# WEATHER DERIVATIVES - A NEW CONCEPT IN THE WEATHER INSURANCES

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**Abstract:** As the negative effects of climatic warming are more and more obvious, the demand for insurance solutions to cover the costs resulting from weather whims shall increase in direct ration with risk exposure. Although the situation might be interpreted as a business opportunity, in order to be able to offer the proper cover it is necessary to comply with fundamental demands regarding the weather risk insurance. Thus, when conceiving viable insurance solutions of the consequences intervened in case of a catastrophic event generated by harsh weather conditions we must take into consideration factors such as measurement possibility of the respective risk, in order to decide if this can or can not be accepted. Weather risk management is a quite new process wherethrough many businesses can have an advantage regarding the manner of weather effects handling, with positive results upon earnings and expenses. The weather risk management instruments are weather insurances and weather derivatives.

Three transactions mark the beginning of the current weather risk market. So, early pioneers in the market – energy traders Aquila, Enron, and Koch Industries – conceived of and executed the first weather derivative transactions in 1997. The first deals were all arranged as privately-negotiated over-the-counter transactions and were structured as protection against warmer or cooler than average weather in specific regions for the winter or summer seasons.

The innovative idea was based upon using weather forecast as an initial point for determining some ”trigger mechanisms” called ”index”, which actually represents borders or limits measured by statistic accounts which typically cover the temperature local variations, rainfalls or of other weather parameters, from one week to a whole season. Once identified the ”index”, it shall represent the solution which makes weather risk become fungible.

The three innovative companies performed or had connective liaisons with electric power field. As a consequence, we may say that electric power risk management introduced a class of risk management instruments which offer protection to risks due to goods level variation/services sold or bought, generated by average temperature changes on definite periods of time: weather derivatives. Jointed to price risk management instruments, these level protections increase the supplying potential of a risk superior management.

Therefore, weather derivatives market has its roots in USA and has as an account the electric power industry privatization. Although weather conditions variability has always been acknowledged as one of the most important factors which affect the electric power consumption, the effects of unpredictable weather variations were, in the past, immersed and managed in a monopolist environment, controlled by government. Along with privatization, the varied participants to the production process,

merchandising and supplying the electric power to domestic and industrial consumers had to confront the weather – a new and significant risk, with an impact upon operational impacts.

Beyond the obvious initial applications of weather derivatives for risk hedging in electric power field, the market expanded, referring to a wide diversity of weather risks, specific to other industrial fields. The transactions of the last years offered protection against this risk to companies from different fields such as entertainment, commerce, agriculture and constructions. Being very attractive for companies with background regarding financial instruments such as futures options and contracts, weather derivatives put the companies into the situation to fulfill the investors expectations and to make profit, by maintaining the cash-flow even under weather conditions unfavorable to their business [Pilipovic, 1998].

In many regards, weather derivatives market represents a convergence border between insurance market and bigger financial markets. Due to its increasing, the market attracted rapidly not only the involvement of electric power traders, but also the insurance-reinsurance companies, investment banks and hedging funds.

In USA, the wide option basis issued by insurance companies supplied the necessary liquidity for developing the weather derivatives market. At the same time, investment and commercial banks saw in weather derivatives management products of financial risk which they could associate in crossed sale with other financial products used in the hedging of interest rate or exchange risk. Anyway, certain stock-exchange players, as well as hedging funds noticed the opportunities to trade weather derivatives on speculative bases. Nowadays, all three fields – electric power commerce, insurances and capital markets – are well represented both in issuing activity and also in dealing USA weather derivatives.

There are in train introducing projects of weather derivatives for beer industry, other branches of food industry, eolian power producers, sugar industry and other branches.

A sampling of weather risks faced by various industries is presented in the table below.

The weather derivatives market also expanded rapidly outside USA, both in terms of covered risks and nationality of companies involved in the market. Among the countries where there have been accomplished dealings now rank Great Britain, France, Germany, Norway, Sweden, Spain, Austria, Italy, Canada, Australia, New Zealand, Mexico, Japan and India. Among the important issuers of weather derivatives we can mention Guarantee Weather, Energy Koch (USA electric power traders) and banks such as Credit Lyonnais (Calyon), ABN AMRO Bank, Gensec Bank and so on.

