The Lab

India Innovation Lab for Green Finance

P50 Risk Solutions

Lab Instrument Analysis

October 2016

The India Innovation Lab for Green Finance is a public-private initiative in India that brings together experts from government, financial institutions, renewable energy, and infrastructure development to identify, develop, and accelerate innovative investment vehicles for green growth in India.

AUTHORS AND ACKNOWLEDGEMENTS

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P50 Risk Solutions

INSTRUMENT DESIGN AND ANALYSIS

October 2016

DESCRIPTION —

P50 Risk Solutions is a facility that aims to provide hedging against weather-related volume risk, primarily for wind power, for utility-scale renewable energy project developers.

GOAL —

This instrument aims to reduce the cost and increase the amount of long-term debt available for renewable energy projects, by transferring weather-related volume risk from banks to the weather insurance market.

SECTOR —

Utility-scale renewable energy

PRIVATE FINANCE TARGET —

Commercial capital

1. CONTEXT

The Government of India has set ambitious renewable energy targets for 2022, targeting a total installed capacity of 175 GW, including 120 GW from utility-scale renewable energy. This is an ambitious increase from the current installed capacities of 3 GW and 22 GW of solar and wind power, respectively, and will require significant finance.

However, one key risk to financing utility-scale renewable energy is weather-related volume risk – the risk of variation in the availability of natural resources for renewable energy, such as wind, sunlight and water flow. This is of particular concern with wind power. Recent record low wind scenarios in different parts of the world, including the UK in 2010, Southern Europe in 2011, Australia in 2014, and the US in 2015, have brought wind variability risk to the forefront in India.

Weather variability effectively translates into revenue variability, and it can be challenging to accurately forecast expected revenue generation from renewable energy projects. In India, infrastructure projects typically rely on bank credit for their debt requirements, and this uncertainty around expected revenue causes bank lenders to act more conservatively. Banks in India will only lend to renewable energy projects that are viable based on a P90 estimate of generation levels.[1] This limits investment to renewable energy by reducing the risk threshold of investable projects, and increases the cost of lending. It would be more efficient for a market participant with a higher risk appetite and the appropriate technical capacity to shoulder the risk of weather variability, leaving banks free to supply liquidity.

The practice of actively managing weather risk in the renewable energy sector has been increasing in markets in developed countries, especially via the insurance industry. The insurance industry has gained experience in offering weather risk hedging solutions, and has gained the technical expertise to price and assess this risk efficiently. However, a similar approach to manage weather risk has not been fully explored in India.

P50 Risk Solutions aims to transfer weather-related volume risk from banks to the weather insurance market by providing a minimum revenue guarantee to renewable energy projects through an insurance company. This means that projects can be financed on the basis of revenue certainty rather than revenue forecasts, leading to more efficient pricing of this risk by the insurance market instead of banks. There are two hypotheses for the impact that such an insurance intervention can have:

- Hypothesis 1: Reduce the cost of financing
- Hypothesis 2: Attract new sources of capital to increase availability of capital

While both solar and wind power suffer from the risk of weather-related volume risk, the variability is much more of a concern in the case of wind power. The P50 Risk Solutions instrument provides a hedging solution to this risk for wind power. Similar protection may be made available for other sources of renewable energy through the insurance industry.

[1] The P90 level is a level of energy generation such that the probability of the actual energy generation exceeding it is 90%

2. INSTRUMENT MECHANICS

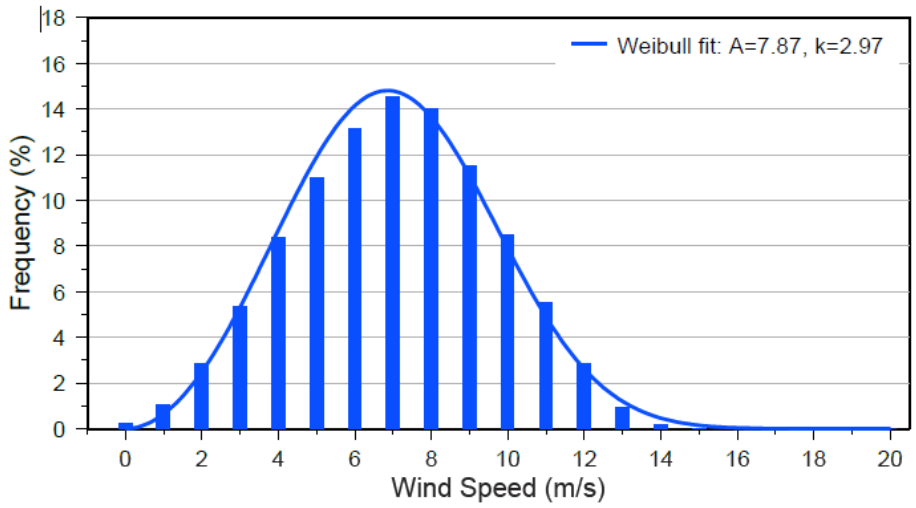
The P50 Risk Solutions instrument guarantees a minimum assured revenue by providing downside protection in a low-wind scenario. By increasing the projected revenues and reducing the volatility, it can lower the cost of financing.

2.1 PROBABILITY LEVELS OF WIND POWER

Before setting up a wind farm, a wind farm developer typically assesses the energy generation potential at the site of the wind farm through a process called a Wind Resource Assessment. In this process, anemometers are set up at the actual location of the proposed wind farm, at an appropriate height based on the height of the turbines to be used. These anemometers measure the wind speed and the direction at sub-hourly intervals for a period of two years. In industry parlance, this is called the met-mast Data. Further, wind speed data for the geographical coordinates of the site is also sourced from external meteorological sources (e.g. NASA MERRA) for a longer historical period such as thirty years. This is referred to as the reanalysis data.

