

LOCKED-IN

The Financial Risks of New Coal-fired Power Plants
in Today's Volatile International Coal Market

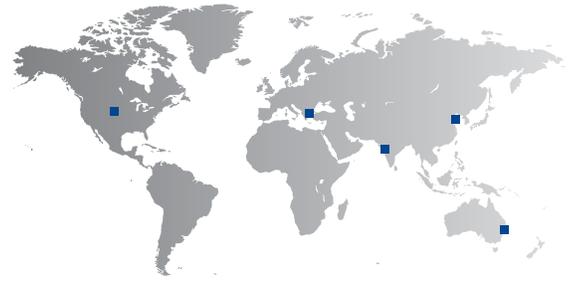


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EXECUTIVE SUMMARY

Coal “lock-in,” rather than rational investments in coal power, is one of the largest global threats today. This lock-in results from high capital costs and long asset lifespans associated with coal-fired power plant investments. Over the past six years due to large scale public opposition, mounting costs, and dramatic changes in the energy market, an irrational coal lock-in was successfully averted in the US and the EU. However, excessive coal reliance is now becoming a serious economic, as well as long-term environmental and public health threat, to China, India, and other parts of the developing world.

While the environmental and human health impacts of coal plant investments are increasingly well known, the financial impacts are not. This report examines the wide ranging risks these coal investments force countries to bear in today’s rapidly changing energy market. Understanding and incorporating these risks in decision making is particularly important given the potentially untenable opportunity cost of financial flows that could otherwise be directed to increasingly affordable clean energy and energy efficiency alternatives. The following is a summary of our findings:

Plant construction costs are rising and increasingly unpredictable: Over the past decade, in the U.S. and elsewhere, plant costs have increased by up to 100 percent over initial estimates proposed during the construction

phase. Moreover, even in the absence of market conditions that increase the cost of construction, lengthy design and construction periods for new coal-fired generating units result in the use of out-of-date cost projections that may significantly underestimate the cost of future projects.

Coal prices are volatile, increasing, and less predictable: Once constructed, a plant will have limited options over the next 40 to 50 years for sourcing and transporting its coal requirements reducing flexibility and exposing it to significant coal price risks. Internationally, coal prices have historically been, and remain, linked to oil prices exposing these investments to the volatility of this market. As oil prices have increased significantly over the past decade, international steam coal market prices have also trended sharply upward.¹ Upward price trends are also evident across many of the world’s largest domestic coal markets including the United States and China.

Political risk from an emerging ‘OCEC’ is rising: Just as the international oil market is dominated by a small number of countries, so too, the international coal market is dominated by just six countries that produce 80 percent of internationally traded steam coal. The top two exporting countries alone — Australia and Indonesia — are responsible for roughly 50 percent of all internationally traded steam coal. Increasingly these coun-

FIGURE 1: IHS CERA Coal Plant Capital Costs North America

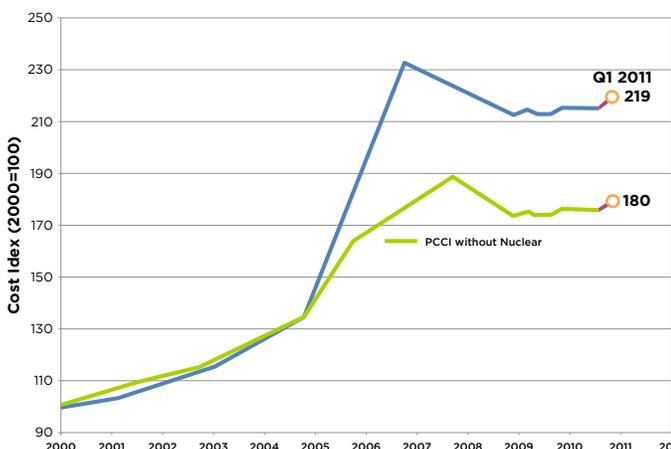
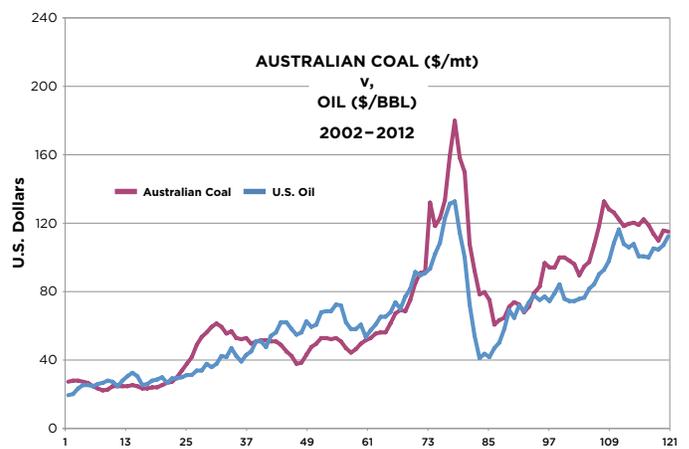


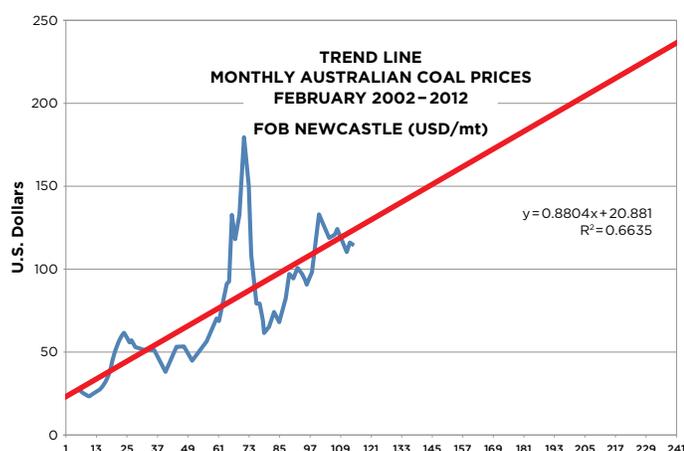
FIGURE 2: Benchmark Australian Coal Prices vs. Crude Oil Prices 2002-2012



tries are directly or indirectly acting to set international prices and secure economic rents; acting in effect, if not in name, as “Organization of Coal Exporting Countries” (OCEC).

Regulatory risk and a lack of cost pass-through exacerbates exposure to volatile coal prices: Large scale coastal coal plants reliant on imported coal supplies face the highest risk as coal prices climb. In recent years a number of countries, including China and India, have developed plans for large numbers of such plants, which are simultaneously exposed to the economic power of the emerging ‘OCEC’ and severely limited in their ability to pass through increased costs due to domestic regulatory structures. Market analysts have warned of the pressure this market concentration places on profit margins, specifically in Asia, where several large projects such as the 4 GW Tata Mundra and Krishnapatnam Ultra Mega Power Projects (UMPPs) face severe financial strain.

FIGURE 3: Benchmark Australian Coal Price Trend 2002-2012



Competing renewable energy sources are coming down in price further increasing market uncertainty:

Most reliable estimates put the levelized cost of new wind power at between 5 and 10 cents/kWh³ — at or below the cost of new coal-fired power in the United States. The same is true for solar photovoltaic (“PV”) in the sunniest parts of the U.S., where it now competes for peaking power applications with the cheapest fossil fuel — natural gas.⁴ In fact in just one year, from 2008 to 2009, the price of solar PV fell 50 percent, followed by another 14 percent reduction in 2010.⁵ Rapid cost reductions in these technologies pose an opportunity cost that few financial institutions are accounting for in power sector investments. While high in capital expenditure (CapEx) clean energy sources like wind and solar are not exposed to fuel price (OpEx) volatility. Investing billions today in assets that have fuel requirements whose input is likely to continue to rise over the next

40 years reduces exposure to the upside of disruptive technologies like solar PV. In essence, they lock themselves into the ever increasing costs of coal while competitors increasingly offer attractive returns that are not just environmentally preferable, but also economically preferable.

Coal use is at its lowest point in recent history in the U.S. and Europe: In the United States, plans for 168 new coal-fired power plants have been abandoned and another 100 existing plants are planned for retirement due in large part to increased financial and environmental costs along with intense grassroots opposition. As a result, coal-fired generation has fallen to its lowest share of overall generation in the past 35 years; The contribution of coal-fired generation in the U.S. dropped to 34 percent in March 2012, marking the lowest monthly share since January 1973.⁶ In Europe, coal’s share of generation has declined from 39.4 percent to 25.7 percent over the past 20 years.⁷ Of the 120 coal-fired power plants proposed in Europe since 2007, only half a dozen have broken ground and the overall share of coal in the fuel mix is declining rapidly. In 2011, 71 percent of the new electricity capacity in the European Union was renewable energy, while 22 percent was natural gas-fired generation.

‘Too Big to Fail’ coal projects can and should be avoided: Despite significant coal price OpEx many new coal project sponsors routinely underestimate price volatility, the cost of construction, and the risk of cost overruns. When comparing new coal projects against alternatives, such as energy efficiency and renewables, advocates of new coal projects often choose discount rates that bias the decision. Frequently, the optimistic scenarios predicted by these analyses fail to materialize, with significant adverse consequences. For example, even before construction of the 4 gigawatt⁸ (“GW”) Tata Mundra project in India is complete, coal prices are three times those cited in its bid; an outcome that all parties should have anticipated based on the trends of the past decade. However, Tata Mundra is now bound by a long-term power purchase agreement that fixes wholesale electricity prices for decades to come forcing the government and investors to face billions in losses if it does not pass on significant price increases to average Indian consumers.

In addition, in January 2012, the operator of the recently completed Spiritwood Station plant in North Dakota announced that it would not operate a recently constructed plant, but would idle it in order to limit its financial losses from the operation.⁹ The operator cited slower-than-expected growth in electricity demand,

lower prices on power sales to the grid, and the loss of a key industrial customer for some of the plant's steam as factors leading to its decision. In the absence of a sufficient market for the electricity for the plant, the operator found it cheaper to close the plant until a market develops, even though it must repay bondholders for the investment costs while the plant is closed.

Failing to adequately incorporate financial risks into a rigorous review that determines whether the underlying fundamentals of new coal investments are sound poses significant lock-in risk to developing countries. The procedures of many of the world's leading financial institutions, including the World Bank, currently lack appropriate analytical tools for doing so. In order to protect average citizens from dramatically increasing electricity rates, as well as the health and environmental harm associated with new coal plants, we recommend the following:

Recommendations:

- **Assume rising coal prices:** In particular, for the foreseeable future, financial institutions should assume that domestic coal costs will rise to international coal prices over the next 10 years and that international coal costs will increase at the rate of at least 6 percent per year (or two percent more than the rate of inflation, whichever is greater) for the life of the plant.
- **Assume accurate discount rates:** Inappropriate discount rates can discriminate against projects with relatively high percentages of CapEx relative to OpEx. In particular, for purposes of internal evaluation, financial institutions should use a discount rate equal to its proposed lending rate for the project, not a discount rate based on the cost of capital asserted by the proponent of the project.
- **Establish a risk premium:** Financial institutions should review data concerning the variability of the factors listed above in the host country and establish a "risk premium" to monetize the risk of project failure for fossil-fueled projects based on the increase in the cost of fuel over the lifetime of the plant, in comparison to alternatives including energy efficiency and clean energy projects, where such risks are not present.



INTRODUCTION

For much of the modern era coal was “king.” Just five years ago it was commonly thought that a resurgence in cheap coal-fired generation was inevitable. The 2007 U.S. National Energy Technology Laboratory’s (“NETL”) Tracking Review was titled “*Coal’s Resurgence in Electric Power Generation*” and touted 151 proposed and new plants that would provide 90,000 MW of new coal-fired capacity.¹⁰ In that same year, the Massachusetts Institute of Technology (MIT) concluded an extensive multi-disciplinary review of U.S. energy resources with a similar prediction of cheap and abundant electrical energy based on coal’s clear advantage as a fuel for the future. MIT concluded by saying: “*We believe that coal use will increase under any foreseeable scenario because it is cheap and abundant.*”¹¹

However, the promise of a resurgence of cheap coal-fired electric power generation has failed to materialize. Nowhere is the failed resurgence of coal-fired generation more evident than the United States and Europe. In the United States, only a few of the projects predicted in the 2007 NETL report were actually built. Of the 120 coal-fired power plants proposed in Europe since 2007, only half a dozen have broken ground and the overall share of coal in the fuel mix is declining rapidly.

