

Executive Summary

- Whilst some argue thermal coal is only in a cyclical downturn, IEEFA is of the view that thermal coal has entered structural decline. Global demand will peak by 2016, coinciding with a peak in China's domestic thermal coal consumption.
- IEEFA argues that the coal industry has dramatically underestimated China's intent to improve energy security through electricity system diversity, and to drive rapidly towards a lower energy intensity of growth. Premier Li is categorical in saying: "There is no turning back in China's commitment to a sound ecosystem".¹
- When the Premier of China trumpets the 5% annual reduction in energy intensity of demand achieved to June 2014 as a key national achievement, the global implications are clear: China is rapidly moving towards a lower carbon economy.
- Japan delivered a 15% reduction in electricity intensity per unit of real GDP over the three year period post-Fukushima. This should be seen as proof that energy efficiency gains could massively transform global electricity systems over the next two decades.
- Renewable energy installs totaled 116GW in 2012 and 120GW in 2013. IEEFA forecasts another 1,000GW of new renewable energy capacity will be commissioned by 2020. This is 20% more than forecast by the IEA in their New Policies Scenario.
- IEEFA forecasts that thermal coal demand globally will peak during the 2013-2020 period around 5,700Mtpa (excluding lignite). Demand will plateau over the following decade. Beyond 2030, we forecast global thermal coal demand to decline at an increasing rate thereafter.
- Given seaborne coal imports are usually the marginal source of supply, a downturn in global demand is likely to hit the seaborne market hardest. IEEFA forecasts seaborne thermal coal demand will average 850Mtpa over 2013-2035, down 15% from current peak levels.

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Peak thermal coal demand

China is forecast to reach peak thermal coal demand by 2016.

China is expected to return to being an opportunistic net exporter of thermal coal by 2020.

Over 2013-2020 China will add 150GW of hydro, 160GW of wind 55GW of nuclear, 65GW of gas and 125GW of solar capacity.

IEEFA forecasts 1,000GW of new solar, wind and hydro capacity additions globally by 2020.

Japan reduced electricity intensity of GDP by 15% over three years post Fukushima.

Japan will add 65 GW of solar over 2013-2020. Add with energy efficiency gains, and this reduces coal demand by 28% by 2020.

South Africa is the 4th largest consumer of thermal coal globally. Its massive renewable program is inspiring.

US thermal coal consumption to decline 16% by 2020.

India, Korea and SE Asia are the last key growth markets for thermal coal.

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1. Introduction – a global ‘Energiewende’ is pending

“The challenge now faced by the whole world is far more urgent and important. But it can be solved by the same methodical, determined process. The world has no choice.”

Rio Tinto’s Energy CEO, Harry Kenyon-Slaney, Sept’2014ⁱⁱ

There is an increasing debate about whether global thermal coal is in a deep cyclical downturn or structural decline. The 80-90% share price collapse of almost every coal company globally over the last four years gives a clear guide of how the global equity market views the situation. IEEFA argues that thermal coal has entered structural decline. Global thermal coal demand will peak by 2016, coinciding with a peak in China’s domestic thermal coal consumption.

IEEFA forecasts global thermal coal demand over 2013-2020 will be flat at best, and decline 0.1% annually over 2020-2035. This masks the magnitude of the transformation that is rapidly emerging. With the IEA New Policies Scenario forecasting global electricity demand to increase 1.8% pa over the next two decades, IEEFA forecasts that the entire 50% expansion in global electricity demand by 2035 will be met by non-coal fuel sources.

There is also an inbuilt lag in that once built, a coal-fired power station will serve out most of its effective life due to the largely sunk capital cost of construction. As is happening across Europe and America over this decade, the decline in thermal coal demand globally beyond 2030 will accelerate as inefficient plants built over the last two decades are increasingly decommissioned. With many Indian coal-fired power plants having a useful life as short as 25 years, this underscores IEEFA’s forecast that thermal coal decline will accelerate to -0.4% pa over 2035-2050.

As Rio Tinto’s Energy CEO Harry Kenyon-Slaney said, the magnitude of the climate change crisis is reaching an imperative nations can’t ignore. And like the race to the moon, technology innovation provides the solution. China certainly is driving this transformation far faster than anyone realises. Germany realised the critical importance a decade ago, and its **Energiewende** is both the blueprint for the world and has driven the cost of implementation down dramatically for everyone else. A Sputnik moment will drive innovation and technology, then economies of scale and financial capital will collectively solve this global imperative.

Key drivers

- **Energy Security:** A key motivator of countries’ energy policy, particularly when most major economies are critically dependent on fossil fuel imports. IEEFA views the strategy of energy sector initiatives to diversify fuel supply towards domestic renewable capacity (on and offshore wind, distributed and utility scale solar, hydro) as playing a key role to improving energy security in Japan, China, India and Germany.
- **Energy Efficiency:** Japan achieved a reduction in total electricity demand of 12% from 2010-2013 despite 1% pa real GDP growth – a reduction of electricity demand per unit of real GDP of 5% pa.

This sets the benchmark of how rapidly change can be achieved with proactive policy. We forecast energy efficiency will play a significantly larger role in curtailing demand going forward.

- The IEA's Sept'2014 paper "Capturing the Multiple Benefits of Energy Efficiency" is a useful guide.ⁱⁱⁱ UK energy security envoy Rear Admiral Neil Morisetti puts it like this: *"Recent events in Ukraine and the Middle East have served to highlight the vulnerability of our energy supplies and the political straitjacket that results from our over-dependence on fossil fuel imports from these volatile regions. The quickest and most effective form of energy security is to use less."*^{iv}
- We note that the UK has reduced electricity intensity of GDP by 2.1% pa over 2005-2013, illustrating sustained reductions are readily achievable. The EU is likely to target a 30% energy efficiency target by 2030, further driving technology uptake and innovation.
- The IEA's Sept'2013 paper "South East Asia Energy Outlook" shows energy efficiency as the hidden opportunity to meet the rapid acceleration in demand for electricity across Asia, trebling to 1.9% pa over 2013-2035 from the 0.6% pa from 1990-2011. Technology and smart grids will play an increasingly critical role in leapfrogging the emerging market electricity development.
- **Renewable Energy:** IEEFA forecasts a continued acceleration in the deployment of renewable energy. With 116 gigawatts (GW) of solar, wind and hydro-electricity capacity installed in 2012, rising to 120GW in 2013, this follows a CAGR of 10% since 2007. We expect this to continue, such that 1,000GW of additional renewable capacity will be installed globally by 2020.
- Onshore wind has been the main renewable capacity deployed over 2008-2013, running at 37GW pa. Global hydro capacity has been growing at 28GW pa. We forecast deployment rates will accelerate towards 130-150GW pa by 2020, led by 50-70GW pa of solar going forward.
- IEEFA's forecast for the addition of 1,000GW of new renewable capacity by 2020 is 20% higher than the IEA's forecast under the New Policies Scenario. However, we note the IEA has consistently underestimated the economies of scale and technology improvements in renewables over the last decade, and continues to do so in our view. The IEA has therefore again underestimated the rate of expansion in this energy market transition over the next decade.
- Whilst the offshore wind market has suffered significant issues in moving towards commercial deployment at scale over 2010-2020, we forecast a near halving of costs per kWh post 2020 this will emerge as another key renewable energy segment of scale. Adding system diversity, offshore wind also offers utilisation rates double that of solar and onshore wind.
- The fossil fuel industry has long argued that grid stability and the need for baseload electricity will prove to be irresolvable obstacles to the continued expansion of renewable energy. IEEFA entirely disagrees with this excuse. Germany reaching 30.8% renewable energy in the first half of 2014, the South Australian market reaching 38% in Aug'2014, and more than 90% of the Brazilian economy being electrified by renewables for the last decade are just three examples illustrating the a smart grid of the future will be increasingly flexible. The increasing ability of electricity storage and Demand Response Management (DRM) to match variable electricity demand and variable supply will reduce the need for expensive reserve capacity. Baseload as an excuse will go the way of thermal coal and the dinosaurs.
- An underappreciated aspect of renewables is the deflationary impact on wholesale electricity prices. It is noteworthy that European wholesale electricity prices are at a decade low, and the decline has accelerated as the share of renewables has expanded. Energy markets have been inflationary for a century. Renewables are like the internet – transformational and deflationary.

Demand Study – A Country by Country Analysis

The electricity sector varies dramatically by country. In Section 3 we examine 12 of the largest electricity markets globally to illustrate country specific drivers of demand and supply, and differing regulatory and resource impacts. To highlight a few:

- Some countries like the US, Indonesia, South Africa and China have huge thermal coal reserves.
- The shale gas explosion is revolutionising the American electricity supply and lowering the cost and emissions of electricity, with profound economic and energy security implications.
- However, most of the largest economies globally import gas (via pipelines or liquid natural gas (LNG)), making this an increasingly expensive if slightly cleaner fuel source.
- Four of the largest electricity markets – Japan, Korea, Taiwan and the UK, import almost all their fossil fuel electricity needs. Energy efficiency becomes key to reducing demand to limit imports.
- The European Union (EU) is increasingly utilising a pan-EU electricity grid, with imports and exports providing valuable balance and flexibility to the system. By contrast, Korea, Japan and Taiwan's electricity and gas grids are 100% isolated, heightening energy security issues.
- The Fukushima disaster has had profound implications for nuclear power's social acceptability in Japan, Korea, Germany and France – four of the 10 largest electricity markets globally.
- Fukushima had another profound implication. Severe adversity has driven energy efficiency innovation that has cut Japan's electricity intensity 15% in just three years. This illustrates what can be done and the speed of the transition. Energy efficiency will progressively be adopted globally to curtail electricity system growth more than is currently anticipated.
- South Africa is the 16th largest electricity market globally, but surprisingly is the 4th largest thermal coal user. The new focus on renewable energy by Eskom is globally important.
- We include France and Brazil as two of the ten largest electricity sectors that both have almost no exposure to coal fired power generation. France is 75% nuclear, and now rapidly adding on and offshore wind and solar, plus boosting energy efficiency. Brazil is 80% hydro and now rapidly adding very cost competitive onshore wind and solar. No talk of boosting coal in either country.
- China and India have underpinned more than 90% of the growth in global thermal coal demand over 2000-2013. A systematic shift in China away from coal is underway, India is likely to follow.

Conclusion

IEEFA forecasts that thermal coal demand globally will peak over the 2013-2020 period around 5,700 million tonnes per annum (Mtpa) (excluding lignite). Demand will plateau over the following decade as key markets like China, America, Japan and the EU continue to decline, but this being offset by still strong growth in coal from India, Korea, Taiwan and South East Asia. Beyond 2030, we forecast global thermal coal demand to experience an increasing rate of decline thereafter.

A second key implication of this study is the consequences for seaborne traded thermal coal. As the flexible but most costly source of incremental supply, a stalling then downturn in demand for coal will first and foremost affect higher cost export coal mines and the associated rail and port infrastructure. Mine mouth coal-fired power plants will be the least affected, given they have the lowest transportation cost (which represent 50-80% of the delivered cost of much of the seaborne thermal coal supply sector when shipping costs of US\$5-15/t are included). We see global seaborne coal demand declining 15% to average 850Mtpa over 2013-2035 relative to the 2013 peak.

2. Projections of future coal demand

This study focuses initially on the long-term coal thermal demand forecasts of the International Energy Agency (IEA), the world's most referenced energy projections. Comparisons are then made from this basis to fossil fuel industry and broker forecasts to understand where widespread agreement and disagreement exists.

The IEA's principal document, the World Energy Outlook (WEO), examines the energy trends to 2035 under three different scenarios^v:

- **Current Policies Scenario:** A scenario that takes into account "only those policies and measures affecting energy markets that were formally enacted as of mid-2013." The purpose of this scenario is to illustrate both the consequences of inaction and makes it possible to evaluate the potential implications of additional policy measures.
- **New Policies Scenario:** The central scenario of the 2013 World Energy Outlook. In addition to assuming the incorporation of government policies and measures adopted as of mid-2013, the New Policies Scenario also takes into account "other relevant commitments that have been announced, even when the precise implementation measures have yet to be fully defined." This scenario takes a "cautious view as to the extent to which these commitments will be implemented."¹
- **450 Scenario:** This scenario shows a global energy sector on a trajectory with a "near 50% chance of limiting the long-term increase in the average global temperature to two degrees Celsius (2°C)." Up to 2020, the 450 scenario assumes the full implementation - more vigorous policy action than the New Policies Scenario therefore - of commitments under the Cancun Agreements made in 2010. After 2020, OECD countries and other major economies are assumed to set "economy-wide emissions targets for 2035 and beyond to collectively ensure an emissions trajectory consistent with stabilisation of the greenhouse-gas (GHG) concentration at 450 parts per million."

In light of our focus on the potential impacts of a global energy transition on coal production, this study focuses on the New Policies Scenario and to a lesser degree the 450 Scenario that integrate assumptions of such a change occurring. When referenced, the Current Policies Scenario is principally utilised as a baseline rather than a forecast per se, representing the highly unlikely eventuality that no further energy transition-related policies will be implemented to 2035.

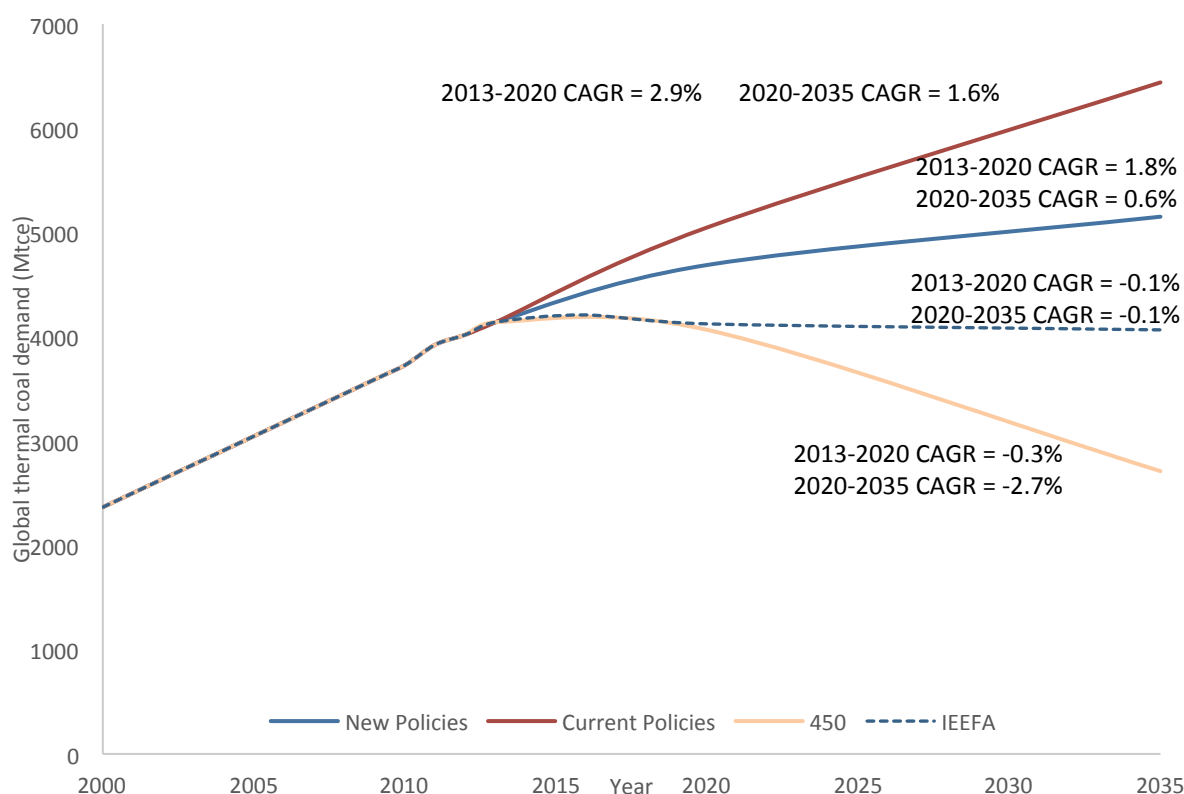
Furthermore, demand forecast analyses in this study have been split into two periods, from 2012 up to 2020 and from 2020-2035 to be consistent with the IEA's approach and the significance they attribute to climate and environment-related government policies around these timescales.

¹ A full explanation of the assumptions made for each region in each scenario can be found in the IEA WEO, pages 646-655.

IEA thermal coal demand trends

The figure below reflects the IEA's WEO thermal coal demand forecasts under these three scenarios in million tonnes of coal equivalent (Mtce) and plots the IEEFA model forecast as a reference point.

Figure 1: Thermal coal demand diverges dramatically between the New Policies and 450 Scenarios²



Source: IEA, ETA analysis 2014

- Starkly different pathways exist:* From 2013 onwards, the New Policies and 450 Scenarios take on very different trajectories. The former reflects an absolute growth in demand of 1012Mtce (24% of 2013 level) to 2035, while demand peaks immediately in the 450 Scenario and falls by 1,428Mtce (35%) by 2035. For thermal coal demand to shift from the New Policies Scenario to the 450 Scenario requires a 2.9% reduction in a compound annual growth rate (CAGR) from 2013-2035, which represents a 2,440Mtce (49%) reduction in thermal coal demand by 2035.
- Particularly after 2020, the pronounced divergence emerges:* Post-2020 the 450 Scenario reflects strong policy measures being implemented to keep long-term GHG-induced temperature change to 2°C, whereas the New Policies Scenario assumes a less stringent policy effort to “foster renewables, penalise CO₂ emissions and address other environmental issues.” This results in the difference between the two scenarios’ CAGRs widening from 1.9% to 2.8%.

² To ensure consistency and readability of the graph, demand data from 2000-2013 is from the IEEFA model.

- *Growth continues in the New Policies Scenario, but slows markedly:* Thermal coal demand does not peak in the New Policies Scenario with a compound annual growth rate of 1.0% to 2035. However, as the IEA notes, this is a significant slowdown on previous years. Furthermore, approximately one half of this growth in the New Policies Scenario occurs before 2020, after which the CAGR slows to 0.6%.

Total coal demand projections by type

Coal is typically split into three classifications that reflect the varying composition and energy content of assets. This in turn determines its end use.

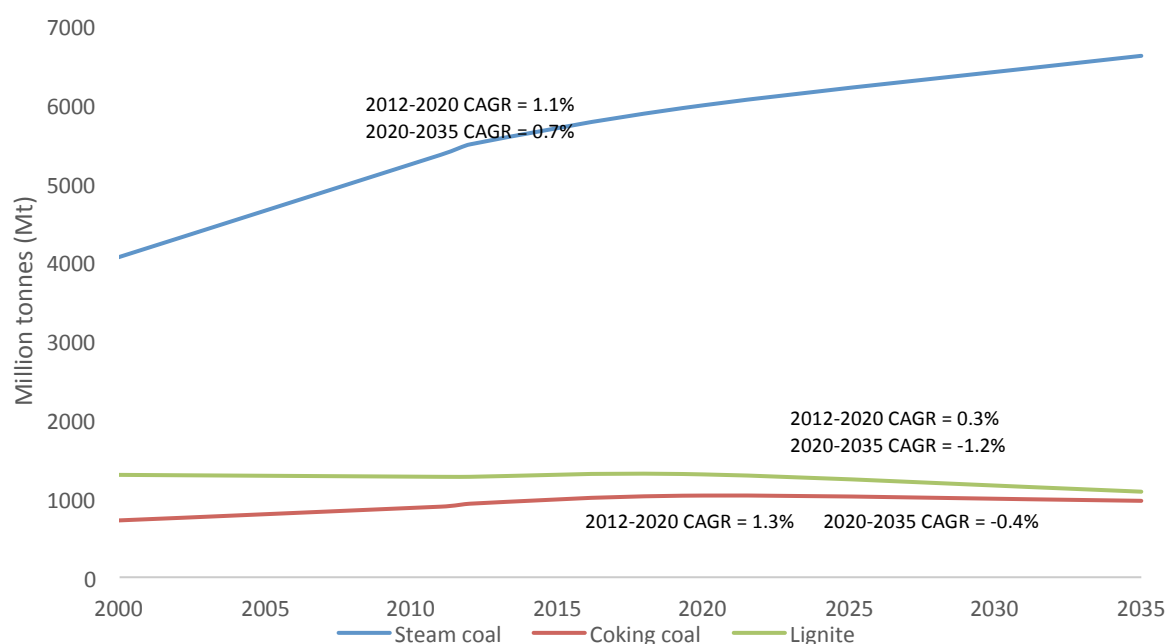
Steam/thermal coal: Accounts for 71% of global coal demand in 2013 in terms of millions of tonnes. Approximately 70% of global thermal coal is consumed for power generation, 15% in industry and the remainder consumed by residential, commercial and public services, forestry and fishing sectors.

Lignite coal: Approximately 16% of global coal demand used almost solely for power generation. While lignite is widely considered to be low quality, most lignite is used at 'mine-mouth', and the power stations are configured to utilise this type of low-energy coal. As such, lignite avoids the massive rail/port/shipping transportation and infrastructure costs almost entirely and as such can be extremely cost effective (with the right pollution control technologies in place).^{vi}

Coking/metallurgical coal: Makes up 13% of total global coal demand. Over 85% of coking coal is used for steel making where it produces coke to support a blast furnace charge. Small portions are used in power generation and in industry.

Figure 2 illustrates demand for thermal, coking and lignite coal in the IEA's New Policies Scenario.

Figure 2: IEA New Policies Scenario by coal type to 2035 (Mt)³



Source: IEA, ETA analysis 2014

³ Figures have been adjusted to classify Chinese lignite coal as lignite rather than thermal coal.

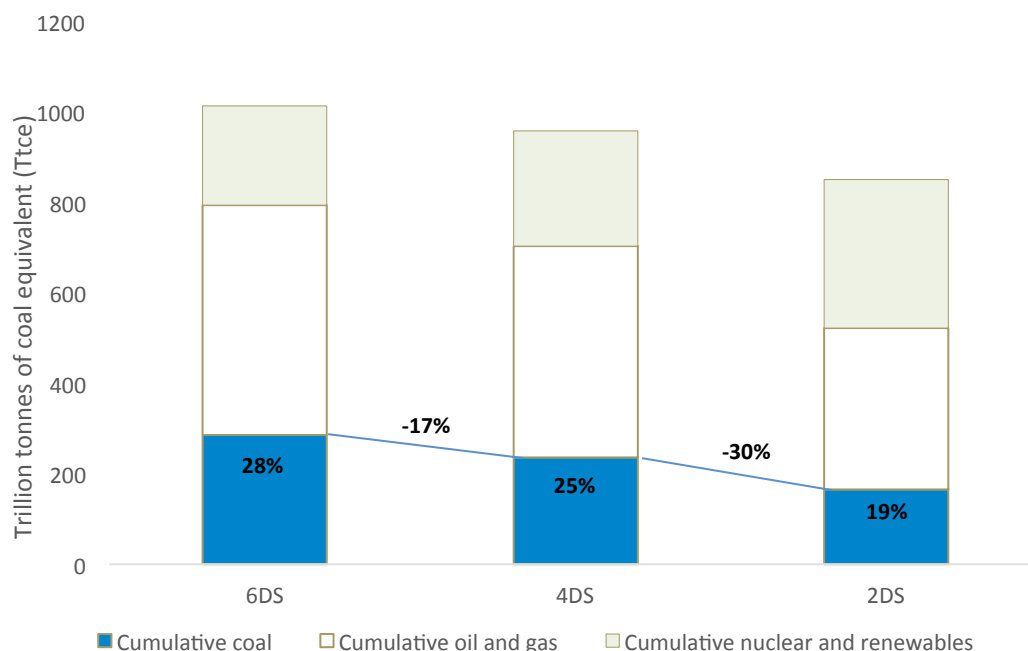
- *Thermal coal grows its share of total coal demand:* The combination of: i) falling lignite demand as low quality coal gets pushed from the market; ii) falling coking coal demand as the steel and industry sectors improve their energy efficiency (see point three below); and iii) growing thermal coal demand mean thermal coal's share of total coal demand grows, but slower than in the past.
- *Thermal coal demand growth halves post-2020:* Slowing thermal coal growth post-2020 is evident, principally as a result of air pollution, climate and other environment-related policies to which the power generation sector is most exposed. Total OECD demand falls in this period, but is more than offset by non-OECD growth. Towards the end of the forecasting period, however, non-OECD growth begins to mirror the path of OECD demand before it. We note this is a continuation of the well established deceleration in growth estimated for the 2012-2020 period of only 1.1% CAGR, a third of the 3.0% CAGR in thermal coal volumes over 1990-2012.
- *Coking coal demand begins to fall:* Over the forecast period, coking coal demand remains more stable than thermal coal because it is less easily substituted in its applications and less influenced by government environmental policies. Total demand grows to 2020 in spite of falling OECD demand due to increased use of pulverised coal injection (PCI). Post-2020, other technologies such as electric arc furnaces are more widespread, efficiency improvements take hold and global crude steel output flattens around 2030. In fact, steel output in China – responsible for over 70% of global coking coal growth over the forecast period- begins to decline.

Looking to 2050

Carbon Tracker's previous research and this report's accompanying paper consider the impacts of carbon constraints through to 2035. This exceeds the projections of the scenarios in the IEA's World Energy Outlook publication. However, in the Energy Technology Perspectives 2014 document the IEA presents their 2DS, 4DS and 6DS Scenarios that extend to 2050. These scenarios closely parallel the 450, New Policies and Current Policies Scenarios (through 2035) referred to thus far. The IEA describes the 2DS Scenario as reflecting 'a concerted effort to drastically reduce current dependency on fossil fuels, primarily through energy efficiency, renewables and nuclear energy.'^{vii}

Figure 3 shows the differences between coal sector demand across the three scenarios and contextualises this with demand projections for other energy sectors. It is noteworthy that the figure illustrates *cumulative* demand over the period 2011-2050.

Figure 3: Total cumulative fossil fuel demand in trillion tonnes of coal equivalent (Ttce) 2011-2050 in IEA Scenarios

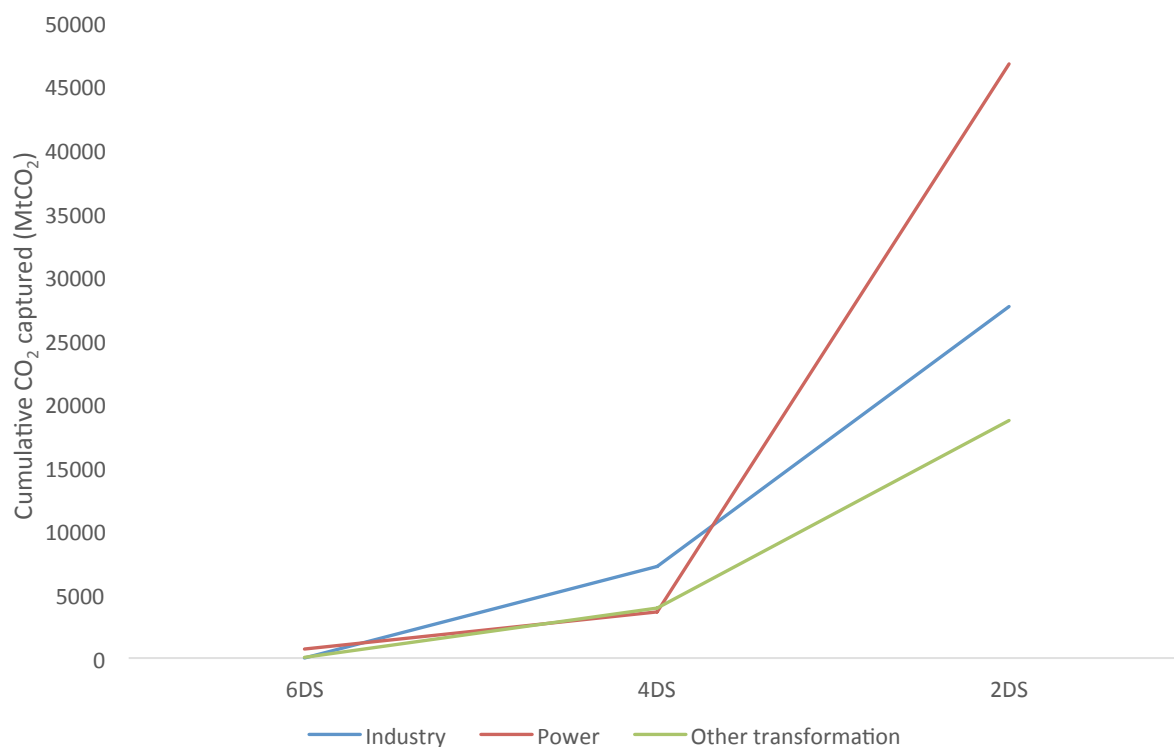


Source: IEA, ETA analysis 2014

- *Lower coal demand is central to achieving 2DS rather than 4DS:* Over the period of 2011-2050, cumulative coal demand in a 4DS Scenario is 30% higher than in a 2DS Scenario – the difference between 4DS and 6DS Scenarios is lower at 17%, illustrating that coal demand is disproportionately significant to achieving the 2DS Scenario. To achieve the 2DS Scenario to 2050, the IEA predict emissions (GtCO₂) from power generation will need to reduce by 41% - this would serve to suppress coal demand significantly.
- *Lower primary energy demand growth constrains coal:* By 2050, the 6DS Scenario shows approximately 70% growth in primary energy demand compared to 2011 levels - the 2DS Scenario assumes policy actions that constrain energy demand to 25% over 2011 levels, limiting the growth prospects for coal demand in this scenario.
- *Fossil fuel demand remains significant in 2DS:* Figure 3 reflects that by 2050 fossil fuels make up 70% of energy demand in the 4DS Scenario, which falls to just over 40% in the 2DS. This remains a significant share of energy demand in 2050 of which coal comprises approximately 33% in the 2DS. This is because carbon capture and storage (CCS) is assumed to play a substantial role in supporting coal demand in this period.

Figure 4 illustrates the CCS emissions mitigation assumptions of the three scenarios broken down by sector.

Figure 4: Cumulative MtCO₂ captured by CCS by sector 2011-2050⁴



Source: IEA

This graph demonstrates the scale with which CCS is assumed to increase its emissions mitigation contribution in the 2DS compared to the 4DS and 6DS – approximately half of the captured CO₂ is assumed to come from the power sector, currently dominated by coal. In the 2DS, CCS is assumed to contribute one-sixth of the total CO₂ emissions reductions required to 2050.

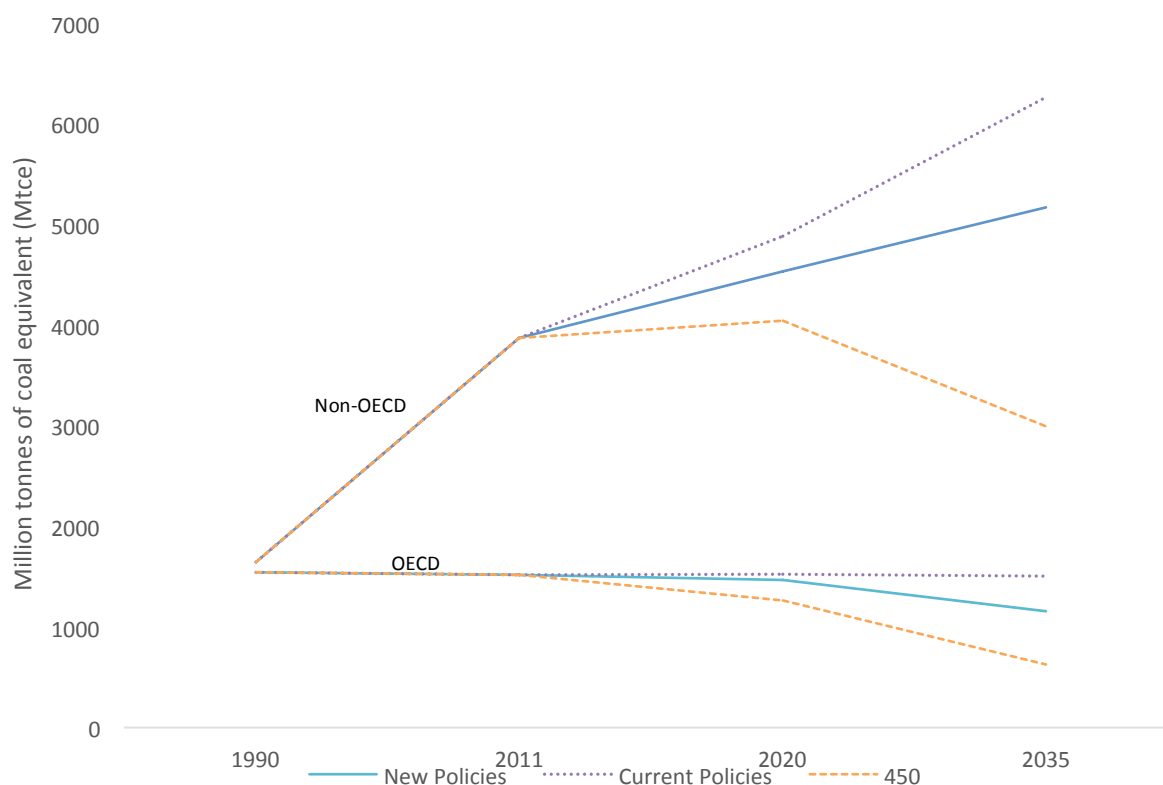
The achievability of such contributions seems debatable, however, in light of the lack of current CCS capacity and slow pace with which additional capacity is being installed. According to the IEA, a cumulative 50MtCO₂ have been captured globally to date^{viii} – Figure 4 illustrates this total needs to be over 46,500MtCO₂ by 2050 to achieve the 2DS pathway. Consequently, coal demand projected in the 2DS Scenario, which has been demonstrated to be 30% lower compared to 4DS, could be on the optimistic side if CCS does not scale-up sufficiently.

⁴ Note that the 'Power' sector includes both coal-fired and gas-fired with the IEA unable to split this total by fuel type. This is because, for instance, coal and gas may both be used in a blast furnace equipped with CCS. Due to the more CO₂ intense nature of coal-burning over gas consumption, it can be assumed coal consumptions comprises the majority of power sector captured emissions.

Total coal demand by region: OECD vs non-OECD dynamics

The figure below illustrates the split in total coal demand between OECD nations and non-OECD in the IEA's three World Energy Outlook Scenarios.

