



Carbon Market Special Report

PointCarbon™

Weather and the Carbon Markets

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EXECUTIVE SUMMARY

The weather and carbon markets are intuitively related: Cold weather drives up heating demand and emissions and abnormally dry conditions require the replacement of non-emitting hydro power with fossil based generation. Increasingly, hot summer weather fuels air conditioning demand, and emissions.

Two case studies in the European Union Emissions Trading Scheme were selected to illustrate the effectiveness of weather hedging in the carbon markets. The winter 2005/2006 was colder than average in Germany, while winter 2006/2007 was very mild. Spain saw a 35% shortfall in hydroelectric production in 2005. This deficit was only partially compensated by relatively wet conditions in 2006.

This report analyzes two hedging approaches. The pure weather hedge pays out proportionally to the departure of the weather variable from normal conditions. While this approach performs well during the first season in both case studies, it fails during the second season for not taking into account the dependency on allowance prices. A second hedging approach creates a payoff which combines weather conditions and allowance prices. This "quanto" hedge pays the purchaser in European Union allowances proportionally to the weather departures from normal. By capturing the price drop in EU spot prices since the spring of 2006 in the payoff, this hedging approach provides quality risk management.

The carbon markets are becoming increasingly sophisticated. Point Carbon and Nephila Capital fully expect structures like the weather - commodity quanto, which has to date only been executed on a limited basis, to be offered and used more broadly and particularly within the emissions markets.

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Introduction

Variance in weather and in the volume of carbon emitted is intuitively linked, to the extent that cool and warm anomalies drive energy consumption (demand). This co-variance is elevated during peak heating and cooling seasons, driven by higher volatility in temperature, and absolute deviation from 'normal' (18C/65F). Precipitation and wind-speed also impact the availability of hydro and wind capacity and thus the emissions intensity of electricity generation. Examples of weather-driven changes in emission volumes can be found throughout Europe:

- Denmark saw emissions 16% higher in 2006 than 2005 on the back of strong coal-fired electricity generation, which was required for export to other Scandinavian countries where low hydro availability created supply shortfalls.
- Spanish electricity consumption increased 4.3% in 2005 due to elevated demand both for heating (winter was colder than average) and for cooling (summer was then unusually warm). The increase in national emissions, however, was fully 7.4mt, or 7.5% higher in 2005 when compared to 2006, the result of dry conditions that reduced hydro production to a 48-year low. Conversely, a large Spanish utility recently announced that its emissions would drop 15% in the first three quarters of 2007 when compared to 2006 thanks to more abundant availability of hydro power.
- German energy use increased 3% in the first quarter of 2006 compared with the same time period a year earlier due to unusually cold weather (Berlin temperatures were 1.5 standard deviations below

average for January and February, versus more normal conditions the previous winter). This led to increased consumption of natural gas (+13%) and light heating oil (+11%), driving emissions up.

Weather is not the only marginal driver of emissions levels. Changes in the level of industrial production and the relative scarcity and price of low- versus high-emitting generation fuels each have an impact on a dynamic basis. In addition, as carbon trading remains a young market, volumes and prices of carbon emissions are not perfectly correlated. Uncertainty surrounding aggregate scarcity, created by regulatory risk, foments disequilibrium. All market players do not respond rationally to incremental changes in individual (or universal) surplus or deficit. Therefore, information about expectations of future scarcity unrelated to climate change or economic growth is embedded into the term structure of carbon prices.

There is, however, abundant evidence that weather effects have an impact on the behavior of the European Union Emissions Trading Scheme (EU ETS) allowance contract. Point Carbon developed a weather index to track the impact

of temperature and precipitation on European emissions. The calculation method is summarized in the textbox at the bottom of the page. The correlation between that index and the EU ETS phase I spot price was close to 90% in the beginning of the first phase of the EU ETS. This correlation pattern was only established once major policy decisions had determined the supply of allowances, and broke down after the over-supply of the EU ETS in Phase I was revealed. This highlights how policy and other factors influence a market otherwise driven by fundamentals.

Phase II of the EU ETS will begin in January 2008, extending through December 2012. The European Commission's allocation decisions are estimated to leave the scheme short which would suggest that ETS volume and price will again be highly influenced by weather.

In order to model hedging alternatives for a single installation seeking to manage its exposure to allocation shortfalls, it is important to layer risk into internal demand drivers and external market forces. At the most basic level, given an allocated credit stream, a generator is exposed to the incidence of colder winters/warmer summers (higher

The Point Carbon Weather Index

Point Carbon calculates the impact of weather on emissions on a daily basis. For each member country of the EU ETS, emissions are calculated daily by using the same input fuel prices and:

- actual and forecasted weather conditions for temperature and rainfall; this represents the "best guess" estimate of emissions;
- normal weather conditions; this simulation represents weather normalized emissions.

The difference between best guess emissions and weather normalized emissions represents the incremental impact of weather on emissions, all other conditions held constant.

demand) and/or drier/less windy conditions (decreased supply). If generation needs are greater than expected, its carbon account will go into deficit, and credits must be bought to address the shortfall. This represents the basic business exposure for generators – they have ‘received fixed credits and pay floating climate.’ Other regulatory and market forces may introduce additional short-term volatility in their carbon budgeting, but over time weather fluctuation from “normal” will be an ongoing source of earnings volatility for which generators and others will have to consider risk management alternatives.

This paper provides a high-level summary of the current carbon and weather markets in order to provide a framework to consider the intersection of the two markets. As this intersection where weather will impact carbon prices becomes clearer over time, market participants will seek financial products to help them to quantify, manage and transfer risk. We explore below some examples of potential products and their applications.