At the same time the economics of alternatives have dramatically improved. The wind industry has rapidly matured, creating cost reductions that enable it to directly compete with fossil fuels to supply energy to the U.S. grid.¹² Substantial energy efficiency gains have effectively decoupled long term economic growth from energy production in large states like California and continues to constitute an enormous and still untapped “supply” of energy. As a result wind, along with energy efficiency and natural gas, have captured the market share that coal would have otherwise constituted in the U.S.

Despite this dramatic reversal of fortunes, the underestimation of the cost of coal-fired generation of electricity and overly optimistic predictions for its future continue.¹³ In fact, far from being artifacts of a forgotten past, predictions of “cheap and abundant” coal-

THE DISRUPTIVE POTENTIAL OF SOLAR PV

The economics of solar PV have rapidly improved in recent years to the point that it is at or near grid parity for peaking applications in the sunniest parts of the United States.¹³ For instance PV has become so competitive that it now competes with the cheapest peaking fossil fuel in the United States — natural gas — in California.¹⁴ This has been enabled by dramatic cost reductions and rapid increases in installed capacity.¹⁵ In just one year, from 2008 to 2009, the price of solar PV fell 50 percent, followed by another 14 percent reduction in 2010.¹⁶

The recent trend toward falling costs and increasing installations is expected to continue as every doubling in the installed capacity of PV has led to a 22 percent reduction in cost.¹⁷ Analysts now predict the installed capacity will grow three times between 2010 and 2018 (from 40 GW to 320 GW), implying a 53 percent reduction in costs¹⁸.

These rapid cost reductions pose an opportunity cost that few financial institutions are accounting for in power sector investments. Investing billions today in assets that have fuel requirements whose input is likely to continue to rise over the next 40 years reduces exposure to the upside of disruptive technologies like Solar PV. In essence, they lock themselves into the ever increasing costs of coal while its competitors increasingly offer attractive returns to investors.

fired electricity remain as staples of today’s discourse. This report seeks to inform decision makers about the changing pricing patterns for coal over the past decade and the now inherent risk of substantial additional fuel cost increases over the 40 year lifetime of a new coal-fired power plant.

WHY COAL IS A “DEAD MAN WALKING” IN DEVELOPED COUNTRY ENERGY MARKETS



In late 2010 Kevin Parker, head of asset management and member of the executive committee at Deutsche Bank, famously asserted

“Coal is a dead man walking, banks won’t finance them, insurance companies won’t insure them. The EPA is coming after them...and the economics to make it clean don’t work.”

This dramatic statement cogently summarized a series of changes that have upended the coal market in the United States. However, it misses one further element of risk facing new coal plant proposals — widespread grassroots opposition facing each and every new coal plant proposed.²⁰ Many of these factors are similarly curtailing new coal build in Europe. They are outlined below.

NEW VS. EXISTING PLANTS AND THE COST OF POLLUTION CONTROL

An important underlying factor impacting the cost of electricity from coal-fired power plants over the next several decades in the U.S. and the E.U. is the age of the existing fleet. In the U.S. a substantial majority of the coal-fired capacity came online between 1968 and 1988, while much of the natural-gas fired capacity is approximately 10 years old. In Europe a similar age gap exists. The average age of both coal and lignite-fired plants is 36 years, while the average age of gas-fired capacity is roughly half.²¹ After 30-35 years of operation of coal-fired plants, forced outages start to increase dramatically, thus reducing the availability and capacity factor (the percentage of its theoretical total production) of the unit.²² A substantial portion of the existing fleet, both in the United States and in Europe (and presumably elsewhere around the world) is now reaching the age where operators must decide whether to retire the unit or invest hundreds of millions of dollars in major “life extension” programs.

Existing plants of this vintage are ordinarily fully amortized and carry only a relatively small amount of debt in their overall cost structure. However, for a new plant to

be economically viable, the revenue it generates must cover the significant additional costs associated with life extension. Further, environmental control requirements for associated pollutants are typically more stringent for new units than existing units, and so pollution control costs are higher.

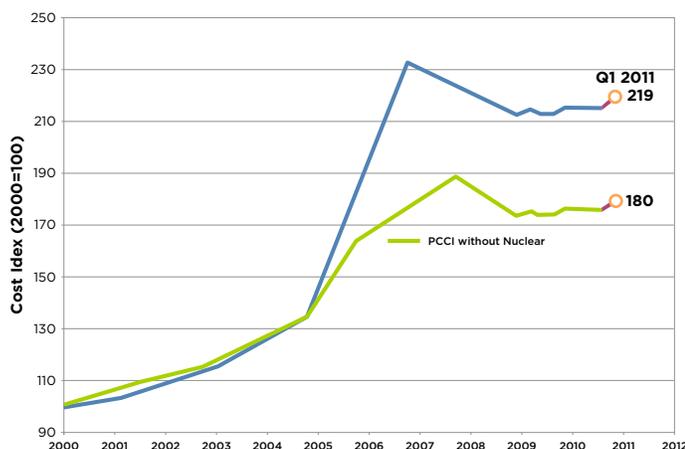
For these reasons, during much of their useful lives power from new coal-fired units is almost always more expensive than that from existing coal-fired plants.²³ This factor has contributed significantly to the closure of a large number of coal-fired plants in the United States. Even where the operator chooses to rebuild, rather than replace a plant, it will seek to recover the added investment costs over a relatively short period of time, thus incurring relatively high fixed costs.

The trend in the U.S. has been to extend the useful life of the larger, more efficient units — while closing smaller and less efficient units. But life extension programs are limited by the overall age of the unit and at some point life extension is no longer economically feasible. For this reason, closures of larger units in the U.S. have recently been announced. While newer designs can be somewhat more fuel efficient than the units they replace, the available increase in efficiency is often not sufficient to offset the cost of capital for the new construction until the construction loan has been amortized. As a consequence, the directional impact of replacing an aging fleet of coal-fired plants will be to *increase*, rather than decrease, the cost of electricity to average citizens.

CONSTRUCTION COST INCREASES AND POTENTIAL FOR COST OVERRUNS

Data concerning the cost of construction of new coal-fired power plants are by nature “out of date”²⁴ as soon as they are published, since these data reflect construction of facilities where contracting and commencement of construction occurred at least five years earlier. This is also true of data respecting natural gas-fired, solar, and wind plants; however for these sources the time lag is two years or less. The available data demonstrate that between 2000 and 2008, capital costs for coal-fired

FIGURE 1: IHS CERA Coal Plant Capital Costs North America



power-plant construction roughly doubled, with particularly steep price hikes occurring in 2005-2008.

By 2008 average costs for new coal plants in the U.S. had reached \$3,500/kW (before financing costs are included), up from as little as \$1,500/kW to \$1,800/kW in 2005.²⁵ At the same time, international costs in 13 different countries (including financing during construction), as published by the International Energy Agency in 2010, generally exceeded \$2,500/kW.²⁶ Both the international and the U.S. domestic data show that the costs of construction are highly variable, with reported differences of more than 50 percent for similar facilities. For example a U.S. unit has a capital cost of \$1,355/kW — but also has a unit that cost \$5,350/kW.

This time lag in reporting also serves to distort rational investment decisions in clean energy. Construction costs for wind and solar power are being driven down rapidly, which in the case of Solar PV can render prices out of date in as little as a year. Given the two very different trajectories coal and clean energy are on, time lags conspire to make coal seem unrealistically cheap and clean energy unrealistically expensive.

FIGURE 4: Global Copper Price Trend 1992-2012



In addition, extremely large cost overruns have been reported for a number of projects during this period as prices for commodities used in constructing power plants (e.g., steel, copper) rose dramatically. Figure 4²⁷ sets out the cost for internationally traded copper during the 1992-2012 time frame. For new large scale power plants like Tata Mundra in India (discussed below) exceedingly low construction cost estimates (\$1000/kW) raise substantial concerns about the potential for a cost overrun or ongoing operational problems.

At the same time costs have steadily risen, widespread public opposition to new coal-fired power plants has grown, supported by dozens of environmental organizations that have collectively challenged each proposal for a new coal-fired plant in the U.S. While public opposition to new coal-fired generation focused on the high public health, environment and climate threats posed by new coal-fired plants, members of the public also opposed these plants on the basis of the substantial rate increases the projects would cause. Of the 441 new

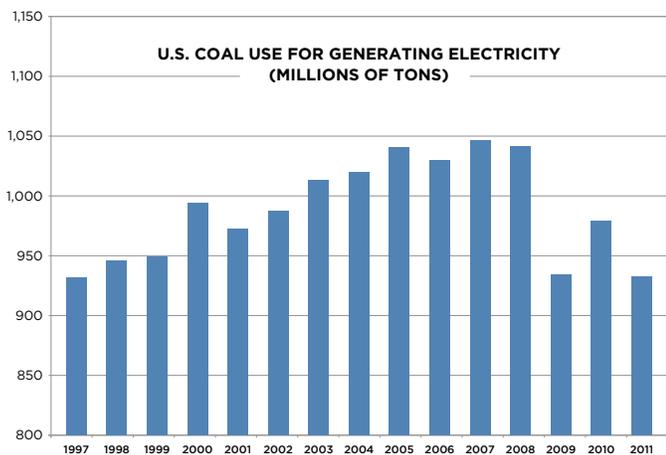
COST OVERRUNS FORCE PLANT CLOSURES

- In November 2009, American Municipal Power announced that the projected costs of its proposed Ohio plant had jumped 37 percent since the preceding May. As a result, the company announced the project's potential conversion to a more cost effective natural gas plant (AMP 2009).²⁸
- Peabody coal announced that the construction cost of its Prairie State coal plant in Illinois had increased to \$4.4 billion, more than double the original estimates (Hawthorne 2010).
- In January 2012, the operator of the recently completed Spiritwood Station plant in North Dakota announced that it would not operate the plant, but would idle it in order to limit its financial losses from the operation.²⁹ The operator cited slower-than-expected growth in electricity demand, lower prices on power sales to the grid, and the loss of a key industrial customer for some of the plant's steam as factors leading to its decision. In the absence of a sufficient market for the electricity for the plant, the operator found it cheaper to close the plant until a market develops, even though it must repay bondholders for the investment costs while the plant is closed.

energy projects that have come online in the United States in 2011 and thus far in 2012, only 6 projects, representing 3,372 MW of capacity (16 percent of the total newly added capacity of 20,776 MW) are coal-fired. These additions are more than offset by the 24,700 MW of plants that have been specifically identified as “retiring” in the tracking summary of coal-fired capacity maintained by the NETL.³⁰ The NETL tracking report shows no anticipated additional coal capacity in the “near construction” or “under construction” categories after 2014, and no new coal projects, other than carbon capture and sequestration demonstration projects, even contemplated for the period after 2018.

As a result, the share of U.S. power generation that comes from coal has now fallen to historic lows. The contribution of coal-fired generation in the U.S. dropped to 34 percent in March 2012, marking the lowest monthly share since January 1973.³¹ While total U.S. electricity generation was down 7 percent in December 2011 compared to December 2010, natural gas-fired generation increased by 12 percent. During this period coal-fired generation declined by 21 percent. This has allowed energy efficiency, wind power, and natural gas to capture market share as the price of alternatives has rapidly dropped.

FIGURE 5: U.S. Coal Consumption for Electricity Generation³²



THE RISING COST OF INTERNATIONALLY TRADED COAL – AN EMERGING “OCEC”?