Presently, Chicago Commodity Exchange, which has am european branch office in London (Chicago Mercantile Exchange, CME) is the only place where one can make dealings with weather derivatives by Romanian natural or legal persons. For the moment contracts for reference weather stations in Romania are not available. But, together with attraction increase for these instruments, the matter shall be definitely solved.

**Table 1**

**Illustrative Links between Weather and Financial Risk**

| Risk Holder | Weather Type | Risk |
|---|---|---|
| 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 |
| Hydro-electric power generation | Precipitation | Lower revenue during periods of drought |

**What is and how it works the weather derivative**

Weather derivative is a financial instrument used by companies to reduce the risk associated to unfavorable or unpredictable weather events evolutions. The derivative seller accepts the risk by cashing a bonus (derivative price). If the event doesn't take place, the seller makes a profit, but if the event takes place, the buying company cashes a preliminarily agreed amount. In USA, Europe and Australia, temperature, snowfall quantity, freeze expansion and rainfall quantity are key conditions for which corporations buy weather derivatives. The cost of a weather derivative depends on the probability of weather negative impact upon the business and duration of the contract concluded between the bank and corporative entity.

A weather derivative is defined by many elements, as it follows:

***Reference weather station***. All contracts of weather derivative type are based upon weather observations accomplished at one or more specified weather stations, accomplished by an entity certified by national weather authority of the state on which territory there are the respective stations. Most part of the dealings are based upon only one station, but some contracts are based upon a combination of reports from many stations, and others upon differences between the values noticed at two stations. The reference weather stations situation from european countries where dealings with weather derivatives are accomplished is the following:

**Table 2**

| Country | Number of meteorological stations | Period |
|---|---|---|
| Austria | 1 | 1960 – present |
| France | 1 | 1952 – present |
| Germany | 46 | 1961 – present |
| Italy | 15 | 1961 – present |
| Holland | 9 | 1950 – present |
| Norway | 1 | 1960 – present |
| Sweden | 1 | 1961 – present |
| Spain | 20 | 1960 – present |
| Great Britain | 12 | 1959 – present |

*Source: http://www.climetrix.com*

***Index*** of a weather derivative defines the weather parameter which establishes when and how the payments agreed by contract shall be accomplished. The indexes most frequently used are Heating Degree Days (HDD) and Cooling Degree Days (CDD) – which measure the cumulated variation of daily average temperature comparing to the level of 18°C (65 Fahrenheit degrees) along a season. We must mention that other basic temperature levels may be adopted, for instance in Great Britain these are of 15,5° C.

The arithmetic expression used in order to determine the HDD and CDD is the following [Zeng, 2000]:

$$HDD = \sum_{i=1}^{N} \max\left(0, 18^{o}C - T_i\right) \quad (1)$$

$$CDD = \sum_{i=1}^{N} \max\left(0, T_i - 18^{o}C\right) \quad (2)$$

where,

*N* represents the number of days for which a contract is developing;

$T_i$ - arithmetic average of maximum ($T_{max}$) and minimum ($T_{min}$) thermic temperatures of day *i*.

For instance, the daily accumulated CDD number is equal to the difference between the average temperature of the day and the value of 18°C (65 Fahrenheit degrees), if the temperature is over 18°C and to zero if the temperature doesn't exceed 18 Celsius degrees. If the average temperature of the day is under 18°C ($T_{base}$), then the difference between 18°C and average temperature of the day leads to HDD number, CDD and HDD values are never negative, being at least equal to zero.

As a consequence, if $T_i$ shall be of 10 °C when the HDD value for that day is of 8 (18 °C - 10 °C = 8 HDD), instead, if $T_i$ shall be of 20 °C, then the HDD value is 0.

In the same way there can also be determined the CDD value. If $T_i$ shall be of 20 °C, then the CDD value is 2 (20 °C - 18 °C = 2 CDD), and if $T_i$ shall be of 10 °C then the CDD value is 0.