State of the weather market

Weather derivatives are financial instruments that can be used by organizations or individuals as part of a risk management strategy to reduce risk associated with adverse or unexpected weather conditions. The difference from other derivatives is that the underlying asset (rain/temperature/snow) has no intrinsic value from which to price the derivative. These contracts (whether provided as an insurance policy or a derivative instrument) have been executed worldwide over the past ten years by a range of large financial and corporate institutions. The market

continues to grow at a healthy pace, in two broad segments: weather trading, and corporate hedging. Volume is dominated by futures traded on the Chicago Mercantile Exchange, which lists monthly and seasonal temperature contracts for 35 major cities in North America, Europe and Japan. Settlement is typically based on cumulative experience for a given weather variable over the contract term, equivalent to settling based on the aggregate payout of a strip of daily options on an underlying asset. Investment banks and multi-strategy hedge funds tend to view weather risk as complementary to their existing energy trading activities, and are increasingly using weather derivatives as a dynamic risk management tool during peak heating (and to a lesser extent, cooling) seasons. Given the high correlation between weather and energy prices, actively traded weather portfolios are generally managed as subsets of broader commodities strategies. Such speculative capital has focused on forecast arbitrage opportunities which provide a basis for trading, adding some degree of liquidity to front-month temperature contracts.

The appetite for such forecast-based trading strategies is effectively limited to commoditized instruments with little transfer friction. Several reinsurance players have therefore entered the market in a different way as risk capacity providers to weather-exposed corporates, for whom exchange trading is inappropriate. The attraction for these players is that weather is a statistical risk similar to existing property catastrophe exposures, however it is independent and therefore diversifying. End-users benefit from the availability of highly customized cover, with little basis risk and the ‘more tailored’ coverage characteristics not offered by the exchange-traded contracts. Significant principal risk capacity is available in this over-the-counter

(OTC) market for transactions where structure, tenor, index and/or transaction size are customized to the hedging requirements of end-users. As interest in weather hedging grows, this corporate hedging market is becoming a larger segment of the overall weather landscape, where large (up to \$100mm or more) customized structures provide real risk transfer capacity. These two pools of risk capital offer different but complementary appetites to absorb the hedging demand of weather-sensitive businesses.

Winter temperature exposure in the Northern Hemisphere is the variable on which the largest volume of hedges is transacted. Basic drivers for this are both deregulated power generation in the U.S. and Europe, and the large energy inventories that must be stored pre-season. Summer temperature hedging volumes are significantly lower, due to the lower installed capacity of air-conditioning in Europe. Precipitation-based hedging dominates risk transfer for the Southern Hemisphere, where agriculture and hydropower generation are exposed to insufficient rainfall. These water based transactions tend to have annual risk terms while the more seasonal nature of temperature risk typically means that hedging transactions have terms of one to six months. Such seasonal weather hedges are usually to address basic capacity demand for energy rather than impact on margin variance.

As the weather market evolves, end-users and underwriters are collaborating to construct hedges in ways that best minimize basis risk. One of the difficulties in designing a structure is that temperature tends to be mean-reverting. This renders seasonal coverage inappropriate for hedging short, sharp demand or supply shocks caused by volatile peak-season conditions. Splitting risk periods into segments alleviates this

problem by better isolating short-term anomalies and allowing end-users to collect when they occur. Coverage that is broken into a 'strip' of monthly contracts, for example, can be further optimized by weighting the payouts to reflect the end-user's underlying economic exposure to temperature volatility during each period. Finally, the 'currency' of contract payout can be set to compensate the hedger for exposure to commodity price given an existing risk-management program for power or energy delivery.

The way in which hedges are constructed also varies according to an end-user's risk management budget and philosophy. New or cost-sensitive participants often choose to swap exposures, trading away potentially financially favorable situations for protection under adverse conditions, rather than buying coverage. This can be achieved through a swap or a premium-neutral collar transaction. Given the reciprocal payout of these deals, vanilla index structures are the preferred option for end-users as they seek to accurately and easily measure downside exposure. Others prefer purchasing options, often creating a customized underlying index that better matches economic exposure. Fitting structures to specific weather outcomes, for example number of days where minimum temperature is below freezing, isolates coverage required and reduces cost.

While customized hedges are available in limits of up to \$100 million of capacity (or more) per transaction, data can also be an impediment to seamless risk transfer. The problem of data robustness is two-fold: unlike temperature, other weather variables such as wind-speed can be acutely local in nature, and often no extended historical data set exists, creating a challenge in building an underlying index for risk transfer. However, adequate historical data (typically 20 years or more) and

robust ongoing reporting at a location will usually translate to an executable structure based on that data. Europe is particularly well-resourced for weather data for temperature, rainfall, and streamflow and thus fertile ground for product development looking at weather impact on carbon exposures.

State of the carbon markets

The carbon market began in earnest with the introduction of the European Union Emissions Trading Scheme in January, 2005. The scheme caps the overall emissions of approximately 12,000 installations in the power and heat sector, but also in the metals, cement, lime, glass, pulp and paper and refining sectors in 25 European countries (28 in the second phase). The overall European cap is divided into country targets, which are further broken down into facility by facility allocations. Each facility must hand in a sufficient number of allowances by March of each year to remain in compliance with the program. The penalty for non-compliance of €100/t plus makeup of the allowance shortfall in phase II is sufficient to provide a functional deterrent.

Phase I will be remembered as having been over-allocated by close to 300mt, or 5% of the overall cap. The publication of the verified emissions data for 2005 was a major blow for the EU ETS, as the market turned out to have been long allowances in 2005, and not short as previously thought. The surplus is probably due to a combination of two factors; i) generous allocation and ii) internal abatement and efficiency improvements. The first is by far the most important.

Surprisingly, the market moved on after the meltdown of Spring 2006, and market volumes have continued to grow steadily since then. In total,

the brokered and exchanged market saw 775 Mt CO₂ changing hands in the first half of 2007, corresponding to €11.5 billion. Brokers did 71 per cent of this volume, whereas the European Carbon Exchange took over 75 per cent of the volume carried on exchanges. Total projected volume for 2007 in the EU ETS is 1.75 Mt CO₂, worth €18.5 billion. 2006 showed clearly that prices could move up or down, and liquidity could be impacted by a number of factors. Even so, the EU ETS has shown that it will remain a multi-billion-euro market. The lessons from the 2005 verification have not been lost on (most) policy makers, and the allocations for the next phase of the EU ETS, to start in January 2008, are considerably stricter.