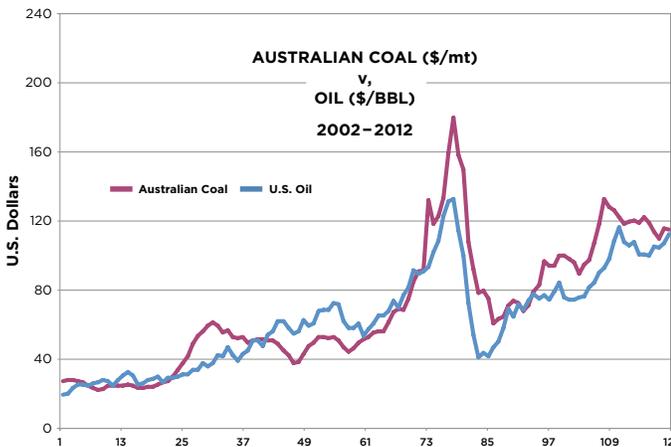
While new coal build in the United States and Europe has faced tremendous cost pressure and public opposition, new coal build throughout the developing world, particularly in Asia has surged. Now however, in addition to rising construction costs, a historic rise in the price of coal itself is threatening the financial viability of many of these projects. This price rise is due in large part to the direct correlation between oil and coal prices in global markets, explained below. But more worrisome for potential investors, it may also be the result of what can best be described as an emerging Organization of Coal Exporting Countries ‘OCEC’; a limited set of producers able to extract economic rents by directly or indirectly acting to maintain high prices. Lacking the ability to easily pass on the increased fuel costs, OCEC and other market forces are creating many existing plants that now face significant pressure on profit margins, adding a new layer of risk exposure to coal plants, particularly those planned in Asia. Since roughly 2002-2003 internationally traded steam coal prices, particularly for plants relying on coal shipped long distances, have risen due in large part to the close linkage between coal and oil prices. The price of oil and the price of steam coal traded on international markets are illustrated by Figure 2, below, which sets out the monthly prices identified in the March, 2012 World Bank Commodity Price Data Report (Pink Sheet)³³ (“WB Pink Sheet data”).

This linkage is generally considered to result from two factors. The first is that transportation costs (largely diesel and fuel oil costs) are embedded in the cost of coal at a particular location and may, in some instances, represent a majority of the delivered price of coal. For Australian coal (the world’s largest coal exporter), the cost of transporting coal by rail from the mining areas to the export facility typically ranges from \$8/ton to \$15/ton. Thereafter, ocean transport to the import facility can cost up to \$50/ton, followed by further land transport to the generating facility.³⁴ The second factor is that import steam coal price contracts for future

SHORT TERM PRICE FLUCTUATIONS

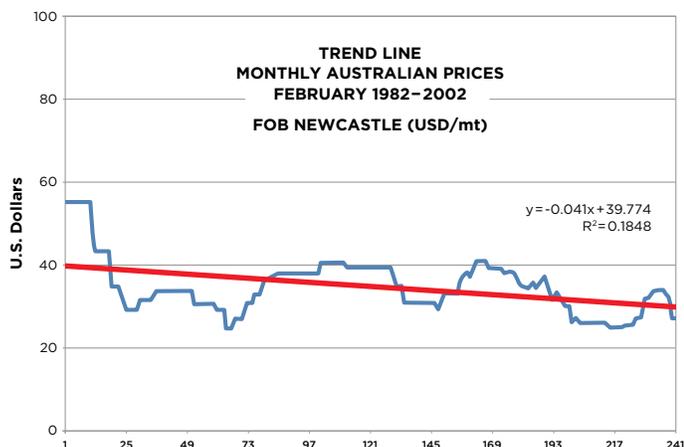
As illustrated by Figure 3, coal prices experienced extreme short term price increases and decreases in the past decade, rising to almost \$200/ton before receding to \$60/ton and then climbing to the \$100/ton range. In the past two or three years, oil and internationally traded steam coal prices have fallen below the short term peaks of the prior decade. Such short-term variations are to be expected as these volatile commodity markets respond to daily fluctuations in economic and market conditions. This paper focuses, not on the short-term fluctuation in the market, but on the long-term trend that is relevant to the 40 year life expectancy of new coal-fired plants. The long-term data have and continue to show a trend for increasing prices, well above the levels of prior decades. Recent estimates of the high cost of developing new mines in market leaders such as South Africa and Australia, and Indonesia’s revised tax policy suggest that there is no reason to believe that the long-term trend of constantly escalating coal prices will be reversed in the coming decades.

FIGURE 2: Benchmark Australian Coal Prices vs. Crude Oil Prices 2002-2012



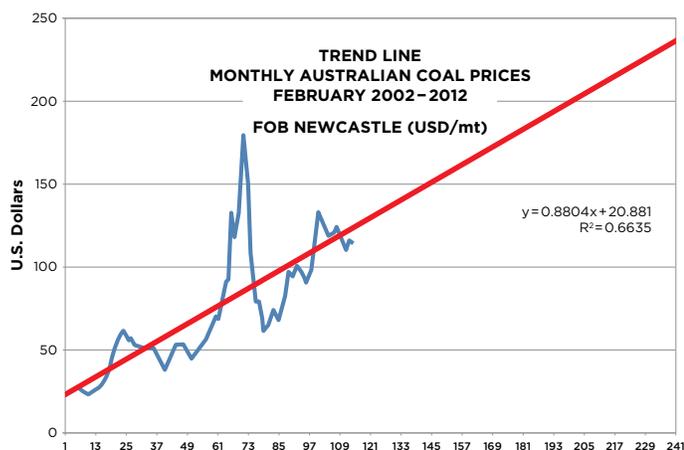
delivery have historically been indexed to oil prices as a way to protect both buyer and seller from the effects of inflation. As Figure 6 demonstrates, this arrangement resulted in relatively stable and slowly decreasing coal prices for many years.

FIGURE 6: Monthly Australian Coal Prices 1982-2002³⁵



However, as shown in Figure 3, it is clear that the downward trend of the 1980s and 1990s has reversed. Since 2002, Australian coal prices have risen substantially, as have prices for coal from the other leading exporters.³⁶ A number of reasons for this shift are possible. First producers and/or governments may be determining that the resource is finite and that they should accept the possible loss of market share to maintain a high market price. Second, production costs may be increasing as the easiest (and cheapest) sources of coal have already mined leaving more difficult and expensive deposits for today’s producers. Last, and most troublesome from an investor’s point of view, the market may be moving from a “cost plus” pricing model to a “mark to market” model, where the major producers “set” market prices and the smaller producers follow (much like the role OPEC plays in the global oil market).

FIGURE 2: Benchmark Australian Coal Prices vs. Crude Oil Prices 2002-2012⁴⁰



Clear evidence of the rise in power of a virtual cartel³⁷ of a few large coal producing nations came with the Indonesian government’s 2011 decision to index the sales price of Indonesian coal to international sales prices in South Africa and Australia.³⁸ This was complemented by the Australian system of differential pricing for domestic and international coal and its recent imposition of a 30 percent tax on international coal.³⁹ These decisions in effect set the bar for internationally traded coal at historically high prices that currently exceed \$100/ton in many locations.

Other than the rapid development of very large amounts of unconventional natural gas in India and China (discussed below) there are no obvious factors that would suggest that a return to \$30/ton coal prices is at all probable. It is difficult to believe that, having established triple-digit prices for internationally traded steam coal, the major exporting countries will decide to, or be forced to, return to the long-term “cost plus” contracts of the past, especially over the next decade as the world economy recovers from the current recession. Indeed, the current situation may worsen for import dependent countries, as a coal price of \$150/mt FOB Newcastle plus \$40/mt shipping costs does not appear to be unrealistic in the next few years. For an existing coal-fired power plant with mid-range efficiency,⁴¹ such a price translates to \$76.62/MWh or \$0.077/kWh in fuel costs alone. For a new coal-fired power plant with improved efficiency,⁴² the fuel costs would be reduced to \$68/MWh, but the added debt and equity costs associated with new construction (nominally 3.5 to 4 U.S. cents/kWh at today’s estimated costs) would increase the overall wholesale cost of electricity produced by this facility to above \$100/MWh (\$0.10/kWh). These prices are entirely plausible and substantially higher than some of the more extreme low-end predictions of future coal-fired electric generating costs.

This poses tremendous risk for a number of Asian countries that have undertaken construction of large numbers of new coastal coal plants that would rely to a significant extent on imported coal supplies. In India, for example, 30 percent of the staggering 700 GW pipeline of coal projects is sited in coastal locations to take advantage of imported coal. These new coastal coal plants had been premised on cheap international coal supplies. Now however, their foremost risk is the availability of affordable coal supplies over the life of the plant.

It is important to note that absolute availability of coal supplies threatens the remaining 70 percent of the pipeline in India. Coal India Limited (CIL), the state

owned coal company provides the vast majority of coal to domestic power plants. In recent years it has been unable to increase production to meet the growing demand in the country, leading to increased levels of imports. In February of 2012 the coal minister sent a letter to the power ministry requesting an immediate freeze in the pipeline of coal projects because the world's largest coal miner is unable to ensure adequate supply of coal and therefore the financial health of the coal project pipeline.

Almost immediately after CIL announced its desire for a freeze, the Reserve Bank of India (RBI) followed suit by suggesting banks freeze lines of credit for this "distressed sector." The move followed months of warnings from financial analysts that systemic defaults loomed on coal plant loans and the widespread impact it would have on Indian banking sector due to high exposure.⁴³ These circumstances will almost certainly lead to a substantial increase in the cost of domestic coal in India.

ASIAN IMPORT DEMAND THREATENING PLANT ECONOMICS

While fuel price risk is increasing, international steam coal price trends can still be altered if the two Asian markets that have the most impact on the international coal market — China and India — significantly alter their

"Indonesia will not change its stance for Tata Power or any other company...In fact all the three countries exporting coal have changed rules in recent times. South Africa, Australia, and Indonesia are in sync as far as coal exporting is concerned."

— CEO, Tata Power

purchasing patterns. For prices to decrease however, that would require a significant reduction in import demand, a situation unlikely to occur for the reasons outlined below.

On the demand side, the international coal market is largely determined by its largest consumer — China. While China has historically been a net exporter, it experienced a dramatic shift in 2009 becoming the world's largest importer, because even despite high international prices at the time, imported coal was still less expensive than domestic supplies.⁴⁷ Therefore, for Chinese import demand to soften and thereby reduce internationally traded coal prices, domestic prices must

RISING COAL PRICES IN THE UNITED STATES

As Figure 7 shows, while generally lower, U.S. domestic coal price trends show the same generally increasing price pattern as international steam coal trends. For several decades coal prices were generally stable and slowly declining. In 2003, this pattern reversed and coal prices began climbing rapidly. As with international steam coal prices, a large part of this increase is the embedded oil cost associated with transporting western coal to generating stations in the southern and eastern parts of the U.S.

Unlike China and India, the U.S. has experienced a rapid development of low-cost unconventional natural gas supplies that has led to substantially lower wholesale electricity prices and greatly reduced demand for coal. Instead of this competition suppressing coal prices, U.S. coal prices *actually rose*⁴⁴ throughout the period.⁴⁵ Moreover, the U.S. Energy Information Administration (EIA) recently revised its projection for future U.S. coal prices from "flat" to increasing. According to the EIA, the upward trend of coal prices primar-

ily reflects an expectation that cost savings from technological improvements in coal mining will be outweighed by increases in production costs associated with moving into reserves that are more costly to mine.⁴⁶ Thus, it appears that coal prices in the United States are unlikely to decrease in ways that would spur additional generation of electricity from coal.

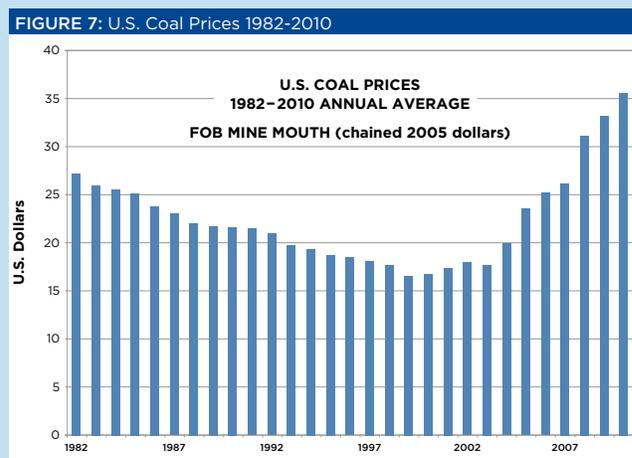
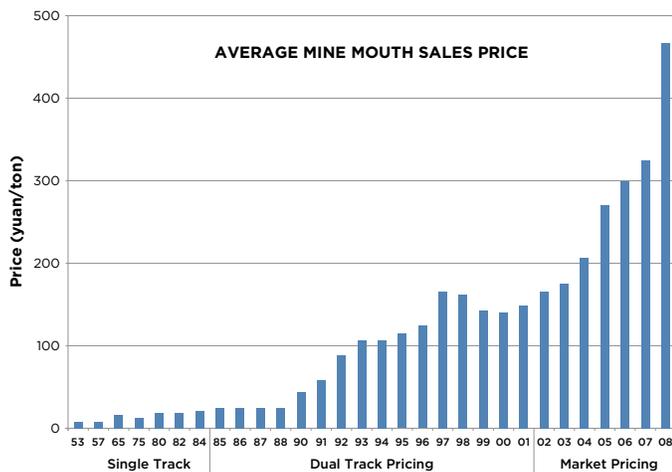


FIGURE 8: Average Minemouth Price of Coal Produced in China



Source: Yang et al. (2009), Wang and Pan (2009) and Energy Research Institute.

decrease. However as demonstrated in Figure 8, the trend toward steadily increasing domestic coal prices experienced elsewhere in the world is also readily apparent in Chinese domestic coal prices.

