India's Electricity-Sector Transformation

"Our goal here is to fundamentally change the way the world uses energy. The goal is a complete transformation of the entire energy infrastructure of the world."

-Elon Musk, CEO of Telsa & Chairman of SolarCity, May 2015

"We are confident that in the next year or two, we will be able to stop imports of thermal coal."

Indian Energy Minister Piyush Goyal, May 2015

Institute for Energy Economics and Financial Analysis
IEEFA.org

August 2015 -updated August 11, 2015

By Tim Buckley, Director of Energy Finance Studies, Australasia (tbuckley@ieefa.org)

With inputs from Jai Sharda, Equitorials

India's Electricity-Sector Transformation

In this briefing paper, the Institute for Energy Economics and Financial Analysis (IEEFA) provides an overview of India's electricity-sector transformation. This report seeks to outline the direction of the Modi government's electricity strategy and to analyse the progress and implications of that strategy.

Executive Summary

In 2014, the government of India announced a massive electricity-sector transition. A year into this program, the evidence suggests momentum is building on a number of key fronts.

In a reference to Hindu mythology and the Chariot of the Sun being drawn by seven white horses, Prime Minister Narendra Modi's refers to "Seven horses of energy." The goal for India is to build energy security by diversifying supply reliance beyond coal, hydro, nuclear and gas, to significantly expand levels of wind, solar and biomass. The Modi government's goal of adding 175 gigawatts (GW) of renewables by 2022 and accelerating the deployment of distributed-energy microgrids underpins this transformation.

Key enablers of this transformation will be a sustained reduction in the aggregate technical and commercial (AT&C) loss rates of 26%, and a successful reform of the state-based distribution companies (Discoms) to resolve unsustainable net operating losses (US$11bn in 2012-13).

IEEFA models a 60%, or 500 terawatt hours (TWh), increase in net electricity demand to 1,318TWh per annum over the seven years to 2021-22. Reducing AT&C losses by 100 bps per annum could deliver a 114TWh saving, equating to a massive 23% of the required increase in net electricity generation.

If energy efficiency initiatives can deliver a net electricity savings of 1% per annum, this likewise could reduce required electricity generation growth by 75TWh, or 15% of the total required.

Solar electricity installs of 75GW by 2021-22 could deliver 110TWh or 22% of the required electricity increase. Access to international finance is key, and SoftBanks' June 2015 US$20bn endorsement shows the momentum in this realm. Plans to take wind installs to 60GW could deliver 19% of the uplift. A combined capacity expansion across nuclear, gas, biomass and hydro could deliver another 25%.

The net result is that India could supply net electricity sufficient to underpin 7% annual gross domestic product (GDP) growth in the seven years to 2021-22 (60% overall) with coal-fired electricity delivering only 32% of the overall expanded electricity production required. Even here, a 1.25% per annum improvement in average thermal efficiency of coal-fired power plants could reduce the required increase in coal tonnage by a cumulative 65 million tonnes per annum (Mtpa).

Energy Minister Piyush Goyal's hope for India to cease thermal coal imports is entirely feasible. In this context, the Government of India's (GoI) ambition to double Indian domestic coal production to 1,500Mtpa by 2021-22 is actually likely to oversupply India with coal by 400Mtpa. On this basis, we believe it would be prudent for India to go slow on new thermal power plant additions, lest they end up stranded similar to generator fleets in China, the U.S. and Australia.

The obstacles are like everything about India: vast, interrelated, and complex. If India is unable to achieve sustained economic grow of 7-8% per annum, it will not need current imported coal levels, and achieving zero thermal coal imports could occur earlier than forecast. Likewise, lower than projected growth rates could leave US$100bn of stranded thermal power plants running at low utilisation rates and delivering continued net losses for shareholders and banks.

Contents

Introduction

The government of India has initiated a radical transformation of the Indian coal-mining, renewable-energy, power-generation and electricity-distribution sectors. Energy Minister Piyush Goyal has set extremely ambitious targets in regard to increasing Indian energy supply, including adding 175GW of renewable energy installation by 2022, a US$50bn modernisation of the electricity grid and a target that would increase India's domestic coal production to 1,500Mtpa.

For such a transformation to come about, efficiency will be key—efficiency of coal production and delivery of targets; efficiency in railway dispatches by lifting freight-utilisation rates with measures such as washing coal to lower tonnage required to be moved; grid-efficiency gains to lower the highest AT&C grid-loss rates in the world (26%); operating efficiency to drive the Discoms from their current unsustainable operating-loss position so that power purchase agreements (PPAs) have bankability and cash-flow security; energy efficiency to lower the ratio between electricity demand growth and economic growth; raising coal-fired power plant thermal efficiency to lower the tonnage of coal required per kilowatt hour (kWh) of electricity produced; carbon efficiency to lower the electricity sector's emissions intensity through better emissions standards and a greater reliance on low carbon alternatives such as wind, solar and hydro electricity; and finally, financial-market efficiency to drive down the cost of capital and increase access to capital.

IEEFA's Indian-electricity sector model illustrates that the GoI's plans can achieve a cessation of Indian thermal coal imports by 2020-2022. As a base scenario, IEEFA forecasts GDP growth of 6-8% per annum through 2021-22. Net electricity demand growth is assumed to run at 1.15 times GDP less energy efficiency gains of 1% annually. AT&C loss reductions of 1% annually are factored in. This would see net electricity demand grow at 7% annually. IEEFA assumes the GoI achieves 75% of its targeted 175GW of additional renewable energy installations by 2021-22. IEEFA assumes the initiative to double gas-fired power plant utilisation rates from the current 23% levels is also achieved. Combined, these initiatives serve to build India's energy security through enhanced system diversification, reducing reliance on coal-fired power generation from the 2014-15 rate of 74% to 64% by 2021-22.

Energy Minister Goyal seeks to build India's energy security through enhanced system diversity utilising domestic resources. Increasing efficiency and productivity should limit the impost of higher retail electricity prices on Indian electricity consumers.

The grid transmission and distribution system of India, including the exceptionally inefficient and loss-making Discoms, and their associated lack of enforcement of their renewable purchase obligations (RPOs), is a key bottleneck constraining the Indian electricity sector.

Energy Minister Goyal has also made it clear that India's reliance on thermal coal imports is not sustainable for the economy or ratepayers, nor is it commercially viable for the coal-fired power plants involved. Goyal has also made it clear that with Coal India's output now growing at a record high 11% year-on-year, India faces the potential issue of excess thermal coal and electricity supply for the first time in decades. In an important statement in May 2015, Goyal said this: "We are confident that in the next year or two, we will be able to stop imports of thermal coal." If Coal India Ltd lifts production to anywhere near its 1,000Mtpa target, India will cease thermal coal imports.

Section 1 - Indian Electricity Generation

The Indian electricity market is of global importance for a number of reasons.

India will soon be the largest country in the world in terms of population, and India is already the world's third largest market in terms of gross electricity generation (Figure 1). Of the 10 largest electricity systems in the world, India is likely to have the fastest growing electricity market over the next decade.

While Indonesia and Australia are the two largest exporters of coal, India's domestic coal production is larger than either. Combined, China, the U.S. and India produced 68% of the world's total coal in 2014, and account for 72% of the world's total consumption.

While 85% of all coal is consumed in the country of production, the international coal market exceeds 1,100Mtpa. China was the largest coal-importing nation in 2014. However, Chinese coal imports declined 11% in 2014 and are down a further 38% year-over-year to date in 2015. India, with a history of below-forecast domestic coal production, has tripled imported coal volumes over the past five years, to supply 22% of India's total coal consumption in 2014. By 2015, IEEFA expects India to be the world's largest importer, consuming 20% of all internationally traded coal.

Figure 1: The 10 Largest Countries for Electricity Generation (TWh, 2014)

Country (TWh)	2014	Rank	Change vs 2013
China	5,650	1	4.0%
US	4,297	2	0.7%
India	1,208	3	9.6%
Russian Federation	1,064	4	0.5%
Japan	1,061	5	-2.4%
Canada	615	6	-1.7%
Germany	614	7	-3.0%
Brazil	583	8	2.2%
France	556	9	-2.2%
South Korea	518	10	0.1%

Source: BP Statistical Review of World Energy 2015

Coal-fired power generation provided 74% of India's electricity in 2014/15, making India the most coal-dependent nation among the top 10 (China is second at 72%, down from 79% in 2011). In contrast, Brazil and France are the lowest coal-dependent countries among the world 10 largest electricity systems, having achieved a less than 5% reliance on coal in 2014. What happens in India is important, too, because the country's electricity sector in 2014 was the second most carbon emission intensive among the top 20 nations, behind only Australia.

The Government of India's announcement in 2014 of policies aimed at transforming the country's electricity sector also make India a more important global force in energy markets. The Modi government's plan, to install 175GW of renewable energy, is one of a number of initiatives that stands to underpin a significant diversification away from coal-fired power generation. Such a move would progressively lower the emissions intensity of Indian electricity, and if global capital can be leveraged to facilitate this transformation, it could create a "Road to Paris" platform that aligns India's need for more sustainable growth with the developed world's need for decarburization. Changes in India also will probably carry substantial weight in their effect on the structural decline of the seaborne thermal coal market.

Section 2 – Indian Electricity-Sector Transformation

Under the leadership of Prime Minister Narendra Modi, who came to power in May 2014, the GoI is looking now to transform India's electricity sector. This push is driven by the longstanding need to reform the ailing finances of India's power-generation and electricity-distribution sectors. If effective, the Modi transformation would reduce the current financial burden on the electricity sector, a change that would ultimately benefit all Indian consumers. However, simply announcing a program is not the same thing as implementing it. The Modi initiatives must overcome a history of bureaucratic inertia that has supports underperformance in the domestic coal-mining and rail-freight industries as well as the excessive financial leverage crippling these industries and the country's largely unfunded electricity system subsidies.

The GoI objectives, in IEEFA's view, are fourfold:

- To deliver, in a sustainable way, a significantly bigger electricity supply across India in order to build a period of high economic growth (7-8% per annum) without excessive retail electricity price inflation;
- To improve grid efficiency significantly so that money-losing power utilities can begin to turn a profit;
- To encourage infrastructure investment, creating higher-value jobs and extending electricity to 400 million Indians now living off the grid;
- To support a rapid diversification away from coal-based power and reducing reliance on coal imports.

The diversification objective is all about building India's energy security. The Indian economy today is reliant on imported energy. Oil imports hold an almost 80% market share of the market within India, while 28% of the country's liquid natural gas comes from imports, thermal coal imports' market share has doubled in the past five years to 22%, and most of the methanol India burns (70%) is imported. Such reliance on fossil-fuel imports is a major drag on the current account and on the GoI's budget balances. In 2013/14 alone, GoI petroleum subsidies totaled US$14bn (more than a third of total GoI subsidies for food, fertilizer and petroleum).

Some of these energy goals have the potential to kick start a lower carbon, less pollution intensive phase of India's development. Energy Minister Piyush Goyal is leading this transformation, which has a dozen distinctive components worth noting:

1. A tenfold increase in solar installation rates to 100GW by 2022, trebling to 60GW of new wind farms, 10GW of biomass and 5GW of small scale, run-of-river hydro. These initiatives, which total 175GW of new renewable-energy installations, require an investment of over US$200bn, with new national legislative support currently proposed under the National Renewable Energy Act;
2. Opening up access to international debt and equity markets to assist with a proposal to price power purchase agreements (PPAs) in U.S. dollars as a way to fund low-cost, long-duration loans with centralised currency hedging;
3. US$50bn in investments toward upgrading the capacity and efficiency of the electricity transmission and distribution grid, with an associated smart-meter program aimed at significantly reducing the Indian electricity grid's 23-25% transmission and distribution (T&D) loss rate and to drive a 6% energy efficiency saving for 2015 alone (reducing in the process the frequency and duration of blackouts);
4. A doubling of Coal India Ltd's production output to 1,000Mtpa by 2021/22, with a focus on greater integration and co-ordination with Indian Railways to reduce logistical bottlenecks;

5. A more than doubling of India's overall coal production in 5-7 years to 1,500Mtpa with the intention to expand domestic private coal-mining capacity to 500Mtpa building competition;
6. Reducing railway inefficiencies, increasing railway capacity and better aligning coal mine-mouth power plants, all aimed at reducing coal transportation distances;
7. Improving utilisation rates of existing thermal power plants to reduce the need for more capacity which could then progressively allow a phase out old, inefficient coal-fired power capacity and replacing it with the latest, highest-efficiency technology;
8. Re-evaluating the merits of pursuing the country's now stalled Ultra Mega Power Project (UMPP) plan;
9. Pursuing Rural Electrification by an accelerated off-grid or distributed-energy solution with the longer term aim of "24X7 electricity supply for all";
10. Developing more hydro-electricity capacity;
11. Promoting the government's National Mission on Enhanced Energy Efficiency;
12. Resolving the electricity distribution company (Discom) sector's ongoing operating losses of more than US$10bn annually, a situation that chronically undermines the financials of the whole system and that makes many PPAs unbankable.

That last plank is probably the most significant in the Modi energy-transformation platform. Reduced reliance on thermal coal imports is a commercial necessity because the low wholesale price of electricity in India is incompatible with import-coal costs. Less reliance on coal imports would also avoid the negative implications associated with bigger current account deficits, which add to devaluation pressures on the Indian currency.

Given the Modi government's stated intent of seeing GDP grow by 7-8% per annum, IEEFA considers the government's energy initiatives as an unmistakable signal that it means to impose ambitious reforms that will fundamentally restructure India's failing coal-mining, power-generation and electricity sectors. These reforms stand also to alleviate the financial stress these sectors have placed on India's banking system.

Any growth plan predicated on more coal-fired power generation, however, would escalate the country's already high rate of air and water pollution. Such a plan would create more costs in the long run, it would also meet with continued and costly grassroots resistance to the inevitable community relocations and loss of traditional farmlands and forests.

The current near-crippled state of the Indian electricity market is made clear by its inability to deliver reliable and consistent power to Indian households and industry. The reliance on unfunded electricity subsidies is further evidence of industry failure. The country's generally state-owned power utilities indeed lack commercial viability, especially given their excessive leverage and their ongoing operating losses.

A key outcome of the Modi government's proposed energy-sector transformation would be the elimination of India's reliance on imported thermal coal—a change crucial to preventing the buildup of excessive electricity-system inflation that would otherwise result from a reliance on imports. Energy Minister Goyal has repeatedly stated this objective, even if the global coal industry seems unwilling yet to accept the possibility that India will free itself of imported thermal coal.

Such an outcome can be achieved, however, and India can do it through greater reliance on energy efficiency, better grid efficiency, and the Modi government's initiative to install 175GW of wind, solar, run-of-river hydro and biomass over the next eight years combined with an acceleration in public and private domestic coal mining.

In fact, these policies will very likely drive a double transition: an India no longer reliant on imported coal, and a country that in the long term will lose its appetite for coal as renewable

energy and energy efficiency becomes an ever larger bigger piece of the pie. This assertion may seem contradictory on its face value. After all, if India burns more coal—even it is produced domestically, the end result will be further reliance on coal. In IEEFA's view, however, any plan to triple domestic coal production would by definition see air and water pollution triple, an outcome that would exacerbate costly and perhaps catastrophic social unrest. According to the World Health Organisation, India already has 13 of the 20 most polluted cities in the world, many of them far worse than the most badly polluted cities in China. As China is doing already because of social unrest, the GoI will have to act to remedy air and water pollution, a trend that is beginning to take root now. In April 2015, New Delhi started a crackdown on pollution, a regulatory shift that included closing old coal-fired power plant—and a strategy that mimics China's.

IEEFA is optimistic that as momentum builds, the Indian electricity market will rapidly pivot toward a significantly higher reliance on renewable energy and energy efficiency. Our confidence is predicated on the fact that once built and once implemented, renewable energy plants and energy efficiency initiatives have an almost zero marginal cost of production. That means they work immediately to undermine the viability of coal-fired power plants that have a high marginal cost of production. Further, Minister Goyal's plan to access global debt capital markets will significantly lower the cost of renewables in India, accelerating the transition away from coal.

As the technology revolution around renewable energy rapidly develops, many coal-fired power plants will prove to be stranded assets, unable to generate a financial return. India will mostly likely run into the same electricity-sector problem Europe has grappled with over the past decade with major utilities like RWE and E.ON seeing unprecedented shareholder wealth destruction. The same trend is hammering China's coal-fired power sector, which saw record low coal power utilisation rates of 53.7% in 2014 and 49.4% in the first half of 2015, a development that undermines the profitability of even the newest coal-fired power plants.

For India to sustain strong economic growth, a significant growth in its electricity consumption is inevitable. For this to occur, the exceptional AT&C losses across the grid must be at least halved in the medium term. Concurrently, the US$10bn aggregate annual loss by the State-based Discoms must be rectified. Excessive subsidies for electricity are a third facet of the problem because low retail electricity prices dramatically reduce the incentive for the deployment of energy-efficiency initiatives. Massive Discom losses mean power purchase agreements have limited bankability, and that payments to electricity producers are unreliable. Tariff and subsidy reform are all intertwined. Absent significant progress on these issues, India's economic growth will be significantly impeded.

If Energy Minister Goyal's electricity sector transformation is successful, on the other hand, thermal coal imports will rapidly recede. Alternatively, failure would see excess production of domestic coal for an electricity sector that fails to deliver growth, likewise dissipating the current peak demand for imported coal. The end result under either scenario, in IEEFA's view, is that India's coal imports will peak in 2015 and rapidly decline into 2020.

Section 3 –
Aiming for 175GW of New Renewable Energy by 2022

Finance Minister Arun Jaitley in the 2015/16 Indian budget includes a proposed tenfold increase in solar installation to 100GW by 2022, trebling to 60GW of wind farms, an additional 10GW of biomass and 5GW of new small-scale, run-of-river hydro.[1] This is 175GW of additional renewable energy installations in total, requiring an investment of more than US$200bn and representing a fivefold increase on the current installed total of 36GW of renewable energy (excluding large scale-hydro) — Figure 3.1.

The 2015/16 GoI budget also doubles the Clean Energy Cess levied on coal from Rs100 to Rs200 per tonne, (following a doubling of this coal tax in the 2014/15 budget) to acknowledge coal's externalities and to encourage the diversification away from coal-fired power.