The EUA price is, as in any market, set by supply and demand. The supply is here determined by the allowances (EUAs) and carbon credits available to the market (CERs and ERUs). Demand is determined by the volume emitted through the year in relation to the overall allocation. This volume is in turn influenced by a number of factors, primarily fundamentals like weather (as temperature determines power/heat demand and precipitation the potential for hydropower production), fuel prices (as the relative price differential between coal and gas will determine which of the fuels that will be used for power production), macro-economic conditions and internal abatement within the industrial and power sectors.

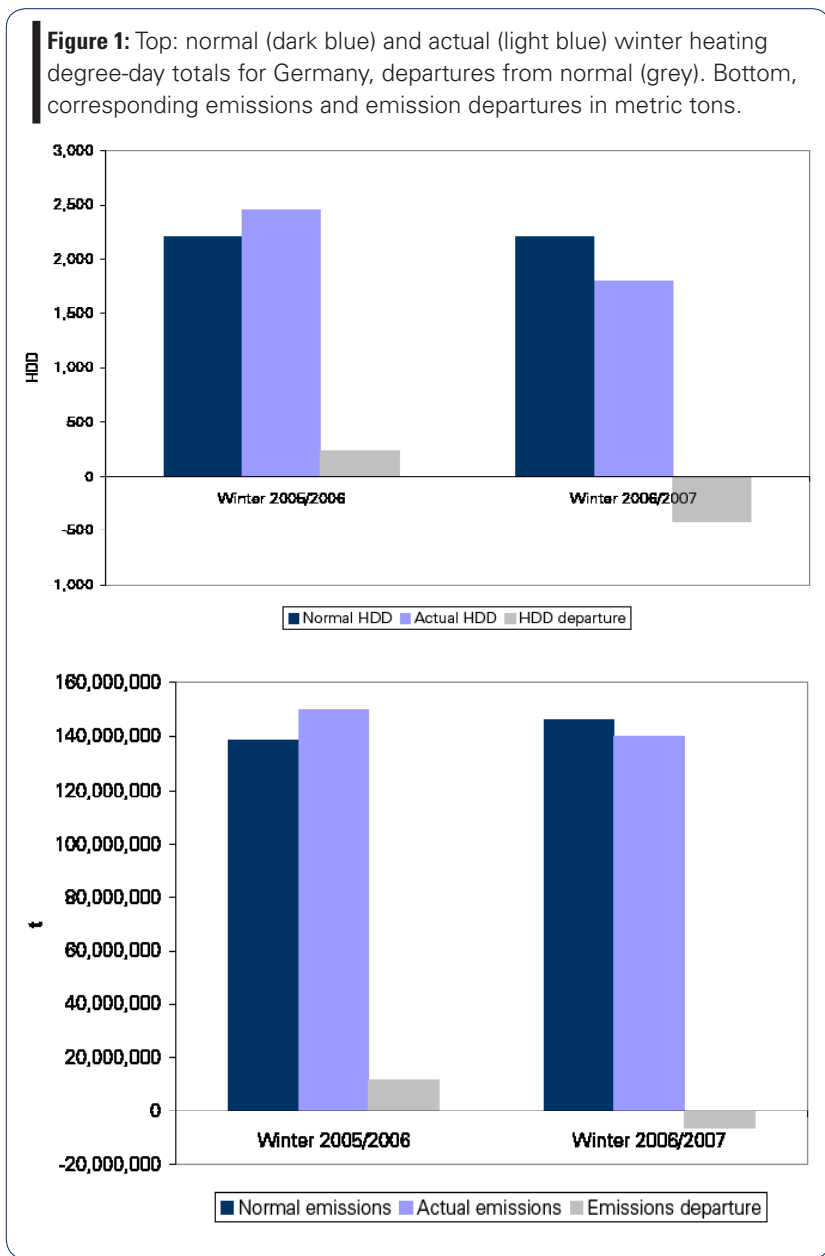
Supply and demand impacts, particularly those related to weather, were felt strongly during the first year of the EU ETS. In fact, the correlation between the EUA price and the combined effect from fuel and weather was 0.92 over 2005 as a whole. The individual correlations to fuel prices and weather were 0.48 and 0.89 respectively. The strong

correlation between weather and allowance prices was lost with the market meltdown in the spring of 2006: it averaged only 0.42 for 2006. While fuel prices, which trade on a forward basis, are already affecting the carbon contract for delivery in 2008, the link to weather is expected to re-emerge in the beginning of 2008 as the spot contract for delivery in phase II of the EU ETS is again affected by temperature and hydrological conditions.

The net allowance cap in phase II of the EU ETS will be approximately 2.1bt/year, or 10bt over the five year compliance period (2008-2012). The European Commission's allocation decisions are estimated to leave the scheme short by approximately 1bn tons over that period once the set-aside for new market entrants are taken into account. This represents a shortfall of 11% of the cap. The net shortfall of approximately one billion metric tons is expected to be largely balanced by a supply of approximately 1bn tons of carbon credits from the Clean Development Mechanism and Joint Implementation.

The approximate supply and demand equilibrium creates a system which is expected to be particularly price sensitive to weather and fuel price effects. Weather effects can increase emissions by up to 60 Mt/year in extreme conditions (3% of the annual cap) when compared to a normal year and the impact of fuel prices can swing emissions by as much as 45 Mt/year (2.3% of the annual cap). Either effect thus can tilt the net carbon from approximately balanced to short or long, with a dramatic influence on market volatility and prices.

Few "carbon-linked" financial instruments have been available to market participants to date to mitigate and manage the risks of these effects. The OTC and exchange traded carbon markets focus exclusively on forward



and spot contracts. Limited liquidity exists in options on carbon contracts, though the European Carbon Exchange has recently introduced a set of option contracts.

The trend towards more sophisticated financial products in the carbon space – financial options, allowances to offset swaps, carbon indexed

fuel or weather derivatives – will undoubtedly be an important aspect of the growth and development of these markets in 2008 and beyond.