Using a combination of the met-mast data, the reanalysis data, wind shear data, and parameters derived from the topography of the surrounding areas, a model for the wind speed over the lifetime of the proposed wind farm is developed. The probability distribution curve of the wind speed typically resembles a distribution which in mathematics is called a Weibull Distribution.[2] The figure below shows the hourly distribution of the average wind speed for a project, and the Weibull Distribution which best fits it:

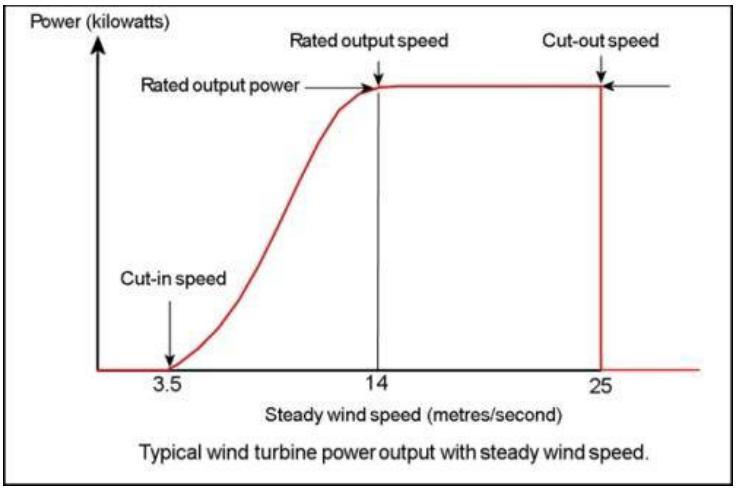
Figure 1: *Hourly distribution of the project-average wind speed using 1 m/s bins. Best Weibull fit is also shown with the scale (A) and shape (k) parameters listed*



[2] http://www.math.uah.edu/stat/special/Weibull.html
The best Weibull Distribution fit for wind speeds in India typically has a shape factor k ~ 3 which closely resembles a normal distribution, but slightly skewed to the right (in this case, the median is less than the mean)

The power produced by a wind turbine does not follow a linear relationship with the speed of the wind impinging on its rotors. Every turbine follows a particular relationship between the power output and the corresponding wind speed input, which is called the power curve of the turbine, which is provided by the manufacturer of the technology.

Figure 2: *A typical power curve for a wind turbine*



Source: http://www.wind-power-program.com/turbine_characteristics.htm

By using the wind model for the wind farm and the power curve of the turbines, a model for the wind generating potential of the wind farm is thus developed. We define the Wind Energy Potential (WEP) as the energy output obtained by applying the wind speed to the power curve of the turbine. Thus, the Wind Resource Assessment of the wind farm leads to a probability distribution function for the WEP of the wind farm. Using this probability distribution function, various exceedance probability levels for the wind farm may then be computed, especially the oft-quoted P50, P75 and P90 levels:

- **The P50 level** is a level of energy generation such that the probability of the WEP of the wind farm exceeding it is 50%.
- **The P75 level** is a level of energy generation such that the probability of the WEP of the wind farm exceeding it is 75%.
- **The P90 level** is a level of energy generation such that the probability of the WEP of the wind farm exceeding it is 90%.

Clearly, the P90 level is less than the P75 level, which is in turn less than the P50 level.

It is important to note that the Wind Energy Potential refers only to the “ideal” output of the wind farm, i.e. the power that would be generated by the turbine under ideal conditions. In the real world, the energy output differs from the WEP due to a variety of factors such as planned and unplanned maintenance activities, transmission losses, grid availability issues, limitations of control systems, wind turbulence, etc.

2.3 P50 RISK SOLUTIONS MECHANICS

The P90 level of a wind farm with the embedded P50 Risk Solutions insurance is equal to the original P75 or P50 level of the wind farm.

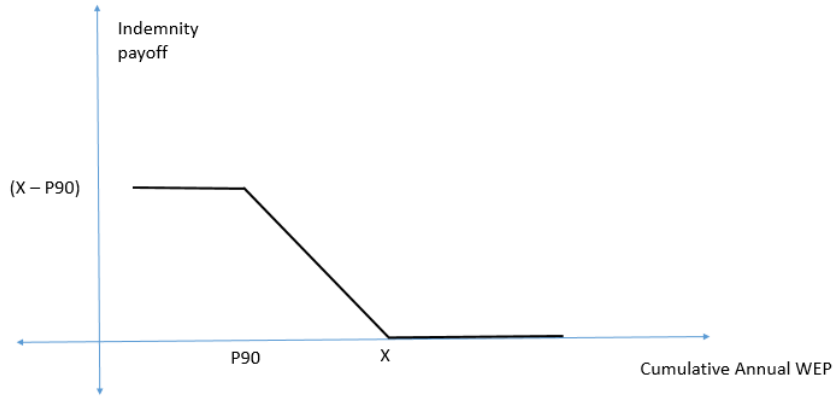
The P50 Risk Solutions product would be offered by insurance companies. Customers may buy this protection for a single turbine, a wind farm, or a portfolio of wind farms, to hedge its Wind Energy Potential to a predetermined level (the strike level "X"). The insurance may be purchased for one of the below two covers for some 'n' number of years:

- P90 level to P75 level
- P90 level to P50 level

The customer purchases the insurance by making upfront annual insurance premium payments to the insurer. If at the end of the year, the cumulative Wind Energy Potential of the wind farm over the year is less than the hedged level X, the insurer makes an indemnity payoff to the customer to make up for this difference (up to a maximum payment equal to (X – P90)). If the cumulative Wind Energy Potential over the year falls below the P90 level, the indemnity payoff is capped to a maximum amount of (X – P90).

In a situation where the cumulative annual Wind Energy Potential exceeds the hedged level, the insurer need not make any indemnity payments to the insured. Thus, in either case, the customer is assured of a revenue corresponding to at least the hedged level with a 90% probability. The P90 level of the wind farm with the embedded P50 Risk Solutions insurance is therefore equal to the hedged level "X".

Figure 3: *Indemnity payoff curve of the P50 Risk Solutions instrument*



2.4 SETTLEMENT PROCESS

P50 Risk Solutions hedges the Wind Energy Potential of the wind farm i.e. the wind speed at the location of the wind farm applied to the ideal power curve of the technology being used. The actual losses arising in energy production are not accounted for in this hedge, as mentioned above. Because of these factors, the actual energy generation of the wind farm may vary substantially from the metric being hedged – and the P50 Risk

Solutions instrument may over-compensate or under-compensate the customer for their losses. This risk – that offsetting investments in a hedging strategy does not generate offsetting payoffs – is called the Basis Risk.

The insurance settlement for P50 Risk Solutions - the mutual agreement between the insurer and the insured on the amount of indemnity payment as per the original terms of the policy - may be done in one of two ways depending on the terms of the agreement between the insurance company and the customer, each of which suffers from advantages and disadvantages.

