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# An Assessment of India's Energy Choices: Financial Performance and Risk Perception

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## About the Series: An Assessment of India's Energy Choices

This report is part of a four-report series that looks at the future of renewable energy in India along different economic dimensions. The four reports in the series are:

### **Social Costs of Coal-Based Electricity in India: Estimates of Impact on Health and Agriculture**

Ashwini Chhatre, Indian School of Business

### **What it Means for the Economy, Jobs, and Energy Security**

Dr. Meeta Keswani Mehra, JNU and Dr. Saptarshi Mukherjee, IIT

### **Financial Performance and Risk Perception**

Vinit Atal and Gireesh Shrimali, Climate Policy Initiative

### **Managing India's Renewable Energy Integration through Flexibility**

Vivek Sen, Saurabh Trivedi, and Gireesh Shrimali, Climate Policy Initiative

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With deep expertise in policy and finance, Climate Policy Initiative works to improve the most important energy and land use practices around the world. Our mission is to help governments, businesses, and financial institutions drive growth while addressing climate risk.

CPI works in places that provide the most potential for policy impact including Brazil, Europe, India, Indonesia, and the United States.

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## Executive Summary

India has prioritized electricity access as a key driver of socio-economic development. Each year, as part of the country's successive National Electricity Plans, the government has set targets that scale up electrical capacity additions.

India has also set ambitious targets for renewable energy in the context of climate change commitments, with a goal to increase the proportion of renewable energy sources in the country's electricity generation mix to up to 40% by 2030 from 14% as of March, 2016.

**These dual electricity generation targets require significant investment.** The total investment requirements for generation capacity addition is estimated to be INR 10.3 trillion during the period 2017-2022, which includes the funds required for renewable energy sources capacity addition, as well as the advance action on the projects coming up during the years 2022-27. The total fund requirement for the period 2022-27 is estimated to be INR 6.1 trillion (Draft National Electricity Plan, 2016).

This represents a massive opportunity for investors to make profitable investments in the power sector, using both fossil fuel and renewable energy technologies. Policymakers need to design policies to reduce barriers to investment to be able to reach government targets for each technology.

This paper is part of a four-part series produced by Climate Policy Initiative that compares renewable energy and fossil fuel based power along different dimensions including social costs, macroeconomic impacts, environmental impact, financial risk, and flexibility considerations.

**This particular study seeks to study and compare the historical and present-day financial performance and risk profile of the renewable energy and fossil fuel power sectors**, in order to inform investors and policy-makers, by answering questions such as:

- How have the renewable energy and fossil fuel power sectors fared financially in the past with respect to risk and risk-adjusted returns?
- How does investors' risk perception of the renewable energy and fossil fuel power sectors differ?
- What factors contribute to the differing risk perceptions of the renewable energy and fossil fuel power sectors?

We answer these questions using two approaches – ex post empirical analysis of financial performance data of power-producing companies, and primary research with investors in the sector to understand their perceptions of the risk and the areas of concern.

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*How have the renewable energy and fossil fuel power sectors fared financially in the past with respect to risk and risk-adjusted returns?*

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**We find that the renewable energy power sector has been less risky than the fossil fuel power sector.** The listed renewable energy power sector in India has historically exhibited half as much systematic (or non-diversifiable) risk as the listed fossil fuel power sector. Using past trends as an indicator of future performance, there is reason to believe this trend will continue in the absence of major upheavals to the sector. This presents evidence for continued growth of the renewable energy power sector in spite of gradual easing of policy support from the government.

**Renewable energy power has been a more lucrative investment than fossil fuel power.** Renewable energy power portfolios have historically shown more attractive investment characteristics including, on average, 12% higher annual returns, 20% lower annual volatility, and 61% higher risk-adjusted returns. Thus, a portfolio of renewable energy power companies would be deemed more efficient than a portfolio of fossil fuel power companies, as per the modern portfolio theory, providing an investor with a given risk appetite higher returns in comparison.

**Stock returns for both renewable energy and fossil fuel power companies are robustly correlated with market returns.** Using econometric methods, we were unable to determine whether other relevant factors such as company size, value, leverage, coal prices, rupee exchange rate, and term premium are robustly priced into the stock returns.

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*How does investors' risk perception of the renewable energy and fossil fuel power sectors differ?*

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**Investors perceive renewable energy power investments to be less risky than fossil fuel power investments.** The expected returns on debt to the fossil fuel power sector is at least 80 basis points (bps) higher than for expected returns on debt for the renewable energy power sector. The higher risk perception of the thermal power sector may be attributed to sourcing issues and import dependency for coal and natural gas, longer construction periods due to delays in obtaining clearances, and stricter water usage and emission standards.

**Within the renewable energy power sector, solar is perceived as less risky than wind.** The cost of debt for wind power investments is about 150 bps higher than the cost of debt for solar power investments. This may be mainly due to the higher perceived resource risk for wind power over solar power, as also evidenced by the stricter conditions for assessing viability imposed by banks for funding wind projects over solar projects.

**In the fossil fuel power sector, coal is perceived as less risky than natural gas.** This may be because there is higher resource risk associated with natural gas based power due to insufficient domestic reserves, import dependence, high global prices and lack of transport infrastructure in India.

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*What factors contribute to the differing risk perceptions of the renewable energy and fossil fuel power sectors?*

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**The main risk factors driving the risk perception of both renewable energy and fossil fuels are counterparty, grid, and financial risks.** These risks together account for 50% - 54% of the total risk premium. Further, for the fossil fuel power sector, the resource risk and power market risk are also significant, contributing to 26% of the total risk premium.

Accordingly, policy and market interventions targeting the mitigation of barriers associated with these risks have the highest potential for reducing the cost of capital for investments, by up to 4% of the cost of debt of renewable energy investments, and up to 5.1% of the cost of debt for fossil fuel energy investments.

**Counterparty risk is the most significant risk by far.** Counterparty risk, related to state distribution company (DISCOM) non-payment is the most significant risk, contributing to approximately one quarter (22-27%) of the risk premium for both renewable and fossil fuel energy. In fact, this risk contributes to 60-90% more than the second highest risk, indicating a clear need for an appropriate solution. Long-term solutions like the Ujjawal DISCOM Assurance Yojana and short-term fixes like well-designed Payment Security Mechanisms may help mitigate this risk. Further work needs to be conducted to uncover the efficacy of these interventions.

**Grid/transmission risk contributes 14% to the risk premium for both sectors.** This risk pertains to the inadequacy of the transmission infrastructure to absorb the electricity capable of being generated by the installed capacity. There is no apparent short-term solution to mitigate this risk, and, over the long term, better demand-side planning as well as strengthening of the grid at the inter-regional and intra-regional levels should help alleviate concerns around this risk.

**Financial sector risk, related to the inability of project sponsors to access sufficient equity and debt capital, is the third major driver of risk.** The solution to this risk may be a combination of mitigating the other barriers to investment identified in this paper, as well as the introduction of innovative modes of financing such as InvITs, Green Bonds, etc. which can attract new investor classes to the sector.

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## 1. Introduction

Electricity is a key driver of socio-economic development. To meet increasing electricity demand, the Government of India has been working to increase electricity capacity addition targets in successive National Electricity Plans. According to the draft National Electricity Plan, December 2016 (Draft National Electricity Plan, 2016), the net energy requirement in India (accounting for savings on account of demand side management, energy efficiency and conservation measures) is likely to vary at a compounded annual growth rate (CAGR) of 6% between 2016-17 and 2021-22, and a CAGR of 5.76% between 2021-22 and 2026-27. Similarly, the peak demand is projected to grow at a CAGR of 7.53% between 2016-17 and 2021-22, and at 6% between 2021-22 and 2026-27. In contrast, globally, electricity demand is forecasted to grow at a CAGR of 1.9% per annum between 2015 and 2040 (Exxon Mobil, 2017).

In addition to these energy access goals, India also has renewable energy growth targets stemming from environmental goals. Under India's Intended Nationally Determined Contribution towards meeting the global climate change goals of limiting global warming to within 2 degrees over 2005 levels, India has targeted 33-35% of emissions intensity reduction of its GDP by 2030 over 2005 levels. India will focus on achieving these targets primarily by increasing the proportion of renewable energy sources in its electricity generation mix to up to 40% by 2030 from 14% as of March, 2016. To this end, it has targeted 175 GW of renewable energy capacity addition by 2022.

Taking into account both growing electricity demand and renewable energy targets, India has adopted a generation planning approach, which takes into account:

- Achieving sustainable development
- Power generation capacity to meet demand
- Fulfillment of desired operational characteristics such as reliability and flexibility
- Most efficient use of resources
- Fuel availability
- Integration of renewable energy sources

The 2016 Draft National Electricity Plan estimates total investment required for generation capacity addition is INR 10.3 trillion for the period 2017-2022, which includes the funds required for renewable energy sources capacity addition, as well as the advance action on projects in the period 2022-27. The total investment required for the period 2022-27 is estimated to be INR 6.1 trillion but does not include advance action for projects coming up during the period 2027-2032 (Draft National Electricity Plan, 2016).