Prices have risen for several reasons. First and foremost domestic coal production in China has not kept pace with the demand as the country has embarked on an ambitious plan to consolidate the industry. In addition, production has not kept pace despite considerable sums spent on new exploration activities and recently announced major new finds.⁴⁸ No details have been released as to the likely cost of development and production but much of China's coal resources are distant from major population centers and so, any new coal finds will continue to incur substantial transportation costs. While consolidation may increase domestic production in the long term, the amount of coal that China imports is related more to affordability rather than quantity of domestic supply. Affordability in turn is driven by transportation constraints and domestic political issues.⁴⁹

Given the rapid increases in domestic coal prices within China, the continued growth in demand, and the long-term structural supply changes necessary in the domestic coal industry needed to soften import demand, it seems unlikely that China will return to its earlier position as a significant net exporter of coal.⁵⁰ This situation strongly suggests that in Asian markets high international prices will continue going forward.

While South Korea and Japan are also large, but relatively stable, consumers of imported coal, the other fast growing consumer with the potential to buoy future

demand, and therefore prices, is India. In contrast to China, India is forced to import coal due to long-term structural problems associated with increasing production and transportation infrastructure within the country, which has limited domestic supplies. Because of the constrained domestic supply, and limited transmission capacity, up to 30 percent of India's new coal-fired generation capacity is now sited for coastal areas so as to have access to imported steam coal.⁵¹ As a result, Indian coal imports grew by 36 percent between 2007 and 2009, reaching 11.5 percent of total consumption in 2009.⁵² Many now predict that imports will more than double by 2013 reaching 140 million tons — roughly the same as Chinese demand for imported steam coal in 2009.⁵³

It appears highly unlikely that in the next few years Indian officials will be able to resolve the decades-long difficulties that the country has had in expanding domestic coal production. Moreover, costs are surging as unions demand fair wages for their workers, production costs increase, and highly subsidized prices are subjected to political pressures seeking a harmonization with prevailing international prices.⁵⁴ The net result of these forces has been government encouragement to both domestic production and increasing the price of domestic coal.⁵⁵ The most likely trend for coal-fired generation in India would appear to include continuing imports of coal and a continual narrowing of the gap between domestic and international market prices for steam coal. This would eliminate the last major "cost-plus" producer in the international coal supply chain.

Ultimately, the continued increase in domestic coal prices in India and China is consistent with the trend in domestic coal prices in most countries around the world.⁵⁶ There also appears to be no strong reason to believe that coal prices will retreat to much lower levels than today,⁵⁷ especially as the world economic climate improves and demand increases. As a result, sector analysts have warned that Asian coal markets in particular are increasingly subject to greater price volatility due to a combination of surging demand and high oil prices. Even the International Energy Agency, a historically conservative organization, now projects continually rising prices for international steam coal.⁵⁸

TATA MUNDRA: A CASE STUDY IN COAL PRICE RISKS



Given the rapidly changing economics of today's energy market, exposure to the risks outlined above have become increasingly acute. Nowhere is the nature and impact of this risk exposure more clearly demonstrated than the Tata Mundra coal-fired power project in Gujarat, India. The Tata Mundra power plant is one of a series of nine 4,000 MW "Ultra Mega" power plants ("UMPP") being planned for construction across India. It is also a clear example of the economic risks facing developers of new coal-fired plants today. As the price of coal more than doubled from the time the company bid on the project, the chief executive officer of Tata Power has now declared the project "economically unviable" given today's coal prices.⁵⁹

The Tata Mundra procurement process began in 2006 with competitive international bids solicited by the Indian government on "construct, own and operate over a 25 year period" terms. The bids submitted ranged from 2.236 Rs/kWh (\$0.044/kWh) to 3.746 Rs/kWh (\$0.074/kWh), reflecting vastly different understandings of the future cost of coal-fired generation.⁶⁰ The lowest bid, submitted by Coastal Gujarat Power Ltd., a subsidiary of Tata Power Company, Ltd. ("Tata Power"), was selected. The contract for the project was signed in 2007 and scheduled for completion in 2012. The first unit was brought on line in February 2012. A second unit is expected to come on line in the fall of 2012 and the remaining three units in 2013.

Tata Power has a 30 percent equity stake in the project; the balance of the funding is provided by loans from external commercial borrowings, a \$450 million International Finance Corporation ("IFC") loan, a \$450 million Asian Development Bank loan, and Rupee loans provided by domestic banks. While the public loans (IFC and ADB) are a minority portion of the overall debt, project sponsors asserted that the World Bank participation in particular was critical to obtaining long-term loans from other lenders. The project proponents assert that without the credibility and assurance these lenders provided to the project, it would have been far more difficult and expensive to secure financing for the project.

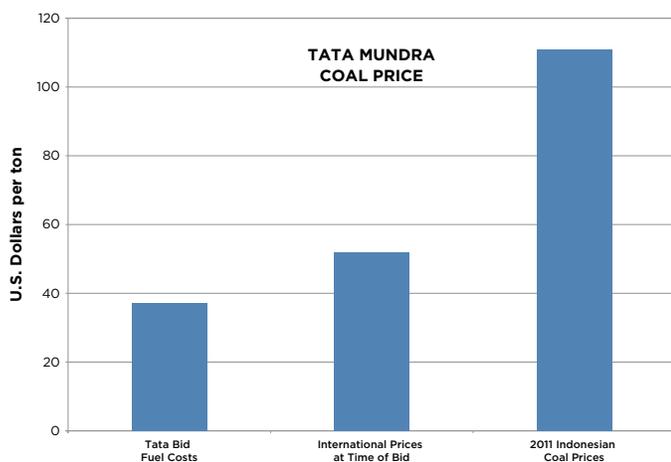
The actual cost of construction of the project is not yet known, but it appears that Tata Power may have underestimated the total project costs. Tata Power's bid was premised on a construction cost of slightly more than \$1 million/MW (\$4.2 billion for a 4000 MW plant), far less than the cost for similar plants, and substantially less than contemporaneous bids for other supercritical plants in India. Since 2005, capital costs for coal-fired power plants have increased by approximately 15 percent. In addition, since the date the contract was signed, the value of the rupee has fallen steadily. As of the writing of this paper the rupee has declined 20 percent against the dollar and 18 percent against the euro.

Adding to the potential underestimation of project costs are the substantial risks associated with the rapid rise in internationally traded coal prices. Steam coal prices have increased by \$60/mt since Tata Power submitted its fixed price bid of five years ago. For every \$28/mt rise in the cost of coal, wholesale electricity costs increase by approximately \$0.01/kwh. However, Tata Power cannot lawfully pass on these increased costs to its customers due to the nature of its contract and regulatory restrictions under Indian law. Tata Power is now demanding that the Indian government release it from its original contract and raise the tariff up to 40 percent above its original bid five years ago.

Tata Power's request comes in response to a regulation adopted by Indonesian authorities in late 2010 that establishes a minimum benchmark price for export sales of coal and other minerals. This law effectively doubled the price of coal exported from Indonesia, directly threatening the economic rationale on which the Tata Power project was based. Tata Power's bid was based on fuel (coal) costs of \$0.01290 and coal transportation costs of \$0.00384 which were set to increase very gradually over the next 25 years, so that by the end of the contract the fuel cost would be \$0.01308/kWh and transportation costs would be \$0.0047. Converting these prices into costs per ton of coal based on the proposed thermal efficiency of the plant and published data concerning the calorific value of internationally

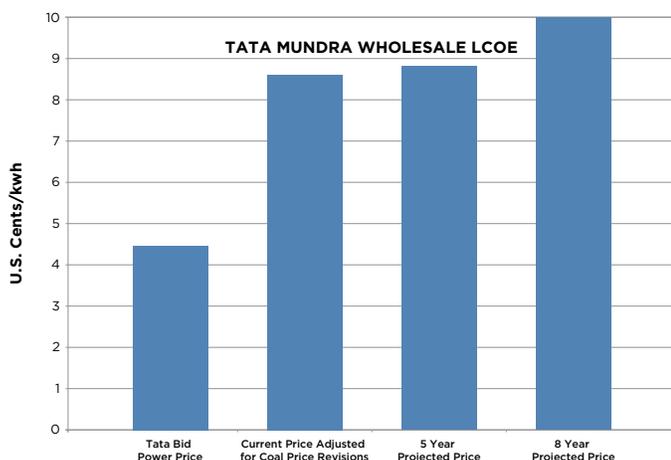
traded steam coal⁶¹ reveals that Tata Power's bid incorporated a 2012 coal price of \$36.86/mt that would rise over 25 years to \$37.37/mt; while shipping costs start at \$10.97/mt and rise to \$11.43/mt. Thus, Tata Power's coal price⁶² bid is \$15/mt less than the prevailing spot market price for Australian coal (FOB) at the time of its bid, \$25/mt less than published coal prices at the time of award and \$74.21/mt less than the most recent published Indonesian benchmark price of \$111.58/mt.⁶³ Thus, even before construction of the project is complete, coal prices are actually triple those cited by Tata Power in its bid.

FIGURE 9: Tata Mundra Electricity Price Impact From Rising Coal Prices



This paper will not attempt to predict what international coal prices will be in 2017. However, if the ten-year trend in Australian coal prices continues as it has, application of the equation of the trend line in Figure 3 leads to a FOB coal price of \$179/mt; \$68/mt greater than in March of 2012, which would add another \$0.024/kWh to the fuel costs and generate a wholesale price of \$0.086, roughly double the cost of electricity the Tata Mundra project is contractually obliged to provide. If the fuel costs increase over the next five years at the same rate they have since 2007,

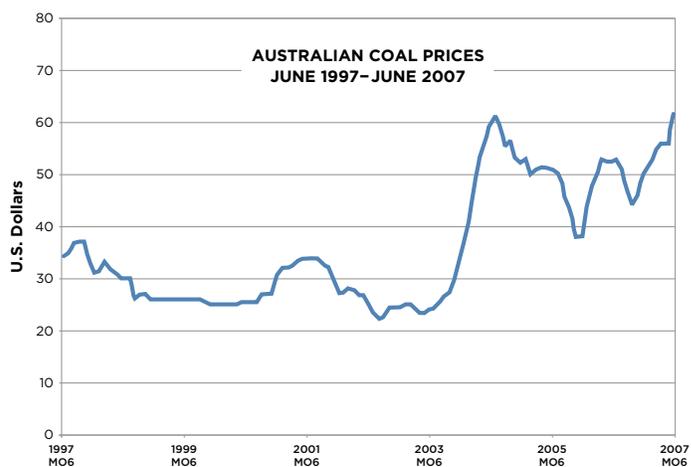
FIGURE 10: Tata Mundra Electricity Price (LCOE) Projections



the increase would be slightly larger at \$74.21/mt and \$0.26/kWh, for a wholesale price of 8.8 cents per kWh. Under either trend, the tariff needed to cover fixed and variable costs would exceed \$0.10/kWh in the next seven or eight years.