2.4.1 Settlement using anemometer data

In this method of settlement, masts with anemometers are placed at the actual location of the wind farm at an appropriate height, and the wind speed and direction are measure at sub-hourly intervals. This wind speed is then applied to the power curve and the settlement is done on the basis of this metric. Ideally this settlement method ensures a smaller basis risk since the wind speed being measured is that of the wind impinging on the turbines. However, this method poses a risk to the insurer owing to the possibility of misconduct by the customer.

2.4.2 Settlement using reanalysis data

The second possible method of settlement is using the reanalysis data (i.e. using a wind index published by external meteorological sources) from a point on the grid closest to the location of the wind farm. This method does not suffer from the risk of manipulation of data since the wind index data is published by an independent third party source. However, it suffers from a higher theoretical basis risk since the wind speeds at the wind farm may differ from the wind speed as calculated in the reanalysis data.

2.5 IMPACT ON FINANCING

P50 Risk Solutions is expected to have two hypothesized impacts on the financing available to the project being insured: reducing the cost of financing, and attracting new sources of capital.

2.5.1 Hypothesis 1: Reducing the cost of financing

Non-recourse or limited-recourse infrastructure project finance relies on the revenues generated by the project to service its debt obligations. In order to assess the creditworthiness and feasibility of a project, banks tend to follow a conservative approach and perform an ex-ante calculation of cash flows using P90 levels of revenue generation.

One of the most important metrics considered by banks while making their investment decision is the Debt Service Coverage Ratio (DSCR). The DSCR is the ratio of the Cash Flow Available for Debt Service (CFADS; the project cash flows before making interest and tax payments) to the debt obligations, including the principal payment and interest, for a particular period. A DSCR greater than one implies that a project will be able to service its debt, whereas a DSCR of less than one would imply a technical default scenario. The DSCR of a project fluctuates from year to year over the repayment period of the debt due to various factors. To finance a wind power project, banks typically require the project to maintain a minimum DSCR of about 1.15, and an average DSCR of about 1.3, over the repayment period of the debt.[3]

[3] Source: primary research with banks

The P50 Risk Solutions instrument could lower the cost of financing of the project via one or more of the following pathways:

a) Higher debt-equity ratio:

In Section 2.2 we saw that the P90 level of the project with the embedded P50 Risk Solutions product is equal to the hedged level of the insurance, which is higher than the P90 level in a business as usual (BAU) situation. This level may now be used by banks to compute the projected cash flows of the project. Thus, a debt principal amount higher than that in the BAU case would now be able to satisfy the DSCR requirements of the bank. This is referred to as debt sculpting. Since debt is a cheaper form of capital than equity, a higher debt-equity ratio in the capital mix has the effect of reducing the weighted average cost of capital (WACC). Further, the higher proportion of debt used to finance the project leads to additional equity capital being unlocked, which can then be redeployed into the renewable energy sector, thus supporting the construction of additional generation capacity.

b) Reduction in the interest rate

The interest rate charged by a bank over the risk-free interest rate is a measure of the bank's assessment of the borrower's likelihood of defaulting on the loan. The higher the probability of default, the higher the interest rate will be. Not only does the P50 Risk Solutions product enhance the P90 level of the project, at the same time, it also leads to a higher revenue certainty for the project. Typically, for project finance, the bank has no (or limited) recourse to repayment of the debt from the borrower's assets in the case of default, and is mostly entitled to repayment from the project's cash flows. Therefore, a higher revenue certainty (i.e. lower revenue volatility) for the project translates to a lower risk exposure to the bank. Thus, the P50 Risk Solutions insurance could lead to a reduction in the interest rate charged by banks owing to the reduced perception of probability of default. For further reading on the underlying theory, please refer to Appendix A.

c) Reduction in the returns on equity

Equity investors form the junior tranche in the waterfall structure of a project, i.e. they get paid only after the senior tranches (debt investors) have been paid. Thus, they face the highest risk of a project not performing as expected. For this they expect to earn returns commensurate to the risk. To assess the viability of a project, the ex-ante cash flow projections factor in the pay-out to equity investors and the discounting rate to be used according to the expected returns on equity. Since the P50 Risk Solutions insurance reduces the earnings volatility (and hence, risk) of projects, one may expect equity investors to lower their expected returns on equity to reflect the lower risk.

2.5.2 Hypothesis 2: Attracting new sources of capital

There are three classes of investors who have not traditionally invested in the renewable energy sector in India but who have potential – institutional investors, investors in the bond market, and investors in certain instruments like INvITs.

Institutional investors, such as pension and insurance funds, are a potentially significant source of capital for renewables in India, but at present, their investment remains negligible owing to the mismatch between their investment mandates and the riskiness of investments in renewable energy. Typically, this class of investors invests only in securities with a credit rating of AA or better, whereas most wind farms in India have credit ratings in the B to BB range. Additionally, the corporate bond market in India is very underdeveloped and shallow, with corporate bonds' outstanding being equal to only 13% of the GDP in 2014[4]. Further, market uptake for bond issues with low credit ratings remains dismal, and there is no precedent (save

[4] http://www.careratings.com/upload/NewsFiles/Studies/Indian%20Bond%20Market-%20Striking%20a%20Chord%20with%20Asian%20Peers.pdf

one)[5] of bond issuances to finance renewable energy projects in India. Bond investors are very prudent in their investments compared to those in the developed markets, who are open to investing in lower rated bonds. Because the ratings of most wind farms in India are in the B to BB range, it is likely that bonds issued to finance them may not gain much traction.

The P50 Risk Solutions insurance has a two-pronged effect on the forecasted cash flows – enhancing the P90 levels and reducing the earnings volatility. Both of these effects should lead to an increase in the credit ratings of the project insured. A sufficiently large enhancement of the credit rating could ensure that the project meets institutional investors' required investment grade, or could make bond-issuance a viable option for debt-raising.

Institutional investors represent a large pool of capital that could now be made available to the renewable energy sector in the form of either debt or equity capital. The stability in earnings effected by the P50 Risk Solutions insurance also makes projects better-suited to be invested in as a part of an InvIT (Infrastructure Investment Trust) structure, whose investors value steady and stable returns over the investment lifetime. It is worth investigating the possibility of raising investment – either as debt or equity – from institutional investors, the bond market, and investors in instruments like INvITs, either for financing or refinancing projects.

[5] In September 2015 Renew Power issued a USD $68 million project bond to refinance a wind project under the project bond guarantee facility set up by ADB and IIFCL in 2012.