Figure 5: Total coal demand by region, 1990-2035 (Mtce)



Source: IEA, ETA analysis 2014

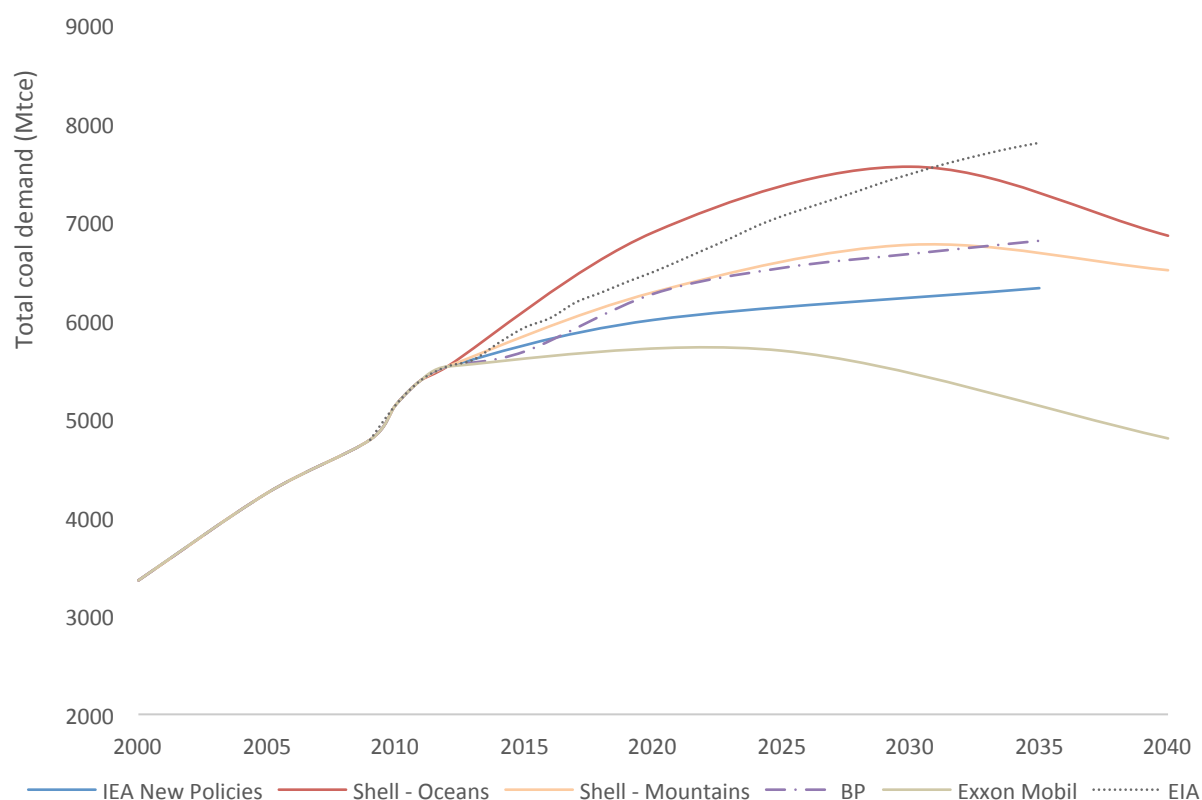
Figure 5 shows a general consensus exists across the IEA's Scenarios that in the OECD, coal demand will slow if not decline in the immediate future. A far greater range of outcomes exists across the scenarios for non-OECD nations.

Consequently, the fate of future global coal demand will, in large part, be determined by i) the scale of economic growth and hence coal demand growth in the more unpredictable and volatile non-OECD markets; ii) the extent to which non-OECD nations closely mirror the OECD's trajectory of substituting coal consumption with low carbon alternatives; iii. the accelerated uptake of energy and grid efficiency initiatives; and, crucially iv) the rate at which the transition between these two pathways occurs.

Industry and broker projections

The forecasts of industry associations and brokers can be key influencers on expectations of future demand trends. Figure 6 compares total coal demand forecasts from the IEA and the oil & gas majors with the IEA New Policies Scenario.

Figure 6: Shell^{ix}, ExxonMobil^x, BP^{xi} and EIA^{xii} total coal demand forecasts compared to the IEA New Policies Scenario^{xiii}



Source: BP, Shell, IEA, ExxonMobil, EIA

Table 1: Projected total coal demand change under different scenarios

	Short-term CAGR 2012-2020	Long-term CAGR	Absolute change from 2012 (Mtce)
IEA New Policies	1.1%	2020-2035: 0.4%	814
ExxonMobil ^{xiv}	0.5%	2020-2040: -0.9%	-711
BP ⁵	1.6%	2020-2035: 0.6%	1294
Shell - Mountains Scenario	1.7%	2020-2040: 0.2%	996
Shell – Oceans Scenario	2.8%	2020-2040: -0.0%	1346
EIA	2.0%	2020-2035: 1.2%	2289

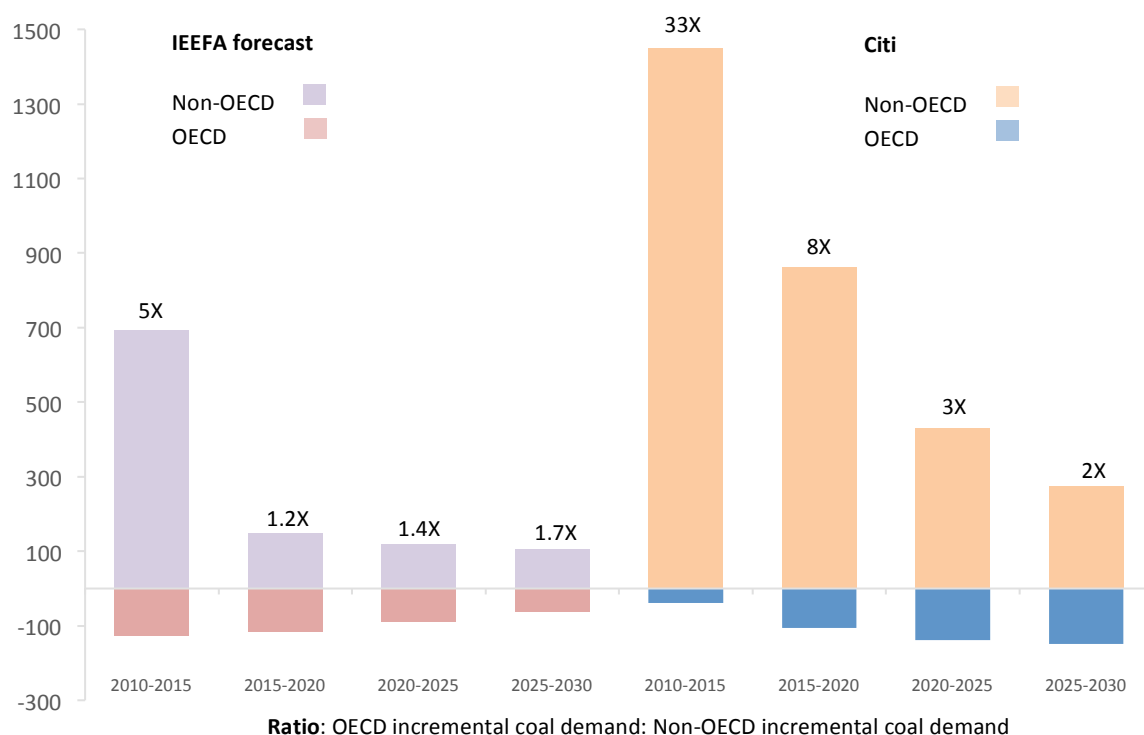
⁵ For BP we used the World Coal Association's conversion factor to Mtce: 1mtoe = 1.435mtce

- *All forecasts, with the exception of ExxonMobil's, are more bullish on demand growth than the IEA Scenario:* The scenarios of Shell, BP and the EIA all foresee higher growth in coal demand than the IEA New Policies Scenario. The EIA Scenario, the most bullish of those featured, forecasts global coal demand will be 1475Mtce higher by 2035 than estimated in the IEA New Policies Scenario, equivalent to 185% of the 2035 IEA total. This forecast is based on the assumption of strong non-OECD growth to 2035 – the EIA scenario is consistent with the general consensus that OECD growth will decline marginally. We note the EIA is exceptionally detailed but very US centric in its analysis.
- *The IEA's New Policies seems aggressive even against Shell's 'firm and far-reaching' policies scenario:* Relative to Shell's 'Mountains' Scenario that models a case where 'stability is the highest prize' and where those unlocking fossil fuel resources do so 'cautiously, not solely dedicated by immediate market forces', the IEA New Policies Scenario is more aggressive by forecasting coal demand approximately 425Mtce lower in 2035. We attribute this to the IEA's detailed and ongoing analysis into the capital cost trends in non-fossil fuel technologies. With each year, the IEA has consistently increased its rate of technology learnings in renewable energy and decreased capital costs as economies of scale have surpassed all historical expectations. The IEA is therefore more current in its estimates of the huge scope for low carbon solutions to take share from coal in particular.
- *The rate of coal demand growth slows post-2020 in all scenarios:* While the majority of forecasts are bullish on future coal demand growth, all scenarios covered in Figure 7 display significantly lower CAGRs post-2020 than before this date. This could represent agreement that coal demand growth in non-OECD nations will temper and mirror OECD demand trajectories before 2035. In other words, there is agreement the global energy transition will speed up post-2020.
- *In fact, post-2020 three fifths of scenarios have slower growth rates than the IEA New Policies Scenario:* While the forecasts of Shell and ExxonMobil consider absolute coal demand to be higher by 2035 than the IEA's New Policies Scenario, both also foresee post-2020 coal demand to slow more rapidly than the IEA New Policies Scenario, particularly post-2030. This reflects the inevitability of governments collectively or individually being held to account for carbon emissions pollution. China's accelerated and comprehensive policy response to air pollution since 2013 shows that tipping points are reached, and then change can be dramatic and rapid. India is rapidly approaching a similar point. Greater demand peaks and troughs, as illustrated in these scenarios in Figure 6, could reflect the effects of more reactionary and aggressive environmental policy actions, potentially in response to increasingly severe climate change.

Citi and IEEFA see a convergence towards zero coal demand growth

In addition to these industry forecasts, brokers have published various perspectives on future coal demand. As illustrated in the figure below, Citi and IEEFA's forecast for total coal is largely consistent with the IEA's New Policies scenario – OECD growth declines at a consistent rate from now, while non-OECD demand growth slows to mirror this pathway in the medium-term. Citi has closely examined the deflationary and parasitic nature of renewable energy, energy storage and energy efficiency technologies, and hence the risks to incumbent fossil fuel generators as real retail electricity prices decline going forward.

Figure 7: Incremental coal demand by region, 2010-2030 (Mt)^{6xv}



Source: Citi 2013, IEEFA Analysis 2014

Figure 7 reflects Citi's forecast of relatively rapid convergence towards zero growth, without achieving it, by 2030, as OECD coal demand reductions are to increasingly smaller degrees exceeded by non-OECD demand growth. This sees non-OECD increases in coal demand fall from being over 33 times larger than OECD declines in coal demand to under double the size by 2030. Current data suggests that Citi's forecast of a convergence may be overly conservative with OECD coal consumption declining in 2011 by 29.6Mtce and by 56.2Mtce in 2012 – far exceeding the projections for 2010-2015 made above.

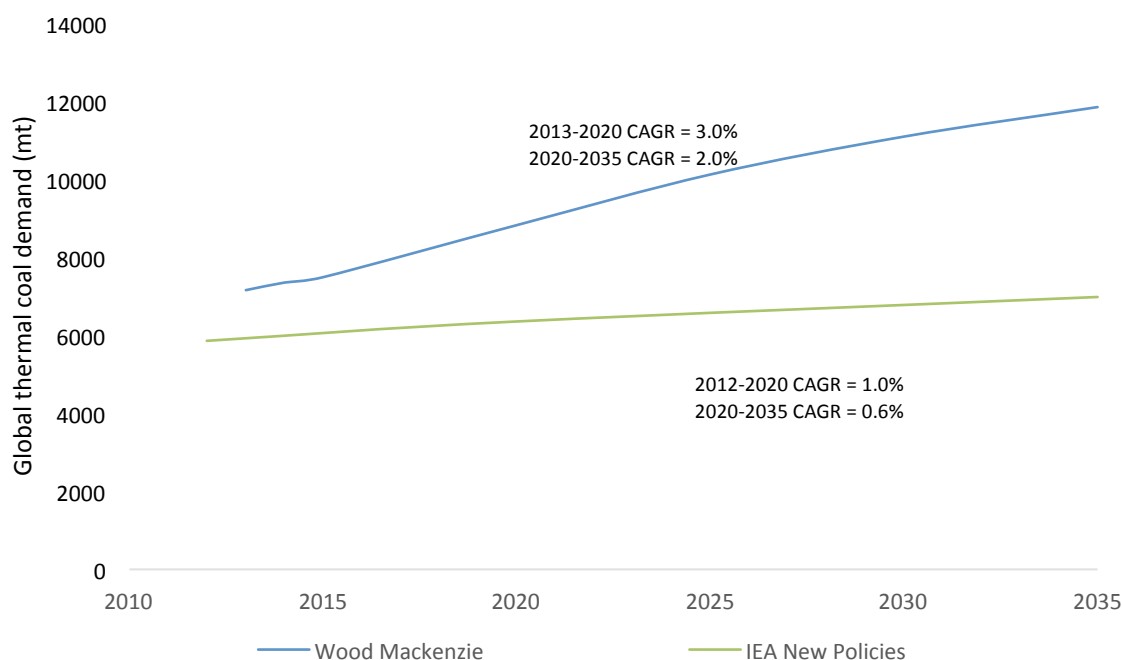
⁶ The data used in this figure are approximate readings from graphs presented in Citi's Energy Darwinism: The evolution of the energy industry, 2013. Converted to Mt from Mtoe using IEA WEO figures to estimate a global-level conversion factor which was applied to all data.

This is one reason ETA/IEEFA's forecast is more bullish on the extent of this convergence by 2030. This sees non-OECD coal demand growth to be lower and OECD declines larger than in the Citi forecast between 2010 and 2015. Over each of the following 5 year intervals, the level non-OECD demand growth exceeds OECD declines is smaller than Citi's most aggressive prediction, as illustrated by the ratios in Figure 7.

Wood Mackenzie foresee strong demand growth: An outlier?

Wood Mackenzie foresee a coal demand curve completely contrasting that of Citi. Whereas Citi believe global coal demand will converge towards zero growth, Wood Mackenzie see very strong growth in demand to 2035. Figure 8 graphs Wood Mackenzie's forecast for thermal coal (which accounts for 76% of total coal demand today) against the IEA's New Policies Scenario.

Figure 8: Wood Mackenzie forecasts for thermal coal, 2013-2035^{xvi}



Source: Wood Mackenzie 2013, ETA analysis 2014

Wood Mackenzie forecast a 3% CAGR to 2020, but in contrast to other broker and industry forecasts is the persistence of this growth through to 2035. While Wood Mackenzie believe the CAGR for thermal coal will slow post-2020, the rate of growth still far exceeds that of the IEA New Policies Scenario, the general consensus amongst forecasters included in this analysis and even that of the EIA who represent the next most bullish coal demand scenario over this period.

The Wood Mackenzie forecast is so bullish about the prospects of future coal demand that they foresee global thermal coal demand to be approximately 11,850Mt in 2035 – this is equivalent to 138% of total global coal demand *for all types* under the IEA New Policies Scenario and even exceeds total global coal demand *for all types* under the IEA Current Policies Scenario.

The outlook for coking coal is equally strong, according to Wood Mackenzie. Figure 8 displays their forecasts for coking coal imports to 2035⁷. While traded coal accounts for 35% of total coking coal demand, a number of factors underpin the dynamics of traded coal that prevent import data from being able to conclusively reveal absolute coking coal demand globally. Tentatively, however, Figure 8 shows Wood Mackenzie are again more bullish than the IEA New Policies Scenario predicting coking coal imports to grow at a 4.8% CAGR to 2020 and 0.6% afterwards, compared to 1.3% and -0.4% of the IEA.

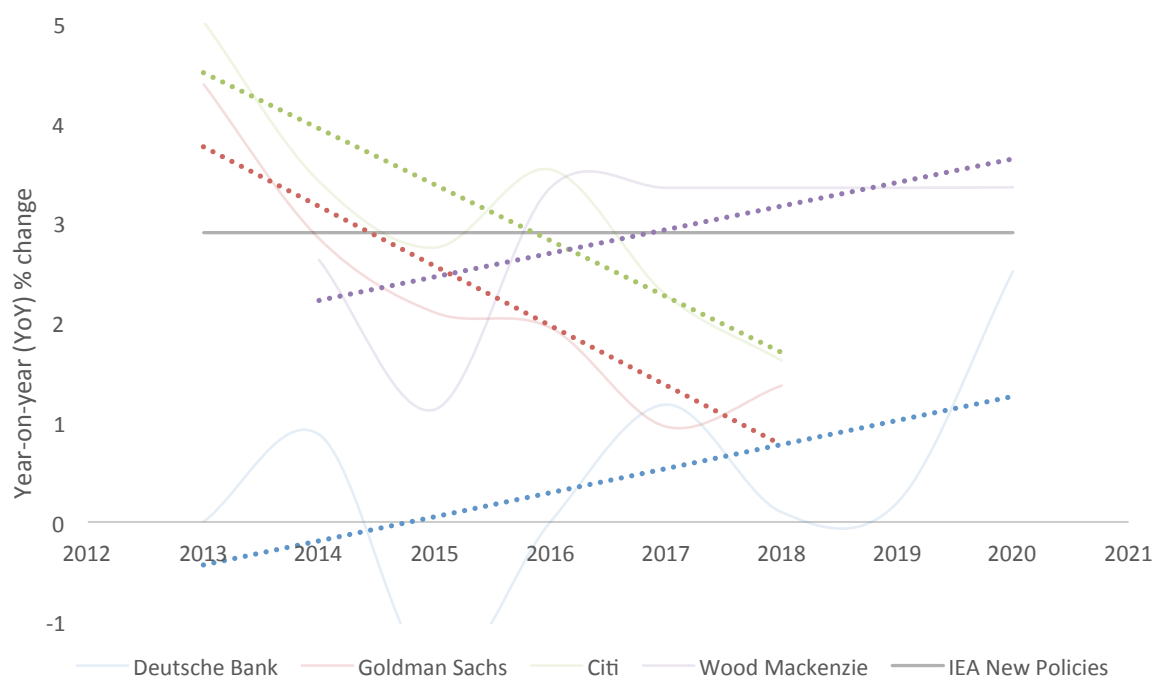
Overall, this means Wood Mackenzie's thermal coal demand forecast appears to be an outlier. In light of the upside potential we see for renewable energy, energy storage and energy efficiency technologies and accelerating policy measures transitioning China and India's coal consumption, we foresee a very different forward demand curve for coal.

Broker forecasts of seaborne thermal coal demand to 2020

The IEA predict traded coking coal to 2020 will be largely consistent across their three scenarios in the World Energy Outlook. The outlook for traded thermal coal is far less agreed.

Current levels indicate approximately 15% of all thermal coal is traded, of which over 90% is seaborne.^{xvii} Figure 9 shows forecasts of seaborne thermal coal imports up to 2020 from a number of brokers – due to the lack of consistency in the level of imports in the start year across the brokers, the year on year percentage change is used to allow comparability.

Figure 9: Comparing broker forecasts of seaborne thermal coal demand with the IEA New Policies Scenario^{xviii}



Source: ETA analysis 2014

⁷ Best available data.

Figure 9 demonstrates a consensus that seaborne demand for thermal coal will grow to 2020. Only three of the four brokers foresee import demand to grow as rapidly as the rate predicted by the IEA's New Policies Scenario.

Within these trends, two schools of thought seem to exist among the major commodity forecasters. The first, consisting of Wood Mackenzie and Deutsche Bank, sees a trend of increasing rates of growth in thermal coal imports. This is consistent with Wood Mackenzie's forecasts of strong growth across the global coal sector generally. Deutsche Bank, however, display a growth trend that oscillates around zero growth due to 'new demand preferences in the largest consuming nations... result[ing] in much lower demand growth going forward' - that is until 2020 where import demand jumps, relative to previous years, that somewhat distorts the trend over the forecast period.

The second grouping of brokers consists of Citi, Bernstein and Goldman Sachs who both foresee seaborne import demand of thermal coal to increase at a much slower rate than previously to the end of the forecast period in 2018. Goldman Sachs attribute this trend to 'structural headwinds from regulation, energy efficiency and changes in the energy mix' due to heightened competition from gas and renewable energy. Citi cite many of the same drivers. Bernstein sees China moving from the world's largest importer of thermal coal in 2013 to a position post 2015 where China will protect its domestic industry as a priority and hence move to being an occasional, opportunistic exporter. This school of thought is consistent with our outlook of the *structural* nature of the drivers that will serve to suppress the long-term growth of coal demand.

In focus: Key coal demand regions

This summary of coal demand forecasts highlights that the understanding of the regional variations in forward demand is integral to understanding the dynamics of global coal demand. The present nature of the global coal sector is such that just a handful of countries within these regions will fundamentally determine future coal demand.

China

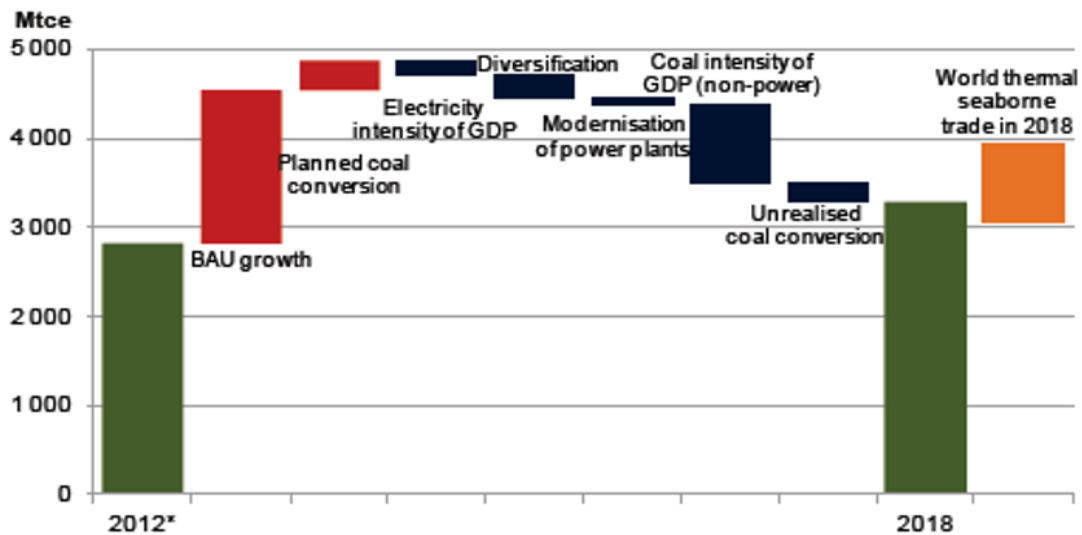
Bernstein Research calculate that global total coal demand excluding China from 2007-2012 has declined by 1.2%^{xix} - China's significance on shaping past and future form of the global coal sector can not be understated.

There is simultaneously agreement and uncertainty between brokers in their forecasts of China's future coal demand. Agreement lies in the fact that China is taking steps to slow the growth of its coal consumption – an era that Citi brands an 'anything but coal' energy strategy - through a portfolio of approaches including carbon intensity, energy intensity and coal consumption targets, emissions trading schemes, carbon taxes and low-carbon energy incentives, all driven on the large part by its worsening air pollution crisis.

What appears uncertain across opinion is when these drivers will combine with each other and those drivers supporting further coal demand to peak China's coal demand and begin its plateau. For example, credit ratings agency Standard & Poor's predict peak demand will occur by 2020^{xx}, Deutsche Bank put this date at 2016^{xxi} while Bernstein Research forecast the peak to arise in 2015

and Morningstar forecasts a peak in China coal in 2014.^{xxii} The IEA summarise the underlying drivers creating such uncertainty when predicting China's thermal coal demand in Figure 10.

Figure 10: Uncertainties within the China's short-term thermal coal demand^{xxiii}

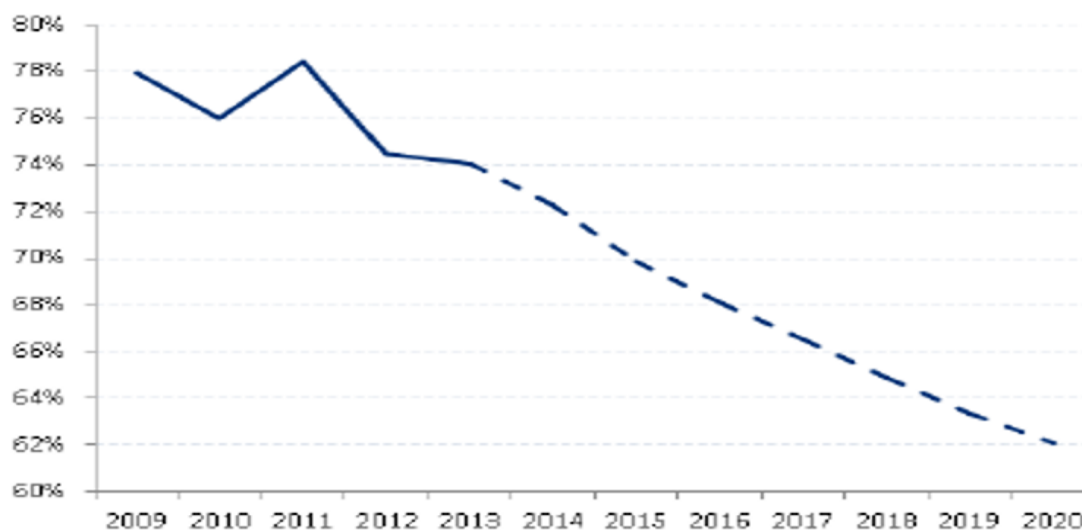


Source: IEA 2013

Beyond 2018, the IEA's New Policies Scenario foresees steady coal demand growth in China to 2020, after which demand only rises a further 69Mtce (2% of 2011 level) to a plateau between 2025 and 2030. The CAGR between 2020 and 2035 is a meagre 0.05%. Inherently, therefore, coking and thermal coal demand do not grow strongly in this scenario.

Citi's research is largely consistent with the IEA outlook. Thermal coal for power generation is by far the largest single coal consuming sector in China, accounting for approximately 50% of the total. The figure below demonstrates Citi's forecast for coal's share of power generation to steadily decline to 62% by 2020.

Figure 11: Citi forecast declining coal share of power generation^{xxiv}



Source: Citi 2014

The IEA New Policies Scenario continues along this trajectory anticipating coal to supply 55% of power generated in 2035. Wood Mackenzie are more bearish seeing coal make up 51% of total power generation by 2030.^{xxv} This future would significantly reduce China's thermal coal demand, having knock-on effects for the global coal sector.

With regards to coking coal, the picture is similarly bearish with the IEA forecasting in their New Policies Scenario that Chinese production of steel and cement, the major consumer of coking coal, peaks before 2020 and declines thereafter resulting in a CAGR of -0.9% between 2020 and 2035.

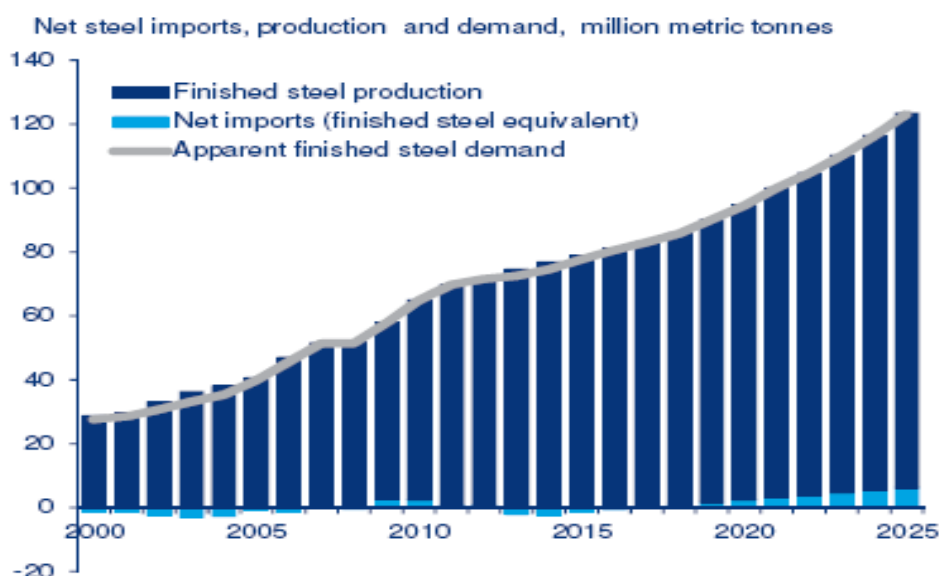
India

Since 1965, global total coal demand has essentially been flat, apart from China and India which have represented over 100% of the world's demand growth. With many agreeing that China's coal demand could lower in the medium-term, Indian demand becomes increasingly integral to the fate of the global coal sector.

Since 2000, India's coal use has more than doubled to 485Mtce in 2012 and forecasts generally indicate this strong upward trend will continue. Two-thirds of coal demand in India stems from the power sector, where two-thirds of electricity is from coal-fired power plants. Coal burning for power generation sees a CAGR of 3.1% between 2011 and 2035 - more than doubling to 452Mtce – in the IEA's New Policies Scenario. Citi concur, but foresee much of this growth occurring in the very short-term, with CAGR at 9% from 2013-2017.

The IEA and Wood Mackenzie are in agreement over industry metallurgical coal demand growth, with the New Policies Scenario predicting a tripling of crude steel production to 2035 that largely correlates with the production curve produced by Wood Mackenzie in the figure below.

Figure 12: India steel production 2000-2025



Source: Wood Mackenzie 2013

US

The rapid emergence of gas-fired and wind on the supply side plus energy efficiency on the demand side in the US resulted in thermal coal's share of electricity generation to drop from 53% in 1990 to 43% in 2011 – the IEA and broker forecasts predict this trend to continue. In the New Policies Scenario power sector coal consumption will drop to under 520Mtce in 2035 from 625Mtce in 2011.

The switch to gas-fired power has already retired 22GW of coal-fired power generation capacity to date. The US House Energy and Commerce Committee's Subcommittee on Energy and Power in July 2014 called for an independent reliability assessment in light of the U.S. EPA's projection that nearly 180 GW of generation capacity will retire between 2010 and 2020 because of the Clean Power Plan and other factors, such as the Mercury and Air Toxics Standards, or MATS.^{xxvi} While politically motivated, this call is likely to show that electricity system reliability is improved with the increased diversity of supply coupled with better grid interconnectivity across regions.

Environment-related policy implementations are the main driver of this change, in particular i) 2013's New Source Performance Standard (NSPS) which mandates new power plants not to exceed the new standard of 1,100lb CO₂/MWh; ii) emissions standards set by the National Ambient Air Quality Standards set to tighten from 2015; iii) implementation of the EPA's Maximum Achievable Control Technology (MACT) standards; and iv) the potential implementation of the proposed Clean Power Plan Rule to regulate existing coal- and gas-fired power plants to achieve a 30% reduction of power sector emissions by 2030.

Europe

The IEA's New Policies Scenario sees Europe's thermal coal demand fall steeply from 445Mtce to 253Mtce. This equates to just 11% of power generation in 2035, a 57% fall on the 2011 level. Europe's transition mirrors that of the US quite closely with increasingly stringent policy regulations retiring coal consumption capacity that is nearing the end of its lifetime.

Indicatively, Wood Mackenzie and Citi research expect 55GW of coal-fired capacity to be retired by 2024 in Europe's major economies (Figure 13) as plants close as a result of the Large Combustion Plan Directive initially, followed by those who opt out and close due to regulations outlined in the Industrial Emissions Directive. Overall, this results in coal's share of power generation to fall by 42% over this time period in their scenario (Figure 14).

Figure 13: Cumulative power generation in major European economies^{xxvii}

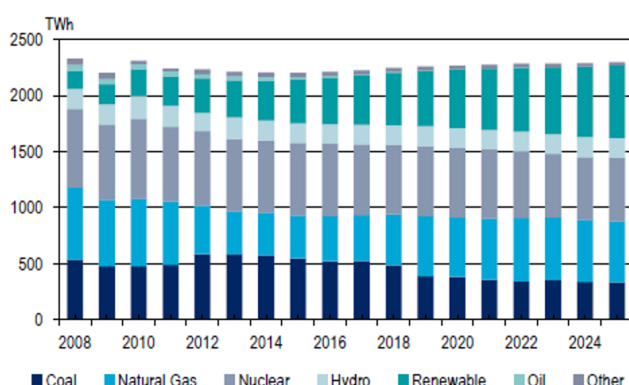
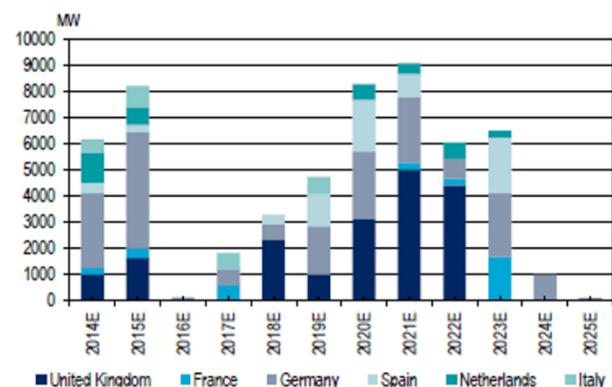


Figure 14: Coal-fired capacity closures in major European economies



2.1 Where IEEFA differs from the IEA New Policies Scenario

The New Policies Scenario is the IEA's central scenario as set in third quarter 2013. The thermal coal forecasts presented by IEEFA incorporate a number of new developments over 2014 we expect are yet to be incorporated into the IEA's annually revised forecasts. IEEFA expects material changes to the assumptions underpinning the IEA's central premise when the 2014 edition is published next month, many of which reduce electricity and / or coal consumption expectations.

IEEFA's global thermal coal demand forecast of 5,510Mtpa by 2035 is 1,103Mt or 16.7% below the IEA New Policies Scenario estimate for 6,614Mtpa by 2035. Relative to 2013 coal demand, this presents a very different trajectory. Where the IEA New Policies estimate assumes 18% growth over the next 22 years, IEEFA forecasts an absolute decline of 2% or 80Mtpa from 2013 levels.

Key points of difference to the IEA reflect IEEFA's assumption of:

1. Lower forecasts for real GDP growth in China and India;
2. A longer assumed useful life for renewable generation capacity;
3. Greater technology advances driving higher capacity utilisation rates for wind and solar;
4. Greater capital cost reductions for onshore wind and solar energy driving greater installations;
5. Taxes at coal's point of use have seen a material step up in 2014;
6. A faster removal of fossil fuel subsidies; and
7. IEEFA's projections assume the US Clean Energy Plan is enacted largely as proposed.