During a month there can be accumulated both CDD (during the days with average temperature over 18 degrees – days with high temperature) and HDD also (during the days with average temperatures under 18 degrees – days with low temperatures). The

weather (options) derivatives are defined on HDD or CDD accumulation over a specific period.

A wide range of indexes is used for the dealings restructuring which offer the most adequate hedging mechanisms for the users from different economic fields. Many dealings are based on the so-called event indexes, which count the number of days when the temperature exceeds or drops under a defined limit, during the contract. Similar indexes are used for other variables; for instance the rainfall accumulation or the number of days when the rainfall accumulation as snowfall exceeds a defined level.

According to the most recent study of Weather Risk Management Association (WRMA) made by PricewaterhouseCoopers (June 2006) shows that HDD was, even in 2005, the most used dealing index with weather derivatives, while the number of contracts based on the CDD index was growing during 2005 comparing to 2004.

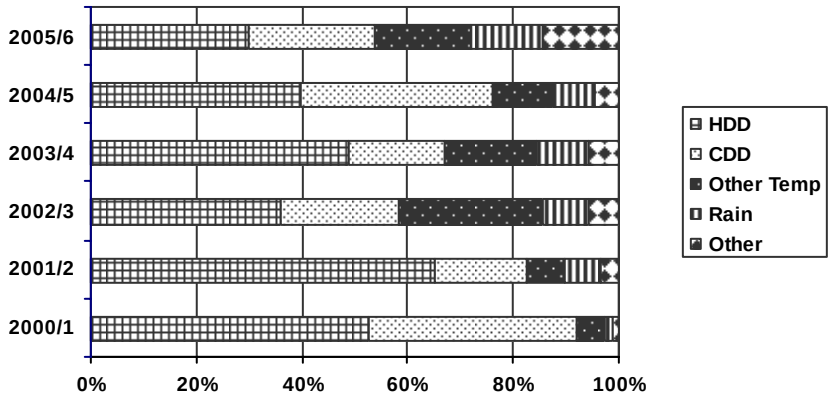


**Fig. 1: Distribution of Number of Contracts by Type: 2000/1 – 2005/6 (Excludes CME trades)**

***Term.*** All contracts have a defined day of beginning and termination, which define the period for which the specific index is calculated.

The most frequent market terms are 1st of November - 31st of March for the winter contracts and 1st of May - 30th of September for the summer contracts. However, there has been noticed an increasing level of contracts for a month or a week, along with the market development. Certain contracts also specify various calculation proceedings of the index in the agreed term - such as weekends exclusion or the double share for the specified days – in order to meet some individualized exposures.

***Structure***. Weather derivatives are based on standard structures of the derivative financial instruments, such as put, call, swap, collar, straddle, strangle. The key attributes of these structures are:

1. Strike – meaning the specific index value when the contract begins the payment;
2. Tick – meaning the paid amount per growing unit of the index over strike;
3. Theoretical limit or value – meaning the maximum payment stipulated by contract.

***Premium.*** The buyer of a weather option pays a premium to the seller that is typically between 10% and 20% of the theoretical amount of the contract. Still, the bonus may significantly vary depending on the risk profile of the contract.

In order to exemplify, we may take into account a common shape of weather derivative, meaning the put option which offers protection to the effects of a warm winter. Such a dealing might look like this:

*Reference weather station: Chicago O'Hare International Airport (WBAN #94846)*
*Underlying index: Heating Degree Days*
*Term: Nov. 1 – Mar. 31*
*Structure: Put option*
*Strike = 4.850 HDDs*
*Tick size = $5.000*
*Limit = $1 million*
*Premium $150.000*

In this case, the issuer of the derivative is going to pay the buyer, in case if the season 1st of November – 31st of March, the HDD index has a value lower than 4850, an amount equal to 4850 – the total number of HDD multiplied with 5000$, but in any case no more than 1 million dollars.

The HDD shall be as higher as the temperature is lower for several days, being the amount for the entire season of values 65 (Fahrenheit degrees) – *Ti*. In this case *Ti* is the average temperature of a day *i* of the season, in terms of Fahrenheit degrees.