3. INNOVATION AND RISK MITIGATION

There are similar insurance instruments for weather variability in other countries, but P50 Risk Solutions would be innovative in pioneering this concept in India.

3.1 BARRIERS ADDRESSED

The P50 Risk Solutions instrument explores the applicability of the intervention of the insurance industry to mitigate the risk of weather-variability in the utility-scale wind energy sector, from a financial and regulatory perspective, in an Indian context. The main barrier addressed by the P50 Risk Solutions instrument is the inherent weather-variability risk in the wind power industry and its consequent effects on:

- Raising the cost of capital
- Limiting the availability of capital

If effective, the P50 Risk Solutions instrument would address both of these barriers in the ways explained in Section 2.4, by reducing the cost of finance, and by making available new sources of capital. It is interesting to note that another possible product structure could also address the same barriers in a different way. This structure – the swap structure – was also explored as part of the analysis conducted, but was found to be ineffective due to regulatory hurdles in implementation (please refer to Appendix B).

3.2 INNOVATION

As mentioned earlier, offering weather-variability protection for the renewable energy sector via the insurance market is not an entirely new concept, and has precedence in several developed markets. The innovation in the P50 Risk Solutions idea lies in pioneering this concept in the Indian markets, and adapting it to suit the peculiar financial and legal requirements of the country. The product would have to be structured in a way that simultaneously addresses the concerned barriers, is commercially feasible from a financial perspective, and fits into India's legal and regulatory framework. Sections 3.2.1 and 3.2.2 detail how the instrument aims to achieve this.

3.2.1 Financial feasibility in India

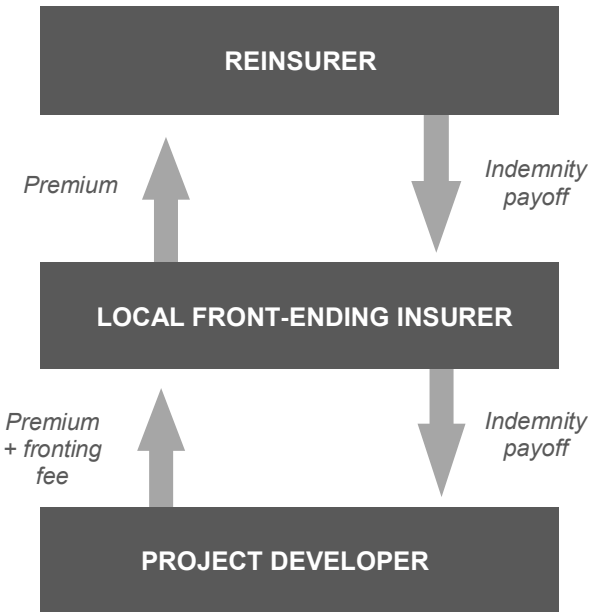
P50 Risk Solutions strives to offer weather-variability solutions to the Indian market, and this report aims to explore its feasibility in India. The price of the insurance product and its consequent financial effects on the project depend heavily on the project's technical assessment and its underlying financial data. Thus performing a cost-benefit analysis across the board for the sector is not possible. To perform this cost-benefit analysis, the authors have adopted as case-study method. Data was sourced from a test case-study which is representative of a typical wind farm which could benefit from such an insurance product, under a confidentiality agreement with the project's developer. The methodology and results of this analysis are described in detail in Section 4.

3.2.2 Legal structure

Being an insurance product, P50 Risk Solutions falls under the ambit of the IRDA (Insurance Regulatory and Development Authority) regulations. Currently, the only insurers having the wherewithal to offer weather-variability insurance products are a few international underwriters. The authors of the report have conducted primary research with Swiss Re, Munich Re, Endurance Re and Unison Insurance, all of which offer weather-variability insurance products.

As per IRDA regulations, general insurance contracts such as P50 Risk Solutions may only be signed between an Indian insurer and the customer. This necessitates a structured deal in which a local insurer would front-end the contract with the customer, and this fronting agency would then sign a reinsurance treaty with the foreign underwriter(s) offering the P50 Risk Solutions insurance, to offload its risk. In the process, the domestic fronting agency would charge a commission for facilitating the transaction. Indemnity payments would flow from the foreign underwriter(s) to the end customer through the conduit of the local insurer.

Figure 4: *Instrument Legal Structure*



4. IMPACT AND RESULTS

Presently, P50 Risk Solutions is unlikely to be successful in reducing the cost of financing, and even if implemented using donor assistance, it would most likely not have any significant impact in bringing new investor classes to the table.

For our cost-benefit analysis, we used a mixture of primary research, secondary research, and quantitative financial modeling to measure the impact of the P50 Risk Solutions instrument in terms of our two impact hypotheses:

- Hypothesis 1: Reduce the cost of financing
- Hypothesis 2: Attract new sources of capital to increase availability of capital

Section 4.1 explains the quantitative model created to measure the impact of P50 Risk Solutions on the cost of financing, along with its results; whereas Section 4.2 discusses the findings of the research on the impact on attracting new sources of capital.

4.1 IMPACT ON REDUCING THE COST OF FINANCE

We created a model to compare the costs of the P50 Risk Solutions insurance and its benefits to the terms of financing, and applied it to the data from the case study of a representative wind farm. The following sections explain the analysis surrounding the cost, the benefit and the comparative analysis respectively:

4.1.1 Cost of the insurance product

Insurance companies that offer weather-variability insurance price them using their proprietary models, which are very involved and require significant commitment of time and financial and human resources. For conducting the cost-benefit analysis, we devised a model to derive an indicative price of the P50 Risk Solutions insurance for the representative wind farm (please refer to the methodology in Appendix C). The methodology and the corresponding results were verified by professionals from insurers offering such products. In a real world scenario, the actual price provided by an insurer may slightly differ from this price due to differences in the internal rates of finance available, diversification effects across their portfolio, and the existence of competition.

The results for the indicative prices of the P50 Risk Solutions insurance for a P75 hedge and a P50 hedge respectively obtained by applying this model to the test case data are captured in Table 1 below. The prices have been quoted as a percentage of the annual P50 revenue of the wind farm.

