GONE WITH THE WIND

AN ASSET MANAGER'S GUIDE TO MITIGATING WIND POWER RESOURCE RISK

February 2017 Report

GCube
Renewable Energy Insurance

FOREWORD

Resource underperformance is often the most significant risk faced by a renewable energy asset owner, and yet it has habitually been the least mitigated. For wind and other renewable energy sectors, the revenues forgone during unpredicted lulls are frequent and significant. In light of recent advances in the product and its delivery, purchasing weather risk cover has now emerged as the preferred solution for diligent asset managers seeking to stabilise returns. This signals that the renewable energy industry is now reaching maturity and embracing hedging mechanisms which are common financial practice in other fully developed markets.

Weather risk cover has existed since the late 1990s (when the weather derivatives market launched); but it is only now – with the development of longer contract periods, advances to settlement indexes, and project-specific product tailoring – that the market has begun to build serious momentum. The emergence of over-the-counter (OTC) offerings, which incorporate advances like turbine-by-turbine wind speed analysis, and the popularity of premium neutral structures, have combined to make products that are both reliable and affordable in a way they never were before.

'Gone with the Wind' is the seventh in a series of GCube reports. The previous six focused on renewable energy downtime events. This report differs slightly, as it will focus on weather underperformance risks, which can cause lower energy outputs and therefore revenues. Concentrating predominantly on wind power, it will run through the weather risk transfer products available to mitigate this risk.

As with previous reports, it will be shared exclusively among GCube's insureds, which collectively represent 15% of the global installed wind power capacity, located in 35 countries. The report uses a blend of GCube's proprietary data, technical expertise and publicly available market information, as well as in depth interviews with key stakeholders. In particular GCube would like to thank Vaisala, Infigen, Kim Diamond, and REsurety for their time, perspectives, and contribution.

We strongly encourage our insureds and supporting brokers to provide suggestions and improvements for future editions, as well as ideas for new publications. We empower our insureds to leverage the benefit of GCube's data, expertise, and industry contacts to minimise all their renewable energy asset risks. Once again, we hope 'Gone with the Wind' will expand opportunities for further collaboration and demonstrate GCube's ongoing commitment to support our insureds.

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*Terms in bold throughout the report are included in the glossary

OVERVIEW

Developing, generating, and delivering electricity from renewable energy assets is a process beset with financial risks. In response, the market has developed a range of methods for mitigating these risks. The reliability of turbine, panel and other technologies has improved, and the risk of malfunction or damage to them has been covered by insurance products. As the impact of these threats to profitability has increasingly been managed, the industry has become progressively more aware that the major remaining obstacle to achieving bankable renewable energy is the risk of resource underperformance.

In the wind energy sector, in particular, underperformance now represents the biggest challenge that stakeholders face during the lifetime of a project. Concern about the financial impact of wind speed fluctuations has grown. This is partly as a result of the realisation that financial strife is still a common and real threat in spite of improvements to the reliability of technology and the standardisation of practices to protect it.

Most significantly, however, this is because many wind projects are failing to generate wind energy outputs that were forecast by resource analysts prior to their construction. This ties in to the experience of regions with large wind fleets, where widespread wind lulls have affected entire portfolios. These resource shortfalls often form part of wider climate change trends, which were unforeseen when projects were first developed.

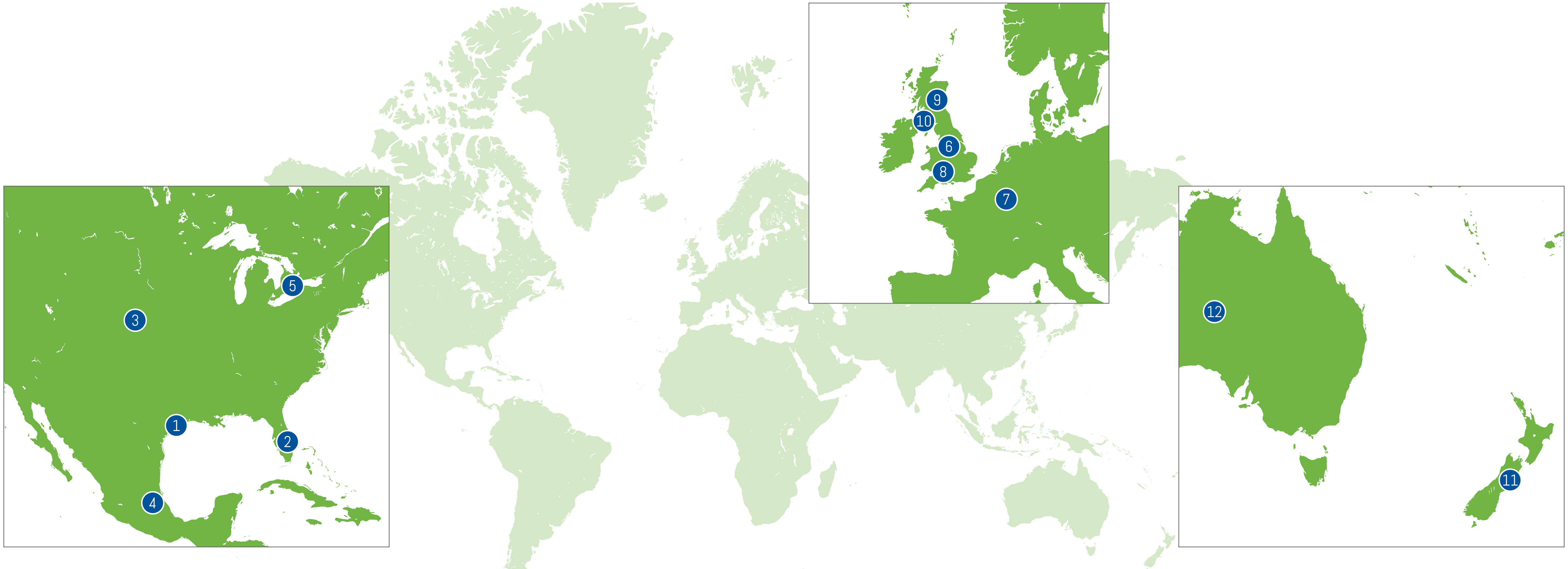
These growing concerns have coincided with major recent advances in the ability of insurers to provide reliable and affordable protection for periods of renewable energy asset resource underperformance. Improvements to data measurement and analysis mean that both insurers and **insureds** are now confident that weather risk transfer products will provide compensation for underperformance precisely when that underperformance occurs. Further, the availability of longer contract terms (often up to 10 years) has made near life-cycle project cover possible.

These advances have brought about the emergence of an efficient and growing market for weather risk reallocation. There are many parties who are attracted to taking on weather risk because it is uncorrelated with financial markets and it is mean reverting. This has brought about a **Pareto optimal** improvement (for both asset owners transferring weather risk, and insurers accepting it) as a more efficient allocation of resources is realised via market forces.

Across 430GW of global installed onshore and offshore wind capacity, GCube estimates that there is an unrealised value of USD 56 billion due to a failure to efficiently transfer weather risk. To put that into context – for a 50MW onshore wind farm worth USD 80 million the average value increase achieved by successfully transferring weather risk is USD 5.8 million.

The degree of value creation will of course vary significantly from project to project, and as such the figure is only illustrative – however it does serve to highlight the magnitude of the untapped value. The common measure of value we are using is **Net Present Value (NPV)**, and the increase will depend on a wide variety of factors including: the site's wind and electricity regime (the more volatile the greater the potential for value creation), the applicable tax regime, the potential reduction in the cost of equity, and the acknowledgement by lenders of the value of the product for stabilizing debt service. Increasingly holders of wind volume risk are executing risk transfer agreements to harness one or more of these sources of value.

THE VOLUMETRIC RESOURCE PROBLEM: SELECTED NEWS STORIES



North America

Key	Date	Market	Risk Category	Details
1	February 2008	United States	Wind	Loss of wind causes a Texas power grid emergency as energy production falls by 82%
2	2012 – 2015	United States	Wind	Fitch progressively downgrades FPL (Florida Power & Light Energy) due to wind underperformance, from BBB- in January 2012 to BB in December 2012
3	September 2015	United States	Wind	US wind farm generation falls by 6% in spite of capacity increasing by 9% over 6 months
4	February 2016	Mexico	Wind	Many regions of Mexico see wind speeds up to 20% below average in 2015
5	May 2016	Canada	Temperature	Hydro One revenues fall by USD $122 million as a result of a mild winter and storm-related costs

Europe

Key	Date	Market	Risk Category	Details
6	March 2011	United Kingdom	Wind	REG attributes a £1 million earnings shortfall for its 41MW portfolio to abnormally low wind speeds
7	2014 - 2016	France, Germany	Wind	Moody's progressively downgrades Breeze Finance due to wind underperformance, from Ba3 in December 2014 to B2 in November 2016
8	August 2014	United Kingdom	Temperature	E.On sees profits fall by 31% (£85 million) after a mild winter
9	November 2014	United Kingdom	Wind and Temperature	Energy giant SSE blames the weather as it reports a loss of £17 million
10	July 2016	United Kingdom	Wind	Scottish Power profits fall by around £40 million over six months due to less windy weather

Australasia

Key	Date	Market	Risk Category	Details
11	August 2008	New Zealand	Wind and Rainfall	TrustPower confirms USD $15-10 million downgrade after lack of wind and rain
12	January 2015	Australia	Wind	Infigen Energy revenues fall by 23% due to low wind speeds

THE RISK TRANSFER PRODUCT

Explained simply, the weather risk transfer (WRT) product provides cash in years of resource underperformance. So, when a renewable energy project suffers from a year of low wind, irradiance, or water volume, the product will pay out. The buyer of the product will be able to determine: a) how they pay for this cover (i.e. via a premium or by giving up profits in years of plenty), and b) what constitutes an unfavourable period of wind, irradiance, or water. These factors will be explained in what follows.

Covering reductions in demand for energy

Most of this publication focuses on the risks associated with resource underperformance reducing the amount of energy generated. For example, when the wind does not blow as much as expected a wind farm will generate less electricity, and therefore less revenue. However, the product can also serve to protect against reductions in demand for energy. For example, if an energy company suffers lower demand as a result of mild winters, cool summers, or excess wind, irradiance, or water, this is a risk that can be covered. The product will simply be structured so compensation is triggered whenever the weather surpasses the defined weather threshold

Settlement

Because the product is **parametric**, the scenarios under which compensation will be due are clearly stipulated in the contract. This ensures that there is complete clarity when it comes to settlement. The payment due is settled within days of contract expiry. The relevant data is measured by an independent third party and applied to the contractually predefined triggers to determine the settlement amount. This differs from indemnity-based insurance in which complicated root cause analysis and loss adjustment is often required in order to determine whether and how much compensation is due. Effectively, parametric settlement is straightforward, transparent and quick.