This represents a massive opportunity for investors to make profitable investments in the power sector, in both fossil fuel and renewable energy technologies. Policymakers need to design policies to reduce barriers to investment to be able to reach government targets for each technology.

This report seeks to study the historical and present-day financial performance and risk profile of the renewable energy and fossil fuel power sectors, with a view of informing both investors and policymakers.

In particular, the study seeks to answer the following questions:

### **How have the renewable energy and fossil fuel power sectors fared financially in the past with respect to risk and risk-adjusted returns?**

Section 2 of the report employs an empirical analysis methodology using historical stock returns data of listed Indian companies in the power sector. The section begins with an overview of the listed stocks in the Indian power sector, along with the methodology used to classify stocks as renewable or fossil fuel stocks. In Section 2.2 we perform a historic comparison of the risk of listed equity in the two sectors using the beta as a measure of the risk. Section 2.3 deals with the historical risk-adjusted returns using the Sharpe ratio as the metric. Section 2.4 describes attempts to develop a risk factor model for listed equity in the Indian power sector.

### **How does the investor risk perception of the renewable energy and fossil fuel power sectors differ?**

Section 3 studies the perception of risk and risk factors of the power sector in India from the point of view of investors, using a primary research approach. While Section 2 compares historical trends, Section 3 performs a snapshot analysis of risk perception. We also seek to explain the drivers affecting this risk perception.

### **What factors contribute to the differing risk perceptions of the renewable energy and fossil fuel power sectors?**

Having understood how investors view absolute risk for different renewable energy and fossil fuel power technologies in Section 3.2, Section 3.3 seeks to quantitatively allocate the total risk amongst different risk categories for both sectors. The output is a "financing waterfall" that iteratively allocates the risk premium associated with each risk category towards the total cost of financing.

The power generation companies were identified from the Capitaline database by using the Global Industrial Classification System (GICS). GICS is a global, four-tiered industrial taxonomy system, widely recognized as the gold standard in industry classification. The set of independent power producers was selected as those companies with an industry class 551050 - "Independent Power and Renewable Energy Producers." This subset of companies represents all the listed companies engaged primarily in the business of power generation i.e. independent power producers (IPPs). Within this set, the companies were classified as fossil fuel based power producers and renewable energy power producers using the sub-industry classification codes 55105010 "Independent Power Producers and Energy Traders" and 55105020 "Renewable Electricity" respectively. It is important to note that some companies with the classification of fossil fuel power producers have a small portion of their power portfolio comprising of renewable sources as well. Further, under this classification system, hydropower is treated as a renewable energy source. In contrast, Section 3 deals explicitly only with two renewable energy technologies i.e. Solar PV and Wind.

## 2. Empirical analysis of risk in the listed power sector equity markets

This section studies the historical performance of the renewable energy and fossil fuel power sectors through empirical analysis of the performance of listed companies in the sector.

Section 2.1 provides an overview of the capital markets in the Indian power sector, the methodology used to categorize companies as predominantly renewable energy based or fossil fuel based power producers, and the methodology for creating a portfolio of companies to be studied as a proxy for the broader sectors.

Section 2.2 looks at risk through the lens of the Capital Asset Pricing Model, using the beta as the metric for the systematic risk of the sectors, and finds that the renewable energy power sector has historically shown almost half the risk of the fossil fuel power sector.

Section 2.3 studies the risk-adjusted returns of the two sectors by analyzing the Sharpe ratios of the two sectors historically. We find that not only did the renewable energy power sector exhibit lower risk, but that it has also provided higher returns and that, adjusted for risk, the renewable energy power sector outperforms the fossil fuel power sector on average by 61%.

Section 2.4 discusses the attempts made to create a multi-factor risk model to describe the stock returns of Indian power sector stocks.

### 2.1 An overview of the Indian power sector capital markets

India's power sector is one of the most diversified in the world. Sources of power generation range from fossil fuel sources such as coal, lignite, natural gas, oil, and nuclear power to viable non-fossil fuel sources such as wind, solar, hydro, and agricultural and domestic waste.

However, given that the corporate bond markets in India are very under-developed, very few companies in the power generation sector have issued bonds. Hence, an empirical analysis of the risk to debt investors for the fossil fuel based power generation sector using daily data of debt instruments is not feasible.

Companies in the power generation business include those listed on the equity capital markets and privately held companies. While privately held companies account for a large share of the power generation industry in India, share price data for such companies, as well as financial data, is rarely available. Due to this paucity of data, in this section we consider the class of power generation companies operating in India that are listed on at least one of the two major Indian stock exchanges - the Bombay Stock Exchange or the National Stock Exchange.

Accordingly, a set of 23 companies has been chosen for the analysis - this includes 11 fossil fuel power producers and 12 renewable energy power producers. The full list of the companies can be seen in Table 1.

Table 1: Listed independent power producers in India as of May, 2017 (in USD millions, historical rate)

PREDOMINANTLY FOSSIL FUEL BASED POWER				PREDOMINANTLY RENEWABLE ENERGY BASED POWER			
COMPANY	NAME	MARKET	CAPITALIZATION	COMPANY	NAME	MARKET	CAPITALIZATION
	Adani Power Limited		2,261.7		Advance Metering Technology Limited		6.1
	Elango Industries Limited		0.2		Entegra Limited		8.9
	Gujarat Industries Power Company Limited		237.9		Globus Power Generation Limited		34.2
	JSW Energy Limited		1,555.9		Ind Renewable Energy Limited		0.7
	NLC India Limited		2,435.8		Indowind Energy Limited		5.7
	NTPC Limited		20,006.8		K.P. Energy Limited		19.1
	RattanIndia Infrastructure Limited		68.5		Karma Energy Limited		7.4
	RattanIndia Power Limited		318.3		Kintech Renewables Limited		-
	Reliance Power Limited		2,004.4		Morgan Ventures Limited		1.8
	Suryachakra Power Corporation Limited		5.1		Orient Green Power Company Limited		112.5
	Tata Power		3,765.0		S. E. Power Limited		8.0
					Sun Source (India) Limited		0.7

### 2.1.1 INDEX CREATION METHODOLOGY

In finance, an equity index is a hypothetical portfolio of stocks representing a particular segment of the equity markets. To analyze the renewable and fossil fuel energy power sectors in India, two corresponding indices were created for the purpose of the study – the India Renewable IPP Index and India Fossil Fuel IPP Index. The India Renewable IPP Index is an annually reviewed, market-weighted index. The constituent elements for a particular year of this index are determined as those stocks listed on an Indian stock exchange with a GICS sub-industry categorization of 55105020 at the beginning of that year, and the constituents are weighted by their market capitalization at the beginning of that year. Similarly, the India Fossil Fuel IPP Index is an annually reviewed, market-weighted index. The constituent elements for a particular year of this index are determined as those stocks listed on an Indian stock exchange with a GICS sub-industry categorization of 55105010 at the beginning of that year, and the constituents are weighted by their market capitalization at the beginning of that year.

The India Fossil Fuel IPP Index and the India Renewable IPP Index as thus created are used as proxies to represent the Indian fossil fuel power sector and the Indian renewable energy power sector respectively, and the results of the analysis conducted thereon are assumed to be representative of the broader sectors.

## 2.2 Historical risk analysis of the renewable energy and fossil fuel power sectors

Financial risk typically refers to an investor's uncertainty in their ability to collect expected returns on their investment and the potential for monetary loss. This risk can take several forms, and each form can often be measured by various metrics. Under the Modern Portfolio Theory (Markowitz H, 1952), standard deviation is used as the measure of risk of an asset. Under the Capital Asset Pricing Model (Sharpe W, 1964) beta is used as the measure of risk of an asset.

In this section we seek to compare how the renewable energy and fossil fuel power sectors in India have compared in terms of risk historically. Beta is defined as the volatility of the price of an asset or portfolio relative to the market/index. Since the beta compares the risk of an asset relative to the market risk, the beta of a portfolio comprised of stocks belonging to a particular sector is a better measure of the systematic risk of that sector, as compared to the standard deviation of the portfolio's returns. We use the beta as a proxy for risk to compare how the renewable and fossil fuel power sectors in India have performed on risk from 2006 to 2016.

### 2.2.1 METHODOLOGY

Under the Capital Asset Pricing Model, the expected returns of a stock/portfolio are given by :

$$E(R) = R_f + \beta (R_{\text{market}} - R_f)$$

Where  $E(R)$  is the expected return of the stock/portfolio,  $R_f$  represents the risk-free rate,  $\beta$  the beta of the stock/portfolio, and  $R_{\text{market}}$  are the returns of the market/ broad index. In India, the BSE Sensex 30 Index is de facto treated as the broad market index, and the 10-year Indian Government bond yield as the risk-free rate. This beta is called the "levered beta" which takes into account the debt of a company. To calculate the systematic risk of a company, the "unlevered beta" is a much better measure. Unlevering a beta removes the financial effects of leverage, and provides a measure of how much systematic risk a firm's equity has when compared to the market. The unlevered beta and levered beta are related by the formula:

$$B_U = \frac{B_L}{[1 + (1 - T_c) \times (D/E)]}$$

Here,  $B_U$  is the unlevered beta of the company,  $B_L$  the levered beta,  $T_c$  is the corporate tax rate for that period, and  $D/E$  the debt to equity ratio of the company for the given time period.