Table 1: *Indicative price of the P50 Risk Solutions insurance for the case study*

Hedge level	Hedged level gross CUF[6]	Maximum indemnity level	Max indemnity gross CUF	Insurance price as % of annual revenue
P75 level	26.86%	P90 level	24.68%	3.5%
P50 level	29.4%	P90 level	24.68%	7.5%

[6] The gross Capacity Utilization Factor (CUF) refers to the ratio of the average energy output of a wind farm (excluding losses) to the rated power output of the farm

4.1.2 *Impact on the cost of financing*

As discussed in Section 2.4, the P50 Risk Solutions instrument can have an impact on the cost of financing via three pathways:

a) Higher debt-equity ratio
b) Reduction in the interest rate
c) Reduction in the returns on equity

a) Higher debt-equity ratio:

Wind farms currently have a typical capital structure where debt constitutes anywhere between 60% and 80%, and most often between 65% and 75%, of the total capital. P50 Risk Solutions has the potential to increase the leverage of the project while maintaining the risk exposure of the lending bank. However, even when the credit risk exposure of banks is held within acceptable levels, investment guidelines followed by banks often place a hard cap on restricting the proportion of debt in the capital structure of a project to within 80%.

In projects where the proportion of debt used is already on the higher end of the spectrum, P50 Risk Solutions will be unable to effect any meaningful change in the leverage. In projects which would have been able to secure a lower proportion of debt, the P50 Risk Solutions insurance affects the projected cash flow available for debt service in two ways:

- Increases the P90 levels of generation up to the P75 or the P50 level of the uninsured project, depending on the hedged level
- Reduces the cash flow because of insurance expenses

These two forces act in opposing directions. Their combined effect is to increase the leverage of such a project by up to a maximum of 15 percentage points.

b) Reduction in the interest rate:

Primary research with several stakeholders, including banks, credit ratings agencies, project developers, and developmental bodies, has led to the findings that:

- Many domestic Indian banks use standard credit risk models which may not factor in P50 Risk Solutions' ability to reduce revenue volatilities.
- As of September 2016, wind farms are able to raise debt finance at rates lying anywhere between 10.5% and 13% for up to 12 year tenors. This is very competitive with the benchmark interest rates for infrastructure projects available in the debt market. Further, once a project is under operation, and a track record has been established at around the 4 to 5 year mark, most project developers refinance their debt in a manner that brings the capital structure back to a similar debt-equity ratio as at the initiation of the project, so that the overall debt repayment period is up to 17 years.

Given these ground realities, banks do not have much leeway in reducing the cost of debt that they provide, and any impact that the P50 Risk Solutions insurance would have, would be minimal.

c) Reduction in the returns on equity:

The reduction in the riskiness of their investment in the project owing to the P50 Risk Solutions instrument should lead to equity investors recalibrating their expectations of their returns. However, primary research with some equity investors indicates that equity investors in the renewables space have minimum thresholds on their expected returns, and

not their risk-adjusted returns. Independent Power Producers (IPPs) take a business risk in accurately predicting the expected generation from their investments, and would like to be appropriately rewarded for it, and are reluctant in reducing their expected earnings. Their cost of equity is between 16-18%, which is not a very high figure for the renewable energy sector to begin with. Hence any reduction in the cost of financing due to reduction in the returns on equity would be negligible.

Based on these findings, we performed a cost-benefit analysis for three hypothesized impact scenarios (for each of the two hedged levels under consideration). These impact scenarios are enumerated in Table 2. The first scenario (A1 and A2) is the least optimistic one, in which the insurance is not effective in changing either the leverage or the interest rate. On the other hand, the third scenario (C1 and C2) considered is the most optimistic one of the lot, in which the presence of the insurance affects both the leverage and the interest rate favourably.

Table 2: *Hypothesized Impact Scenarios*

Scenario	Hedged Level	Increase in Debt-equity ratio	Reduction in Interest Rate	Bank Category
A1	P75	No	No	Public Sector Banks
B1	P75	Yes	No	Domestic Private Sector Banks
C1	P75	Yes	0.25%	Foreign Banks
A2	P50	No	No	Public Sector Banks
B2	P50	Yes	No	Domestic Private Sector Banks
C2	P50	Yes	0.50%	Foreign Banks

We built cash flow models for these six scenarios to understand the impact of P50 Risk Solutions insurance on the project financials. In the scenarios where the instrument has an effect of increasing the debt-equity ratio, the debt-equity ratio is iteratively changed till the DSCR requirements of the bank are fulfilled. For Scenario C, the reduction in the interest rate was assumed to be 25 basis points for a P75 level hedge, and 50 basis points for P50 level hedge, as an optimistic assumption based on primary research with private sector banks. In each case, the levelized cost of electricity (LCOE)[7] is calculated as the least possible tariff that simultaneously achieves the equity investors' expected returns and the requirements of the lenders' debt covenants.

A reduction in the LCOE relative to the BAU scenario would make the project more competitive and thus lead to the conclusion that the P50 Risk Solutions is a viable option. On the flip side, an increase in the LCOE over the BAU case would mean that the P50 Risk Solutions is not a commercially feasible option.

4.1.3 Cost-benefit analysis:

The cash flow models for the seven different scenarios under consideration led to the results listed in Table 3. In each of the six impact scenarios, the LCOE computed for the insured

[7] The levelized cost of electricity is defined as the least levelized tariff that would make an energy project financially viable.

project is actually higher than the LCOE in the BAU scenario, so that the net annual savings to the project are actually negative.

Table 3: *Cost-benefit analysis for a standalone project*

Scenario	Debt	Equity	Interest	Insurance Cost as % of annual revenue	LCOE
BAU	64.0%	36.0%	13.00%	0.000%	4.91
A1	64.0%	36.0%	13.00%	3.5 %	5.07
B1	70.5%	29.5%	13.00%	3.5%	5.13
C1	71%	29%	12.75%	3.5%	5.08
A2	64.0%	36.0%	13.00%	7.5%	5.29
B2	78.5%	21.5%	13.00%	7.5%	5.39
C2	79%	21.0%	12.50%	7.5%	5.30

This cost-benefit analysis was conducted for a standalone project. Purchasing the P50 Risk Solutions insurance for a portfolio of projects, on the other hand, is less expensive than purchasing insurance for each of the projects in the portfolio individually owing to the diversification benefits within the portfolio (please refer to Appendix 7.4 for more details). Table 4 shows these cost-benefit calculations for the case when the Wind Energy Potential of a portfolio of wind farms is insured. Using reasonably optimistic approximations for the reduction in the insurance cost (as a percentage of the annual revenue) done on a portfolio-wide basis, based on the inputs from experts from the weather insurance industry, we still find that this reduction in the cost is not sufficient to make the product commercially viable.