It should be noted that this discussion is limited to increases associated with the price of fuels and does not reflect the tariff to the consumers needed to pay for the added transmission line costs as well as the ordinary costs of transmission and distribution.⁶⁴ The low price quoted for the estimated capital cost for the project increases the risk that at some point in time Tata Power may seek increases in rates for “unforeseen” cost overruns. At the time of Tata Power's bid all parties — Tata Power, CERC, the IFC, ADB, and the commercial banks — knew or should have known that, just as \$1 per gallon gasoline was a thing of the past, so too were the low, stable coal prices of the 1970s and 1980s. Numerous articles had been published concerning the dramatic coal price increases that occurred in 2005.⁶⁵ The published commodity prices for international steam coal clearly demonstrated this increase.

FIGURE 11: Australian FOB Coal Prices June 1997–June 2007



When considered in light of the then-available information, it is difficult to understand how those reviewing Tata Power's bid could accept the notion that coal and coal transportation costs could be expected to remain at such low levels for 25 years. It is also surprising that India, a country with a strong tradition of its own resource nationalism, should have been caught so unprepared by the decision of the Indonesian government to change the pricing rules on foreign investors. India did that earlier itself with the infamous Enron Dabhol project; and it has been quite clear in response to lawsuits⁶⁶ against Coal India that India's domestic coal is going to be priced according to India's interests, not those of foreign investors. Sovereign risk, which should have

been clear since the Arab oil embargo, is a permanent feature of international trade in commodities, like marginally accessible coal, closely held within a few national economies.

The only real question was when, not whether, Tata Power and other UMPP developers would seek a rate increase, and it appears that no real thought was given to the impact on the Indian economy of a doubling or tripling of electricity prices. Indian companies have now invested several billions of dollars that might have been more wisely spent on alternative sources of energy had more realistic estimates of the cost of the projects been considered. These power companies have completed, or will soon complete, construction of several thousand MW of coal-fired generating capacity for which Coal India cannot provide sufficient coal. These units will either run at substantially less than full capacity or they will need to continue to import expensive steam coal.

As of this writing, the state government of Gujarat has rejected Tata Power's request for tariff increases, effectively deferring the issue to federal authorities, and the Indian Appellate Tribunal for Electricity ruled that a similarly situated company, Adani Power, was bound by the terms of the power purchase agreement it had signed.⁶⁷ These decisions raise the prospect that the operators will default on billions of dollars of loans and highlight the Hobson's choice that overly optimistic assumptions concerning the cost of coal-fired electricity create. On one hand, if the project operators default, the ability of other developers of power (including renewables) to obtain financing for other projects will be compromised and the plants may not operate for years as issues are addressed by bankruptcy courts. Yet, if regulatory authorities accept the premise that tariffs will be increased on the basis of the increased fuel costs, the government's relationship to these "independent power producers" will be altered forever. Under this new "re-regulated" regime, one can anticipate that the companies will seek additional rate increases for future increases in the cost of coal and may seek additional recoveries for construction cost overruns or based on fluctuations in the currency exchange rate.

As Indian authorities review the requests of Tata Mundra and others to revise contracts and increase tariffs⁶⁸ they should engage in a transparent review of the UMPP procurement process to determine whether the successful bids were made in good faith or whether they were "low ball" bids that the developers assumed would be revised upward at a later date. This review should be based on company and government documents rather

THE PUBLIC HEALTH CRIME OF UNCONTROLLED COAL-FIRED POWER PLANTS

"Among all industrial sources of air pollution, none poses greater risks to human health and the environment than coal-fired power plants. Emissions from coal-fired power plants contribute to global warming, ozone smog, acid rain, regional haze, and—perhaps most consequential of all from a public health standpoint fine particle pollution."⁷⁴

In the United States, studies estimate that fine particle pollution from existing coal plants causes 13,200 deaths, an estimated 9,700 hospitalizations, and more than 20,000 heart attacks per year. The total monetized value of these adverse health impacts adds up to more than \$100 billion per year. In addition, it is often the marginalized sections of society who live near power plants, as well as those who live in areas downwind of multiple power plants, that are likely to be disproportionately exposed to the health risks and costs of fine particle pollution.

The technology to dramatically reduce many of these impacts exists but is often excluded from new power plant proposals to minimize costs to the developer. There are now proposals for enormous levels of new coal-fired power plants in countries like India with little to no pollution control technology for a vast array of toxic pollution including sulfur dioxide, carbon monoxide, fine particulate matter, volatile organic compounds which lead to ozone formation, mercury, arsenic, lead, cadmium, and several other heavy metals. Worse, many in countries like India are cited in clusters leading to cumulative impacts that will exact a horrific toll in terms of morbidity and mortality for surrounding populations.

than representations of interested parties, and all such documents should be available for public review. The needs of the companies petitioning for review should be carefully determined, including the construction costs for the units incurred to date and those to be incurred for completion; the status of construction of each of the units (and the penalties associated with cancellation of the unit); the transmission and other infrastructure expenditures; and future needs. In addi-

tion, the contractual arrangements for coal supplies for each of the petitioners should be audited to determine what percentage of the increase in coal costs will go to companies in which the petitioners have an interest.

EXPENSIVE POWER OR NO POWER?

According to one Indian analyst, “India must choose between expensive power or no new power.” However, this was not the only choice in 2007 and is not the only choice today. The Indian Planning Commission has previously stated that “[s]everal [energy-efficiency] options are less expensive than coal or gas-based generation, and therefore, *should be the ‘first resource’ considered for fulfilling demand.*”⁶⁹ In March of 2012 the Indian government imposed a 6 percent energy efficiency improvement requirement on 400 of the largest industrial users of power, backed up by a \$200/mtoe fine for companies that fail to achieve this obligation.⁷⁰ Had the government recognized the likely cost of electricity from new coal-fired generation in 2007, it could well have adopted such a program at that time and might now be embarked on a third or fourth generation of industrial and commercial energy-efficiency programs. Such programs require an initial investment that customers may not be able to afford, but pay for themselves over a period of a few years in terms of energy savings.

Additionally, a substantial portion of the billions of dollars invested in international coal mines and coal-fired power plants could have been spent in reducing India’s considerable transmission and distribution losses. Further, had Indian officials considered the actual cost of new coal-fired generation in 2007, they may have made development of India’s substantial renewable energy resources a much higher priority.

This opportunity cost is tremendous given what India knows about its increasingly affordable clean energy resources today. Recent revisions of its wind energy potential have increased total installed capacity estimates from 45 GW to roughly 100 GW.⁷¹ At the same time discovered prices resulting from the first phase of the national solar mission have been half what were initially projected to be and have helped raise installed capacity from a meager 17 MW to over 506 MW in just two years.⁷² In fact, estimates are that solar alone could replace 30 percent of India’s coal imports.⁷³

KOSOVO —THE NEXT WORLD BANK COAL BOONDOGGLE?

Kosovo is one of the poorest nations in Europe and while it has substantial lignite deposits, and available hydropower and wind power resources, the country has no natural gas or oil reserves and no currently functioning pipeline to facilitate importing natural gas. Kosovo's energy needs are almost entirely met by two lignite-fired plants, Kosovo A (with a nominal capacity of 450 MW) and Kosovo B (with a nominal capacity of 600 MW), and some imports of electricity. Two of the units at Kosovo A have been closed for years and the pollution controls at both plants are substandard. Neither plant has been well maintained or operated. The Kosovo A plant has been identified as the most polluting plant in Europe and the government has pledged to close it by 2016 to resolve EU complaints about the plant's emissions.

The World Bank has conducted an analysis of a proposal to renovate Kosovo B⁷⁵ and construct a new 600 MW lignite plant (known as Kosovo C). This analysis employed obsolete construction cost estimates that had been designated as preliminary and significantly understated the likely cost of a new plant. It also underestimated the likely cost of lignite from a new mine that was to be created to meet the needs of the new plant. Most importantly, the World Bank analysis did not endeavor to determine whether the new plant would address Kosovo's needs or would be affordable.

A review of Kosovo's electric load patterns by the Sierra Club and the Kosovo Institute for Development Policy⁷⁶ concluded that the Kosovo B plant alone had sufficient capacity to meet Kosovo's base load needs and that addressing the very large (37 percent) technical and commercial losses were a higher priority that could provide additional useful capacity to accommodate future load growth at lower cost. The Sierra Club review determined that peak and load following (seasonal) demand was a significant part of the overall electric demand in Kosovo and that the World Bank proposal would not meet these needs. Importantly this review revealed the World Bank had never determined the amount of tariff increase that would be required to support the simultaneous construction of the new Kosovo C plant, refurbishment of Kosovo B, and development of the new mine — or had even considered whether the ratepayers could afford the cost of these investments, which could be

two to three times initial estimates and well in excess of a billion dollars.

In response to the Sierra Club review, the World Bank doubled the estimate of the cost of construction for the new plant and acknowledged the need (presumably to be addressed by others) for load following (seasonal) and peaking capacity, for improvements to the transmission system, and for the development of the renewable resources, but maintained that it would go forward with the construction of Kosovo C. The Kosovo Energy Corporation, operator of the Kosovo plants has recently acknowledged its agreement with many of the issues raised in the Sierra Club review⁷⁷, including the need for peaking capacity and transmission system upgrades. The final resolution of the Kosovo plant will not be known for some time, but it appears that, for the time being, Kosovars might not be forced to pay for base load capacity that they do not now need and cannot now afford. However, the history of the proposal demonstrates the very real danger to public welfare of overly optimistic "grand" plans for new coal-fired generation.



THE POTENTIAL IMPACT OF NATURAL GAS PRICES ON COAL-FIRED GENERATION OF ELECTRICITY

A factor that could contribute to significantly lowering global coal prices, and avoiding stranding billions of dollars in projects like Tata Mundra, would be the discovery and rapid production of large new reserves of unconventional gas. Natural gas and coal are in theory substitutes, which create a competitive environment that can drive down prices when significant supplies of either are brought into production. In the United States production of natural gas from unconventional formations has grown from 1 percent in 1990 to 23⁷⁸ percent of all U.S. natural gas consumption in 2010.⁷⁹ Low development costs and overly aggressive drilling have led to a glut in natural gas supplies. As a consequence, natural gas prices have decoupled from oil prices in the U.S. market and a Henry Hub⁸⁰ natural gas price of less than \$2.050/MMBtu for sustained periods in the winter and spring of 2012. Figure 12 sets out European and U.S. wholesale spot gas prices during this period.

However, while the increase in supply of low-cost⁸¹ unconventional natural gas has lowered wholesale electricity prices in the U.S. it has not led to conditions that would favor the increased generation of electricity from coal. Instead, while this generation has displaced coal-fired generation it has not resulted in lower prices for coal because the costs of producing coal are primarily driven by the price of embedded diesel fuel in transporting it, the increased difficulty of accessing

depleting reserves, and rent seeking by both transporters (railroads in particular) and sovereign exporters. Accordingly, there is no reason to believe that new large scale production of unconventional gas will exert significant downward pressure on international coal prices.