Reduced GDP Growth in China and India

The IEA World Energy Investment Outlook 2014 details that the IEA / IMF has materially downgraded their medium term real GDP growth forecasts for the world's two largest coal consuming nations, China and India. For China, the IEA in March 2014 confirmed it will incorporate China's real GDP at 7.0% pa through to 2020, downgraded from 8.1% pa. For India, GDP growth through to 2020 has been downgraded from 6.5% to 6.1% pa. IEEFA forecasts real GDP growth averaging 6.5% pa for China and 5.5% pa for India for 2013-2020, both marginally lower than the likely new rates incorporated by the IEA. This reflects our confidence that both countries will need to continue to push for more sustainable growth over the long term, lowering the near term to deliver better balance. Both countries financial systems reflect massive imbalances of excessive near term growth and will constrain the ability of each country to fund unsustainable growth near term.

Reducing China's GDP growth for 2014-2020 by 1.1% pa equates to 7% cumulative – which could reduce the IEA's projected coal demand from China of 3,026Mtce by 200Mtce pa, everything else being equal.

Reducing India's GDP growth for 2014-2020 by 0.4% equates to 3% cumulative – which could reduce the IEA's projected coal demand from India of 605Mtce by 20Mtce pa, everything else being equal.

Stronger Performance of Renewables – Useful Life

The IEA assumes wind and solar power have a life of 20 years.^{xxviii} The useful life used by the equity markets is generally 25 years (see Iberdrola 2013). Repowering (replacing small, old wind turbines with new, larger, taller turbines to triple the electricity output) has been a feature of the wind

market prior to end of useful life for many EU windfarms, but this actually arises because the site has excellent wind resources and sees the installation of new wind turbines that are 2-5 times more powerful, meaning this upgrade is commercially valuable. The IEA could be underestimating wind output by 10-20% pa by outer years to 2035, and overestimating winds levelised cost of energy.

Stronger Performance of Renewables – Technology

The IEA assumes that rooftop solar capacity factors will improve by 1% in aggregate over the 2012-2020, and a further 1% over 2020-2035 globally on average.^{xxxix} For the US, this takes rooftop solar up 100basis points (bps (each is 0.01%)) to 17% and Europe up 100bps to 13% by 2020. For utility scale, the gain is 150bps over 2012-2020, and then 100bps over 2020-2035. China and India are assumed to both reach 18% and the US 19% by 2020.

By contrast, First Solar Inc. in 2014 set out its five year solar roadmap that includes a 100bps annual improvement in the capacity factor through to 2018, targeting 20%. The technology rate of learning in solar continues to exceed all expectations and First Solar is ahead of plan for its 500bps improvement by 2018.

The first audit of India's average utility scale solar projects of 2012-13 delivered an average utilisation rate of 19%, already ahead of the 18% IEA target for 2020.

Stronger Performance of Renewables – Lower Capital Costs

The IEA assumes that utility solar see economies of scale improve by 4% pa real over the 2012-2020, and a further 2% pa real over the 2020-2035 period.^{xxx} For the US, this takes utility solar down to US\$2,230/kW by 2020.

By contrast, First Solar Inc. forecasts in its 2014 five year solar roadmap a 10% pa reduction in the total installed cost of solar, with a 2018 target of US\$990/kW.

The IEA assumes the real capital costs for onshore wind decline by a marginal 0.3-0.7% pa over 2012-2020, despite massive technology improvements that have seen the average size of an onshore turbine double to over 2.0MW over the last five years alone. The cumulative installed onshore wind base globally should double in this period to approach 700GW by 2020.

The IEA has made key assumptions on the capital costs of power projects, using 2012 real prices. For renewables this cost estimate is generally being revised down over time as the massive deflationary effect of the two factors above combine – technology and economies of scale. The starting point of the 2012 capital cost of renewables is too high, implying a higher levelised cost of capital and hence a lower take-up rate.

To illustrate, for 2012 the IEA uses a capital cost for large scale hydro in India at US\$1.9m/MW rising to US\$2.0m/MW in real terms by 2020, yet a review of 5 recent major hydro projects with a combined capacity of 4.5GW currently under construction have an average capital cost of US\$1.1m/MW, 40% below the IEA estimate.^{xxxi}

For large scale solar, for 2012 the IEA uses a capital cost in India at US\$2.1m/MW, falling to US\$1.5m by 2020. Yet in 2013 the World Bank estimates the average capital cost for Indian utility solar projects tendered at US\$1.2-1.3m/MW, again 40% below the IEA.^{xxxii}

The economies of scale and rate of technology improvement in solar continues to exceed all expectations, be it from the IEA, the EIA, the NREL or the solar companies themselves. The IEA has a history of underestimating the magnitude of change with respect to renewable energy, resulting in an underestimation of installation rates. Figure 15 provides an illustration of the growth in cumulative solar and wind installations globally over the decade to 2010, and contrasts that to the IEA forecasts made at the start of the decade. The IEA underestimated renewable installs by a factor of 500%. Given the rapid advances being reported through 2014, IEEFA is of the view that this 'conservatism' results in an underestimate of renewables and hence a significant overestimation of thermal coal demand.

Figure 15: The IEA has materially, consistently underestimated Renewables^{xxxiii}

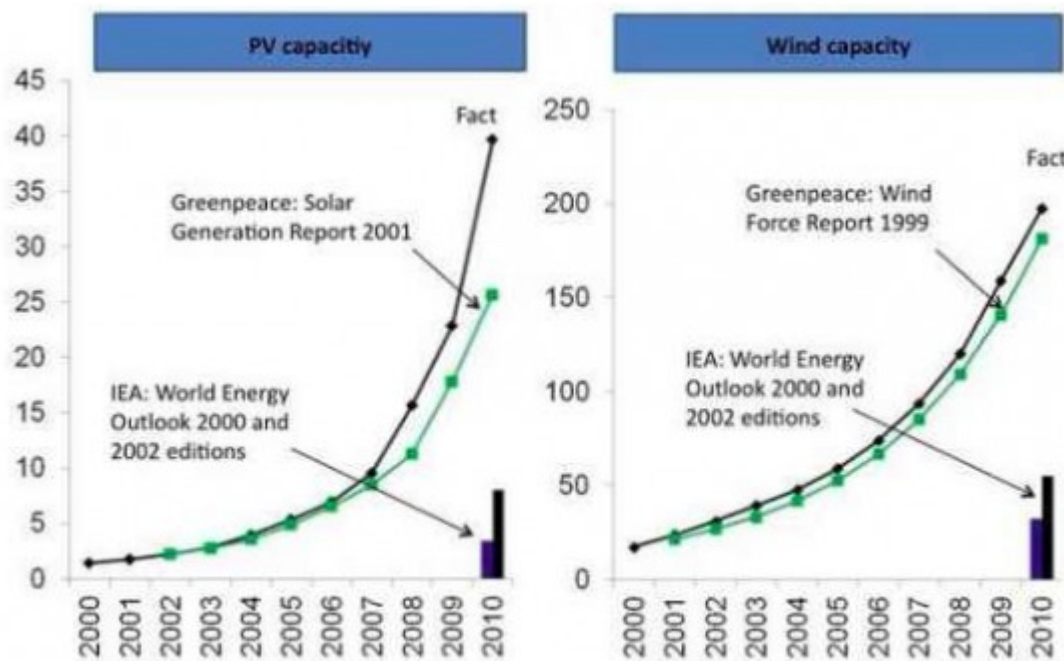
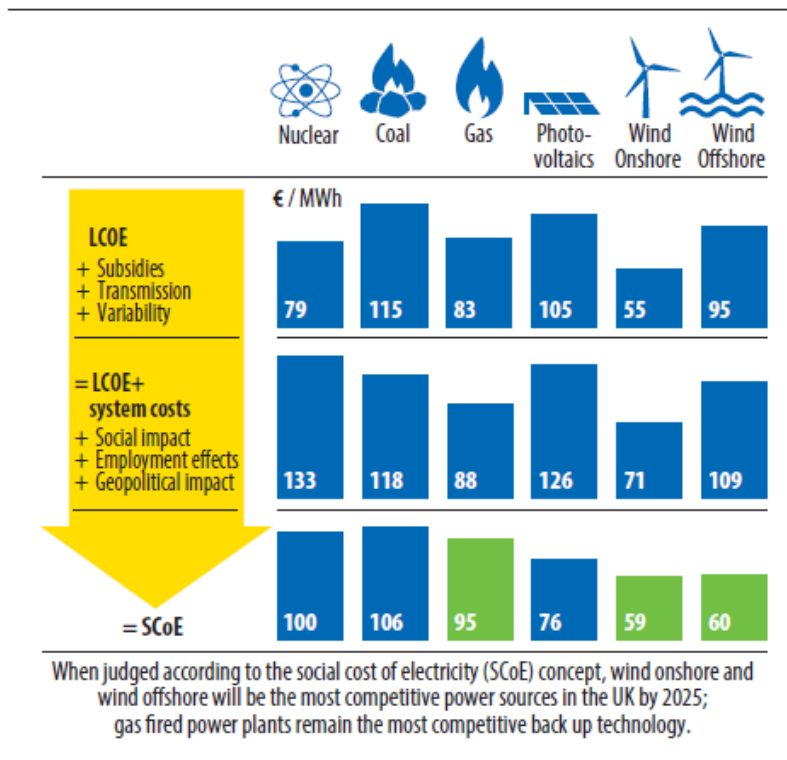


Figure 16 provides a forecast of relative cost competitiveness of each main type of electricity source, as estimated by Siemens, assuming deployment in the UK by 2025. Siemens employs an all-in cost of electricity. This starts with the levelised cost of energy (LOCE) and adds transmission and variability costs to derive a system cost. To the system cost Siemens adds social impact, employment effects and geopolitical effects to determine a social cost of electricity. IEEFA has applied a similar if less complicated logic – renewable costs keep coming down, and fossil fuel-power plant costs are appreciating. Renewables increase energy security and boost local employment. The relative merits mean an increasing rate of deployment of renewables over an ever wider geographic sphere.

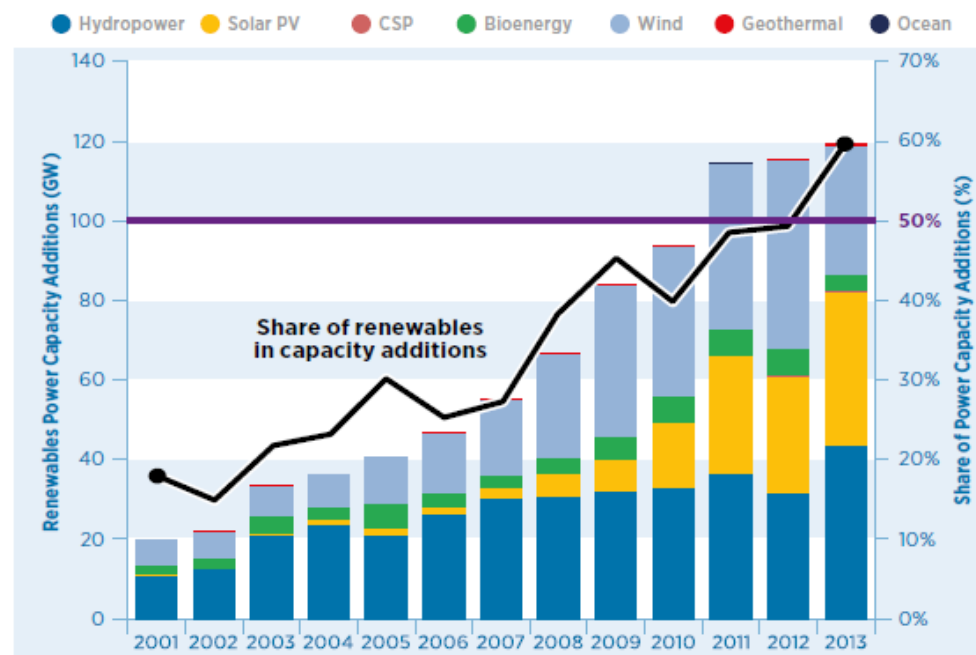
Figure 16: The Levelised Cost of Energy, plus system and social costs – the UK by 2025



Source: Global Wind Energy Council April'2014^{xxxiv}

Figure 17 details renewable energy installs globally over 2001-2013. This illustrates the 10% CAGR over this period. IEEFA forecasts 1,000GW of renewables will be installed over 2014-2020.

Figure 17: Annual Renewable Capacity Added by Technology (2001-2013)



Source: IRENA Sept'2014^{xxxv}

The US Clean Energy Plan

Under President Obama's direction, the EPA in June 2014 proposed a raft of measures to achieve a combined 30% reduction in carbon emissions across America by 2030 from 2005 levels.^{xxxvi} This targets 5-10% larger cuts to coal-fired power generation by 2030 that the IEA's New Policies Scenario builds in. This could reduce the US's coal demand by 2030 by an additional 50-100Mtpa. Refer Appendix C for more detail.

Coal Taxes at Coal Point of Use

IEA assumes excise and tax rates on fuels remain unchanged.^{xxxvii} This assumption is likely to be challenged when the IEA releases its 2014 estimates in light of the number of coal taxes introduced or existing coal taxes doubled in 2014 alone (Mexico, Chile, Korea, India and China – refer Appendix D). Increasing fuel taxes at the point of consumption is a policy initiative to encourage the use of lower carbon emission technologies. Korea's \$16-18/t coal tax could reduce Korea's coal demand by 5-10% pa, or 5-10Mtce pa.

A faster removal of subsidies

The IEA assumes that energy-related consumption subsidies are removed over time.^{xxxviii} The biggest subsidy for electricity consumption is in India where the distribution utilities, who are mostly state owned entities, lose US\$10bn pa and are subsidised another \$5bn pa. As this \$15bn pa consumption subsidy is removed via increased prices, consumption will fall, everything else being equal. Given this would see retail electricity rates rise on average 20% pa as a result, electricity demand would fall 10-20%, assuming a price elasticity of demand of 0.5-1.0x. This could reduce India's coal demand by 2025 by 75-100Mtpa.

3. Country Analysis for Thermal Coal

Energy Demand Trends – Top Global Electricity Markets

Our global thermal coal demand analysis reviews the growth trends of the 20 largest countries in terms of population, GDP, coal consumption and / or electricity demand to 2020 in detail, with a extrapolation of our top-down analysis through to 2035. We present a summary of twelve of the largest electricity systems in the world, providing a comparison of the electricity intensity, real GDP growth and electricity growth since 2000 to give a base historic growth rate. To this we provide an evaluation of energy intensity and economic transition, plus evaluate the current and likely renewable energy, gas, nuclear and hydro electricity generation plans. The impact of key regulations and the increased impact of taxes and emissions trading schemes (ETSs) on coal-fired power generation are also taken into consideration. Examining the compound impact of these drivers, ultimately, determines the change in coal demand forecasted for that country.

Figure 18 details the world's top 20 Electricity markets and highlights the oversized importance of the top two – China and the US.

Figure 18: World's Largest Electricity Markets (2013, TWh)

Country	2013	Rank
China	5,362	1
US	4,260	2
India	1,103	3
Japan	1,088	4
Russian Federation	1,061	5
Germany	634	6
Canada	627	7
France	568	8
Brazil	557	9
South Korea	535	10
Mexico	294	11
Saudi Arabia	292	12
Italy	288	13
Spain	285	14
Iran	263	15
South Africa	256	16
Taiwan	252	17
Australia	245	18
Turkey	239	19
Indonesia	216	20

Source: BP Statistical Year Book 2014^{xxxix}

Figure 19 details several key statistics for 2013 for each of the countries reviewed in detail. The US is still the largest economy in terms of GDP, and also has the highest per person electricity consumption (as measured in terawatt hours per person).

Since 2011 China has had the largest electricity system globally, with total consumption of 5,362TWh in 2013. Not only the world's largest electricity market, China also has a very heavy dependence on coal-fired power generation, such that China consumed 50% of the world's thermal coal production

in 2013. IEEFA forecasts China's coal consumption will peak by 2016, and decline thereafter as the country installs more of every non-coal source of electricity to diversify their grid.

Figure 19: Adjusted Real GDP, Populations and Electricity Consumption

2013 Country Name	Population m	Electricity System TWh	GDP PPP	TWh / GDP	TWh / Person
Australia	23.5	245	1,000	24.5%	10.4
Brazil	203.0	557	2,423	23.0%	2.7
China	1,366.0	5,362	13,395	40.0%	3.9
France	65.8	568	2,278	24.9%	8.6
Germany	80.6	634	3,233	19.6%	7.9
India	1,270.0	1,103	1,293	85.3%	0.9
Japan	127.3	1,088	4,699	23.2%	8.5
Russia	142.9	1,061	2,556	41.5%	7.4
South Africa	53.0	256	597	42.9%	4.8
South Korea	50.2	535	1,667	32.1%	10.7
United Kingdom	63.2	357	2,391	14.9%	5.6
United States	319.5	4,260	16,800	25.4%	13.3

Source: World Bank, BP Statistical Review 2014^{xi}

The US electricity and thermal coal consumption is second largest globally. However, US thermal coal consumption is down 12% in 2013 relative to 2000. A steep decline in US coal demand is forecast for the 2013-2030 period, reflecting the huge impact of the shale gas revolution that is still very specific to the US. President Obama's Clean Power Plan will accelerate this decline.

India is not only the third largest electricity and thermal coal market globally, but has also been the fastest growing major coal import market. Given the very low electricity consumption per person, the challenges for India are huge. India has to somehow maintain sufficient electricity system growth to support continued GDP growth whilst removing the massive subsidies that put retail electricity prices around the lowest rates in the world. India also has an excessively financially geared power sector, and one of the highest transmission loss rates globally. The problems facing India's electricity sector are legion, and will take considerable time to overcome. We forecast that India's coal demand will grow, but that the import coal demand will disappoint the very optimistic views generally held in the financial market.

South Africa is the 16th largest electricity market globally, but surprisingly is the 4th largest thermal coal consuming nation. An abundance and dependence on coal historically could change rapidly with the massive focus on renewable energy by the South African government, Eskom, global renewable energy developers and the major African banks to jointly build electricity system diversity.

Japan is the 4th largest electricity market and the 5th largest thermal coal end market. However, given Japan imports almost 100% of its fossil fuel needs, energy security has taken on an even greater national focus post-Fukushima. As such, IEEFA has a very non-consensus forecast for Japanese coal imports to peak in 2013/14 and decline thereafter based on massive world-leading energy efficiency gains and the accelerated deployment of solar since 2012 (11GW in 2014, second only to China).

Korea is the 6th largest coal consumer globally and like Japan almost entirely dependent on fossil fuel imports (oil, coal, uranium and LNG). Unlike Japan, Korea has four trends working driving up coal demand; 1. economic growth above the OECD average; 2. is heavily skewed to electricity intensive sectors (eg steel, construction, shipbuilding); 3. no material renewable energy installation programs are underway; and 4. energy efficiency has not been effective in curtailing electricity demand growth. We see Korea as one of the few major growth markets for thermal coal.

Europe has led the world with the development of the European Union's ETS and a number of mutually reinforcing policies like the Large Combustion Plant Directive issued in 2001. The global financial crisis has weakened the absolute focus on reducing the EU's carbon intensity. Nevertheless, Germany and the UK illustrate the magnitude of the transition achieved to-date, which will increasingly emerge over the 2013-2020 period. This is driven by the sustained focus on energy efficiency (an EU target of 30% by 2030), the pricing into the system of the cost of carbon emissions and the continued build-out of renewables. Germany's progress has been masked near term by the dramatic reduction in reliance on nuclear post-Fukushima. Over the next decade, the UK will dramatically cut coal consumption under closures driven by the European Union Large Combustion Plant Directive,^{xli} while Germany will continue to transition away from a collective reliance on nuclear, thermal and lignite fuel sources.

France was included in this analysis to illustrate that a country can successfully remove its reliance on coal without any economic impact. France's electricity system is 75% reliant on nuclear, and having unsuccessfully tried to diversify into gas-fired generation in recent years, now onshore and offshore wind and solar are increasingly the key to electricity system diversity.

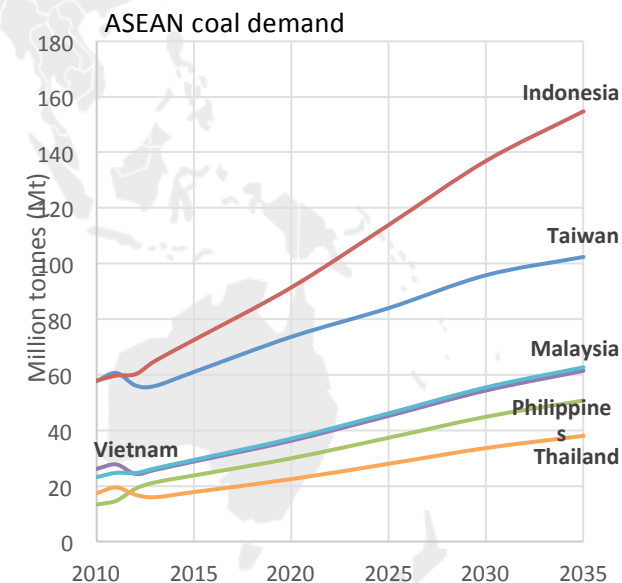
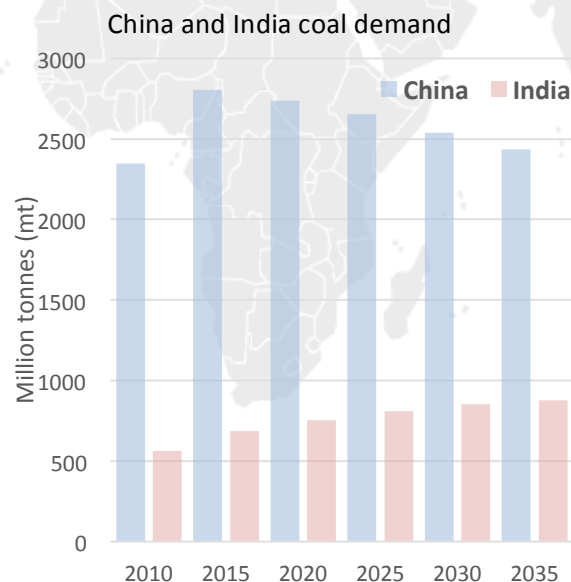
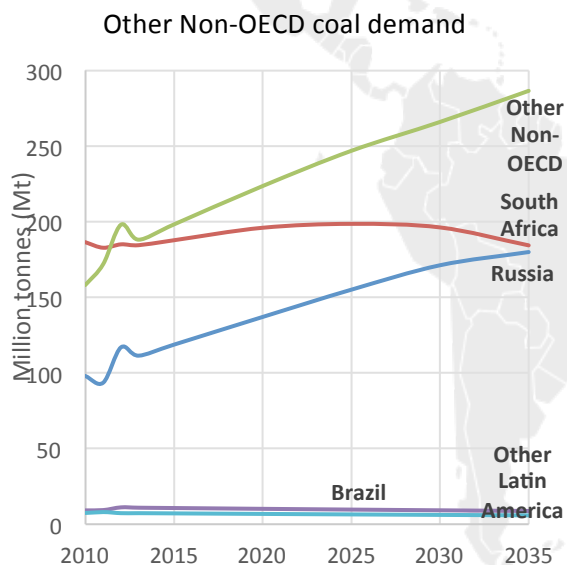
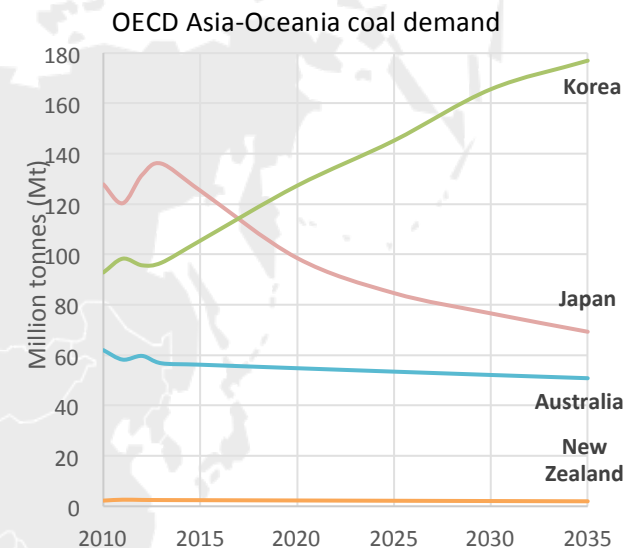
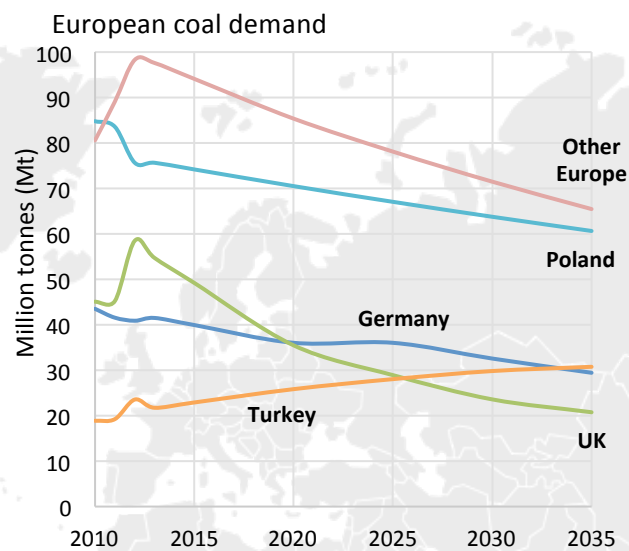
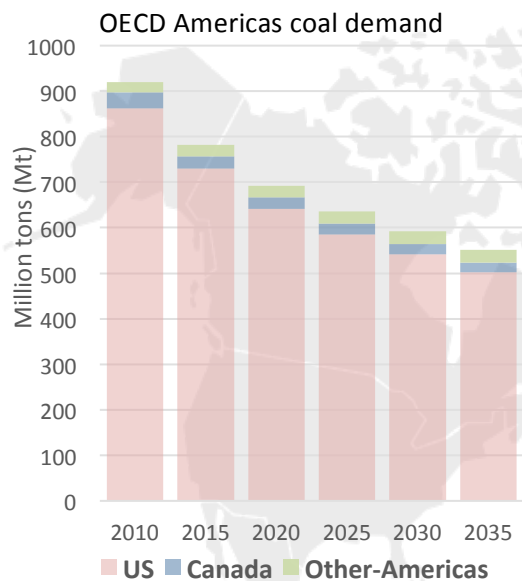
Despite being the largest exporter of thermal coal globally, Indonesia has a relatively small electricity market and hence limited domestic coal demand. However, like much of South East Asia, Indonesia is forecast to sustain strong economic growth and this will continue to drive a rapid electrification of the country. With only a limited national focus on energy efficiency and renewable energy, much of this demand growth will be derived from coal over 2013-2020. The opportunities are significant for system diversification, particularly for wind, geothermal and distributed solar with storage.

Australia is burdened by one of the most expensive electricity grid structures globally, giving rise to very high and rising retail electricity prices. Given excessive investment and a low population density, grid operating costs are 70% of the retail price of electricity. Australia has experienced five years of declining electricity demand, leaving the country with 8GW of surplus generating capacity. With good solar radiation and high retail prices, the increasing penetration of distributed solar (adding distributed solar with storage) will accelerate this decline.

Last but not least, we analyse the Brazilian electricity sector. The 9th largest in the world, Brazil is unique in this selection of leading countries in that coal-fired power generation is almost totally absent from its electricity mix. With no material fossil fuel production (except for deep sea oil), Brazil has an electricity system some 80% reliant on domestic and imported hydro-electricity. With exceptional onshore wind and solar resources, Brazil is rapidly diversifying its electricity grid into these newer areas to improve energy system diversity and hence energy security.

Section 3.1 overleaf presents the high level trends of the IEEFA coal demand model to 2035 before looking at each major economy in more detail.

3.1 IEEFA Global thermal coal demand overview (excl. lignite) 2010-2035 (Mt)



Data table: Global thermal coal demand (excl. lignite) 2010-2035 (Mt)

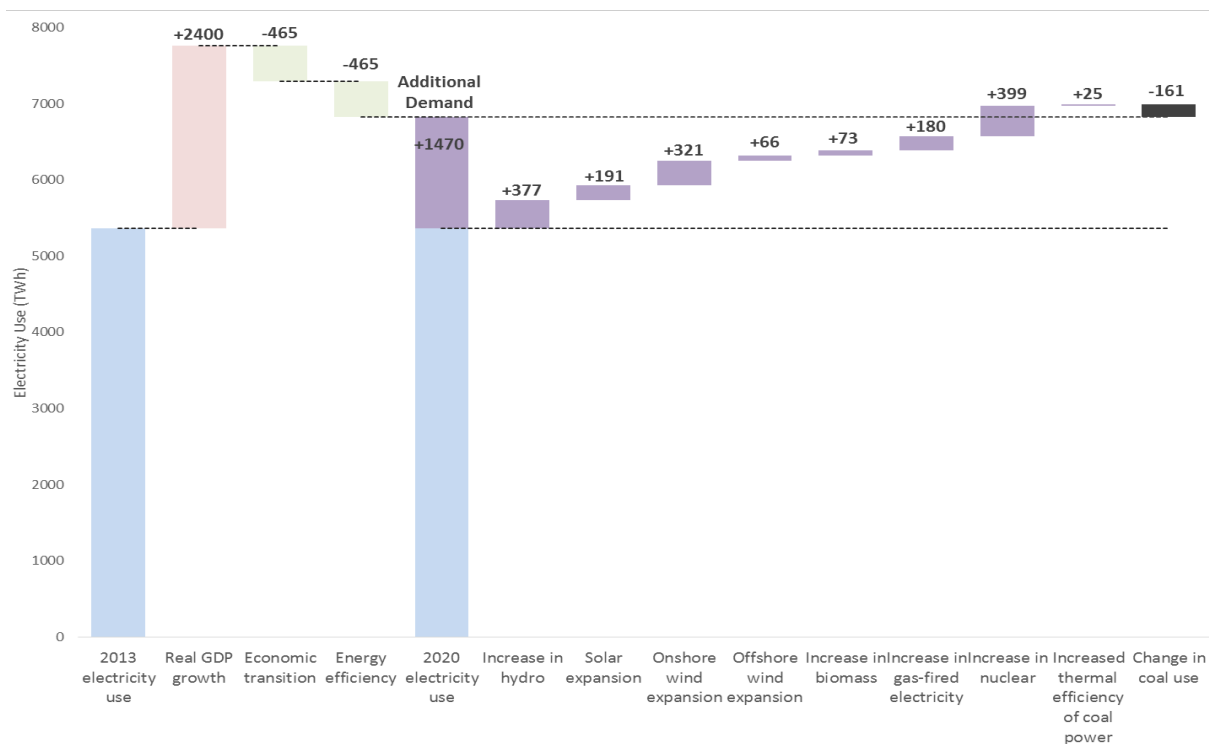
Mt		2010	2013	2020	2025	2030	2035	CAGR 2013-20	CAGR 2020-35
OECD	Total	1,477	1,401	1,229	1,159	1,109	1,057	-1.9%	-1.0%
Americas	Total	919	818	693	636	591	551	-1.8%	-1.5%
	Mexico	15	16	17	18	19	20	1.0%	1.0%
	Canada	34	27	25	23	22	21	-1.0%	-1.2%
	US	862	765	641	585	542	502	-2.5%	-1.6%
	Chile	8	10	9	9	8	8	-1.0%	-1.0%
Europe	Total	273	291	253	238	221	207	-2.2%	-1.3%
	Germany	43	41	36	36	33	29	-2.0%	-1.3%
	France	13	13	11	11	10	10	-2.0%	-1.0%
	UK	45	55	35	29	24	21	-6.0%	-3.5%
	Italy	17	20	18	17	15	14	-1.5%	-1.5%
	Poland	85	76	70	67	64	61	-1.0%	-1.0%
	Turkey	19	22	26	28	30	31	2.5%	1.2%
	Other-Europe	51	65	56	51	46	41	-2.0%	-2.0%
Asia-Oceania	Total	285	292	283	285	296	299	-0.3%	0.4%
	Japan	128	136	99	85	77	69	-4.5%	-2.3%
	Korea	93	97	127	145	166	177	4.0%	2.2%
	Australia	62	57	55	53	52	51	-0.5%	-0.5%
	NZ	2	2	2	2	2	2	-1.0%	-1.0%
Non-OECD Total		3,574	4,208	4,361	4,442	4,468	4,456	0.5%	0.1%
Non-OECD	Russia	98	111	137	155	171	180	3.0%	1.8%
	South Africa	186	184	196	199	196	184	0.9%	-0.4%
	Other Non-OCED	158	188	224	247	266	286	2.5%	1.7%
Asia	Total	3,116	3,706	3,788	3,826	3,820	3,791	0.9%	0.0%
	China	2,349	2,833	2,736	2,654	2,537	2,436	-0.5%	-0.8%
	India	565	657	755	810	853	876	2.0%	1.0%
	Pakistan	6	5	6	7	9	9	3.0%	2.7%
	Taiwan	58	56	74	84	96	102	4.0%	2.2%
	Indonesia	58	65	91	114	137	155	5.0%	3.6%
	Philippines	13	21	30	37	45	51	5.0%	3.6%
	Vietnam	26	26	36	45	54	61	5.0%	3.6%
	Malaysia	23	26	37	46	55	63	5.0%	3.6%
	Thailand	17	16	22	28	34	38	5.0%	3.6%
Latin America	Total	16	18	17	16	15	15	-1.2%	1.0%
	Brazil	9	11	10	10	9	9	-1.0%	-1.0%
	Other non-OCED Americas	7	7	7	6	6	6	-1.0%	-1.0%
World	Total	5,051	5,610	5,590	5,602	5,577	5,513	0.0%	-0.1%

3.2 China's coal demand

- China consumed close to 50% of the world's total coal production in 2013. Consumption of thermal coal has seen a CAGR of 8% since 2000.
- China's thermal coal demand growth rate slowed in 2012 and again in 2013 to average 4% annually, half the rate of the previous decade. Further, coal import and production data to date in 2014 implies that an unprecedented decline in coal consumption occurred most recently.
- IEEFA forecasts China's thermal coal demand will peak in 2016 and gradually decline thereafter. This will have profound implications for the seaborne coal markets, given China accounted for over 20% of total imports in 2013. We forecast that China will potentially become an opportunistic net exporter of thermal coal post-2016.
- Our forecast for slowing demand reflects a combination of a slowing in the rate of real GDP growth combined with a continued program of energy efficiency, plus the structural transformation of China's economy away from more energy intensive basic and heavy industry towards a service-based economy.
- China's absolute focus is on energy security through increased system diversity. This drives increased investment in power across the board, everything but coal. Dramatic expansions of hydro electricity and wind capacities are now being supplemented by an increasing installation rate of solar, gas, biomass and nuclear.
- Increased supply of non-coal based electricity plus reduced demand growth means a forecast peak in thermal coal demand by 2016.