Using the composition of the India Fossil Fuel IPP Index and the India Renewable IPP Index as derived from the methodology in Section 2.1.1, the beta of the two indices for the given year was derived as the weighted average of the unlevered one-year betas of its constituents for the same year. This analysis was performed for a period starting year 2006-07 to 2016-17.

### 2.2.2 RESULTS

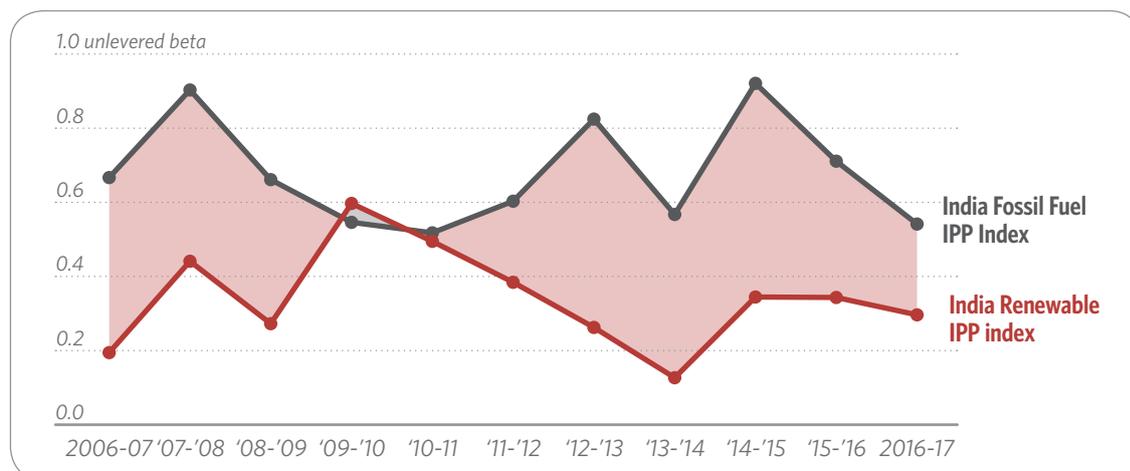
*The listed renewable energy power sector in India has historically exhibited, ex post, half as much risk as the listed fossil fuel power sector*

**The analysis indicates that, ex post, the renewable energy power sector has on average been half as risky as the fossil fuel power sector.** For the period 2006-07 to 2016-17, the beta of the India Fossil Fuel IPP Index has been consistently higher than that of the India Renewable IPP Index, with the exception of just one out of the 11 years observed, namely 2009-10. For this year, the beta for the Renewable Index is comparable with the beta for the Fossil Fuel Index. On an average, the beta for the Renewable IPP Index is 47% less than the beta for the Fossil Fuel IPP Index, indicating that over the past 11 years, the Renewable IPP index has exhibited nearly half the riskiness of the Fossil Fuel IPP index. These

results are aligned with the results of the risk perception of investors as studied in Section 3. The hypotheses for the lower risk of the renewable power sector over the fossil fuel power sector are discussed in further detail in Section 3.

**The anomalous results for the year 2009-10 may be explained by the heightened policy uncertainty risk leading up to policy changes for the wind energy sector in 2012.** The discontinuation of accelerated depreciation and generation based incentives subsidy scheme for the wind energy sector in 2011 was announced effective March 31, 2012. It is also important to note that, as of March 2012, wind energy capacity accounted for nearly 70% of the

Figure 1: A comparison of the unlevered betas for the India Renewable IPP index and the India Fossil Fuel IPP index for the period 2006-07 to 2016-17



total renewable energy capacity in India (MNRE Annual Report 2010-11, May 2012), and as such was the predominant technology driving the renewable energy sector. The removal of these incentives had a negative effect on the Indian wind energy industry, and consequently the entire renewable energy industry, in the subsequent years, leading to a reduction in installed capacity for wind energy in 2012-13 (The Hindu, May 2013).

### 2.3 Historical analysis of risk-adjusted returns of the renewable and fossil fuel power sectors

Harry Markowitz introduced the concept of the optimal portfolio as part of his modern portfolio theory in 1952. Different portfolios have different levels of risk and returns. It is assumed that rational investors want to earn the maximum possible returns while holding the minimum possible risk. For a given level of risk, the optimal portfolio concept states that there is a theoretical maximum level of risk that can be achieved, and a portfolio that achieves this mix of risk and returns is said to be on the "efficient frontier."

Figure 2 is an illustration of the optimal portfolio concept. An optimal-risk portfolio is typically somewhere in the middle of the curve, owing to the fact that the higher you go up the curve, the greater the proportion of risk you take on to the potential of return. On the other end, low risk/low return portfolios are generally considered unreasonable, as one can achieve a similar return by simply investing in risk-free securities and assets, like government treasuries.

To effectively assess the performance of a portfolio, it is not enough to merely assess its returns or risk, but also the risk-adjusted returns.

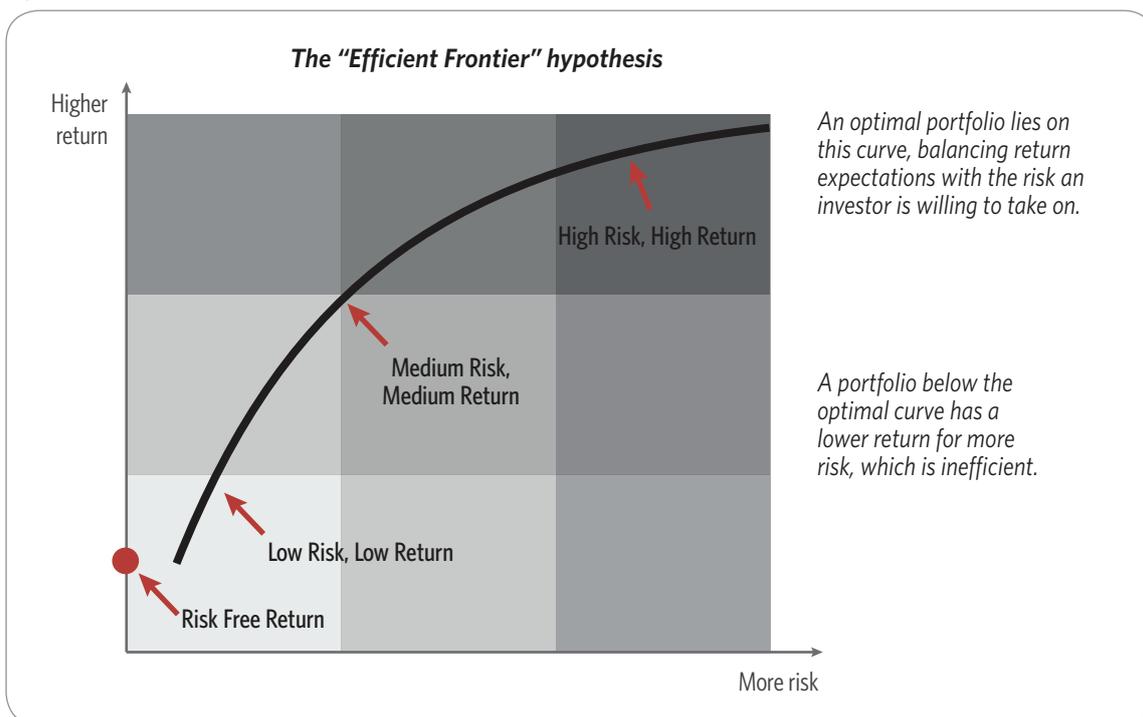
The Sharpe ratio (Sharpe, 1964), part of the capital asset pricing model, is the most widely used metric for risk-adjusted returns. The Sharpe ratio is defined as the ratio of the excess returns of a portfolio over the risk free rate, to the volatility of the portfolio. The Sharpe ratio of a risk-free asset is, by definition, zero. Typically, the higher the Sharpe ratio of a portfolio, the better it is considered.

$$\text{Sharpe ratio} = (\text{Portfolio returns} - \text{risk-free rate}) / (\text{Portfolio volatility})$$

Comparison of Sharpe ratios of two portfolios that have negative excess returns over the risk-free rate gives misleading results. To take this into account, the Modified Sharpe Ratio is defined (Ardia D, 2015).

$$\text{Modified Sharpe Ratio} = \text{ER} / [\text{Portfolio volatility} \wedge (\text{ER}/\text{abs}(\text{ER}))]; \text{ where ER} = \text{portfolio returns} - \text{risk-free rate}$$

Figure 2: Illustration of the efficient frontier theory source: investopedia.com



2.3.1 METHODOLOGY

To compare the risk-adjusted returns of the renewable energy and fossil fuel power sectors, we compare the historical Sharpe ratios of two portfolios tracking the India Renewable IPP index and the India Fossil fuel IPP index, respectively. The standard deviation of a portfolio incorporates the effects of diversification between the constituent stocks. The portfolio variance is given by the matrix formula below, and the standard deviation is the square root of this portfolio variance.