Weather risk in the carbon markets

Weather affects the emissions of greenhouse gases within the EU ETS

in a variety of ways. Most of these risks are concentrated in the power and heat sector.

- Supply: risk in electricity generation is primarily tied to precipitation and the availability of water for hydroelectric generation. A smaller effect can be attributed to the availability of wind, in particular in countries such as Germany with large wind capacity. Both wind and hydro are cost-free, non-emitting generation. If precipitation or wind are insufficient, the shortfall in generation typically has to be made up by emitting generation, either coal or natural gas fired.

- Demand: Weather also affects the demand for electricity within the EU ETS region. Those effects have historically been dominated by abnormally cold weather in the winter driving up emissions. However, the increasing use of air conditioning during hot summers is driving up electricity demand, as well.

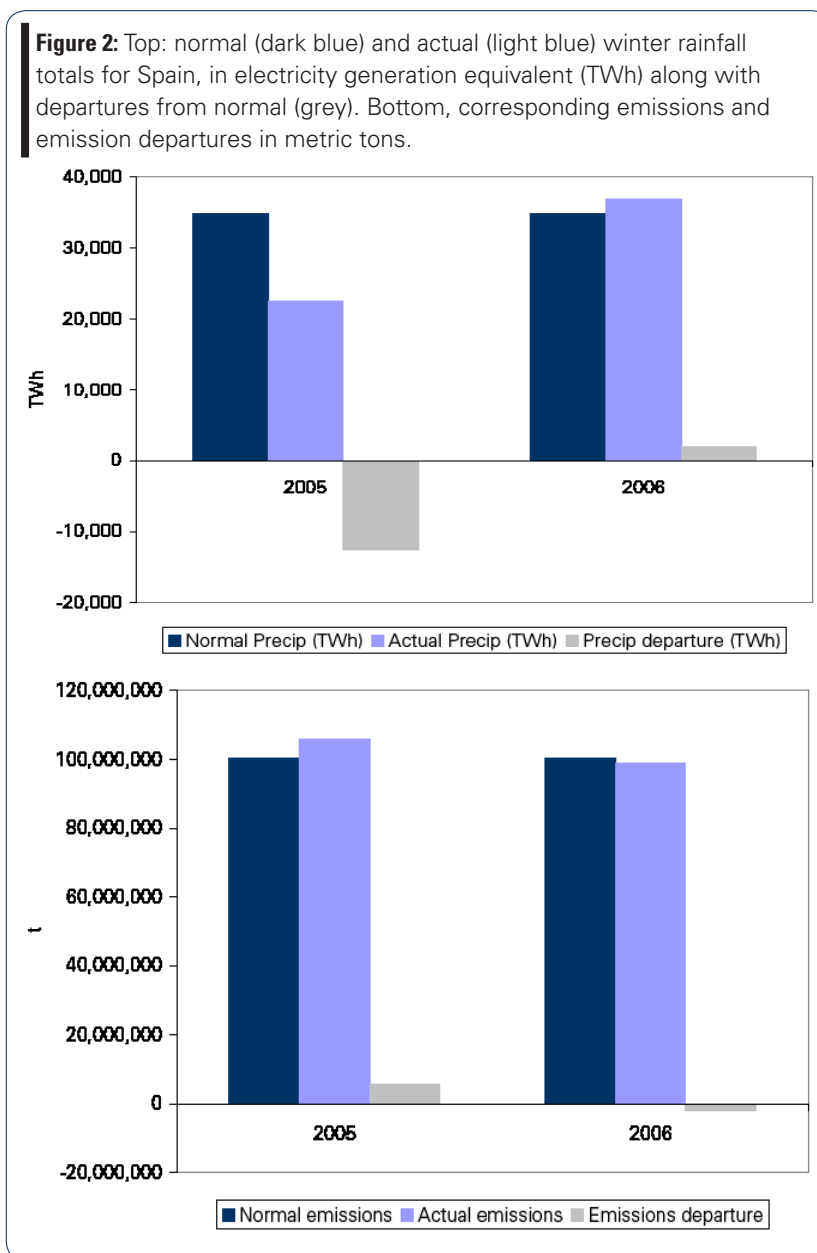
Case Study Descriptions

We have selected two case studies to illustrate how weather hedges and combined weather and EUA allowance hedges can be used to mitigate companies' weather related volumetric risk in the EU ETS.

Temperature in Germany

The first case study deals with winter temperatures (November - March) in Germany. Lower temperatures mean more heating degree-days and higher emissions.

Temperatures in the winter 2005-2006 were colder than average. Using heating degree-day departures from normal, that winter was 11% colder than a normal winter, defined as 2215 HDD. As a consequence, emissions in Germany were, by our estimate, 8% above normal weather values. Winter 2006-2007 was warm,



with a heating degree-day total 19% lower than average. Not surprisingly, emissions were 11mt lower than in 2005 and 5% lower than normal. It is worth noting that while "normal" weather varies only very slowly, so-called "weather normalized" emissions will vary from year to year depending on the price of underlying fuels.

Companies that hedge out their expected emissions are typically left long allowances in a mild winter and short allowances in a cold one. The EU allowance market is, in theory, sufficiently large to not be influenced by any individual country's weather. However, temperature departures from normal in Germany are closely linked (as high as 90% correlation across the winter) to temperature

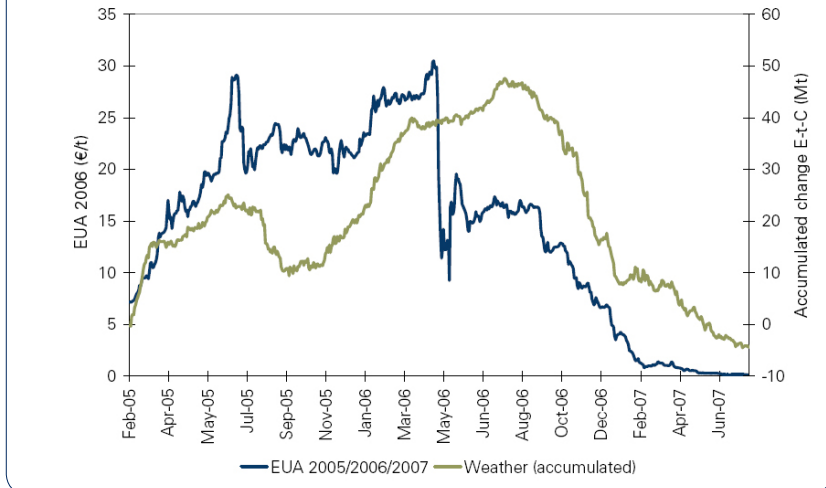
departures over northern Europe. Broader geographical temperature correlation will likely drive allowance prices up during cold spells and down during warm spells once a short market is established in 2008.