Figure 20 details our forecast for changes to the Chinese electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 20: China's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA analysis 2014

In summary, IEEFA forecasts 6.5% pa real GDP growth for China over the 2013-2020 period, expanding electricity demand by 2,420TWh. Against this, we then assume that the lower intensity of economic growth will reduce electricity demand by 1.5% pa or 465TWh annually by 2020.

We assume the continued emphasis on energy efficiency in China will reduce electricity demand by 1.5% pa, resulting in a reduction in electricity demand of 465TWh by 2020 relative to 2013. The combination of these three factors sees net electricity demand grow by 3.5% pa or 1,490TWh in total.

China continues to pursue an aggressive strategy of electricity system diversification. This is forecast to see a significant expansion of capacity across all alternative sources of electricity other than coal. In the forecast period to 2020, expansions of hydro should supply 377TWh of additional electricity, solar 191TWh, onshore wind 321TWh and offshore wind 66TWh, plus biomass 74TWh. Nuclear is set to expand significantly and IEEFA estimates an additional supply of 399TWh by 2020, whilst increased gas-fired production adds 180TWh. An increase in the average thermal efficiency of coal-fired power plants should add 23TWh of supply without any increase in tonnes coal burned.

All up, this represents a multifaceted transformation of China's electricity grid that is forecast to see coal-fired power generation drop from 76.1% of the 2013 total to 55.8% by 2020. Total thermal coal demand is forecast to peak by 2016 and decline by 98Mtpa by 2020 relative to 2013 levels (a CAGR of negative 0.5%).

China Forecast to Return to an Opportunistic Export Position

China's thermal coal consumption only increased 3-4% yoy in 2013, compared to an annualised growth rate of 8.0% between 2000 and 2012. China's consumption in the first six months of 2014 was down marginally, and imports year-to-date to Aug'2014 are down 5% yoy.^{xlii}

Given China imported more than 240Mtpa of thermal coal in 2013 (22% of total global thermal coal imports), and domestic coal production is forecast to increase marginally over the period to 2020 despite our forecast for falling total thermal coal demand, the combination of these two factors would return China to a position where it could become an opportunistic thermal coal exporter post-2016. China held this position for many years prior to 2008.

To reduce overall coal imports and limit air pollution, China is reviewing the impact of introducing a new proposal to halt the importation of low quality coal, defined as having an ash content exceeding 15% and a sulphur content above 0.6% in coastal cities unless specific emission control filters are installed.^{xliii}

China's Electricity Market Structure

The Structure of the Chinese Electricity Generation sector is detailed in Figure 21. Coal-fired power capacity as at Jun'2014 stands at 829.3GW or 66.3% of China's total.

Figure 21: China's Electricity Power Capacity (2013/14, GW)

GW Installed	Jun'2013	Jun'2014	Percent of total Installed	Change yoy	Change GW	Percent of new installs
Thermal	833.8	878.8		5.4%		
<i>Coal</i>	<i>793.7</i>	<i>829.2</i>	<i>66.3%</i>	<i>4.5%</i>	<i>35.5</i>	33%
<i>Gas</i>	<i>40.1</i>	<i>49.6</i>	<i>4.0%</i>	<i>23.8%</i>	<i>9.6</i>	9%
Hydro	221.8	253.7	20.3%	14.4%	31.9	30%
Nuclear	14.6	17.8	1.4%	21.7%	3.2	3%
Wind	67.5	82.8	6.6%	22.6%	15.3	14%
Other (Solar, EfW, CHP)	6.0	18.1	1.4%	202.3%	12.1	11%
Total	1,143.7	1,251.2		9.4%	107.5	100%

Source: National Energy Agency, 15 July 2014^{xliv}

Hydro-electricity is the second largest installed base of capacity, with 253.7GW operational as of Jun'2014, that being 20.3% of China's total. Wind farms total 82.8GW (6.6%), gas 49.6GW (4.0%), nuclear 17.8GW and Solar/other 18.1GW.

Figure 21 also details the extent of new capacity additions in the 2013/14 period at 107.5GW in total. While coal-fired capacity was still the largest at 35.5GW, it represented only 33% of all new installs – the lowest rate of new contribution from coal in decades. Given total electricity demand grew by 5.4% year-on-year in the first six months of 2014, the merit order effect is such that coal-fired electricity's share of total generation declined in the first six months of 2014. Given IEEFA forecasts the continued installation of 71GW of non-coal generation capacity over 2014-2020, additional net coal-fired capacity in China will not be needed beyond completion in 2015/16 of the current round of plants under construction.

China's Economic Growth to Moderate

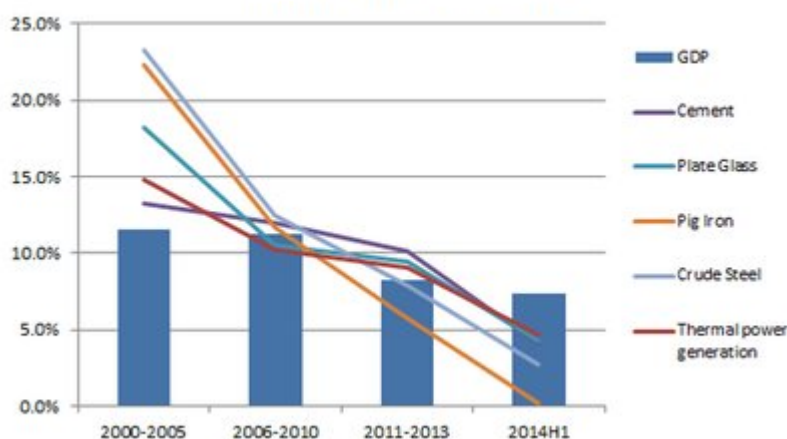
IEEFA expects China's economy will continue to mature, with GDP growth moderating, marginally slowing as a result. The year to date performance suggests the economy is on track for up to 7.5% GDP growth,^{xlv} down from the 7.5-9.5% range seen over the last decade. We expect China's GDP growth rate will continue to moderate towards a 2013-2020 average 6.5% real growth.

China's slowing economy will have a profound impact on the ways it produces and consumes energy. The growth rate for the country's energy demand is set to decelerate from 7-9% pa to between 4-5% over the longer term, according to the Development and Research Centre of the State Council, the Chinese cabinet. However, the absolute size of demand will continue to rise.^{xlvi}

Reduced Energy Intensity

A key forecast component is the expectation that China's economy will continue the recent transformational change away from heavy electricity intensive activities such as heavy industry, fixed asset investment and construction towards consumer goods and services. The latter is estimated to have a power intensity of only a sixth of heavy industry. This is assumed to reduce electricity demand by 1.5% pa relative to GDP. The reduced growth rates of China's heavy industries are illustrated in Figure 22.

Figure 22: China's Basic Industry, GDP and Thermal Power Generation Growth



Source: Sierra Club, Aug'2014^{xlvi}

Therefore, a slowing in GDP growth coupled with continued energy efficiency initiatives and a lower electricity intensity of GDP means that China's electricity demand is likely to slow to 3-4% pa over the next decade, consistent with the 4.0% growth reported in the year to date August 2014.

In 2013, with GDP growth of 7.7% the second lowest rate in the last 14 years, energy consumption grew 4.7% - well below the 10 year average of 8.6% pa.^{xlvi} Figure 23 details the material step down in the ratio of electricity demand growth relative to real GDP growth post 2010 and details Morgan Stanley's view that this will prove a point of structural change going forward. For the 2005-2013 period, electricity demand growth of 10.0% pa was equal to real GDP growth of 10.1% (a ratio of 1.0x), down from 1.18x over 2000-2010.

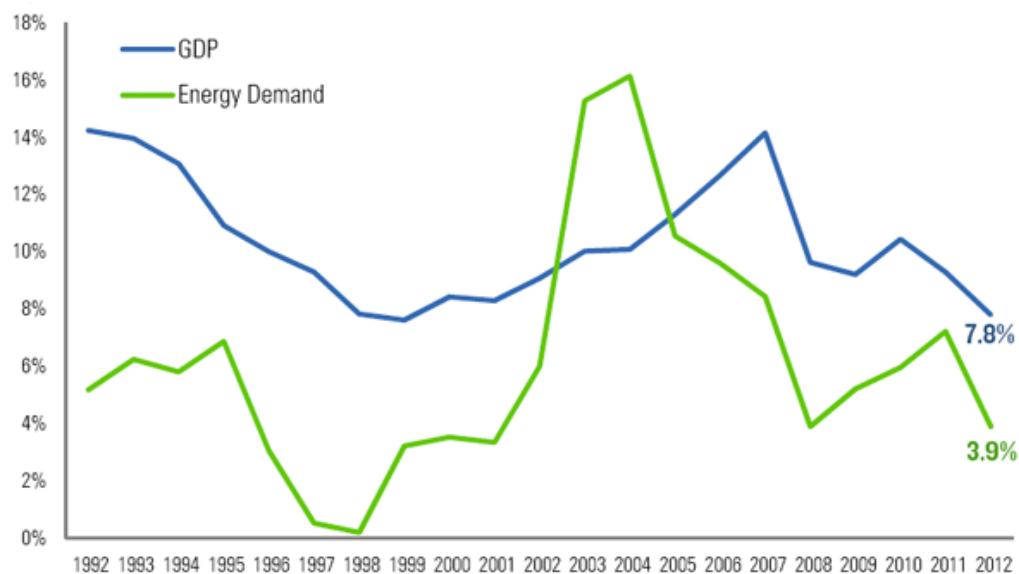
Figure 23: China's Electricity to GDP Co-efficient (2006-2016)



Source: Company Data, China Electricity Council (CEC), Morgan Stanley Research^{xlix}

Figure 24 details the longer term decoupling of energy consumption (across all forms, not just electricity) relative to China's real GDP over 1990 through to 2012.

Figure 24: China GDP Growth vs Energy Consumption – 1990-2012



Source: CEIC and Rhodium Group, Feb'2013^l

The Chinese Energy Revolution

In light of the country's economic structural shift, worsening environmental problems, and advances in new technology, Chinese President Xi Jinping has called for an energy revolution in China:

"To ensure national energy security, China needs to take steps to rein in irrational energy use and control the country's energy consumption by fully implementing energy-saving policies ... There is no turning back in China's commitment to a sound ecosystem."^{li}

President Xi's "energy revolution"^{lii} will focus on energy security of supply and energy efficiency measures. President Xi made several key points about China's energy industry that will have lasting consequences for the global energy sector:

1. The first is the push to diversify China's energy sources. Xi emphasised the importance of having a diverse range of energy suppliers by both geography and fuel source to ensure the country's energy demand and security;
2. Chinese authorities will place new prominence on clean coal technology and upgrade polluting coal fired power stations;
3. China will explore and develop new sources of energy beyond coal and petroleum including natural gas, renewable energy such as solar, and wind and nuclear power; and
4. China will continue to emphasize the importance of reducing the energy intensity of growth.

The Chinese premier also emphasized the need to invest more in the renewable energy sector as part of the broader strategy to upgrade the country's industrial structure. The country is already the world's largest builder of wind turbines and the largest producer of solar photovoltaic cells. Chinese authorities see the development of renewable energy not only as a solution to address its energy demand and worsening environmental problem but also part of the plan to overtake Western competitors in emerging sectors.

The announcement to leverage the seven regional pilot schemes already underway and bring forward the launch of the national emissions trading scheme to 2016 is yet another tangible sign of China's commitment to the reform of its energy system to move to a more sustainable growth platform.^{liii}

Increased reliance on Gas

China continues to develop and diversify its imports of gas as an alternative to coal to ensure better energy security. The US\$400bn Russia-China transaction highlights the magnitude of the task faced by China, and the magnitude of the financial resources at their disposal to create alternative sources of energy for electricity. In August 2014 it was reported that China intends to build an entirely new LNG tanker fleet to facilitate a trebling of LNG imports to 60Mtpa by 2020.^{liv} China's demand for natural gas increased 15.4% in 2012 and 13.9% last year.

Whilst much of the additional gas supply will be used directly in heating applications, we do forecast an expansion in China's installed gas-fired electricity generation capacity from an estimated 46GW at the end of 2013 to 106GW by 2020, increasing electricity system flexibility. The EIA forecasts that gas will rise from 4.9% of China's total energy mix in 2012 to 10% by 2020.^{lv}

Renewable Energy – Onshore Wind

China has pursued a sustained program of onshore wind farm expansions averaging 15GW annually over 2009-2013 that has taken total cumulative wind installs to 91GW by end 2013 (82GW of grid connected wind farms, with another 10GW still waiting on grid connections). The National Energy Administration has set a target for 18GW of wind installs in 2014, and we expect this to be comfortably exceeded given the substantial step-up in activity reported in the interim results of Xinjiang Goldwind Science & Technology Co.^{lvi} and China Ming Yang^{lvii} in Aug'2014.

IEEFA forecasts that 18GW pa of onshore windfarm installs will be maintained through to 2020, putting China well on track to exceed the National Development and Reform Commission (NDRC) 2011 target for 200GW of wind by 2020. This wind program is supported by a differentiated tariff regime that pays windfarms Rmb510-610 (US\$83-99)/MWh in 2014, some 30% higher than that offered for coal-fired power generation. However, wind power has zero inflationary impacts, and few external impacts on water or air pollution and as a result health, unlike coal-fired power.

Renewable Energy – Solar

From a virtual standing start, China has installed 2GW of solar in 2011, 5GW in 2012 and then a world record 13GW in 2013. We expect total Chinese solar installs to be steady in 2014 at 13-14GW, with a significant 400-800% year-on-year expansion in distributed solar systems and reduced emphasis on utility scale systems.^{lviii} This is a strategic shift designed to reduce the burden on the electricity grid structure,^{lix} particularly transnational high voltage direct current (HVDC) networks that are already constrained in accommodating China's rapid wind farm program. Beyond 2014, IEEFA forecasts 16GW of new solar installs annually through to 2020, taking China's cumulative installed base of solar above 130GW, compared to the current target of 70GW by 2017.

In Sept'2014 China increased its small scale solar Feed-in-Tariff by 20% to Rmb0.90-1.00 per kilowatt hour (US\$15-16c/kWh) to ensure the acceleration of small scale distributed solar across China.^{lx}

Renewable Energy – Offshore Wind

The NDRC in 2011 set a target of 30GW by 2020 of offshore wind (as part of the wind total of 200GW), with the offshore target rising to 200GW by 2050. However, three years on, China has only commissioned 0.4GW of offshore wind. In large part this was a deliberate slowdown to ensure the construction, grid connection and technology issues of Europe in the North Sea over 2012-13 were avoided, and to wait for the deployment cost to materially decline. With significant technology advances achieved in the last three years, China is progressively stepping up activity in offshore wind. To encourage more investment in the sector, the NDRC in June 2014 announced China's power grids will pay 0.75-0.85 yuan per kWh (US\$120-140/MWh) for electricity produced by offshore wind turbines if commissioned by 2017.^{lxi} IEEFA forecasts offshore windfarm installs of 18GW by 2020.

Renewable Energy – Hydroelectricity

China installed a record 31.9GW of new hydro in 2013/14 (Figure 21), a significant lift on the 21GW of annual installs averaged over 2008-2013. IEEFA forecasts an additional 138GW will be commissioned by 2020, taking China's 2020 installed total to 392GW – four times the level currently operational in the US (the number two country in hydro). While China will then have reached close to its maximum installable capacity of hydro due to physical constraints, we expect the gap left by reduced hydro installs will be adequately filled by a massive ramp-up in offshore and tidal wind farms. This will further build out China's electricity system diversity and, as another domestic source of fuel, it will materially enhance energy security.

Renewable Energy – Biomass

IEEFA forecasts that China will have 30GW of biomass and energy from waste (EfW) capacity operational by 2020 relative to the 2013 level of 7GW.

Nuclear Energy

China had planned on a major nuclear capacity expansion over the decade to 2020, targeting close to 100GW of installed capacity relative to 13GW in 2013. The Fukushima disaster in Japan saw China put its nuclear energy plans on virtual hold for two years. We understand that China used this delay to review the safety and technology aspects of its nuclear program. 2013/14 saw the commissioning of 3.2GW of new nuclear capacity. IEEFA expects a rapid acceleration of plant commissioning over 2014-2016, potentially of 20-30GW in total. IEEFA forecasts total nuclear installs will reach 67GW by 2020, such that nuclear contributes over 7% of China's total electricity generation (vs 2.1% in 2013).

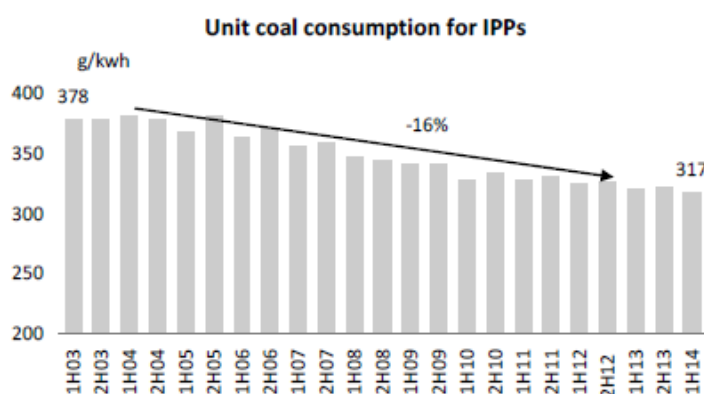
China's from-Coal-to-Electricity Strategy

Under a program launched last year, State Grid Corp of China intends to replace many district heating boilers with large-scale heat pumps. SGCC's strategy for cleaning up China's pollution problem and cutting greenhouse emissions is essentially similar to the climate plans being pursued by governments in Europe and North America. The strategy consists of two separate transitions: electrification and decarbonisation. It would shift more energy consumption away from direct use of coal to an indirect use via the electricity grid, then cutting emissions from power plants by replacing fossil fuels with more renewables and nuclear power.^{lxii} A much larger portion of China's thermal coal use is outside the electricity system that in most developed countries, so the decline in direct household and industrial burning of coal could be very material but hard to quantify.

A 16% increase in Coal-Fired Power Plant Efficiency over a Decade

Figure 25 details the gains made in efficiency of coal-fired power stations across China in the last decade. The amount of coal required to generate a kilowatt hour of electricity has fallen by 16% from 378g/kWh in 2003 to 317g/kWh in 2014. We assume a further 0.6% pa improvement to generate an extra 23TWh of electricity by 2020 with no additional use of coal. The plans to curb low quality coal that is high in ash content and sulphur could accelerate this trend.^{lxiii}

Figure 25: China Average Coal Consumption per unit of Electricity – 2003-2014



Source: Company Data, China Electricity Council (CEC), Morgan Stanley Research^{lxiv}

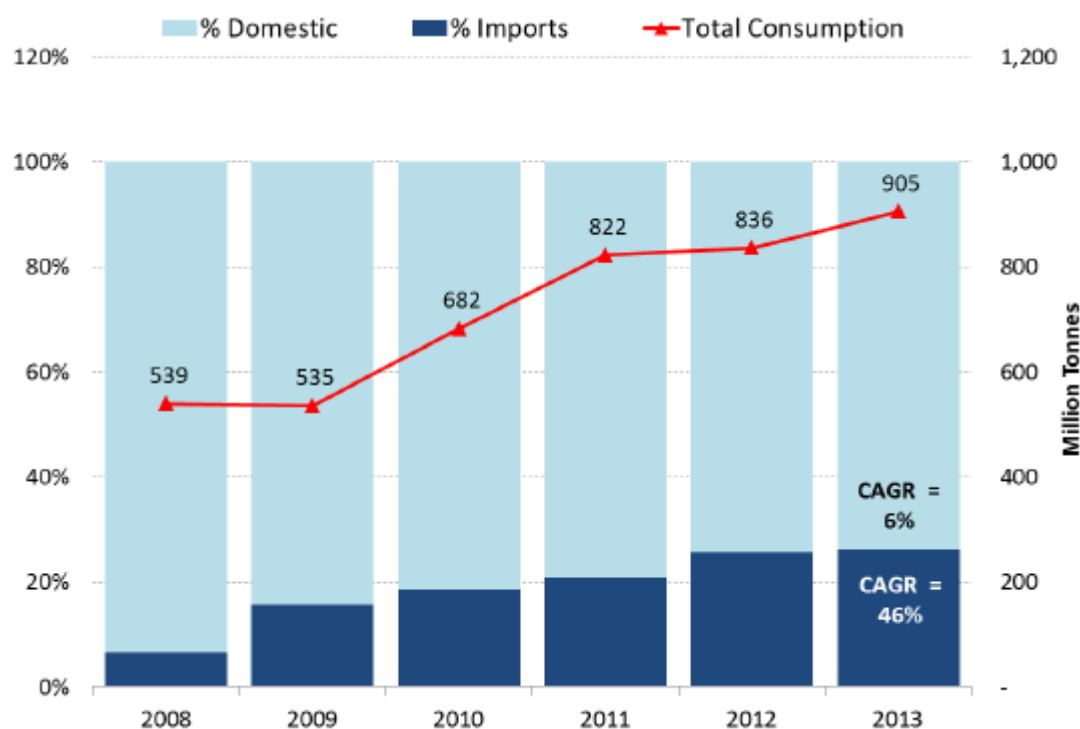
Reduced Coal-Fired Generation Capacity in Beijing

In Jul'2014 the 50-year old Datang coal-fired power plant was mothballed as the first step in a plan involving closing an estimated 6.1GW of coal-fired power capacity under the Beijing Energy Plan covering 2011-2017.^{lxv} Whilst even 6.1GW is only a fraction of the 35.5GW of new coal-fired capacity commissioned in just the 2013/14 year, the trend for a significantly more diversified electricity structure is clear, as is China's commitment to reduce air and water pollution if this can be achieved without materially impacting sustainable economic growth.

China's coal freight railway expansion

China's rail infrastructure constraints meant that until 2014, Chinese domestic coal supply to its coastal regions was unable to cost-effectively meet the rapid growth in demand (+11% CAGR 2008-2013). The result was that China went from being a net coal exporter prior to 2008 to being the world's largest coal importer by 2013.

Figure 26: China's Coastal Coal Demand – 2008-2013 (Mt)



Source: Adaro Energy, April 2014^{lxvi}

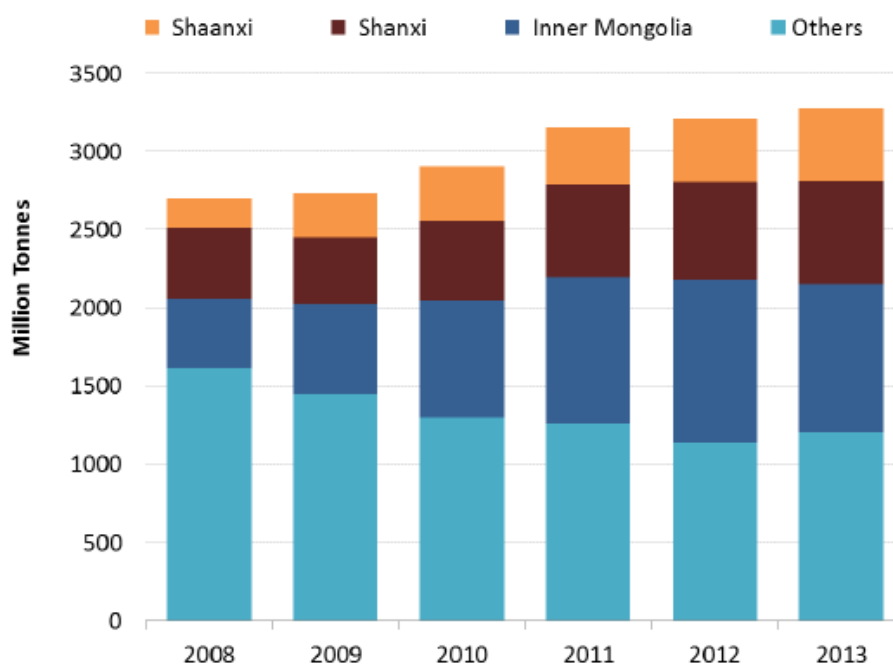
While IEEFA forecasts Chinese thermal coal imports will peak in the 2013-2016 period at 200-250Mt and decline thereafter, Wood MacKenzie forecasts China's imports will expand to 300-400Mt by 2020.^{lxvii} The expanded railway capacity within China and the resulting cost reductions are expected to play a significant role in the reversal anticipated by IEEFA. The expansion of the transnational HVDC grid system will play a major role in facilitating the relocation of China's electricity generation

system westward. Coastal nuclear power additions will also play a key role in reducing China's thermal coal imports in the next six years.

China's railway expansions are key

Lower mining costs and greater scale has seen Inner Mongolia's coal production more than double since 2008 – refer Figure 27. On the whole, coal producing provinces in the North and West have been supported by a massive national railway network upgrade linking them to demand centres in coastal areas.

Figure 27: China's Coal Production by Basin – 2008-2013 (Mt)



Source: China Coal Resource, 2014; WoodMackenzie, Coal Market Service, 2013

Source: Adaro Energy, April 2014^{lxviii}

This will have profound implications on the global seaborne coal dynamics, not the least due to the rapid cost reductions in transportation costs in China (rail is one third the cost of trucking). We note the cost variance of coals from Inner Mongolia are typically 4,000-4,800NAR – similar to the cost variance of Indonesian coal, facilitating a relatively straightforward import substitution.

China's Coal to Chemicals Conversion

China has a low self-sufficiency in oil and chemical products. This drives a policy to encourage alternative feedstock and supply sources, including converting coal-to-olefins (CTO), coal-to-gas (CTG) and coal-to-liquids (CTL) projects. This is a major new area of demand for coal, and with a multibillion capex program underway across more than a dozen projects currently, this could boost the demand for coal within China by 200-300Mtpa by 2025.

Key issues that are emerging in this conversion are the extreme water intensity of the projects, the heavy carbon emission intensities and the high capital cost of projects. Should this expansion prove commercially viable, this may provide a partial offset to reduced domestic thermal coal demand in China.

Coal Demand in China Beyond 2020

IEEFA forecasts that China's domestic thermal coal demand peaks by 2016 and falls by a net CAGR of 0.5% from 2013 to 2,736Mt in 2020. A key outcome of this forecast peaking of Chinese domestic demand is that China is likely to favour its domestic coal industry over imports. IEEFA forecasts that China ceases being a major thermal coal importer, and could actually return to being an opportunistic exporter on any price strength in seaborne thermal coal. To this end, it is noteworthy that China's thermal coal imports fell 18% month-on-month to a 2014 low of 19Mt in Aug'2014.^{lxix}

Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 0.8% over 2020-2035 as a function of a number of factors: China continues to develop on and offshore wind, solar, biomass and nuclear; real GDP growth continues to decelerate; the transition towards more service orientation in China's economy continues; China accelerates energy efficiency initiatives; and aging coal-fired power plants are progressively decommissioned. We assume a continued decline thereafter, with a CAGR of negative 0.8% for 2035-2050.

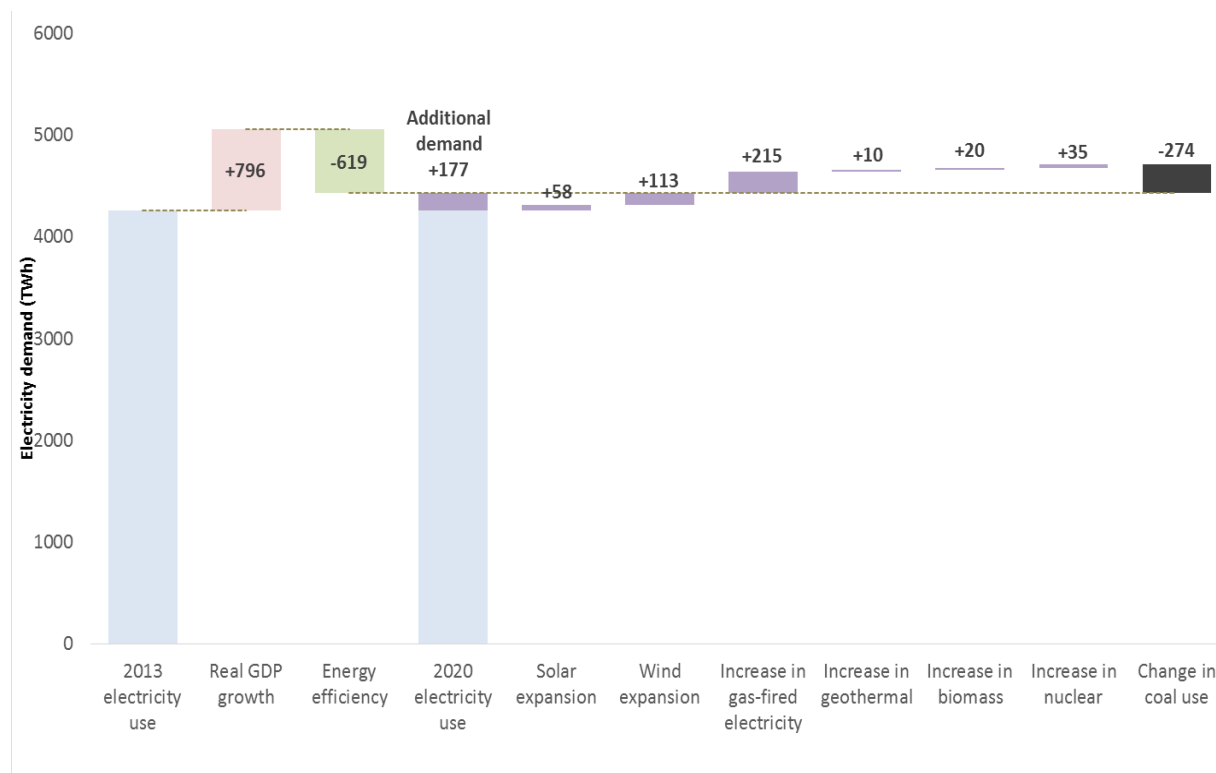
3.3 The United States (US) coal demand

Trends in US Coal

- From 2000 to 2013, US thermal coal consumption is down 101Mtpa to 765M metric tonnes.
- Energy efficiency gains mean total US electricity consumption is up only 0.2% pa over 2004-2013. We see scope for energy efficiency gains to be significantly stepped up.
- Coal-fired electricity production is down 2.4% pa over 2004-2013.
- Coal-fired power capacity closures are forecast to cut US domestic thermal coal demand by another 124Mtpa or 16% by the end of this decade.
- Expanded renewable energy and gas-fired electricity generation will increasingly replace what has traditionally been a coal-fired electricity system.
- IEEFA forecasts the addition of 39GW of wind to take the US installed base to 100GW by 2020. IEEFA forecasts the addition of 22GW of solar from 2013 to 2020 to take the US to a total installed base of solar of 35GW by 2020.

Figure 28 details our forecast for changes to the American electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 28: America's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA analysis 2014

In summary, the IMF forecasts 2.8% pa real GDP growth for America over this period, expanding electricity demand by 796 terawatt hour (TWh). Energy efficiency will continue to reduce electricity demand by 2.2% pa, resulting in a cumulative reduction in electricity demand of 619TWh by 2020. Expanded solar capacity will produce an additional 58TWh by 2020, and the opening of two 2.2GW

nuclear power plants in Georgia will add 35TWh pa of electricity supply. Second only to energy efficiency, expanded gas-fired power generation capacity and higher operating rates across the entire gas-electricity fleet is forecast to add 201TWh of additional American electricity supply annually by 2020. Opening 5GW pa of new wind farms will generate a combined 113TWh pa by 2020, with more incremental expansions of geothermal (+10TWh) and biomass (+20TWh).

The combined impact is a material, permanent reduction in coal-fired power generation. With US domestic thermal coal demand having fallen at a CAGR -3.4% over 2005 to 2012, we expect this trend to accelerate under President Obama's Clean Energy Plan reversing the slight increase in thermal coal demand in 2013 and likely for 2014.

We conservatively assume a 2.5% pa decline in thermal coal use in the US for 2013-2020, resulting in a cumulative 124Mtpa or 16% decline from the 765M metric tonnes used in thermal coal for electricity in 2013. Overall, these drivers combine such that IEEFA forecast domestic US coal use will fall by 274TWh by 2020. Coal usage is down 1.1% year to September 2014 year-on year.^{lxx}

Electricity Demand and Generation Trends – 2004 vs 2013

Figure 29 details the trend in total US electricity demand over the last decade through 2013. Total demand has grown 2.2% in total or a CAGR of 0.2%.

Within this, coal-fired electricity generation has declined from 49.8% share in 2004 to 39.1% in 2013, down 20% in total or a CAGR of negative 2.4%. Use of oil-fired electricity capacity has dropped 78%, while nuclear and hydro has been flat. Renewable energy (RE) generation (excluding hydro) has grown at a CAGR of 11.8% or 173% in total to 266TWh. Gas-fired generation is up 55% and now accounts for 27.7% of total US electricity generation.