Figure 3.1: India's Generating Capacity: Breakdown by Fuel Type (GW)

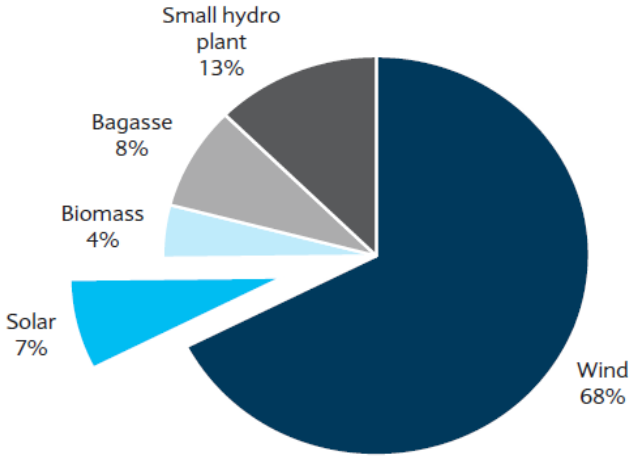
Capacity (GW)	Mar'1997	Mar'2002	Mar'2007	Mar'2012	Mar'2015	Mar'2015
Coal-fired	54.2	62.1	71.1	112.0	164.6	60.6%
Gas-fired	6.6	11.1	13.7	18.4	23.1	8.5%
Diesel	0.3	1.1	1.2	1.2	1.2	0.4%
Hydro	21.7	26.1	36.4	42.6	41.3	15.2%
Small hydro				3.4	3.8	1.4%
Nuclear	2.2	2.7	3.9	4.8	5.8	2.1%
Wind	0.4	0.8	4.1	16.5	24.2	8.9%
Solar	0.0	0.0	0.0	0.6	3.7	1.4%
Biomass & SMP	0.5	0.9	1.9	3.8	4.1	1.5%
Total	**85.9**	**104.9**	**132.3**	**203.3**	**271.7**	100.0%

Source: Central Electricity Authority, India, March 2015.

This focus on renewables and the rationale for it was reiterated in March 2015 by Minister Goyal:

> *"We have planned a 5X growth in renewable energy in the next five years. It is an article of faith for Prime Minister Narendra Modi. India is much more conscious today and all of us recognize that we have to leave behind a cleaner and greener country as we move forward."*

Figure 3.2: India's 30 GW of Renewable Capacity – By Technology (March 2014)



Source: Ministry of New and Renewable Energy, Barclay's Research

[1] http://indiabudget.nic.in/bspeecha.asp

Section 3.1 - Access to International Finance Will be Key

For India to fund 175GW of renewable energy by 2022, and for the associated improvement in grid transmission and distribution to occur, some US$250bn of funding will be needed. With the typical debt-to-total-investment ratio of 60-70%, this means US$150-175bn is required for project finance debt over the next seven years. The Indian power sector is very equity-capital constrained, a reflection of its excessive financial leverage that stems from its commitment to concurrently undertake a multitude of infrastructure projects. Many of these thermal power projects are only partly completed following significant project delays due in large part to community opposition.

Domestic Indian Finance Is Constrained

Indian finance laws allow excessively leveraged promoters to avoid insolvency by relying time and again on loan extensions and on the inability of banks to enforce loan covenants. Much of the Indian power sector has been described as "drowning in debt."

Three "leading" power companies in India illustrate the magnitude of this problem. Lanco Infratech has been in formal corporate debt restructuring since the end of 2013. Adani Power is reported to have seen two major subsidies through a 5/25 loan-restructuring program in April 2015 that taps a Reserve Bank of India program that has allowed Adani Power to extend debt duration from 10 years to 19 and to gain an 18-month payment moratorium (Adani's new Udupi Power Corp. also entered a 5/25 restructuring, in June 2015). Likewise, GVK Power has been loss-making for the past four years, its gross operating cash flow is insufficient to cover its interest bill and net debt is 10 times the book value of equity.

The weak financial footing of the industry has left the relatively small Indian domestic banking sector carrying an estimated US$100bn in loans to just 10 of the larger power and infrastructure conglomerates. A 2013 report from Credit Suisse titled "*House of Debt – Revisited*"[2] highlighted the continued growth in financial leverage in a sector already characterised as being overleveraged. With few asset sale transactions achieved in 2014/15, continued net losses, the acquisition of coal blocks at market prices, and no resolution of the stranded power project pipeline, power and grid sector aggregate net debt has grown another 10% in the 12 months from March 2014 to March 2015.

The Climate Policy Institute (CPI) has written extensively on the importance of getting the cost of debt and equity finance down as a priority for renewable energy project uptake. This issue is a constraint in India, especially, because of its closed financial markets and its high inflation and high interest rate environment. Easing this constraint is by far the most cost-effective way to spark the Indian electricity-sector transformation.

The GoI is working with KfW, the Asian Development Bank and the World Bank to provide and enhance financing for solar, and initiative Bridge to India says "will provide debt at a lower cost of about 8.5% in comparison to the current cost of 12-12.5%."[3]

Simply stated, solar and wind development under such initiatives means effectively paying up front for 25 years of almost-free electricity because lowering the weighted average cost of finance lifts a project's net present value. Renewable energy is also inflation free, given that once such generation is built it requires minimal operating costs, creating a key new deflationary driver for the Indian economy.

[2] Credit Suisse Equity Research, Ashish Gupta, "India Financial Sector: House of debt—revisited," 13 August 2013.
[3] Bridge To India, "India Solar Handbook 2015, http://www.bridgetoindia.com/

Equity Capital

Energy Minister Goyal has articulated a plan to encourage major Indian companies to diversify into renewable energy projects, with a tax incentive that consists of an accelerated depreciation allowance of 80% in Year 1. The aim is to encourage corporates with established and conservative balance sheets to deploy excess capital into new renewable projects, stimulating investment by a tax deduction "pull-forward."

This initiative could create access to a significant equity base across India and promote diversification away from the excessively leveraged Indian fossil-fuel power sector. Firms that have committed capital so far include: Coal India Ltd (US$1.2bn for 1GW of solar projects); NTPC Ltd (a reported US$10 billion to set up 10GW of renewable energy by 2019); Adani Enterprises (US$10bn in three solar ventures); Sembcorp (US$250m pa for 0.8GW of renewables by 2022); India Railways (US$1bn for 1GW of distributed solar on railway stations); Reliance Power (6GW MoU with Rajasthan); Tata Power Renewable Energy (targets adding 200-300MW per year of renewables); Aditya Birla Group (US$1bn for 1GW of solar within 5 years); Hindustan Powerprojects (1GW of solar by 2016); and the massive US$20bn, 20GW joint venture of SoftBank/Foxconn/Bharti Enterprises (Refer Appendix F).

As momentum builds, it will create more capital access to international renewable energy project developers beyond the early movers like Sun Edison (which has signed a 5GW solar proposal with the Rajasthan government as well as Adani) and First Solar Inc. This trend could see increased access to low-cost equity investment vehicles such as the rapidly growing U.S.-listed Yieldco sector.[4]

Debt Capital

Energy Minister Goyal continues to explore ways to sidestep the constrained and relatively closed domestic Indian financial system in hopes of tapping into the almost unlimited capacity of the global financial system. His work plays to the GoI's desire to contribute to the United Nations Climate Change Conference, COP21, in Paris at the end of 2015. Prime Minister Modi recognises India's buy-in to any global pollution accord is crucial, but that the principle of "common but differentiated responsibilities" means the biggest and most developed economies providing financial assistance to facilitate this move toward a decarbonised energy system in India.

To this end, in 2015 U.S. President Obama pledged US$4bn of debt financing for Indian renewables (via the Overseas Private Investment Corporation and the U.S. Trade and Development Agency). The Partnership to Advance Clean Energy—Deployment Technical Assistance Program (PACE-D), a U.S.-India bilateral initiative, aims to create expertise to help India raise green funds. PACE-D is funded by the U.S. Agency for International Development (USAID), which made this observation in a recent paper on the topic:

> *"In the Indian context, there are certain challenges for the issuance of Green Bonds in the international markets. These include high currency hedging costs; poor sovereign ratings (currently at BBB-); low tenure (currently, Green Bond tenures are mainly concentrated between 3-10 years, with only some issuances reaching or exceeding 15 years tenure),"*

A second international commitment to support renewables in India was achieved in April 2015 with France's President Hollande pledging €2bn.

[4] Yieldco: A new financial structure pioneered in 2013 by NRG Yieldco. A listed US finance vehicle that owns generally renewable energy assets that are post construction and hence de-risked. The Yieldco accesses low cost equity finance at rates of 7-8% pa and long dated debt finance secured against the long dated power purchase agreements of 15-25 years duration. The structure uses the strong cashflow profile to leverage up and generate shareholder returns by financial engineering. The Yieldco concept has been created to provide an alternative to the current exceptionally low 1-3% pa yields offered by the long dated bond markets across the US and Europe.

In March 2015, Goyal proposed a system of U.S.-dollar-denominated long-dated solar PPAs, with an associated, centralised hedging of the long-term Rupee/USD exchange rate risk. By utilising the GoI credit rating and by offering a U.S.-dollar-, Chinese-yuan or Euro-denominated bond, such a system could access multi-billion dollar global markets for long-dated debt while materially lowering the cost of debt available for renewable energy projects. Goyal is trying also to improve counter-party risk—bidding in dollar-denominated tariff and creating an escrow account to help developers hedge risk. In May 2015 Goyal stated the following:

> *"We are looking at innovative financing models. Dollar tariffs can perhaps bring solar power down to grid parity from day one, with the added advantage of 20-25 years of stability of tariffs, which no other source of electricity can give."*

One source of long-dated international debt is the newly emerging global green climate bond market. This market has grown by over 100% annually in recent years and saw issuance of US$36.6bn bonds in 2014, with the possibility of US$100bn in such bonds in 2015.[5]

In April 2015, Yes Bank self-issued India's inaugural green bond to raise INR10bn (US$161m) for a 10 year, 8.85% coupon, bearing a AA+ local rating (roughly equivalent to BB+ internationally). This event was followed by EXIM Bank of India issuing a US$500m green bond for India (of 5 years tenor, 2.75% pa coupon, and rated investment grade at BBB-/Baa3) to fund low-carbon transport, solar and wind projects.

It was reported in Mary 2015 that NTPC Ltd planned US$500m green bond issue, with a second US$500m of rupee-denominated bonds. The funds raised will be used to assist in the financing of NTPC's 10GW of pledged solar power capacity projects. Further US-dollar- and rupee-denominated green bonds are expected to be raised by India Infrastructure Finance Co. Ltd (IIFCL), Rural Electrification Corp. Ltd (REC), Power Finance Corp. Ltd (PFC), IDBI Bank Ltd, Indian Renewable Energy Development Agency Ltd (IREDA) and ICICI Bank Ltd.

In June 2015, possibly the most significant investment announcement to date saw SoftBank of Japan, Foxconn Technologies of Taiwan and Bharti Enterprises of India announce the formation of a joint venture with the mandate to invest up to US$20bn in 20GW of solar in India.

In July 2015, Aditya Birla Nuvo, a US$4bn equity-capitalised listed division of the gigantic Aditya Birla Group announced board approval to enter the Indian solar sector.

Each of these initiatives will help build initial momentum for the development of global debt finance access for renewable energy in India.

One key financing constraint that remains is the relatively insolvent nature of many of the state distribution companies (Discoms) (see Section 4), a problem acknowledged in April 2015 by Anil Razdan, a former power secretary, when he said:

> *"The issue is who are they going to supply this power to? If they are going to supply to the same distribution companies, how is this debt going to be securitized? It comes back to the same issue of getting the Discom story right."*

Section 3.2 - Solar Installations: 100GW by 2022

With a cumulative national installed solar projects base of just 4GW as of June 2015, the Modi government's aim for a tenfold increase in installs to 10GW annually has met with some skepticism—even by key proponents for solar[6]—given the magnitude of the many barriers that need to be overcome for India to meet that goal.

[5] http://www.climatebonds.net/2015/01/seb-tops-annual-green-bond-underwriters-league-table-%E2%80%93-whisker-q4-results-have-morgan-0

[6] http://www.bridgetoindia.com/blog/is-indias-national-solar-mission-becoming-even-more-ambitious/

The GoI's solar strategy aims nonetheless to attract global leaders like SunEdison Inc. U.S., which signed a memorandum of understanding (MoU) with the Karnataka state government to develop 5GW of solar energy over the next five years and a second US$4bn venture with Adani Enterprises to build an integrated, world-scale module-manufacturing facility. Any collaboration between Adani and SunEdison initiates a step-change in the scale of Indian solar facilities built with world-leading technologies.

By comparison, IEEFA notes how China stepped up solar installs from 2GW in 2011 to 5GW in 2012 to 13GW in 2013, and then raised it higher national target further, to 17.8GW in 2015, with 5GW installed in 1Q2015 alone. A rapid ramp-up in India over several years is just as feasible.

India has long studied the regulatory, engineering and financial framework required for solar, a sector incentivised by a 70% decline in the cost of solar electricity over the past five years. Minister Goyal, in seeking industry support for his target in February 2015, was met immediately with high-level offers of 266GW in renewable-energy proposals.[7] Much needs to be done still to turn this intent into action, but a number of recent developments give substance to the objective. As solar becomes more and more commercially viable, the step-up in Indian investment and employment, and the benefits of energy system diversity, will only add momentum.

In March 2015, the revised documentation for the implementation of 15 GW of GoI-sponsored solar projects by 2019 was released.[8]

In April 2015, the Ministry of Power announced that all new coal-fired power plants would have to be accompanied by a renewable-energy plant for at least 10% of their generating capacity. (Additionally, the renewable purchase obligation (RPO) has been revised recently from 3% by 2022 to 8% by 2019, and Bridge to India estimates this mandate will require 69GW of new solar by 2019).

In May 2015, Bridge to India reported that the Ministry of New and Renewable Energy was planning for 10GW of solar tenders with completion occurring as early as the end of this financial year.

State Government Solar Programs

IEEFA notes that as the GoI has set an ambitious tone to ramping up solar installation, development of solar is being driven just as much by state governments across India.

In October 2014, Andhra Pradesh held a tender for 500MW of new solar capacity, receiving bids of 1.3GW from 50 project developers. The range of first-year tariff offered by the successful bidders was Rs5.25-5.99/kWh[9] with a 3% per annum escalation for the first 10 years, then flat thereafter. This auction is part of a longer-term plan to develop 2,500 MW of solar parks in Andhra Pradesh. First Solar Power India offered the lowest tariff of Rs 5.25/kWh for capacity of 40MW in Ananthapur District. The levelised tariff works out to Rs 6.17/kWh, which is lower than the earlier tariff (Rs 6.49/kWh).

In March 2015, the state of Tamil Nadu tendered to buy 3.0GW of solar energy and had 200 firms express interest. The chairman of Tamil Nadu Generation and Distribution Corporation forecast at the time that the present cost of solar power of Rs7.00/kWh would fall to Rs.5.45 by 2016.[10] Tamil Nadu has a target of 3GW by 2015 with plans to add 1GW of solar annually thereafter. In July 2015, Adani signed a fixed 25-year PPA at Rs7.01 for 648MW of solar at Kamuthi in Tamil Nadu.

[7] http://www.hindustantimes.com/business-news/293-companies-pledge-266-gw-clean-power/article1-1317191.aspx
[8] http://mnre.gov.in/file-manager/UserFiles/Scheme-for-15000-MW-through-NTPC-NVVN.pdf
[9] Rs5.25-5.99/kWh translates at 63.6 Rupee per US$ into US8.2-9.4c/kWh wholesale. Rs 6.17 is US9.7c/kWh.
[10] Rs7/kWh translates at 63.6 Rupee per US$ into US11c/kWh, while Rs5.45 is US8.6c/kWh.

In April 2015, the Southern Power Distribution Company of Telangana issued a request for selection including a PPA for the proposed allocation of 2GW of solar. The request offers a maximum tariff of Rs6.32 for large-scale projects. Bridge to India notes the successful allocation of 500MW of solar projects in 2014 at Telangana after receiving over 1.85GW in bids.

In April 2015, Madhya Pradesh announced plans to build the world's largest solar power plant. Located in Rewa, the project has a 750MW capacity and has World Bank support. The project is due to go on line in August 2016 and has a target cost of Rs45bn (US$712m). In July 2015, Madhya Pradesh signed tenders for 300MW of solar at a Rs5.05/kWh fixed flat rate for 25 years.

In June 2015, the new BJP-led government of Maharashtra saw cabinet approval of a renewable-energy policy with a target to triple total installs to 21GW by 2020. Of this expansion, 7,500 MW was earmarked for solar. State Energy Minister Chandrashekhar Bawankule said this:

> *"We expect the cost of solar energy to drop to Rs 4.5-5 per unit from over Rs 7 at present. We will soon come out with an off-grid energy policy to encourage rooftop solar panels, energy conservation and energy-efficient technology such as LEDs."*

In July 2015, the State of Telangana accepted 2,000MW of solar auctions at a record low price of Rs5.27/kWh. The prior week, 300 MW of solar capacity was auctioned in the Indian state of Madhya Pradesh, with a then record low average tariff of Rs3.35/kWh, fixed flat for 25 years – a perfect example of the deflationary power of renewable energy. Both tenders put utility solar already below the cost of imported-coal fired power generation.

Private Company Solar Projects

IEEFA notes also that a single firm, NTPC Limited of India, has proposed investing US$10bn in the development of 10GW of renewables within the next five years. As previously flagged by Bridge to India, NTPC in April 2015 announced Invitations for bids for 500MW of utility-scale solar at the Ghani Solar Park in Andhra Pradesh under the National Solar Mission Phase-II, Batch-II, Tranche-1. NTPC in May 2015 announced a 420MW Invitation for bids for the Bhadla Phase-II Solar Park in Rajasthan and a second for 500MW at the Gani-Sakunala Solar Park in Andhra Pradesh. The maximum tariff to be tendered for is Rs6.35/kWh.

In February 2015, Reliance Power signed a MoU with the Rajasthan Government for a 6GW solar-development program over 10 years. This follows the commissioning of a 40MW solar PV project in Jaisalmer, Rajasthan, in March 2012 and the world's largest compact linear Fresnel reflector-based concentrated solar power (CSP) project (100MW in Rajasthan) in November 2014.

Adani Power has made a number of announcements, too, proposing a rapid-solar sector entry and its CEO recently said this:

> *"India has embarked on an ambitious program to become a world leader in power generation from renewable technologies, and [Adani] sees solar as a key part in realizing that goal,"*

In February 2015, Adani Enterprises announced a new MoU to develop a joint venture with the Rajasthan government's Rajasthan Renewable Energy Corp for a new solar park facility with scope to warehouse up to 10GW of solar with a potential investment totaling Rs60,000 crore (US$10bn or US$1m per MW). In addition to its 648MW project in Tamil Nadu, Adani Power is also considering a second 1GW solar industrial park in Uttar Pradesh, with an initial solar project of up to 50MW under way there now.

In December 2014 Fortum of Finland connected a 10MW Indian solar project in Madhya Pradesh.

In July 2015 Sky Power of Canada announced it has been awarded 150MW of solar PPAs in the Indian State of Madhya Pradesh, securing rights to develop 3 projects of 50MW capacity each at tariffs ranging from Rs 5.051/kWh (US7.95¢/kWh) to Rs 5.298/kWh (US8.34¢/kWh), a fixed flat rate

for 25 years. The previous lowest bid in India were placed by First Solar at Rs 5.25/kWh (US8.27¢/kWh) for a 40 MW project in Andhra Pradesh. Sky Power has a solar development pipeline of 25GW globally, including major projects in Kenya and Egypt. Sky Power has set a target to add 9.9 GW solar power capacity in India over the next 5–7 years.

In July 2015 ENGIE of France (formerly GDF Suez) proposed to acquire a majority stake in Kiran Energy Solar Power, a solar project developer based in Mumbai. It was reported ENGIE will invest Rs 1,200 crore (US$180m) to acquire the stake. In 2010, Kiran Energy sold a 75-80% stake to three private equity investors — New Silk Route, Bessemer Ventures, and Argonaut Ventures, for US$40m. Kiran Energy operates 80MW of solar power projects. The company has several other projects under development. Kiran Energy also owns a 75% stake in another renewable energy project developer, Mahindra Solar One. Like Kiran Energy, Mahindra Solar One also operates several solar power projects in India.