Rain in Spain

The second case study relates to precipitation and hydrological conditions in Spain. Spain's electricity sector relies heavily on hydropower. 2005 was an extremely dry year, with total rainfall only 65% of average. In order to compensate for the shortfall in hydropower, fossil-based units, in particular natural gas units, ran more than expected, leading to emissions 6mt higher or 6% higher than in a normal weather year. This extra demand for allowances took place in the face of high allowance prices. 2006 was wetter than average, by 6%, which did not come close to compensating for the shortfall in 2005. The resulting 2mt (2%) excess in allowances held by utilities relative to normal conditions would have been sold at extremely low prices.

Figure 3 shows an accumulated pan-European weather based emissions index plotted against the first phase allowance price. The pan-European weather index is based on the impact of wind, rainfall and temperature departures from average on emissions in 25 European countries. The dry Spanish weather of 2005 contributed to the increase in the weather driven emissions that year, and after a relatively mild fall, cold weather in mainland Europe during the winter of 2005/2006 drove emissions up further. In contrast, the winter of 2006/2007 was milder than average, with reduced demand for fossil-based peak generation capacity. In effect, weather in both Spain and Germany combined to drive emissions, relative to normal, up in 2005 and down in 2006.

Figure 3: Left axis and dark blue line: European Union Allowance spot price in euro/ton. Right axis and green line, accumulated change in emissions associated with weather (temperature and rainfall) deviations from normal, in million metric tons.



Financial Exposure

A dynamic hedging strategy using existing carbon market instruments would require that the volumetric exposure be managed over time by purchasing or selling allowances as the shortfall or excess relative to expectations emerges. The financial risk to a company exposed to weather risk can be assessed from two different viewpoints:

- Absolute (simple) weather: Higher emissions represent an incremental cost since extra allowances have to be purchased on the spot market. Lower emissions represent a benefit since the excess of allowances can be sold off for a profit.
- Relative (compound) weather: The variance arising from both higher and lower emissions is exacerbated by the "correlation blade;" Assuming positive weather to price correlation, the allowance shortfall has to be purchased at a price above expected values, and the excess sold off at a

price below expectations. In both cases, the sharp edge of this "blade" of correlation creates a worse financial loss (or smaller financial gain) relative to budgeted values.

Absolute or relative weather exposure can conceivably be managed with weather-based instruments; we will first consider "absolute" weather risk management. The financial cost or benefit for a fictive entity responsible for 5% of Germany's power sector emissions is calculated from the product of seasonal emissions shortfall or excess and prevailing EUA spot prices. This strategy assumes that the expected level of emissions is either covered by the allowance allocation, hedged by using the forward markets, CER/ERU purchases or a combination thereof. During the winter of 2005/2006, this fictive entity would have had to purchase 570,000 tonnes over its expected allowance budget of 6.9mt (+8.4%) at an average price of 23€/t for an overall cost of 13.9 million €. In 2006/2007, the 320,000 tonnes excess (4.4%

below weather normalized emissions) would have been sold off at very low prices, for a net gain of 470,000€. This financial exposure represents the baseline relative to which the efficacy of the weather based hedges will be assessed.

To extend this German example, the financial impact to a fictive entity responsible for 5% of Spain's emissions was as cost of 4.3million € (a shortfall of 5.7mt or 5.7% of emissions at an average cost of €18/t) against a gain of only 530,000€ in 2006 (a surplus of 1.7mt or 1.7% over "normal" emissions at an average cost of €17.3/t).

The negative financial consequences in both Germany and Spain might appear at first to simply a case of bad luck: higher emissions took place during a high price period and lower emissions during lower prices. The consequence of the emission data release of spring 2006 and phase I over-allocation is clearly unique and not expected to be repeated in the forthcoming phases of the EU ETS. However, removing the singular regulatory impact still leaves the "correlation blade" phenomenon, which cuts both ways against a hedger. Commodities markets with positive weather to price correlation, such as power, natural gas or emission

markets, will most often see negative financial consequences of volumetric risk: positive demand (or negative supply) volume deviations drive prices upwards relative to expectations while negative demand (or positive supply) deviations drive prices down.

Financial structures designed to manage weather risk in the carbon markets

Having established a financial exposure framework, we now can outline a number of approaches to managing weather exposure to the EU ETS volume and price variability. The simplest form of hedge is based solely on weather indices, temperature or rainfall, leaving out the price component of the EUA. While cost effective and perfectly suitable for managing the volumetric component of the risk, pure weather hedges fail to address the additional component of contingent price risk. Engineering a more elegant "quanto" hedge creates a payoff which addresses the combined exposure to weather and EUA market prices.

All structures assume that participants have hedged their initial expected allowance exposure, whether

through allocation, by purchasing EUAs on a forward basis or by buying CER/ERUs. This leaves companies exposed to weather-driven deviations starting from this expected level.

Pure Weather Hedge

A weather swap pays the swap buyer if the number of degree days exceeds an agreed-upon swap level. In the German case, the winter temperature swap would be indexed to the number of cooling degree-days during the November through March winter season in Germany. If temperatures are colder than anticipated (HDD deviations > 0) the swap buyer receives a payoff proportional to the HDD deviation. For example, if the normal winter HDD level is 2215 and a cold winter leads to a greater degree-day total, for example 2459 in 2005, the payoff is proportional to the difference between actual and normal weather (2459 – 2215 = 244) if the structure is based on seasonal deviations. Conversely, in a mild winter, the swap holder pays the entity from which it bought the hedge an amount proportional to temperature deviations.