Portfolio variance =  $[w_1 \dots w_n] \times \begin{bmatrix} \sigma_1^2 & \dots & \sigma_{1n} \\ \vdots & \ddots & \vdots \\ \sigma_{n1} & \dots & \sigma_n^2 \end{bmatrix} \times \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix}$  Here,  $w_i$  is the weightage of the  $i^{\text{th}}$  constituent of the index, while  $w_{ij}$  is the pairwise correlation of the returns of the  $i^{\text{th}}$  and the  $j^{\text{th}}$  components.

The annual returns for the portfolio is calculated as the weighted average of the annual returns of the constituent stocks, with the weightages as described in Section 2.1.1. The excess returns for that year is then calculated as the excess returns over the average risk-free rate for the year. The risk-free rate for India is taken as the average 10 year Indian Government bond yield for the particular year.

Having thus computed the excess returns of the portfolio, as well as the portfolio variance, the modified Sharpe ratio may now be calculated.

## 2.3.2 RESULTS

*Historically, renewable energy power company portfolios have shown investment characteristics more attractive than fossil fuel power portfolios, with on average 12% higher annual returns, 20% lower annual volatility, and 61% higher annual risk-adjusted returns over the period 2011-2017.*

**The Renewable IPP Index outperformed the Fossil Fuel IPP index on average by 12% during this period.** We observed that the annual excess returns for two indices over the risk free rate<sup>1</sup> for the Renewable IPP index outperformed the Fossil Fuel IPP index fairly consistently, between -1% and 29%, and on average by 12% per year. Thus, not accounting for the variable risk, if an investor had a portfolio of Renewable IPPs, their portfolio would have yielded more handsome returns than a portfolio of fossil fuel energy IPPs in this period.

**The Renewable IPP index also exhibited lower systematic risk than the Fossil Fuel IPP index in the same period. On average, the volatility of the Renewable IPP index was less than that of the Fossil Fuel IPP index by 6%.**

The annual volatility difference between the two indices ranges from -2% and 12%, and on average by 6%. For realized volatility of both indices in the range of 19% to 32%, a 6% difference in volatility is significantly different. These results are in agreement with the results from Section 2.1, where the analysis showed that the systematic risk of the renewable energy power sector was almost half that of the fossil fuel power sector using beta as the proxy for risk.

**The Renewable IPP index exhibited 61% higher risk-adjusted returns than the Fossil Fuel IPP index in the 2011-17 period.** The lower volatility and the higher returns of the Renewable IPP index has the effect that the modified Sharpe ratio of the Renewable IPP index is consistently higher than the Sharpe ratio for the Fossil Fuel IPP index, on an average by 61%. The modified Sharpe ratio is used as a proxy for the risk-adjusted returns of an asset/portfolio. As discussed above, a portfolio with higher risk-adjusted returns is closer to the efficient frontier, and is thus capable of offering the same investor who is willing to hold a given amount of risk higher returns.

Using the two indices studied as a proxy for renewable energy and fossil fuel energy equity investments in India, we can thus conclude that, historically, equity investments in renewable energy power have shown a much more attractive investment profile than fossil fuel power investments on account of:

- Returns outperformance of 12%, on average
- Volatility lower by 20% on average
- 61% higher average risk-adjusted returns

<sup>1</sup> The risk-free rate was chosen as the 10 year Indian Government bond yield

Figure 3: Annual historical excess returns for the Renewable IPP and Fossil Fuel IPP indices from 2011 to 2017. The excess returns are the annual returns of the index over the annual average risk free rate

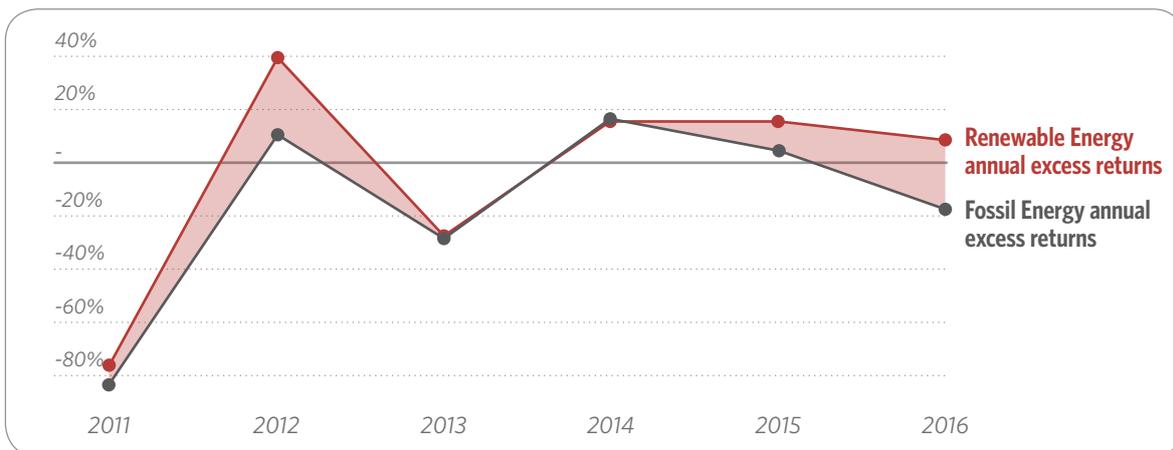


Figure 4: Historically exhibited portfolio volatility of the Renewable IPP and Fossil Fuel IPP indices from 2011-12 to 2016-17

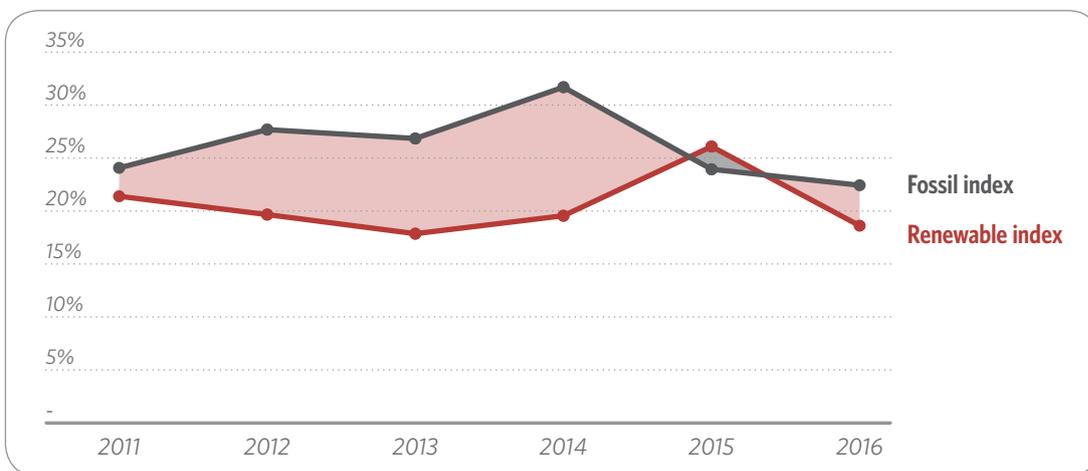
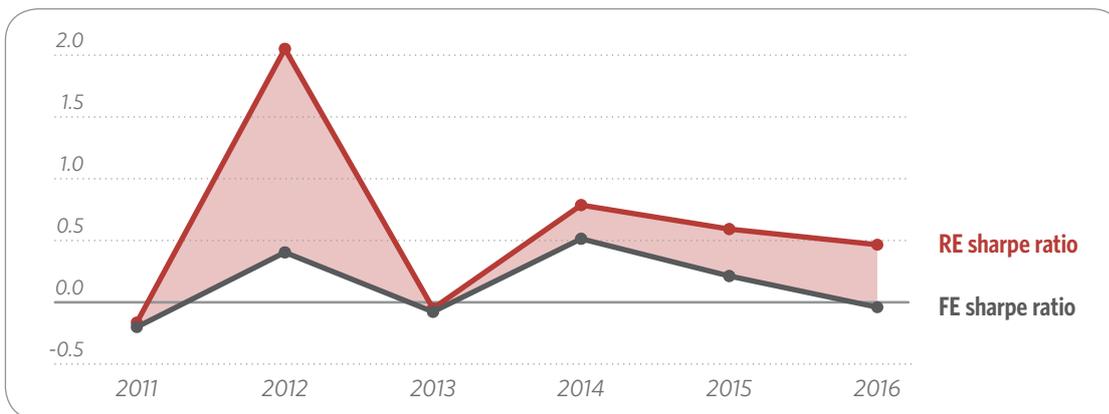


Figure 5: Historical variation of Modified Sharpe ratio for the Renewable IPP and Fossil Fuel IPP indices from 2011 to 2017



## 2.4 Risk factor model for the listed Indian power sector equity asset class

*For listed stocks in the Indian power sector, our model showed that stock returns are robustly correlated with market returns. We were unable to determine that factors such as company size, value, leverage, coal prices, rupee exchange rate, and term premium are robustly priced into the stock returns.*

This part of the study aims to compare the risk factors that drive the risk/returns of listed equity in the fossil fuel energy generation and renewable energy generation sectors by building a multi-factor risk model for the asset class of independent power producers (IPPs) in India. A risk factor model is a model that explains the returns of an asset (most often publicly traded equity) based on different factors – some that are specific to the company (called specific factors), and some that are not company-specific (called macro factors).