In July 2015 ENGIE acquired SolaireDirect, establishing ENGIE as the solar market leader in France, with a gross total installed capacity of 383MW, including 186MW in train in India. SolaireDirect has a 2GW target for solar in India by 2019. This provides access to significant capital resources.

In July 2015 Renew Power of India (part owned by Goldman Sachs and the Asian Development Bank), announced a JV agreement with Hanwha Q CELLS, the flagship company of Hanwha Group, a diversified South Korean conglomerate, to develop two solar projects in the State of Telangana, totaling a capacity of 149MW. This follows the July 2015 agreement with Hareon Solar, one of China's largest solar energy companies, to develop a solar project of 72MW capacity in the State of Andhra Pradesh. Renew Power now has over 1GW of renewable projects operational or under development in India.

In July 2015 Welspun Renewables commissioned its 52MW solar project in Maharashtra as part of Welspun's target to commission over 11GW of solar and wind capacity in India. In July 2015 Welspun Renewables also announced a 550 MW Indian MoU with iPLON of Germany.

Distributed Rooftop Solar Target: 40GW

In its 100GW total solar target for 2022, the GoI in March 2015 set a target for 40GW of distributed rooftop solar as a way of circumventing the nation's massive grid AT&C losses. This includes an interim target of 10GW by 2018. This initiative also reduces potential impact on arable farming land and could reduce reliance on diesel-generator backup systems across the residential and commercial sectors. Installations to date of distributed solar across India are estimated at 400MW, highlighting the need for time to establish a trained and experienced workforce that can support quality installations. However, with the country's exceptionally high grid losses and its regular but unpredictable power outages, distributed solar is a key GoI objective and should prove highly cost effective and scalable over time. IEEFA notes the rapid penetration of rooftop residential solar across Australia (at a total 1.4m installations, or 15% of all residences), despite early policy errors. To date, some 25 Indian states have draft or approved net-metering rules for rooftop solar.

One important obstacle to the rapid deployment of distributed rooftop solar is the heavy subsidisation of retail electricity prices for residential and agricultural users. While retail grid parity is some way off, commercial- and industrial-grid parity exists already. Tariff reform to reduce residential subsidies would accelerate the deployment of rooftop solar and energy efficiency initiatives, as would a proposed Ministry of Urban Development mandatory requirement for rooftop solar.

Solar Manufacturing: 'Make in India'

India has been trying to establish an upstream solar-manufacturing base for over a decade. However, inconsistent policy, low quality, lack of manufacturing scale and pervasive, excessive financial leverage have undermined this effort. Under India's National Solar Mission, the GoI has used a tiered tendering system to allow lowest-cost solar project development while reserving 3GW per annum of solar projects dedicated to domestic manufacturing.

Moser Baer Solar, one of the earlier solar module manufacturers, continues to report net losses and very low capacity utilisation rates, highlighting one of the country's many obstacles to success.

The scale of ambition that Energy Minister Goyal envisions requires a step-change in technology and a scaling up of upstream solar manufacturing. This will require the manufacturing of polysilicon, solar cells and modules, associated balance-of-system requirements like inverters and racking systems, and integrated solar-with-storage and hybrid-solar-with-agricultural pump technologies.

In February 2015, Adani Enterprises and SunEdison Inc. announced a MoU for the development of a US$4bn solar module manufacturing facility in Gujarat.

In April 2015, Vikram Solar signed MoUs with Meyer Burger and Centrotherm, two European solar firms for development of manufacturing in India.

As part of the agenda around Prime Minister Modi's trip to China In May 2015, it was reported that the world-leading Trina Solar of China signed a MoU with Welspun Energy of India to set up a US$500m, 1,000MW per annum solar cell and module-manufacturing facility in India. However, this report is very preliminary given that neither Trina Solar nor Welspun Energy have yet made announcements to shareholders.

In May 2015, Essel Solar of India announced a MoU with JA Solar (a China-based global solar leader) to set up a solar cell and module-manufacturing facility in India. JA Solar is also yet to notify its shareholders of this development, again suggesting a very early notice of intent.

Section 3.3 – 175GW of Additional Renewables by 2022

Wind Installations: 60GW by 2022

The rapid investment in renewables includes wind farms, with a target of 60GW of wind-powered energy by 2022. This compares to the cumulative installed base of wind farms in India of 24GW at March 2015. The total installed base increased 10% year-on-year with the addition of 2.3GW installed 2014.

India offers an accelerated tax-depreciation allowance (80% depreciation in the first year of installation) and a Renewable Purchase Obligation (RPO) scheme, both designed to incentivise new wind projects. The Indian Ministry of New and Renewable Energy has an RPO target of 15% by 2020, and 28 states have defined their own RPO targets. To date, however, weak enforcement has materially undermined the RPO renewable-energy certificate (REC) process.

Onshore wind is the most cost-effective renewable energy source in India, and PPAs have ranged from Rs3.39-6.50/kWh,[11] more than competitive with imported coal-fired power generation's wholesale cost of Rs5-6/kWh.[12] The installed cost of wind sits at around US$1.0m / MW of capacity, well below global averages of US$1.5-2.0m/MW. The low cost reflects the use of

[11] Rs3.39-6.50/kWh translates at 63.6 Rupee per US$ into US5.5-10.2c/kWh.
[12] Rs5.00-6.00/kWh translates at 63.6 Rupee per US$ into US7.9-9.4c/kWh.

lower-quality and older technologies, with capacity utilisation rates reported at 25% versus 30-35% in the U.S. and Australia and upwards of 40% at some sites in Brazil and New Zealand.

A key constraint remains the high cost of domestic Indian debt (at 12-14% annually), so GoI initiatives to provide policy certainty and access to a larger pool of lower cost, longer duration debt capacity can dramatically transform the country's already attractive wind-industry fundamentals.

A second constraint is the weak national grid transmission structure, although in 2014, the GoI announced plans for a national Green Energy Grid Corridor to spur greater renewable-energy reliance.

Wind energy has played a significant role in the rapid diversification of the Chinese electricity grid, although much of that diversification includes hydro-electricity expansion. IEEFA sees the potential for China to exit 2020 with a cumulative total of 240GW of onshore and offshore wind installed, a sixfold increase on the 43GW installed in 2010. IEEFA forecasts China will generate 540TWh annually from wind by 2020.

A strong and crucial vote of confidence for the Modi-Goyal transformation came in February 2015, when Sembcorp (a leading Singaporean power conglomerate) acquired for US$170m a 60% stake in Green Infra, a leading Indian wind farm developer (the remaining 40% is held by IDFC Private Equity Fund III). Sembcorp Green Infra has 700MW of renewable energy in India (665MW of wind and 35MW of solar power assets), 70% of its operational and 30% under development. Tan Cheng Guan, the company's head of group business development, said in April 2015 that the Green Infra acquisition was strategic in that it triples Sembcorp's renewable portfolio and provides growth options: "We plan to have 200-250MW capacity addition every year. Based on investment needed per MW, that is about US$200-250m/year." Guan said the Singapore government owns two of the largest sovereign wealth funds (GIC and Temasek) in the world. IEEFA sees the investments by Singapore as catalysts for creating access to considerable new foreign capital, a key part of Modi's plan to accelerate infrastructure development.

Mytrah Energy (UK AIM listed) owns an Indian wind portfolio with 543MW of operational capacity, a further 300MW under construction, and more than 3,500MW of projects in the pipeline.

While Indian-domiciled Suzlon Energy was one of the top tier wind turbine blade manufacturers globally last decade, its heavily contested €1.35bn acquisition of REpower of Germany in 2007 proved disastrous as the global financial crisis unfolded. Since then, Suzlon has made significant restructuring progress, and in 2015 divested from REpower and attracted a major new cornerstone equity partner in the Dilip Shanghvi family, which invested Rs18bn for a 17% stake in the company. This necessary restructuring has halved Suzlon's debt and shrunk the global group while allowing Suzlon to resume growth.

In June 2015, SunEdison acquired Continuum Wind Energy, a Singaporean company that owns 242MW of wind farms in Maharashtra and Gujarat states. In July 2015, SunEdison Inc. also acquired a 102MW wind-farm portfolio in Karnataka and Rajasthan states from Fersa Energias Renovables SA of Spain. Combined with its solar project investments, this move makes SunEdison Inc. one of the largest foreign investors in renewable energy in India.

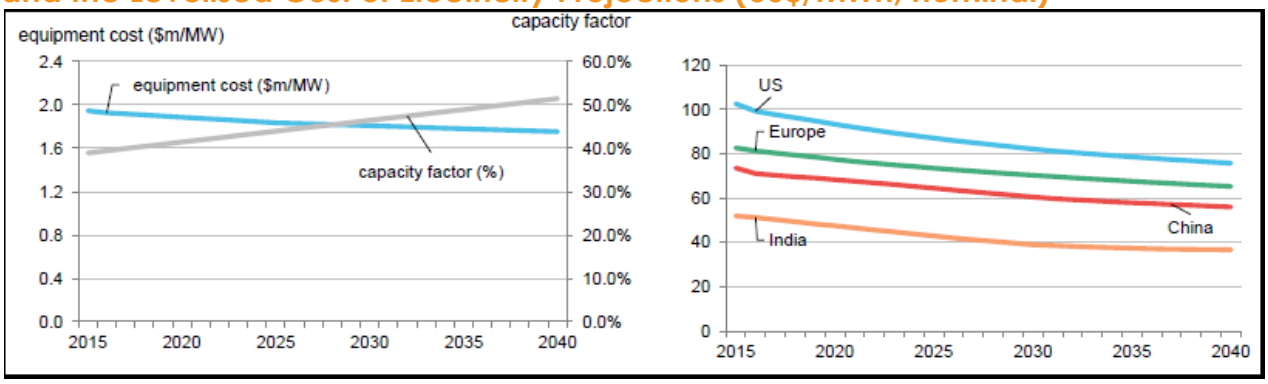
Wind-energy technology generally speaking has undergone a significant improvement over the last decade, with gains in electricity-generating capacity achieved through the use of taller towers with ever-longer, lighter blade designs. Onshore wind-turbine capacity has expanded from a global average of less than 1MW/turbine a decade ago to 2-3MW/turbine today, and the largest onshore turbines commercially deployed in Europe generate 6MW/turbine. Capacity-utilisation rates have likewise consistently improved, with the best wind sites delivering capacity-utilisation rates of over 40%.

Through the process of "repowering," India has significant scope to deploy the latest wind turbine technologies, particularly as existing older wind farms reach the end of their useful life. With its existing turbines sitting at capacities of 0.5-1.0MW/turbine, India—through "repowering"

alone—can raise its installed wind capacity by 300% and lift utilisation rates from the current 20-25% average to the best-practice outcomes of 30-45% seen in the U.S., New Zealand and Australia.

Bloomberg New Energy Finance (BNEF) forecasts the continued decline in nominal installation costs for wind, and a progressive increase in utilisation rates through 2040 (Figure 3.3). BNEF also calculates the wholesale cost of electricity from wind in India at US$55/MWh,[13] one of the lowest rates in the world due to Suzlon consistently delivering one of the lowest installation. This trend will only improve with higher utilisation rates and lower financing costs.

Figure 3.3: Onshore Wind Experience Curve and Efficiency Improvements (2015-2040) and the Levelised Cost of Electricity Projections (US$/MWh, nominal)



Source: Bloomberg New Energy Finance, "New Energy Outlook 2015, June 2015.

Distributed-Energy Solutions

Energy security was a key component of the May 2014 general election victory of the Bharatiya Janata Party (BJP). On assuming office, the new BJP-led government launched a scheme aimed at ensuring eight hours of quality power supply per day to agricultural consumers and 24-hour electricity for households. The GoI has approved a Rs 43,033-crore (US$7bn) rural-electrification scheme, called Deendayal Upadhyaya Gram Jyoti Yojana."

By setting an intermediate goal of eight hours of electricity supply for agricultural consumers, the Modi government has recognized that a centralized grid-based "24x7" solution relying on expensive imported coal is not an economically viable proposition. Investing billions of dollars to extend the grid to remote areas for small subsistence-farming villages that can't afford the commercial cost and scale of such electricity is a commercial solution (Figure 3.4) nor a commercial one.

In a March 2015 report, "Battery Ram: Storage Set to Shake Things Up," the equities research and investment group CLSA emphasized how expensive imported-coal-fired power generation is not a viable solution to Indian energy poverty. From Chet Lyons[14] of CLSA:

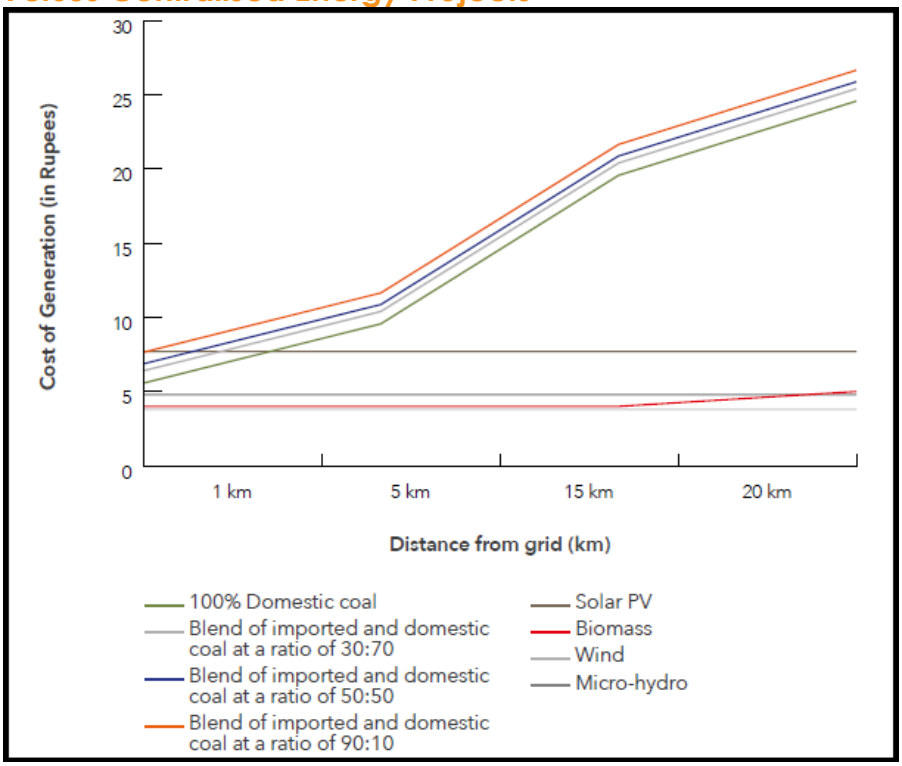
> *"The cost of building T&D infrastructure to reach them is prohibitively expensive. Fortunately, paralleling development of wireless cell-phone technology and its penetration into remote parts of the world, distributed renewable generation (primarily solar PV) coupled with energy storage provides a workable and economically realistic solution. Microgrids that combine solar PV and/or wind, plus storage, represent enormous hope."*

[13] US$55/MWh translates to a levelised cost of electricity (LCOE) at Rs3.50/kWh.
[14] CLSA Blue Book "Battery Ram: Storage set to shake things up", Chet Lyons, 18 March 2015.

Providing access to some distributed renewable electricity at low cost and with a rapid installation timeframe is a logical first step on this front.

SunEdison Inc. (U.S.) is working with Imergy Power Systems, a leader in advanced energy storage solutions, announcing in February 2015 the purchase of 1,000 vanadium-flow batteries totaling over 100 megawatt hours of long life. This energy-storage initiative in conjunction with India's Rural Electrification Corporation offers a model for providing remote villages with microgrids leveraging mobile-phone towers, which provide a bankable counterpart for baseload demand and for underpinning the whole system of commercial microgrid financing.

Figure 3.4: Cost Comparison of Low-Carbon Solutions Versus Centralised Energy Projects



Source: Vasudha Foundation, "ELECTRICITY FOR ALL IN INDIA", October 2014 by Sunita Dubey, Siddharth Chatpalliwar and Srinivas Krishnaswamy.

CLSA speculates that India could invest US$12bn in energy storage through 2020, and that such an investment will help drive the country's Electricity for All program. IEEFA sees economies of scale as likely drivers of dramatic cost reductions and technology enhancements for battery storage and microgrids over the next five years. As such, a cost effective solution could evaluate demonstration projects along the lines of SunEdison / Imergy Power for several years before ramping up full scale deployment.

The economics for distributed renewable energy solutions are rapidly improving, as is feasibility of a rapid implementation measured in months, particularly compared to that of large-scale thermal-power deployments that involve considerable external costs and take 5-10 years to complete. India's largest rooftop installation is reported at 7.5MW, with plans to go to 31MW which would be the largest in the world. Rooftop solar reduces the call on arable land and avoids all the complications associated with centralised power and its 25-26% AT&C losses.

The April 2015 announcement by Tesla of its 7kWh and 10kWh residential storage units starting from US$3,000 will drive a transformation of distributed energy markets globally. Initial uptake is likely to be predominantly in wealthy countries with high solar radiation and high peak retail electricity prices. But for the wealthier residential, retail and commercial sectors in India, the replacement of expensive diesel backup generation with rooftop solar linked to a Tesla Powerwall will be an increasingly viable alternative toward the end of this decade. Distributed grid-based power storage is also likely to be increasingly used to assist in grid stability and load management, particularly for peak demand periods and extreme-weather events.

The Africa Progress Report of June 2015 makes clear that a vital opportunity for relieving energy poverty lies in distributed renewable energy. Here's an excerpt from that report:

"Energy is the link connecting the global poverty agenda and climate change …. renewable technologies have two distinctive advantages. They can be deployed far more rapidly than coal-fired power plants and they can operate both on and off-grid …. offer a triple-win: boosting agricultural productivity, reducing poverty and strengthening international efforts to combat climate change."

Several firms have developed very interesting models for commercial deployment of solar microgrids, including Simpa Energy India Ltd and the Australian firm Pollinate Energy.

Section 4 - Improving Grid Efficiency

Energy Minister Goyal has outlined a US$50bn investment program to upgrade the capacity and efficiency of the Indian electricity transmission and distribution grid. A key piece of that upgrade would permanently address the crippling aggregate technical and commercial losses (AT&C) that total 25-27% annually (Figure 4.1).[15] Simply put, this loss rate means electricity generators have to produce four units of electricity for every three units they sell to their retail and industrial customers. A loss rate of this magnitude is financial suicide, particularly when coupled with subsidized retail electricity prices. The combined effect of Goyal's initiatives, in IEEFA's view, could be materially higher than the 1% conservatively assumed in our modeling. Goyal's recent wins from improving coal-rail efficiency (Section 5.4) and a doubling in gas-fired generation-capacity utilisation rates (Section 6.4) bode well for these similarly practical reforms.