Barriers to adoption of WRT and potential solutions

Barrier	Solution
Limited understanding of costs/benefits by operators, notably those in risk/insurance management roles.	Insurance and risk management professionals are increasingly becoming informed about and convinced of the efficacy and importance of weather risk mitigation strategies. Standardised terminology will remove further barriers to understanding.
Limited financial incentives for advisers/intermediaries/brokers to offer products, particularly those which are premium neutral.	Promote understanding that commissions are standard in this market, and are not typically based on premiums (which are often zero), but taken as a percentage of annual cash settlement limits.
Unlike traditional property & casualty insurance, lack of resource is not yet a standard requirement imposed by regulators, lenders or lenders' insurance advisors.	It is becoming more and more common for lenders and advisors to look favourably upon the acquisition of weather risk transfer products.
Awareness of the financial impact of resource risk on renewable energy operators is limited, and industry bodies/trade associations wish to avoid possible negative press from such findings.	Greater willingness of operators to disclose deviations from annual energy production, particularly where resource underperformance has been a significant contributor, and where this has resulted in tangible financial strife.
Attitude of operators has been to seek protection after a significant revenue shortfall, demonstrating that buyers tend to focus on personal experience rather than their wider peer group.	Again, this reactive approach is diminishing as operators are becoming more sophisticated and are proactively securing their futures before shortfalls can have a negative impact.

Recent significant developments in weather risk transfer market

Reductions in **basis risk** - improvements in data collection and analysis means that **payment triggers** can now be based upon on measurements of the actual production of projects (adjusted to exclude non-resource driven events) or on ideal production which uses the SCADA data from the generating assets themselves.
Increased contract lengths - the recent availability of long term contracts, typically of up to 10 years, are better able to match loan tenor lengths, and to sync with project life cycles.
Decline of the contingent PPA - until recently contingent PPAs were the standard method of mitigating price risk. As these PPAs have become less common the weather exposure now includes the timing (shape) and price of generation, as well as the total generation. This is something new in the wind industry, which has seen an increase in interest in weather risk transfer as a means to alleviate volatility.

PRODUCT STRUCTURES

The WRT product can be tailored to the preferences of the buyer and the structures available to them are outlined below. In order to illustrate how these structures would work in practice, the following hypothetical wind farm will be used as a case study:

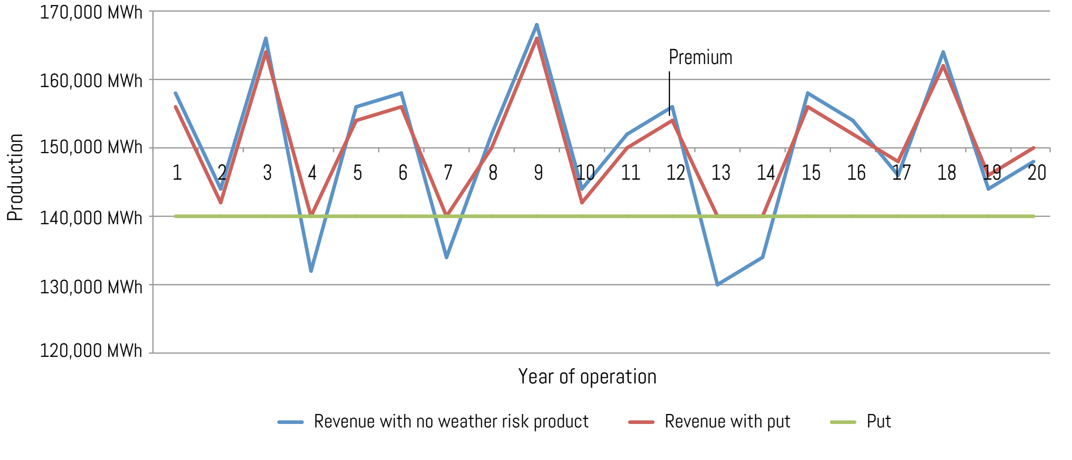
CASE STUDY

- 50MW wind farm in the US
- Capacity factor of 34%
- Therefore, anticipated production of 150,000 MWh per annum
- Power Purchase Agreement at USD 40 per MWh
- Therefore, anticipated revenue of USD 6,000,000 per annum

Put structure

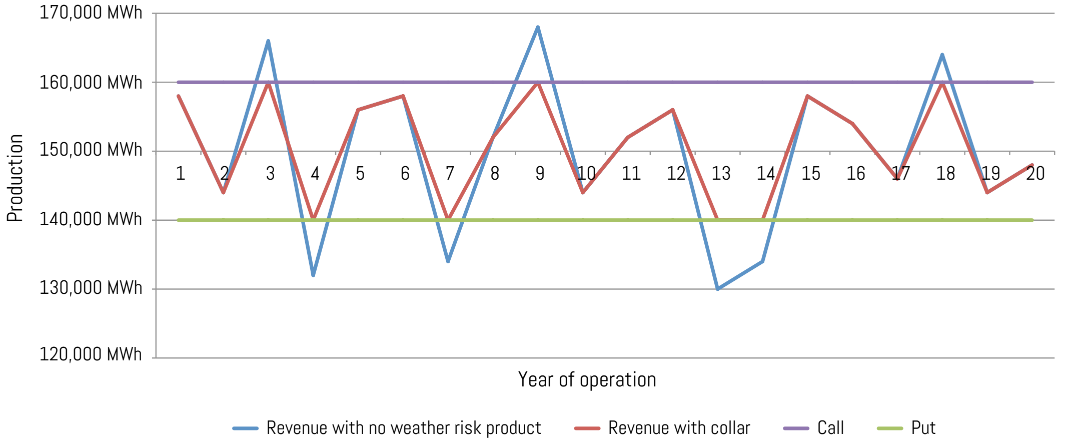
Under the put structure, the buyer pays a premium upfront and receives compensation in years of resource underperformance. What constitutes a year of resource underperformance will be stipulated in the policy contract. This contract will set out a trigger, and whenever production (due to resource underperformance) drops below this trigger, there will be a payout. This payout is proportional to how far production falls below the trigger.

So, if the trigger is 140,000 MWh, and production turns out to be 130,000 MWh, the buyer will be compensated for that 10,000 MWh shortfall. They will be paid 10,000 times the notional payment. The notional payment is the energy price the insured faces, and is stipulated in the contract. In the case study, the notional payment would likely be USD 40 so the compensation paid would be USD 400,000 (10,000MWh times USD 40). The annual premium will depend in part on the estimated probability of breaching the trigger.



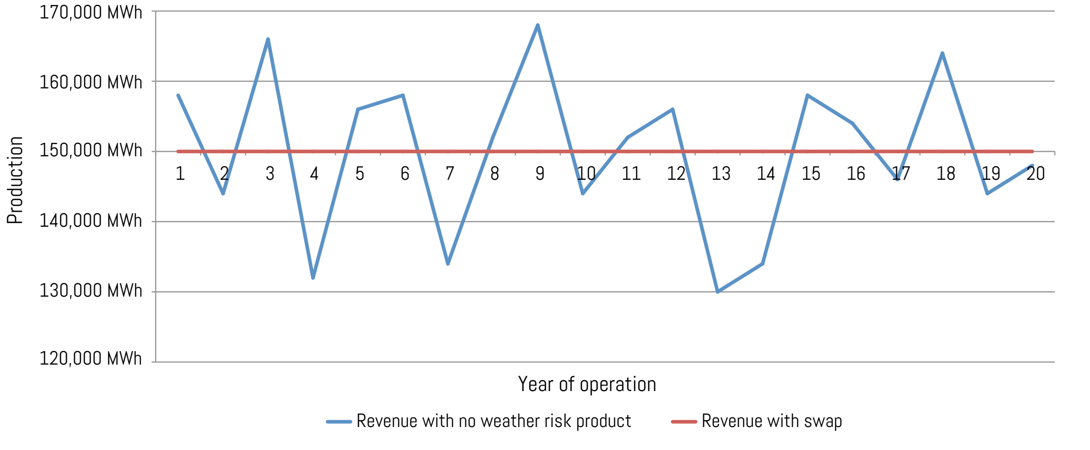
Collar structure

Here, the buyer will pay zero/negligible upfront premium. Instead, in years of resource overperformance, the insured will compensate the insurer (i.e. whenever revenues are above the 'call' – in this instance 160,000 MWh). As with a put structure the insurer will compensate the insured whenever there is resource underperformance (i.e. revenues are below the 'put' – in this instance 140,000 MWh). When revenues are between the call and the put neither party will compensate the other.



Swap structure

Again, with the 'swap' structure, the insured will pay zero/negligible upfront premium. The difference is that, unlike a collar structure, at the end of the settlement period one party will always compensate the other. This is because there is a single trigger point represented by the red line in graph 3. So, whenever revenues are above this trigger the insured will compensate the insurer, whenever revenues are below it the insurer will compensate the insured. This has the effect of providing stable year-on-year revenues; revenues which would be otherwise be fluctuating due to variable resource performance.



Notes & assumptions

These graphs apply to one (hypothetical) wind farm and are illustrative only – premiums and production will vary by wind regime and time period. Insureds can choose how to determine both of these.

GCube's Onshore Risk Seminar at The Shard in London, February 2015

Comparative Overview

	Put	Collar	Swap
Downside protection	The placing of the trigger is flexible – the insured will be able to stipulate any MWh amount that satisfies their preferences and circumstances. Typical structures have exceedance probability triggers of ‘P90’ and ‘P75’	As with the put structure, the MWh trigger for payout will depend on the buyer’s preferences and circumstances.	The trigger is typically near the average anticipated production for the wind farm
Premium	Dependent on a number of factors including the trigger point and the notional payment which have been decided with the insured.	Flexible premium (near-zero, depending on the preferences of the insured). This structure will be funded to at least some degree by sacrificing some of the upside, as explained below.	Flexible premium (near-zero, depending on the preferences of the insured). This structure will be funded to at least some degree by sacrificing some of the upside, as explained below.
Upside sacrifice	There is no upside sacrifice with this product except for the annual upfront premium. That is, in years of good resource performance - when profits are expected to be high - the insured will retain those profits in full (minus the pre-agreed premium).	When revenues are above the call, the insured will compensate the insurer. However, because there is a gap between the call and the average anticipated revenue, there will be years in which the upside is retained.	Windfall gains are sacrificed in exchange for guaranteeing near-expected revenue
Revenue certainty	‘Floor’ placed on revenues.	‘Floor’ and ‘ceiling’ placed on revenues.	Structure designed so that no revenue fluctuations due to resource variability will occur, thus granting high revenue certainty.