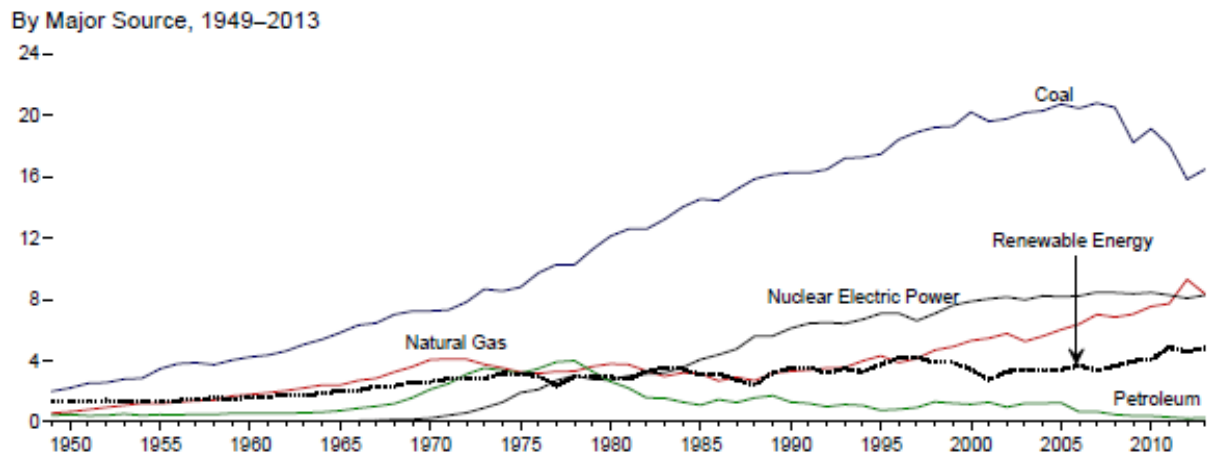
Figure 29: US Annual Electricity Demand (2004-2013, TWh)

TWh	Coal	Oil	Gas	Nuclear	Hydro	RE	Total
2004	1,978	121	725	789	268	97	3,971
2005	2,013	122	774	782	270	100	4,055
2006	1,991	64	831	787	289	109	4,065
2007	2,016	66	910	806	248	117	4,157
2008	1,986	46	895	806	255	138	4,119
2009	1,756	39	932	799	273	156	3,950
2010	1,847	37	999	807	260	180	4,125
2011	1,733	30	1,025	790	319	208	4,100
2012	1,514	23	1,238	769	276	232	4,048
2013	1,586	27	1,126	789	269	266	4,058
Change - 2013 vs 2004	-19.8%	-77.8%	55.2%	0.1%	0.3%	173.1%	2.2%
CAGR	-2.4%	-15.4%	5.0%	0.0%	0.0%	11.8%	0.2%
As a percent of total							
2004	49.8%	3.1%	18.3%	19.9%	6.8%	2.5%	100.0%
2013	39.1%	0.7%	27.7%	19.4%	6.6%	6.5%	100.0%
Change	-10.7%	-2.4%	9.5%	-0.4%	-0.1%	4.1%	0.0%

Source: EIA June 2014^{lxxi}

The longer term trends in total demand and the breakdown in terms of fuel-source is presented in Figure 30.

Figure 30: Electric Power Energy Production (Quadrillion Btu)



Source: EIA Jun'2014^{lxxii}

Energy Efficiency could keep US electricity demand flat through to 2035

There remains significant scope to enhance energy efficiency gains. While the EIA forecasts US electricity growth of 0.9% pa over the next three decades, this assumption is being increasingly questioned in light of the high electricity intensity of the US economy. An Apr'2014 EIA study reviewed the scope for energy efficiency alone to keep US electricity consumption flat for the next 15-25 years and found that just the deployment of best in class existing technologies could achieve this.^{lxxiii}

A July 2014 study suggested the US was materially lagging against its peers in an industrialized country survey.^{lxxiv} IEEFA would concur with this analysis – it reflects in large part a lack of regulatory focus and also a lack of strong price signal given the relatively low retail and industrial pricing of electricity in the US. In light of this, we see the scope for the US to deliver sustainable energy efficiency gains of 2.2% pa over the period to 2020, such that IEEFA forecasts electricity demand growth at only 0.6% pa despite a strong 2.8% pa in real gross domestic product (GDP) growth.

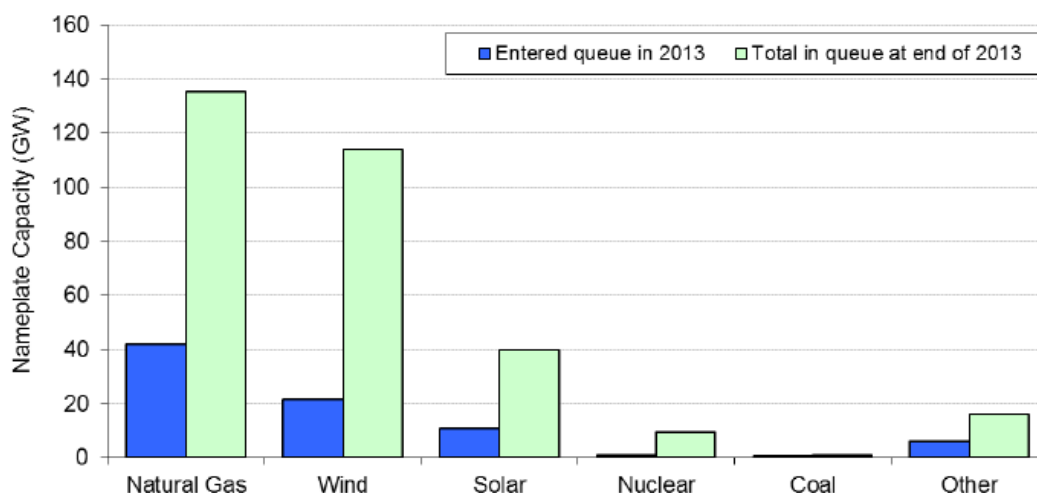
Renewable Energy - Recent Installation Rates

In 1Q2014, 74% of all new electricity capacity installs in the US were solar. Equally important in this was that for the first time, residential solar installs exceeded utility scale solar capacity additions. This is being driven by the Federal tax incentives, renewable portfolio standards (RPS), regional and local rebate programs for solar, innovation in the financing of debt and leasing, plus innovative new equity structures (Yieldcos), and ever-decreasing cost structures and improved technologies.

Wind electricity production has grown over at a CAGR of over 100%, and total renewables (including biomass and hydro) has grown at a 4.6% CAGR. Nuclear production has been static, and gas has grown at a 5.4% CAGR.^{lxxv}

Figure 31 details the existing plans for potential new electricity capacity installs in the US by fuel type. It clearly highlights non-coal electricity sources, in particular gas, wind and increasingly solar, as the predominant fuel sources for electricity.

Figure 31: New Electricity Capacity Interconnection Queue – By Fuel Source, 2013 (GW)



Source: DOE, Exeter Associates (Aug'2014)

Gas-Fired Electricity to Dominate

Gas as the fuel for electricity has grown from 18.3% to 27.7% of the US total in the last decade. Continuing the trend of the last decade, and fueled by record low domestic natural gas prices, IEEFA expect gas to overtake coal as the dominant fuel type for US electricity by 2025, with 75GW of new gas fired power capacity forecast to be installed over the next decade. This is entirely consistent with President Obama's Clean Energy Plan of Jun'2014, whereby the EPA is strongly advocating an increase in the installation of gas capacity and also significantly higher operating rates for existing gas power plants.

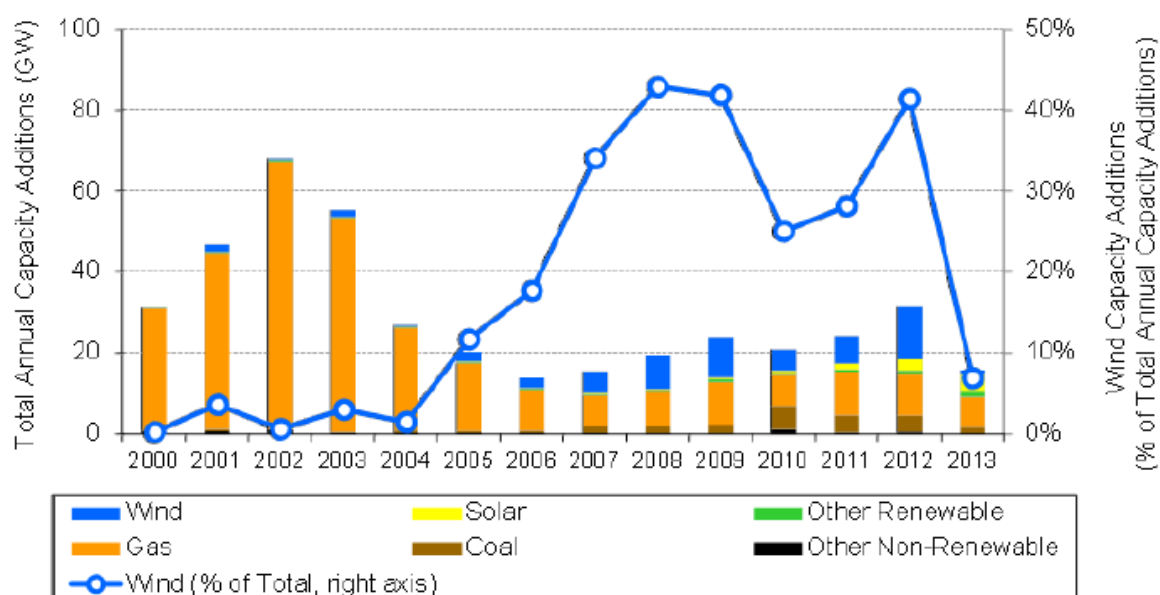
In the first six months of 2014, 2.3GW of new gas-fired power capacity was commissioned in the US, against no new coal power, and 1.0GW of old coal-fired capacity retired (with 1.1GW of solar and 0.7GW of wind also added).^{lxxvi}

Renewable Energy – Wind

In 2013, the US installed 61GW of wind energy capacity, the second most globally after China with 91GW. The US Department of Energy's "2013 Wind Technologies Market Report" of Aug'2014^{lxxvii} noted that as at the end of 2013, there was an additional 114GW of wind power capacity within the transmission interconnection queues, with 21GW of these added to the queue in 2013 alone. The study also highlighted that off the back of the 20% decline in install costs to US\$1.6m/MW of new capacity from 2008-2013, the average power purchase agreement (PPA) in 2013 reached an all time low of US\$25/MWh (US2.5c/kWh). This puts wind power supply costs below the low end of the possible range of gas-fired power generation and makes wind the lowest cost source of electricity in the US. The DOE concludes that wind could provide 20% of all US electricity by 2030 vs only 3.5% in 2013.

US wind installations have run at 7.1GW pa over the last six years despite ongoing regulatory uncertainty as shown in Figure 32. IEEFA conservatively forecast a slowing in the install rate to 5GW pa in the US going forward – meaning less than 20% of the total projects already in the planning pipeline are initiated by 2020. This also represents an installation rate of only 25% of that forecast for China. We would note that a record 14.6GW of windfarms were under construction in the US as of Jun'2014.^{lxxviii} The EIA forecasts a 9% growth in wind capacity in the US in 2014, and a further 16% growth in 2015.^{lxxix}

Figure 32: US Annual Electricity Capacity Installs – By Fuel Source, 2000-2013 (GW)



Source: EIA, Ventyx, AWEA, Interstate Renewable Energy Council, SEIA/GTM, Berkeley Lab

Renewable Energy – Solar

IEEFA forecasts total solar installations will reach 50GW by 2020, a 40% higher level of penetration than forecast by the EIA. Double digit declines in the total installed system costs for solar are forecast to continue for the rest of this decade, making solar increasingly competitive at the utility scale level in the peaking wholesale power markets. Despite relatively low retail power prices of US12.5c/kWh across the US, we expect installations of distributed rooftop solar with storage to

accelerate into the end of this decade. Into the 2020-2030 period, behind the meter self-generation will become a defining factor that permanently erodes total grid-system electricity demand.

In the US utility-scale solar sector, average system prices fell to \$1.69/w. That has corresponded with a "precipitous" drop in prices for power purchase agreements according to GTM Research.^{lxxx} Solar PPA prices are now US\$50-70/MWh, compared to between \$80-100/MWh less than two years ago.

Renewable Energy – Hydro

At 99GW of installed capacity, the US has the second largest base of hydro electricity globally (again, behind China). However, unlike China, India, Brazil and South Africa, the US hydro-electricity industry has been static for several decades. Given the Clean Energy Plan and the increasingly ambitious Renewable Energy Targets, we note the EIA in Jul'2014 reviewed the scope for both new hydro and repowering of existing dam systems in the US. The EIA estimates 61GW of additional hydro capacity is easily and commercially accessible across the US.^{lxxxi} Given the significant lead times involved in hydro, we do not expect any net new additions prior to 2020, although there is scope for 5-10TWh pa of additional hydro imports from Quebec into the New England area by 2020. However, we conservatively forecast 1GW pa of US hydro additions beyond 2020.

Renewable Energy- Geothermal

The US has 2.7GW of geothermal power plants in operation, running at an average 70% utilisation rate, giving them baseload power characteristics. The EIA forecasts geothermal electricity to quadruple to 67TWh by 2040.^{lxxxii} IEEFA has assumed 10TWh of this will be added by 2020. This is not a major contribution, but it is another source of electricity so builds the US energy diversity and hence energy security.

US Nuclear

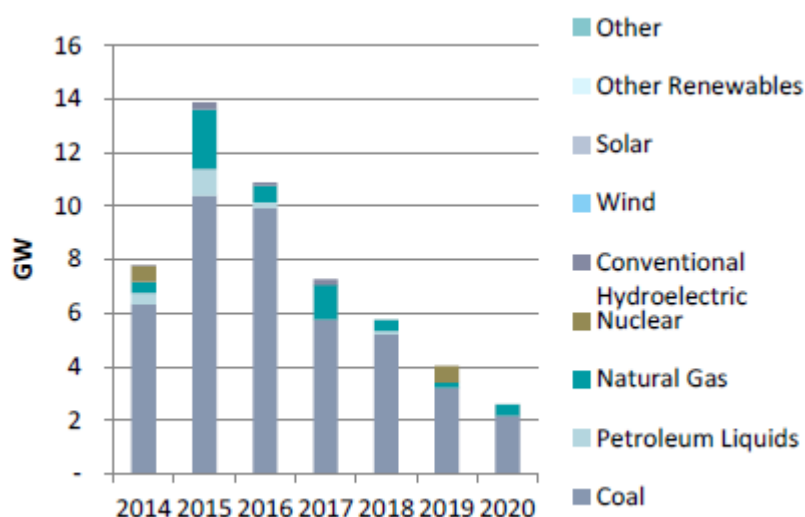
The US has 99GW of operating nuclear power plants, two new plants under construction in Georgia by Southern Co. at Votie at a cost of US\$6.7bn for 2.2GW with a commissioning date of 2018,^{lxxxiii} and the second by Scana Corp for 2.3GW at a cost of US\$10bn due online 2018-19,^{lxxxiv} and an additional four new nuclear units under consideration in South Carolina, Georgia and Tennessee that could be brought on line in the period 2020-2030 should rules be clarified on nuclear waste disposal.^{lxxxv} We assume total nuclear capacity is stable post 2020 as new builds and refurbishments offset retirements of the increasingly aging US nuclear fleet of generators.

Coal-fired power plant trends ... 60-180GW of closures this coming decade

US coal demand has been heavily affected by the failure of coal industry efforts to build new coal plants. In the mid 2000's the industry launched plans to build 150 new plants. Since then over 177 new plant proposals have been cancelled. A combination of adverse market conditions and public advocacy by environmental organizations lead by the Sierra Club effectively reduced any market expansions for new coal plants. The cancellation of these plants has been followed by a wave of retirements of existing coal plants, a trend that is expected to continue as the aging coal fleet struggles to maintain compliance with air, land, water and climate regulation.

Retirements of coal-fired power plants in the US has risen markedly over the past few years. In 2012, 10GW of coal capacity was retired, up from 2GW in the previous year. New policy measures being introduced suggest this upward trend is set to continue. In the single month of August 2014 7.3GW of coal-fired power stations were announced for decommissioning. Figure 33 illustrates Citi Research's estimate of 61GW of coal-fired power plant retirements from 2014-2020. Note – this report pre-dates and hence does not include the additional closures resulting from the Clean Energy Plan.

Figure 33: US Coal-Fired Power Plant Retirements: 2010-2012



Source: Citi Research, May 2014^{lxxxvi}

The introduction of the Mercury and Air Toxics Standards (MATS) with an implementation date of April 2015 combines with President Obama's June 2014 EPA "Clean Power Plan" Rules (refer Appendix C), sustained low natural gas prices, significant new renewable capacity installations, weak electricity demand and a significantly aging coal-fired power plant fleet to see a significant number of coal-fired power plants slated for closure over the 2015-2018 period, with estimates of from 50-100GW.^{lxxxvii} Beyond this period, significant further closures are expected, with additional costs and controls resulting from the National Ambient Air Quality Standards.

In February 2014 the EIA forecast that 60GW of coal-fired power capacity will retire by over 2012-2020.^{lxxxviii} This was up from the EIA's 2013 forecast for 40GW of closures, and more than double the 27GW it predicted in 2012.^{lxxxix} The EIA has a long history of under-estimating renewable energy installations, under-estimating energy efficiency initiatives with the obvious outcome of overestimating electricity demand growth and demand for coal from coal-fired power generation respectively.

For example, the Sierra Club estimates that 177 coal-fired power plants with in-excess of 74GW of capacity have either closed or announced their closure plans since 2010, with 4GW announcing closure in Aug'2014 alone.^{xc} The US Environment Protection Agency (EPA) believe the impact of the MATS and Clean Power Plan will be even more pronounced than this, projecting that nearly 180GW of coal-fired power generation capacity will have been retired between 2010 and 2020.

This contraction of the US coal industry has already caused 26 bankruptcies over the last two years - these forecasts suggest further losses are expected.

Coal Demand Reductions from Plant Closures

The aging nature of the coal-fired power plants to be closed means they are generally higher cost and hence running at low capacity utilisation rates, losing out to natural gas and renewables. As such, the impact on coal demand is less than the headline implies. Assuming a 30% utilisation rate, the closure of 50-60GW of coal capacity over 2014-2016 would reduce US coal consumption by a cumulative 60-70Mtpa.^{xc}

Analysts at Sanford C. Bernstein & Co. are forecasting that the US EPA's Clean Power Plan will cut the nation's coal burn by 204M ton by 2020, a reduction of 18% from 2013 (including 39Mt of production will be lost from lignite mining regions such as Texas). Bernstein expects a decline of 63M ton equal to a 7% decline due to the impact of MATS by 2020 driven by the closure of 50GW of capacity. Combining the two regulatory imposts would see demand down 25% or 228M short tons by 2020.^{xcii}

The EPA, which expects overall coal production for the electric power sector would fall 25% or 208M tons by 2020.^{xciii} IEEFA forecasts are a little more conservative than these very ambitious forecasts – IEEFA assumes 124M tonnes annually of coal replacement by 2020 (down 16% vs 2013), with significant reductions continuing post 2020 as well.

Coal industry efforts to offset domestic market losses with a strong export strategy have met with resistance within the US and a softening of the global thermal trade. U.S. coal exports are currently at 100Mtpa, and are not expected to rise materially as efforts by the industry to secure approvals for greater port capacity within the US are meeting with resistance.

US Coal Subsidies

The US Federal Government manages the majority of the US coal reserves under a program administered by the Bureau of Land Management (BLM). Historically the Powder River Basin (PRB) produced over 40% of the nation's annual coal production. Over 2009-2013 the BLM has tendered 2.2 billion tons of coal deposits to coal mining companies at an average cost of US\$1.03/t.^{xciv} The program is seen as a giveaway to industry.^{xcv} The PRB remains the 'go to' region for coal in the U.S.

even as the cost structure of other regions is resulting in reduced demand. Despite the PRB being the most productive coal region in the country, demand for PRB is also decreasing. In 2010 the EIA's Annual Energy Outlook projected 2013 production of 583Mt (short tons), rising at a rate of 0.9% pa to 696Mt (short) by 2040.^{xcvi} In its 2014 outlook the PRB produced 470Mt (short) in 2013 and the estimated 2040 output is 518Mt (short).^{xcvii} Coal industry plans to utilize this coal subsidy to enhance export sales have also not materialized as community opposition to ports and a weak global market for thermal coal has undermined these investments. The thirty year subsidisation of coal from the region is no longer sufficient to maintain the level of demand and profitability historically enjoyed by the industry.

According to the United States Geological Survey (USGS) the level of economical coal reserves in the western part of the U.S. are significantly overstated. The USGS study has largely been ignored by industry. However, the recent mine closures and mothballing in the PRB suggests that the broader economic issues raised by this 2008 study are now materialising on the balance sheets of the major coal producers in the region. Neither the USGS, EIA nor any of the companies doing business have substantially adjusted their reserve calculations based on this analysis. And, despite the last three years of significant value destruction in the U.S. coal industry and a very weak forward outlook, coal companies are continuing to carry billions of tons of coal on their balance sheets that may in fact not be economically recoverable.

The fundamental coal demand drivers in the U.S. are geological, financial and regulatory/political. US coal demand up through the 1990's concentrated in Central Appalachia (CAPP). As its reserves have become depleted the region has become more expensive to mine. Tightening markets for thermal and coking coal combined with rising costs of production have placed the region in a permanent downward spiral. In the middle 1990's the region produced upward of 300Mtpa, almost 30% of the U.S.'s coal supply. The EIA now estimates the region will produce only 100Mtpa by 2020 and decline slowly thereafter.

The last three years of low power prices from the shale gas glut and rising renewables penetration has also had an impact on other, more prolific coal regions – the PRB and Illinois Basin (ILB). The PRB is experiencing some of the same cost of production issues as CAPP. The ILB is a low cost region and anticipated to grow. The growth assumptions for both ILB and PRB are slowing as demand from domestic coal consumers and the global thermal markets weaken.

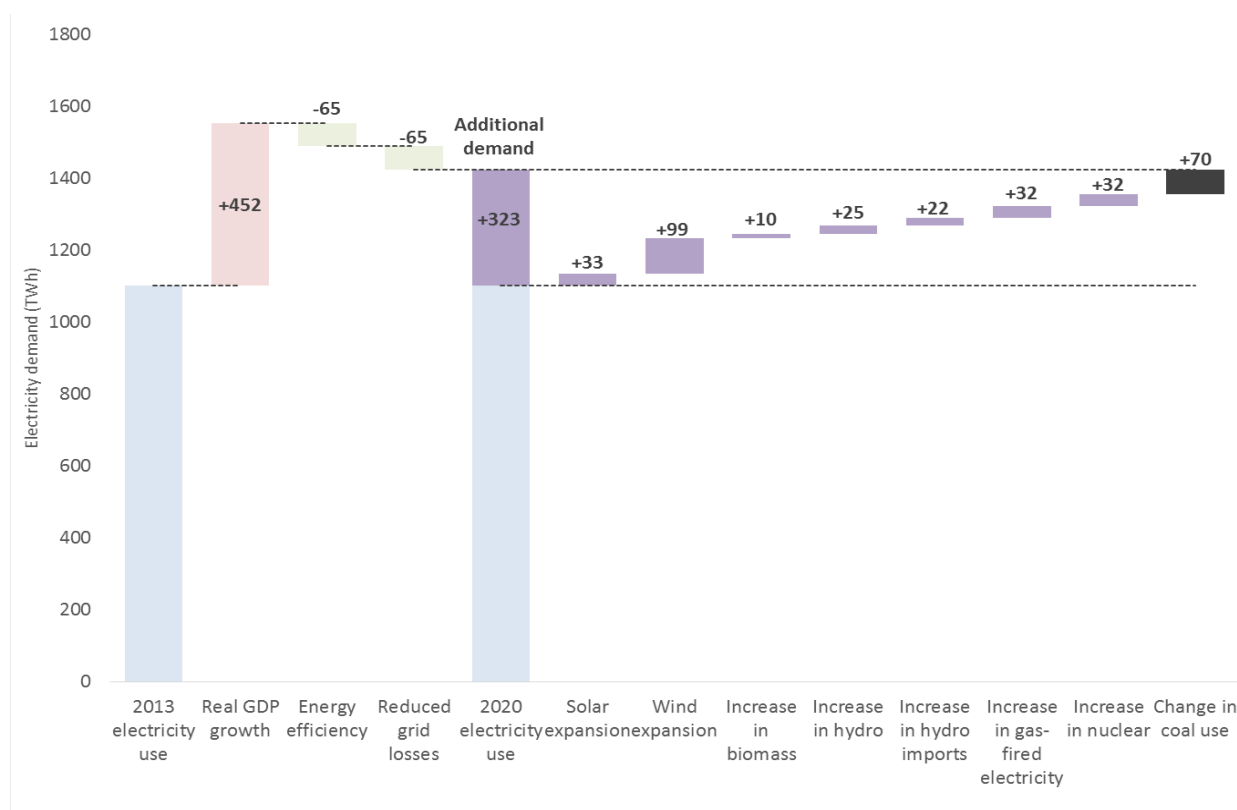
Coal in the US Beyond 2020

IEEFA forecasts that the US's domestic thermal coal demand falls by a CAGR of 2.5% from 2013 to 641Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 1.7% over 2020-2030 as the Clean Energy Plan continues to be implemented and coal-fired power plants are decommissioned. We assume a continued decline thereafter, with a CAGR of negative 1.2% for 2035-2050. While the US has low retail electricity prices relative to the OECD, we assume eventually there will be a progressive implementation of energy efficiency measures to rein in excessive electricity wastage. The US consumption of electricity in 2013 is 13.3TWh per capita, 50-100% higher than the West Europe average of 6-8TWh per capita. The US has very significant on and offshore wind resources, plus huge solar potential, as well as significant geothermal and hydro potential. We expect an outcome of significantly reduced electricity demand and a much more diverse, low carbon electricity system.

3.4 India coal demand

- IEEFA does not see India delivering as the great white hope of the export coal industry.
- IEEFA estimates annual electricity system growth of 3.5% pa to 2020. This is derived from GDP growth of 5.5% pa less 1% energy efficiency gains and 1% pa grid distribution savings.
- Energy security, economic growth targets and poverty alleviation are the primary objectives of Indian energy policies. Imported coal is at odds with these goals for a number of reasons and will be de-prioritised.
- Over the short term to 2020, we expect coal to contribute 70 TWh or 16% of the total additional electricity demand in India. The balance will come from improvements in demand management and network efficiency and other generation technologies.
- Much of this increase in thermal coal demand can be met from expanded domestic production of coal. Over the longer term term (2020 to 2035), IEEFA assumes India's demand for thermal coal will grow by a CAGR of 1.2%.
- The Government of India (GoI) targets increasing renewable energy capacity from 32GW today to 72GW by 2022. Coupled with expanded hydro-electric capacity and increased imports of hydro-electricity from Nepal and Bhutan this will drive a significant diversification of the Indian electricity system. IEEFA expects India to significantly exceed these targets.

Figure 34: India's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

Figure 34 details our forecast for changes to the Indian electricity sector by 2020 relative to the 2013 base. Total electricity demand is forecast to grow a net 323TWh in total. This reflects 5.5% real GDP

growth annually (which would add 452TWh of demand), less 1.0% pa energy efficiency savings (cutting demand an incremental 65TWh). We also assume a reduction in grid transmission and distribution losses of 1% pa (from 23-25% pa currently), allowing reduced gross electricity demand by 65TWh by 2020. A substantial renewable energy expansion is forecast to see 33TWh of new electricity sourced from solar, 99TWh from wind and 10TWh sourced from biomass. Expanded nuclear capacity should add an incremental 32TWh and expanded gas-fired electricity another 32TWh by 2020. Increased hydro will add 25TWh of additional annual supply by 2020, whilst additional hydro imports from Bhutan and Nepal should add a combined 22TWh pa by 2020.

Despite the planning and partial development of a huge number of new coal-fired power stations in recent years, thermal coal is forecast to contribute only an extra 70TWh or 16% of net new electricity supply by 2020. In order to sustainably grow its economy, India will need to successfully diversify its electricity system, adding to energy security and system stability.

Factors Driving Energy Policy in India

Energy Security – A Major Impediment to Sustainable Growth

India is faced with seemingly insurmountable challenges to its economic growth relating to energy. Many of these constraints are intertwined. India's weak financial system in large part reflects huge non-performing loans to the loss-making electricity power and distribution sectors. Heavily subsidised retail electricity and fertilizer prices have left the government running a major fiscal deficit. Heavy reliance on imported fossil fuels (oil, kerosene, gas, coking coal and increasingly thermal coal) has pushed the trade current account into deficit and has destabilized the exchange rate, pushing inflation to 6-8% pa and corporate interest rates to 11-13% pa. The unenviable answer is to reduce subsidies and lift electricity prices significantly.

However, a more sustainable answer is to increase efficiency and concurrently rapidly diversify the electricity system away from coal. While relying on domestic thermal coal for the baseload of electricity production, India also has huge renewable energy resources that can be developed using low-cost, skilled Indian labour and increasingly a domestic manufacturing base. More hydro, wind, solar, biomass, geothermal, nuclear, imported electricity sourced from Bhutan and Nepal hydro, energy efficiency and grid efficiency can rapidly diversify the Indian electricity system, build sustainable growth and reduce the pressures on the trade deficit.

Prime Minister Modi – An Energy Reformer?

As State Minister for Gujarat for 12 years, Narendra Modi implemented the most successful renewable energy investment program in the whole of India. Given renewable energy costs have fallen dramatically since then, the decision for the newly elected Prime Minister of India would seem financially and economically logical. A rapid expansion of domestic renewable energy in all its commercial forms looks inevitable.

Since being elected in May 2014, PM Modi has made a number of announcements and comments that signal a more of everything electricity policy:

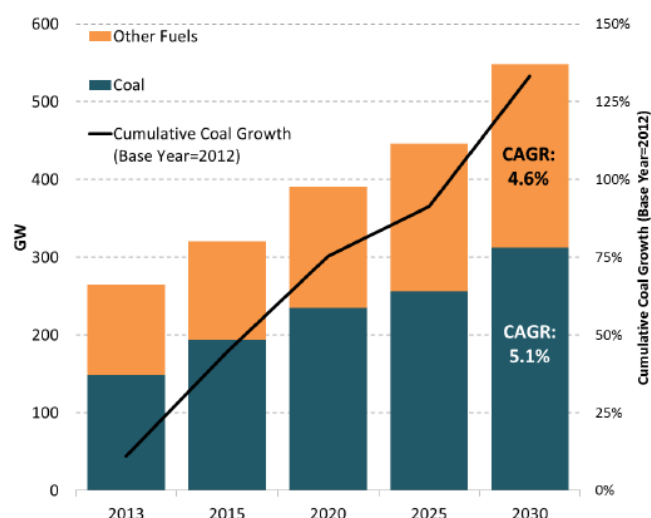
1. The Green Energy Corridor involves a US\$8bn expansion of India's interstate grid to facilitate more renewable energy, with funding assisted by Germany's KfW;
2. Reintroducing the 80% wind turbine accelerated depreciation allowance, building on the existing Rs0.5/kWh generation-based incentive scheme applying for wind. This looks to be part of a larger ambition to see India raise wind installs fivefold to 10GW pa;
3. Discussion of introducing a solar feed-in-tariff system comparable to the world-leading German model, ideally with bi-monthly price digression to drive prices ever lower;
4. Expansion of the plans for industrial scale solar parks of 0.5-1.0GW each, and a target to provide low-cost loans and grants drive installation of 20GW of new solar;
5. A commitment to accelerating distributed solar with storage rather than trying investing billions to build out an antiquated and ineffective grid structure to those currently living without electricity;
6. A suggestion of a 1GW offshore wind target by 2020 to kick-start this new sector;^{xcviii}
7. Accelerate three critical railway projects to improve domestic coal availability 300Mtpa;
8. Phasing out the previously massive subsidies / price controls on diesel;^{xcix}
9. Doubling the cess(tax) on all coal to Rs100/t (US\$1.60/t); and
10. Increasing the duty on imported thermal coal from 2.0% to 2.5%.

Analysis of Factors Influencing Coal Demand in India

Coal-Fired Electricity Generation

The alternative is to continue building ever more coal-fired power generation capacity, which will in turn require an increasingly larger percentage of India's coal requirements to be imported. This will further push the current account into deficit, weaken the currency and fuel import-price inflation into the domestic electricity sector. This scenario is favoured by those forecasting significant seaborne thermal coal demand growth. Wood Mackenzie forecasts India will add 160GW of new coal fired capacity by 2030 against 2012 levels, up over 120% from current levels – Figure 35.

Figure 35: Indian Thermal Coal-Fired Capacity Expansion – 2013 to 2030 (GW)

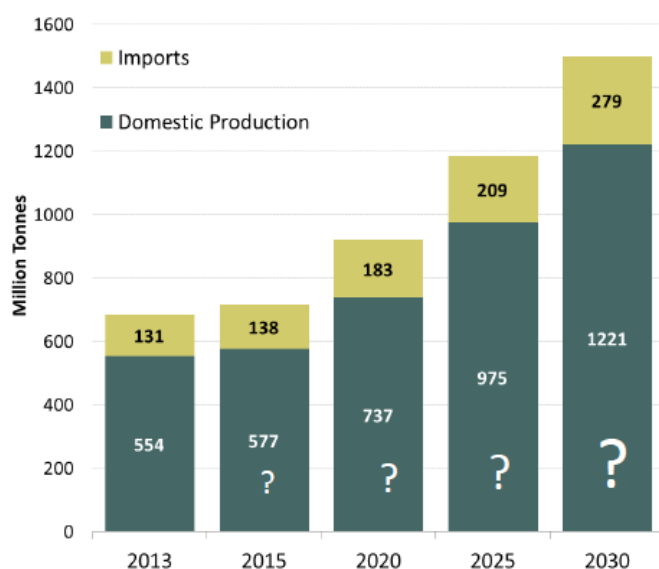


Source: WoodMackenzie, Coal Market Service 2013

Source: Adaro Energy, April 2014^c

From this assumption Wood Mackenzie then forecasts a near 50% expansion in India's thermal coal demand by 2020 and a more than doubling in consumption by 2030 as displayed in Figure 36.

Figure 36: India's Coal Consumption (2013-2030, Mtpa)



Source: WoodMackenzie, Coal Market Service 2013

Modi – Upgrading Old Generating Capacity

The new Government of India (GoI) is proposing to incentivize the modernisation of up to 25GW of coal-fired power plants that have passed their 25 year useful life. The GoI is offering to extend and expand coal supply contracts on the proviso the plants are retrofitted to supercritical capacity thresholds in terms of size and thermal efficiency. This initiative could significantly reduce the coal and carbon intensity of a significant portion of the existing Indian coal-fired power sector.^{ci}

India – Planning for Coal-Fired Power Plants

Over the last five years India has planned for the construction of a massive pipeline of coal and gas-fired power plants this decade. However, with more than half of India's 20GW of gas-fired power plants now mothballed due to inability of procure domestic gas fuel supplies (and imported gas is too expensive relative to the low prices agreed in their Power Purchase Agreements (PPAs)), the underlying capacity and production of the fossil fuel electricity sector in India is quite opaque.

In July 2014 the Adani Group reported that there was in the order of 50,000MW of planned or partly constructed thermal power plants available for sale on the market currently. A report in Aug'2014 upgraded this estimate to 80-85GW of stranded thermal projects.^{cii} In a significant strategic shift, two of India's largest thermal power plant owners, NTPC and Adani Power are now seeking to purchase existing stalled projects rather than proceed with their previous strategy of undertaking new greenfield coal-fired power capacity expansions.^{ciii} As with gas fired power plants, the inability for new coal-fired power plants to enforce contracts for the supply of consistent and quality supplies of coal has left utilisation rates well below design capacity.