Figure 4.1: India's grid transmission, distribution and technical losses 2005-2013 (GW)

	T&D losses	AT&C losses
2004/5	31.3%	34.3%
2005/6	30.4%	33.0%
2006/7	28.7%	30.6%
2007/8	27.2%	29.5%
2008/9	25.5%	27.4%
2009/10	25.4%	26.6%
2010/11	24.0%	26.4%
2011/12	23.7%	26.6%
2012/13	23.0%	25.4%

Source: India Central Electricity Authority March 2015

In December 2014 and again in March 2015, amendments were proposed to the federal Electricity Act of 2003 aimed at unbundling distribution and electricity supply to provide improved customer choice and to exploit competition to drive productivity enhancements. The amendments are facing steep resistance, particularly because electricity is a shared responsibility of the central and state governments. In May 2015 Energy Minister Goyal stated common of the common flaws in India's Discoms:

"[Discoms] have T&D losses, power theft upward of 40-50%. There is a state which has 70%. Many states are in the region of 30-50%. … If you run your operations inefficiently, you can't expect your consumer to pay for your inefficiencies… which is why we are also bringing in amendments to the Electricity Act so the consumers have the power to choose the most efficient suppliers, bring in some sort of competition like the mobile industry, give the consumer the power to choose and change."

A key constraint on Goyal's vision is the financial distress evident in so many of the state-owned Discoms. This is an area of critical reform, given that the lack of Discoms' financial viability undermines PPAs for renewables and thermal power alike, completely blunting the

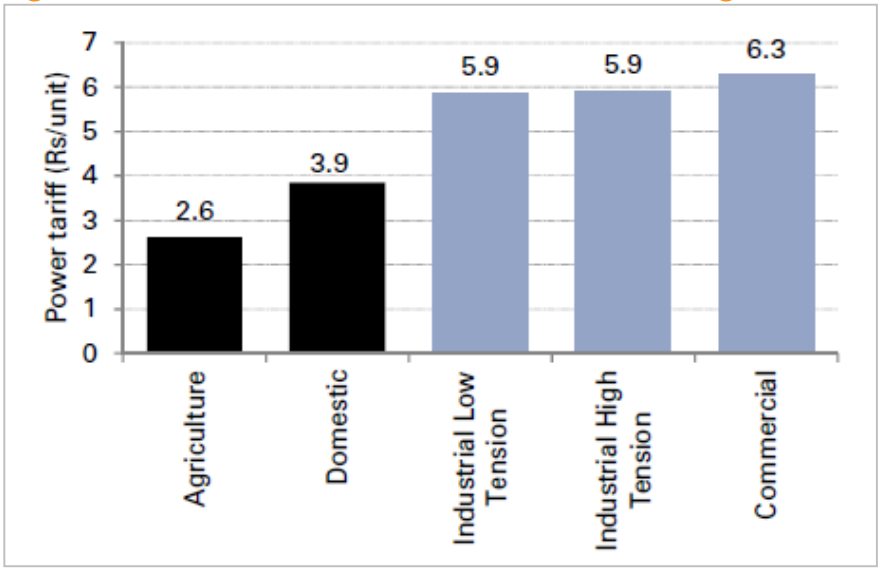
[15] http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS?page=3

implementation of mechanisms like RPO/REC that promote the addition of renewable, and given that electricity losses undermine the financial viability of the entire electricity sector.

As a measure of the depth and breadth of the problem, Goyal announced in March 2015 that distribution losses had incurred a staggering Rs 69,108 crore (US$11bn) net after tax loss to power utilities in 2012-13. These losses have risen drastically since 2007-2008, when the totaled US$3bn. The trend reflects a combination of excessive and growing financial leverage, retail price subsidies for electricity—particularly in the agricultural sector—high levels of technical losses (theft), and under-investment in maintaining the grid-transmission and distribution system.

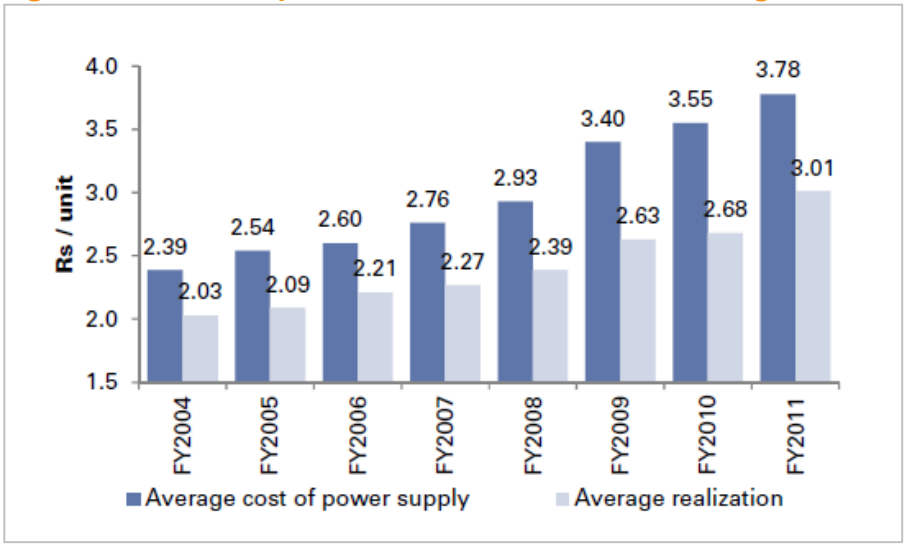
As well as carrying excessive AT&C losses, Discoms also face the financial hurdle of massive retail electricity price subsidies for the residential and agriculture sector (Figure 4.2). That problem has worsened over the past decade (Figure 4.3).

Figure 4.2: Commercial / Industrial Subsidies Agriculture and Domestic Electricity



Source: CEA, CERC, Goldman Sachs Global Investment Research

Figure 4.3: The Gap Between the Cost and Average Realisation of Electricity Is Rising



Source: CEA, Goldman Sachs Global Investment Research[16]

[16] Goldman Sachs Global Equity Research, Pulkit Patni & Mohit Soni, "Energizing India: Reforms the bright spark, but regular tariff hikes key", 19 January 2014.

Focusing on the resolution of Discom losses, Goyal is actively working with state governments to implement turnaround plans and cut AT&C losses, stating the following in June 2015:

> *"I don't agree to the one-size-fits-all mechanism. State-wise plans for all the states will be ready within 12 months. We don't need new funds. What we need is to implement existing programs".*

Discoms across a number of states in the first half of 2015 have announced planned tariff increases ranging from 5%-26%, albeit history would suggest the likelihood of a rollback is high.

In November 2014, the GoI approved a US$4bn smart-meter capital investment program aimed at addressing the most pressing cases of power theft. Additionally, US$8 billion is available for loss-reduction programs, and dozens of initiatives are now under way across India's 29 states.

Goyal has committed also to a National Mission on Enhanced Energy Efficiency, of which the initial target is for savings of 100TWh of electricity by the end of 2015, a 6% national saving, using fast-to-implement strategies like shifting to LED lighting. Here's Goyal stating the new policy in June 2015:

> *"The plan is to cut down energy demand by nearly 10,000 MW in peak hours by changing to LED lights in street and homes by 2019. This itself will save power to the tune of US$2bn.".*

In April 2015, the Ministry of Power announced that promotion of renewable energy was yet a fifth objective of India's electricity policy. Consistent with this announcement, renewable power is now exempt from interstate transmission charges, an exemption that encourages concentration of solar projects in states that have the highest solar radiation, like Rajasthan and Gujarat.

In May 2015, the GoI approved the National Smart Grid Mission, with grants to cover up to 30% of the capital cost of new projects.

It was reported in July 2015 that grid-transmission capacity constraints were forcing the grid management agency Power System Operation Corporation to curtail electricity transportation from the eastern region to the north. This is pushing Discoms into load-shedding and means that many power companies are unable to honour their supply contracts.

In July 2015, the GoI announced plans to launch a 20-year transmission plan to better manage the balance of electricity growth and electricity generation by region, and to better incorporate the planned 175GW of new renewable energy generation. That initiative includes a significant high-voltage direct-current (HDVC) grid-investment program that will probably be modeled after the one China has been implementing since 2010.

Section 4.1 – Power Grid India Capital Expenditures

A more integrated national grid will facilitate a greater penetration of renewable energy.

While Power Grid Corp. of India is undertaking a sustained heavy capital-expenditure program that is running at US$4-5bn annually to cover grid-transmission line and substation expansions and upgrades while expanding inter-regional capacity. The Indian grid has an installed generation capacity of 260GW. By 2022, that figure will approach 500GW, requiring an investment of more than US$20bn by Power Grid Corp. The Power Ministry is looking for global political and financial support for this program, saying recently that "negotiations are going on with the Asian Development Bank (ADB), World Bank and state governments to stitch a soft loan."

Section 4.2 – Wholesale Pricing of Electricity in India

The wholesale price of electricity is a key measure of the relative merits of different electricity-generation sources. However, some forms of generation have very significant external costs to the community and the economy, that is, costs that aren't reflect in wholesale prices. Figure 4.4 attempts to tabulate the average cost of various types of electricity generation and to quantify some of the external costs.

While renewable-energy sources generally have a slightly higher up-front capital cost, they bring significant advantages in the form of energy security through diversifying the supply of electricity across a wider range of free domestic fuel sources. Renewable energy is also favorably ranked in terms of the limited externalities that include no toxic-chemical and particulate pollution, no carbon pollution and no water consumption. Done properly and in the right places, hydro-electricity has limited external impacts and can add significant advantages in terms of pumped hydro storage (but done poorly can have extensive methane emissions and can seriously damage critical water systems).

A major advantage in domestic fuel sources (be they domestic thermal or renewables), is the avoidance of the ongoing impost on the current account deficit and hence currency valuation. Renewables have the long-term advantage of being deflationary; once established, the electricity generated from them has almost a zero marginal cost and no fuel price inflation risk. A further advantage of solar and wind is the rapid installation timeframes, particularly for distributed solar, which has yet another advantage in its avoidance of the failing grid-,distribution structure in India.

The latest domestic coal-fired power tariffs, from June 2015, ranged from Rs4.27-4.98/kWh in Andhra Pradesh, while 2013 domestic coal tariffs of Rs5.41/kWh in Rajasthan and Rs5.66/kWh in Tamil Nadu. The numbers illustrate that the bids of Rs1-3/kWh seen in 2008-2011 were unsustainable and unrealistic. IEEFA estimates imported coal-fired power in India requires Rs6/kWh, plus the standard coal requirement of an annual inflation link, making coal imports the least financially viable fuel source by 2016-2018.

By comparison, solar currently costs Rs5-7/kWh, and is forecast to fall below Rs5/kWh by 2016. With further declines of 5-10% annually over the next few decades, solar is rapidly becoming very competitive.

Figure 4.4: An All-In Cost Comparison of Wholesale Electricity Sources

Fuel source	Capital cost (US$m/MW)	Install time	Fuel Supply Risk	Fuel Currency	Wholesale price Rs/kWh	Air polution	Water consumption/ pollution	Inflationary Impact	Ongoing Currency Impact
Coal-fired - domestic	0.8-0.9	4-5 yrs	Medium	Rs	Rs3-5	Extreme	High	Low	Nil
Coal-fired - imported	0.8-1.0	4-5 yrs	High	US$	Rs5-6	Extreme	High	Upward	Negative
Diesel-fired	0.8-0.9	3-4 yrs	High	US$	Rs12-15	Extreme	High	Upward	Negative
Gas-fired - domestic	0.7	4-5 yrs	High	Rs	Rs5	High	Medium	Low	Nil
Gas-fired - imported	0.7	4-5 yrs	Medium	US$	Rs6-8	High	Medium	Upward	Negative
Nuclear	2-3	5-10 yrs	High	US$	n.a.	Nil	High	Upward	Negative
Hydro - large scale	1.3	5-15 yrs	Zero	Nil	Rs3-4	Low	Low	Down	Nil
Hydro - run of river	1.2	4-5 yrs	Zero	Nil	Rs3-5	Nil	Nil	Down	Nil
Wind	1.0	1.5 yrs	Zero	Nil	Rs4-5	Nil	Nil	Down	Nil
Solar PV	1.0-1.3	1 year	Zero	Nil	Rs5-7	Nil	Nil	Down	Nil
Distributed Solar	1.3-1.5	1 day	Zero	Nil	n.a.	Nil	Nil	Down	Nil

Source: IEEFA estimates

Section 5 – Less Reliance on Imported Coal

Section 5.1 – Aiming to Double Coal India Ltd's Production to 1,000Mtpa by 2022

Energy Minister Goyal has set Coal India Ltd a target of 1,000Mtpa of production over the next 5-7 years, doubling its 2014/15 production of 494Mt. This goal requires a compound annual growth rate (CAGR) of 15%, a seemingly unrealistic expectation, especially against the 1.5% CAGR of volume seen over the last five years.

However, progress is being made. The Ministry of Coal has identified projects it estimates would take production to 908Mtpa. Coal India has reported coal production of 494Mt in 2014/15 , marking a 6.9% year-on-year increase, reporting additional growth in April 2015 and monthly production of 41.5Mt, up a record 10.7% year-on-year, and then again in April-June 2015 setting another record with a 12% year-on-year increase, on track for Goyal's 550Mt target for 2015/16. Analysts who remain fixated on the 1.5% CAGR reported under the previous government (like those in the Australian government's Office of the Chief Economist's Office (Coal in India report), fail to recognise that the ship has turned.

While 1,000Mtpa remains a stretch target for 2019/20 or 2021/22, financial markets are progressively upgrading their expectations. In April 2015, Deutsche Bank almost doubled its production growth rate for Coal India and now forecasts 675Mt by 2019/20.[17] India's Motilal Oswal's Sanjay Jain is more aggressive and in an 11th May 2015 report forecasts 780Mt by 2019/20. In August 2015 Coal Secretary Anil Swarup re-affirmed Coal India Ltd was on target for 11.5% annual growth in coal production in 2015/16 to 550Mt.

In February 2015, Coal India said it would invest nearly US$1 billion in mines and equipment in 2015/16, an increase of 15% from last year and said it would put an additional US$1 billion into rail construction. Energy Minister Goyal in May 2015 flagged capital investment by Coal India Ltd and said it could reach US$25bn over the next five years as Coal India develops new mines, modernises equipment and upgrades technology. IEEFA notes also that Coal India Ltd has an estimated US$7bn of net cash on its balance sheet as of March 2015, suggesting that financing of this investment program will not be a problem.

However, a key part of Coal India Ltd's expansion involves the relocation and resettlement of hundreds of thousands of residents, including a reported 100,000 people in Jharkhand alone. "Confusion" is being reported over the compensation to be paid under the highly controversial 2013 land acquisition act that would enable Coal India's expansion, with subsequent modifications sought by Modi facing repeated delays.

Singareni Collieries Produced 52.5Mt in 2014/15

Singareni Collieries Company, the second largest Indian government coal miner (owned jointly by the Andhra Pradesh state government and the central GoI), delivered production of 50Mt in 2013/14, rising 4% year-on-year to 52.5Mt in 2014/15. However, as a sign of a sustained improvement in coal, dispatches were up 10% year-on-year to 52.7Mt in 2014/15, and overburden removed was up 54% year-on-year to 263 bank cubic metres (BCM). IEEFA assumes this production rate can be stepped up at a CAGR of 4% to 72Mtpa by 2020.

[17] Deutsche Bank Market Research, Manish Saxena, "Coal Chronicles: From Rationing to prosperity", 8 April 2015.

Neyveli Lignite Corporation Produced 26Mt in 2014/15

Neyveli Lignite Corporation, a GoI-owned domestic lignite coal miner, produced a relatively stable 25-26Mtpa of lignite coal for power generation. IEEFA assumes production will remain relatively constant as India tries to limit growth in the use of the least effective, low-energy-content coal.

Section 5.2 - Doubling India's Production to 1,500Mtpa by 2020

Minister Goyal has laid out an even more ambitious target to double India's domestic coal production by 2021/22 to 1,500Mtpa. This assumes 900-1,000Mtpa from Coal India Ltd, 65-75Mtpa from Singareni Collieries Company and peak production from the captive coal blocks being progressively auctioned in 2015 of 500Mtpa.

The coal block tenders that commenced in February 2015 have seen aggressive bidding and strong demand from numerous private companies, in both the industrial and coal-fired power sectors. The tenders will create a major inflow for state government budgets, the auctions of the first 33 mines alone having yielded Rs 2 lakh crore (US$32bn) payable over the next 30 years. IEEFA notes this aggregation makes for a grand headline but that it equates to total payments of an estimated US$1bn annually. The total figures also masks additional benefits, since it includes the 14% coal royalty that was due to be paid under the previous ownership allocation.

One important aspect of the captive coal-block auctions was the reverse tariff process for the electricity-generation sector. This process has seen negative coal margin bids on most power sector tenders, delivering locked-in savings in line with the GoI's key objective of keeping electricity tariffs low.

Of the 204 cancelled by the Supreme Court, the government has so far auctioned and allotted 67 mines and blocks. These auctions will clarify ownership and should drive private sector coal production up significantly. A target of up to 500Mtpa has been reported as possible by 2020. Given the history of delays, IEEFA assumes a lift in the medium term to 200Mtpa by 2020 from mines that are currently producing at an estimated 40-50Mtpa.

Key to success is to reintroduce competition into the four-decade-long GoI monopoly in coal mining. Finance Minister Jaitley stated as much in May 2015 when he said, "*Competition will make everyone work better.*"

Minister Goyal has suggested additionally that Singareni Collieries Company and the newly created private coal-mining sector could give rise to as much 500Mtpa of additional coal capacity, such that Goyal has articulated a possible long-term domestic coal target of 1,500Mtpa.[18] IEEFA considers both the 1,000Mtpa and the 500Mtpa targets as aggressive. Key constraints are the enormous community resistance against coal mining that already exists, that water and air pollution is already materially worse in India than in China (and would be twice as bad with twice the production), and that alternative-energy expansion (renewables, grid improvements and energy efficiency) will likely prove far easier to sustainably and swiftly implement.

The government's ambitious domestic coal-production goals are predicated on:

1. Significantly improving labor productivity;

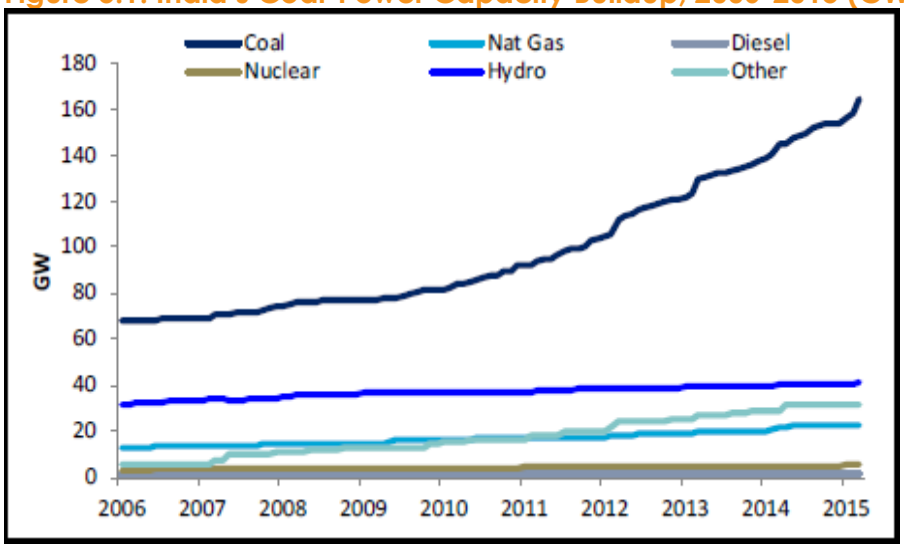
[18] http://www.moneycontrol.com/news/economy/see-15-bn-tonne-coal-productionyrs-to-come_1317114.html?utm_source=ref_article

2. a further erosion by the Modi government of the rights of communities by tightening corporate and government ability to undertake compulsory land acquisitions against the wishes of traditional owners (a strategy likely to be met with significant local resistance);
3. increased coal washing to increase the energy content per tonne shipped;
4. a reduction in logistics bottlenecks through greater integration and co-ordination with India Railways along with a significant step-up in railway capital spending.