CALCULATING REVENUE

The structure settlements are based upon calculated revenue. The revenue is determined by the MWh production of the project(s) and the payment they receive per MWh. There are three ways of determining this MWh production. These are set out below. Similarly there are a number of options for determining what the payment per MWh is (i.e. notional payment). These are also outlined below.

Calculating production (converting wind speeds into energy output)

There are three methods of turning wind speeds into (proxy) production.

Synthetic wind speed – wind data at the wind farm location is converted to production using the appropriate power curve for each project. The data will not be trained against onsite wind speed and/or actual historical production. However, since the resulting theoretical production generally correlates with actual production at an annual scale, the data can be used to settle a transaction

Actual metered production – this is adjusted to exclude performance and availability losses, and curtailment, which are treated as operational risks to be retained by the asset owner. Settling on actual metered production internalizes all geographic and weather driven effects (i.e. wind shear, turbulence intensity, air density, wakes effects, etc.) and losses, accurately capturing the timing of production. This calculation therefore has less basis risk than synthetic wind speed.

Ideal production – this is determined by nacelle-based wind speeds observed at every single turbine and converted to production output using either the manufacturer’s power curve or non-empirical power curve supplied by the asset owner. This calculation also has less basis risk than synthetic wind speed.

Setting the energy price (thereby determining the notional payment)

This proxy production, which will be a MWh figure, must be multiplied by a power price in order to calculate proxy revenue. The buyer can stipulate whether they want this power price (i.e. the notional payment) to be:

- fixed e.g. if they have an existing Power Purchase Agreement (PPA)
- the spot market power price
- a weighting of the two

Spot market price triggers

The product can also build in double triggers in which there is a volumetric trigger, and a spot market price trigger. For example, if a utility with a large renewable energy portfolio has agreed to provide a certain MWh quantity of energy then they will be particularly financially vulnerable to periods of low wind and high spot market prices. This is because they will not be generating enough energy from their own portfolio, and so will have to purchase energy on the spot market to meet their supply contracts. If the energy they have to buy is expensive, they will suffer. As such, a weather risk transfer product can be designed to pay out when wind across that utility’s portfolio is lower than expected, and when the spot market price rises above a certain price.

Indeed, the product can be structured so as to cover volume risk only, or some combination of volume, price, and revenue risk (as above).

FINANCIAL BENEFITS OF WEATHER RISK TRANSFER

The financial benefits of acquiring weather risk cover generally fall into two categories. The first category covers the benefits that can result during financing or refinancing. The second covers the broader benefits of smoothing revenues.

(RE)FINANCING

Because the product effectively guarantees that a wind farm will always earn a minimum revenue in spite of the variability of wind speeds, borrowers can apply less conservative estimates about its minimum expected revenue. As such, they are able to offer more favourable debt service coverage ratios. This enables the asset owner to use more debt and less equity, which, in turn, can improve the internal rate of return and tax shielding benefits.

Furthermore, lenders and investors can be more confident in the covenant of the borrower and offer lower lending rates in light of the additional security the WRT product provides.

BROADER BENEFITS

Other buyers of protection are motivated by risk aversion. Smoothing year-on-year revenue can have multiple benefits, which include:

- Fostering investor confidence
- Minimising weather linked share price volatility
- Ensuring debt repayments are met
- Avoiding profit warnings
- Guarding against ratings downgrades by Rating Agencies

Photo courtesy of Bart Sadowski / Shutterstock, Inc

ADDING VALUE: THE DECISION TO BUY

INTERVIEW: DAVID KRSEVAN
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Who are Infigen and what do you do?

Infigen is a developer, owner and operator of renewable energy assets in Australia. We currently own six wind farms and a solar farm with a combined capacity of 557 MW, located across New South Wales, South Australia and Western Australia. In addition, we have interests in an extensive pipeline of renewable energy projects - 1200 MW in total - covering large-scale wind and solar across five states in Australia.

We were formed in June 2003, but listed on the stock exchange in October 2005. In terms of size, we are still a modest company, and employ about 60 people at the Sydney head office.

Who and what were the key drivers that led to the decision to buy weather risk cover in 2015?

One of our core mantras is to constantly look for opportunities to make our revenue more predictable and stable across our portfolio, but at the same time also retaining the upside of good production or market conditions. So we had been looking at a number of different products for a few years.

At the end of the day, the contract that we actually executed was one that we co-developed with a large reinsurer - and that was the result of a lengthy process of developing an appropriate mechanism that delivered the desired outcome for us. In the end, it was a portfolio product, across all of our wind assets.

You might expect this kind of product to be of more interest to asset owners who don't have a portfolio, but actually we've been seeing demand from companies with significant portfolios like yourself – why might this be?

I would say there are probably a few reasons why demand is not exclusive to young companies that generally don't have a portfolio. Australia is already a pretty big market and our portfolio extends across multiple regions, so we do already benefit to some extent from geographical diversification.

However, having access to in-house skill sets and resources enables larger companies to assess and identify opportunities to participate in weather risk transfer products more readily. A company with just one wind farm for example, may not be able to commit the intellectual capital, time or resources to assess products and make an informed decision to participate. For larger companies with a portfolio of assets, they are more likely to be able to do this.

That said, if smaller companies did acquire this sort cover, it may mean that they don't have the same motivation to expand for the purposes of portfolio diversity; they can operate a portfolio of just one or two assets, secure in the knowledge that their revenue flows will stay predictable within the limits of the product entered into.

Was your motivation for buying this cover purely risk aversion, or were you hoping to achieve better terms on (re)financing?

While we understand that there could be some benefit to people that want to refinance - or perhaps even want to finance a new asset - in this case our need to underpin a minimum level of cash flows from the portfolio was the primary reason. The decision was based on a desire to manage risks within the wind portfolio. It was a short-term (12-month) deal. Obviously if you're looking at refinancing you would probably seek a longer-term product. On both sides it involved 'road-testing' the product to see if the structure in question worked and was viable to look at again for a longer period in future.

What advice would you give to one of your peers considering their exposures to sustained low wind speeds and resource risk?

The important part is really investing the time to drill down into and assess the risk profile. That's the first point. The second point, once you've reached that stage, is actually working with your insurer to find a structure that works for both sides.

You must also know how resource variations are actually affecting your revenue streams. This will involve looking at both interactions with market prices, with other contracts you have in place, and also other operational risks you have in your portfolio. Another important point that we spoke a lot about when formulating the product was basis risk; making sure that the product didn't expose us to underinsured basis risk in terms of the contract pay out versus our revenue structures.

We spoke to a number of insurers and underwriters, enabling us to work through the high-level concept with a number of players. Once we had filtered the shortlist, there was a lot of work still to be done after the initial structure had been agreed to actually document and agree the delivery mechanisms.

We understand you based the structure on actual energy production rather than synthetic wind speeds or other potential settlement methods. Why?

The contract was settled off a measure closely related to actual energy production. Obviously the structure itself includes some specific contract mechanisms, so it is not as simple as just looking at the naked energy production. There were several layers of structure within the product itself. But, as you say, it was not based on a wind index like a satellite measurement or a separately measured wind index from somewhere off-site.

How could the market make procuring lack of wind cover easier?

We found that you have to build up a fair amount of understanding in terms of what your risk profile is and what types of low wind risk might manifest as issues for a particular company. You could probably identify 4 or 5 different ways that low wind might be an issue for your assets, and a number of different ways you might want to look at protecting them.

For smaller companies with limited resources it may be difficult to achieve a thorough initial understanding of what those risks are and what sorts of cover might be available. So, for the insurance market, making procuring risk transfer easier will, to a large extent, come down to helping clients reach that thorough understanding.

This could involve standardising some of the terminology, or the ways these risks are talked about. In addition, this would help to build that knowledge of what the risk types are, what type of product structures are available, and what sort of indices can be used to settle them.

From our perspective, having gone through the process of talking to a number of underwriters and looking in depth into what sorts of areas we would like to cover for our business, it's evident that the product will always need to be bespoke in nature. If you go back a couple of years, the Chicago exchange weather derivatives had a very high amount of basis risk because they were highly standardised. As such, it is likely to be a balancing act of standardising concepts where possible, while retaining the ability to tailor products for each client.

Would you say weather risk transfer products are more complex than traditional insurance products covering property damage?

It can be argued, especially from the clients' side, that the complexity is probably a bit higher for weather risk products. The way they interact with revenue streams is different from outage protection, for example. Outage protection is pretty standard and fairly simple to understand, including how it might affect your revenue, whereas, with these kinds of resource-based products, it can be a bit more complicated for the client to get an accurate picture of how they will impact revenue flows and therefore the precise value they offer.

Looking at the traditional insurance industry, there is standardised language, and standardised types of risks that are put into various baskets. With weather risk, there is always going to be a bit more complexity, but the sector could move further towards having common descriptions of similar types of risks.

Would you agree that one advantage of weather risk products is that the settlement process itself is much more simple?

I agree. The documentation is quite detailed, so the process of settlement becomes relatively straightforward because a lot of time has already gone into documenting mechanisms and actually building the spreadsheets. It's probably fair to say that we spent roughly as much time analysing how to create a settlement structure that functions correctly as we did analysing the underlying risk itself. But you don't have concerns like bringing in independent engineers, and, once you have the structure set up, the settlement process is pretty simple.

What benefits have there been to transferring weather risk, and, more broadly, what benefits could there be to yourselves or others in the future?

Once you have a product in place, you will have greater revenue certainty, so that you can focus more on actually running the business and making best use of the available resources within it. That means having to allocate fewer contingencies or buffers in forecasts, particularly related to concerns about low production periods. It also leads to greater efficiencies with capital, which allows companies to focus on other areas that create more value. So you can deploy capital to value creation or growth areas with the knowledge that wind risk has been kept in check.

What impact does this, and could this have on (re)financing?

We do think there is potential down the track for weather risk transfer to positively impact financing, because it reduces the effect of resource variations. This is still fairly new ground in Australia – we haven't seen this play out in discussions with financiers or live projects yet, but it's certainly something we'll look at for future projects.