Table 4: *Cost-benefit analysis for insurance for a portfolio of projects*

Scenario	Debt	Equity	Interest	Insurance Cost as % of annual revenue	LCOE
BAU	64.0%	36.0%	13.00%	0.00%	4.91
A1	64.0%	36.0%	13.00%	3.15 %	5.05
B1	70.5%	29.5%	13.00%	3.15%	5.10
C1	71%	29%	12.75%	3.15%	5.06
A2	64.0%	36.0%	13.00%	6.75%	5.25
B2	78.5%	21.5%	13.00%	6.75%	5.35
C2	79%	21.0%	12.50%	6.75%	5.26

The above cost-benefit calculations suggest **the P50 Risk Solutions product is not commercially feasible from the standpoint of reduction of the cost of financing** for any of the considered impact scenarios – from the least optimistic (Scenario A) to the most optimistic (Scenario C) – for a standalone project, as well as an optimistic scenario for a portfolio of wind farms.

Thus, **the real value-add of the P50 Risk Solutions, if any, would lie not in the reduction of financing costs, but in creating more availability of capital through new institutional sources**. If the P50 Risk Solutions instrument were to be implemented to achieve this end, it would need donor capital to support it to the extent of the equity investors not facing any decrease in their expected returns, since the analysis shows that the product is not commercially viable.

4.2 IMPACT ON ATTRACTING NEW SOURCES OF CAPITAL

Our analysis suggests that the P50 Risk Solutions insurance does not have any net benefits in terms of reducing the financing costs. The second part of the analysis aims to verify the second posited hypothesis, and measure the impact that the P50 Risk Solutions could have on attracting additional capital to the sector.

Interviews with credit ratings agencies involved in the business of rating power projects led to the consensus that wind projects in India in the pre-operational phase usually have credit ratings between BB and BBB, which may go up to a rating of A once operational (in case the project exhibits a promising track record over a few years). By contrast, the investment mandates of the institutional classes mentioned above prohibit them from investing in projects or firms rated below AA.

India's DISCOMs, or state public electric distribution companies, are the primary power purchasers (off-takers) and are also suffering from extremely poor financial health, leading to delays in payment to independent power producers (IPPs), often several months or even years. This problem is more acute in the case of certain states' DISCOMs, and less so with certain others. Interviews with several classes of stakeholders such as project developers, ratings agencies and banks unanimously indicated that the magnitude of risk of delayed off-taker payments is very high compared to wind variability risk.

In contrast with this risk, investors are not very concerned about the risk of wind variability. The disproportionately high perception of the risk of delayed off-taker payments ensures that the wind variability risk is treated as low-priority, and does not contribute substantially to the credit rating of wind projects. Thus, mitigating the risk of wind variability through the P50 Risk Solutions insurance would enhance the credit rating of an overwhelming majority of the projects only by up to a maximum of one level, which still would not push the rating over to the investment grade category.

It is unlikely that the second hypothesis put forward would be satisfied in the short term. This is due to the fact that resource risk is considered secondary to the risk of off-taker payments. Once the latter is resolved – either through policy intervention or some other means – it is likely that this hypothesis may be satisfied. In conclusion, in the present situation, neither is the P50 Risk Solutions insurance likely to be successful in reducing the cost of financing, and even if implemented using donor assistance, it would most likely not have any significant impact in bringing new investor classes to the table.

5. IMPLEMENTATION PATHWAY

5.1 KEY MILESTONES

The key implementation milestones are to design the appropriate legal structures for the implementing entity, the insurance product and the mixed pool of commercial and donor capital, to fit the regulatory framework applicable to insurance products.

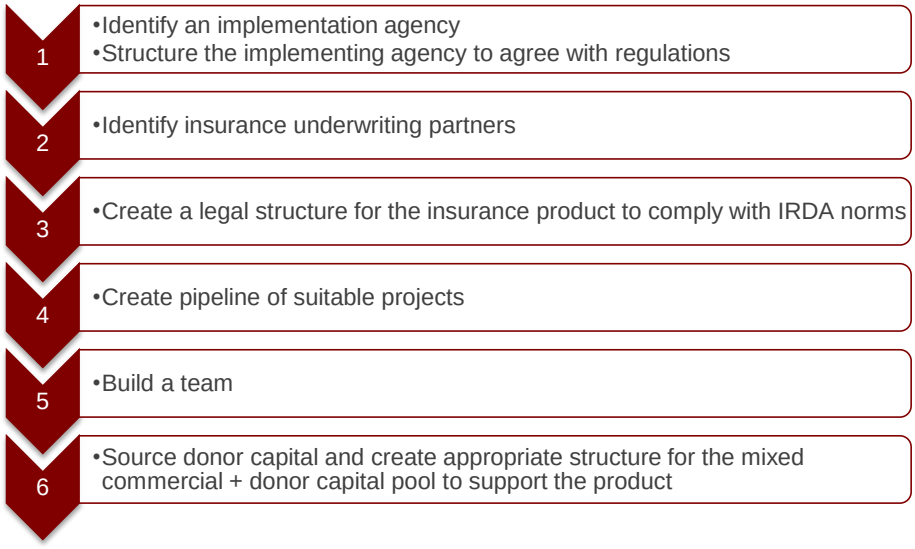
P50 Risk Solutions requires an implementing agency to carry out negotiations among three stakeholders:

- The local insurer and the reinsurance underwriters
- The customer
- The lender/ bank

Registering the implementer as an insurance broker exposes the implementing agency to the purview of IRDA regulations for general insurance brokers, which imposes restrictions on its eligibility criteria and the scope of permissible activities. The first step in the implementation process would be to design an appropriate legal structure for the implementing organization by employing legal aid to work around this regulatory hurdle.

Given the necessity of employing donor capital to partially fund the P50 Risk Solutions product, a necessary milestone in the implementation process is to structure the mixed capital pool made up of commercial and donor capital to support the insurance product in a fashion that meets the expectations of the donors, and avoids moral hazard while simultaneously enabling the insurance product to meet its objectives.

Figure 5: *Key milestones for implementation*



5.2 RISKS TO IMPLEMENTATION

5.2.1 Lack of demonstrable impact and market demand

The analysis for the instrument indicates that the instrument may not be successful in neither reducing the cost of capital nor attracting new sources of capital. Given this lack of demonstrable impact, it would be extremely challenging to convince project developers and other equity investors in the renewable energy market to invest in this risk-management device.