Section 5.3 - Re-Evaluating the Rapid Expansion of Coal-Fired Power Plants

India has seen a coal- and gas-fired power plant installation boom, with 58GW installed in the three years to 2015 (Figure 5.1). However, many existing and fully-commissioned thermal power plants are operating well below designed capacity and/or are losing money because of excessive financial leverage and having agreed to power purchase agreements that are too low to leave a profit margin. Despite excess demand for electricity, underutilisation shows an inability to source domestic coal, and indicates that imported coal is either too expensive to justify relative to the wholesale tariff of the plant in question and/or impractical to transport due to rail bottlenecks.

Figure 5.1: India's Coal-Power Capacity Buildup, 2006-2015 (GW)



Source: India Central Electricity Authority, Citi Research

In coal-fired power specifically, since 2010 79GW of new capacity has been completed in India, taking the country's total installed coal-fired power plant capacity to 165GW. In 2011 a study by Prayas Group reported more than 512GW of new coal plants proposed and received at least preliminary approval from the Ministry of Environment, Forests and Climate Change. Beyond the 69GW already under construction, that total has now shrunk to just under 300GW of new plant proposals, with only 76GW of these proposals permitted. For every coal-fired power plant that has been completed in India since mid-2012, in other words, six projects have been shelved or cancelled.[19]

A recent example of this trend is Reliance Power's cancellation of its proposed 4GW UMPP at Tilaiya in Jharkhand in April 2015. The company, in explaining its change of plans, cited five years of land-acquisition delays, although the chief minister of Jharkhand disputes the company claim, and in IEEFA's view the cancellation most likely reflects the uncommercial PPA that Reliance Power originally tendered.

An additional factor limiting new coal-fired power plant construction: Water scarcity. In July 2015, coal-fired power plants in Maharashtra were closed due to water shortages.

[19] "Boom and Bust: Tracking the global coal plant pipeline", March 2015, Ted Nace et al. http://action.sierraclub.org/site/DocServer/Coal_Tracker_report_final_3-9-15.pdf?docID=17381

Community Resistance to Coal Mining and Coal-Fired Power Plants

IEEFA's analysis of the Indian electricity transformation is predicated on the financial aspects of the Modi government's plan and on the economic cost-benefit equation. Any analysis is incomplete of course if it ignores the social costs of air and water pollution and the land-acquisition issues that will inevitably rise when a country the size of India proposes tripling its coal-mining volumes and doubling its coal-fired power generation.

Beyond the global implications of carbon emissions for climate change, coal mining and thermal power plants have very material adverse public-health impacts. These include respiratory issues associated with particulate matter as well as wider health implications from emissions of sulphur dioxide, nitrogen oxides, mercury and other toxic chemicals. An additional environmental problem with India's thermal-power plan is that India's coal-rich areas are located in the greenest regions in the country.

In May 2014, the World Health Organization's reported that India has 13 of the world's 20 most air-polluted cities. A doubling of coal-fired power plant output would also double India's already unacceptable levels of air and water pollution

In April 2015, the GoI Ministry of Environment, Forest and Climate Change announced draft amendments to the Environment (Protection) Act of 1986 that would significantly tighten emission limits for thermal power plants beginning in 2017. These proposals are very significant indeed, as there are currently no Indian power-plant standards to curb emissions of sulphur dioxide, nitrogen oxides and mercury. The draft proposal sets emissions and pollution limits at rates well below the optimal for plants constructed before 2017.

A second environmental consideration driving the need to re-evaluate India's expansion of coal-fired power is the dramatic impact a similar strategy in China has had on water pollution there. In May 2014, the Chinese Ministry of Land and Resources reported that 61.5% of China's water is now unsuitable for agriculture or for drinking. Any plan that revolves around a doubling of coal-fired-power generation within eight years is likely to create socially unacceptable demands on India's water security. Thermal power plants already account for more than half of India's total water use. The draft emissions-limits legislation includes new restrictions on freshwater use in thermal plants.

Economic development in India invariably also runs into land-use conflicts, given the enormous population of the country and the inherent wealth and power disparities. Local communities understandably resist compulsory land acquisition, particularly when India's history is so littered with examples of broken promises of improved social amenities and local employment opportunities. Coal deposits in India are often found under tracts of irreplaceable national forests, waterways and areas populated by indigenous communities ill-prepared for industrialisation. Heavy-handed tactics persist. Prime Minister Modi in December 2014 used executive orders to impose compulsory land-acquisition orders. And coal-related corruption is a given, be it in Australia, China or India.

The implication here is that project delays and community resistance are financial risks that should be factored into project viability. Such risk is extremely evident across India's coal-mining industry, railway infrastructure and thermal power plants, but also applies to many of India's proposed nuclear and large-scale hydro-electricity expansions. Poor implementation and lack of community trust materially increase the risks of stranded assets, particularly in the fossil-fuel sector.

Solar, wind, run-of-river hydro, biomass, energy efficiency and grid efficiency initiatives are that much more informed—and cost effective—when social issues are factored into their total value.

Section 5.4 - Reducing Railway Inefficiencies

India's existing thermal power generation fleet is running at well below optimal utilisation rates due to a myriad number of complexities, not the least of which is the inability to secure a reliable, consistent fuel supply. Coal India has significantly lifted its coal production, but coal sales are lagging as coal stockpiles grow due to an inability to move the coal to the end customers on a timely basis. Likewise, imported coal is reported to be stranded at the port due to rail logistical constraints.

Energy Minister Goyal is seeking to reduce logistical inefficiencies such as the distance that coal has to be railed by linking coal mines more closely to nearby coal-fired power plants (in some instance coal domestically produced coal is moved up to 1,000km). Deutsche Bank in April 2015 estimated such fuel swaps alone had released 5% of rail freight capacity. This particular initiative could cut freight distances and rail costs by half and could also reduce current rail bottlenecks. Phase I involved swapping "coal linkages" for 19 power stations on 14Mtpa of coal, saving an estimated US$16/t or US$160m annually on freight costs, a savings that is contractually passed on to retail customers. The entire plan involves potential freight savings of US$1bn annually.

A greater use of coal-handing and preparation plants (CHPP) for coal washing prior to shipment would also remove some ash and debris, resulting in an increase in the energy content per tonne by 10-20%. This program would materially reduce increased demands on rail freight capacity, but comes at significant cost if appropriate waste water treatment is not deployed.

A significant rail-carrying capacity upgrade is under way, but has suffered ongoing, extensive delays.[20] In his 2015/16 budget, Railway Minister Suresh Prabhu announced a new five-year action plan to transform Indian Railways and considerably improve its services, including plans for a 50% increase in freight volumes. The total capital investment plans for 2015-2019 amounts to US$120bn, with network decongestion and network extensions the two largest areas of focus.

In May 2015, Minister Goyal said he was optimistic about timely completion of railway lines, hastening the process of land acquisition and environmental clearance to help Coal India reach it's 1 billion tonne annual target, stating the following: "We have identified 51 infrastructure projects where the ministry is ready to put in money as part of a joint venture with the railways."

The three rail-corridor projects entailing US$1.2bn of capital expenditure have been long stalled: Tori-Shivpuri- Kathotia in North Karanpura in Jharkhand, Barpali-Jharsuguda in IB Valley in Odisha and Bhupdeopur-Korichhaapar to Mand Raigadh mines in Chhattisgarh. The three projects have the combined capacity to move up to 300Mtpa of extra coal (a 50% increase in Coal India's current production). With a target for commissioning over 2016-2018, this expansion would underpin a key part of Coal India's five-year growth plan. That's if the GoI can get these projects commissioned.

Section 5.5 - Increasing the Utilisation and Thermal Efficiency of Coal-Fired Power Plants

Poor fuel-supply logistics and explicit contractual terms in pricing of wholesale power have left the Indian thermal-power generation sector running well below optimal utilisation rates. For coal-fired power plants, the Central Electricity Authority reports average utilisation rates in March 2015 of 62%, well below the 69% in March 2014 as significant new capacity has been commissioned but electricity demand growth has stalled. Coal-fired power generation utilisation rates have progressively deteriorate from the sector-high average of 78% back in 2009/10. Energy Minister Goyal sees significant room to raise the utilisation rates and viability of existing power plants, reducing the need for further investments in what often prove to be stranded assets.

[20] http://www.businessinsider.in/Railway-Links-For-Coal-Supply-Of-300-Million-Tonne-May-Take-Five-Years/articleshow/38358051.cms

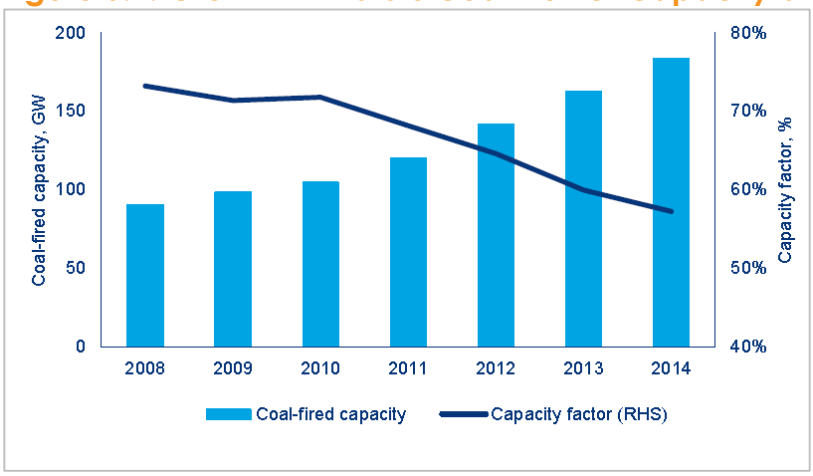
In February 2015, the Centre for Science and Environment's (CSE) Green Rating Project released its "Heat on Power" report that rated the average coal-fired power plant in India at 23% effectiveness, whereas a plant adopting all the best practices would have scored 80%. The study found that the average thermal efficiency in India was 32.8% and average CO2 emissions were 1.08g kg/kWh. Both averages are two of the worst globally (better only than backward Australia).

In April 2015, the GoI Ministry of Environment, Forest and Climate Change announced draft proposals under the "Environment (Protection) Act 1986" to significantly tighten emission limits for thermal power plants.

It was reported in May 2015 that Energy Minister Goyal had targeted US$25bn of new capex to drive the replacement and modernisation of aging power plants, with reduction of air pollution a key objective.

Gas-fired power generation in India faces especially dire circumstances, with more than half the 23GW of installed capacity financially stranded due to an inability to acquire fuel at a commercially viable rate (Section 6.4). In March 2015, the average Indian gas-fired power plant utilisation rate was 19%.

Figure 5.2: Growth in India's Coal-Power Capacity and Utilisation Rates 2008-14 (GW)



Source: Wood Mackenzie

Section 5.6 - Development of the Latest in Coal-Fired Power Plant Technology

One of the key inefficiencies in the current Indian electricity sector is the reliance on old and low-thermal energy-efficiency equipment. Conventional Indian coal-fired power plants have an energy efficiency of 30-32%, with 99% of installed capacity employing subcritical technologies.[21] Because of poor construction and maintenance, Indian coal-fired power plants have a useful life span of about 25 years, well below the 40 years of coal-fired plants in the West.

In March 2015, the GoI announced a pilot program to be led by Bharat Heavy Electricals Ltd of India and NTPC Ltd to develop advanced ultra-supercritical equipment with thermal efficiencies of up to 46%. An advanced ultra-super critical (AUSC) 800MW prototype is planned by 2017 to accelerate this initiative. The Japanese government has been pushing this angle aggressively, offering financing tied to the use of Japanese technology.

The Indian government has signaled its preference that new coal plants—beyond those currently under construction—be built with higher-efficiency technology. The government also faces growing public concern about the health impacts of declining air quality, of which old and highly-inefficient coal plants are a significant contributor. Indications are that the GoI is likely to

[21] Oxford University's Smith School, "Stranded Assets and Subcritical Coal: The Risk to Companies and Investors," Mar'2015

ensure that new plants are based on the most efficient modern coal technology and that they address air quality concerns in part by the concurrent phase-out of end-of-life, low-efficiency capacity. Combined, these two measures can dramatically reduce the rate of coal consumption growth in India and start to mitigate PM2.5 and PM10 emissions pollution.

Ultra-supercritical power plants have greater thermal efficiency, using 20% less coal to produce a unit of electricity relative to a subcritical coal plant. Assuming this promising trend takes a decade to implement, Indian coal consumption could drop by 2% annually through improved efficiency of coal use. China has achieved a 1.5% annual reduction in coal over the last two decades employing such a strategy. Should the AUSC program be undertaken, coal use could drop by 30% relative to that used by current technology.

Ultra Mega Power Project Proposal of 2005

The previous GoI proposed an ambitious plan in 2005 for 16 coal-fired power plants of 4GW each. This grand UMPP plant has failed to materialise, with only 2 UMPPs operational: Reliance Power's Sasan plant in Madhya Pradesh (with an exceptionally low Rs1.19/kWh PPA); and Tata Power's Mundra plant in Gujarat (Rs2.26/kWh). Reliance Power won a tender in 2007 for a proposed imported-coal-fired UMPP at Krishnapatnam (Andhra Pradesh) with a PPA of Rs2.33/kWh. In 2015, Reliance walked away from its 2009 commitment to build a domestic coal-fired power plant at Tilaiya (Jharkhand) because it had committed itself to a commercially unviable PPA of Rs1.77/kWh. Neither project commenced construction.

The latest two UMPP offered to investors, a proposed imported coal based plant at Cheyyur (Tamir Nadu) and a domestic coal-based plant at Bedhabhal (Odisha), had tenders delayed twice and then withdrawn after they failed to attract sufficient interest. IEEFA published a detailed review in May 2015 into the lack of financial viability of Cheyyur UMPP, concluding that the required levelised cost of electricity over the project life of Rs5.95/kWh was prohibitive.

While the 2015/16 GoI budget mentions plans to relaunch five UMPPs once domestic coal blocks have been allocated and all approvals and clearances and land acquisitions have been completed, the guidelines to even start the five-year planning and construction process have yet to be announced and the industry is skeptical that financing is available.

Section 5.7 - India to Potentially Cease Thermal Coal Imports

India is currently the third largest thermal coal market in the world. In November 2014, Energy Minister Goyal caught the global coal industry by surprise when he said this:

> *"Possibly in the next two or three years we should be able to stop imports of thermal coal."*

Energy Minister Goyal followed this statement in February 2015 with this:

> *"At no point of time do I feel that imported coal will work except at two or three plants that are in the coastal areas. While we had this major power requirement and shortage of coal, I did a study and found that there were very few plants dependent on imported coal or were situated on the coast."*

In April 2015 Energy Minister Goyal said this:

> *"We are confident that in the next year or two, we will be able to stop imports of thermal coal while imports of coking coal will continue till we are able to explore more reserves."*

IEEFA notes that most global financial houses' forecasts are for Indian imports to stablise or continue to grow at around 5% annually through the next five years. The IEA New Policies

Scenario (of November 2014) is the most bullish of all major forecasts, with an estimated 11% CAGR to reach 256Mtpa of import demand in India by 2019.

Adani Mining Australia's CEO, Jeyakumar Janakaraj, has predicated his support for the US$10bn Carmichael Coal proposal in the Galilee in Central Queensland, Australia on the view that India will remain a major importer of low-quality thermal coal for many decades to come.

IEEFA sees Indian thermal coal imports peaking in 2015-16, however, at 195Mtpa and then declining by 80% to 36Mtpa by 2020 (Appendix B).

In April 2015, Morgan Stanley became the first global financial house to take Energy Minister Goyal's target to cease thermal coal imports seriously. Morgan Stanley at that time reduced its Indian thermal-coal imports forecast by 20%. Morgan Stanley now forecasts a 30% decline to 130Mtpa by 2019-20 relative to a forecast peak in imports in 2015/16 of 180Mt (a halving of imports-market share in five years). Morgan Stanley's Vipul Prasad stated the following:[22]

> *"In F16-F20 (India thermal coal) imports will now shrink 8% p.a. … Imports to decline faster than earlier Morgan Stanley estimates… Despite a jump in power demand growth…. We expect coal block auction to lift Indian coal production at a 12.2% CAGR over F15-F20, while the import share is likely to decline from 23% in 2015 to 12% in F20e."*

In May 2015, the Indian Ministry of Coal issued a statement stating that with the projected coal demand of India would rise to around 1,200Mt by 2019-20 at a growth rate of 7%, with Coal India expected to deliver 1,000Mt, of which 908MTs is the expected contribution from already-identified projects. As discussed in Section 5, Singareni Collieries and the development of private coal deposits tendered over 2015/16 are expected to more than make up the balance to reduce thermal coal imports to zero by 2019/20.

In June 2015, the Union Coal Secretary Anil Swarup assured the public that there would be no shortages of coal for power plants in India, commenting on the significant increase in domestic production.

In July 2015, it was reported also that India's coal imports for the month were down 11% year-on-year, after double-digit increases over the last four years.

India's Power Plants That Rely on Imported Coal Are Loss-Making

Tata Power is the prime case of note here. One of the top two private electricity producers in India, Tata Power built a US$4bn, 4.0GW UMPP at Mundra, Gujarat, with the aim of relying on what at the time were low-cost Indonesian thermal coal imports. In 2011, the Indonesian government changed coal-export rules to ensure Indonesia received commercial prices for coal, and since then Tata Power has lost money. Despite a court-sanctioned PPA increase in the previously agreed electricity tariff for Tata Power, the Mundra project remains stuck in dispute and commercially unviable.

Like Tata Power, Adani Power continues to report a net loss after financing in its quarterly results, where its 4.6GW Mundra power plant (half the group's current total installed power capacity) is also materially reliant on imported coal.

Likewise, despite being designed and financed as an import-coal-fired power unit, Lanco Infratech's 1,200MW Udupi plant has a long-term PPA that is insufficient to cover its operating and financing costs; as a result, it too is loss-making.[23] Adani Power completed the acquisition of this power plant in April 2015.

[22] Morgan Stanley, Vipul Prasad, "*India Coal: Asia Insight – Mine Auctions: Harbringer of a New Era*", 24 April 2015.
[23] Lanco Infratech, Interim Result to September 2014, 14 November 2014.

In March 2015, Minister Goyal questioned the merit of putting any new import-coal-based ultra mega power project (UMPP) up for tender, given the lack of commercial value.