We have, however, heard of smaller, single-asset companies that have secured better financing terms and higher gearing as a result of having similar products. Also if these players are looking at contracting off the offtake for a new asset, this allows them to provide a bit more certainty to the off-taker on the levels of energy they'll be able to contract to. Our understanding is that this has happened for a few operational assets internationally – but it's very new ground globally and to our knowledge, hasn't been done on a portfolio level, only for single assets.

Do you see weather risk transfer becoming an increasingly popular risk mitigation strategy among renewable asset owners?

Absolutely, yes. Looking at the Australian market, the country is geographically diverse, so assets do have diverse resource risk profiles. However, we also have a market that is fairly well integrated across the entire country - the NEM (National Electricity Market) connects a good portion of the country into a single electricity market. Furthermore, national green certificates ensure similar value can be extracted from wind resource across the country. There is already an advantage in being able to spread the resource risk across a nation where the market as a whole is well put together and connected. Initially, when you've got targets of higher renewable penetration and a large number of the players are looking to build one or two assets at a time, it can be helpful to get those first projects underway with a degree of resource protection in place, rather than deploying capital to achieve geographic diversification by building multiple wind farms. You can gain some of these advantages through the use of WRT products.

Why do you think that the product is starting to take off now and hasn't done so before?

I think the origination process is improving. Several products have been successfully implemented, and we're getting a lot of insurers approaching us with different ideas now. This is part of the evolution of the weather risk management market. On top of that, as you get more build of renewables, you have a more liquid market - you are not trading exactly the same thing, but, if insurers are pricing and selling products to a large number of potential customers, there are efficiencies to be gained in terms of how insurers can price the product with regards to margining on their side – which in turn leads to more effective products for customers. It has a snowball effect.

In addition, with more capital going into the market, you need more risk management products to protect that capital. And, with the regulatory space improving, particularly in Australia, the uncertainty surrounding renewable energy targets has settled in the last year or so – translating into more demand for renewable energy assets and as a consequence more demand for these kinds of products.

CAUGHT IN THE WAKE

INTERVIEW: KIM DIAMOND
ATTORNEY, ADJUNCT PROFESSOR, AND CHAIR OF WOMEN OF WIND ENERGY'S
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Tell us about your background in the wind industry and what you do?

I was inspired to become active in the wind industry after driving across the California desert and seeing hundreds of utility-scale wind turbines outside of Palm Springs in motion, producing renewable energy. It took my breath away! It was like I was looking into the future, and seeing the potential the wind energy could offer.

For the last eight years or so, I have been deeply involved in the renewable energy sector generally and in the wind industry in particular. To share with others my enthusiasm about these areas, I keep up with the cutting-edge issues and policies impacting them, writing extensively and being a regular speaker on these topics. People joke with me that I have taken my understanding of these matters in the wind industry and other renewable energy sectors, and have combined it with my experience as a lawyer covering the fixed income desk at a global investment bank and my many years of big law firm securitization experience to become superhero-like – I now use my 'powers' for the 'greater good,' negotiating complex renewable energy contracts. As an adjunct professor at Fordham Law School in New York City, Chair of Women of Wind Energy's New York/New Jersey Chapter, and immediate past Co-Chair of the American Bar Association's Renewable, Alternative, and Distributed Energy Resources Committee, I have endeavoured to use these 'powers' to get others excited and invigorated about the prospect of having a renewable energy future. I've also encouraged them to get involved in its evolution, which is currently taking place.

Over the last number of years, I have become deeply interested and involved in the issue of wind wakes, wake effects, and the financial implications they have for utility-scale wind farms. Not only have I worked with colleagues who handled landmark, precedent-setting litigation wind wake cases, but I've also interacted with leaders in the engineering community who conduct scientific research on wakes. Having both a legal and scientific perspective on wind wakes gives me unique insight into this phenomenon that I can share with developers and others who have boots on the ground in the wind energy sector.

What is wind wake effect?

To understand to wind wake effect, it´s important to understand what a wind wake actually is. By way of background, the term 'wake effect' originates from the wake behind a ship. A ship´s wake consists of two parts. First, a wedge-shaped wake which fans out behind the ship, and second, a turbulent wake, which travels in a corkscrew-like pattern and bisects the wedge-shaped wake.

Offshore wind farm. Author: Vattenfall. License: Creative Commons

So a wind wake is something that a utility-scale wind turbine creates. Typically 'wind wake' refers to a long trail of turbulent wind behind the turbine that has diminishing speed and energy content. Once wind has flowed through a wind turbine, the air downstream of that turbine has reduced wind speed and increased turbulence, compared with wind flowing in the free stream before it interacts with that wind turbine. These wakes, like ships' wakes, rotate in a corkscrew-like pattern.

What factors impact wind wakes?

There are several factors that substantially impact a wind wake´s size, magnitude and pattern - with each turbine's wake taking a unique shape called a 'wake-rose'. These factors include environmental and atmospheric conditions, turbine blade characteristics and turbulence.

Environmental factors include changes in the atmospheric conditions, relative humidity, temperature and the surrounding topography (like trees and complex terrain). Blade characteristics include the blade's length, pitch and angle at which it's attached. The direction of the blade can impact the shape of the wake, which is important to consider if a wind turbine has an angular error affecting any of its blades. The third factor is turbulence, which is a major parameter in wake models. Turbulence refers to random fluctuations in wind speed in a designated area during a short time interval, such as a ten-minute period. Wind flow disturbances are caused by two main factors – topographical features and temperature variation. Things like a silo, barn, or tall trees can interrupt normal wind flow patterns, causing wind above these objects to flow at a different rate than wind flowing around them and creating turbulence. Wind shear, for example, is the friction between two wind currents moving at different speeds. When low levels of atmospheric turbulence are present, wind turbine wakes can materially impact the energy generation of downwind turbines – an effect which can cover very large distances.

What impact can wake effects have on wind farms?

Downwind turbines that experience wake effects can produce substantially less power than upwind turbines that receive wind in the free stream. The downwind turbines also experience increased mechanical loads, and diminished capacity as a result of vibration-induced fatigue on their rotors – this is where the turbulence comes in.

The magnitude of this impact largely depends on the turbine's rotor size and the distance between turbines. The further away a downwind turbine is from an upwind turbine, the smaller the impact will be. The setback limit, which refers to how far a wind turbine must be sited away from a shared property line, is therefore important. It's worth noting that, in the US at least, setback limits are generally safety-based (and usually don't take wake effects into account). So, in practice, there might be an insufficient buffer zone between an upwind turbine and downwind turbine.

This can make certain land financially unfeasible as a project site because of an inability to site the originally anticipated number of turbines. It may deprive a wind farm developer of the opportunity to meet its investment-backed expectations, and effectively render the parcel useless for its intended purpose.

Have you come across a case where unanticipated wake effects have negatively affected a wind project following its construction?

Yes. The case is called 'Wind Energy Partnership vs NextEra' and involved a city-wide wind repowering in Palm Springs, California. NextEra, as one of the developers in the area, participated in this repowering. The plaintiff wished to construct turbines on a parcel of land it purchased that was adjacent to NextEra's parcel, which already had turbines on it. Apparently, the owner of the land who sold its parcel to plaintiff did not take the proper measures to mitigate the risk of repowering on NextEra's property, including failing to air its grievances at widely-publicised hearings. When plaintiff purchased the parcel, it stepped into the shoes of this owner, inheriting all the risks that accompanied the parcel. While there is no way to be sure, it's possible that the case could have been decided differently had the original owner of the parcel voiced its concerns at these public hearings.

What lessons can asset owners learn from this case?

Owners may find, as with the plaintiff above, that they are in a position where they have not taken sufficient precautionary measures to mitigate the risks of their assets being waked. Some of these owners may only own a single project, and can't spread their resource risk across multiple projects. For any wind farm owner, large or small, the risk of wake effects from a nearby property that has or may have wind turbines on it is something that person should think about carefully beforehand.

How has developer behaviour changed in light of the wake effect?

The wake effect is a problem developers don't normally want to discuss. Some have even said the subject sends 'shivers down their spines' and that 'it's so stressful it keeps them up at night!'. There are essentially two camps into which developers fall: the risk avoidance camp, and the gambler camp. The risk avoiders tend either create a buffer zone by buying or leasing upwind land, or buying the land around the grid interconnection point (so that other nearby developers must agree not to wake their land if they want their turbines connected to the grid). The gambler developers, by contrast, believe that it's not economic to buy a buffer zone and so they roll the dice on whether there is going to be upwind build out in the future.

Given current developments in the US wind industry, why would there be an increased focus or concern about wake effects in the future?

There are two current developments that are helping to shift more focus to wake effects. First, we've now reached the point where certain turbines are nearing the end of their 20-30 year life expectancy, so these projects are often being repowered. Second, there's the production tax credit (PTC). Due to uncertainty regarding whether it will be renewed in the future, certain developers are trying to take advantage of it while they can. Some are repowering or partially repowering their turbines on an accelerated timetable, even when these turbines are little as ten years old.

Does a 'right to wind' arise for existing wind farm owners?

It depends. In Norway, the high court has held that wind is not subject to property rights so no compensation can be available for those seeking damage awards. In contrast, Denmark recognises the right to wind and will offer compensation for violations of this, and courts have offered compensations for upwind repowerings. In the US, there is currently no federal right to unobstructed wind flow across property. This has left state courts and district courts to make their own determination about wind rights. This means decisions are made on a case-by-case basis, and can include consideration of the interests of the local community. Depending on the situation, local Zoning Boards will decide these cases and attempt to make a decision on the basis of the interests of the majority of the parties involved. For instance, in North Dakota, one such Board had to decide a fair set-back limit and took into account the royalties local land owners would receive for each turbine built on their land. Because the upwind developer offered the local community a greater benefit than the downwind developer, due to the number of turbines each landowner would get to have on their property, the Board decided in favour of the upwind developer. Realizing the adverse wake effect impacts the upwind developer's turbines could have on the parcel it wanted to buy, the downwind developer ultimately decided against purchasing the land and against building the project.

Is there anything else wind farm developers could be doing to mitigate against potential losses arising from wake effects or other resource risks - such as buying weather risk cover, for instance?

Yes, there are long-term hedge products available on the market now to protect investors against wind-related risk. For example, the Black Oak Wind Farm, located near Cornell University in upstate New York, entered into a wind hedge. This hedge settles off power production rather than wind speed. So, if Black Oak experiences wind volumes lower than expected and thus has lower revenues than anticipated, its volume risk has been mitigated, and the project remains protected. Hedge products like these are available for up to a 10-year term, which is the length of Black Oak's hedge.