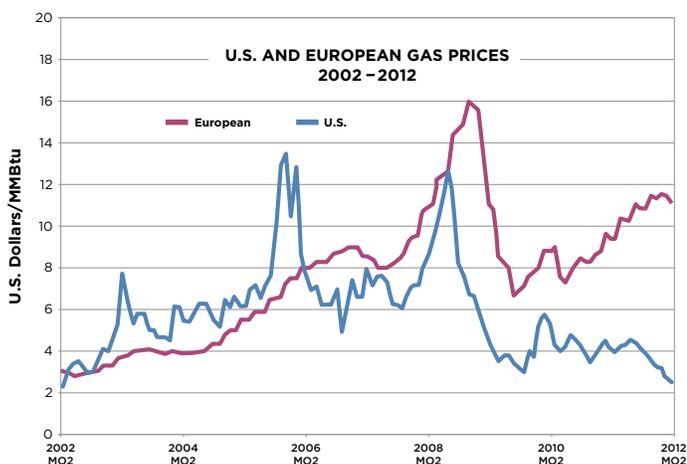
FIGURE 13: Worldwide Unconventional Gas Resources



However, the rapid commercialization of unconventional natural gas in the United States did not go unnoticed by the rest of the world. Gas bearing unconventional deposits are found in each continent and in a number of offshore areas.⁸⁶ Assisted by the United States,⁸⁷ exploration and early development activities are underway in a number of countries. Current surveys do suggest a strong potential in China, but only moderate potential in India, Japan, Korea, Vietnam, Bangladesh, Pakistan, the Philippines, and other major electricity consumers. Moreover, some large consumers of electricity, such as Japan, employ substantial quantities of liquefied natural gas, whose pricing is still tied to global oil prices that continue to trend upward.⁸⁸

It should be noted that international unconventional gas exploration and development is still at a very early and uncertain stage. Sweden has abandoned its efforts after determining that its unconventional resources are not commercially developable. The first two wells in Poland, thought to have the largest reserves in Europe, did not yield commercially developable gas, and recently estimates of recoverable reserves in Poland that were only one year old were reduced from 5.3 trillion cubic meters (tcm) to between 0.35 and 0.77 tcm.⁸⁹ Drilling

FIGURE 12: U.S. and European Natural Gas Prices 2002-2012



costs have been substantially higher in Poland than in the U.S. and the underlying rock has proven to be harder to penetrate. According to Exxon Mobil's CEO "[n]ew methods and tools need to be invented to tap some rocks in Europe and China and many fields may prove unresponsive to drilling techniques that worked in the U.S."⁹⁰

With the degree of understatement that often occurs with such developments, Indian developers reported finding an "unlimited reserve" of unconventional gas at the Durgapur basin in 2011 and, portrayed this single reservoir as "the potential answer to the world's energy woes."⁹¹ However, this assertion was based on the results of a single well. India does not anticipate leasing unconventional gas production rights for at least another year and has recently partnered with Conoco

Phillips to gain technical understanding of how best to develop its resources."⁹² The nature of this partnership, "... a broad memorandum of understanding, without any financial commitment at this stage,"⁹³ reveals that India is still very early in the process of determining whether and at what cost its unconventional gas resources can be developed.

Similarly, China is at a very early stage in the development of its unconventional gas resources and signed its first production contract with Shell Oil in March of 2012. However, China appears to be moving toward developing its unconventional gas resources at a more aggressive rate. Approximately 20 appraisal wells have been completed in a number of different development blocks; commercial flow rates have been achieved in a number of these wells.⁹⁴ The Chinese government plans

ENVIRONMENTAL CONCERNS ASSOCIATED WITH DEVELOPMENT OF UNCONVENTIONAL NATURAL GAS

Although generation of electricity using natural gas generates 40 to 50 percent less CO₂ than coal-fired generation, depending on relative plant efficiency, increased emissions from the natural gas production process offset this benefit.⁸² Natural gas systems, and especially unconventional natural gas production, produce large amounts of methane, an extremely potent greenhouse gas. Recent analyses suggest that methane leak rates above 3 percent of total production may offset any climate advantage that the combustion efficiency difference otherwise provides,⁸³ and that leaks are present even in relatively well-controlled gas production fields in the United States.⁸⁴ Climate modeling is also demonstrating that wholesale coal-to-gas switching does not reduce total emissions enough to bring global temperature increases resulting from those emissions within safe levels.⁸⁵ Natural gas combustion does have other benefits over coal, however, as it generates lower emissions of conventional pollutants, such as SO₂ and NO_x, and hazardous air pollutants, such as mercury.

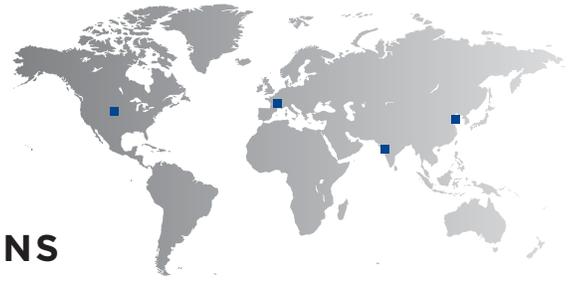
However, as with the mining and transportation of coal, natural gas production and transmission is associated with significant environmental impacts, and unconventional natural gas production, which will likely dominate future gas supplies, has particularly high environmental risks. Natural gas production and transmission generates large amounts of air pollution, including leaks of volatile organic compounds,

which form smog and can cause cancer. Substantial questions have also been raised about the contamination of drinking water by the chemicals employed in the "fracking" process and by methane and other gases escaping from wells. Improper management of "flowback" and "produced" water returning from these wells, which is generally highly contaminated, can also cause significant water pollution, as can sediment run-off from the vast network of sites needed for production and transmission. Concerns are also increasingly being raised about damage from earthquakes caused by injection wells used for waste disposal, and about the major disruption to existing landscapes, wildlife, and communities which are associated with the shale gas boom.

These issues have been raised by scientists and environmental organizations and have led several jurisdictions in the U.S. and elsewhere to ban the "fracking" process used to develop unconventional gas. The U.S. EPA has commissioned studies and commenced rulemaking activities. However, the question of whether unconventional natural gas will, or can, be developed in an environmentally sound manner is as yet unanswered. Unconventional natural gas development is discussed in this paper, not as an endorsement of the technology as currently deployed, but because it may be relevant to the question of whether coal-fired generation will be more expensive over time.

to drill 200 wells by 2013 and has set production targets of 6.5 BCM/yr by 2015 and up to 100 BCM/yr by 2020 — an amount roughly equal to China's 2010 consumption of natural gas.⁹⁵

The effect of Chinese development of its unconventional gas resources on international coal prices cannot be gauged without knowing the rate of growth of Chinese energy demand and whether the Chinese government is willing to invest in additional natural gas base load generating capacity and strand its massive investment over the past few years in coal-fired power plants. Since Chinese domestic coal prices reportedly do not cover current costs, the addition of lower cost natural gas supplies may simply displace coal generation (as in the U.S.) and not reduce coal prices or spur an increase in coal generation. Ultimately, China will continue to arbitrage imports and maintain price pressure in international coal markets.



THE CROSSOVER POINT BETWEEN COAL-FIRED GENERATION AND RENEWABLE AND EFFICIENCY OPTIONS

On review of the trends of the past several decades it appears that only a breakout in unconventional natural gas supplies would lead to significantly reduced fossil fuel electricity prices worldwide, and then only in those countries with pipeline access to such reserves, since the costs of compressing and shipping LNG ensure that even cheap-at-the-wellhead gas cannot provide cheap kilowatt hours of electricity if delivered as LNG. Even if such plays are found to be commercially viable over the next five years, and the potentially significant environmental impacts mitigated, greatly increased low-cost natural gas supplies would not be expected to be commercially significant for another decade or two. Unless and until such developments occur, the most plausible scenarios would be for the prices of coal-fired and natural gas-fired power to continue to escalate as they have, or perhaps at a greater rate than currently experienced. Ultimately, as the Indian, and Kosovo coal plants examples clearly illustrate, the underlying economic rationale for new coal-fired power plants — that they are cheap sources of power — is simply no longer true. Under these scenarios, prices for electricity from an increasing number of renewable sources are a less expensive option than new coal-fired power plants for both developed and developing nations. As the cost of fossil-fueled electricity generation continues to increase “[a] portfolio of renewable energy technologies is becoming competitive in an increasing range of circumstances and countries.”⁹⁶

ENERGY EFFICIENCY PROGRAMS — THE CHEAPEST SOURCE OF NEW POWER

Residential energy efficiency programs have been implemented at some level in the United States since the passage of federal legislation in the 1970s. Where utilities were subsequently deregulated in the 1990s, utility scale energy efficiency programs continued in many states where “system benefits” charges were imposed to fund such investments. While there is some disagreement as to how to determine the cost of these programs, the utilities themselves identified costs that

trended in the 3-4 cent/kWh range. A recent comprehensive study of the cost of such residential programs puts the cost of these programs to the utility at 5 cents/kWh, substantially less than the 8-9 cents per kWh estimated by the EIA for the cost of new coal-fired electricity.⁹⁷

Commercial and industrial energy efficiency programs offer far greater opportunities for cost effective savings.⁹⁸ For some projects, the capital cost of the efficiency upgrade can be offset by savings in electricity usage in as little as one or two years.⁹⁹ Many developing countries, most notably China, now routinely bundle energy efficiency measures into what are known as “energy efficiency power plants” that are able to provide the same level of power in “negawatts” at substantially lower costs than building new costly coal plants.¹⁰⁰

CLEAN RENEWABLE ENERGY — TODAY'S CHEAP FORM OF ENERGY

While the cost of coal continues to rise, over the past decade the cost of wind and solar has fallen dramatically. Most reliable estimates put the levelized cost of new wind power at between 5 and 10 cents/kWh¹⁰¹ — at or below the cost of new coal-fired power in the United States and, at current international coal prices, in Asia. The U.S. Energy Information Agency now agrees that wind power at most sites in the United States will be cheaper than new coal-fired plants by 2016.¹⁰² The same holds true for many developing economies. In March of 2012, the Lawrence Berkeley National Laboratory published its reassessment of India's wind resources based on these higher hub heights and concluded that the resource is approximately 20 times greater than the current government estimate. This study concluded that India has approximately 100 GW of capacity that can be developed for less than 4.0 Rs/kWh (\$0.078/kWh) and an additional 200 GW of capacity that can be developed for less than 4.5 Rs/kWh (\$0.087/kWh).¹⁰³ In addition, the industry has developed designs with larger rotors to improve efficiency in areas where the wind velocities are lower. As a consequence of these

design advancements, the LCOE of new wind farms is now projected to fall over the next two or three years to the lowest levels in a decade.¹⁰⁴

While the cost of utility scale, remote solar thermal and photovoltaic (“PV”) electric generation remains higher than base-load coal-fired generation, PV generation correlates well with peak loads in most countries and its true costs compete with peak-load coal power or where systems pay a high price to import or generate power during peak periods. (In some countries peak-load power is under-priced, so solar may look expensive in the marketplace — but its true cost to society is

competitive or lower). Because of the very high cost of installing transmission lines distributed, small scale distributed PV systems are also often times less expensive than conventional generation, and almost invariably and by a large margin undercut the cost of diesel or gas-line powered remote generators. In developing countries, the source of power for lighting may be limited to candles or kerosene burners. In such instances, PV can provide a highly cost effective alternative, especially if CFB or LED lights are employed and can provide power for internet access, to support cell towers or to re-charge cell phones and portable computers.





CONCLUSION: A RATIONAL EXAMINATION OF THE ECONOMIC RISKS OF COAL-FIRED POWER PLANTS

The business community has started to recognize that the era of cheap power from coal may be over.¹⁰⁵ However, the continued failure to assign a risk factor for new coal-fired power where it is economically untenable shows that some policymakers as well as some independent power producers have failed to grasp the economic realities facing new coal-fired generation today. It is clear that financial institutions should exercise their own independent review of the fundamentals of proposed projects. Where, as in the Tata Mundra case, the future cost of coal or other key features are not demonstrably correct, based on the best available data, approval should be withheld, notwithstanding the nature of the Power Purchase Agreement that is to be executed.

OUR RECOMMENDATIONS:

- **Assume rising coal prices:** In particular, for the foreseeable future, financial institutions should assume that domestic coal costs will rise to international coal prices over the next 10 years and that international coal costs will increase at the rate of at least 6 percent per year (or two percent more than the rate of inflation, whichever is greater) for the life of the plant.
- **Assume accurate discount rates:** Inappropriate discount rates can discriminate against projects with relatively high percentages of CapEx relative to OpEx. In particular, for purposes of internal evaluation financial institutions should use a discount rate equal to its proposed lending rate for the project, not a discount rate based on the cost of capital asserted by the proponent of the project.
- **Establish a risk premium:** Financial institutions should review data concerning the variability of the factors listed above in the host country and establish a “risk premium” to monetize the risk of project failure for fossil-fueled projects based on the increase in the cost of fuel over the lifetime of the plant, in comparison to alternatives including energy efficiency and clean energy projects, where such risks are not present.