Section 5.8 – India's Failed Strategy to Build Foreign Coal Capacity

Energy Minister Goyal's stated goal of ceasing thermal coal imports represents a major strategic change in direction for India's electricity sector. IEEFA estimates over the last five years that imports doubled their share of India's thermal coal supply from 10% to more than 20% in calendar year 2014.

Given the consistent failure of Coal India to deliver on its production targets, until 2014 the Government of India was actively encouraging its power firms to seek overseas coal-mining investments. A number of Indian ventures that have expanded into international coal markets have been consistently unsuccessful, however, with delays, ongoing losses and missed targets. The list includes:

- International Coal Ventures Private Limited (ICVL), set up by the GoI in 2008 as a joint venture to acquire international coking, thermal coal deposits and mines as "a step towards security of supply."[24] The ICVL has failed time and again to implement this objective.
- Tata Steel, a 35% shareholder alongside Rio Tinto Coal Mozambique in the Benga coal mine, initially expected to export 4.5Mtpa of coal. In July 2014, ICVL paid just US$50m for Rio Tinto's 65% share of Benga, with Rio Tinto writing off close to US$4bn on this failed project. However, the Benga mine is reported to be losing US$7-10m per month and problems are mounting. In May 2015, Tata Steel announced a second round of investment losses related to its Mozambique coal division as part of total write-downs of US$1bn in 2014/15.
- Coal India Ltd's own move in the Tete Province of Mozambique in 2009, which has consistently failed to deliver on expectations. Despite $80m of capital expenditures, the company recently announced that the project didn't actually have coal and that Coal India was likely to exit.
- Tata Power acquisition of a 26% stake in PT Baramulti Suksessarana (BSSR) in Indonesia in November 2012, securing a 10Mtpa coal supply contract for export to India. BSSR listed in Indonesia in November 2012 at Rs1, 950 per share; the stock is trading 20% lower two and a half years later.
- Tata Power in March 2007 paid US$1.3bn for a 30% stake in two other Indonesian coal mines owned by Bumi Resources. Tata exited one of these mines in February 2014 and sold a 5% stake in the other in July 2014 for a combined US$750m;
- Essar Group's 2010 US$600m Trinity Coal Corp. (US) acquisition; Trinity went into Chapter 11 in 2013.
- GVK's 2011 US$1.26bn acquisition of Hancock Prospecting P/L's Galilee thermal coal proposal, now stalled prior to financial close and without a completed initial purchase transaction.
- Adani Enterprises investment of over A$1bn since 2011 in the Carmichael coal and rail proposal for the Galilee basin; four years on financial close remains elusive.
- Lanco Infratech's 2011 A$740m acquisition of Griffin Coal, an operation that is losing money and recently had its 15Mtpa coal export proposal revoked.

[24] ICVL is owned by Steel Authority of India (SAIL), Coal India Ltd (CIL), Rashtriya Ispat Nigam Ltd (RINL), National Mineral Development Corp. and National Thermal Coal Corp (NTPC); refer http://icvl.in/aboutus.php?tag=company-aboutus

- Gujarat NRE's failed ownership of ASX-listed Wollongong Coal Pty Ltd (previously named Gujarat NRE Coking Coal), bought out in 2013 by another Indian firm, Jindal Steel and Power, which has reported a similar lack of progress.

While both Coal India Ltd and Singareni Collieries Company have announced intentions to invest in offshore coal mines, in light of the outcome of the 10 initiatives above, IEEFA views such a move as increasingly unlikely given the significant capex requirements. Singareni is looking at mines with a production of 2Mtpa or more, so acquisitions are not likely to be material to India overall.

Minister Goyal's strategic shift away from imported coal is economically sound in that it reduces India's exchange-rate risk from an over reliance on fossil-fuel imports, which poses a threat to energy security.

Should India be able to deliver on its 175GW renewable-energy target, reduce transmission and distribution losses, enhance energy efficiency and double domestic coal production, it is more than conceivable that India's thermal coal imports would decline or cease through the end of this decade.

IEEFA sees India's thermal-coal imports as having the potential to peak in 2015/16 and cease entirely by 2020-2022. While this is an outlier forecast, the Indian coal-fired power industry is increasingly starting to factor this scenario into its core plans. The following statement is a clear sign that Minister Goyal's plans are gaining wider acceptance:

> *"Our aim is to have zero import of coal, and manage with the coal from Coal India sources or our own mines. You can say in the next five years."*
>
> - National Thermal Power Corp. Managing Director Arup Roy Choudhury, April 2015

In March 2015, Energy Minister Goyal flagged that the rate of change will take the market by surprise, and that with the rapid improvement in Coal India Ltd's delivery of coal combined with a still-patchy economic recovery, India is moving from a structural deficit in electricity over the past decade to a possible position of surplus:

> *"The demand (for power) is being met. I'm now concerned that with this rate of growth, I could end up with surplus coal and surplus power … I don't know what to do with it,"*

Imported coal stockpiles were reported to have reached a record high of 16Mt in June 2015.

One recent report suggests that no major new power purchase agreements for coal-fired power plants had been signed in the past two years. This would reflect the combined complexities of forfeited coal deposits from Coalgate, the lack of viable power purchase agreement counterparties (due to Discom's lack of credit worthiness), financial distress on existing thermal power projects and slower-than-expected growth in underlying demand for electricity.

Section 6 – An Indian Electricity Model

The Indian electricity sector faces an increasingly serious energy-security issue rooted in its lack of diversity in generating capacity, and a growing reliance on imported fossil fuels over the past five years. As of the end of March 2015, coal-fired generation capacity of 164.6GW was 61.5% of total installed capacity, and coal is the fuel type that has grown fastest over the past five years. Even with a depressed plant load factor (PLF) at a record low 57.5% in 2014/15 (down from its peak, in 2008/09, of 79%), coal-fired electricity supplied 74.3% of India's total (Figure 6.1).

While gas-fired electricity capacity has doubled over the past five years, a critical decline in domestic gas supply has likewise saw gas PLF drop to a record low 22.4% in 2014-15.

Hydro-electricity is the second largest installed capacity of 41.3GW, representing 11% of generation in 2014/15, albeit operating with a high seasonality tied to monsoon flows.

Figure 6.1: India's Electricity Capacity and Generation (2014/15)

	---- Capacity ----		-- Generation --		PLF
	GW	%	TWh	%	%
Coal-fired	164.6	61.5%	829.3	74.3%	57.5%
Gas-fired	23.1	8.6%	45.2	4.0%	22.4%
Diesel-fired	1.2	0.4%	3.2	0.3%	30.0%
Large Hydro	41.3	15.4%	123.1	11.0%	34.0%
Nuclear	5.8	2.2%	36.1	3.2%	71.3%
Renewables	31.6	11.8%	74.7	6.7%	27.0%
Bhutan	n.a.	n.a.	5.4	0.5%	n.a.
Total	**267.5**	100.0%	**1,116.9**	100.0%	

PLF = Plant load factor, otherwise termed the utilisation rate.
Source: Central Electricity Authority, IEEFA estimates

Plans for renewables, and to a lesser degree nuclear, are starting to take a more material role, as we discuss below.

Section 6.1 – An Electricity Demand-and-Supply Model for India

GDP versus Electricity Growth

IEEFA forecasts gross domestic product (GDP) growth for India of 6-8% annually through 2022 (Appendix D).

A key assumption here is that net electricity demand in India will grow at 1.15 times the growth in GDP, less 1% per annum in energy-efficiency savings—giving net growth of 7% annually (a ratio of 1.0x).

In comparison, China has seen electricity growth of 1.0-1.3x GDP growth over the past decade, with this ratio dropping to 0.5x in 2014 and even lower to date in 2015 at 0.2x as transformation toward a more service-based economy becomes a defining aspect of China.

The Electricity for All program of rural electrification in India should see the development of distributed solar and battery systems off-grid and hence will add to the 1.0x on-grid system growth rate.

With GDP growth forecast at 7% per year, net electricity demand growth for India is therefore assumed to be 7% too. This is marginally ahead of the five year average through 2014/15 of CAGR of 6.6%, but the reported April and May 2015 outcome of electricity demand averaged increases of only 2-3% yoy (after being up 1.7% yoy in March 2015). And record low spot

electricity prices suggest the economy and hence electricity demand is still not robust. Overcoming financial-leverage constraints on the economy will take some time, and efficiency gains are key to sustainability.

Grid Transmission and Distribution Efficiency

A major constraint on Indian electricity-sector efficiency are AT&C grid losses, which average around 26% annually over the past decade. With a major GoI focus on modernizing and upgrading the electricity grid, IEEFA models an assumption of grid AT&C efficiency gains of 1% annually. If this improved grid efficiency can be delivered, then 7% per annum net electricity demand growth translates to a need for 5-6% per annum growth in gross electricity power-generation growth.

Growth in Electricity Demand Through 2022

IEEFA estimates that India's net electricity consumption in fiscal year 2014/15 was about 818TWh. We assume 7% annual real GDP growth through 2022, and we see electricity demand growth in line with real GDP, net of a 1% per annum energy-efficiency gain. This suggests Indian net electricity consumption will grow to 1,318TWh net electricity consumption by 2021/22 (Figure 6.2). We note also that a 1% per annum gain in energy efficiency would deliver a cumulative savings of 75TWh by 2021/22.

If India's transmission grid can achieve a 1.0% annual reduction in AT&C losses from 26% in 2014/15 to 18% by 2021/22 (still double the global average), India would realize a critical savings. Gross electricity production (before AT&C losses) is therefore forecast to grow from 1,106TWh in 2014/15 to 1,627TWh by 2021/22 (a CAGR of 4.7%).

Assuming the GoI achieves 75%, or 75GW, of their target for 100GW of solar-capacity additions, India would see 110TWh per annum of new gross electricity production by 2021/22. Interestingly enough, this suggests solar would be contributing 7% of the 1,627TWh of India's gross electricity produced by 2021/22. Put another way, solar could deliver 22% of the required electricity-generation expansion over the next seven years.

Assuming the GoI achieves two-thirds or 40GW of its 60GW target for new onshore wind farms by 2021/22, taking India's to cumulative wind installs of 61GW by 2021/22, the country would be one of the top three nations globally in terms of total wind installations. This would add a further 88TWh per annum of new gross electricity production. A cautious move into offshore wind development starting at the end of this decade could see 5TWh added by 2021/22.

New large-scale and smaller run-of-river hydro-electric generation across India of 1-2GW per annum, plus expanded hydro imports from Nepal and Bhutan, could add a combined 44TWh to India's supply by 2022 and deliver system diversification, increased use of pumped-hydro storage and load-balancing flexibility (Section 6.3).

Doubling the utilisation of existing gas-fired capacity from the 22.4% average in 2014/15 on the 23GW of currently installed gas-fired electricity capacity would add 40TWh per annum (Section 6.4).

Biomass and nuclear capacity expansions could each add 25-30TWh by 2021/22 (Section 6.6).

However, even a reduction from 26% to 18% AT&C losses by 2022 would almost offset the grid losses on all new gross electricity production added to the grid, with total AT&C losses rising marginally from an estimated 287TWh in 2014/15 to 309TWh per annum by 2022. Put another way, there are massive system-wide avoided costs that distributed generation like solar with storage would deliver to India, for both on- and off-grid applications.

Figure 6.2: India's Net Electricity Consumption (2014/15-2021/22, TWh)

Net Electricity consumed in India in 2014/15 (TWh)			818	
Real GDP Growth	7.0%	pa		
Electricity to GDP multiplier	1.15	times		
Electricity Demand Growth	8.1%	pa	553	
Energy Efficiency	-1.0%	pa	-75	
Growth in gross production losses			136	
Reduced grid AT&C losses	-1.0%	pa grid efficiency gain	-114	
Net Electricity consumed in India in 2021/22 (TWh)			1,318	
The Increase in Net Electricity Demand is met by (TWh):				**Uplift**
Solar expansion			110	22%
Onshore wind expansion			88	18%
Offshore wind expansion			5	1%
Increase in biomass generation			25	5%
Increase in hydro electricity			34	7%
Increase in hydro imports			10	2%
Increase in gas-fired electricity			40	8%
Increase in nuclear generation			30	6%
Change in Coal Use			158	32%
Net expansion in Electricity Demand 20121/22 (TWh)			500	100%

Source: IEEFA estimates

Growth in Coal for Indian Electricity Generation of 4-5% Per Year (2015-2022)

Figure 6.3 details IEEFA's forecast for coal-fired power generation and resulting thermal coal consumption estimates through 2021/22. Relative to 2014/15, coal-fired power generation is forecast to grow at a CAGR of 4-5% to 2021/22. Accelerated energy efficiency, grid efficiency, coal-fired power plant thermal-efficiency gains and greater fuel diversification would see this 4-5% CAGR estimate as materially too high. Figure 6.2 above (showing only 158TWh of additional coal-fired power generation is required) suggests our coal-growth forecasts are considerably too high.

Working on this base assumption, coal-fired power generation will see its market share drop from 74.3% of total Indian electricity generation in 2014/15 to a record low for India of 64.4% in 2021/22. This would reflect the impact of increased diversification into all alternative sources of electricity.

IEEFA assumes the thermal efficiency of the average Indian coal-fired power plant improves 1.25% per annum from 32% in 2014/15 to 35% by 2021/22 (Appendix C). As such, Indian-coal fired power plants should see a gradual reduction in coal tonnes required per TWh of electricity generated, falling from 0.64Mt/TWh in 2014/15 to 0.59Mt/TWh by 2021/22.

This assumes the average Indian coal energy content of ~4,000kcal/kg remains constant. While India is witnessing the exploitation of progressively lower-grade coal deposits over time, the

increased emphasis on coal washing by the Power Ministry should offset this trend, holding constant the delivered coal energy content per tonne.

Working through these assumptions, we see coal required for the Indian power sector to grow at a CAGR of 4% through 2021/22 to 686Mt, a total consumption increase of 184Mtpa over this seven-year period.

Figure 6.3: India's Coal-fired Power Generation and Coal Consumption (2013-22, Mt)

Year to March	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
Coal fired power generation (TWh)	700	747	829	907	969	1,018	1,071	1,120	1,149	1,169
Coal-fired power - market share	72.2%	72.2%	74.3%	73.3%	72.5%	71.2%	70.0%	68.6%	66.6%	64.4%
Coal-fired power thermal efficiency	31.6%	31.3%	32.0%	32.4%	32.8%	33.2%	33.7%	34.1%	34.5%	34.9%
Tonnes per TWh	0.65	0.66	0.64	0.63	0.62	0.62	0.61	0.60	0.59	0.59
Thermal coal demand - for power (Mt)	455	489	531	574	605	628	653	674	683	686
Thermal coal demand - growth (% pa)	4.9%	7.7%	8.6%	8.0%	5.5%	3.8%	3.9%	3.3%	1.3%	0.4%
Calendar year (Mt)	439	463	500	542	582	611	634	658	676	684

Source: CEA, IEEFA estimates

Section 6.2 – Indian Domestic Coal Production

The analysis above forecasts the total coal required for the Indian power sector to grow at a CAGR of 4-5% through 2021/22 to 684Mt, a total consumption increase of 184Mtpa over this seven-year period.

Adding in expanded industrial-sector use of coal suggests a 275-350Mtpa thermal coal demand increase by 2021-22 versus an estimated 704Mt in 2014/15. Assuming that private captive coal-mining sector output rises to 250Mtpa by 2021/22, Singareni Collieries at 70Mtpa and Coal India Ltd at 812Mtpa, India's thermal coal imports could peak at 195Mt in 2015/16 and cease at the latest by 2021/22 (Figure 6.4).

IEEFA's Coal India production forecast assumes growth of 8% per annum, implying it comes in at 712Mt by 2019/20 i.e. 30% below their 1,000Mtpa target. Relative to 2014/15, this is only 40% of Coal India's target production increase. Should Coal India Ltd deliver closer to their stretch target, imports would cease well before 2021/22, as first forecast by Energy Minister Goyal in November 2014.

Figure 6.4: India's Thermal Coal Production, Imports and Consumption (FY2013-22, Mt)

Year to March, Mt	**Coal Type**	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
Coal Inda Ltd - Despatches	Thermal + coking	465	472	489	526	565	608	653	703	755	812
Singareni Colleries	Thermal + coking	53	50	53	55	57	59	62	64	67	70
Neyveli Lignite Corporation	Lignite	26	26	26	26	26	26	26	26	26	26
Private captive mines	Thermal + coking	86	69	62	74	111	145	174	200	225	250
Less domestic coking coal	Coking	-52	-52	-52	-54	-57	-60	-63	-66	-67	-67
Domestic thermal coal	Thermal + Lignite	579	565	578	626	702	778	852	926	1,006	1,090
Imported thermal coal	Thermal + Lignite	108	124	152	195	170	139	108	72	36	0
Total coal consumption	**Thermal + Lignite**	**686**	**689**	**730**	**821**	**872**	**917**	**960**	**998**	**1,042**	**1,090**
Imports market share		16%	18%	21%	24%	19%	15%	11%	7%	3%	0%

Source: IEEFA estimates

Is Our Outlook for India's Coal Imports Too Conservative?

Zero thermal coal imports could be achieved significantly earlier than proposed if momentum toward a number of the 2021/22 GoI targets accelerates over the next two to four years, or if the Indian economy does not achieve its strong growth potential.

Risks to our outlook:

- That Coal India Ltd continues to be successful in accelerating its mining and rail productivity/capacity-expansion initiatives, and/or the private captive coal sector expands faster toward its full tendered capacity target of a combined 1,500Mtpa by 2020;
- That grid transmission loss-reductions and energy efficiency gains are accelerated, thereby dramatically reducing the growth rate for new wholesale electricity production;
- A rapid acceleration in the deployment of new wind, solar, nuclear and hydro capacity, accelerating the diversification away from thermal power generation and diminishing the use of thermal coal. While current targets will dramatically erode existing thermal coal imports, any move to mitigate the rising air and water pollution impacts of thermal coal will accelerate this trend;
- That the Indian economy takes longer than expected to sustainably deliver strong economic growth, with excess system financial leverage and stalled investment programs both key constraints.

In March 2015, Energy Minister Goyal made a telling statement about the risks of accelerating power generation investments and coal-mining capacity expansions ahead of a wider economic pickup:

> *"The demand (for power) is being met. I'm now concerned that with this rate of growth, I could end up with surplus coal and surplus power… I don't know what to do with it."*

In light of a decade of power shortages, this sort of conjecture might seem premature. But stranded assets resulting from overinvestment in coal mining and coal-fired power generation are exactly what has emerged in China over the past 18 months. Coal mining is being rapidly curtailed there, and China Shenhua Energy Corp. reported operating rates of coal-fired power plants at decade lows of 53.7% across China in 2014,[25] and year-to-June 2015 reported a further drop to 49.4%.

In India, the risks of the coal-auction process could create situations where firms have acquired expensive, captive coal mines but are now unable to vertically integrate them into coal-fired power plants due to the absence of commercially acceptable PPAs. Fixing one aspect of the electricity sector without wholesale progress across the board is problematic, particularly if the Discom issues are not resolved in the near term.