In Aug'2014 the GoI stated that over 28GW of approved coal-fired power plants had been provided government supported loans even though the projects had neither PPAs nor fuel supply tie-ups, making the projects unbankable.^{civ}

Domestic or Imported Thermal Coal

Assuming 5.5% pa real GDP less 1% pa of energy efficiency and a 1% pa reduction in transmission and distribution (T&D) losses implies an underlying growth in gross electricity demand of 3.5% pa through to 2020. Coal India Ltd is forecasting a 60Mtpa or 6% pa expansion in domestic coal production. Even assuming the historic blockages continue to constrain domestic performance to only 2-3% pa growth, this would couple with a diversification of electricity system fuel supply to accommodate more renewable energy. This suggests the explosion in imported thermal coal over the last 3-4 years (with imports rising from 10% to a 20% share of India's total coal consumption) will not continue.

Imported Coal vs Domestic Renewables

There is scope for PM Modi to reinvigorate the Indian economy through a massive infrastructure upgrade program. The renewable energy and grid infrastructure sectors are likely to be key components of such a transition and India has the domestic manufacturing capacity and energy security / energy diversity needs to accommodate a doubling or trebling of the rate of annual renewable energy installs. We see that becoming increasingly reliant on expensive imported coal is mutually exclusive to Modi's efforts to sustainably lift India's economic growth rate.

More of the Same will Give ... *More of the Same*

IEEFA sees this scenario as having an inevitable conclusion – the continuation of the current stalling of India's economy at below target rates of growth. For the last two years, India's industrial production has flat-lined. Continuing on the same strategy is likely to deliver the same result – high inflation, increased financial distress in both the power and banking sectors, a widening current account and fiscal deficit and sustained high interest rates, and declining capital productivity, all of which will constrain GDP growth well below the current targets of 5-8% pa.

An Alternative Scenario – Increasing Energy System Diversity

Prime Minister Modi is expected to pursue an energy system policy that embraces domestic solutions to India's electricity needs, and builds energy security through diversity. IEEFA expects India to embrace an energy strategy similar to that of China, more of everything but imported fossil fuels, including coal. Increasing domestic coal production is likely to be a priority. This will in-turn require a sustained improvement in the productivity and capacity for India Railways to best leverage India's existing domestic coal mining activity.

How Far can India Go With Renewables?

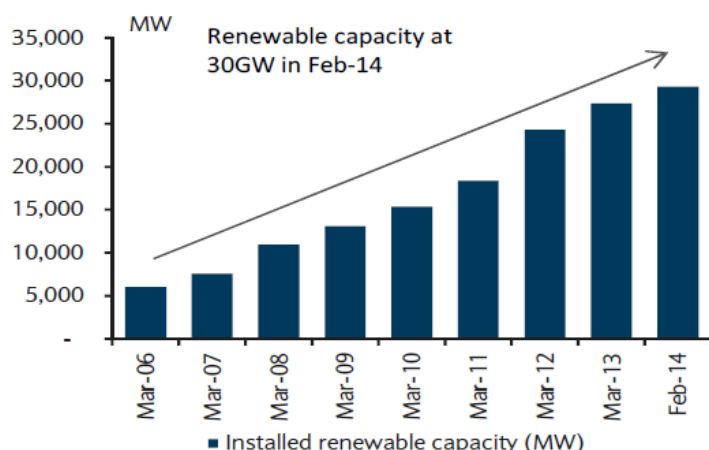
In April 2014 the Indian Planning Commission published a report forecasting a tripling of wind, solar and biomass share of electricity generation to 18% by 2030, taking wind capacity to 120GW and solar to 100GW.^{cv}

Even more ambitious targets are definitely feasible. Darshan Goswami, a veteran of the US Department of Energy, recently published an opinion piece titled “Can India Achieve 100% Renewable Energy?”^{cvii} In IEEFA’s view India’s nearer term target to double the current 32GW installed base of renewables to 72GW by 2022 needs to be doubled again; in doing so this proves up the commercial viability of such a longer term ambition.^{cvi} As Goswami points out, with potential for 1,000GW of solar across India’s deserts, canal systems, water-pumps and farmlands, 170GW of potential offshore wind farms, 148GW of hydro and 10GW of geothermal potential, there remains huge scope to lift India’s renewable energy ambitions. The two outcomes of an ambitious renewables policy will be to reduce reliance on imported fossil fuels firstly, then progressively phase out domestic coal before India’s resources, water and air pollution limits are exhausted.

30GW of Renewables, target of 70GW by 2017

India has grown its total installed renewable energy capacity significantly, from a base of just under 3GW in 2002, total installs surpassed 30GW in Feb’2014 – Figure 37. India is targeting 72GW of renewables capacity by 2022. We are increasingly confident that the new GoI will seek to double this objective, such that renewable energy installs could quadruple in the next decade.

Figure 37: India’s Renewable Capacity has Growth Rapidly since 2006



Source: CEA, Barclay’s Research Mar’2014

Other Factors Influencing the Demand and Viability of Coal

Electricity Demand

India’s electricity consumption per capita has shown a 5.9% CAGR over the decade to 2013/14,^{cviii} reaching 967kWh.^{cix} This compares to a decade of real GDP growth of 7.5% pa. Electricity growth was up 6.0% in 2013/14 after being up 4.0% in 2012/13,^{cx} reflective of the slowdown in real GDP growth to 4.9% and the even more pronounced flat-lining of industrial production in India over the last two years.

IEEFA forecasts India’s real GDP growth at 5.5% pa for 2014-2020, with electricity demand forecast to grow at 85% of this rate, reflecting a 1% pa gain in energy efficiency.

Additionally, we assume that any move towards a viable electricity system will require a reduction in distribution losses such that we model a 1% pa reduction in T&D losses towards 16-18% by 2020.

Given the history of poor operational performance, weak governance and inadequate social planning, large scale hydro is not classified as renewable energy in India. Including the 40GW of large scale hydro plus renewable energy, the total installed capacity in India as at Feb'2014 is 70GW.

Transmission and Distribution – Unsustainably High Losses

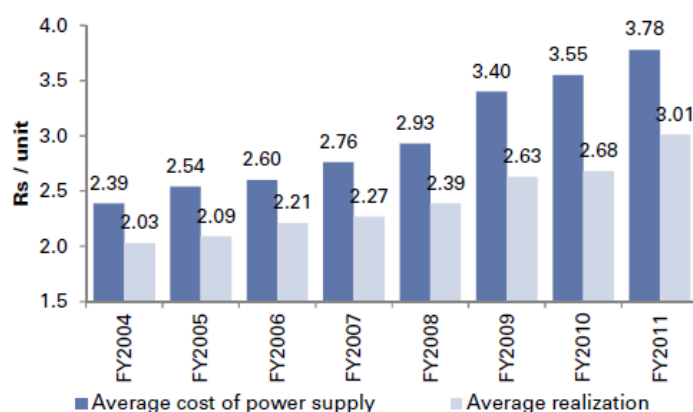
The Indian electricity transmission and distribution (T&D) system has reported a loss rate of 23-27% annually over the last decade, with no noticeable improvement evident. This compares to a global average 8% T&D loss rate, and the world's best practice of Germany running at 4%. A move to 100% metering of all customers would allow utilities to know who to charge for electricity. T&D losses of 23-27% is an unsustainable rate of electricity loss – if not rectified, this will see a continuation of the enormous unfunded losses by the generally State Government owned distribution utilities.

Both reform and major upgrades to the Indian grid transmission and distribution system is critical. India is currently caught in a situation where coal is moved by road or rail often well over 1000km before reaching the power station. This is causing massive road and rail infrastructure logjams. Building power stations at the coal mine mouth and transporting electricity rather than coal would be dramatically more efficient. Reforming T&D would also allow thermal power plants to move towards optimal operating rates well above current levels by alleviating constant fuel shortages.

State Electricity Boards Need Reforming

A critical issue with the electricity sector of India is a basic flaw that sees the average price of electricity below the cost of generation. To compound this, the State Distribution companies are heavily financially leveraged and unable to fund their interest bills, nor often even the basic maintenance of the grid distribution. India faces the prospect of significantly higher electricity prices as the electricity system is forced to raise prices to cover the massive capital investment undertaken over the last decade. In July 2014 Delhi announced across the board 8% electricity price rises.^{cxii}

Figure 38: The Gap Between the Average Cost and Average Realization of Electricity is Rising, Crippling the Financial Profile of the State Electricity Boards of India



Source: CEA, Goldman Sachs Global Investment Research^{cxii}

The Indian State Electricity Boards in aggregate reported losses in 2011/12 of Rs928bn (US\$15bn). After State government subsidies, the losses in 2011/12 were Rs626bn (US\$10bn), reflecting excessive debt, the unsustainable cost of 23-27% T&D losses and electricity prices being too low.^{cxiii} The loss before subsidies was forecast to decline 10% in 2012/13, but the figures have yet be published. Figure 38 details the current situation where wholesale electricity prices are materially higher than average retail prices, putting the utilities at a loss before depreciation, operating costs and interest expenses are considered.

This generally reflects the subsidised pricing of electricity at the retail level such that on average it is below the wholesale price of electricity, but without factoring in a margin to cover the loss of one in four units of electricity purchased from generators – Figure 37. It is inconceivable that India can sustainably build out a centralized, large scale electricity generation model without concurrently addressing these technical losses and inefficiencies.

In addition to a financial restructuring package to try to alleviate the massive interest expense burden on these State Electricity Boards (8 states alone have accumulated debts of US\$26bn), the GoI is forcing through higher retail prices of electricity as the cost of assistance.

We forecast high single digit electricity price rises will be needed annually for the rest of this decade to restore the Indian electricity sector to acceptable levels of return on the existing investment to cover interest rates of 12-13% pa and cover the cost of the subsidies already being given. This 30% plus rise in electricity prices will see a significant dampening of demand growth, and stimulate a significant uptake in distributed rooftop solar with storage, further eroding market expectations for significant electricity system growth.

Failure to reform the State Electricity Boards means continued unfunded losses and continues to erode the bankability of the long term power purchase agreements required to build new power stations.

Analysis of Trends in India's Energy Generation Mix

Wind energy

India has huge potential to expand its wind generation capacity. In 2013/14,^{cxiv} India installed 2.0GW of wind, taking total installations to 21GW by Mar'2014, the fifth largest wind market globally.

Policy indecision saw total wind installations over 2012/13 and 2013/14 decline by over 30% from the levels achieved in the preceding years. The 2014/15 budget saw the re-introduction of an 80% accelerated depreciation allowance for wind farms.^{cxv} This builds on the existing Rs0.5/kWh generation-based incentive scheme applying for wind that means the cost of wind electricity is Rs4-5/kWh, below the Rs5-6/kWh cost of imported coal fired power generation.^{cxvi}

Combined, these two budget policies are a major endorsement of the domestic Indian wind sector such that Suzlon forecast a doubling on annual wind installations this coming year to 3-4GW.^{cxvii} With a continuation of the right policy settings, the Indian wind energy sector has both the manufacturing and installation capacity for installations to double again to 5-8GW pa for the next decade at least.

This is consistent with the Global Wind Energy Association's estimate that 46GW of wind could be installed by 2020.^{cxviii} The reports that New and Renewable Energy Minister Piyush Goyal is evaluating raising India's wind install rate to 10GW annually would be a transformative decision of global significance.^{cxix} We conservatively assume 6GW pa from 2015-2020, driving a significant diversification of the electricity grid and diluting the growth in demand for thermal coal.

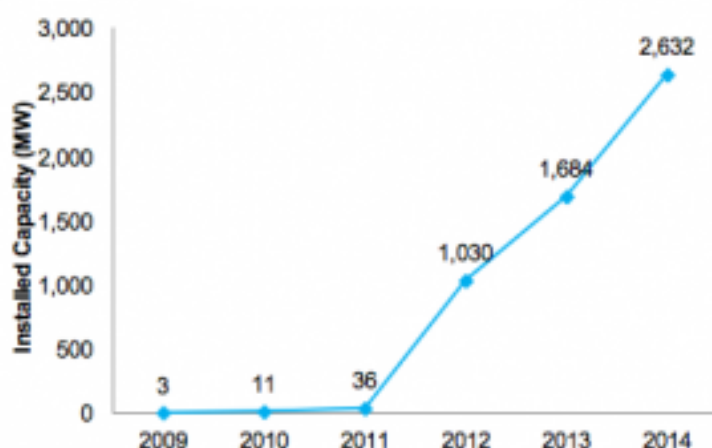
Offshore wind

India is considering the introduction of an offshore wind policy targeting 1GW by 2020. The Ministry of New and Renewable Energy will seek cabinet approval for the policy shortly, according to Joint Secretary Alok Srivastava, saying: "Development of the technology has made offshore wind projects viable now".^{cxx} By 2018, the cost of electricity from offshore windmills will equal that of land-based projects and onshore wind farms in some states in India are generating power cheaper than new coal plants.

Solar energy

India has made significant progress in developing world leading solar development programs, consistent with the National Solar Mission's target of 34GW by 2022.^{cxxi} Several Indian States have announced utility solar project targets of 1-4GW each, including Andhra Pradesh and Telangana. This is working to build on the model developed by the Gujarat government at the Charanka solar park under then Chief Justice Modi that has an installed capacity of more than 200MW already and capacity to house 600MW of solar PV projects.^{cxixii} Tarun Kapoor, joint-secretary at the Ministry of New and Renewable Energy said in August 2014: "We're preparing a scheme for solar parks and it will be out after cabinet approval in about one month".^{cxixiii} Solar deployment has accelerated in the last three years – refer Figure 39. We expect solar installations to rise to 3GW pa over the period to 2020, with scope for significantly higher installation rates beyond 2020.

Figure 39: Solar Installs Are Accelerating Across India



Source: Deutsche Bank, MNRE

Solar is readily able to be rapidly deployed on a dramatically expanded scale using an increasing portion of domestic content. The pricing of utility scale solar is currently below Rs5.50/kW, after taking the 30% capital subsidy into account. We see continued double digit declines in the installed cost of solar, driving cost effective and rapid new capacity expansions for India's grid. Further, solar (like wind) offers a dramatic long term benefit to India – with pricing fixed for 20 years, solar and wind will have an enormously beneficial deflationary impact over the long term.

A Sept'2014 report by Bridge to India and Tata Solar estimates that India can commercially deploy 145GW of solar in the next decade using a mix of distributed small and medium installs in combination with a series of solar industrial parks, generating 675,000 jobs in India in the process.^{cxixv}

Distributed Solar with Storage

Given excellent solar radiation, the massive grid losses and the GoI's objective to rectify the significant areas of India that remain unconnected to the electricity grid, there is scope for a massive expansion in distributed solar with storage, and/or the development of microgrids, potentially leveraging off the investment in mobile phone towers throughout the country. We would also expect the GoI to rapidly expand its solar powered water-irrigation pump program, likewise building domestic industry and providing scope for excess power to be utilized by remote farms and villages.

Hydropower

India has tremendous reserves of untapped hydro-electricity potential. With power generation costs of Rs3-5/kWh, this is directly competitive with domestic coal-fired electricity generation, and lower cost than imported coal-fired power.

India has 12.2GW of hydro under construction and assessed potential for 145GW (on major projects in excess of 25MW).^{cxixv} The Central Electrical Authority's "Hydro Development Plan for the 12th Five Year Plan (2012-2017)"^{cxixvi} identified 109 projects aggregating to 30.9GW, and forecast that of these, 25.3GW was feasible for completion by 2017 given the length of the planning and construction cycle. However, with many projects taking 10-15 years for construction, 5-10 year delays are common.

IEEFA forecasts up to 1GW pa of additional large and small scale run-of-river hydro development through to 2020, adding to the installed hydro-capacity of India of 40GW already in operation.

Imported Hydro

To raise the foreign capital and engineering expertise to exploit its hydroelectric potential, the Royal Government of Bhutan (RGoB) entered into an agreement with GoI in 2006. India has agreed to purchase 10GW of power from Bhutan by 2020. Bhutan, with the support of India, has set up 10 major hydroelectric projects, which are expected to be completed by that time. The agreement for these projects was signed at the first joint group meeting held in New Delhi in March 2009. Of these 10 projects, the first three are the 720MW Mangdechhu Hydroelectric Project plus the 1,200MW and 1,020 MW Punatsangchhu-I & II Hydroelectric Projects are currently under construction and due for completion by 2016/17 and 2017/18 respectively. Whilst some slippage to the original timetable has occurred, in conjunction with a similar program with Nepal, India is expected to see a trebling of hydro-electricity imports by 2020.

Gas-Fired Electricity Generation

Over the last six years, the GoI has facilitated a doubling of India's installed base of gas-fired electricity capacity to over 20GW. However, a collapse in the production of domestic gas has meant that more than half of this new capacity is idle or operating at exceptionally low rates of utilisation. Similar to the situation with coal, domestic gas pricing is regulated and trades at one-third of import gas price parity. The previous GoI had proposed a doubling of the domestic gas price in order to stimulate domestic gas exploration and development, but this initiative has been stalled post elections.

Prior to stimulating even more capital investment in the thermal electricity sector, we would expect the GoI will need to come to some accommodation to overcome these otherwise stranded assets. In part this might require a significant lift in the contracted off-take pricing agreed by the independent power producers and state distribution companies. Similar to the situation with respect to the Adani and Tata Mundra coal-fired power plants, a higher tariff will meet with significant resistance from the various state distribution companies. However, we assume some resolution to this impasse will be facilitated, otherwise over US\$10bn of sunk capital costs will remain idle and firms will not be able to raise financing for further capacity expansions needed to sustain GDP growth. Significant asset write-downs are also forecast.

A resolution could see gas-fired power generation double to 70-80TWh pa by 2020. Woodside Ltd of Australia envisages demand for LNG in India could triple or quadruple over the next 10 years, up to as much as 50Mt by 2024.^{cxxvii}

Nuclear Power In India

India currently operates 4.8GW of nuclear power capacity. IEEFA assumes a further 5GW will be commissioned by 2020. The GoI hopes to increase its nuclear capacity to 63GW by 2032 by adding nearly 30 reactors at an estimated cost of US\$85bn,^{cxxviii} but IEEFA assumes there will be huge slippage in this target.

Coal in India Beyond 2020

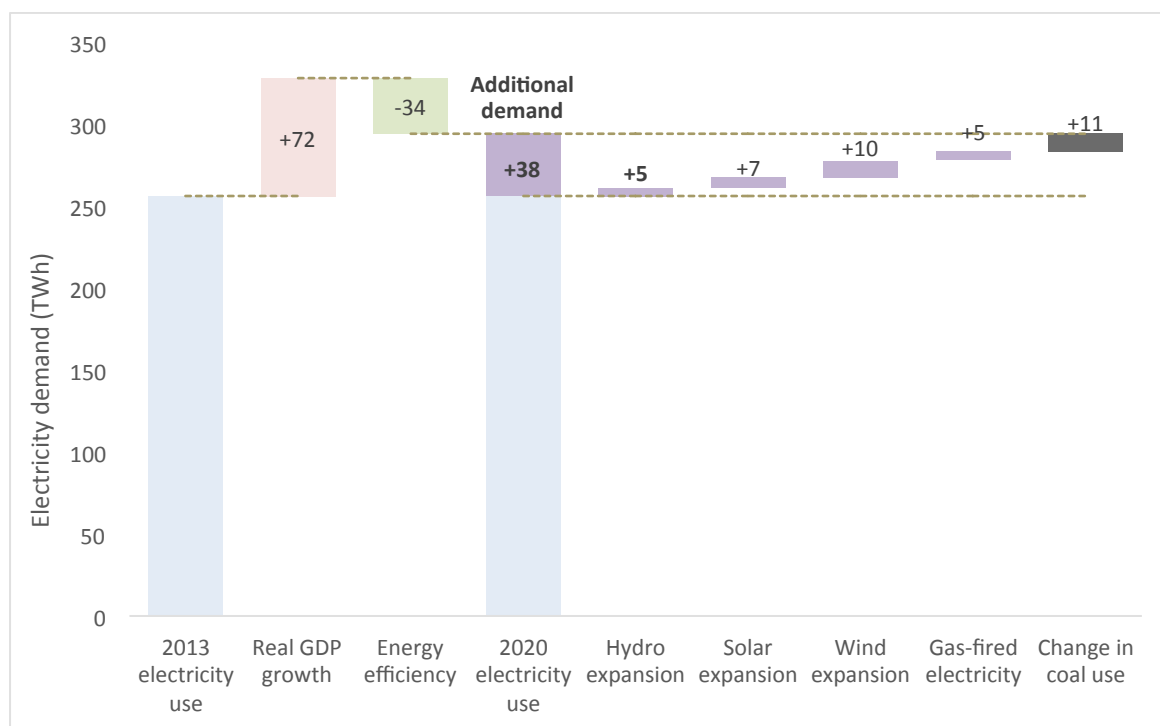
IEEFA forecasts that India's domestic thermal coal demand will rise by a CAGR of 2.0% from 2013 to 755Mt in 2020. Beyond 2020, IEEFA forecasts that India's demand will grow by a CAGR of 1.2% through to 2030, and then progressively slow (we assume a CAGR of positive 0.3% for 2035-2050). Whilst the Indian economy has scope to see above world average GDP growth for much of this period, we assume that with the rapid depletion of domestic coal reserves, India will increasingly turn to alternative domestic renewable sources of electricity. India will also at some stage need to rapidly accelerate grid efficiency improvements, and a wider embracing of energy efficiency in buildings, residential and industrial sectors. With significant solar, wind, offshore wind, biomass and hydro resources – India's electricity sector is forecast to continue to rapidly diversify away from coal-fired power generation beyond 2020.

3.5 South Africa's coal demand

- South Africa has seen electricity demand growth at a 1.7% CAGR over 2000-2013, well below real GDP growth of 3.4% in this same period. Even should 4.0% pa real GDP growth be sustained over the medium term forecast period, IEEFA expects energy efficiency to continue to deliver a 2% annual reduction in electricity intensity of growth.
- South Africa is the 16th largest electricity market globally. Thermal coal consumption has grown by 1.5% CAGR over 2000-2012 to 185Mtpa. However, given a very high reliance on coal-fired power generators and a very high electricity intensity of GDP, South Africa is the fourth largest domestic market for thermal coal globally, 40% larger than Japan.
- IEEFA forecasts a major expansion of South Africa's installed base in each of pumped hydro, wind, solar and demand response management over the forecast period, providing much needed energy system diversity.
- Overall, total thermal coal consumption in South Africa should grow only marginally over the forecast period, rising by 1% pa over 2013-2020 and peaking by 2025.

Figure 40 details our forecast for changes to the South African electricity sector by 2020 relative to the 2013 base. Total electricity demand is forecast to grow a net 38TWh in total, representing 2.0% pa over the 2013-2020 period. Real GDP growth of 4.0% annually (which would add 72TWh of demand), less 2.0% pa energy efficiency / economic transition savings (cutting demand an incremental 34TWh). Increased pumped hydro storage will add 5TWh of additional annual supply by 2020. A substantial renewable energy expansion will see 10TWh of new electricity sourced from onshore wind and 7TWh sourced from solar, while 5TWh is added from gas-fired electricity by 2020.

Figure 40: South Africa's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

Despite the development of two major new coal-fired power stations by Eskom, coal is forecast to contribute only an extra 11TWh of net new electricity supply by 2020. This suggests that South Africa can successfully diversify its electricity system, adding to energy security and system stability. We explore this in more detail below.

South Africa's Current Electricity Market Structure

Electricity demand in South Africa reached 256TWh in 2013, a CAGR of 1.7% over 2000-2013. This puts South Africa as the 16th largest electricity consuming nation globally. Compared to relatively low real GDP, as measured by the IMF PPP estimates, South Africa consumes a significantly high level of electricity per unit of GDP. This ratio is more than double that of Germany and 70% higher than the US. To give a different perspective, South Africa consumes as much electricity per person as the UK, despite having an economy a quarter of the size.

To compound this very high electricity usage relative to GDP, South Africa's electricity system is one of the most coal intensive in the world, with coal-fired power generation providing 80% of total capacity. Eskom operates 38GW of relatively old, low efficiency, highly polluting coal-fired power stations, 2.4GW of gas, 1.8GW of nuclear power and 2.0GW of hydro-electricity and pumped hydro storage capacity.

South Africa has recently undertaken a major strategic energy policy shift to accelerate the deployment of renewables, hydro, energy efficiency and possibly even nuclear. The combined impact of a significant diversification away from coal and the energy efficiency opportunities presented by a very electricity-intensive economy suggest domestic coal consumption growth will be very subdued going forward.

Integrated Electricity Resource Plan

The Integrated Electricity Resource Plan (IRP) for 2010-2030 was released in 2011. The IRP outlines the country's electricity demand, how this demand might be supplied, and what it is likely to cost. Its balanced scenario represents the best trade-off between least-investment cost, climate change mitigation, diversity of supply, localization, and regional development. The December 2013 update of the IRP requires 45GW of new capacity by 2030, assuming 3.4GW of demand-side savings. South Africa's generation mix by 2030 should include: 48% coal; 13% nuclear; 6% hydro, 15% other renewables; and 11% peaking open cycle gas turbine.^{CXXIX}

Expanding Coal-Fired Capacity

South Africa will remain predominantly a coal-fired power market for some time. Eskom has two 4.8GW coal-fired power plants under construction, Medupi and Kusile, progressively adding to its existing 38GW of coal-capacity over 2014-2018.^{CXXX} However, the cost of these new coal-fired electricity is estimated to be US\$9.7c/kWh, 20-30% higher than the cost of wind power.^{CXXXI} Post commissioning, this capacity expansion will drive a decline in average operating rates for coal-fired power plants, and/or the decommissioning of the antiquated coal plants fired up during the blackout crisis of 2007/08.

Building Diversity

South Africa plans to reduce its reliance on fossil fuels as a source of electricity to approximately 50% of its energy mix by 2050, down from more than 80% now. The 50% goal is part of an integrated energy plan under development, according to Nelisiwe Magubane, director-general of the country's Energy Department. She continued by acknowledging the need to diversify:

"A large coal base is going to work out to be very expensive for us The fuel, going into the future, is uncertain. Not because you can't dig it out of the ground but because of possible carbon taxes or penalties we may face as a country producing products from coal."^{cxxxii}

The plan is to build 18.2GW of new wind, solar, biomass and hydro capacity, plus 9.6GW of nuclear as well as new gas-fired generation by 2030 to better diversify the electricity system, cater for significant demand growth over time, enhance local employment and lower the carbon intensity of South Africa's power generation capacity.

Energy Efficiency

Despite 3.3% CAGR in real GDP over 2005-2013, South Africa's electricity demand has grown by only a CAGR of 0.5%. Rolling blackouts over 2008 highlighted the underinvestment in power generation capacity and prompted Eskom to call for 10% savings in demand through energy efficiency in order to balance the load structure. Energy efficiency is a core strategy within the IRP^{cxxxiii} and we forecast 2% pa growth in electricity demand over the forecast period despite continued strong real GDP growth of 4% pa.

An African Clean Energy Corridor Grid

The South African National Energy Development Institute (Soned) has developed a strategic plan to implement a smart grid^{cxxxiv} that expands upon the existing Southern African Power Pool (SAPP).^{cxxxv} The SAPP connects South Africa to Namibia, Zambia, Zimbabwe and Botswana and beyond. The SAPP was developed by Eskom during the apartheid era to reduce energy security risks and leverage the huge hydro resources of central Africa.

The International Renewable Energy Agency has been working under the leadership of the World Bank to develop the Africa Clean Energy Corridor to create an integrated 5,000-mile north-south electricity transmission grid stretching from Egypt through Sudan, South Sudan, Ethiopia, Kenya, Malawi, Mozambique, Zambia and Zimbabwe to South Africa.^{cxxxvi} This would provide significantly enhanced electricity system stability and security, whilst also facilitating the development of an almost limitless amount of renewable energy spanning hydro, geothermal, solar and wind.^{cxxxvii}

Renewable Energy

In 2011 the South African government set about a plan that targets 42% of all new generating capacity to come from renewables. The country has set a goal of having 3,725MWs of renewable energy by 2016 by a 120 billion-rand program, from an almost zero base in 2012. The renewable energy plan involves 1.85GW of onshore wind, 200MW of concentrated solar thermal, 1.45GW of

solar, 50MW of biogas/biomass/landfill gas, 74MW of small-scale hydro and 100MW of small scale distributed energy.^{cxviii}

South Africa has a target of 9.4GW of solar power capacity by 2030, and is moving rapidly to implement plans to achieve this target. A key success has been the marshalling of significant domestic and international bank and funds management investment in rapid order. This has included a US\$2bn funding commitment from the US Ex-Im Bank in 2012.^{cxix}

The Energy Department in November 2013 approved 34 billion rand to be invested in 17 clean-energy projects under Round 3. Round 2 involved renewable energy projects totaling 1,275MW of capacity in May 2012. That followed 1,416MW of projects costing 45 billion rand, approved in the first round in December 2011.

Renewable Energy - Solar

Projects are being granted licenses under South Africa's Renewable Energy Independent Power Producer Programmes (REIPPP). The programme targets the installation of 1.45GW of photovoltaic solar plants by the end of 2014 and 8.2GW by 2030. The program has not only attracted significant global financial involvement, it has also attracted many of the top global renewable energy firms keen to gain a foothold in this new growth market.^{cxl}

Given a significant portion of the South African population remains without electricity access, we expect a rapid expansion of distributed solar with storage over the next decade. This will bypass the need for a massive expansion of the grid and take advantage of the strong solar radiation available. We forecast that South Africa will generate in-excess of 7TWh pa of electricity from solar by 2020.

Renewable Energy - Wind

To date under the REIPPP 2.0GW of wind projects have been awarded. From a zero base, this has established South Africa as a key new market for wind development. The IRP calls for 9GW of wind by 2030.^{cxli} We forecast that South Africa will generate in-excess of 10TWh pa of electricity from 4GW of onshore wind by 2020.

Renewable Energy - Hydro

Eskom is due to commission the 1.3GW Ingula pumped hydro storage facility at the end of 2015 to primarily cater for peak power demand periods.^{cxlii} This will take pumped hydro capacity to 2.7GW. There remains significant scope to expand hydro, but only plans for another 0.1GW at this stage.^{cxliii} We forecast that South Africa will generate in-excess of 13TWh pa of electricity from 3.4GW of hydro / pumped hydro by 2020, an uplift of 5TWh vs 2013 levels.

Nuclear

The Integrated Electricity Resource Plan models in 9.6GW of new nuclear capacity towards the end of the 2030 timeframe. Progress to-date has been slow. Should distributed solar with storage installation rates accelerate beyond 2020, and grid integration expand to encourage new hydro capacity in central Africa, we would question the need for any additional nuclear installations, given the history of massive capital cost blow-outs and time delays in Europe and the U.S.

Carbon Tax Plans

South Africa's renewable energy capacity addition targets are part of a larger low-carbon policy to achieve peak in greenhouse gas emissions between 2020 and 2025. The country also plans to reduce GHG emissions by 42% by 2025 from business-as-usual levels. The cornerstone of the low-carbon policy is a carbon tax and offsets program. Entities covered under this scheme would be given emissions reduction targets or caps which they can meet by purchasing compliance instruments like emissions allowances and offsets. This national policy is in-line with those being implemented by other advanced developing countries like India, China and Brazil.^{cxliv}

Coal Demand in South Africa Beyond 2020

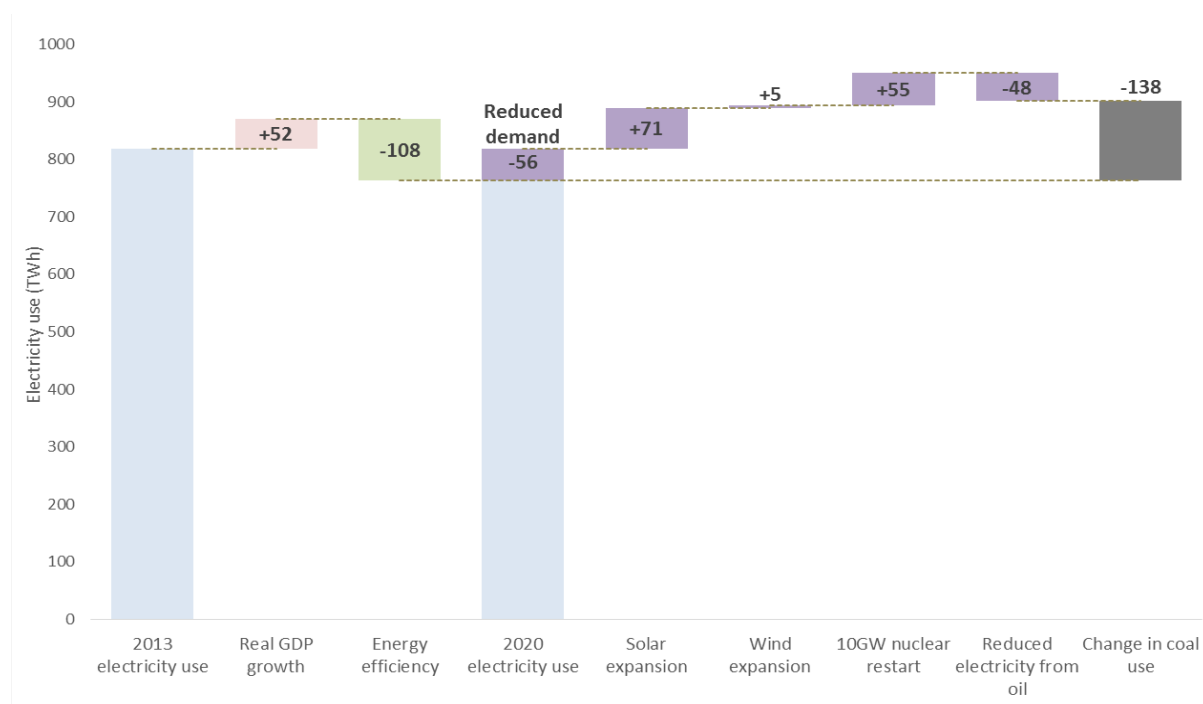
IEEFA forecasts that South Africa's domestic thermal coal demand grows by a CAGR of only 0.9% from 2013 to 196Mt in 2020. Beyond 2020, IEEFA forecasts thermal coal demand will peak by 2025, declining by an average CAGR of negative 0.4% over 2020-2035 as antiquated coal-fired power plants are progressively decommissioned and Eskom drives a significant improvement in energy efficiency and diversifies the electricity grid to incorporate substantial on and offshore wind, solar, hydro and renewable energy imports from Central Africa. We assume a continued decline thereafter, with a CAGR of negative 1.7% for 2035-2050.