Ultimately, there are energy efficiency options to help mitigate the potentially significant financial repercussions of risky “mega” coal investments. There are also cost effective clean energy alternatives that can help meet energy needs. These alternatives can also help mitigate the potential political risks over reliance in coal-fired electricity creates. The Tata Mundra example demonstrates the potential consequences of approving massive coal projects that are “too big to fail” without a rigorous review to determine whether the underlying fundamentals of the bid are sound. It and the Kosovo example also reveal deficiencies in the procedures of many leading financial institutions, including the World Bank, for evaluating fossil-fueled projects compared to renewable energy. For a wind, solar, or geothermal plant that can be operational in a year, the cost of procurement can be documented at the time of the contract and forward based risks can be minimized by extensive data acquisition prior to construction. However, calculations of the LCOE of a coal-fired power plant are extremely sensitive to the cost of construction of the plant, the discount rate employed, the currency exchange rate, and the estimate of the cost of coal. For a large coal-fired plant, planning and construction can exceed five years and the fuel cost and currency exchange rates can vary widely over the life of the plant. As the Tata Mundra case shows, these factors cannot be controlled and “fixed price” contracts cannot be relied upon to manage the risk to the ratepayers and the economy.

ENDNOTES

- 1 March, 2012 World Bank Commodity Price Data Report (“WB Pink Sheet”).
- 2 WB Pink Sheet, supra.
- 3 The American and British Wind Energy Associations estimate the cost at between 5 and 6 cents/pence per kWh, while the U.S. EIA places the cost at 8 cents/kWh for the best sites and 9.7 cents/kWh for the average site.
“Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011.” *U.S. Energy Information Administration*. Nov. 2010. Web. <http://www.eia.gov/oiaf/aeo/electricity_generation.html>.
- 4 “Solar PV becoming cheaper than natural gas in California?” *Renewable Energy World*. Web. <<http://www.renewableenergyworld.com/rea/news/article/2011/02/solar-pv-becoming-cheaper-than-gas-in-california>>.
- 5 “Re-considering the Economics of Photovoltaic Power.” BNEF. Web. <<http://www.bnef.com/WhitePapers/download/82>>.
- 6 “U.S. Coal’s share of total net generation continues to decline.” *Energy Information Administration*. Web. <<http://205.254.135.7/todayinenergy/detail.cfm?id=6550>>.
- 7 Average for the EU-27 countries, <http://ec.europa.eu/energy/publications/statistics/doc/2011-2009-country-factsheets.pdf>.
- 8 A gigawatt is one billion (109) watts or 1000 megawatts (“MW”).
- 9 Shaffer, David. “Brand New Power Plant Is Idled by the Economy.” *StarTribune.com*. 9 Jan. 2012. Web. <<http://www.startribune.com/business/134647533.html>>.
- 10 Shuster, Erik. “Tracking New Coal-Fired Power Plants.” *Cmnnow.org*. 1 May 2007. Web. <<http://www.cmnnow.org/NETLpercent20Newpercent20Coalpercent205.2007.pdf>>.
- 11 Katzner, J. *The Future of Coal: Options for a Carbon-constrained World*. [Cambridge, MA]: MIT, 2007.
- 12 “American Wind Power.” *Powerofwind.com*. Web. <<http://www.awea.org/learnabout/publications/upload/AmericanWindpowerBrochure.pdf>>.
- 13 Trabish, Herman K. “New Study: Solar Grid Parity Is Here Today.” *Greentech Media*. 7 Dec. 2011. Web. <<http://www.greentechmedia.com/articles/read/New-Study-Solar-Grid-Parity-Is-Here-Today/>>.
- 14 Lacey, Stephen. “Solar PV Becoming Cheaper than Gas in California?” *Renewable Energy World*. 8 Feb. 2011. Web. <<http://www.renewableenergyworld.com/rea/news/article/2011/02/solar-pv-becoming-cheaper-than-gas-in-california>>.
- 15 “Photovoltaic Solar Power.” *IEA ETSAP Technology Brief*. Web. <http://iea-etsap.org/web/Highlightspercent20PDF/E11_PV_gs_am_gb_gsEPIA2011_FINALDRAFTpercent201.pdf>.
- 16 “Re-considering the Economics of Photovoltaic Power.” BNEF. Web. <<http://www.bnef.com/WhitePapers/download/82>>.
- 17 IBID
- 18 Leun, Kees Van Der. “Solar PV Rapidly Becoming the Cheapest Option to Generate electricity.” *Grist*. 11 Oct. 2011. Web. <<http://grist.org/solar-power/2011-10-11-solar-pv-rapidly-becoming-cheapest-option-generate-electricity/>>.
- 19 Carbon, Post. “Why Coal Prices Will Soar in the Coming Years.” *Oilprice.com*. 19 July 2011. Web. <<http://oilprice.com/Energy/Coal/Why-Coal-Prices-Will-Soar-In-The-Coming-Years.html>>.
- 20 See Beyondcoal.org
- 21 This figure includes simple cycle gas turbines as well as NGCC. Source: RWE, HSBC estimates.
- 22 See, “42.” *Steam, Its Generation and Use*. 40th ed. New York: Babcock & Wilcox, 1978.
- 23 In the last few years of a plant’s useful life maintenance costs and forced outages may render further operation of the plant uneconomic.
- 24 At the same time construction costs for wind and solar are going down, so the time lag in reporting distorts rational investment decisions in both directions — makes coal seem unrealistically cheap and renewables unrealistically expensive.
- 25 See, “Updated Capital Cost Estimates for Electricity Generation Plants.” *U.S. Energy Information Administration*. Nov. 2010. Web. <http://www.eia.gov/oiaf/beck_plantcosts/index.html>.
- 26 “Projected Costs of Generating Electricity.” *International Energy Agency*. 2010. Web.
It should be noted that costs reported to the IEA for construction in China were substantially lower at \$663 and \$740/kW.
- 27 March, 2012 World Bank Commodity Price Data Report (“WB Pink Sheet”).
- 28 Recently, local “pro-coal” objections have pushed for a reversal of this decision.
- 29 Shaffer, David. “Brand New Power Plant Is Idled by the Economy.” *StarTribune.com*. 9 Jan. 2012. Web. <<http://www.startribune.com/business/134647533.html>>.
- 30 “Tracking New Coal-fired Power Plants.” *NETL*. Web. <<http://www.netl.doe.gov/coal/refshelf/ncp.pdf>>.
- 31 “U.S. Coal’s share of total net generation continues to decline.” *Energy Information Administration*. Web. <<http://205.254.135.7/todayinenergy/detail.cfm?id=6550>>.
- 32 “Projected Costs of Generating Electricity.” *International Energy Agency*. 2010. Web.
- 33 Updated March 5, 2012. Prices reflect current U.S. dollars. The crude oil price reported by the World Bank is the average spot price of Brent, Dubai and West Texas Intermediate crude products, equally weighted. The natural gas (Europe) price is the average import border price and a spot price component. Prior to March 2010 the price excludes UK gas; thereafter UK prices are included. It should be noted that a barrel of oil provides about one-fourth the heat energy as a metric ton of steam coal.
- 34 Ocean transport costs are not included in these data.
- 35 Source: “WB Pink Sheet”, supra.
- 36 See, “E-COAL.COM Coal Prices, Tenders and Market News.” *E-COAL.COM*. Web. <http://www.e-coal.com/>.
- 37 This is not to suggest that these countries have formed an organization of coal exporting countries similar to OPEC; but that “mark to market” pricing policies produce the same outcome.
- 38 It should be noted that the Indonesian government has plans to enforce domestic consumption quotas, a ban on export of unprocessed low-heat content coal, and a further increase in export taxes that will further impact the global market.
- 39 “Aussie Tax May Push Global Iron Ore, Coal Prices.” *MSN News*. 22 Mar. 2012. Web. <<http://news.in.msn.com/business/article.aspx?cp-documentid=5947439>>.
- 40 WB Pink Sheet, supra.
- 41 This calculation assumes that the plant has a heat rate of 10,700 Btu/kWh and that the delivered coal has a heat value of 12,060 Btu/lb.
- 42 This calculation assumes a plant heat rate of 9500 Btu/kWh.
- 43 Naidu, Katya B., and Abhijit Lele. “Power Plants in Pause Mode, Lenders Press Panic Button.” *Business Standard*. 3 Aug. 2011. Web. <<http://www.business-standard.com/india/news/power-plants-in-pause-mode-lenders-press-panic-button/444689/>>.
- 44 The reason for this counter intuitive result may be related to the lack of concentration in the U.S. coal market. Unlike many other countries that consume large amounts of coal, production in the United States is widely dispersed among a large number of large and small entities and so the market has been price competitive for some time. The production and transportation costs form a floor that limits the extent to which coal prices will be reduced by these producers.