Section 6.3 – Large-Scale Hydroelectricity

India has 41GW of operating large scale hydro capacity but also a significant potential new hydro electricity. However, we also note there are significant environmental issues with hydro, not the least being the loss of rich farmlands and forests, risks of seismic activity plus the requirement for large scale resettlement of traditional owners.

The Central Electricity Authority of the GoI in 2008 released a plan estimating that more than 30GW of hydro could be brought online in the 2012-2017 12th Five Year Plan. To-date very little of this has been progressed, but the plans remain in place.[26] A 2014 study suggested India has over 55GW of potential hydro capacity of which 10GW is under development, albeit with significant

[25] China Shenhua Energy Corp 2014 annual report page 44.
[26] http://www.indiawaterportal.org/sites/indiawaterportal.org/files/hydro_development_plan_for_12th_five-year_plan.pdf

delays due to community opposition.[27] Energy Minister Goyal has articulated an increasing level of concern with hydro, which suggestions the GoI will advance with considerably more caution than previously. Retrofitting existing dams with hydro-electricity capacity and developing strong maintenance / remediation works to reduce silt build up would be two logical areas to start.

Projects under consideration include Jammu and Kashmir State Power Development Corp.'s plans to add of 9,000MW of new hydro in the state. The 450MW Baglihar Stage-II is due onstream in 2015, adding to the 450MW Baglihar Stage-I opened in 2013. GVK Infrastructure has also commenced commissioning its 330MW Alakhnanda hydropower project in May 2015. NTPC Ltd in July 2015 announced commencement of the Koldam Hydro Power Project with a combined 800MW of capacity. Reliance Power reports a 5.3GW pipeline of hydroelectricity projects.

Energy Minister Goyal recently described major hydro projects as "stalled" due to a range of factors including local opposition and the result of legal challenges. Other smaller run-of-river projects, he said, lack ready access to transmission infrastructure. Many proposed hydro schemes in India are also in what has been designated as a region at high risk of high-intensity earthquakes. Potential hydro projects are currently being reviewed by the Ministry of Environment with Goyal indicating he will await the outcome of the review.

The Indian Government is also pursuing the development of major hydro projects in neighbouring Bhutan and Nepal. In November 2014 the Nepal Government approved the controversial 900MW Arun III project to provide domestic power as well as substantial exports to India. Other projects are proposed under a power trading agreement between the two countries. [28] However, the massive Nepalese earthquake in April 2015 will certainly require considerable re-evaluation of economic and engineering viability of many of these proposals.

The government of Bhutan has also foreshadowed the potential development of as much as 10GW of hydro capacity for export to India by 2020, though these projects are controversial and running well behind schedule.[29]

While there is uncertainty about some of these projects in India and beyond, it is probable that some will proceed. The development of hydro, particularly pumped hydro storage will materially assist the development of grid capacity to manage peaking capacity and deal with intermittent renewable energy supply.

Section 6.4 – Gas-fired Electricity Generation: Stranded Assets

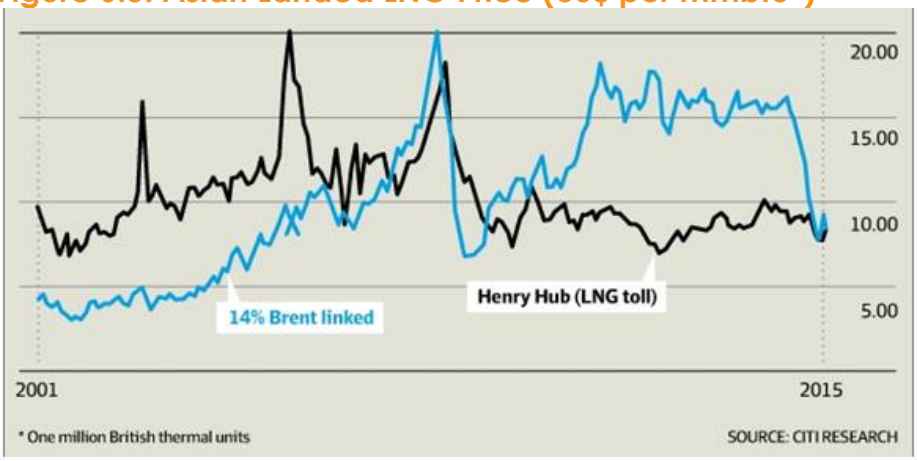
India has a total of 23GW of gas-fired power generation capacity installed as of March 2015, representing almost 9% of total electricity capacity installed in India –refer Figure 3.1.

Of this, over 14GW of newly installed capacity remains stranded, idle due to an inability to source fuel at a commercially viable price. These gas-fired generation facilities were built with power purchase agreements in place to supply electricity at an agreed wholesale price, generally at Rs3-4/kWh. The PPA pricing was predicated on the assumption the plants could utilise domestic gas sourced at a price set by the GoI, well below the import price parity level. The flaw in this US$10bn investment program proved to be that Reliance Power's supply of domestic gas has collapsed over the last five years as existing gas fields matured, and the GoI proscribed price was insufficient to incentivise further domestic gas exploration and development. Total domestic gas production in 2013/14 was down more than 35% vs 2010 and expensive imported LNG has grown to take a 35% market share. The average gas-fired power plant capacity utilisation rate has fallen from 66% in 2010/11 to just 21% in 2014/15.

[27] http://www.ijettjournal.org/volume-10/number-3/IJETT-V10P222.pdf
[28] http://in.reuters.com/article/2014/11/25/nepal-energy-idINKCN0J908520141125?feedType=nl&feedName=inmoney and http://www.internationalrivers.org/files/attached-files/lori_udall_on_aruniii.pdf
[29] http://pib.nic.in/newsite/erelease.aspx?relid=77616 and http://www.internationalrivers.org/blogs/328-5

However, with liquid natural gas (LNG) import gas prices linked to the oil price, the LNG import price has collapsed over the last year – Figure 6.5. The GoI has used this price correction as an opportunity to partly remedy these stranded projects. The GoI has offered an imported gas subsidy sufficient that idle facilities can be operated at 35% of capacity to allow electricity generation at a delivered wholesale price of Rs4.70/kWh, with an emphasis on delivery at times of peak summer demand. This is a harsh form of corporate welfare: the fuel price subsidy is set to allow these gas-fired power plants to generate only sufficient cashflow to service interest expense obligations on the projects' debts, but with no return to equity holders.

Figure 6.5: Asian Landed LNG Price (US$ per mmbtu*)



Source: Citi Research, Australian Financial Review 4 June 2015

With almost no new capital investment and a total fuel subsidy of Rs844 crore (US$134m pa), Energy Minister Goyal has allowed US$10bn of stranded assets to provide peak electricity supply at a wholesale price of Rs4.70/kWh. This is expected to boost electricity supply by 5.7TWh in 2015. Goyal has also warned that with existing gas-fired power plants already stranded, plans for new gas-fired capacity should be re-designed as solar projects instead.

Section 6.5 – Offshore Wind: A Commercial Solution Post 2020

Offshore wind farms are being rapidly deployed across Northern Europe, with the global market being led by the UK, Germany, Denmark and Belgium. Europe had over 8GW of installed and operational offshore wind farms at the end of 2014, with 1.7GW installed in 2014 alone. More recently France has tendered for up to 3GW of offshore wind deployments, adding to momentum and underwriting the investment required to generate new economies of scale. Bloomberg (BNEF) forecasts over 4GW of deployments of offshore wind in 2015 alone.

However, while the technology and engineering requirements are proven and established, the commerciality is still a long way off. Major engineering and grid connection obstacles are being gradually overcome, with the necessary truth of '*learning by doing*' very evident. Major cost blowouts where incurred by leading global engineering firms ABB Group and Siemens over 2011-2013. Both firms have long articulated the goal to reduce the deployment cost of offshore wind by 40% by 2020, and remain on track for this goal. Scale and technology gains are both key, with BNEF forecasting global installs growing at a CAGR of 51% to reach 47GW offshore wind by 2020.

Over 2013-2015, the opportunities for offshore wind has seen global giants in a number of countries looking to buildout capacity and technology leadership in this emerging industry:

- China: China Longyuan Power, China Datang Corp. Renewable Power Co and Goldwind Science & Technology Co.;

- UK/Germany: Dong Energy, Siemens;
- France: EDP Renováveis, S.A, ENGIE and Areva;
- Korea: Hyundai Heavy Industries Co. and Samsung Heavy Industries Co.; and
- Japan: Toshiba Corp and Sumitomo Electric Industries Ltd.

The offshore wind market has three significant advantages that has seen development continue despite the high cost and harsh terrain involved. Four reasons:

- wind farm capacity utilisation rates for offshore wind are 40-50% given the more consistent and stronger winds prevalent in large parts of the ocean relative to land. Onshore wind farm utilisation rates average 20-35% by comparison;
- technology advances by firms including Seimens, GE, Areva, AMSC and Goldwind have allowed the development of ever larger wind turbines. Whereas onshore wind turbines currently being deployed are 2-3MW each, the offshore market is seeing the deployment of prototypes of 6-8MW per turbine. Being three times the size and double the utilisation rate, the wind generation opportunity is a sixfold increase;
- the land acquisition issues are far less material (although shipping lanes are a constraint). Fourthly, most population centres are in proximity to the coast; and
- offshore grid connectivity is boosting the commerciality of international grid connections (Germany-Sweden, Denmark-Norway).

The IEEFA electricity model for India assumes the deployment of 2GW of offshore wind at the end of the period through to 2021/22, generating 10TWh pa. This is included more as a placeholder.

Significant cost reductions are likely by 2020. Combined with India's very long coastline and limited land resources, plus energy system diversity needs, offshore wind development in India is likely to be a very significant area of industry expansion next decade.

Section 6.6 – India's Nuclear Plans

India's 20 nuclear plants currently account for less than 2% of total power capacity, but the GoI has talked of a possible increase to a 25% share by 2050. Prime Minister Modi has made nuclear a priority, having secured Japanese Prime Minister Shinzo Abe's pledge to speed up discussions on a nuclear agreement and signing a deal with Australian Prime Minister Tony Abbott in late 2014 that will pave the way for uranium sales to India.[30]

The second unit of the new Kudankulam Nuclear Power Station is due to be commissioned in 2015/16, adding 1GW to India's current 5.8GW of nuclear capacity. The 1.4GW Kakrapar Atomic Power Station in Gujarat, 1.4GW Rajasthan Atomic Power Station, and the 2.8GW nuclear power plant at Gorakhpur in Haryana are also already under construction, suggesting that up to an additional 6.6GW of nuclear could be operational by 2019. Given the significant community resistance and the technical complexities to these projects, IEEFA expects material delays will continue, however, consistent with what has transpired in Europe, Korea, Japan, China and the U.S.

[30] http://news.yahoo.com/india-turns-nuclear-energy-crisis-deepens-055906814.html

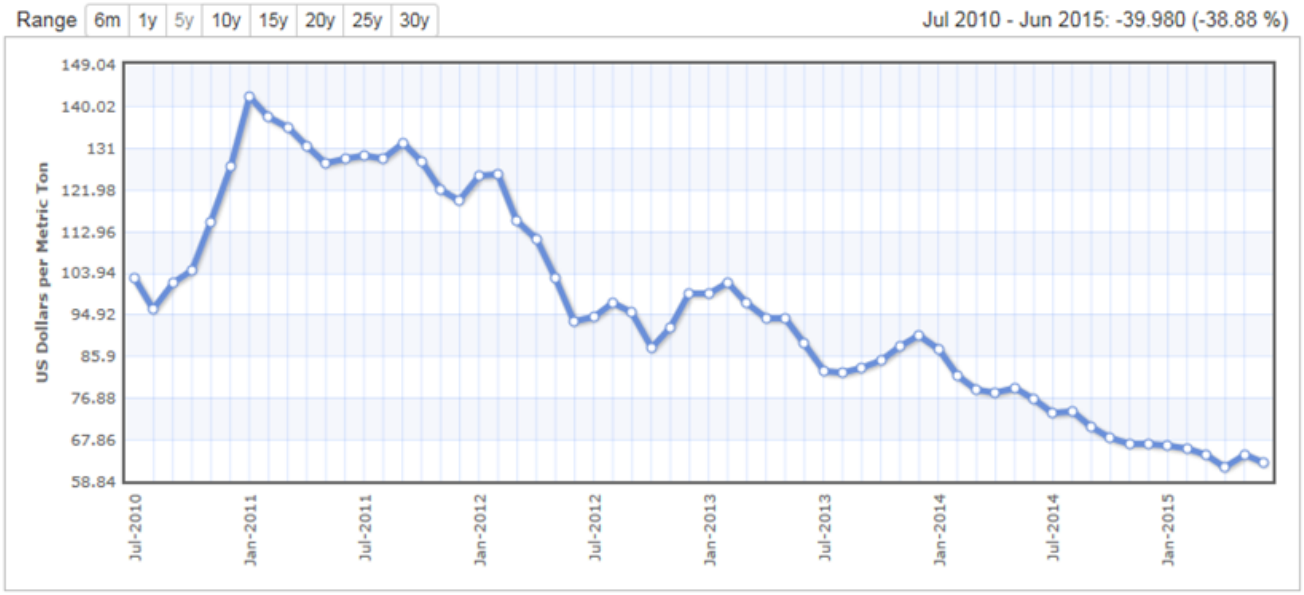
Appendix A - Structural Decline of Seaborne Thermal Coal

IEEFA views the thermal seaborne coal market as having entered structural decline. This reflects IEEFA's forecast that seaborne thermal coal demand will fall from its 2013 peak of almost 1,000Mt to less than 700Mtpa over 2020-2025. Figure A1 details the 60% decline in coal prices since 2011.

The key driver of this forecast is that China represents 51% of world coal consumption, and in 2014 China's coal consumption declined by 2.9%.[31] China rapidly moved to protect its domestic coal mining operations, resulting in an 11% decline to 290Mt in coal imports in 2014 (of which 240Mt was thermal). The decline in China's seaborne coal imports has accelerated in 2015. China's domestic coal consumption was reported as down 6% year-on-year. Total coal imports in the half year to June 2015 were down 37.5% yoy. Declining coal consumption reflects economic transitions toward less electricity-intensive sectors, greater energy efficiency and a rapid diversification of electricity generation. Considerably more hydro, gas, nuclear, wind and solar capacity has been installed than has been installed in coal-fired power plants in the past three years, and this trend is accelerating. A structural transition is in progress. China's Intended Nationally Determined Commitment (INDC) of July 2015 aiming to cut its greenhouse gas emissions per unit of GDP by 60-65% by 2030 from 2005 levels will have profound implications for coal demand.

India imported close to 200Mt of coal in 2014/15 (this includes coking and thermal coal imports), up 18% year over year. While many commodity forecasters have assumed Indian imports will continue to grow, rising to upwards of 400Mt in the next decade, IEEFA forecasts a peak in Indian thermal coal imports in 2015, with a rapid ~20% per annum decline thereafter. This is directionally consistent, but more conservative, than Energy Minister Goyal's aim for zero thermal coal imports by 2017.

Figure A1: Thermal Coal Export Price - Newcastle 6,000kcal NAR US$/t



Source: Index Mundi, Australian thermal coal Monthly Price - US Dollars per Metric Tonne

[31] China Shenhua Energy Company, 2014 Annual Report, page 65.

Appendix B – Falling Import Demand for Thermal Coal

IEEFA forecasts that global import demand for thermal coal peaked in 2013 at 1,072Mt (seaborne plus international rail shipments combined), and is set for a 30% decline by 2020 to 756Mt. This forecast is predicated on the view that Western Europe, Japan and China have already passed peak demand. India is IEEFA's major contrarian call, as per this report. Should Energy Minister Goyal be successful, seaborne thermal imports will be the first casualty, with a globally material impact. Figure B1 assumes Goyal will be successful, but over five to six years, rather than his hope for cessation of thermal coal imports within two to three years.

Western Europe is forecast to decline materially over this decade due to European Union policy initiatives for renewables, energy efficiency and the Large Combustion Plant Directive 2001/80/EC.

Japan is forecast to decline due to the combination of four factors: ongoing economic growth headwinds; continued energy efficiency gains; the addition of some 10GW per annum of new solar installations; and any potential nuclear facility restart (Japan needs to resolve 42GW of idle nuclear capacity one way or another).

IEEFA forecasts that thermal coal imports peaked into China in 2013, far earlier than most commodity forecasters have anticipated. Thermal coal imports to China declined 9% in 2014, and year-to-May 2015, thermal coal imports have declined a further 41% year-on-year. This is driven by significant ongoing improvements in energy intensity of growth, a gradual slowing of economic growth and continued efforts to diversify away from an excessive reliance on thermal coal (with a significant expansion of wind, hydro, solar, gas and nuclear generation capacity).

Figure B1: Thermal Coal Import Demand (1990 to 2020)

	Actuals				Estimate	Forecasts						
Calendar Year	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
COUNTRY												
China	11	8	126	264	240	163	131	105	84	63	44	29
India	0	10	81	142	152	192	167	139	108	72	36	0
Japan	42	93	128	142	145	142	136	131	125	120	115	111
Korea	12	45	90	96	98	100	103	106	109	112	115	117
Taiwan	14	40	58	61	63	63	65	66	67	69	70	71
South East Asia (1)	4	14	53	60	63	67	71	75	79	84	89	95
Western Europe (2)	48	80	98	128	114	102	99	95	91	87	83	79
Rest of world	191	150	172	179	181	184	188	192	196	199	203	208
Total World	**322**	**441**	**806**	**1,072**	**1,055**	**1,014**	**958**	**907**	**859**	**806**	**756**	**710**
United States	2	10	16	7	7	9	9	10	10	10	10	10
Russia	53	25	24	23	23	21	19	19	19	19	19	19
Net World Imports	**267**	**406**	**766**	**1,042**	**1,025**	**984**	**930**	**878**	**830**	**777**	**727**	**681**

(1) This includes only Thailand, Philippines, Malaysia, Pakistan and Vietnam
(2) This includes only United Kingdom, France, Germany, Spain and Italy
(3) Note - This is global traded thermal coal including lignite, and inclusive of non-seaborne trade.