Unlike fuel prices, where uncertainty increases the further into the future you go, wind volume generally becomes more predictable and quantifiable over a long, fixed period of time, because there is an expectation that weather patterns will revert to the mean. The issue with creating a wind hedge is that highly sophisticated analytics and data are needed to structure and settle such a hedge. Weather-related factors such as temperature, wind shear, and turbulence all impact power output. However, over time, wind volume tends to remain near historical averages. So it's really a matter of predicting future weather in a particular local area based on historical data and past trends for that area. Up until recently, this kind of highly technical data may not have existed. Because this hedge product is so new, there is no market standardisation for it. This, in turn, means solutions must be custom tailored for each project. Right now, we're seeing the market for wind hedges continuing to evolve.

Why would developers be interested in insurance or a hedging product related to wind wakes as part of an overall risk management strategy?

Developers spend a lot of time and money seeking and acquiring an optimal parcel that suits their turbines. They also spend a lot of time and money on advance planning efforts that include turbine layout optimisation, using wake modelling software to maximise the farm's overall energy output. The farm is then expected to produce a certain amount of energy annually over its lifetime. This becomes particularly important for those wind farms that have entered power purchase agreements based on the obligation to deliver a fixed amount of energy. So, after investing all this time and effort, the last thing a developer wants is for another wind farm development to severely and adversely impact the projected energy output of these turbines.

What factors impact offshore wind wakes?

Insofar as wind wakes for offshore wind farms go, there are some key differences between these wind farms and onshore wind farms. One thing to bear in mind is that offshore wind turbines are substantially taller than onshore turbines. This means that offshore turbines' rotor diameters are larger, resulting in the corresponding wakes for offshore turbines being much greater than wakes created by their smaller onshore cousins. According to certain scientists, a wake from an offshore wind turbine generally persists longer than a wake from an onshore turbine. Factors that influence the expansion of an offshore wind turbine's wake as it moves downwind of the wake-generating turbine include wind speed, wind direction, turbulence, atmospheric stability, and the point at which the wake makes contact with the water.

That said, there are generally spacing constraints when it comes to where an offshore turbine can be sited. Due to the expense involved with subsea cables, offshore turbines are generally located approximately 4 to 12 rotor diameters away from one another. Also, a number of offshore wind farms site their turbines in rows and columns. In this set-up, a single turbine could be subject to lateral wakes, as well as to downwind wakes that merge with these lateral wakes from neighboring turbines. This is particularly the case when turbines in an offshore wind farm have been sited in a grid-like "block" formation, such that there are eight or more evenly-spaced turbine rows and there are at least eight evenly-spaced columns of turbines, too. Two Danish offshore wind farms, Horns Rev and Nysted, use this block formation. As a result, they have been the subjects for offshore wind scientific studies on wakes.

To date, research has shown that, as a result of wind wakes, the total projected power output from certain offshore wind farms is much less than originally anticipated. For instance, Cornell professor Rebecca Barthelmie and her colleagues have conducted a number of studies on wind wakes in large wind farms. Their findings suggest that standard offshore wind farm models under-predict wakes, while over-predicting the offshore wind farm's power output. Barthelmie and her colleagues' studies have shown that, in offshore wind farms such as Horns Rev, wake effects within the wind farm have caused wind speeds in that farm to sometimes drop to less than about four fifths of the wind speed in the free stream. These wake effects have also caused the wind farm as a whole to experience an overall loss of more than approximately one-tenth of the farm's estimated potential power output.

BECOMING CLIMATE RESILIENT

INTERVIEW: PASCAL STORCK, PH.D.
HEAD OF RENEWABLE ENERGY, VAISALA
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Who are Vaisala and what services do you provide?

We are an 80-year old company headquartered in Helsinki, publicly traded, with around 300 million euros a year in annual revenue. We have 1600 employees and are the world leader in weather measurements – whether it is providing weather sensors and weather measurement technology for met offices and met agencies, airports, roads, or railways.

In 2013, Vaisala made the decision to enter the renewable energy business and we tend to enter new areas through acquisition - so we bought two companies. One was Second Wind, headquartered in Boston, that manufactures measurement devices designed specifically for renewable energy applications, especially wind. An example is the Triton remote sensor, a ground-based device that collects wind measurements at heights up to 200 meters.

The second was 3TIER, headquartered in Seattle, Washington, a leading provider of renewable energy assessment and forecasting services through its cutting-edge weather modelling, super-computing, and numerical weather simulation. This technology provides the capability to simulate the weather and climate at any location on earth, past and future, stretching back 40 years and forward up to 13-14 months into the future. So Vaisala has an established leadership position in measurement, high speed computing, information services and numerical weather simulations.

What role do your activities play in the renewable energy sector?

Renewable energy is inherently impacted by the weather, and Vaisala's role in the sector is to help our clients manage this risk to build and operate the most effective assets possible.

In the early days of the renewable energy business, the weather was always taken for granted – place a met mast, correlate it with a nearby airport and get on with it! More recently, we're seeing large scale underperformance of wind farms, super El Niños cropping up, large variations in wind patterns from year to year, and we're seeing the consolidation of the financial risk of renewable energy projects and how that risk affects yieldcos and utilities.

People are starting to pay attention to weather impacts and are beginning to understand what it means to have an energy source that depends on the weather. So there is a lot of interest in understanding variability. And there is a lot of interest in being able to use that understanding of variability to optimize portfolios and make the best decisions, whether it is an individual project for greenfield development or whether it is an M&A activity. We bring the weather expertise, measurements, and analytics to bear for our clients in the renewable energy space.

How has the sector's understanding of climate and weather evolved?

There has historically been a tendency for the consultants and engineers in the renewable energy space to over-predict project energy expectations. There used to be limited understanding about how weather and climate impacted these projects, including a lack of detail about how turbines converted complex weather and climate patterns into energy.

As the industry has gained more experience, it has been able to calibrate its approach to energy assessment and incorporated better technology – like mesoscale modeling – for predicting the future energy production of a project - i.e. the net p50 over the next 20 years. There are two main factors that determine deviations from these expectations:

Firstly, how realistic are your expectations? If the long-term average view is optimistic, then your project is doomed to underperform in most years, until you reset expectations to something more reasonable.

Secondly, the year-to-year, month-to-month variability of the wind resource itself.

Vaisala's clients have in the past confused those two things. We do a lot of work helping our clients understand the actual generation potential of their projects. We can use whatever weather data they have from the project - whether that's operational or met mast data - put it into the long-term climate context, bring to bear everything we know about the engineering and the way their turbines work, and provide the most accurate forward-looking expectations of the next 20 years of energy production. We can factor in events like El Niños, La Niñas, global warming and determine how we expect production to deviate from normal. Is it going to be above or below average next month, quarter, year, and why?

Technology trends are also driving increased focus on weather data. Onshore wind turbines are growing to higher and higher hub heights all over the world – to the extent that, in Europe, it is not uncommon to have 120m hubs. We've seen this less in the US, but it's likely to become more prevalent as the production tax credit goes away, and given the strong incentive to reduce the levelised cost of energy. However, it becomes harder and harder to take measurements at those hub heights. The whole industry used to be able to rely on 50 or 60-meter high met masts. This is no longer adequate and higher height development is driving innovation in measurement practices and technology, such as the use of remote sensing devices like our Triton Sodar.

What developments have there been in weather monitoring and analysis in recent years?

When it comes to analysis, we now have access to much better global weather data sets. Typically, annual energy production estimates are produced by using data from a met mast located on the site and correlating that to another met mast nearby that has a longer record to create a 30-40 year understanding of the wind resource. There is significant risk involved with this approach, however, as the longer-term met mast is possibly not nearby and may be uncorrelated to what's happening at the wind farm. Also, many of these long-term met masts were located at airports and had a change in their measurement technology a few years back – so that created a discontinuity in the record that made the long-term correlation problematic.

Over the course of the last couple of years, we have shifted the thinking of the entire industry towards the use of what we would call synthetic datasets – synthetic time series that come from global weather reanalysis data sets. These are made more specific to a particular site by running those global data sets through a super-computer, using numerical weather simulation models and tools to produce an explicit and detailed representation of the expected wind resource at the project location. And, from there, we bring in the advances in on-site weather measurement, tie these into the climate context, and come up with a corrected long-term view of the project.

Synthetic data sets are becoming better and better – indeed one could argue that you may end up not needing measurements at a wind farm in the future because the data sets and our modelling abilities will be so good. For now, there is still considerable risk in using these synthetic data sets on their own, and observations are still imperative. Synthetic data sets won't ever be perfect, but, at the same time, neither are observations - since a met mast will not tell you the wind speeds for all turbines on a farm and is typically installed for just a year or two, so doesn't capture the long-term climate cycle.

What future developments do you expect to see?

Something we have started to work on now with our clients is the idea of longer-term predictions of their assets' energy output - which brings us back to setting the right expectations for energy production in the first place, and then trying to correct those departures from normal.

People are starting to realise that weather and climate variability affect energy outputs and asking some very good questions about quantifying that risk, managing that risk, and how that risk can be minimised. Or even how they can use that knowledge to put themselves at a competitive advantage over others in the sector.

We also expect that the trend toward higher hub heights and bigger rotor (blade) diameters to continue. This trend will necessitate the use of remote sensing to understand what is going on with the wind across the high portion of that rotor, which can in many cases now be above 200 m high. This ability to see the wind patterns across the entire rotor area is important not just for development and financing of wind farms, but also for investigating turbine performance. Perhaps the wind does not increase as rapidly with height as was assumed, or perhaps it changes direction (veers) suddenly. Without direct measurement at these higher heights we are left to make assumptions that may or may not be valid.