Further, implementation would require donor capital. Investing in a product that does not demonstrate any significant social or environmental impact in the wind sector, which is already fairly mature and commercially-sustainable, does not align with the objectives of such impact investors. Additionally, the current risk climate facing the wind energy sector in India, especially the significantly larger risk of delayed off-taker payments, has relegated the risk of wind variability to the side-lines. In such a situation, any interventions to mitigate the risk of wind variability are seen by investors as being of secondary importance, leading to a reluctance in deploying resources to manage this risk.

This lack of demonstrable impact and the consequent lack of market demand and donor support are the biggest roadblocks in the implementation of the P50 Risk Solutions product.

5.2.2 Regulatory risk

The IRDA has released new guidelines for cross-border reinsurance in January 2016,[8] as a revision to the guidelines released in April, 2015. These guidelines, apart from some preliminary filing and Know Your Customer (KYC) requirements, grant parity to three parties - Indian reinsurers, cross-border reinsurers and other Indian insurers in this order of priority. In other words, the guidelines say that every domestic Indian insurer should first offer an opportunity to the Indian public sector reinsurer (which is GIC Re) to participate in its reinsurance business, or a foreign reinsurer which retains a 50% minimum retention, and then to other Indian insurers.

The Insurance Laws (Amendment) Act of 2015 permits foreign reinsurance companies to set up branch offices in India. The possibility that GIC Re may exercise its first right of refusal poses a business risk to the reinsurer offering the P50 Risk Solutions product, since it may not want to share its business with its competitors.

Further, the same IRDA regulations clarify that a foreign reinsurer branch cannot cede more than 50% of its total reinsurance placements made outside India with its parent company. Based on necessity, the Indian reinsurer (GIC Re) should organize domestic pools for reinsurance surpluses in consultations with all Indian insurers and foreign reinsurer branches.

On account of this regulatory risk – the risk of losing the reinsurance business to competitors, along with the lack of demonstrable impact and market demand for the product – the original proponents of the P50 Risk Solutions – Swiss Re and P50 Risk Managers – made the business decision of not pursuing this idea in the Indian market any further. Given the esoteric nature of the product and the requirements for a robust balance sheet and credit ratings to be able to offer such an insurance product, few players in the market possessed the experience and resources to act as implementers for the idea. Outreach to a few of these organizations failed to evince any strong interest in acting as implementers for the P50 Risk Solutions idea. Along with the other discussed risks, this is another major impediment to the successful implementation of the idea.

In the opinion of legal experts consulted in the course of the research work regarding this regulatory risk, while this is theoretically a risk to implementation, practically this does not pose a major risk towards the implementation of the idea. In their view, GIC Re's scope of interest and expertise does not contain insurance products such as the P50 Risk Solutions. Thus, the odds of them exercising their first right of refusal are negligible, making this only a formality.

[8] CIRCULAR NO.IRDAI/NL/GDL/RIN/017/01/2016, DATED 19 01 2016

6. KEY TAKEAWAYS

The proposed P50 Risk Solutions instrument is an attempt to make insurance solutions available to the Indian wind energy market, to mitigate the risk of weather resource variability by offering a guarantee of minimum revenue generation to project developers against the payment of a premium. The expected beneficial outcomes of employing this solution were:

- Reducing the cost of financing
- Attracting new sources of capital

Our analysis to verify these hypotheses led to the conclusions that:

- The expected benefits in the reduction in the cost of finance do not defray the cost of the insurance product, and thus the product is not purely commercially viable.
- Donor support would be needed to implement the product.
- Even with the aid of donor capital, the P50 Risk Solutions instrument does not demonstrate any significant impact in attracting additional capital.
- In the current risk climate, the risk of wind variability is perceived as being of secondary importance by investors.
- Owing to the above factors, the market demand for such an intervention is limited.

Underneath is a comparison of how the P50 Risk Solutions instrument aligns with the four overarching criteria of the India Lab:

- **Transformative**: Because of the lack of market demand for interventions such as P50 Risk Solutions and the hurdles in implementing it successfully, its transformative potential is limited.
- **Innovative:** While actively managing the weather-variability risk in the renewable energy sector has precedent in several other markets, such practices do not have a precedent in the Indian context, and would be certainly innovative.
- **Catalytic:** According to our analysis, the P50 Risk Solutions instrument would not be very successful in raising additional capital, and its catalytic effect on green infrastructure development in India would be minimal.
- **Actionable:** The instrument faces several hurdles towards successful implementation, and being actionable is a major concern.

7. APPENDIX

7.1 REDUCTION OF THE COST OF DEBT

This appendix explains the underlying theory behind how the P50 Risk Solutions product could effect a reduction in the cost of debt, by reducing the probability of default (effectively, the risk) faced by the lending agency.

For non-recourse project finance[9], the distance to default[10] at time t is given by the formula:

$DD_t = 1/S_{CFADS} * (1 – 1/DSCR_t)$[11] -- (1)

Where S_{CFADS} is the standard deviation of the Cash Flow Available for Debt Service and $DSCR_t$ is the DSCR at time t.

Since the insurance product leads to tightening of the cash flows, thereby decreasing the standard deviation of the cash flows, for the same DSCR, the distance to default for the insured project would be higher, implying a smaller probability of default. Hull, Predescu and White in their paper “Bond Prices, Default Probabilities and Risk Premiums” draw out a relationship between the default intensity (which is the conditional probability of default given that a company has not defaulted thus far) and the credit risk premium over the ‘risk-free’ Treasuries. The higher the probability of default, the more is the credit spread over the ‘risk-free’ Treasuries. Since the probability of default has a direct relationship with the standard deviation according to formula (1) above, a reduction in the standard deviation of the CFADS probability distribution implies a reduction in the credit spread, the mapping between which can be derived from Hull, Predescu, et al.

7.2 THE SWAP STRUCTURE: AN ALTERNATIVE DESIGN

The P50 Risk Solutions instrument provides downside protection to customers while allowing them to reap the benefits of higher-than-usual wind speed scenarios, against the payment of a premium. An alternate structure may also be devised to hedge the risk of wind variability. In this swap-like structure, the revenue of the customer is hedged to an agreed level with a 100% certainty. In a low-wind year, the insurer makes an indemnity payment to make up for the difference between the insured level and the actual Wind Energy Potential calculated.