Source: IEA database, IEEFA forecasts

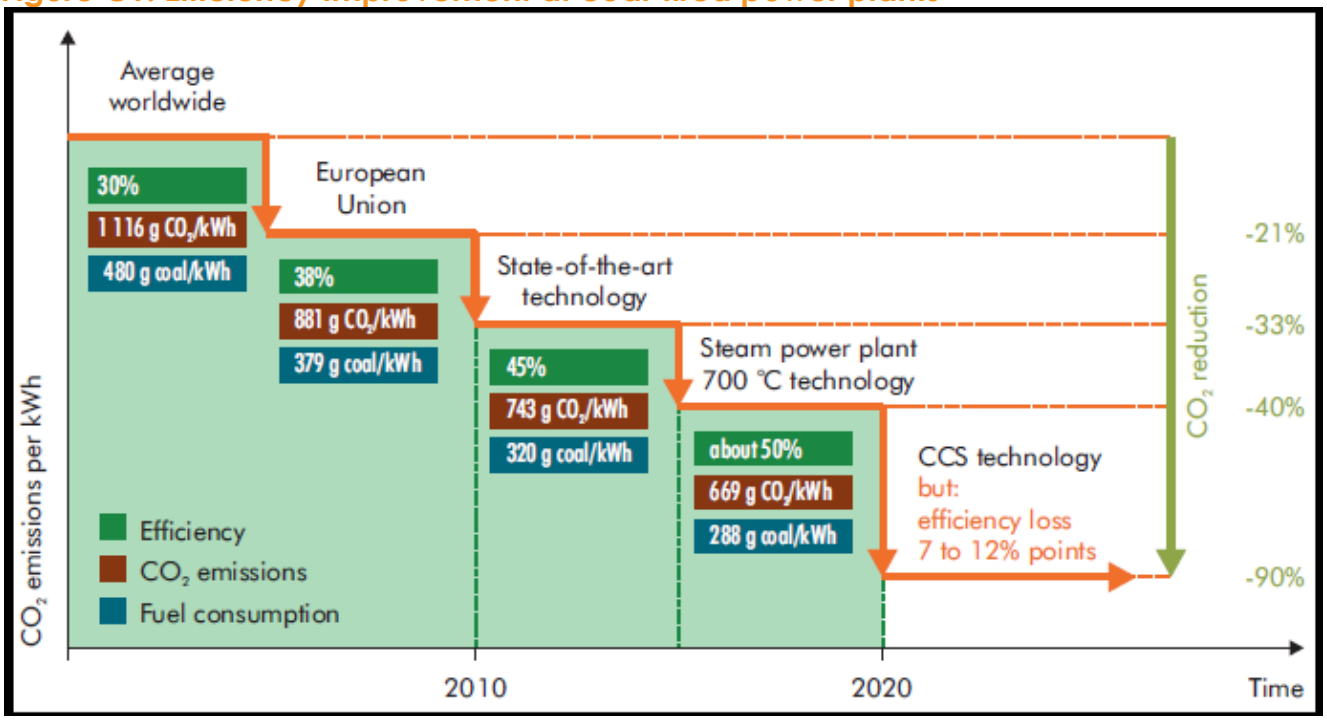
Appendix C – Conversion Efficiency of Coal

A key opportunity to limit the growth in coal consumption in India is to improve the thermal efficiency of the average coal-fired power plant. Current estimates put the average Indian thermal efficiency at 32%, and India uses very low0quality coal, with both high ash content and low energy content (averaging 4,000kcal NAR and 20-40% ash). This means that for every tonne of coal used, less than 1.5 TWh of electricity is produced in India. Inverted, this equates to an estimated coal use of 640 grams per kWh.

By comparison, China in 2015 reports an average 308 grams per kWh (albeit using coal with higher energy content and lower ash). China has achieved a reduction of 1.5% pa over the last decade. Further, China targets <300 gram per kWh in their 2014-2020 State Council Energy Action Plan.

The GoI has referenced efficiency and coal-power technology improvements as key objectives. Improving the average thermal efficiency over the next decade to even half of the European Union average in 2009 of 38% would reduce coal consumption by 10% relative to the base line (down 1.25% annually). A move to 45% by 2035-2045 would allow a sustainable CAGR of down 1-2% for 2-3 decades, making this one of the major opportunities alongside renewables and grid efficiency.

Figure C1: Efficiency Improvement at coal-fired power plants



Source: IEA page 59, VGB PowerTech e.V., Essen, Germany, "Electricity Generation: Facts and Figures 2009/2010"

Appendix D – India's Economy

IEEFA views the Indian economy as poised for a recovery and more consistent growth. The equity market has rallied 30% over the past two years, suggesting increased confidence that transitions are starting to kick-start stalled investment programs. However, as HSBC noted in May 2015, "Progress on regulatory reform across Asia remains frustratingly slow."

IEEFA notes that some significant economic gains have been delivered in the year since Prime Minister Modi was elected. Central to this is the halving of consumer inflation rates to around 5% in 2015. Much of this is fortuitous because of the halving of oil and coal prices (India is one of the three largest importers globally). This trend has driven the dramatic improvement in the current account deficit from a peak of 4.9% in 2013 to about 1% in 2015. However, the GoI has made the brave decision to dramatically curtail oil price subsidies and remove diesel price controls, helping prevent a spike in oil demand and, most importantly, reducing the GoI fiscal deficit.

A key achievement is reflected in reports of a dramatic reduction in corruption and crony capitalism. High-profile charges of corruption by state officials, the unwinding of Coalgate at a profit to the GoI and the absence of corporate bailouts for stranded infrastructure projects (like SBI's refusal to offer finance for Adani Enterprises' Carmichael project) support the press assertions of a much stronger accountability in the GoI. Against this, suppression of freedom of speech is a very negative development for the world's largest democracy.

Lower inflation rates have allowed the Reserve Bank of India to start to lower borrowing costs.

While bank lending grew 10.2% year-on-year in the year to May 2015, a major roadblock to sustained economic growth is the continued buildup in non-performing loans across India. Stressed loans are forecast to rise to US$83bn or 13% of total advances by March 2015, according to press from India Ratings and Fitch Ratings, up from the 10.7% reported by the Central Bank as of December 2014. In IEEFA's view, a widespread corporate deleveraging like that successfully delivered by Suzlon Energy and a resolution to the US$250bn of stalled infrastructure projects are necessary precursors to sustained economic growth. Into July 2015, some progress is occurring.

The June 2015 equity market retreat was led by excessively leveraged Indian infrastructure firms.

While still far from robust, the Markit/HSBC Manufacturing Purchasing Managers' Index (PMI) report shows 18 months of consecutive factory activity expansion in April 2015. The Markit/HSBC Services PMI for India states:

> *"The slowdown in the Indian service sector continued in April, with weaker activity growth reflecting softer demand conditions. Accompanying the subdued outlook in the opening month of the fiscal year, was a return to job shedding as companies maintained a cost-cautious approach. On the positive side, panelists' confidence regarding the one-year outlook for activity improved, indicating that firms are optimistic the current deceleration in growth is a temporary soft patch."*

This caution suggests that the market is yet to see hard evidence of a sustained economic expansion in line with the GoI's 2015-16 target for GDP growth of over 8%. While Finance Minister Arun Jaitley in May 2015 said "India has that potential to make 9 to 10% its new normal in the years to come," IEEFA models a more conservative estimate of India's GDP growth at 7-8% annually. April 2015 electricity demand down 1.2% year over year suggests caution in relying on official GDP numbers.

Appendix E – Solar Cost Deflation of 5-8% pa

IEEFA forecasts an annual 5-8% decline in the total installed cost of solar projects' delivered cost of electricity in the next two decades. This forecast is predicated on continued double-digit growth in global installations that will drive economies of scale, which combined with technology advances, should continue to progressively lift solar-conversion efficiencies.

As an illustration of this trend, Canadian Solar in May 2015 announced a plan to double global module manufacturing capacity to 5.5GW pa. Canadian Solar's target is to reduce module manufacture cost from US$0.47/w in 2014 to US$0.36/w by 2017. As part of this 25% three-year cost reduction target, Canadian Solar aims to lift its module conversion efficiency from the current 16-17% to 20% by 2020.

A second illustration of rampant solar deflation was made clear in the tender of 600MW of new solar capacity tenders in Texas in July 2015 that saw bids of over 1.2GW priced at under US$40/MWh (inclusive of a 30% tax credit). It was only in March 2014 that Recurrent Energy signed a record low 25-year PPA with Austin Energy to deliver electricity from a 150MW solar plant for just US$50/MWh. U.S. solar electricity prices have fallen 20% in just 15 months.

Beyond the absolute cost of modules, IEEFA forecasts significant scope to reduce balance of system solar costs by 5-10% per annum over the next two decades. Key drivers of this forecast are lower financing costs combined with the module conversion efficiency forecast to nearly double, meaning installation costs halve.

Solar energy still poses a shorter-term challenge of commercial viability with electricity costs down to Rs 5/kWh against the average current cost of wholesale electricity in India of Rs3-4/kWh. However, with the fully-installed cost of solar dropping an average 10% per annum over the past six years, the market is increasingly confident that grid parity is rapidly approaching:

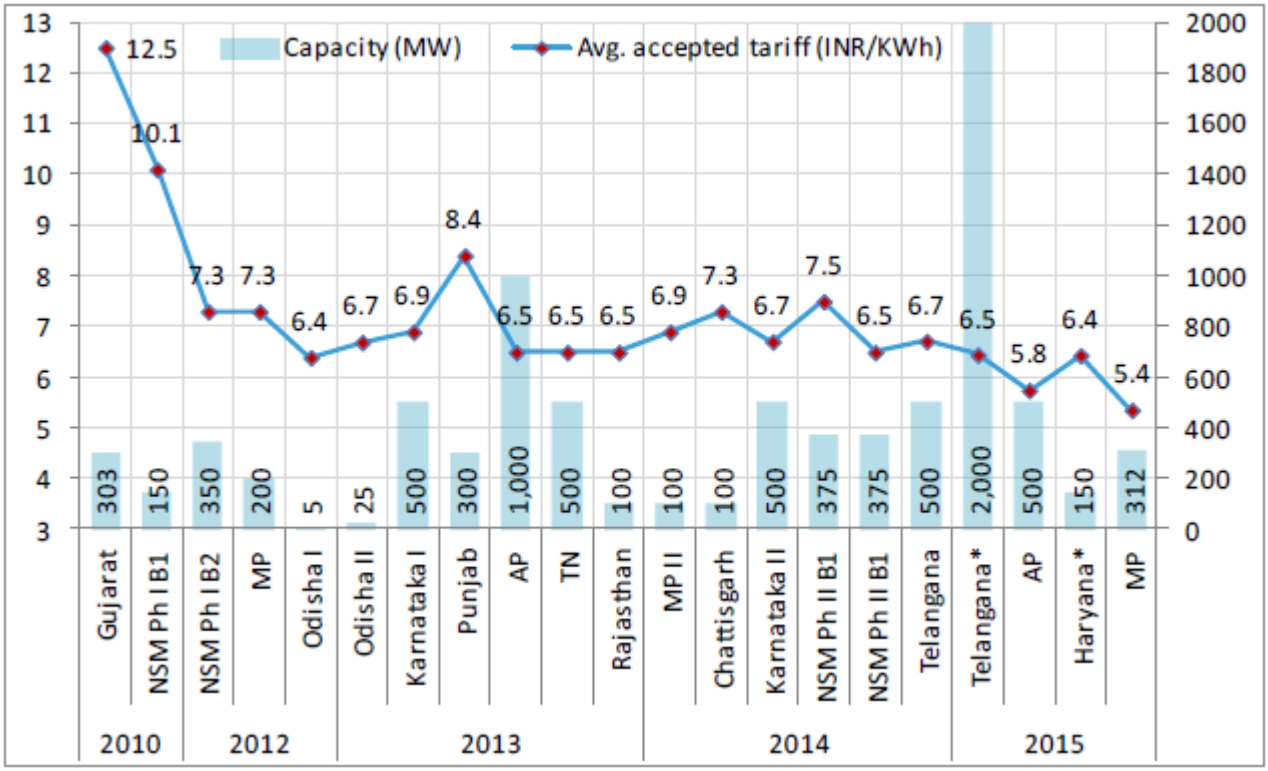
> *"By 2017, the target is to reach 11 GW. Then we are expecting grid parity (where the cost of solar power generation is equal to or lower than the cost of other sources of power generation). And this can accelerate the addition manifold," says a top official in the government.*
>
> *"By then, even if the government doesn't do anything and just sorts policy enablers, solar-based units will multiply,"* says Ratul Puri, CEO, Hindustan Power.
>
> *"These calculations are based on the improvement in technology and cell manufacturing cost reduction. But this (tariff reduction) can be done much faster, if the government intervenes by reducing interest rates, allowing dollar-denominated bonds, reduction in capital cost or introduction of other financial instruments,"* says Anurag Garg, VP of the solar business at Schneider Electric India.

Energy Minister Goyal in May 2015 forecast that innovative financing models will drive solar costs from Rs7/kWh to below Rs5/kWh. Prices hit a new record low of Rs5.17-5.35/kWh in July 2015.

For more details on solar, please refer to Jai Sharda's May 2015 report "*India's Solar Ambitions – Challenges and Options.*"

Figure E1 details the progression of solar feed-in-tariffs across India since 2010, including the latest record low tender result in Madhya Pradesh in July 2015 averaging Rs5.35/kWh fixed flat for 25 years (that is declining each year in real terms). That these FiT are fixed price for 25 years highlights a key aspect of renewable energy, and particularly solar energy, that the systems once they are built have no inflation requirement, so the real price of electricity generation declines over time. With no fuel or foreign currency exchange risk, renewable energy is deflationary.

Figure E1: Solar Tariffs are down 55% since 2010



Source: Deutsche Bank, Abhishek Puri, 19 July 2015, CERC, State ERC, media reports

Appendix F – Major Investors in Renewables

Figure F1: Major Corporate Initiatives announced in Indian renewables in 2015

Company	Investment	Announced	US$m	Wind GW	Solar GW
Adani Enterprises	Adani Enterprises announced a MoU for a JV with the Rajasthan government's Rajasthan Renewable Energy Corp for a new solar park facility of up to 10GW.	Feb'2015	10,000		10.0
SunEdison Inc. U.S. / Imergy Power Systems	Aim to install 1,000 vanadium flow batteries of 100MWh with India's Rural Electricification Corp. for microgrids.	Feb'2015			
Sembcorp, Singapore	Sembcorp acquired a 60% stake in Green Infra, developer of 700MW of Indian RE with plans to add 200-250MW pa.	Feb'2015	170	0.7	
Adani Enterprises / SunEdison Inc.	Solar Module manufacturing MoU JV with SunEdison Inc. for a combined US$4bn	Feb'2015	4,000		
NTPC Limited, India	NTPC has proposed to invest US$10bn to fund the development of 10GW of solar within the next five years.	Feb'2015	10,000		10.0
Reliance Power, India	Reliance signed a MoU with the Rajasthan Government for a 6GW in 10 years solar development program.	Feb'2015	6,000		6.0
First Solar, US	First Solar's "Green Energy Commitment" to develop 5GW of solar capacity in India by 2019, having supplied panels for 700MW of solar projects in India to-date.	Feb'2015	5,000		5.0
SunEdison Inc. U.S.	SunEdison signed a MoU with the Karnataka government to develop 5GW of solar energy over the next five years	Jan'2015	5,000		5.0
Mytrah Energy (UK AIM listed)	Mytrah owns an Indian wind portfolio of 543MW operational capacity with 300MW under construction, and a pipeline exceeding 3,500MW of projects.			0.5	
Hindustan Powerprojects	Targets 1GW of solar by 2016.				1.0

Company	Investment	Announced	US$m	Wind GW	Solar GW
SoftBank, Japan / Bharti Enterprises, India / Foxconn, Taiwan	Announced a JV to invest US$20bn in Indian solar over the next decade, citing high radiation and low install costs.	Jul'2015	20,000		20.0
Sky Power, Canada	Progessing a commitment to build 10GW of solar in India by 2020, Sky Power was awarded a 150MW of solar in MP at a record low Rs5.05-5.30/kWh fixed tarrif.	Jul'2015	150		0.2
Renew Power India / Hanwha Q CELLS, Korea	Renew announced an agreemeent with Hanwha to develop two solar projects in the State of Telangana, totaling 149MW.	Jul'2015	150		0.1
Renew Power India / Hareon Solar, China	Renew announced an agreemeent with Hareon to develop a 72MW solar project in the State of Andhra Pradesh.	Jul'2015	72		0.1
Aditya Birla Group	Aditya Birla Nuvo aims for US$1bn for 1GW of solar within 5 years	Jul'2015	1,000		1.0
ENGIE, France / Kiran Energy Solar Power	ENGIE may take a 80% stake in Indian solar project developer Kiran Energy.	Jul'2015	180		0.1
ENGIE, France / SolaireDirect, France	ENGIE acquired French solar project developer SolaireDirect, who has a stated target of 2GW of solar in India by 2019.	Jul'2015	2,000		2.0
Welspun Energy, India	Welspun commissioned its 52MW solar project in Maharashtra as part of Welspun's target to develop 11GW of RE.	Jul'2015	11,000		11.0
SunEdison Inc. U.S.	SunEdison acquired Continuum Wind Energy, a Singaporean owner of 242MW of wind farms in Maharashtra and Gujarat, & 102MW wind from Fersa Energias (Spain).	Jun'2015		0.3	
Trina Solar / Welspun Energy	Trina Solar announced a MoU with Welspun of India to build a 1.0GW solar cell / module manufacturing facility. Trina expects India to be a Top 3 market in 2016.	Jun'2015	500		1.0
Suzlon Energy / Dilip Shanghvi Family	Suzlon recapitalised with a US$280m equity investment from DSA and agreed to build a 450 MW wind farm	May'2015	700	0.5	
NTPC Limited, India	NTPC commenced discussions with solar developers re reverse tender for 15 GW of solar capacity. This is on behalf of the GoI,separate to its own 10GW plans.	May'2015	15,000		15.0

Institute for Energy Economics and Financial Analysis

The Institute for Energy Economics and Financial Analysis (IEEFA) conducts research and analyses on financial and economic issues related to energy and the environment. The Institute's mission is to accelerate the transition to a diverse, sustainable and profitable energy economy and to reduce dependence on coal and other non-renewable energy resources.

More can be found at www.ieefa.org.

About the Author

Tim Buckley, Director of Energy Finance Studies, Australasia

Tim Buckley has 25 years of financial market experience covering the Australian, Asian and global equity markets from both a buy and sell side perspective. Tim was a top rated Equity Research Analyst and has covered most sectors of the Australian economy. Tim was a Managing Director, Head of Equity Research at Citigroup for many years, as well as co-Managing Director of Arkx Investment Management P/L, a global listed clean energy investment company that was jointly owned by management and Westpac Banking Group.

Acknowledgement

Financial Modeling by Equitorials, Ahmedabad

Equitorials is founded by professionals with work experience across the domain of finance, with a view to provide world-class research and advisory services that investors can rely on, empowering them to make sound investment decisions.

The founders, hailing from top MBA institutes like IIM - Ahmedabad, have worked across asset classes like equities, debt, mutual funds and insurance and handled carious sectors. Equitorials conducts customized research for customers. Should you want more details on the financial modelling undertaken, please email or call the author, or Equitorials directly.

Equitorials can be reached at jai@equitorials.com or at +91 97372 33038

Important Information

This report is for information and educational purposes only. It is for the sole use of its intended recipient. It is intended solely as a discussion piece focused on the topics of the Indian electricity sector, the Adani Group's involvement in the Australian coal industry and the risks of stranded assets. Under no circumstance is it to be considered as a financial promotion. It is not an offer to sell or a solicitation to buy any investment even indirectly referred to in this document; nor is it an offer to provide any form of general nor personal investment service.

This report is not meant as a general guide to investing, or as a source of any specific investment recommendation. While the information contained in this report is from sources believed reliable, we do not represent that it is accurate or complete and it should not be relied upon as such. Unless attributed to others, any opinions expressed are our current opinions only.

Certain information presented may have been provided by third parties. The Institute for Energy Economics and Financial Analysis believes that such third-party information is reliable, and has checked public records to verify it where ever possible, but does not guarantee its accuracy, timeliness or completeness; and it is subject to change without notice. If there are considered to be material errors, please advise the authors and a revised version will be published with a correction.