By regressing this model on an unbalanced panel of time-series data for listed Indian IPPs – both for the renewables and the fossil fuels space – we aimed to find the factors with the maximum explanatory power. By thus ascertaining the factors which help explain the riskiness/ returns of companies in this sector, and the Risk Factor Premium (sensitivity) of a company in the sector to each of these factors, the aim was to chart out future risk scenarios for the renewable power and the fossil fuel power sectors based on different possible scenarios for the underlying risk factors.

Extensive literature review led to several extant risk factor models in the infrastructure sector, including risk factor models for the energy sector, renewable energy sector, oil and gas sector, non-renewable sector, etc. that were empirically tested in different geographies

globally. An analysis of these models, along with economic and financial rationales contextual to the Indian power sector led us to posit a risk model for the Indian power-generation sector, with the specific and macro factors as listed in Table 2. This model is not exhaustive, i.e. some factors with possible explanatory power may not have been considered due to constraints around data availability or lack of sufficient available economic rationale.

Table 2: Posited factors for the risk factor model for listed Indian power generation companies in the renewable energy and fossil fuel energy sectors

SPECIFIC FACTORS	GLOBAL FACTORS
Company size	Market returns
Value	Coal price
Debt to equity ratio	USD-INR exchange rate
	Term premium

This model was empirically tested by regressing it on an unbalanced panel data set consisting of 23 companies described in Section 2.1 over the time period 2006-17 using panel regression techniques. The time-series data for these factors was compiled from a variety of databases.

**Only one factor – the market returns factor – out of the eight posited factors in the model showed statistical significance with the stock returns.** Thus, we were able to conclude that, for companies in the renewable energy and fossil fuel energy based power generation sector, only the market returns are robustly priced in to the stock returns, as stated by the Capital Asset Pricing Model. Using the data available to this study, we do not see a robust statistical significance in stock returns with the company size, the company value, leverage, coal prices, local currency rates or term premium.

The construction of the model, the factors, the data and the regression techniques and results are discussed in further detail in Appendix A.

### 3. Investor perception of risk and risk factors in the power sector

Section 2 of the report studied the historical performance of risk and returns based on empirical studies on time-series data from the capital markets and macro-economic indicators.

In this section, we turn to the investors who are active in the sector, to better understand how the markets currently view investments, their expectations of riskiness of different technologies, as well as the factors that keep them up at night and are priced into the cost of capital. Risk perception is the belief, based on concerns, experiences, and knowledge of an individual or a group, about the chance of occurrence of a risk or about the magnitude or extent of its effects. These beliefs may be rational or irrational, but offer precious information about the factors that affect investment decisions, and the barriers that need to be circumvented to attract more investment into a particular sector. In addition to the risk perception, individual investment decisions are further guided by investors' risk tolerance and their expectations of returns.

Section 3.2 deals with the absolute risk perception of investors of four different electricity generation technologies – solar PV, wind, thermal coal, and natural gas – via their expectations of the returns on debt and equity for power plants employing these technologies. Section 3.3, on the other hand, seeks to quantify the risk premium contributions of different risk categories to the total debt risk premium of renewable energy and fossil fuel power investments.

The methodology for this section has been inspired by the framework developed by the United Nations Development Program (UNDP) (Waissbein O, Glemarec Y, et al, 2013) . The methodology described in the subsequent sections borrows heavily from this framework, for which the authors of this study are indebted to the UNDP. More details about the methodology can be found in the Appendix.

#### 3.1 Primary research sample

The data for studying the risk perception of investors in the Indian power sector was collected using primary research. Structured interviews were conducted with a subset of investors in the power sector with investment interest and experience across the breadth of the sector, including in renewable energy power generation and fossil fuel power generation. The cross-section of investors interviewed include both debt and equity investors (and some with additional expertise in grants and mezzanine investments) and come from a wide range of backgrounds including project developers, private and public sector commercial banks, domestic and foreign institutional investors, development financial institutions, private equity funds, etc.

The interviews were conducted via email and telephone. Investors with expertise in investment in renewable energy power generation were asked to rate their risk perception of renewable energy investment, and those with fossil fuel power generation investment expertise were interviewed regarding their risk perception of the fossil fuel power sector. A few investors held expertise across both the sectors.

The authors reached out to a long list of 76 potential interviewees. Out of the interviewees that responded, 16 complete responses to the structured interview were considered towards deriving the results for this section. The interview responses are completely anonymous and quantitative, and only aggregated results have been used. Table 3 shows the break-down of the interviewees by categories.

Table 3: Interviewees by asset class and area of expertise

Number of interviewers approached	76
Number of respondents	16
Renewable energy investment	11
Fossil Fuel energy investment	8
Debt investors	8
Equity investors	9
Other investment vehicles	Grants, mezzanine

### 3.2 Investor risk perception

*We find that investors perceive renewable energy power investments to be less risky than fossil fuel power investments. Within the renewable sector, solar is perceived as less risky than wind, and in the fossil fuel sector, coal is perceived as less risky than natural gas.*

Different energy generation technologies and resources suffer from different risk factors in varying degrees. This could be because of government policies and regulations, the availability and volatility of fuel prices, dependability of the technology, and several other factors. We discuss these risk factors in further detail in Section 3.3. The effect of this is that investors view investments in a power generation facility using different technologies differently. Further, debt and equity investors perceive risk differently owing to the difference in seniority of their investments and the associated return profiles. Debt investors are assured of consistent returns and first claim in the case of insolvency in return for the possible upsides of the investment's performance. In contrast, equity investors take on a higher risk in exchange for higher possible returns in favorable scenarios.

Investor expectation of return on investments is indicative of their comparative risk perception between different investment opportunities. Higher expected returns are indicative of higher perceived risk, and vice versa. To study the risk perception for various power generation technologies, we considered the two predominant sources of renewable energy and fossil fuel energy each – solar PV, wind, thermal coal and thermal natural gas. We have not considered further sub-technologies within these technology groups.

#### 3.2.1 METHODOLOGY

We asked our interviewees (described in Section 3.1) with relevant sector expertise for their expectations for average

annual returns – for debt or equity or both, as applicable – on investments made in a power generation plant using a particular technology, over the lifetime of the project. These responses were then averaged, and the aggregate results were used to make inferences on the perceived riskiness of the four technologies.

Using the responses from the structured interviews, we came up with three sets of rankings of risk for the four technologies under consideration:

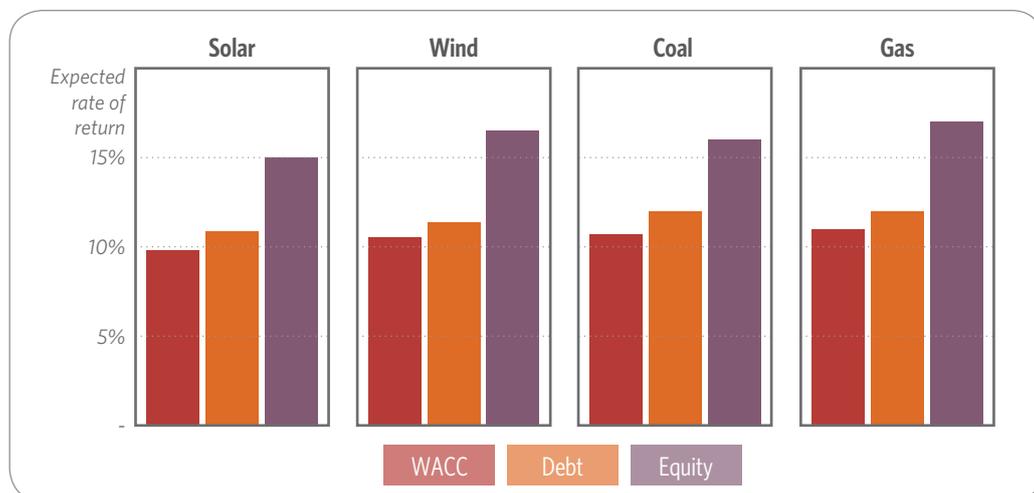
1. Risk perception from the point of view of debt investors
2. Risk perception from the point of view of equity investors
3. Cumulative risk perception of the technologies

The average expected returns on debt and equity for each of the sectors was calculated by averaging the interviewees' response for expected returns. To get an overall, cumulative view for the sector, we also compared the expected weighted average cost of capital (WACC), computed from the expected returns on equity and debt, assuming a debt: equity ratio of 70:30 that is standard for the power sector, and a corporate tax rate of 30% for India as of 2016.

#### 3.2.2 RESULTS

**Overall, we find that investors perceive renewable energy power investments to be less risky than fossil fuel power investments.** This result is in line with the results of the historical empirical analysis carried out in Section 2. The weighted average cost of capital for solar PV investments is the lowest at 9.82%, followed, in turn, by wind, coal, and gas, which has the highest WACC of 10.98%.