The purchasing price (bonus) for this weather derivative is of 150 000 $. In the diagram below there can be noticed how the buyer looses the bonus derivative if the winter is cold (over 4850 HDD), in which case it is assumed that the estimated maximal operational profit is accomplished, and shall begin to cash money from the contract issuer if the season counts under 4850 HDD. Therefore, for seasonal values under 4650 HDD, the contract only ensures the limited amount, meaning a net profit (comparing to the bonus paid at purchase) of 850 000$.

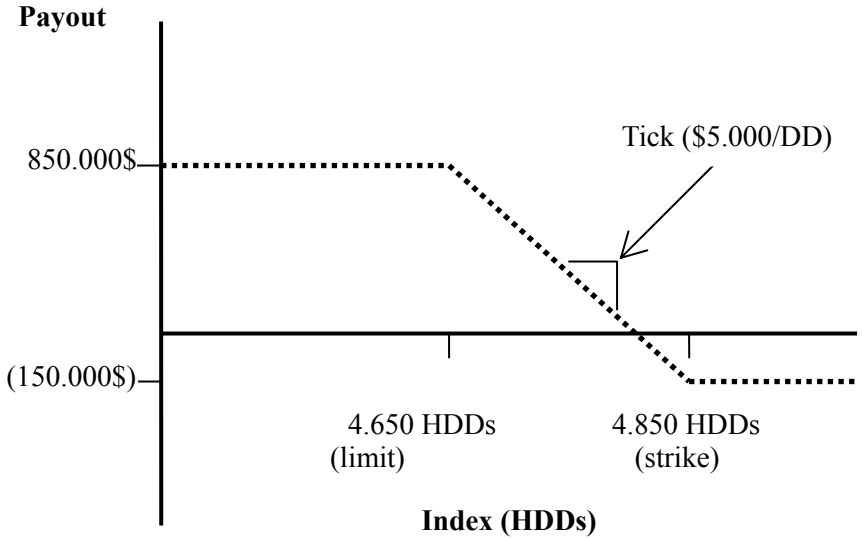


**Fig. 2: Contract payoff diagram (net of premium)**

In order to satisfy the non-electric power users' needs and to increase the variety of risk management capabilities at all participants service on the derivative products market, the range of available products on the American market significantly expanded, through a continuous innovation.

Weather derivatives dealings may now be structured in order to cover almost any type of weather variable (temperature, falls – rainfalls, snowfalls, wind speed, humidity, and so on), on terms between a week and several years and with payable amounts between a few thousand dollars for small risks and up to over 100 million dollars for much larger exposures.

The trade on the weather derivative market took place at the beginning ”over-the-counter” (OTC), in the shape of some contracts negotiated between legal entities, but starting with 2002 a continuous growing volume of standardized contracts weather derivatives type was enlisted on Chicago Mercantile Exchange (CME), Intercontinental Exchange (ICE) and London International Financial Futures and Options Exchange (LIFFE). The dealings volume growing for these contracts had positive impacts upon the market's cash flow and the prices establishment.

Therefore, according to the study of Weather Risk Management Association (WRMA) made by PricewaterhouseCoopers, the weather derivatives market has continuously grown, emphasizing an evolution of about 3.900 dealings made during 2002, with an exposure of over 4,3 billion USD, to over 1.000.000 (1.041.439) dealings in 2006, with an exposure of over 45,2 billion USD (increasing from 9,7 billions in 2005):