This structure is typically crafted at a mutually agreed strike level based upon historical and market views of expected "normal" weather conditions and some risk margin for the seller. The notional amount of the weather hedge (monetary payment per unit of deviation, and total potential monetary payment by either side) is fixed throughout the period and would be calculated at inception by considering the prevailing EUA price and the historical relationship between emissions and temperature, namely by calculating a ratio of average marginal emissions per heating degree-day. The payoffs associated with a weather swap structure in the German and Spanish case studies, and how it relates to the actual exposure of the representative

Table 1: Absolute vs. relative financial risks associated with weather exposure.

Emissions deviation	> 0 (cold winter, dry year)	< 0 (mild winter, wet year)
Absolute financial risk	Net cost (purchasing allowances)	Net profit (selling allowances)
Price deviation relative to expectations	Cost of allowances more than expected	Yield from allowances less than expected
Financial risk relative to budget	Loss relative to budget	Loss relative to budget

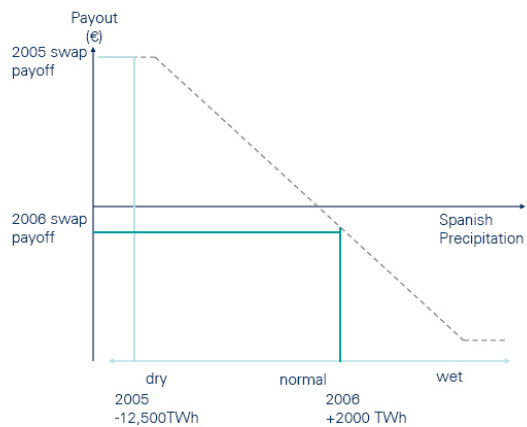
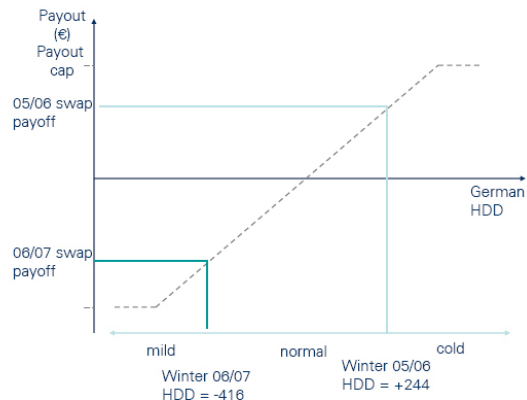
entities, is shown in the following table.

The notional is calculated as 5% of the total emissions from observed emissions per degree-day for the winter season multiplied by a representative EUA price prior to the season start. The 2005/2006 payoff is satisfactory (it compensates the generator buying the swap for slightly more than its cost of additional emissions). However, in 2006/2007, a meaningful loss is incurred as the terms of the swap require a much larger payment than the company receives from selling excess allowances, due to a drop in prices observed during that season.

The payoff for the Spanish structure is relatively satisfactory in both cases. However, this is partly coincidental. The largest precipitation deviations took place in 2005 during a period of high EUA prices. The financial exposure in 2006 was much smaller because of lower EUA allowance prices; the weather hedge happens to pay off smaller amounts because precipitation deviations were much smaller than in 2005.

As long as the correlation between variability in weather and emissions volume remains strong and assuming a constant price of allowances, hedging in the form of a weather swap is an effective tool to manage the absolute volumetric component of the risk. Because allowance price variability is often linked to weather, a pure swap does not offer effective management

Figure 4: Illustration of the payoff structure of a weather swap as a function of the weather driver: heating degree-day or rainfall



What is a quanto?

A quanto typically refers to a type of derivative in which the underlying is denominated in one currency, but the instrument itself is settled in another currency at some fixed rate. In this context we refer to a derivative which has one underlying (weather) index which is settled in another (financial commodity) index at a formulaic rate.

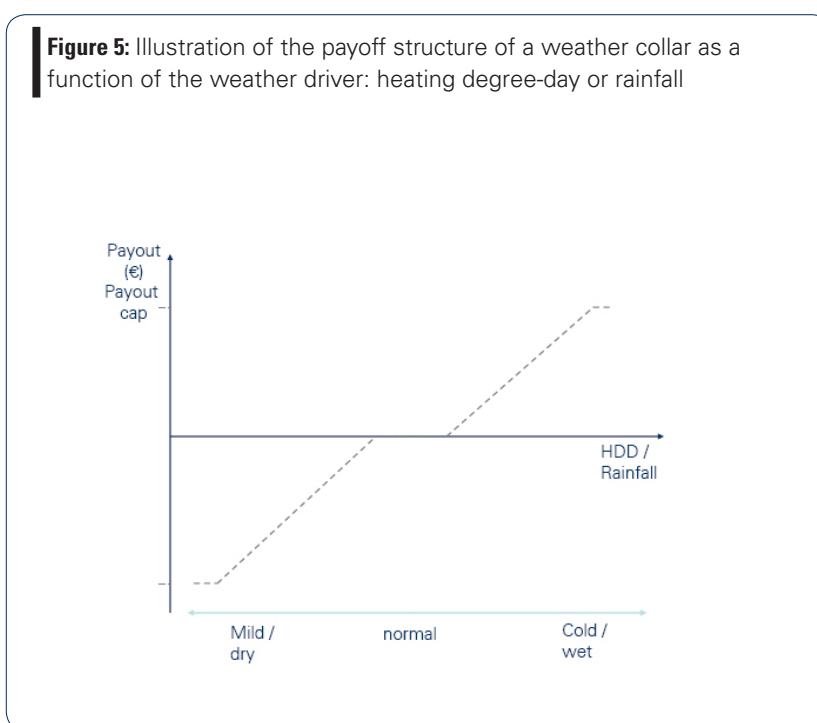
Quantos have, for example, been used to manage the joint volumetric and electricity price risk of hydroelectric utilities.

of all the financial exposure. This relative hedge effectiveness (“basis risk”) can be calculated during the structuring process by looking at the payoff of the swap relative to the actual exposure across a range of potential scenarios and optimizing the structure accordingly to minimize any mismatch in payoffs.