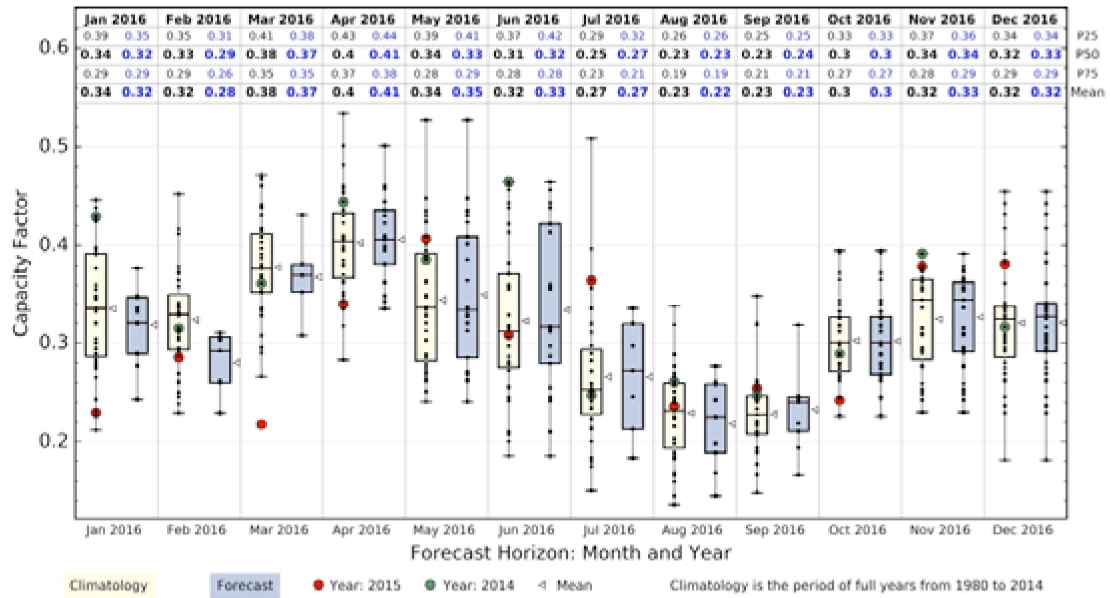
Thinking about wind farms – how often do actual wind speeds significantly deviate from anticipated wind speeds on project sites?

Unfortunately, due to a number of factors, wind farm operators tend to find their wind farms underperform more often than they overperform; and we saw this especially in 2015 in the United States. Part of that underperformance can be attributed to overly optimistic pre-construction energy estimates. We have been working hard on improving the science and technology in that process, so that basis risk disappears and that the bias in the pre-construction estimate is as close to zero as we can possibly make it.

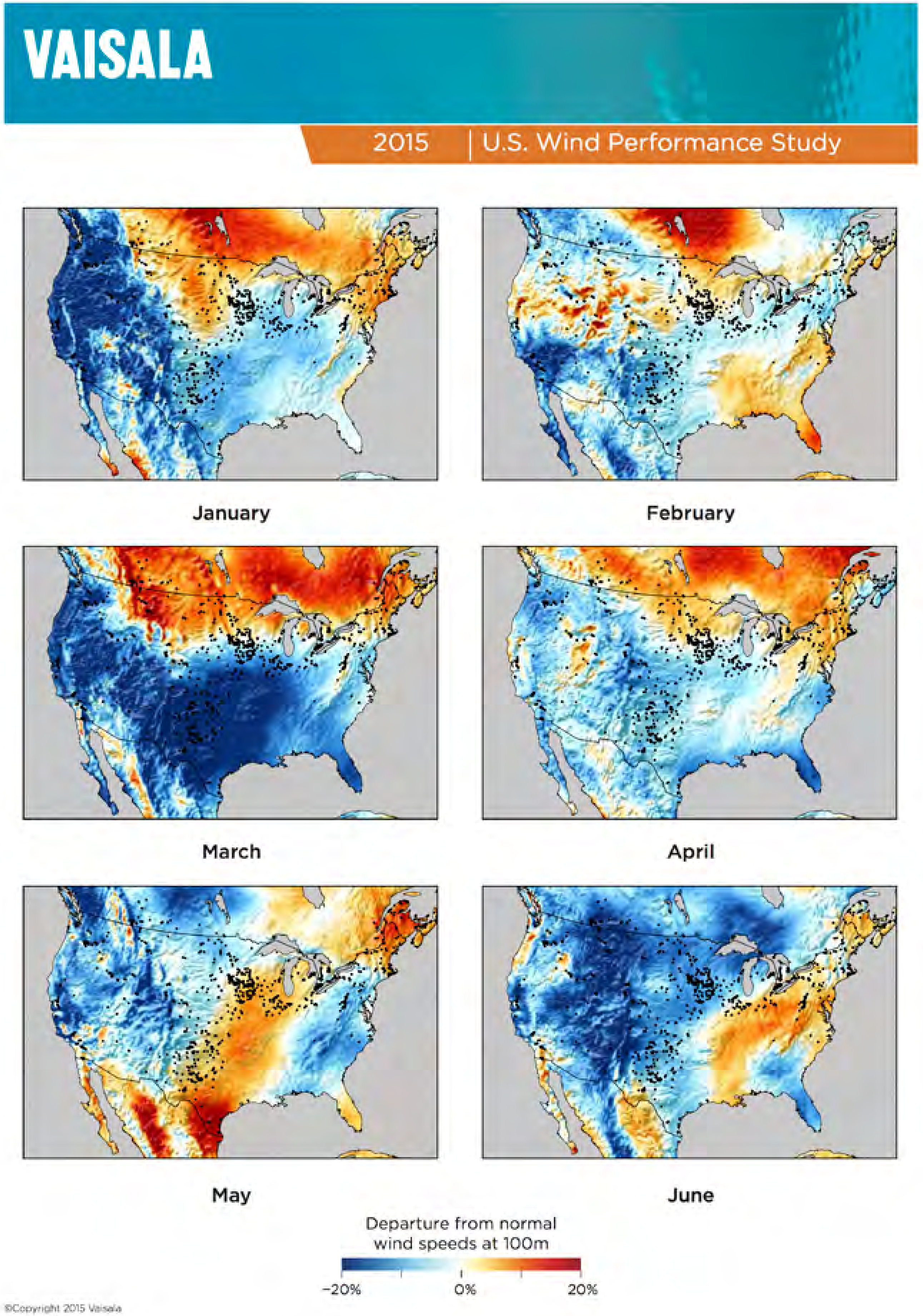
A separate issue is whether one can predict if a project will over or underperform on any particular year, which has to do with weather and climate variability. For instance, Q1 in 2015 for most of the continental U.S. was the lowest Q1 in the last 47 years in terms of wind speeds. This was a major negative anomaly that brought a lot of attention to the issue. An interesting question is whether this was an outlier event, or if we should expect this to happen more frequently - and we found that what happened in 2015 was actually pretty much the worst it can get.

How far away from p50/average/anticipated wind speeds can these deviations be over a quarter or a year?

A 20% drop in wind resource is fairly extreme, and would equate to an up to 40% reduction in energy production. We have seen reductions in energy in excess of 50% from baseline.



The above diagram tends to be very eye-opening for our clients, because they tend to look at performance on a yearly basis – so to see the very large variations (e.g. 80% shortfalls from p50) on a month-to-month basis is not something they necessarily expect.



Do you tend to see greater deviations from anticipated wind speeds in developing countries where data measurement is not as advanced?

As I've mentioned, there are two factors involved in underperformance risk – the reliability of the pre-construction estimate and resource variability - and the way these are handled in emerging markets will determine how great deviations will be.

As far as pre-construction estimates are concerned, a lot of developing countries have not reached the same standard for collecting met mast and using remote sensing data as we have in the US or Europe. In their haste to develop they are not necessarily following best practices and may seek out the cheapest report available to obtain project financing. We are starting to see some evidence that the developing countries are set to have all the same underperformance problems that we had in the US as we were going up the learning curve.

That said, efforts are ongoing to introduce best practices into these developing countries, such as the use of remote sensing to understand what is going on at higher heights, using advanced modelling to understand the spatial wind patterns over a wind farm, and using these synthetic references to carry out climate correction that puts the period of observation into a long-term context.

Regarding resource variability, we do a lot of work in India, Australia, and South America – and there are well-understood patterns of climate variability in those regions too. One of the big questions in Argentina has been whether the huge resource decreases due to El Niño could have been predicted. Large-scale departures from the norm are not only a problem for US and European audiences.

Is all the above also true of solar projects?

Having a long-term view of solar is as important as it is for wind. Solar is a bit more interesting because there is a tendency for medium-sized projects (around 1-20 MW) to be built without any local irradiance data from on-site measurements whatsoever. They exclusively rely on satellite-derived irradiance estimates, which use advanced algorithms to process satellite imagery and other data inputs to calculate the amount of solar resource that reaches ground level. Unsurprisingly, some of those projects are not performing as expected. Sometimes that means underperformance, but there are also many cases of overperformance. Either way, we see this as an opportunity because, even with overperformance, the developer could have secured a lower cost of capital if they had gotten the solar irradiance estimate right in the first place. Why take on that risk if you don't have to?

With regards to solar anomalies – it's evident from the volume of media coverage that these can occur anywhere from California to Texas to Ontario, and that you can have energy reductions anywhere between 10 to 20% on a monthly or even quarterly basis in any of these markets.

In fact, I would say the risks for solar are as significant as they are with wind. Some solar projects are built in locations where it is expected to be sunny all the time, but even there you run into smoke cover from wildfires. The recent wildfires in California, for example, had a negative impact on solar energy output.

The big wildcard for solar is if you have large-scale volcanic eruption like Mount Pinatubo in the southern hemisphere in 1991. These events can actually decrease irradiance around the world by several percentage points and have huge impact on solar thermal projects that rely on direct normal irradiance, which is more sensitive to aerosols and particulates in the environment than the irradiance source PV projects convert to energy.

Many US wind farms suffered from significant shortfalls in wind speeds during 2015, and likewise in Australia during 2014. What causes such lulls, and how often do they tend to occur?

There is a decadal and multi-decadal pattern to the Earth's weather. You have El Niños in the Pacific Ocean and you have other major oscilllations such as the North Atlantic oscillation and Indian Ocean oscillations, all of which are essentially measures of how far the sea surface temperature is below or above average. What we know is that these sea surface temperature changes have an impact on the global circulation (jet stream) and the way that weather will manifest itself across the entire Earth's surface.

However, none of these phenomena are perfectly understood. We can never say with 100 percent certainty, for example, that any particular wind speed reduction was due to El Niño. The best we can do is produce statistical representations that look at when unexpected weather events occur that coincide with an El Niño. At the end of 2015, we had the strongest El Niño in recorded history, and, according to statistical patterns, many of the wind farms in the US should have been significantly below average for Q1 2016, but in fact they were above average. So obviously there was something else going on in the Earth's climate system that is currently unknown to us. What happened between 2015 and 2016 will be the subject of much academic debate for some time to come.

What experience have you had with weather risk transfer products?