3.6 Japan's coal demand

- Japan has always had a major focus on national energy security given it is almost 100% reliant on imported fossil fuels (coal, LNG, oil and uranium). Domestic renewable electricity and energy efficiency have recently emerged as key strategies to provide energy diversity and reduce this energy security risk.
- Energy Efficiency has reduced total electricity demand 12% from 2010-2013 despite 1% pa real GDP growth – a reduction of electricity demand per unit of real GDP of 5% pa. We forecast energy efficiency will continue to play a key role going forward.
- Liquid Natural Gas (LNG) has become the mainstay of the Japanese electricity system post Fukushima, moving from 43% to 57% total market share over the four years to 2013.
- Japan's electricity demand profile should decline over time due to GDP growth remaining limited to 1% pa and a declining population, and energy efficiency reducing demand 2% pa.
- Japan is pursuing 8+GW pa of solar installs via a FiT program. This equates to an additional 57GW by 2020, sufficient to replace 36Mtpa or 26% of current thermal coal imports.
- Beyond 2020, the offshore wind market will be a key priority for Japan, with a target 50GW by 2050 relative to a current installed total wind base of 3GW. This equates to 1.5GW pa.
- All 48GW nuclear capacity is shut. Minimising nuclear's contribution is a strategic priority, but we assume a partial reopening over time, which will further curtail fossil fuel demand (oil, LNG and / or coal).
- Cumulatively, these drivers mean that Japan's thermal coal demand beyond 2014 is forecast to decline 4-5% pa to 2020, and decline a further 2.5% pa over 2020-2030.

Figure 41 details our forecast for changes to the Japanese electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 41: Japan's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA analysis 2014

In summary, the IMF forecasts 1% pa real GDP growth over this period, expanding electricity demand by 52TWh. Energy efficiency will continue to reduce electricity demand by 1.5-2.5% pa, resulting in a cumulative reduction in electricity demand of 108TWh by 2020. Expanded solar capacity will produce an additional 55TWh by 2020, and a probable, partial nuclear restart (say 10GW or 20% of idle capacity) will add 70TWh of electricity supply. A small increase in other renewables (wind, hydro, geothermal, CHP) is also expected. As this increased supply arises, oil-fired electricity production is expected to halve, returning to its traditional role of providing peaking capacity, reducing supply by 48TWh.

The combined impact is a material, sustained reduction in coal-fired power generation. This could see Japan's thermal coal imports decline by 25-50% over this period. We conservatively assume a 4% pa decline in thermal coal imports for 2013-2020, resulting in a cumulative 25% or 37Mtpa decline from the 136Mt imported in 2013. This would imply a key reversal relative to the last three decades of consistent growth in Japanese thermal coal imports.

Strategic Issues of Energy Security

The Fukushima disaster has highlighted critical energy security issues for Japan. There is an almost total absence of domestic fossil fuel production (having minimal reserves of any of oil, coal, gas nor uranium). Further, Japan has to-date been unable to develop an internationally connected electricity grid nor subsea gas pipeline structure. A limited supply of land, deep ocean water and limited solar radiation all combine to limit the scope and increase the cost of renewable energy. Historically the majority of fossil fuel imports come by sea from the south west, giving little geographic diversity of supply. The high cost of fossil fuel imports has also pushed the current account into a significant deficit. Diversity of fuel supply for electricity generation and energy efficiency initiatives are therefore of key priority.

In 2013 Japan invested a record US\$35.4bn in clean energy projects, growth of 56% year-on-year according to Bloomberg New Energy Finance.^{cxlv}

Fukushima Forced a Total Energy System Rethink

Japan's electricity sector has undergone rapid transformation since the disaster of Fukushima in 2011. Nuclear generated over 30% of Japan's electricity supply from 2005-2010. However, the entire installed nuclear base of 49GW (previously worth over US\$100bn) has been shutdown post-2011, and any recommencement remains in limbo, subject to government policy as heavily influenced by an anti-nuclear public sentiment.^{cxlvi}

Outside of nuclear, Japan has a fossil fuel electricity fleet of 185GW, split between coal, gas, oil and oil-coal hybrid capacity. Figure 42 details electricity production by fuel source 2005-2013.

Figure 42: Japanese Electricity Production, by Fuel Source (Calendar Year, TWh)

Calendar Year	Nuclear	Coal	Oil	Gas	Hydro	Total generation	Change year-on-year
2005	293	222	56	309	81	963	
2006	304	187	57	334	89	974	1.2%
2007	279	188	69	375	77	992	1.8%
2008	252	193	82	384	74	987	-0.5%
2009	275	167	42	350	74	910	-7.8%
2010	292	170	36	349	79	929	2.1%
2011	163	162	58	407	73	865	-6.9%
2012	18	166	107	475	68	836	-3.4%
2013	15	189	81	463	69	819	-2.1%

Source: calculated from Japan's official monthly power generation statistics^{cxlvii}

The Role of Nuclear

There is scope for a gradual, partial reopening of some of Japan's 49GW of nuclear capacity at some stage – with suggestions maybe two nuclear units might reopen in 2014/15.^{cxlviii} Should this occur, reducing oil-fired electricity generation will be the priority given the prohibitive cost. Each 1GW of nuclear would generate 7TWh of electricity, so the first 5-10GW of capacity reopened would likely replace oil-fired electricity generation. To the extent any nuclear restart goes beyond this, electricity generation from nuclear is likely to replace coal. Each 1GW would equate to a reduction of coal import demand by 3Mtpa. We are not advocating nuclear, just noting the energy security and commercial imperatives that bind the Japanese government. We note the Strategic Energy Plan is emphatic: "Japan will minimise its dependency on nuclear power."^{cxlix}

Figure 43 details the collapse in nuclear power's contribution, from a peak of 35.7% in 2010, to be only 1.8% in 2013 and zero in 2014.

Figure 43: Japanese Electricity Production, by Fuel Source (Calendar Year, TWh, % of total)

Calendar Year	Nuclear	Coal	Oil	Gas	Hydro
2005	35.8%	27.1%	6.8%	37.8%	9.9%
2006	37.2%	22.8%	6.9%	40.8%	10.9%
2007	34.1%	23.0%	8.4%	45.9%	9.5%
2008	30.7%	23.5%	10.0%	46.9%	9.1%
2009	33.5%	20.4%	5.1%	42.8%	9.0%
2010	35.7%	20.7%	4.4%	42.6%	9.7%
2011	19.9%	19.8%	7.1%	49.7%	8.9%
2012	2.2%	20.3%	13.0%	58.0%	8.3%
2013	1.8%	23.1%	9.9%	56.5%	8.4%

Source: calculated from Japan's official monthly power generation statistics^{cl}

The Role of Gas

As is detailed in Figure 42, liquid natural gas (LNG) imports have filled the majority share of the electricity supply gap created by the closure of Japan's entire nuclear fleet. Upwards of 100TWh pa of electricity generated from gas has been added to the system over the last four years, taking gas' market share up 13% to 56.5% in 2013. Given its lower emissions profile and the expectation that the significant price decline of LNG over 2014 will be sustained, we expect LNG will remain the mainstay of the Japanese electricity system going forward. Four new gas-fired power generators of 7GW capacity are under consideration, and construction of the first has commenced, such that this expansion is due online progressively from 2016. Japan's Ministry of Economy, Trade and Industry wants to increase the 2015/16 government budget to subsidise installations of home fuel cells that use gas to produce distributed electricity and hot water, reducing grid demands for electricity.^{cl}

The Role of Oil

Oil-fired electricity generation was 81TWh or 10% of Japan's total in 2013, up from a longer term average of 5-7%. Oil's role in the electricity sector for other major economies has been progressively phased out over the last four decades. This highlights the extreme and relatively unique energy security issue that Japan faces. Oil represents a high cost source of peak power and emergency backup generation in the absence of any alternatives. As lower cost electricity sources expand, we expect the generation of electricity from oil to return to its previous role and half to less than 5% going forward.

Japan – Real GDP Growth 1% pa

The IEA bases its electricity growth estimates on the basis of IMF forecasts. The IMF forecasts Japanese real GDP growth at 1.0% pa over 2014-2020,^{clii} reflective of the limitations of a declining population. The Japanese population is forecast to decline from 127m in 2013 to 97m by 2050, a CAGR of negative 0.7%. We have used the IMF growth rates as an input into our demand forecasts.

Energy Efficiency and Price Elasticity of Demand – 5% pa Efficiency Gains over 2010-2013

The new Japanese Strategic Energy Plan of April 2014 details the dramatic changes delivered in Japan's electricity system post-2011.^{cliii}

Assisted by price rises of 6-11% in 2012^{cliv} and national buy-in by the population and industry, energy efficiency has played a world-leading role in curtailing Japanese electricity demand. As first determined by Lauri Myllyvirta from Greenpeace International, from a 2010 electricity demand level of 929TWh, Japanese demand has fallen by a cumulative 12% through to 2013 (note, this is calendar year rather than Japanese fiscal year). This compares to 1% pa real GDP growth over the 2010-2013 period, suggesting 5% pa energy efficiency gains per unit of real GDP. An uptake in onsite cogeneration by industry was a contributor to this, as was improved appliance efficiency and heating and cooling of commercial buildings. Japan also introduced critical peak power pricing with customer signals to maximise demand side management efforts.

Rational Use of Energy Act of 1979

Japan has traditionally maintained a focus on energy efficiency, with the Rational Use of Energy Act of 1979 requiring businesses to report on energy efficiency measures and improvements annually.^{clv} Japan's Act also prescribes the Top-Runner Program on energy consuming devices to urge manufacturers to incorporate the best-available energy efficiency standards in their product designs. Over the 1998-2013 period, the Top-Runner Program has delivered improvements in energy efficiency of 30% in airconditioners, 30% in TV sets, 43% in household electric refrigerators and 11% in microwave ovens. In 2013 insulation material standards for residential and commercial construction were added to the scope of the program. The government aims for net zero energy for standard newly constructed houses by 2020.

High efficiency LED lighting was also added in 2013, with a target of 100% penetration for new installations by 2020, and 100% retrofitting by 2030.

Our forecasts assume 1.5-2.5% pa energy efficiency gains per unit of real GDP can be maintained over the medium term and 1.5% pa beyond 2020. This suggests total electricity demand will decline 0-1% pa over the forecast period. This is consistent with the six months to June 2014 experience with average volumes down 0.4% yoy against 1.2% real GDP growth, a further 1.6% gain in energy efficiency per unit of GDP.^{clvi}

Japan's Ministry of Economy, Trade and Industry wants to increase the 2015/16 government budget for energy efficiency initiatives by 32% to 206 billion yen (US\$2 billion pa). This would be used to encourage the installation of more energy-saving devices across factories and offices.^{clvii}

The Growing Impact of Renewable Energy

Japan's energy plan puts a strong emphasis on renewable energy generating an additional 1% pa of Japan's electricity needs. Solar is the focus this decade, with 8GW pa of installations underway. Offshore wind is a strategic priority post-2020 with potentially 1.5GW pa sustainable long term.

For clean energy development, the Ministry of Economy, Trade and Industry is asking for a 16% increase year on year to 158 billion yen (US\$1.5bn) for the funding of offshore wind and geothermal research.^{clviii}

This will help leverage the new frontier of offshore floating energy platforms – be that offshore wind, offshore gas or even offshore nuclear. Japan's Kyocera is trialing an offshore floating solar platform of 2.9MW as a precursor to 30 such installations. Sevan Marine of Norway in Sept'2014 proposed a US\$1.5bn 750MW first of a kind floating gas-fired power generation plant.^{clix}

We forecast that Japan will expand its combined renewable energy generation by 10-12TWh pa sustainably over the long term. Solar and offshore wind will be aided by incremental expansions of hydro and geothermal capacity with a significant ramp-up of floating offshore wind post 2020.

The Growing Impact of Solar

At the end of 2012, Japan had a total installed solar power capacity of 7GW, despite being one of the leading solar module manufacturing bases globally. After two years of intense debate about energy security and energy system diversity, the Japanese government announced a major strategic priority to encourage the installation of solar electricity generation capacity. This was commenced by offering a 20 year Feed-in-Tariff (FiT) set at Yen42/kWh from July 2012 for solar-generated electricity, double the tariff offered in Germany at that time and more than three times that paid in China.^{clx} This saw 7.2GW of solar installed over 2013. The FiT was lowered 14% to Yen36 in 2013/14 to reflect the decline in solar module component prices and the lower balance of system costs being delivered as a result of the combination of learning by doing and economies of scale.^{clxi}

Solar installs in Japan have skyrocketed, with REC forecasting the small scale industrial market alone growing 50% to 4.5-5.5 GW in 2014.^{clxii} IEEFA forecasts 9GW for 2014, but Bloomberg New Energy Finance has forecast as much as 11.9GW this year alone.^{clxiii} As of the end of March 2014, Japan's Ministry of Economy, Trade and Industry had approved 65,726 MWs of solar projects since July 2012.^{clxiv}

IEEFA forecasts Japan will maintain solar installation rates of around 8GW annually for 2014-2020, progressively lower the FiT on offer by around 10% annually till it approaches grid parity pricing. The exceptionally low cost of debt finance in Japan and an influx of equity capital from existing utilities, industrial companies as well as global financiers has seen a massive influx of capital (US\$20-30bn pa) into solar infrastructure from virtually a standing start in mid-2012. We expect a significant step-up in rooftop residential and small-scale commercial solar over 2014-2016 as the scarcity of land starts to limit scope for significant new utility scale solar projects. Should Japan install 8GW pa till 2020, this would add 64GW of solar capacity in total. This is more conservative than the 69GW target by Mar'2021 and 100GW by 2030 forecast by the Japanese PV Energy Association in Aug'2014.^{clxv}

Despite utilisation rates of only 13-14% due to the relatively low solar radiation available in Japan, solar by 2020 could be generating upwards of 80TWh annually – equal to a 10% share of current electricity demand. Considered in isolation, this would mean solar is on track to replace 36Mtpa or 26% of thermal coal imports out of Japan's 2013 total of 136Mtpa.

Renewable Energy – Wind

Offshore wind capacity additions are assumed to commence with large scale commercial deployment of 3GW pa from 2020 onwards. Each of Mitsubishi Heavy Industries/Vestas, Hitachi and JSW are each running world leading proto-types of wind turbines of up to 7MW per turbine in 2014.

Incremental additions of onshore wind are forecast, with the current FiT for onshore wind of US\$0.22/kWh, there is some 4 GW in planning in 2014.^{clxvi} Grid transmission upgrades have been a necessary precursor to these projects.

Renewable Energy – Geothermal

Japan has the third largest geothermal resource globally, so this will be developed as an additional source of base load electricity supply, and for use in heat-pumps to further the rollout of distributed energy.

Renewable Energy – Hydro

Incremental hydroelectricity generation is expected, particularly for pumped hydro storage to add storage capacity and grid management flexibility. An additional 3.3GW of hydro-electricity capacity is also planned by 2023.^{clxvii}

Coal Fired Power Generation

Coal-fired power generation has increased to 23.1% of Japan's total electricity generation in 2013 from a 2009 low of 20.4%. However, this means coal-fired power generation has been flat in absolute terms given the 12% decline in total demand in this period.

New Coal Capacity Build: There are reports from the coal industry that TEPCO plans to build two supercritical coal-fired power plants with a combined capacity of 1.6GW and a thermal efficiency of 45%,^{clxviii} adding to the 1.6GW of new coal-fired capacity commissioned at the start of 2013. Tokyo Gas, J-Power, Chugoku Electric Power Co and Marubeni have all also announced new coal-fired capacity plans for 2016-2023.^{clxix} On any nuclear restart, much of this additional coal capacity would be redundant and just lower overall thermal (coal and/or LNG) plant operating rates should total electricity demand continue to fall as forecast. There is also the offsetting factor that up to 60GW or 30% of Japan's total current fossil fuel electricity generating capacity is nearing retirement age.

Energy Efficiency in Coal-Fired Generation Capacity: Japan has developed some the most efficient coal-fired power plants in the world, with the latest build plants having thermal conversion efficiencies of 42-46% vs the global coal-fired power fleet average of around 33%. There remains scope for Japan to introduce available leading-edge technology. Japan's Strategic Energy Plan highlights this as a policy initiative with the dual purpose of reducing greenhouse gas emissions and to promote Japanese exports of world leading technology.

Japan – Forecast Thermal Coal Demand – down 4% or 5Mtpa

With real GDP growth of 1% pa, energy efficiency gains of 1.5-2.5% pa and renewable energy capacity additions fielding an incremental 1.0-1.5% pa of demand, total fossil fuel electricity demand is forecast to decline by 1.7-2.7% pa. Assuming any restart of nuclear is used to reduce reliance on oil imports for electricity production, and that Japan continues to reduce carbon dioxide emissions through prioritizing LNG as the preferred fuel source, this suggests Japanese thermal coal imports of 136Mt in 2013 will be flat in 2014 (given the final nuclear plant closure end 2013) and then decline by 4.5% pa or 5Mtpa through to 2020.

Coal Demand in Japan Beyond 2020

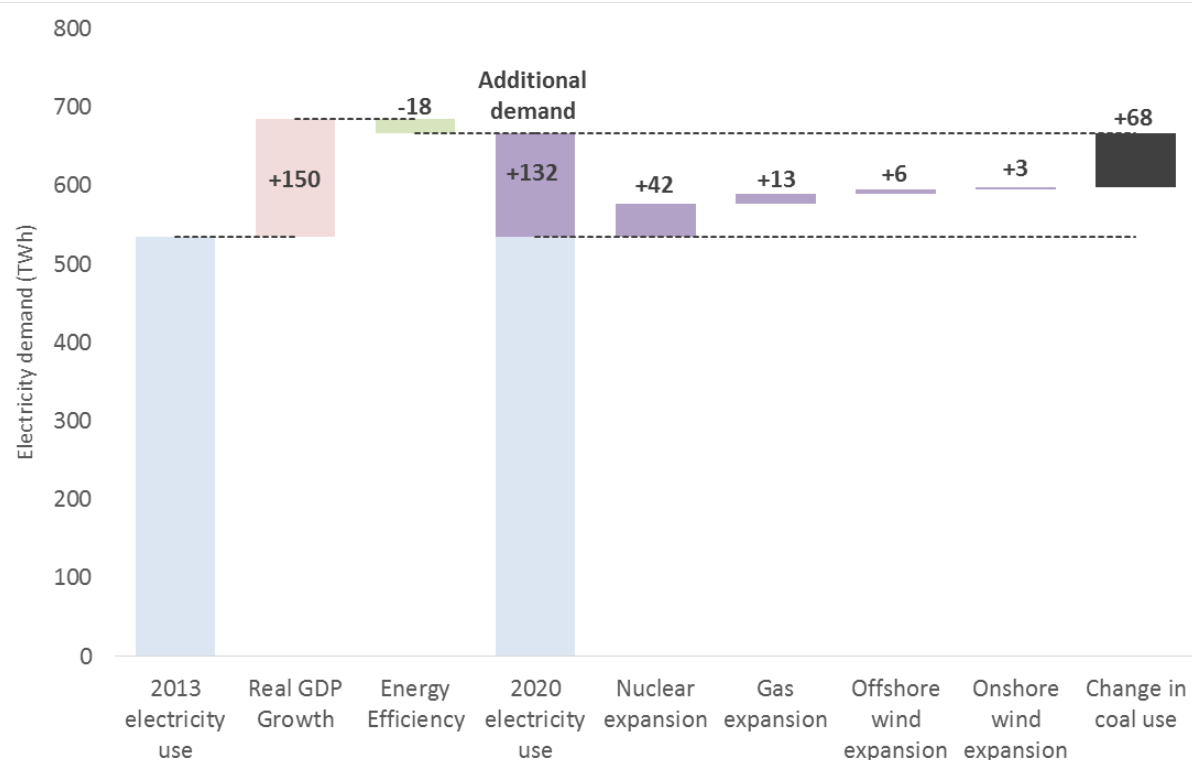
Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 2.3% over 2020-2035 as energy efficiency initiatives more than offset weak real GDP growth, and the onshore and offshore wind ramp-up gradually displaces coal-fired power generation. We assume a continued decline thereafter, with a CAGR of negative 1.5% for 2035-2050.

3.7 Korea's coal demand

- South Korea's new energy strategy was announced Jan'2014, an energy policy framework covering the period 2014-2035.
- Key targets are for a Renewable Portfolio Standard (RPS) of 11% by 2035 vs 1.3% in 2013. However, to-date very little progress is evident on developing projects to achieve this target.
- Energy efficiency is seen as a key priority, given little progress on this historically.
- In Jun'2014 Korea introduced a US\$16-18/t coal import tax and lowered the import tax on LNG, highlighting a government preference for the lower carbon emissions LNG fuel source.
- Korea continues to rely on nuclear power, with 5GW of additional nuclear capacity under construction to add to the existing 21GW of nuclear currently operational.
- Given the strong economic growth profile and predominance of heavy industry, IEEFA forecasts that South Korea will remain a key growth market for thermal coal over the forecast period. Coal imports are forecast to rise 4% pa or by 30Mtpa to 127Mtpa by 2020.

Figure 44 details our forecast for changes to the South Korean electricity sector by 2020 relative to the 2013 base. Total electricity demand is forecast to grow a net 132TWh in total. This reflects 3.7% real GDP growth annually (which would add 150TWh of demand), less 0.5% pa energy efficiency savings (cutting demand an incremental 18TWh). A substantial nuclear expansion is forecast to see 42TWh of new electricity sourced by 2020, 9TWh from wind and 13TWh sourced from new gas-fired electricity capacity. Coal-fired power generation is expected to remain the mainstay of the South Korean electricity sector, expanding by 68TWh over 2013-2020 and seeing thermal coal imports rise 4% pa or by 30Mtpa to 127Mtpa by 2020.

Figure 44: South Korea's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

Energy Market Structure

South Korea is the ninth largest electricity consuming nation globally in 2013, with total electricity demand of 535TWh. Electricity demand has seen a CAGR of 5.3% over 2000-2013, ahead of GDP growth of 4.4%. Figure 45 details the generation mix. Thermal electricity generation is the dominate source, representing 71.6% of the total in 2013. Nuclear power was 26.7%, and South Korea has minimal renewable energy capacity (hydro at 1.3%, geothermal at 0.4%). South Korea has 26GW of coal-fired and 22GW of gas-fired electricity capacity, plus 13GW of oil-fired generation peaking capacity available. Korea imports 97% of its energy needs, making it the second largest importer of LNG and the fourth largest coal importer globally.

Figure 45: South Korean Electricity Demand, by Fuel (2010-2013, TWh)

TWh	2010	2011	2012	2013	2013 Split
Thermal	330.2	345.4	353.8	366.9	71.6%
Hydro	6.4	7.8	5.9	6.5	1.3%
Nuclear	141.9	147.8	147.9	136.5	26.7%
Geothermal / other	1.9	2.2	2.2	2.2	0.4%
Total (TWh)	480.4	503.2	509.8	512.1	100.0%
Growth in Demand	10.4%	4.8%	1.3%	0.5%	

Source: IEA 2014

Energy Efficiency and Economic Growth

South Korea has reported an average 4.4% annual real GDP growth over 2000-2013, and electricity demand has grown at an even stronger 5.3% pa over this period. With an emphasis on heavy industry, any energy efficiency gains have been more than offset by the growth of electricity intensive industries overall in Korea.

Korea's Second Basic Energy Plan of January 2014 has a large focus on energy efficiency. For example, all new buildings should be "zero energy" by 2025 and the introduction of a Renewable Heat Obligation for large buildings requires 10% of heat energy consumption to come from renewable sources. Minister for Trade, Industry and Energy Yoon Sang-Jick called it a decisive shift from "conventional supply control to demand-side control".

The IMF forecasts South Korea's real GDP growth at 3.7% pa through to 2020, well above the 2.2% average forecast for the OECD. Assuming a material step up in energy efficiency initiatives, we forecast Korean electricity demand will grow 3.2% pa over the medium term and slow to 2% pa beyond 2020.

Nuclear Energy

South Korea has the highest density of nuclear reactors in the world and its 23 reactors of 21GW total capacity make up 27% of the power mix. There is considerable public pressure against

increased reliance on nuclear following Fukushima and a corruption scandal involving false safety certifications from its domestic nuclear industry. This will make it increasingly difficult for the existing approved plan to increase nuclear by 60% to 33GW by 2022.^{clxx} With KEPCO planning to commence three new units over 2014-2016 and two more under construction, we assume 5GW of additional nuclear capacity is online by 2020.

Renewable Energy

Korea has not made any significant progress on renewable energy to-date. The Korean Government's RPS obliges Korean utilities to source 3.5% of electricity generation from renewables by 2015, and 11% by 2035. This compares to the 1.7% generated by renewables in 2013, predominantly from hydro. While South Korea does target an increased use of distributed energy, scope is limited due to the low solar radiation and limited land availability.

Total wind capacity installed by end 2013 was only 0.6GW, constrained by a lack of land for onshore development. Offshore wind is being targeted, with Hyundai Heavy Industries developing its knowledge base with a 5.5MW prototype installed in 2013, and Samsung is likewise building up capacity with the development of its first 84MW offshore windfarm using 7MW turbines in 2014. Korea has a target of 1.5GW of offshore wind by 2019.^{clxxi}

LNG Expansions

With little scope or effective policy support for renewable energy, and increased public resistance to nuclear, Korea will continue to be a source of growth for coal and LNG imports. As part of a government policy to improve the relative position of LNG over coal, in June 2014 South Korea's government announced a plan to introduce a US\$16-18/t coal import tax and commensurately reduce the tax impost on LNG imports.^{clxxii} Korea currently has six new gas-fired power plants under development, with a planned 5GW of additional capacity by 2027.

Increased reliance on Coal Capacity

Korea South-East Power Co., Ltd. (KOSEP) plans to put unit 6-8 of Yeonghung coal-fired power station, each having output of 870MW, into operations and raise total output of the power station by 2.6GW by 2019. Korea East-West Power Co., Ltd. (EWP) plans to start operations of unit 9 and 10 of Dangjin coal-fired thermal power plant, each having output of 1.0GW by 2016, raising the total plant's capacity to 6.0GW.

Coal in South Korea Beyond 2020

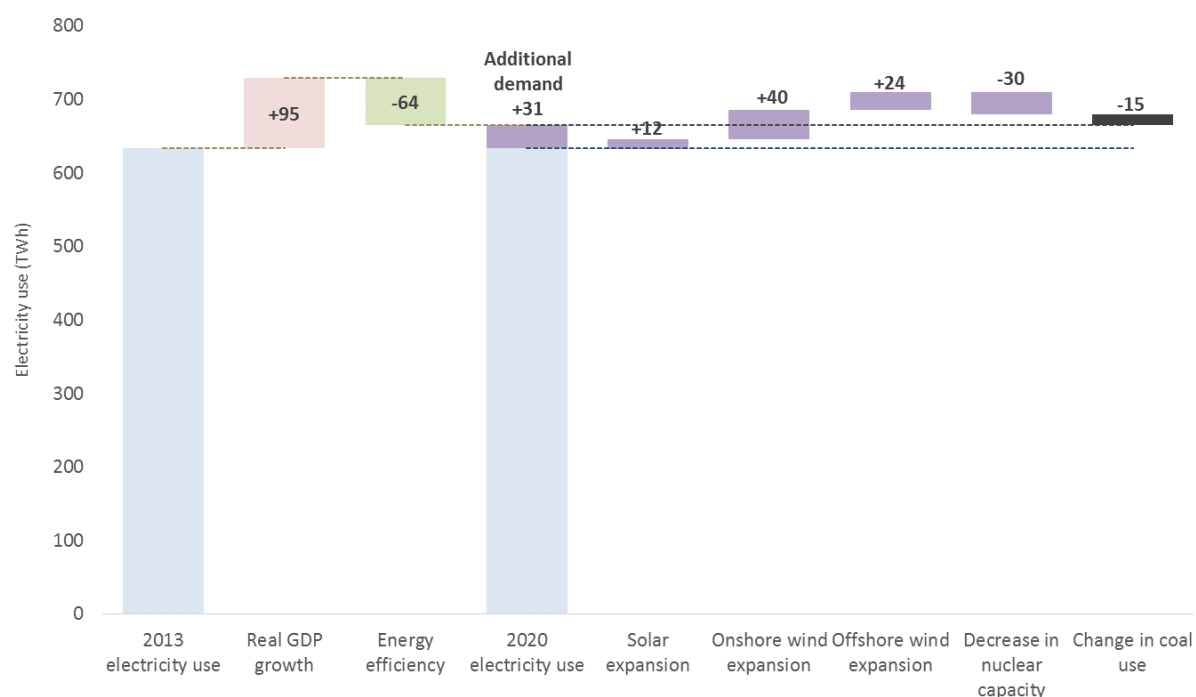
IEEFA forecasts that South Korea's domestic thermal coal demand will rise by a CAGR of 4.0% from 2013 to 127Mt in 2020. Beyond 2020, IEEFA forecasts that South Korea's demand will slow to growth of a CAGR of 2.2% through to see a peak by 2030-2035 at 196Mtpa as distributed solar and offshore wind farm developments are accelerated post 2020. We assume a CAGR of negative 0.8% for 2035-2050 on the assumption that a pan-Asian electricity grid facilitates renewable energy imports into South Korea via HVDC subsea cables initially developed to facilitate offshore windfarms.

3.8 Germany's coal demand

- German electricity demand has seen a CAGR of 0.4% over 2005-2013 relative to real GDP growth of 1.3%.
- We expect energy efficiency gains to accelerate to 1.5% pa over the forecast period, such that even with 2.2% pa GDP growth, the electricity demand should see only 0.5% pa growth.
- Germany continues to add significant renewable energy capacity each year. Although solar installs are forecast at only 2GW pa through to 2020, onshore and offshore wind installs are expected to accelerate to a combined 3GW pa.
- Germany remains committed to fully closing its remaining 13GW of nuclear capacity by 2022. Renewable energy capacity expansions should be sufficient to offset these closures.
- Germany's net thermal coal consumption is forecast to decline marginally through to 2022, and decline thereafter by 2% pa. Additional coal-fired power plant closures suggest there is downside to this forecast.

Figure 46 details our forecast for changes to the German electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 46: Germany's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

In summary, the IMF forecasts 2.2% pa real GDP growth for Germany over the 2013-2020 period, expanding electricity demand by 95TWh. Energy efficiency is forecast to reduce electricity demand by 1.5% pa, resulting in a cumulative reduction in electricity demand of 64TWh by 2020 relative to

2013. Expanded onshore wind capacity is forecast to add 40TWh with offshore wind adding an additional 24TWh of production by 2020. Germany has scaled back its installation rates of solar pre-2013, but we still estimate an additional 12TWh pa of additional solar electricity will be online by 2020. Increased production from CHP/biomass/EfW is forecast to offset any further decline in gas generation.

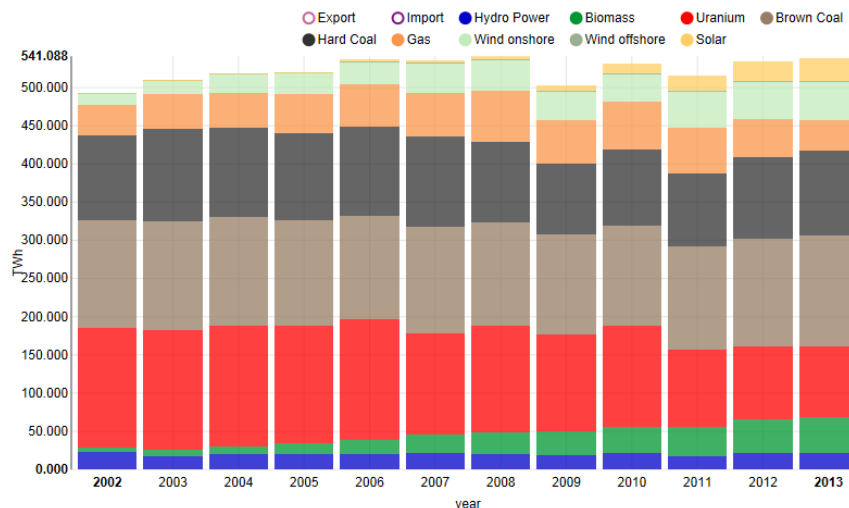
The combined expansion in renewable energy is sufficient to underpin the economic growth of Germany despite a marginal decline in net coal-fired power capacity, notwithstanding the phase-down of nuclear electricity production over this period (down 30TWh) in preparation for a complete closure of the 13GW remaining by 2022. Germany's thermal coal demand is forecast to decline marginally over the period to 2025, and decline 2% pa thereafter.

The Energiewende Has Placed Germany as a World Leader

Germany has led the world with its Energiewende, or energy system transformation over the last decade. Despite GDP growth averaging 1.3% pa for the last decade, total domestic Germany electricity demand has been flat (-1TWh to 660TWh in 2013). Energy efficiency has delivered a net energy saving equal to the growth in GDP over a decade, with plenty of scope for additional gains.

German coal-fired electricity production has flatlined for the last decade, despite the rapid erosion of nuclear production (down more than 40%) and reduced gas dependency (down 10%). Renewable energy including biomass and hydro accounted for a record 30.8% of 1HCY2014 production (vs 10.6% in 2004) – Figure 47. 2014 coal-fired power generation is down 10% yoy year-to-date Aug'2014.^{clxxiii}

Figure 47: German Electricity Production by Fuel Type (2002-2013)



Source: Fraunhofer Institute^{clxxiv}

For the six months to June 2014, Germany's total electricity demand was -5% yoy to 263TWh. Within this, solar power electricity generation was +28% yoy and wind was +17% yoy. Combined with hydro and biomass, renewable electricity generation was 81TWh or 31% of Germany's total. By

comparison, coal-fired power generation was -6% yoy to 121TWh or 46% of the total production. Nuclear held a 17% share and gas at a 9% share provided the balance of Germany's electricity.^{clxxv}

Coal

In June 2014 EnBW of Germany announced *“extraordinary charges totalling €1.5 billion, which are to be included in the consolidated financial statement of 30 June 2014, lies in considerably worsening expectations regarding long-term electricity price developments, particularly from today's perspective and based on comprehensive market analyses.”* This involves write-downs of EnBW's fossil fuel generation plants, and includes the notification over 2Q2014 of coal fired plant closures at Walheim, Marbach and Heilbronn.^{clxxvi}

Germany has 5.6GW of new coal-fired power capacity due online in 2014 and 2015, at the same time as the national grid regulator Bundesnetzagentur shows that an additional 10GW of wind and solar will be added to the German grid.^{clxxvii} With demand flatlining, the consequence is lower utilisation rates for Germany's fossil fuel electricity assets, fuel costs mean that these fossil fuel plants are poorest ranked in the merit order scheme of power dispatch.