Two case studies are insufficient to draw many conclusions about the effectiveness of weather hedges in dealing with supply side risk (precipitation in our case) relative to demand side risk (temperature). The relationship between temperature and electricity demand and by extension emissions volume is, however, almost linear, especially in the winter, favoring swap-like hedging approaches. The relationship between rainfall deficits and emissions is more complex, partly because of storage capability of hydro facilities, but also because alternative ways of generating electricity can range from relatively low emitting natural gas to high emitting coal. Clearly there are many more specific complex situations where supply or demand can be impacted by shorter term weather impacts, and for which a more tailored hedging structure would be more effective.

Weather Collar

Swaps are the most basic form of weather hedge, and useful for examples per above. In many instances a hedger may prefer to purchase simple shortfall protection (a put on rainfall or degree days) which requires payment of an upfront premium in return for specified downside protection (roughly akin to insurance against adverse – higher-than-expected emissions volume – events). Another alternative which



combines aspects of a weather swap and option is a collar. By combining the purchase of an out-of-the-money weather call and the sale of an out-of-the-money weather put, the premium cost of a collar remains low or zero as long as the option strikes are evenly distributed around expected weather conditions. This structure allows the hedger to take advantage of the “sharing” / bounding of both upside and downside variability offered by a swap, but also to manage only large deviations from normal (as typical in an option / insurance structure) while

retaining the risk for more or less average conditions.

The collar strike in this example was set 20 degree-days out of the money for each month of the winter season. The results are in fact quite similar to the swap payoffs discussed above, largely because the heating degree-day deviations in the two winters analyzed were both large and of a similar order of magnitude. The Spanish case, in which precipitation deviations were much larger in 2005 than 2006, shows how the collar can protect downside risk under extreme conditions, while leaving close to normal conditions unhedged. The swap is indexed off of precipitation quantities, which have themselves been converted to an equivalent quantity of electricity generation. Only deviations of 7000TWh on an annualized basis, or 20%, above or below normal quantities are protected by the collar structure. In 2005, the rainfall departure was 35% below normal and the hedge is an effective protection tool. The rainfall surplus in

Table 2: Weather departures and swap payoff for German winter HDD exposure

Germany	Heating degree-day departure	HDD departure as percent of normal	Swap payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	244	+11%	16,100,000	-13,900,000	116%
2006/2007	-416	-18.8%	-15,100,000	470,000	4000%

Table 3: Precipitation departure and swap payoff for Spain rainfall exposure

Spain	Precip. departure (TWh)	Precip. departure (% normal)	Swap payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	-12,500	-35.7%	3,700,000	-4,300,000	88%
2006/2007	2000	+5.7%	-600,000	530,000	113%

2006 is not sufficient to trigger the collar payoff.

Combined Weather and Emission Hedges

In markets where there is a strong relationship between variability of weather and carbon price, pure weather hedges will be less effective as they are only successful at covering the volumetric portion of the exposure, leaving the price component of the risk unmitigated. Introducing the second, compound variable into the payoffs of the hedging structure (quantos) can result in a much more effective structure for the hedger. Quanto structures are defined in the textbox on page 9.

The quanto structure discussed here is simply an extension of a basic weather swap, though the same concept can be applied quite easily to an option or collar. Instead of a fixed notional value expressed in €/HDD, the structure pays out an amount proportional to the EUA price as well as the weather deviations (EUAs/HDD). The seller of the quanto protection structure is thus taking on both weather risk and EUA allowance price risk, thereby likely increasing the payoff to the seller in return for removing the "correlation blade" impact.

Given the typical direct relationship

between increasing volume and price of emissions, this structure provides excellent protection to the purchaser. Figure 6 illustrates the three-dimensional nature of the quanto hedge: the two horizontal dimensions EUA price on the one hand and the weather variable on the other. The payoff is represented in the vertical direction.

The winter 2005/2006 German payoff to the quanto buyer is similar to the basic weather swap. The cost of the structure in 2006/2007 is however only 25% of the cost of the swap. This reflects the drop in prices that took place during the end of 2006 and highlights the greater

hedge effectiveness of this type of structure. The hedge is, however, still not perfect when compared to the observed exposure, primarily because the correlation between weather and emissions deviations is not perfect and cold weather departures have a proportionally greater impact on emissions than mild weather.

The Spanish case has a payoff which falls off in 2006, in particular when compared to the reference case, reflecting the drop in allowance prices and reducing the payoff to the buyer of the quanto hedge.

The choice of the appropriate hedge depends primarily on the expected correlation between weather and emissions on the one hand, and emissions and price on the other. Weather and emissions tend to be highly correlated on a regional basis. Expectations of a low level of correlation between regional emissions deviations and EUA prices favors the cheaper weather hedges, while an expected high level of correlation favors the quanto payoff linked to both weather and allowance prices.