One of our core competencies is being able to predict future energy output from a wind farm, whether it is a pre-construction project or operational, with existing production data available. The ability to get that long-term expected energy estimate right, and understanding deviations from it over any time scale, is fundamental for the pricing and settlement of any weather risk transfer product.

For the last five years, we have met the demand for an independent party to provide weather and contract settlement data – sitting in between the owner and the policy issuers. This data is either collected from a combination of permanent met masts (for which there needs to be an independent quality control review to ensure there is no tampering) or the measurement is taken from some other physical measurement device. In the case of the latter, there is the question of what happens when that device fails – in that situation we act as the agent to fill that data record in (using a variety of approaches).

What role do you see weather risk transfer products playing in the renewable energy sector in the future?

I would like to see any obstacles to broad scale adoption of renewable energy removed from the marketplace. The issue of resource variability is one that causes a certain amount of risk. So far, the renewable energy industry has largely only dealt with short-term intermittency, looking at the fact that the wind blows for one hour and may not in the next. To mitigate this there is expansion of markets, there is transmission, there are shorter duration markets. While there is still work to be done, all of the markets around the world have dealt to some extent with the engineering challenges of renewable energy.

Having largely solved that problem, the industry is now looking more carefully at the problem of larger-scale deviations. It is thinking about how to manage an energy mix that is heavily dependent on renewables, bearing in mind the risk of substantial resource underperformance.

Q1 2015, as discussed, was a massive negative anomaly for the wind sector across the whole of the US. Given the impact felt when wind was around 5% of the total energy production of the US – what would happen if it constituted 30-40% of the total? This raises not just financial questions, but also the problem that the MWhs are going to need to come from somewhere. And the answer will be to make sure that other sources of energy or that from other regions are available when they are needed.

The geographical diversity of having wind farms in Texas and California may not prove entirely effective as a self-insurance policy – our performance maps show that this would not have worked in 2015 because performance in both states was well below average. However, if you had projects in Texas and Alberta, then you came out around average. This type of diversified portfolio is what we like to call a 'climate resilient portfolio' and can be distinguished from a typical portfolio of projects that might be concentrated sub-optimally in only one geographic region or in a single type of energy technology. Climate resilience is one of the ultimate goals when it comes to the successful management of resource risk.

UNDERSTANDING THE BENEFITS

INTERVIEW: LEE TAYLOR
CO-FOUNDER AND CEO, RESURETY
WWW.RESURETY.COM

Who are REsurety and what services do you provide?

REsurety is a risk transfer intermediary. We sit in between risk shedders and risk takers, providing a basket of services including origination, structuring and settlement, with a focus on US wind farms. We were founded in 2012 and spent a number of years building up our analytical models which support structuring and settlement. As of today have worked on over 1GW of hedge transactions in the US.

When financing/refinancing what advantages can purchasing weather risk transfer provide?

Our focus is the US, so I'll speak to the financing structures here. You have three components of a given wind farm's capital structure:

1) The debt
2) The cash equity
3) The tax equity

One immediate advantage of weather risk transfer is the benefit of increased leveraging – increasing debt without changing the risk profile of the project. When the benefit of a lower cost of capital exceeds the cost of the risk transfer, then it is simply a net benefit to the project.

On the sponsor equity side, we are seeing more and more investors looking at US wind infrastructure as a source of yield/long-term investment. However, US wind has become a more complex investment vehicle because traditional long-term, busbar-settled power purchase agreements are hard to come by. In their absence, we've seen the rise of financial counterparties like banks doing fixed volume swaps, and in some cases we are even seeing commercial and industrial power buyers looking for fixed volumes of power. So the weather-driven risk that a sponsor is exposed to still includes annual or quarterly generation and its impact on revenues, but also increasingly the shape of that generation – and essentially how hourly wind speeds correlate with power prices. That creates a new form of weather-linked risk: what happens when you under-produce during a price spike and over-produce during a price trough?

We are seeing that weather-driven component become an increasingly difficult challenge that few sponsor equity providers are excited to hold, and especially not those with a low cost of capital. So we see the ability of weather risk transfer to shore up the revenue volatility of a project on a long-term basis as an opportunity to bring lower cost of capital on the sponsor equity side.

On the tax equity side, it's more binary: either the weather risk transfer – along with all other risk management tools employed by the project – sufficiently de-risks the project to be attractive to tax equity or not. In some cases you'll see tax equity approach an investment a little differently depending on the risk profile, but the cost is relatively stable as it is set by the market. Across the spectrum, that's the way we've seen projects think about the value of weather risk transfer in supporting their cash flow and the financing structure this enables.

How easy is it to quantify those benefits?

It is often difficult to quantify the financial benefits, such as improvements to the internal rate of return through leveraging, since there is very often not a clean pre and post scenario. It's more of a binary event; your project without a certain level of risk management is unfinanceable, but when that risk management is in place, the project is financeable.

On the sponsor equity side, if you are talking to multiple different sponsors, they're looking at the asset and sizing their investment and return expectations for all kinds of different risk profiles. They are all going to have a different view of the basis risk, the risks around operating efficiency – so it's very difficult to split out a single risk factor. It really is viewed holistically from the investment side.

A final challenge is that parties who are buying risk transfer in order to get a better capital structure generally don't want to tell anybody the details of what that capital structure improvement looks like - because then they are basically revealing the ability to perfectly quantify their willingness to pay. That's not information that is typically given away. We know that we have created net value for a project when the contract is signed, because otherwise they wouldn't buy it.

Putting a specific number on the financial impact is one of the challenges we have faced. It can generally be estimated, but we are normally hesitant to state that the internal rate of return improvement is 'x' because it is very site-specific and varies dramatically depending on which portion of that capital structure benefits the project.

How do you tend to demonstrate the financial worth of the product in that case?

When potential buyers receive a proposal in terms of what revenue certainty they can expect, they look at their financial model and they simultaneously talk to all parties of that capital structure. They then come back and either say that this pencils out to being a net positive and that they'd therefore like to move forward - or not.

In terms of how we demonstrate financial worth upfront, generally what we will do is qualitatively walk through the different capital providers' view of this (as set out above). For example, if a project is looking at trying to finance the asset with a fixed volume swap in the US on power prices – you can say with some confidence that they are never going to have access to debt. There are a few exceptions, but in most cases if you have that kind of structure your worst case scenario in terms of revenue is low enough that it doesn't support any debt at the project level or back-levered. So, if the sponsor is looking to lever their asset and their alternative is a fixed volume swap, then you can assure them that, if the value of achieving leverage on this asset is even slightly more than the cost of the hedge, then it is clearly a net value creator for them.

So we tend to stay away from saying things like your internal rates of return will increase from say, 8% to 12%, because we don't know where they are starting from, and every party has a different hurdle rate. It's more a matter of qualitatively walking through those benefits and figuring out which parties value risk transfer based on their own risk tolerance as well as the risk tolerance of their capital providers.

How aware are lenders of the benefits of weather risk transfer?

Overall it remains a new product/structure, so I wouldn't say visibility is widespread, although it's becoming more well-known – and is obviously very well known to those who have closed a deal in connection with a hedge already. We have worked to get in front of a number of lenders in the US market to try to make them aware that this a product that could be crossing their desk. But generally the capital markets – understandably – don't want to diligence a product or structure until it's part of a live transaction, so the heavy lifting comes when one of their clients brings them a deal with this type of hedge in it.

It's our view that this type of hedge structure is in lenders' interests because it enables them to put more money to work at the same or a lower risk level. As such this is something that has been fairly well-received in terms of client requests for lending, with weather risk transfer being a component of guaranteeing that debt service.

Are you aware of situations where lending terms have been improved on the back of weather risk transfer being acquired?

Anecdotally, yes. I know of transactions where lenders have participated because of a weather risk transfer mechanism in place that allowed the project to get built in a way that the sponsor was happy with. Unfortunately again, however, there isn't really a base case. If a project is financeable, the sponsor is never just going to stop and say 'we know we can build the asset today at 'x' rate of return, which is above our hurdle, but everybody stop what you're doing – we're going to see if we can get weather risk transfer, to see what improvement we'll get so we can quantify the improvement in our IRR.'

They are making a decision long before they get to the finish line. We cannot say a project has gone from 9% IRR to 10.5% because of a weather-linked hedge. You would typically need two near-identical wind farms, one with, one without weather risk transfer, and then compare their IRRs in order to quantify this (and the willingness of the two sponsors of the projects to share this information).

I wouldn't confidently be able to put a number on the difference weather risk transfer can make, as the uncertainty around that number is too high – and, more to the point in many cases, the inclusion of weather risk transfer was the difference between the project being built, or not. So it wasn't a quantified improvement, it was a binary event.

What broader financial advantages does weather risk transfer provide?

Ultimately, this is a sponsor equity driven product. It's the sponsor who decides to buy this or not; and they do that because of their own cost of capital and risk tolerance, the leverage that this enables, and the access to tax equity in the US market. So I would highlight the fact that a focus on project financing debt is important - but to exclusively focus on that would be a mistake in terms of the broader financial context.

Are parties other than those who are (re)financing interested in weather risk transfer?

Absolutely – we have been focusing on the longer tenor transactions that have been used to support fundraising for either a new build financing or refinancing existing assets, whether to re-sell or not. However, there is an entire other class of customers who often own operating assets and may be unprotected in terms of the volume and/or shape of their production. In the US market in particular, where you have public entities - yieldcos or public companies that own operating assets - there is value to the stability of forward-looking earnings. And that creates a totally different kind of value, which is simply the value of greater certainty, as opposed to something that is really changing the way a project is financed. The value is in smoothing earnings.

Why has take-up for weather risk transfer not been widespread up until now?

In our view there have historically been three blockers that have limited interest in weather-linked hedging:

First, the tenor of the product has expanded from being relatively short to now being able to offer up to a decade, which dramatically changes who is interested in the product. Some customers are interested in a one to three-year tenor, but many are saying that if they can't get a decade then they can't realise the benefit that they need for all the members of the capital structure, as we just discussed. The expansion of tenor appetite has had a huge impact.

Secondly, the settlement index. There are still hedge buyers who are interested in looking at a fairly simple settlement index; one that uses a single source of wind speed and a power curve to approximate the weather-linked exposure of a project. However, increasingly we see projects that want something that is much more granular and tracks their projects as closely to their actual operations as possible. They want to get very close to indemnity without transferring operating risk to the insurance community - in other words, dramatically reducing basis risk through structures that use the operating data of the project's turbines, as opposed to a single met tower or reanalysis index. This has dramatically reduced the initial aversion to the concept of risk transfer. When we first started talking to clients about the opportunities in weather risk transfer, there was a concern that, depending on any of the factors that drive basis risk, there was a reasonable possibility that during a major loss event they might not get the money they thought they should – which would make the product worthless.