Figure 6: Chart showing the expected rates of return on debt and equity and the expected weighted average cost of capital for a typical project



The results for risk perception according to equity and debt investors show a slight mismatch for wind and coal investments.

We can draw a variety of inferences from these results, as described below. We have supplemented the results with explanations based on primary and secondary research.

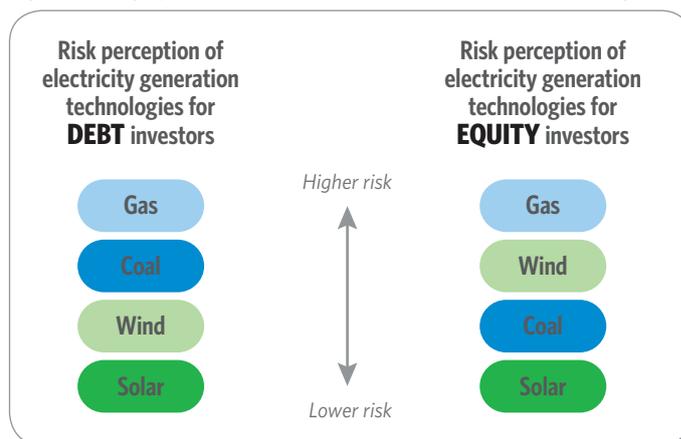
*1. Investors perceive renewable energy power investments as being safer than fossil fuel power investments.*

Investors perceive the fossil fuel power sector as riskier than clean energy for several reasons. These may include issues around the fuel sourcing and import dependency for both coal and natural gas, longer construction periods due to delayed clearances, and stricter emission and water usage standards (CEEW, 2017).

**Domestically produced coal in India is generally of low quality and is not highly cost-efficient, while the natural gas extracted domestically only serves a fraction of the domestic demand.** This necessitates importing high-quality coal and natural gas for thermal power plants. The volatility in global coal and gas prices, added costs of transportation and taxes, and government import and tax policies add to the concerns around thermal power generation.

**Longer construction periods for thermal plants (3-4 years), compared to renewable sources of power (12-14 months), is another important aspect for risk evaluation.** Delays in obtaining environmental clearances affect 89% of projects (Comptroller and Auditor General of India, 2016) and could additionally prolong the construction of thermal plants. On the other hand, renewable energy projects, in most cases, are exempt from environmental clearances, and significant advances have been made in recent years in streamlining the procurement of other clearances for renewable energy power projects. The longer commissioning cycles, combined with higher likelihood of delays, makes investment in thermal power significantly riskier than that in renewables.

Figure 7: Infographic - perceived riskiness of solar, wind, coal and gas power



In order to minimize environmental impacts of running coal-based plants, the Ministry of Environment's 2015 notification, which mandates stricter emissions and water usage standards, has also been troubling the sector (WRI Working Paper, 2018).

*2. Within the renewable energy power sector, investors perceive solar investments as safer than wind investments.*

We find that expected cost of debt for solar energy is 52 basis points below wind energy. This difference is even bigger for equity return expectations, where the gap is 150 basis points. Similarly, we find that debt for coal energy is available at the same rate as wind energy. However, this changes for equity return expectations where the gap is 100 basis points between wind and coal energy.

There are two interesting findings to explore here: first, why the spread is so large between debt and equity for wind; and second, why solar is perceived as less risky than wind.

**The large spread in expected rates of return between debt and equity capital for wind investments** compared to the other technologies could be attributed to the fact that equity investors are exposed to the risk of high variability of wind speeds (resource risk) much more than debt investors. Banks also typically assess viability of wind projects at P75<sup>2</sup> levels of wind speed, and further require, ex ante, high debt service ratios to make

2 A Pxx level of wind speed/solar radiation is one such that the probability of the wind speed/solar radiation exceeding this level is xx%. These Pxx's are called exceedance probabilities.

investments in wind projects (S&P Global, July 2017), which make them less prone to financial downsides of low wind scenarios.

**Most industry practitioners acknowledge the higher perceived resource risk for wind projects over solar projects.** 75% of the wind project observations were below the P50 levels, whereas 70% of the solar project observations were above the P50 levels (Fitch Ratings, August 2017<sup>3</sup>). The more predictable nature of solar investments is also reflected in the fact that solar projects typically need a lower debt-service ratio to achieve investment grade ratings, and that many industry players use P50 level estimates for solar investments and P75 levels for wind (S&P Global, July 2017<sup>4</sup>).

Further, to a lesser degree, the increased risk perception of the wind sector compared to the solar sector might be attributed to the uncertainty due to the recent change in the process that determines wind tariffs in India<sup>5</sup> from a state-determined feed-in tariff system to a price-discovery system through government-run auctions (which are typically lower). Not only has this caused uncertainty — since auction guidelines haven't been made available yet — there is now also a growing risk that state governments may backtrack on PPAs signed earlier as they seek lower tariffs.

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*3. Within the fossil fuel energy sector, natural gas based thermal power investments are considered riskier than coal thermal power investments.*

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Although natural gas is a much cleaner source of electricity than coal, it accounts for only 4% of India's electricity generation (as of 2015). This is because of high costs, low supply and lack of supply infrastructure. In fact, India's demand for natural gas outstrips supply, leading to a large proportion of natural gas being imported. However, because of the limited number of ports with the infrastructure to handle natural gas imports, the total amount that can be imported is limited. Priority is accorded to fertilizer plants and city gas distribution (Scroll, 2013).

Further, India lacks built up pipeline infrastructure to ensure that natural gas reaches the intended end customers. In spite of a dramatic fall in global natural gas prices, electricity generated from natural gas plants still costs substantially more than from coal plants.

The difficulty in sourcing, the high cost, and the lack of supply infrastructure has led to natural gas plants running at 25% capacity, with several plants considered stranded assets by the government (OECD, 2015). This situation contributes to higher perceived risk for natural gas compared with other energy sources.

### 3.3 Risk factors driving investor perceptions

Risk factors are an event or a set of related events, the occurrence of which is likely to cause fluctuations to the financial earnings of a project. The risk associated with a particular risk factor is the product of the likelihood of occurrence of the event(s) and the negative financial impact to be had in the case of the occurrence of the event.

#### 3.3.1 CALCULATIONS

There are two goals of this section, corresponding to methodological outputs:

**Step 1:** Based on an understanding of the local investment behavior and the sector, create a multi-stakeholder barrier and risk table for the power sector (renewable and fossil fuel based) in India

**Step 2:** Quantify the impact of each risk category on the financing costs, for both the renewable energy power sector and the fossil fuel power sector

The output of Step 1 is a risk table enumerating exhaustively and in a mutually exclusive way all the major risk categories for the power sector. The multi-stakeholder and barrier framework that underlies the creation of this risk table, borrowed from UNDP (2013), is explained in more detail in the Appendix. The risks affecting the power sector have been divided into eight categories as described in Table 4.

Based on this identification of risk categories, Step 2 is to identify the pricing of each risk category into the financing costs. The output of this step is "financing cost waterfall." This concept was first developed by Deutsche Bank (DB Climate Change Advisors, 2011)

3 <https://af.reuters.com/article/africaTech/idAFfit84KHbM>

4 <http://www.windpowerengineering.com/business-news-projects/india-plans-triple-investments-renewables-faq-sp-global-ratings/>

5 <https://qz.com/1036577/indias-wind-energy-sector-is-a-complete-mess-right-now-thanks-to-the-narendra-modi-government/>

Table 4: Risk categories' definitions

NO.	RISK CATEGORY	DESCRIPTION
1	Power market risk	Risk arising from limitations and uncertainties in the power market and/or suboptimal regulations to address these limitations and promote power markets
2	Permits risk	Risks arising from the public sector's inability to efficiently and transparently administer related permits and licenses for power plants
3	Resource and technology risk	Risks arising from uncertainty regarding underlying resource/ fuel and technology (includes resource assessment, construction and operational use, hardware purchase and manufacturing)
4	Grid/transmission risk	Risks arising from limitations in grid management and transmission infrastructure
5	Counterparty risk	Risks arising from the utility's poor credit quality and the IPP's reliance on its payments
6	Financial sector risk	Risks arising from general scarcity of investor capital (debt and/or equity)
7	Political risk	Risks arising from country/state specific governance and legal characteristics
8	Macroeconomic/ currency risk	Risks arising from the country's macroeconomic performance

based on the assumption that investors price all relevant risks into the cost of financing.

There are separate waterfalls for debt and equity. Here we consider a financing cost waterfall only for debt since the number of structured interviews conducted is not large enough to segregate responses and create separate waterfalls for both debt and equity.

The waterfall compares the financing cost of the global best-in-class investment environment for the particular technology, and the financing cost in India, and the difference between the two is broken down into risk increments, which quantify the contributions of each risk category to the total risk premium. This quantification can eventually inform the selection of risk mitigation instruments that are aimed at mitigating this risk, and the potential for impact in the cost reduction that these instruments can achieve.

For each of the risk categories, investors were provided a description and were asked to rate the risk on two fronts:

- Likelihood of occurrence of the risk event on a five point scale from least likely to most likely
- Financial impact on occurrence of risk event on a five point scale from lowest impact to highest

These two ratings were then multiplied for each risk category, and this metric then scaled by the total sum-product across all the risk categories to determine the percentage contribution of each risk category to the total risk premium.

