar Richter & Andrea Stopps)

To develop weather derivatives for agriculture, the weather variable must be measurable, adequate and available. The crucial issue with application of weather derivatives in agricultural production is a clear satisfying relationship between the weather factor and the production variable (Andrea Stoppa & Ulrich Hess, 2003). Technological advances have influenced the development of the weather market. Below we have a table on illustrative links between weather indexes and financial risk.

### Illustrative Links between Weather Indexes and Financial Risks

Energy industry	Temperature	Lower sales during warm winters or cool summers
Energy consumers	Temperature	Higher heating/cooling costs during cold winters and hot summers
Beverage producers	Temperature	Lower sales during cool summers
Building material companies	Temperature/Snowfall	Lower sales during severe winters (construction sites shut down)
Construction companies	Temperature/Snowfall	Delays in meeting schedules during periods of poor weather
Ski resorts	Snowfall	Lower revenue during winters with below-average snowfall
Agricultural industry	Temperature/Snowfall	Significant crop losses due to extreme temperatures or rainfall
Municipal governments	Snowfall	Higher snow removal costs during winters with above-average snowfall
Road salt companies	Snowfall	Lower revenues during low snowfall winters
Hydroelectric power generation	Precipitation	Lower revenue during periods of drought

## Agriculture

Risk in Agriculture is a major challenge facing the world as Agriculture is vulnerable to all types of risks. Adverse weather conditions can impact crop yields and this leads to production (or yield) risk, affecting farmers and their ability to repay debt. Lending financial institutions and

agri-businesses are also affected as they attempt to assess the risk exposure of borrowers.

Traditional risk management has become ineffective and methods like use of buffer stocks as precautionary savings and the diversification of income-generating activities through changing labor allocation or planting different crops, like drought-resistant variants, planting in different fields and staggered over time, intercropping, and relying on low risk inputs has not proved to be effective. These strategies have turned out to be costly and often lower vulnerability in the short term at the expense of higher vulnerability over the longer term. (Ulrich Hess, Kaspar Richter, Andrea Stoppa<sup>1</sup>) Use of new effective WRM would allow rural credit to be collateralized more efficiently and loans extended to weather exposed farmers that would otherwise be not bankable.

Effective use and management of weather derivatives is faced by many challenges, but to those who understand options and the risk profile associated with buying and selling weather options relative to their business it could be a very useful risk management tool.

## **Weather Derivatives and the Power Industry**

The traditional risk-hedging tools in the Power Industry are costlier, inadequate, and more importantly, a drag on the country's fiscal system (Sharma & Vashishtha, 2007). An appropriate weather-based derivative contract system may be a more flexible, economical and sustainable way of managing the volume-related weather risk in a developing economy. Though various businesses are affected by unpredictable weather, the effect on agriculture and power industry is substantial. The necessity of hedging weather risk is apparent but there are issues with the sustainable management of weather risk. Energy is one of the most basic components of economic infrastructure. Its uninterrupted and adequate supply to agriculture and industry is indispensable for the rapid growth of the economy.

Available risk management strategies can be divided into four basic groups, regardless of the risk type. They are, in order of their effectiveness: (1) avoidance, (2) acceptance, (3) reduction and (4) transfer.

1. Strategy of avoidance entails avoiding of all activities associated with risk by ceasing trade in areas with historically bad weather
2. Strategy of acceptance entails acceptance of losses incurred as a result of adverse events. Mainly is about small risk that is hard to cover with insurance because premium cost would most likely exceed overall risk exposure.
3. Strategy of reduction entails reduction of actual risk exposure and mitigation of consequences of adverse weather events. The most common examples of weather risk reduction are geographic and product diversification. An example of natural hedge achieved by product diversification is an energy company that owns both hydroelectric plant and solar power plant. Such diversification is effective because rain is negatively correlated with sunshine hours. Natural hedge is much more difficult to achieve through geographical diversification because the feature of negative correlation between meteorological elements in different locations is often not the case in the market size of a single country or even a region. The advantage of natural hedge is that company does not need to pay for it. However, the disadvantage is that weather risk is not eliminated, merely reduced.
4. The strategy of transfer entails the risk transferring process to another party and as such represents the most successful i.e. effective strategy of risk management. A classic example of risk transfer is an insurance contract. Companies exposed to weather risk can also be protected by transferring the risk through contractual contingencies and



commodity futures, while even more effective protection can be provided by weather derivatives. However they are not so effective when considering volumetric risk caused by adverse weather since correlation between energy price and weather is not as strong as the one between quantity and weather. This way, a risk that payoff of commodity futures may not be substantial to cover incurred financial loss is present. This standpoint can be confirmed by the findings of Paoletti, C. (2001) who analysed the movements of electricity price and temperature and found a correlation coefficient of about 0.5. Afterwards the relation between electricity consumption and temperature was analysed and respective correlation coefficient was determined to be over 0.95. This is vivid evidence that weather is primarily a quantity risk and that it has an indirect affect on prices of commodities and services, through the effect on quantity of goods sold or produced.

### **How weather derivatives can be applied to natural gas distributors?**

After computing the required accumulated weather index, the distributor should identify during which period their sales are most affected or is risky. Then the distributor writes the weather protection in terms of HDD (for winter season) and CDD (for summer season) indices. The next step would be the payout option or the strike point. Upon selecting a particular month of unpredictable weather and risky sales, the HDD/CDD index is established from the historical data. After conducting the quantitative weather sensitivity analysis, distributor became aware that 1 HDD/CDD point is worth 'X' monetary units (m.u.) of natural gas sales. The monetary value attached to one index point is called tick. Since natural gas consumption is erratic more during the winter season, consider the distributor goes for protection on a HDD index. Given that HDD index measures deviation of winter temperatures distributor is worried about fall of

accumulated HDD index under certain limit, so he buys a weather protection in a form of a HDD put option with strike of the set HDDs limit and tick value of 'X' m.u. For this protection, he pays an upfront premium of, let us assume, 5 times 'X'. Since weather is not a physical commodity, weather derivatives are always settled in cash. The following equation presents the payout formula for put option.

$$P_{\text{put}} = \text{tick} \times \max [(S - W), 0] - \text{premium}$$

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