- 45 "Total Energy." *U.S Energy Information Administration*. 19 Oct. 2011. Web. <<http://205.254.135.24/totalenergy/data/annual/showtext.cfm?t=ptb0709>>.
- "AEO Table Browser." *U.S Energy Information Administration*. Web. <<http://www.eia.gov/oiarf/aeo/tablebrowser/>>.
- "U.S. Energy Information Administration — EIA — Independent Statistics and Analysis." *2011 Brief: Wholesale Electricity Prices Mostly Lower in 2011*. Web. <<http://www.eia.gov/todayinenergy/detail.cfm?id=4530>>.
- 46 "U.S. Energy Information Administration — EIA — Independent Statistics and Analysis." *EIA*. Web. <http://www.eia.gov/forecasts/aeo/er/early_prices.cfm>.
- 47 Morse, Richard. "The World's Greatest Coal Arbitrage: China's Coal Import Behavior and Implications for the Global Coal Market" *Stanford University*. Web. <http://pesd.stanford.edu/publications/the_worlds_greatest_coal_arbitrage_chinas_coal_import_behavior_and_implications_for_the_global_coal_market>.
- 48 See, For example, Murdoch, Jessica. "China Announces Discovery of Asia's Largest Coal Reserve." *GEMCOM*. 23 Dec. 2011. Web. <<http://info.gemcomsoftware.com/blog/bid/112131/China-announces-discovery-of-Asia-s-largest-coal-reserve>>.
- 49 Xinhau. „Inner Mongolia Reports Rise in Coal Reserves." *Chinadaily.com*. 10 Feb. 2012. Web. <http://www.chinadaily.com.cn/bizchina/2012-02/10/content_14579812.htm>.
- 50 Rui, Huaichuan, Richard K. Morse, and Gang He. "Remaking the World's Largest Coal Market: The Quest to Develop Large Coal-Power Bases in China." *Program on Energy and Sustainable Development*. Web. <<http://pesd.stanford.edu/publications/23050>>.
- 51 Dharmadhikary, Shripad, and Shantanu Dixit. "Thermal Power Plants on The Anvil: Implications And Need For Rationalization." *Prayas Energy Group*. Web. Aug. 2011. <<http://www.prayaspune.org/peg/publications/item/164-thermal-power-plants-on-the-anvil-implications-and-need-for-rationalisation.html>>.
- 52 IEA Coal Statistics, 2010.
- 53 Dutta, Ratnajyoti. "UPDATE 1-India 2012/13 Coal Import Needs Seen 140 Mln T-source." *Reuters*. 28 Feb. 2012. Web. <<http://reut.rs/KfRiad>>.
- 54 The Children's Investment Fund Wages Battle with Coal India. *New York Times*. Available at <http://bit.ly/JFIXKt>
- 55 Singh, Sudheer Pal. "New Coal Royalty Formula to Hit Captive Miners." *Business Standard*. 26 Apr. 2012. Web. <<http://www.business-standard.com/india/news/new-coal-royalty-formula-to-hit-captive-miners/472668/>>.
- 56 "Steam Coal Prices for Electricity Generation." *Energy Information Administration*. 10 June 2010. Web. <<http://www.eia.gov/emeu/international/stmforelec.html>>.
- 57 See, Hirsch, Robert L., Roger H. Bezdek, and Robert M. Wendling. *Peaking of World Oil Production: Impacts, Mitigation and Risk Management*. New York: Novinka, 2005.
- 58 Roper, Ian, and YiangXiang Zhao. "Coal Outlook." *CLSA*. 18 Nov. 2010. Web. <http://www.blackgoldglobal.net/upload/CLSApercent20Novpercent2010percent20Full_report.pdf>.
- 59 Daltorio, Tony. "Thermal Coal Prices Predicted To Rise; Producers To Benefit — Seeking Alpha." *Seeking Alpha*. 20 Dec. 2011. Web. <<http://seekingalpha.com/article/315137-thermal-coal-prices-predicted-to-rise-producers-to-benefit>>.
- 60 "CENTRAL ELECTRICITY REGULATORY COMMISSION." 9 Nov. 2010. Web. <http://www.cercind.gov.in/2010/November/Signed_Order_256-2010_RE_Tariff_FY_11-12.pdf>.
- 61 For this calculation a heat rate of 8,700 Btu/kWh was assumed for the Tata Mundra plant and a value of 11,340 Btu/lb was assumed for the calorific value of the coal.
- 62 A reliable source for international steam coal prices landed in the Port of Mundra has not been identified as of the date of publication of this memorandum. International shipping prices have been highly variable and have ranged from \$20/ton to over \$50/ton in recent years.
- 63 "Indonesia Raises Coal Prices for First Time in Four Months." *Business Week*. 13 Feb. 2012. Web. <<http://www.businessweek.com/news/2012-02-13/indonesia-raises-coal-price-for-first-time-in-four-months.html>>.
- 64 It also does not include second order effects, such as the increased cost of maintaining a 90-day inventory of coal.
- 65 "No Indication of Coal Price Drop in 2005." *The China Daily*. 7 Apr. 2005. Web. <http://www.chinadaily.com.cn/english/doc/2005-04/07/content_432035.htm>.
- "US Coal Prices Increase Dramatically." *Power Engineering*. 25 Aug. 2005. Web. <<http://www.power-eng.com/articles/2004/08/us-coal-prices-increase-dramatically.html>>.
- "Indonesian Coal Miners Initiate Benchmark." *Steelguru*. 23 July 2005. Web. <http://www.steelguru.com/international_news/Indonesian_Coal_miners_initiate_benchmark/625.html>.
- 66 "TCI to Initiate Legal Action against Coal India in a Week." *Business Line*. Web. <<http://www.thehindubusinessline.com/companies/article3317520.ece>>.
- 67 Mahkijani, Shakuntala. "Rising Economic, Environmental, and Human Costs of Coal in India." *Revolt*. 7 Mar. 2012. Web. <<http://blogs.worldwatch.org/revolt/rising-economic-environmental-and-human-costs-of-coal-raise-questions-for-indias-energy-future/>>.
- 68 State Electricity Boards in Tamil Nadu, Andhra Pradesh, Bihar and Orissa have recently raised power tariffs by 12 percent–37 percent. The amount of the tariff varies according to the amount consumed and rises as high as \$0.11 kWh.
- 69 Planning Commission, 2011. *Interim Report of the Expert Group on Low-Carbon Strategies for Inclusive Growth*, at 31.
- 70 "Gov't Introduces Energy Efficiency Norms for Industry — Economy and Politics — Livemint.com." *Livemint*. Web. <<http://www.livemint.com/2012/03/31174516/Govt-introduces-energy-efficie.html>>.
- 71 "Asia Report: India's Wind Potential 30 Times Greater Than Believed?" *Renewable Energy World*. 26 Mar. 2012. Web. <<http://www.renewableenergyworld.com/rea/news/article/2012/03/asia-report-indias-wind-potential-30-times-greater-than-believed>>.
- 72 "Laying the Foundation for a Bright Future." *NRDC*. 4 May 2012. Web. <<http://www.nrdc.org/international/india/national-solar-mission-ph1.asp>>.
- 73 "The Rising Sun." *KPMG*. May 2011. Web. <https://www.kpmg.com/IN/en/IssuesAndInsights/ThoughtLeadership/The_Rising_Sun_full.pdf>.
- 74 Schneider, Conrad, and Jonathan Banks. "The Toll From Coal." *Clean Air Task Force*. Sept. 2010. Web. <http://www.catf.us/resources/publications/files/The_Toll_from_Coal.pdf>.
- 75 Under the proposal the World Bank would participate in funding the new Kosovo C plant, but not in refurbishing Kosovo B plant or other needed improvements.
- 76 Buckheit, Bruce C. "Affordable Electricity for Kosovo?" *Sierra Club*. Oct. 2011. Web. <http://action.sierraclub.org/site/DocServer/Review_of_TOR_Final.pdf?docID=8341>.
- 77 KEK analysis and commentary on Sierra Club reports. April 2010. Available at <http://bit.ly/KWAfff>
- 78 "Review of Emerging Resources: U.S Shale Gas and Shale Oil Plays." *U.S Energy Information Administration*. July 2011. Web. <<ftp://ftp.eia.doe.gov/natgas/usshaleplays.pdf>>. Web.

- 79 The existence of large scale unutilized natural gas capacity in the United States provided a ready means of quickly shifting electric generation away from coal-fired generation as this low-cost “unconventional” gas entered the marketplace. Wholesale spot electricity prices have fallen from an average of \$87/MWh in the first quarter of 2008 to \$39/MWh in December of 2011 but, as discussed above, have not led to lower coal prices in the U.S.
- 80 The Henry Hub in Louisiana is one of the key benchmark prices in the U.S.
- 81 It should be noted that the current trading price of gas is substantially less than the estimated cost of completion of new unconventional gas wells (\$5-6/MMBtu). Most analysts project a reduction in the rate of developing new wells in the U.S., particularly in those locations where the natural gas produced has low levels of associated “high value” liquids. However, these analysts also project that it will take some time for the supplies of natural gas to rebalance with demand at levels approaching the cost of developing new wells. At \$5.00/MMBtu, fuel costs for a high efficiency NGCC plant would be approximately \$35/MWh. Overall generation costs for such a unit would still be substantially less than for a new coal-fired unit at most locations. This would be especially true for those NGCC units built ten or twenty years ago, where debt and equity costs, if any remain, would be substantially less than for a new coal-fired unit.
- 82 The average CO₂ emission rate for all coal-fired generation in the U.S. is 2249 lb/MWh, while it is 1135 lb/MWh for all natural gas-fired generation (simple cycle and combined cycle). <http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html>.
- 83 Alvarez et al., *Greater focus needed on methane leakage from natural gas infrastructure*, Proceedings of the National Academy of Sciences (2012).
- 84 Pétron et al., *Hydrocarbon emissions characterization in the Colorado front range – A pilot study*, Journal of Geophysical Research, in press (2012).
- 85 Myrhvold and Caldeira, *Greenhouse gases, climate change and the transition from coal to low-carbon electricity*, Environ. Res. Letters (2012).
- 86 “Mark Latham Commodity Equity Intelligence Service.” *Commodity Intelligence*. 8 Apr. 2011. Web. <<http://www.commodityintelligence.com/4-8Apr11.htm>>.
- 87 The State Department is the lead agency in the United States’ Global Shale Gas Initiative “Full Report in PDF (51.4 Mb).” *U.S. Energy Information Administration*. 5 Apr. 2011. Web. <<http://www.eia.gov/analysis/studies/worldshalegas/>>.
- 88 “WB Pink Sheet data”, supra.
- 89 These reserves, if commercially viable would still be substantial for Poland. By themselves, they would not have the impact on the European market that unconventional gas has had on the U.S. market. Estimates of reserves in the Marcellus Shale play in the United States have also recently been substantially reduced from earlier estimates.
- 90 ExxonMobil was the lead developer in this project. Strzelecki, Marek. “Shale Boom in Europe Fades as Polish Wells Come Up Empty.” *Bloomberg*. 26 Mar. 2012. Web. <<http://www.bloomberg.com/news/2012-03-26/shale-boom-in-europe-fades-as-polish-wells-come-up-empty-energy.html>>.
- 91 Chakraborty, Debajyoti. “Asia’s First Shale Gas Pool Found near Durgapur.” *The Times of India*. 26 Jan. 2011. Web. <<http://timesofindia.indiatimes.com/business/india-business/Asias-first-shale-gas-pool-found-near-Durgapur/articleshow/7364812.cms>>.
- 92 “Conoco Phillips, ONGC in pact for shale gas exploration.” *Reuters*. Web. <<http://in.reuters.com/article/2012/03/30/ongc-conocophillips-shale-gas-idINDEE82TOC020120330>>
- 93 “UPDATE: ONGC, ConocoPhillips To Sign Pact On Exploration, Development — Executives.” *NASDAQ.com*. Web. <<http://www.nasdaq.com/article/update-ongc-conocophillips-to-sign-pact-on-exploration-development—executives-20120330-00068>>.
- 94 “Shell Gets China’s 1st Shale Gas Deal.” *Reuters*. 21 Mar. 2012. Web. <<http://uk.reuters.com/article/2012/03/22/us-shell-cnpc-shale-idUKBRE82L02120120322>>.
- 95 Cooperative agreements have also been signed with Statoil, BP, Chevron, and ExxonMobil. “Energy, Markets and Money.” *China Shale Gas... The New Frontier*. 19 Mar. 2012. Web. <<http://energyandmoney.blogspot.com/2012/03/china-shale-gas-new-frontier.html>>
- 96 This acknowledgement was made, not by an environmental organization or by a representative of a renewable industry trade organization, but by the Executive Director of the IEA, which has been criticized as being biased toward fossil-fueled electric generation.
- “IEA Recognizes Ascent of Renewable Energy Market with New Report.” *Oil & Gas Financial Journal*. 23 Feb. 2012. Web. <<http://www.ogfi.com/articles/2012/02/iea-recognizes-ascent-of-renewable-energy-market-with-new-report.html>>.
- 97 “Cost-Effectiveness of Electricity Energy Efficiency Programs.” RFF. Apr. 2011. Web. <<http://www.rff.org/RFF/Documents/RFF-DP-09-48-rev.pdf>>.
- 98 “Unlocking Energy Efficiency in the U.S.” *McKinsey Global Energy and Materials*. July 2009. Web. <http://www.mckinsey.com/Client_Service/Electric_Power_and_Natural_Gas/Latest_thinking/-/media/McKinsey/dotcom/client_service/EPNG/PDFs/Unlockingpercent20energypercent20efficiency/US_energy_efficiency_full_report.aspx>.
- 99 “Industrial Energy Cost Reduction Past Projects.” *Onsite Energy*. Web. <<http://www.onsitenergy.com/projects.asp>>.
- This website provides links to other substantial industrial energy efficiency projects, including one that suggests substantial energy savings in the manufacture of cement with minimal upfront investment.
- 100 Weston, Frederick. Virtual Power Plants: Mobilizing Demand-Side Resources to support renewables goals. Regulatory Assistance project 2012. “Virtual Power Plants.” *Rap*. 24 Feb. 2012. Web. <http://forumees.pl/gfx/ees/userfiles/files/34_forum/3.pdf>.
- 101 The American and British Wind Energy Associations estimate the cost at between 5 and 6 cents/pence per kWh, while the U.S. EIA places the cost at 8 cents/kWh for the best sites and 9.7 cents/kWh for the average site. http://www.eia.gov/oiarf/aef/electricity_generation.html
- 102 “Levelized Cost of New Generation Resources in the Annual Energy Outlook 2011.” U.S Energy Information Administration. Nov. 2010. Web. <http://205.254.135.24/oiarf/aef/electricity_generation.html>.
- 103 “Reassessing Wind Potential Estimates for India: Economic and Policy Implications.” *Berkeley Lab*. Web. <[http://ies.lbl.gov/drupal/files/ies.lbl.gov.sandbox/IndiaWindPotentialAssessmentRevisedFinal03202012\[1\].pdf](http://ies.lbl.gov/drupal/files/ies.lbl.gov.sandbox/IndiaWindPotentialAssessmentRevisedFinal03202012[1].pdf)>.
- “Reassessing Wind Potential Estimates for India: Economic and Policy Implications.” *Berkeley Lab*. Web. <[http://ies.lbl.gov/drupal/files/ies.lbl.gov.sandbox/IndiaWindPotentialAssessmentRevisedFinal03202012\[1\].pdf](http://ies.lbl.gov/drupal/files/ies.lbl.gov.sandbox/IndiaWindPotentialAssessmentRevisedFinal03202012[1].pdf)>.
- 104 “LBNL/NREL Analysis Predicts Record Low LCOE for Wind Energy in 2012-2013.” *Wind Program Newsletter*. 2012. Web. <<http://apps1.eere.energy.gov/wind/newsletter/detail.cfm?articleId=45?print=true>>.
- 105 See, Reuters. “Coal May Be Pricing Itself out of the Market.” *Financial Post*. 25 Apr. 2012. Web. <<http://business.financialpost.com/2012/04/25/coal-may-be-pricing-itself-out-of-the-market/>>.



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