The risk premium is defined as the difference between the cost of debt financing for the particular technology in India (sourced from the analysis conducted in Section 3.2) and the best in-class cost of debt financing for the particular technology.

The best-in-class investment environment for the power sector was chosen to be Germany, where debt for the power sector, both for renewable energy and fossil fuel energy, is available at rates circa 1.8% (Ecofys, 2016). To this we have added the country risk premium<sup>6</sup> for India since this is the risk premium associated with the investment environment of India, which cannot be mitigated by existing public risk instruments. The country risk premium for India as of 2017 is 2.66% (Damodaran A, 2017). Thus, we get the best-in-class rate of debt for both renewable energy and fossil fuel energy of 4.46%.

For India, we calculate the average cost of debt for the renewable energy power sector as the average cost of debt for solar PV and wind technologies, being the most predominant renewable energy technologies in India, obtained in Section 3.2. Similarly for the fossil fuel power sector, we calculate the average cost of debt as the average costs of debt for coal and gas thermal technologies as obtained in Section 3.2. Table 5 shows the calculations for the risk premia derived for the renewable energy and fossil fuel power sectors.

Table 5: Calculation of the risk premia

SECTOR	BEST IN-CLASS COST OF DEBT	INDIA COST OF DEBT	DEBT RISK PREMIUM
Renewable energy	4.46%	11.12%	6.66%
Fossil Fuel energy	4.46%	12.00%	7.54%

<sup>6</sup> The country risk premium refers to the difference between the higher interest rates that less stable and riskier countries must pay to attract investors, and the interest rates of an investor's home country.

### 3.3.2 RESULTS AND ANALYSIS

Figure 8: Debt waterfall for renewable energy power

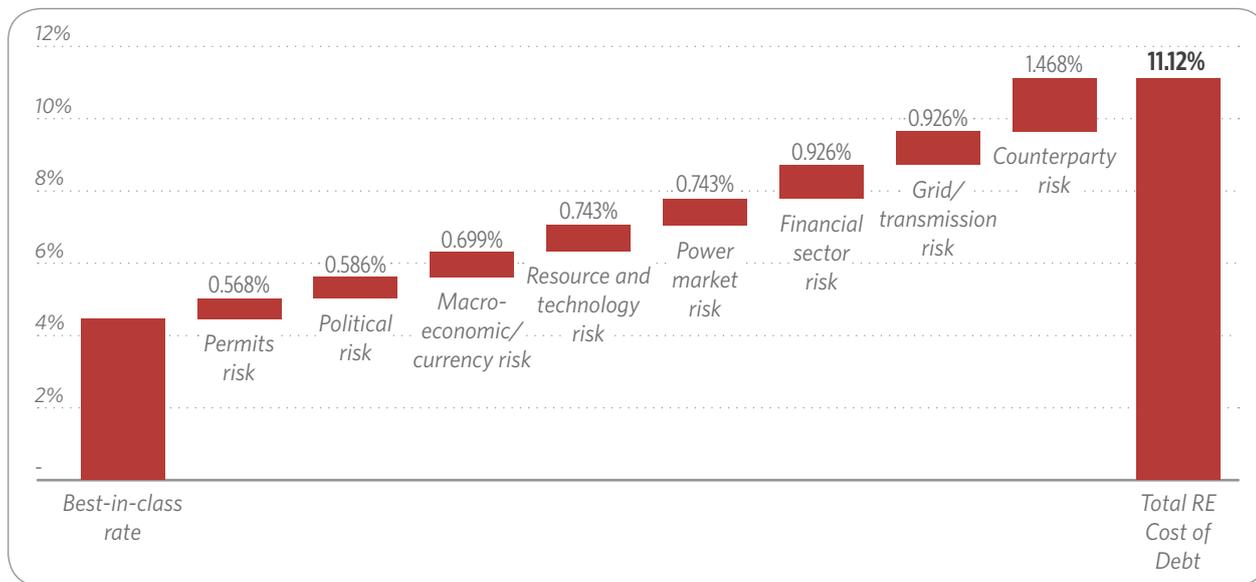
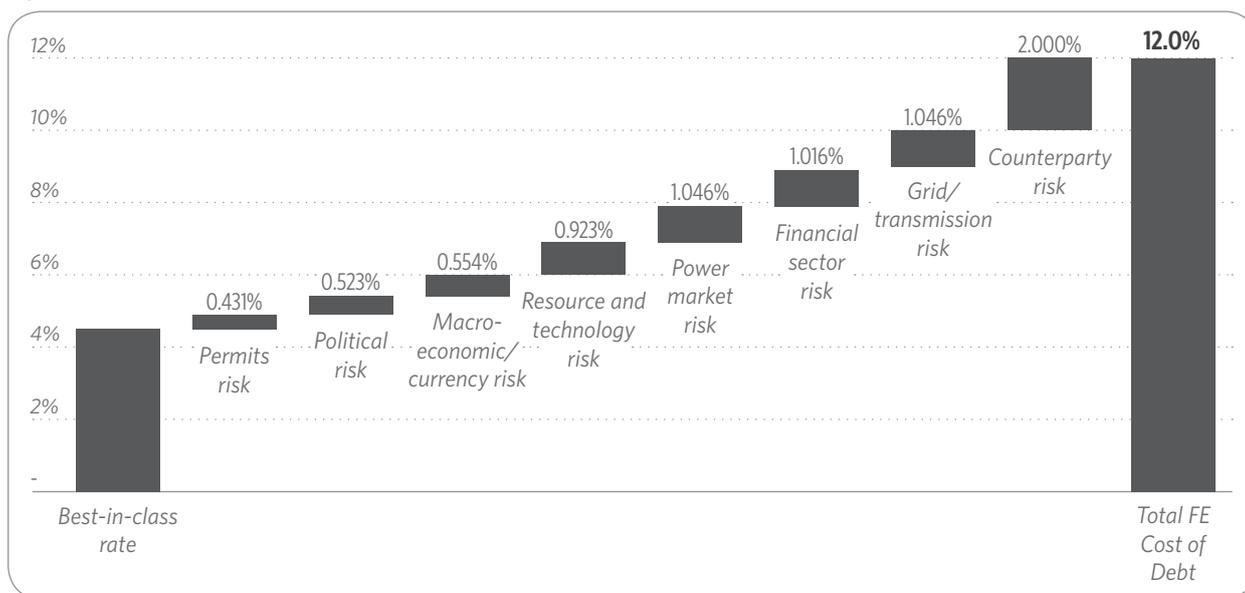


Figure 9: Debt waterfall for fossil fuel power



Based on this exercise, we find several results worth exploring.

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*For both sectors, counterparty risk, financial sector risk and grid/transmission risk are the most important risk factors, together contributing to over 50% of the risk premium.*

*For the fossil fuel power sector, power market risk and resource/technology risk also contribute significantly for the higher risk premium.*

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**Investors perceive counterparty risk to be the most significant factor affecting both renewable energy and fossil fuel power investments. Counterparty risk, related to the inability of state-owned power offtakers to pay on time, contributes 22% and 27% of the total risk premium i.e. 1.47% and 2% to the cost of the debt, respectively.**

Counterparty risk is a result of poor financial health and rising receivables plaguing state electricity utilities (DISCOMs), which are key offtakers of power in India and which often delay or default on payments to independent power producers for power purchased. This creates continued strained liquidity on standalone renewable energy and fossil fuel projects, leading to lower credit quality, higher debt service reserve requirements and higher credit risk premium (India Ratings, 2016).

Thermal power projects face additional counterparty risk due to the lack of PPAs for a large part of the private sector capacity (India Ratings, Feb 2017). The private sector has historically kept a large part of the capacity off of PPAs due to high short-term prices. However, the plant load factor (PLF) of the private sector's coal-based power plants fell to 56.3% in 2017 from 83.9% in 2010. Given that short-term power prices are likely to remain low and DISCOMs' are unwilling to sign PPAs, these capacities are unlikely to see an increase in PLF.

Addressing counterparty risk requires long-term fixes to improve the financial health of the DISCOMs. The Ujjwal DISCOM Assurance Yojana (UDAY)<sup>7</sup> is

a restructuring plan by the Government of India to improve the financial and operational performance of DISCOMs. However, in the short term, public interventions such as a Payment Security Mechanism – an assurance that payments under power purchase agreements would be made on time – can help mitigate counterparty risk and reduce the risk premium associated with investments in the power sector.

**Grid/transmission risk is the second highest contributor to the risk premia for both renewable and fossil fuel energy. This risk contributes 14% to the total risk premia.**

Grid/transmission risk arises when transmission infrastructure, either at the intra and inter regional levels, is not able to efficiently absorb electricity generated.

In India, the National Grid connects generating stations through major network and substations to ensure that electricity generated anywhere in mainland India can be used to satisfy demand elsewhere. It is composed of five regional grids covering mainland India, namely the Northern, Eastern, Western, North Eastern and Southern Grids. Out of these, the Western and Southern Grids are the predominant renewable energy producers.