Table 4: Collar payoff for both German and Spanish case studies

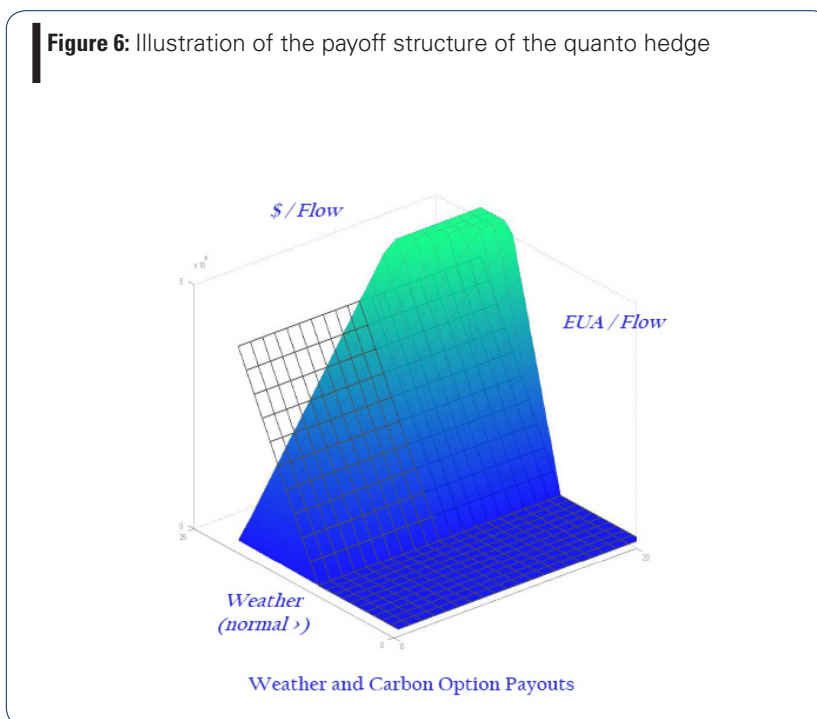
Germany	Heating degree-day departure	Collar payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	244	14,700,000	13,200,000	112%
2006/2007	-416	-18,900,000	-315,000	4000%

Spain	Precip. departure (TWh)	Collar payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	-12,500	2,700,000	4,700,000	53%
2006/2007	2000	0	-530,000	0%

Conclusions

The carbon and weather markets are two of the world’s fastest growing commodities markets, with increasingly sophisticated market participants offering new and creative risk management approaches.

Phase II of the EU ETS is expected to be in an approximate supply and demand balance, with the allowance shortfall created by the allocation process balanced by the supply of credits from the Kyoto mechanisms. This leaves the market particularly exposed to daily fuel and weather impacts, but also creates opportunities for risk transfer, as capacity providers offer structures that assist end-users in mitigating these risks. A few sample structures were discussed in this report, from simple weather linked swaps to the more complex quanto structures, which pay out as a function of both weather variables and EU allowances. The simple weather structures have a transparent payoff tied only to independently measured weather variables, but do not address the anticipated “correlation



blade” effect: cold or dry conditions are likely to lead to higher allowance prices and mild or wet conditions to lower allowance prices. The more complex structures take into account this anticipated correlation

from the outset by providing a payoff in allowances and providing higher quality hedges to end-users.

Corporate hedging rationale and enterprise benefits from hedging external exposures such as weather risk are well articulated and understood. We fully expect structures like the weather - commodity quanto, which has to date only been executed on a limited basis, to be offered and used more broadly and particularly within the emissions markets.

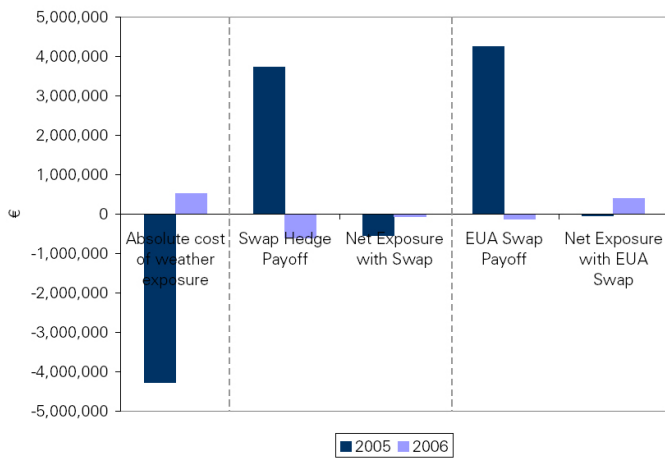
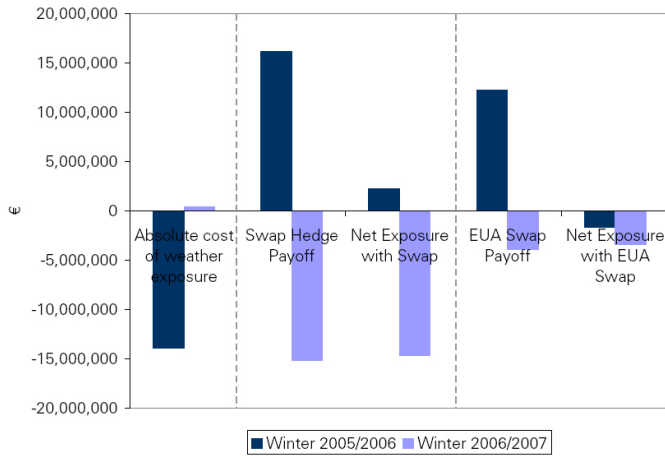
Both Point Carbon and Nephila felt that this research report could provide a springboard to initiate dialogue to provide better hedging products as these new markets continue to grow.

Table 5: Quanto Hedge payoff for both German heating degree-day and Spanish precipitation case studies

Germany	Heating degree-day departure	Quanto payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	244	12,200,000	-13,200,000	93%
2006/2007	-416	-3,800,000	310,000	820%

Spain	Precip. departure (TWh)	Quanto payoff (€)	Actual exposure (€)	Payoff as fraction of exposure (%)
2005/2006	-12,500	4,200,000	-4,700,000	99%
2006/2007	2000	-120,000	530,000	23%

Figure 7: The first bars represent the unhedged cost of weather exposure. The following bars represent the payoff of the swap and quanto structures as well as the remaining financial risk



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About Nephila Capital

Nephila Capital Ltd is a leading
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 investing in instruments such as insur-
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 bonds, insurance swaps, and weather
 derivatives.

The company has been managing
 institutional assets in this space since
 it was founded in 1998 and has over
 twenty employees all based in their
 Bermuda headquarters.

Nephila manages a dedicated
 weather risk fund (Nimbus Weather
 Fund) that was launched in January
 2005.