Thirdly, the rise of fixed volume price hedging contracts has created a new form of weather risk exposure in the shape – not just the sum. If you produce 100MWh a year, and you've got a fixed volume price hedge, you can still have wildly different financial returns based on when during the year those 100MWh were generated. The acuteness of the pain caused by the uncertainty and variability of the weather as source of fuel has risen dramatically with those types of hedging structures, which has caused a spike of interest in understanding what weather risk transfer can do to alleviate revenue uncertainty.

Do you expect the market to grow in the future, and why?

I wouldn't be doing this job if I wasn't optimistic, so, in short, yes! It's an area where we're likely to see significant growth, and that has to do with the reasons just discussed about increased uptake. Once this is no longer seen as novel, and part of routine business, I think there are large groups of customers who are going to look at it more seriously. In the meantime, we have existing clients who are interested in trying something new in an effort to get an edge in the market.

In terms of more macro factors, thinking about the US particularly, with increased penetration of renewables – both solar and wind – in the US grid, as well as more extreme patterns due to global warming - you're seeing the power markets become increasingly sensitive to the weather.

SUMMARY

Mark Twain once said 'Everyone complains about the weather but nobody does anything about it'. He was right; nobody did anything about it...until now. The renewable energy industry has followed the lead of conventional energy and agriculture and has finally woken up, both to the enormous losses that it can suffer and mitigate against, and the great potential for value creation through transferring weather risk effectively. Indeed, renewable energy increasingly utilizes the weather risk transfer market and we expect this trend to continue.

'Gone with the Wind' illustrates the challenges resource underperformance creates for renewable energy operators around the world. The frequency and severity of underperformance is a key and avoidable contributor to the financial strife that can be experienced by asset owners. It is also worth noting the increasing importance resource underperformance will attain as renewable energy comprises an ever greater proportion of overall electricity generation in the years and decades to come. Awareness of this has fuelled a growing market for resource risk reallocation, which, in turn, has driven the creation of economic value via more efficient risk distribution.

As with previous publications 'Gone with the Wind' forms part of GCube's drive to promote collaboration and best practices that minimise balance sheet losses, not just insurance claims. Accordingly, this report has focused on the potential pitfalls of failing to mitigate resource risk, and the ample opportunities and methods of acquiring cover against it. It also features interviews with industry experts involved in purchasing, measuring, and analysing renewable energy resources, and in minimising the risks inherent to them.

GCube appreciates the inevitability and seriousness of resource variability and underperformance. We hope that our insureds will use the report findings to raise greater awareness among asset managers and project teams about the wider macro trends affecting their peer group. Such trends identify risks, as well as opportunities, that complement the experiences of asset managers and their operational fleets.

GCube would be pleased to support the renewable energy sector in its move towards industry-wide adoption of weather risk transfer, whether that is by providing the cover itself, or advising on any of the points raised in this report. Readers are encouraged to contact the report authors for further information and advice.

UNDERSTANDING WEATHER RISK TERMINOLOGY

(Locational) Basis Risk: In weather risk transfer this is the risk that the actual weather on the project site does not match the weather data used for calculating compensation. The greater the basis risk the greater the risk that the product will pay out when it should not, or that it will not pay out when it should. For instance, higher basis risk implies a higher chance that during wind lulls the product won't pay out. Naturally, reducing basis risk is desirable, and this is what many of the recent innovations in the product are designed to do. One simple improvement has been to measure weather on the project site itself (rather than on a nearby airport, for example).

Call Strike: For weather risk products the call strike is the trigger point which determines when the buyer of the product (the insured) will be liable to pay the seller (the insurer). Calls are a component of collar structures in which the upfront premium (present in put structures) will be reduced/eliminated by including a call strike. The call strike (typically a MWh amount) will determine when the insured has to compensate the insurer.

Collar structure: Companies can give up some of the upside in their revenue in order to reduce the price of a weather risk hedge. A collar will have a call strike and a put strike. It reduces volatility and requires less upfront payment than pure downside protection.

Derivative: A financial instrument, in this case a Weather Risk Transfer product whose value is dependent upon or derived from one or more underlying variables. The derivative itself is merely a contract between two or more parties.

Insured: in a weather risk transfer contract the insured is the party that transfers weather risk. This party is often also referred to as the buyer. The insurer (or seller) is the party that accepts weather risk.

Net Present Value: This is a formula used to determine the present value of an investment taking into account the future cash flows that the investment will generate. It is the difference between the present value of appropriately discounted future cash inflows and the present value of appropriately discounted future cash outflows. It is essentially a measurement of the profitability of a financial undertaking.

Notional Payment: The contractually agreed amount to be received by the insured (or insurer) per MWh of underproduction (or overproduction). This is typically set as the power price the insured desires, whether that is a fixed price (e.g. a PPA) or floating price (e.g. spot market price).

Off the shelf (OTS): A financial product that is available without customization. Commonly such products are traded on an exchange and commoditized.

Over The Counter (OTC): A financial product that is customized for the purposes of a direct transaction between two parties. The vast majority of weather risk is transferred OTC, rather than off the shelf. For example, an OTC weather risk transfer product for a wind farm will be customized to location of that farm, its MW size, and the preferences of the insured.

Parametric insurance: This is a form of insurance that does not refer to the 'pure loss' to calculate compensation, but instead pre-agrees to provide compensation upon the occurrence of pre-defined triggering events. For example a weather risk transfer contract for a wind farm, will pay the insured based upon the occurrence of a pre-defined event. This event will typically be the occurrence of low wind speeds or low proxy revenue or proxy production. Criteria for payment are transparent and payment occurs within days of contract expiry because the insured does not have to submit a proof of loss.

Pareto Optimal: A situation in which resources are allocated in the most economically efficient manner. This occurs when no party's situation can be improved without making another party's situation worse. Pareto improvements are changes to allocations which make one party better off without making another worse off. Pareto optimality will occur in the weather risk market when weather risk is allocated efficiently.

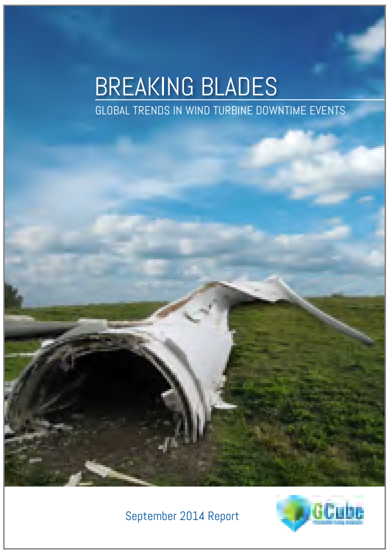
Proxy Production: An estimated amount of energy production based upon wind volume and power price experienced by a particular wind energy asset. For example, if a weather risk transfer product pays out due to wind underperformance, it will be because the proxy production of the wind farm/portfolio in question has fallen below the payout trigger. A proxy production index is structured to closely resemble actual production. There are a number of methods of calculating proxy production (for instance using synthetic wind speeds, (adjusted) actual production, and ideal production – as set out earlier in this report).

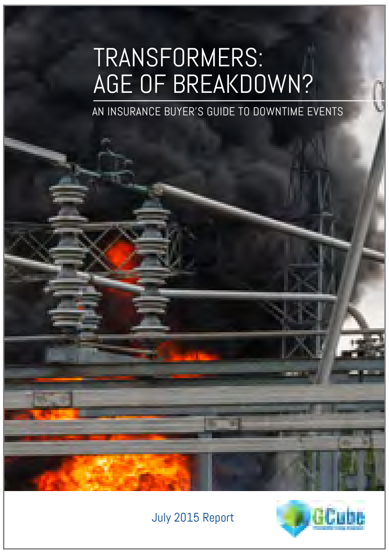
Put Strike: For weather risk products the put strike is the trigger point for compensation to be paid to the insured by the insurer. The value of the put (typically a MWh amount) will determine if, when, and how much compensation the insurer has to provide. For instance, when annual proxy production drops below the put, the insured will be compensated.

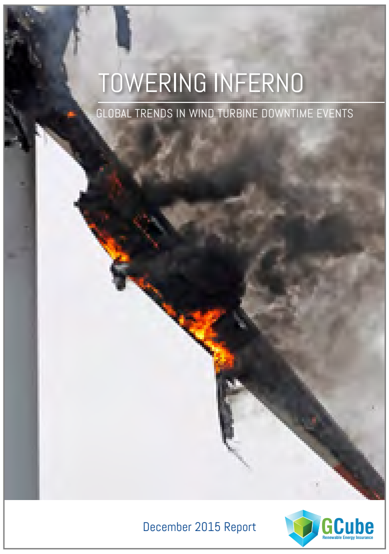
Swap: A fixed-for-floating risk transfer product. This has the effect of entirely transferring weather risk from the insured to the insurer. In practice this structure is associated with completely stable period-on-period revenue flows for the insured. This is because whenever proxy production exceeds the swap's trigger point the insured will transfer the surplus revenue that results to the insurer, and whenever proxy production falls below the swap's trigger point the insured will transfer the surplus to the insurer.

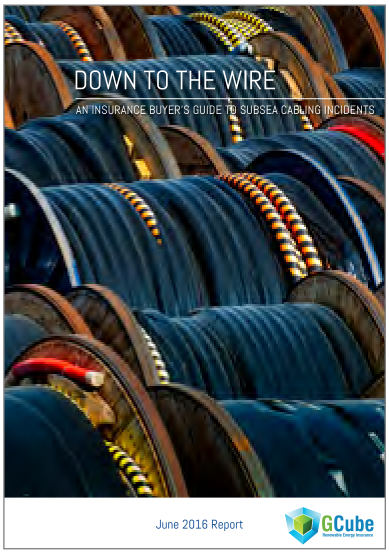
Synthetic data: Any wind or production data that are not obtained by direct measurement.

‘Gone with the Wind’ is the latest in a series of reports produced by GCube®, the leading provider of insurance services for renewable energy projects in wind, solar, biofuels, biomass, wave, tidal, hydro and geothermal around the globe. Our specialised focus and underwriting authority offers comprehensive marine, property and liability insurance coverage for transit, construction and operational risks.









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