However, there is limited transmission capacity between these grids (called inter-regional transmission capacity) as well as limited transmission capacity between sources of generation and nodes of inter-regional transmission (called intra-regional transmission capacity). This situation creates constraints on how much produced renewable power can be absorbed by the national grid, often leading to curtailment of renewable energy. This transmission risk adds up to 0.93% to the cost of debt for renewable energy power investments.

For the fossil fuel power sector, thermal plants are already running at low PLFs owing to subdued power demand, fluctuations in fuel availability, and other causes. The low demand is further magnified due to a mismatch in geographical location of sources of power generation and consumption, limited inter-regional and intra-regional transmission capacity, and must-run status accorded to intermittent renewable energy sources, creating a risk of the transmission of the available generating capacity. As a result, we see that grid/transmission risk accounts for up to 1.05% of the cost of debt for fossil fuel power investments.

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<sup>7</sup> <https://www.uday.gov.in/about.php>

The solutions to mitigating this risk are creation of a more robust grid at the intra-regional and inter-regional level, better demand side planning, and ensuring that the grid reaches upcoming projects in time.

**The third major risk factor common to both the sectors is financial sector risk.** The heavy capital requirement for the power sector, particularly for the renewable energy power sector where the majority of the investment is made upfront, makes the power sector highly sensitive to availability of capital – both debt and equity.

The renewable energy power sector, while still experiencing a 29% shortfall for equity and 27% shortfall for debt capital towards meeting the Government's target of 175 GW of renewable capacity by 2022 (CPI, 2016), has seen a steady growth in investments. The capital expenditure requirement for renewable power projects is also considerably higher than for thermal power plants.

The thermal power sector, owing to falling plant load factors (PLFs), increasing stranded assets, high levels of accumulated non-performing assets of Indian banks, along with growing investor preference for decarbonizing their portfolios, has been seeing a paucity in availability of private sector capital.

This may account for the fact that investors perceive a higher financial sector risk (1.02% risk premium) for the fossil fuel power sector than for the renewable energy power sector (0.93%).

Mitigating this risk is a chicken-and-egg problem. Mitigating all the drivers of risk to investments in these two sectors will attract additional investments, thereby reducing financing risk. Further, innovative new financial instruments such as InvITs, green bonds, as well as measures such as promoting the development of secondary corporate bond markets are needed to tap into new classes of investors that may be better aligned with power sector investments than those investors currently in play in this sector in India.

**Power market risk predominantly affects the fossil fuel power sector, adding 1.05% to the total risk premium.**

As mentioned above, private sector thermal power producers often keep a large part of their capacity untied from PPAs to take advantage of historically high

short-term prices. In the absence of long-term power purchase contracts, however, uncertainty regarding the volume and price of power that can be sold in the short term in the power markets exposes power producers to fluctuations in power markets and constitutes a risk for them. The underdeveloped nature of the Indian power markets and the lack of exchanges further compounds the problem by making the discovery of power purchasers uncertain.

This is in line with our analysis that shows that the power market risk contributes 1.05% towards the cost of debt for the fossil fuel power sector, versus 0.74% for the renewable energy power sector.

**Resource/technology risk is a major risk factor affecting investor risk perceptions of the fossil fuel power sector.**

For thermal coal power producers, the resource risk stems from the poor quality of thermal coal domestically available in coal and the consequent fluctuation of imported coal prices according to the volatility in the global markets and the related taxes and transport costs. For natural gas based thermal producers, the high resource risk has been explained in Section 3.2.

Renewable energy power producers, on the other hand, are exposed to resource volume uncertainty but not price uncertainty, substantially reducing the risk of resource uncertainty compared to the fossil fuels power sector. Within renewable energy, wind resource risk is higher than solar resource risk in India, as described in Section 3.2, however the perception of volatility of wind volume is comparatively less as per investors, compared with the resource volatility for thermal power in recent times.

For this reason, the resource risk contributes 0.92% to the cost of debt for fossil fuel power, against 0.74% for renewable energy power.

**Finally, we find that there is a higher risk premium (more than 20% higher) for permits risk and macroeconomic / currency risk for renewable energy over fossil fuel energy.** It is unclear why this is the case, as it is not backed by popular wisdom or available research, and seems anomalous. This requires further research.

## 4. Conclusions and next steps

The research conducted for this study indicates that, historically, the Indian renewable energy power sector has exhibited significantly lower risk than the fossil fuel power sector, and a more attractive investment profile for equity investors. Using past trends as an indicator of future performance, this trend is likely to continue in the absence of major upheavals to the sector. Further, investor sentiments indicate positive signals for the renewable energy power sector over the fossil fuel power sector. This presents evidence for continued growth of the renewable energy power sector in spite of gradual easing of policy support from the government.

Counterparty risk, grid/transmission risk and financial sector risk are the major risk categories affecting investor confidence for both renewable and fossil based power generation. Additionally, power markets risk and resource risk contribute significantly to the investor risk perception of the fossil fuel based power sector. Having identified the maximum impact of these risk categories to the total risk premium of investments in the sector, additional work needs to be conducted to determine the efficacy of various hypothesized policy and market mechanisms to mitigate risks, and their impact on the cost and availability of capital for the power sector. In particular, it would be valuable to study the risk environment of power sector investments in different scenarios of reduced risk arising from the contributing risk factors identified in this paper.

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## Appendix A – Risk Factor Model

### Literature Review

The Fama-French three factor model and the Carhart four-factor model were extensions of the Capital Asset Pricing Model (CAPM) to be better able to explain the returns of stocks. Building on this, various scholars have built risk factor models for different sectors with risk factors with a higher explanatory power. However, a risk factor model for the Indian power sector has not yet been developed.

Infrastructure project companies have several characteristics owing to which they can be classified as a separate asset class. We make reference to the papers “Common risk factors of infrastructure firms” by (Ammar and Eling, 2013) and “Infrastructure: real assets and real returns” by Bird, Liam, Thorpe to incorporate their learnings into building our model.

“Modeling renewable energy company risk” (P. Sadorsky, 2012) lays the groundwork for risk factors pertinent to renewable energy companies, tested using data from US companies. Similarly the paper “Risk factors and value at risk in publicly traded companies of the nonrenewable energy sector” (Bianconi, Yoshino, 2014) has been referenced to better understand non-renewable energy company risk.

### Building the risk factors

#### SPECIFIC FACTORS:

Specific factors are ones related to the company's financial data. The risk factor model considers three specific factors: company size, value and debt to equity (i.e. leverage).

The company size is a measure of the size of the assets of the company, and is the ratio of the company's total assets to its share price. This is one of the factors in the Fama-French three factor model, and is also considered as a factor in both the renewable energy and non-renewable energy models referenced in the literature review. The Fama French model empirically determines that, used in combination, the company size and value have explanatory power about average returns.

In general larger companies are expected to have more extensive resources and capabilities and experience in deploying their resources, realize economies of scale and higher productivity/ profitability and should thus have lower systematic risk (Caves and Barton, 1990; Bradburd and Ross, 1989).

The value factor is a measure of the ratio of the company's book value to market value. A company with a high book value to market value is typically called a “value” stock, and according to the Fama French model is expected to outperform the market. A company with a low value factor is called a “growth” stock.

When used alone, the leverage factor has explanatory power about average returns of stocks. However, Fama and French determined empirically that used in combination, the company size and value factors absorb the explanatory power of leverage. However, all the three risk factor models we refer to in our literature review consider the leverage factor as an independent factor, hence we too consider this as a separate factor. If Fama French's findings hold true in our case, we shall find that the leverage factor is not statistically significantly correlated with the returns of the stock. It is expected that higher financial leverage should make firms more risky, and thus higher leverage values should increase systematic risk (Brealey and Myers, 2000).

#### GLOBAL FACTORS:

Global factors are those factors that are not specific to a company, and are generally related to macroeconomic indicators. We have considered four global factors in our model: market returns, coal prices, USDINR exchange rates and the term premium.

The Capital Asset Pricing Model, Fama-French three factor model and all the risk factor models referenced in the literature review all contain the market returns factor as one of the primary factors. The coefficient of the market returns is called the beta and is a measure of the correlation of the excess returns of the stock over the risk-free rate with the returns of the broader market. We use the returns of the BSE Sensex 30 index as the proxy for the market returns, as is the best practice for Indian markets.

Bianconi, Yoshino (2014) offer evidence for crude oil price and exchange rates for currencies such as EUR, JPY, BRL and GBP against the USD are robustly priced into returns of companies in the non-renewable sector globally. Extending this to the context of power generation companies in India, we hypothesized coal prices and USDINR exchange rates as possibly having explanatory power to explain power generation company returns.

The term premium is defined as the difference between long term (10 year government bond yield) and short term (1 month government bond yield) interest rates, and is a measure of the unexpected change in the long

term rates. Ammar, Eling (2013) determine that the term premium has power in explaining the returns of infrastructure investments in North America due to their high upfront capital investments and highly leveraged structures. Since the same holds true for the power

sector in India, with the cost of financing contributing up to 20% to the cost of renewable electricity (CPI research), we consider the term premium as a factor in our risk model.