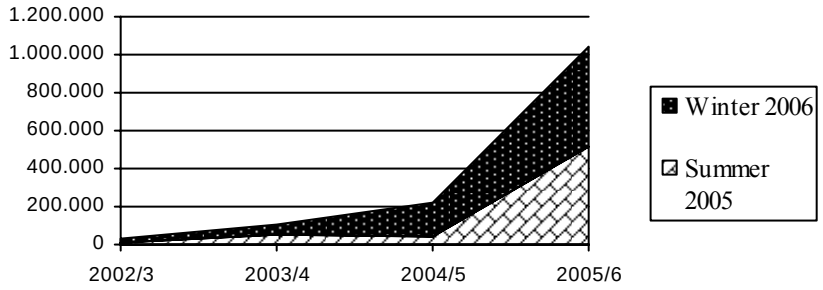


**Fig. 3: Number of Trades on the CME**

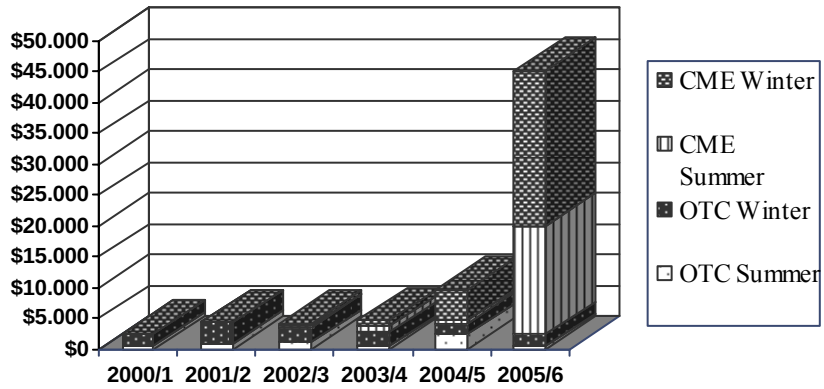


**Fig. 4: Total Notional Value of weather risk contracts: 2000-2005 (in millions of U.S. dollars)**

In the same time, the study shows that both the OTC (over the counter) dealings number and the dealings volume made on the Chicago Mercantile Exchange (CME) grew rapidly during 2004-2006.

The most part of the dealings are taking place in American companies, but the share of the dealings made by Asian and European companies grew after 2001.

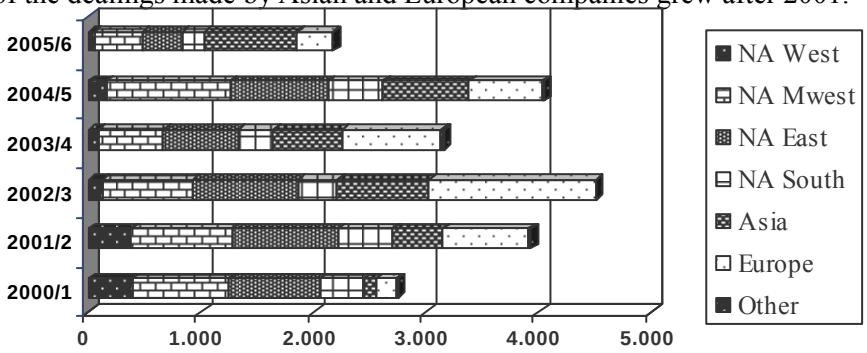


**Fig. 5: Distribution of Total Number of Contracts by Region: 2000 – 2005 (Excluding CME Trades)**

**Derivatives are different from insurances**

Weather derivatives are different from the insurances for weather calamities.

Regarding the formers situation, the compensations are paid in case of goods prejudices, proved to have weather causes. The weather derivatives payment is based on the detected weather evolution, no matter how this has affected the owner of the derivative. You don't even have to own a sensitive weather business in order to buy or take advantage of the weather derivatives. As any other financial derivative instruments, these contracts can be bought and only with speculative purpose. Unlike insurances, which cover events with low probability rate of generation such as floods or calamitous draughts, weather derivatives cover the events having a higher probability rate of generation, such as a colder/wetter summer than normally.

On the weather derivative market a participant who would take advantage of a very cold winter could meet another who made profit if the winter is gentle. These can protect each other for the weather risk (hedging), something that would not happen on the insurance market.

The weather is changeable and unpredictable on long term. How can anybody offer protection for something so hazardous? The answer is simpler than we think. It is not necessary to forecast the weather in order to offer a business protection against the weather risk. The solution resides in finding capable partners willing to accept the weather risks, and this can be best done on a market which allows the weather derivatives dealings.

As a consequence of the economic development of recent period, also in Romania shall become absolutely necessary this kind of instruments for risks control.

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