Conversely, in a high-wind year, the customer passes on the upside to the insurer. It is easy to see that the swap structure would be significantly less expensive than the structure of the P50 Risk Solutions instrument. Such a solution would be extremely attractive to the class of equity investors who value stable returns from their investment highly. This structure has precedence in various developed markets, for example, Allianz Risk Transfer in May 2015 executed a ten year swap for a wind farm in Kansas, USA that hedged both the volume and price risk for the wind farm developer[12].

However, this swap-like structure has been found to be infeasible in an Indian context. This is because Indian regulations prohibit positive cash flows from insurance customers to insurers (with the exception of upfront premium payments), which rules out the possibility of entering into swaps with insurance company counterparties.

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[9] Non-recourse project finance is a loan where the lender is only entitled to repayment from the profits of the project the loan is funding, and not the assets of borrower

[10] The distance to default is defined as the number of standard deviations required for a firm to reach its default point within a specified time horizon t. Conversely, the probability of default at time t may be defined as the area under probability distribution function of the CFADS from the left-most extreme to the (mean - $DD_t * S_{CFADS}$)

[11] “Measuring the credit risk of unlisted infrastructure debt” – Blanc-Brude, Ismail, 2013

[12] http://www.agcs.allianz.com/about-us/news/art-innovative-swap-solution-wind-farms/

7.3 INDICATIVE FINANCIAL PRICING MODEL

Insurance products can be priced using actuarial and financial methods.[13] Insurers would use their proprietary actuarial models to price the premium for the P50 Risk Solutions product. Along with the project data, the pricing is also affected by the internal rates of financing for the insurer, diversification effects within its existing portfolio, etc. For the purpose of the study, we have devised a simplistic no-arbitrage financial model (described below) to derive an indicative price for the insurance product, which has been verified by insurance experts in the working group. However, in a real world scenario the prices may be less due to the above listed effects.

7.3.1 Financial Pricing Model

For the purpose of the study we have derived indicative financial pricing for the P50 Risk Solution insurance product for two coverage levels – P75 and P50 – by drawing an analogy with Asian options. Asian options are cash-settled options whose payoff is based on the difference between the average value of the underlying during the life of the option, and a fixed strike, as opposed to vanilla European options where the payoff is based on the difference between the value of the underlying at expiry and the strike.[14] Consider a portfolio of two Asian options whose underlying is the Wind Energy Potential of the wind farm (this portfolio is typically called a bear spread):

- **Option 1:** a long put Asian option with one year expiry and strike X
- **Option 2:** a short put Asian option with one year expiry and strike = P90 level

The payoff for each of the two options is as shown in Figure 6 below so that superimposing the two gives the desired payoff for the insurance product. The indicative price of the P50 Risk Solutions insurance product can now be modelled as the price of this portfolio. The probability distribution function of the wind speed resembles a Weibull distribution (Figure 3). By applying the power curve to the wind speed distribution, the distribution curve of the Wind Energy Potential can be derived. Since the power curve is a monotonically increasing non-linear function, the probability distribution of the Wind Energy Potential more closely resembles a normal distribution than the Weibull distribution. The price of the portfolio is then found by running Monte Carlo simulations.[15] We make the simplifying assumption that the Wind Energy Potential follows a normal distribution. This has the effect of erring on the side of caution. The Weibull distribution is skewed to the left. Thus, the median level (P50) is less than the mean, whereas in the normal distribution, the median is equal to the mean. Thus, in the case of the Weibull distribution, the put options would be more out of the money than in the case of the underlying following a normal distribution, and ergo less expensive.

The risk-free rate used is the one-year Indian Government Treasury bond yield averaged over the previous year, since the expiry of the contract is one year.

[13] "Actuarial versus Financial Pricing of Insurance" – Embrechts, 1997
[14] "The Value of an Asian Option" – Rogers, Shi, 1995
[15] "Pricing Asian Options using Monte Carlo Methods" – Zhang, 2009

Figure 6: *Payoff diagram of a bull spread using puts. The hedged level X is either the P75 or P50 level here.*

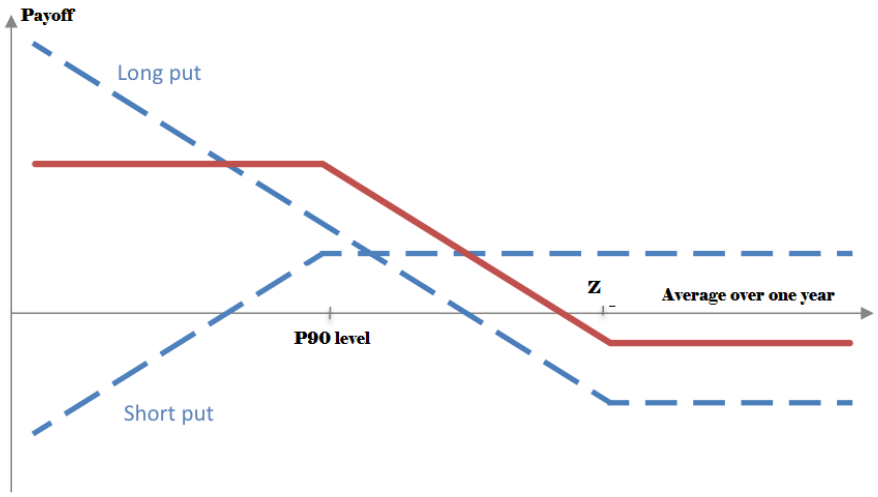

Image source: Wikipedia

7.4 INSURING A PORTFOLIO OF WIND FARMS

Wind speeds measured at measuring stations which are geographically separated are correlated, with the correlation being dependent on several geographical and topological factors[16]. These correlations may be negative or positive. An alternative to individually insuring the energy generation of several different wind farms is to insure the cumulative energy generation of a portfolio of several wind farms. On account of varying correlations between the different pairs of wind speeds, in most cases, the volatility of the energy generation of the combined portfolio would be less than the average volatility of the energy generation of the wind farms in the portfolio. The implication of this is that the price of offering a P50 Risk Solutions insurance for the portfolio would be cheaper than if each of the wind farms were hedged individually.

[16] "A two-site correlation model for wind speed, direction and energy estimates" – Salmon, Walmsley [1999]

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