With Germany's benchmark wholesale electricity contract down 36% since 2010, oversupply and declining demand has decimated utility margins. Vattenfall AG's VP Portfolio Management Alfred Hoffmann commented in July 2014: *“The boom of coal plants is over for now. And the situation won't improve before the next decade, when old coal plants and nuclear reactors go offline.”*^{clxxviii}

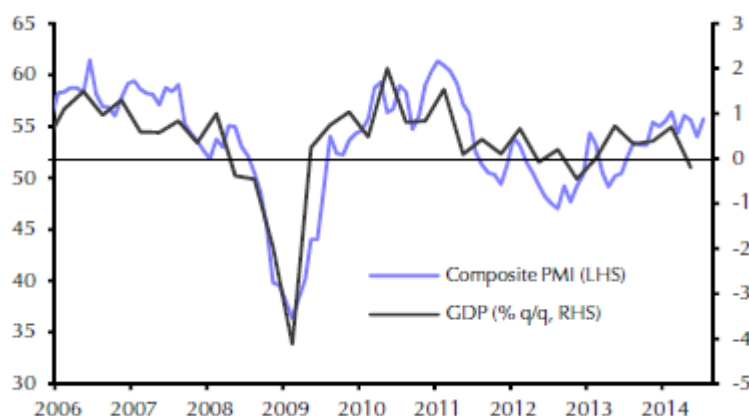
Whilst much has been made of several new coal-fired power plant openings in Germany around 2014, the reality is that net coal-fired power generation is at best holding steady. The profit margin squeeze detailed above, highlights that if not for the legislated closure of Germany's nuclear fleet by 2022, Germany would be seeing a rapid reduction in its coal-fired capacity over the medium term.

To this end, RWE AG announced a further 1.0GW of thermal plant closures by 2017 in Aug'2014, and contract terminations for another 0.5GW.^{clxxix} This takes to 3.7GW of coal-fired capacity RWE will close over the 2014-2017 period in Germany alone.

Below Trend Economic Growth

The German economy has been remarkably resilient post the global financial crisis, but the huge EU wide debt overhang continues to depress economic growth. Germany is not immune, and real GDP growth over the medium term will struggle to exceed 2% pa – refer Figure 48. Our assumption of EU real GDP growth is set at 1-2% pa, reflecting both excessive country financial leverage and the headwind of flat to negative population growth trends.

Figure 48: German GDP and Composite PMI



Source: Capital Economics, Thomson Datastream, Markit.

Energy Efficiency Drive Accelerates

Over the 2005-2013 period, Germany has averaged real GDP growth of 1.3% pa, whilst electricity consumption has risen by 0.4% pa – suggesting energy efficiency and economic transition is delivering a 0.9% pa lower electricity intensity per unit of real GDP.

The Renewable Energy Sources Act (EEG) 2014 includes stricter regulations for energy-intensive companies. Germany's upper house of parliament, the Bundesrat, approved a far-reaching amendment to the country's renewable energy law on the 11th July 2014. This amendment introduces compulsory certified energy and environment management systems for any large energy-intensive businesses eligible for a discount under the special equalization scheme on the EEG surcharge. Historically, only companies with an annual energy consumption of more than 10 GWh have to implement an energy management system.^{clxxx}

This should see energy efficiency gains accelerate from less than 1% pa towards the 2% pa evidenced in the UK. We assume 1.5% pa savings over the forecast period, suggesting a 0.5% annual increase in net German electricity demand over the forecast period. This is consistent with the proposed 30% energy savings target of the EU 2030 climate and energy package.^{clxxxi}

Renewable Energy – Wind

Germany has installed 2-3GW pa of new windfarm capacity for the last decade, taking total cumulative wind installs to 36 GW by June 2014. This is the third largest installed base globally, behind only China and America. Total installs in the first half of 2014 are running at an annualized 3.5 GW in total, ahead of the German Government's annual target of 2.5GW.^{clxxxii}

From the current small base of 0.5GW of offshore wind, the German government has set a target of 6.5GW by 2020 and 15 GW by 2030.^{clxxxiii} Using turbines of 5-8MW each relative to the current 2MW onshore turbines and with operating rates over 50% higher than for offshore, the electricity yield is significantly enhanced.

We expect total wind installs of 2GW pa rate to continue long term. Whilst there have been serious constraints relating to grid infrastructure capacity, these are gradually being rectified, both for onshore and offshore wind development. Repowering of existing onshore wind sites is increasingly a significant opportunity allowing a doubling or tripling of site yields through the replacement of old with new turbines that are more than double the capacity and with greater efficiencies to allow higher utilisation rates. This should add over 50TWh of additional wind-generated electricity over 2013-2020, equivalent to 1.4% pa expansion of total German electricity production.

Renewable Energy – Solar

Germany has the largest installed solar base in the world, with 37GW operational at the end of 2013. Although Germany installed 7.5GW pa over 2010-2012, we expect installs to decline to a more sustainable 2GW pa over 2014-2020. This will add an additional 12 TWh of solar generation, equivalent to 0.3% pa increase in total electricity production.

Closure of Nuclear by 2022

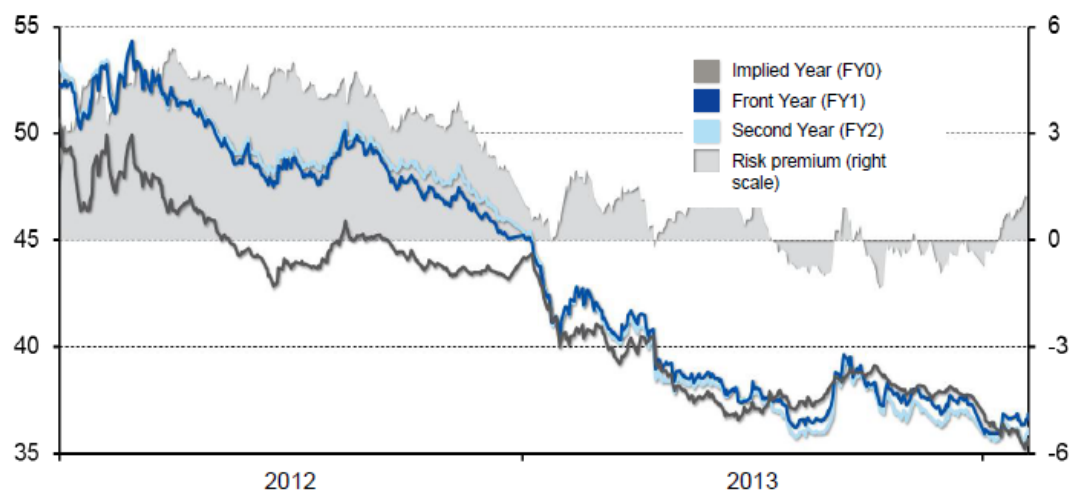
With the decision to phase-out nuclear reinforced post Fukushima in 2011, since 2010 German electricity produced by nuclear has fallen by 40% to 92TWh in 2013.

Germany remains committed to the total closure of its nuclear capacity by 2022.^{clxxxiv} With nine nuclear plants with a total capacity of 13GW still operational, this entire production loss is forecast to be more than offset by the increased generation of wind, solar, hydro and CHP electricity expansions in this period.^{clxxxv}

Cost-Benefit Analysis of Renewables

Any cost-benefits analysis of the Germany Energiewende needs to consider both the tax impost on residential customers but also the benefit of permanently lower wholesale prices. As Figure 49 details, wholesale electricity prices have almost halved in the last three years to €35/MWh. We consider most analyses of renewables focus on the intermittency and high initial cost, and downplay or ignore the system benefits of diversification, improved energy security and the downward pressure renewables place on wholesale power prices through the merit order effect.

Figure 49: Baseload Power Prices in Germany vs 1-2 Year Forward Prices (€/MWh)



Source: RWE, Aug 2014^{clxxxvi}

Coal in Germany Beyond 2020

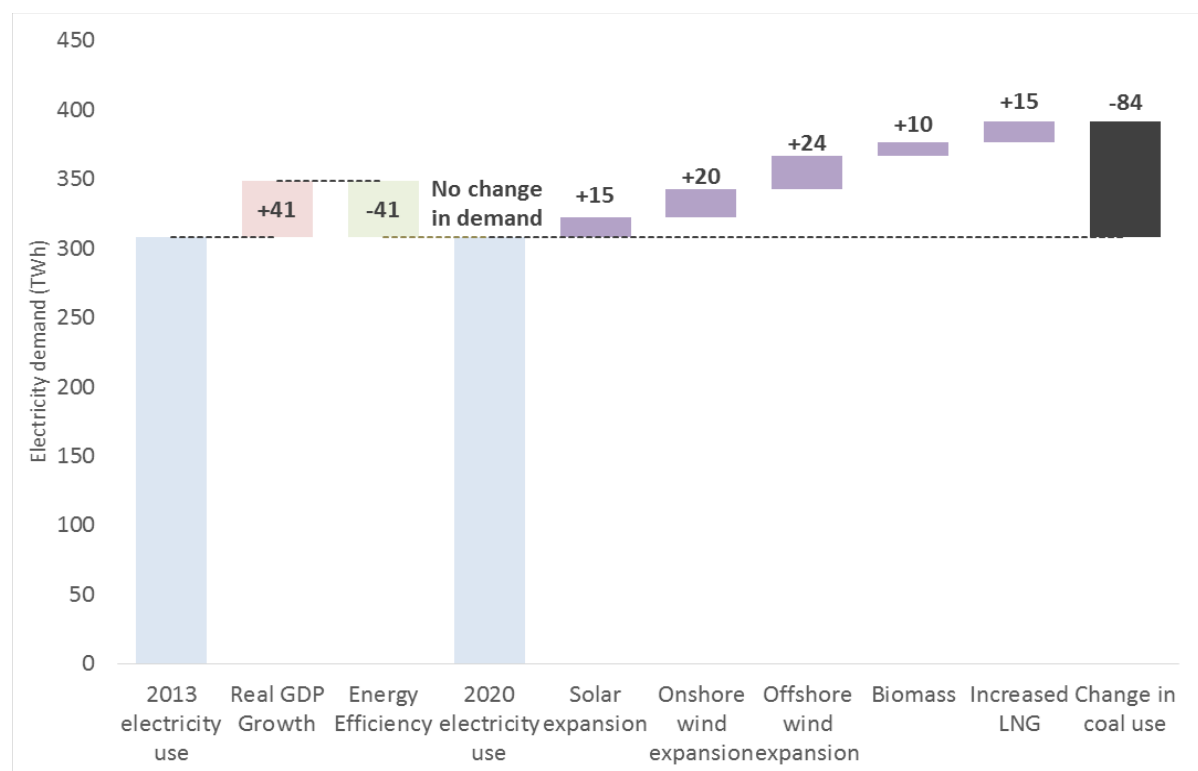
IEEFA forecasts that Germany's domestic thermal coal demand falls by a CAGR of 2.0% from 2013 to 36Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 1.3% over 2020-2035 despite the last 13GW of nuclear power plants being decommissioned in 2022. With Germany having one of the highest retail electricity prices in the OECD and one of the highest levels of electricity consumption per capita, we assume there remains significant scope for energy efficiency measures to rein in excessive electricity wastage. Germany has significant offshore wind resources, plus scope for a significant uplift in electricity generation from repowering the existing onshore wind installations. We expect an outcome of significantly reduced electricity demand and a much more diverse, low carbon electricity system. We assume a continued decline thereafter, with a CAGR of negative 2% for 2035-2050.

3.9 The UK's coal demand

- 4 UK GDP has seen a CAGR of 0.9% against electricity at negative 1.2% over 2005-2013. This is a 2.1% annual reduction in electricity per unit of GDP growth.
- 5 Energy efficiency and an economic transition to a lower carbon intensity should continue, meaning electricity demand is forecast to be flat going forward.
- 6 The EU Large Combustion Plant Directive then the Industrial Emissions Directive from 2016 will see significant coal-fired power plant closures through 2020.
- 7 Ongoing investment in UK solar, onshore and offshore wind should reduce coal demand 4% pa. The UK generated 14.9% of 2013 electricity from renewables, strongly up from 11.3% in 2012. With another Stg8bn invested in 2013 alone, the UK is progressing towards its 2020 target of 30%.^{clxxxvii}
- 8 Conversion of coal-fired power plants to biomass will further reduce coal demand 1% pa and a doubling of gas-fired power generation utilisation rates will cut another 1%.
- 9 UK thermal coal demand is forecast to decline 6% pa through to 2020 from 55Mt in 2013 to 35Mtpa by 2020 and continue to decline 2-3% pa longer term.

Figure 50 details our forecast for changes to the UK electricity sector by 2020 relative to the 2013 base. Total electricity demand is forecast to be steady, reflecting 2.0% real GDP growth annually (which would add 41TWh of demand), less 2.0% pa energy efficiency / economic transition savings (cutting demand an incremental 41TWh). Substantial renewable energy expansion will see 15TWh sourced from solar, 20TWh of new electricity sourced from onshore wind and an incremental 24TWh from offshore windfarms by 2020.

Figure 50: UK's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

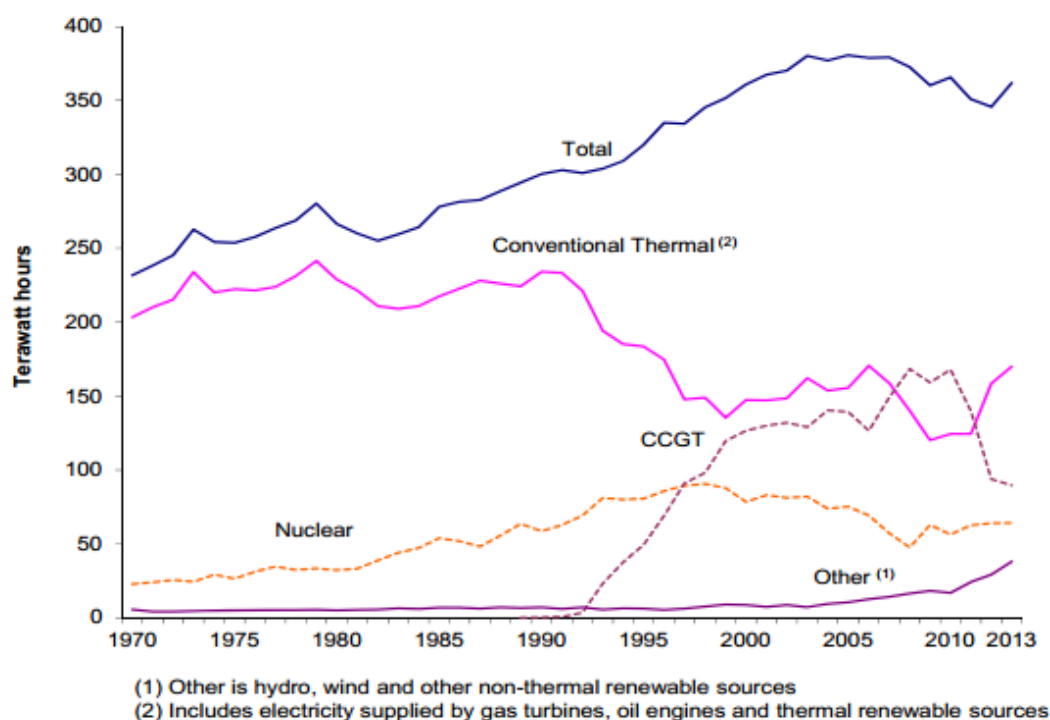
Conversion of the DRAX coal-fired power station to be co-fired on biomass will convert 10TWh pa by 2020 over to wood pellets. Increased gas use will supply 15TWh.

From the 90Mtpa of thermal coal consumed in the UK in 1990, demand has declined to 55Mtpa by 2013 and a forecast 35Mtpa by 2020 (down 6% pa). We forecast that the UK will continue to successfully diversify its electricity system away from coal, adding to energy security and system stability. We explore this in more detail below.

UK Electricity Market to date

The UK electricity market has been roughly flat since 2000. Coal fired power generation has dropped from 77% market share in 1990 to 37% in 2013 – refer Figure 41. Gas-fired generation (CCGT) took off over the 1990s and has held a 26-35% market share over the last five years depending upon the relative price of LNG to thermal coal. Biomass has grown steadily over the last decade to a 7% share in 2013. Wind has grown to an 8% share and hydro has been constant at 2% and nuclear steady at 21%. Given low solar radiation, solar is only a recent impact making a 1% contribution in 2013.

Figure 51: Gross Electricity by Fuel, 1970-2013



Source: DUKES^{clxxxviii}

A key enhancement of the UK electricity system has been the expansion of interconnections of the UK grid across the channel to Europe. BNEF estimates that the current interconnection capacity of 3.5GW will expand to 8.5GW by 2020. This is a key development to facilitate further renewables.

UK Energy Efficiency Gains

Over the 2005-2013 period, the UK rate of real GDP has seen a CAGR of +0.9%. Against this, electricity demand has declined by a 1.2% CAGR, a net decline of 2.1% pa in electricity used per unit of real GDP over the last eight years due to energy efficiency gains and a doubling of retail electricity prices in this period^{clxxxix}. There can be a significant lag before the full impact of the price elasticity of demand takes effect. Given the increased reliance on imported fossil fuels, the UK has some of the highest wholesale electricity prices in the world at £50-60/MWh (US\$85/MWh), giving rise to retail prices averaging £0.16/kWh (i.e. US\$0.26/kWh) in 2013.

IEEFA forecast 2.0% pa gains from economic transitioning and energy efficiency to continue relative to real GDP growth for the UK of forecast at 2.0% pa over the period to 2020. As such, aggregate electricity demand in the UK is likely to be flat going forward.

EU Large Combustion Plant Directive vs UK Capacity Market

Plant closure plans resulting from the EU Large Combustion Plant Directive, and the subsequent Industrial Emissions Directive, means that a significant portion of the UK's aging 28GW coal-fired power fleet are progressively being retired this decade. To-date five coal fired power plants with a combined capacity of 5.6GW have already closed with another two (at Rugeley and Ironbridge) with a combined 3.0GW of capacity slated for closure near term.^{cxc}

We note that in July 2014 the UK introduced a new capacity market program, such that coal-fired power plants are likely to remain on line in a role as backup generation capacity. However, this is likely to be a temporary reprieve. BNEF estimates that 80% of current coal-fired electricity capacity is likely to be forced offline completely by 2024 as a result of tightening EU particulate emissions regulations, to be progressively replaced by new gas-fired and renewable energy generation capacity.^{cxci}

UK Carbon Tax

In order to underpin the regulatory impact of the EU ETS, the 2011 UK budget introduced a carbon price floor commencing April 2013. Initially set at £5/tonne of CO₂ for 2013/14, this steps up to £18/tonne of CO₂ for 2017/18, the equivalent to £43/tonne of thermal coal, further driving the price signals in favour of lower carbon emitting alternatives.^{cxcii}

UK Nuclear, Hydro and Gas

We assume that the UK's combined nuclear, hydro and gas capacity remains constant over the forecast period.

The new 3.2GW Hinkley Point nuclear plant is progressing, with plans for commissioning by 2023. This single plant could supply over 7% of the UK's total electricity needs.

Gas-fired electricity generation hit a five year low on the back of very low carbon prices and high gas prices. With the carbon price floor now in place, and global LNG prices trending down, this could accelerate the decline of UK coal demand beyond our forecast for a decline of 4.5% pa over 2013-2020, and then down a further 3% pa over 2020-30 and down 2% pa over 2030-2050.

UK Coal Production in terminal decline

2013 saw UK domestic thermal coal production down 25% year-on-year^{cxci} to 12Mt, continuing the long term decline. UK coal production has CAGR of negative 7% over 2000-2013, and an annual decline of 8% since 1990. Imported thermal coal now supplies 68% of the UK coal market, up from 29% in 2000.

Conversion from Coal to Biomass - Drax

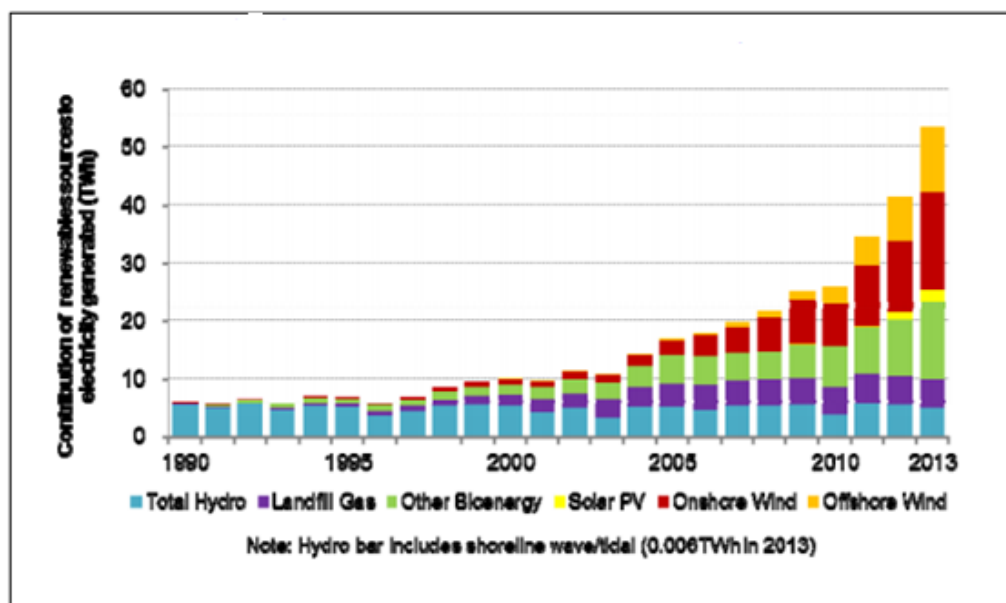
Drax Plc, the UK's largest power station with a capacity of 3,870 MW, is set to become the UK's largest single renewable electricity generator through the operation of the new biomass facilities. The biomass conversion will ultimately see four of the six generating units at the power station converted to burn biomass (wood pellets) in place of coal. The first unit has been running successfully on sustainable biomass since April 2013, the second commences in 2014, the third in 2016 and the fourth in 2017 as part of a £500m capital expenditure conversion program.^{cxci} Biomass is now more than 20% of Drax's power output. Prior to 2013, Drax used 10Mtpa of coal, but coal requirements are down 12% year-on-year in 2014 to below 8Mtpa and a 50% conversion by 2016 will replace 5Mtpa of thermal coal demand.

Overall, conversion of coal to biomass fuel is reducing UK coal demand by 1Mt annually, and the Drax investment alone will continue this substitution for the next half decade. This alone lowers coal demand 1.5% pa.

UK Program of Renewables Support

Electricity generated from renewable energy sources has been increasing since 1990. Growth has been particularly rapid over the past five years as illustrated by Figure 52.

Figure 52: Electricity Generation from Renewable Sources, 1990-2013



Source: DUKES page 247^{cxci}

The UK has progressively expanded its regulatory and financial support for renewable energy since 2008. To ensure long term power purchase agreements were financially robust, the UK has implemented contracts for difference set at £155/MWh for offshore wind and £95/MWh for onshore wind in 2014/15, with a gradual step-down in pricing over the next five years as costs of installation are reduced through technology improvements and economies of scale.^{cxvii} The UK has offered a contracts-for-difference of £105/MWh for biomass.

Solar Energy

The UK is increasingly promoting distributed and small utility scale solar, with 2014 on track to see a trebling of the rate of installations to close to 3 GW (1.5GW were installed in the first six months).^{cxviii} Assuming the UK expands to 16GW of solar by 2020 against 3GW in 2013, this will add 15TWh of additional renewable energy to the UK, reducing coal demand by 8Mt cumulative or 1Mt each year through to 2020.

Onshore Wind Energy

The UK has 10GW of onshore wind installed as at the end of 2013. Growing this to 16.5GW by 2020 will add 20TWh of additional renewable energy supply, enough to replace 11Mt of coal, or 1.5Mt each year to 2020. On 18 Aug'2014 total wind generated a record 22% of the UK's total electricity needs (in 2013 its average share was 7.7%), with 5.8GWh in a single day.^{cxviii}

Offshore Wind Energy

The UK has set a target of 18GW of offshore wind to be installed by 2020.^{cxix} As at the end of 2013 this stood at 3.7GW. We note the rate of installation is falling materially behind schedule, with Centrica and Dong Energy announcing cancellation of 4.2GW in July 2014.^{cc} However, with 37GW in the planning pipeline, there remains significant scope for UK's offshore wind industry over the long term.^{cci} Assuming 10GW by 2020 will add 24TWh of additional renewable energy supply, enough to replace a cumulative 11Mt of coal, or 1.3Mt each year to 2020.

Coal Demand in the UK Beyond 2020

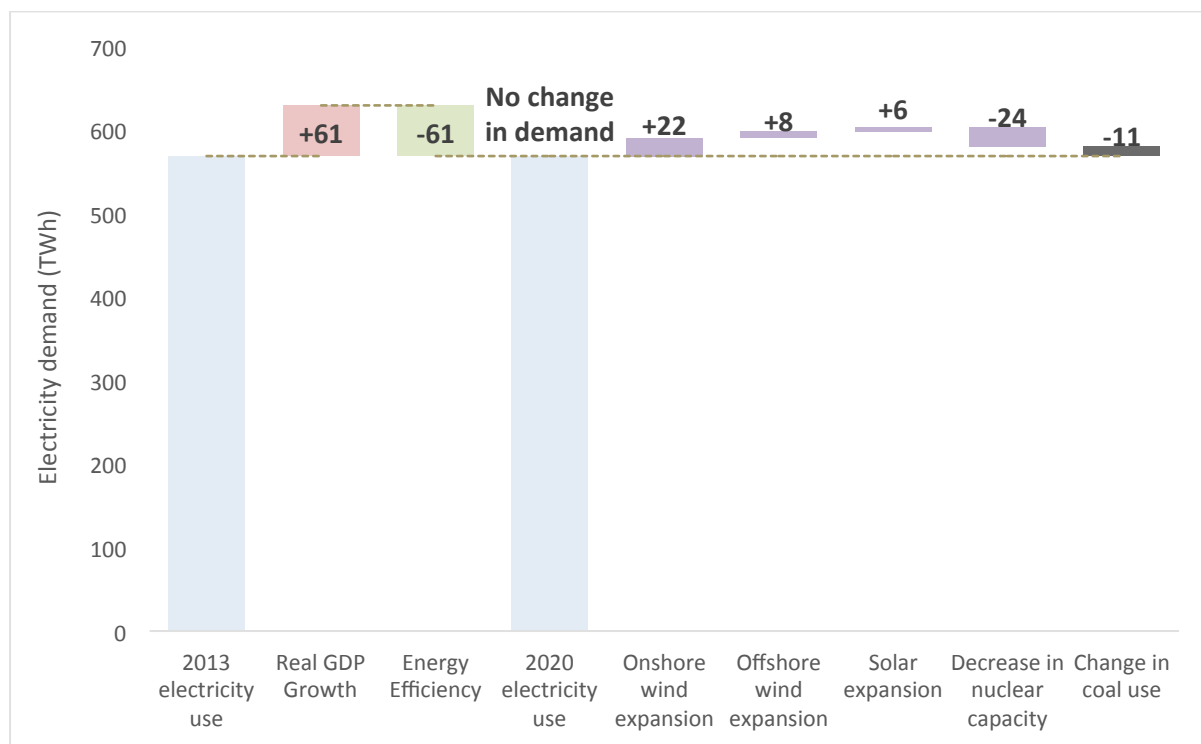
IEEFA forecasts that the UK's domestic thermal coal demand falls by a CAGR of 6.0% from 2013 to 35Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 3.5% over 2020-2035 as most of the remaining coal-fired power plants are progressively decommissioned on the back of the Large Combustion Plant Directive. With the UK having one of the highest wholesale electricity prices in the OECD it already has one of the lowest levels of electricity consumption per capita, so we assume the scope for significant energy efficiency measures to rein in excessive electricity wastage is relatively limited. However, the UK has very significant offshore wind resources, plus scope for an uplift in electricity generation through repowering the existing 10GW of onshore wind installations with more efficient and larger turbines (doubling electricity output from the same sites). We assume a continued decline thereafter, with a CAGR of negative 2.5% for 2035-2050.

3.10 France's coal demand

- French GDP has seen a CAGR of +0.8% vs electricity at -0.1% over 2005-2013. This is a 0.9% annual reduction in electricity per unit of GDP growth.
- France is the 7th largest electricity market in the world, and coal supplies only 5% of total electricity, with coal demand falling 2% pa since 2000.
- Nuclear is the dominant source of electricity, but the Government is targeting a trebling of renewable energy to 32% by 2030.
- Relative to the size of the country, France's electricity use is 80-100% higher relative to the UK and 25% higher than Germany. As such, the opportunities for energy efficiency are significant. New legislation was approved by the French Cabinet in July 2014 to stimulate significant new investment in energy efficiency and renewables.^{ccii}

Figure 53 details our forecast for changes to France's electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 53: France's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

In summary, IEEFA forecasts 1.6% pa real GDP growth for France over the 2013-2020 period, expanding electricity demand by 61TWh. Energy efficiency is forecast to reduce electricity demand by 1.6% pa, resulting in a cumulative reduction in electricity demand of 61TWh by 2020 relative to 2013. Expanded onshore wind capacity is forecast to add 22TWh with offshore wind adding an additional 8TWh of production by 2020. France has scaled up its installation rates of solar post 2013, and IEEFA estimates an additional 6TWh pa of solar electricity will be online by 2020.

The combined expansion in renewable energy and energy efficiency is more than sufficient to underpin the electricity demand requirements of France given subdued economic growth, notwithstanding the phase-down of nuclear electricity production over this period (down 24TWh pa). France's thermal coal demand is forecast to decline 2Mtpa to 11Mtpa by 2020, and decline 1% pa thereafter.

Structure of the French Electricity Sector

France is the seventh largest electricity market in the world, with 568TWh of consumption in 2013 (10% below Germany vs a 20% smaller population). Real GDP growth has seen a CAGR of 1.0% over 2000-2013. By comparison, electricity demand has grown at 0.4% CAGR, suggesting a energy efficiency saving of 0.6% pa over this period. Looking at the last eight years, this energy saving relative to GDP has increased to 0.9% pa.

France's thermal coal usage in 2013 was only 12Mt, and coal usage has been declining 2% pa over 2000-2012. Coal-fired power generation holds a 5% market share in 2013, down from 10% in 1990. The French electricity system is 75% nuclear, 8% hydro, 5% coal-fired, 8% gas, 3.3% from onshore wind and 1% from solar.

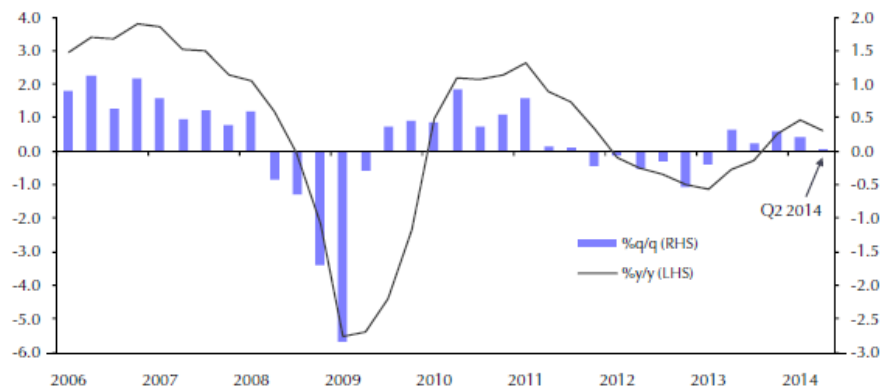
Nuclear is the Dominant Source

France's President Francois Hollande has set a goal to shrink the share of electricity generated with nuclear power to 50% in 2025.^{cciii} France seeks to raise the share of renewable energy France uses to 32% by 2030, compared with about 14% in 2012.^{cciv} Nuclear electricity capacity is capped at the current 63GW level. Initially this suggested net closures of retirement age capacity of some 15GW of nuclear over the next decade, but with offshore wind costs still excessive, no timetable for reduced nuclear capacity has been enunciated and some plant life extensions are probably inevitable to bridge the gap till offshore wind and solar are deployed on scale.

Below Trend Economic Growth

The French economy has experienced flat to negative real GDP growth over the 2013/14 year. The EU overall has seen flat GDP growth since 2011, an outcome of the huge EU wide debt overhang – refer Figure 54. Our assumption of EU real GDP growth is set at 1-2% pa, reflecting both excessive country financial leverage and the headwind of flat to negative population growth trends. Net of energy efficiency, this means French electricity outlook is flat to down.

Figure 54: Euro-Zone GDP Growth



Source: Capital Economics

Renewable Energy - Wind

France has an installed base of wind farms totaling 8GW, the seventh largest globally as at 2013.

France has set a target of 25GW wind power, including 6GW of offshore wind, by 2020 as part of its obligation under the EU renewables directive, which requires France to meet 23% of final energy demand from renewables by 2020, rising to 32% by 2030. However, with significant approval delays this target looks increasingly at risk. We assume installed capacity reaches 19GW, adding 30TWh of electricity generation from wind over 2014-2020.

Energy Efficiency Accelerates

The French government has announced in August 2014 legislation to provide a series of new tax breaks and potentially €5bn of zero-interest loans to help drive investment in clean energy, insulation and energy efficiency measures.^{ccv}

Energy efficiency is a key opportunity for France to transition their economy to a more balanced energy system without increasing the currently very low carbon intensity as they diversify away from the predominantly nuclear electricity generation base. Current electricity consumption in France of 568TWh is 20% higher than Germany and twice that of the UK per unit of real GDP (using the IMF's real purchasing power parity estimates) or 77% higher per person.^{ccvi} With a modern electricity grid and one of the lowest electricity transmission and distribution loss rates globally at 5-6% pa, plus well functioning international interconnects, there structure is there for sustained electricity energy efficiency gains.

We assume this increased focus on energy efficiency drives a decline in the electricity intensity of real GDP by 1.6% pa, meaning total electricity demand is expected to be flat or potentially gradually declining over the forecast period.

We note the announcement in Sept'2014 by Electricity de France Group (EDF) to install 35 million smart meters from 2014-2020 as part of a drive to reduce peak electricity consumption and improve energy efficiency.^{ccvii} This follows a two year trial and cost-benefit analysis.

Coal in France Beyond 2020

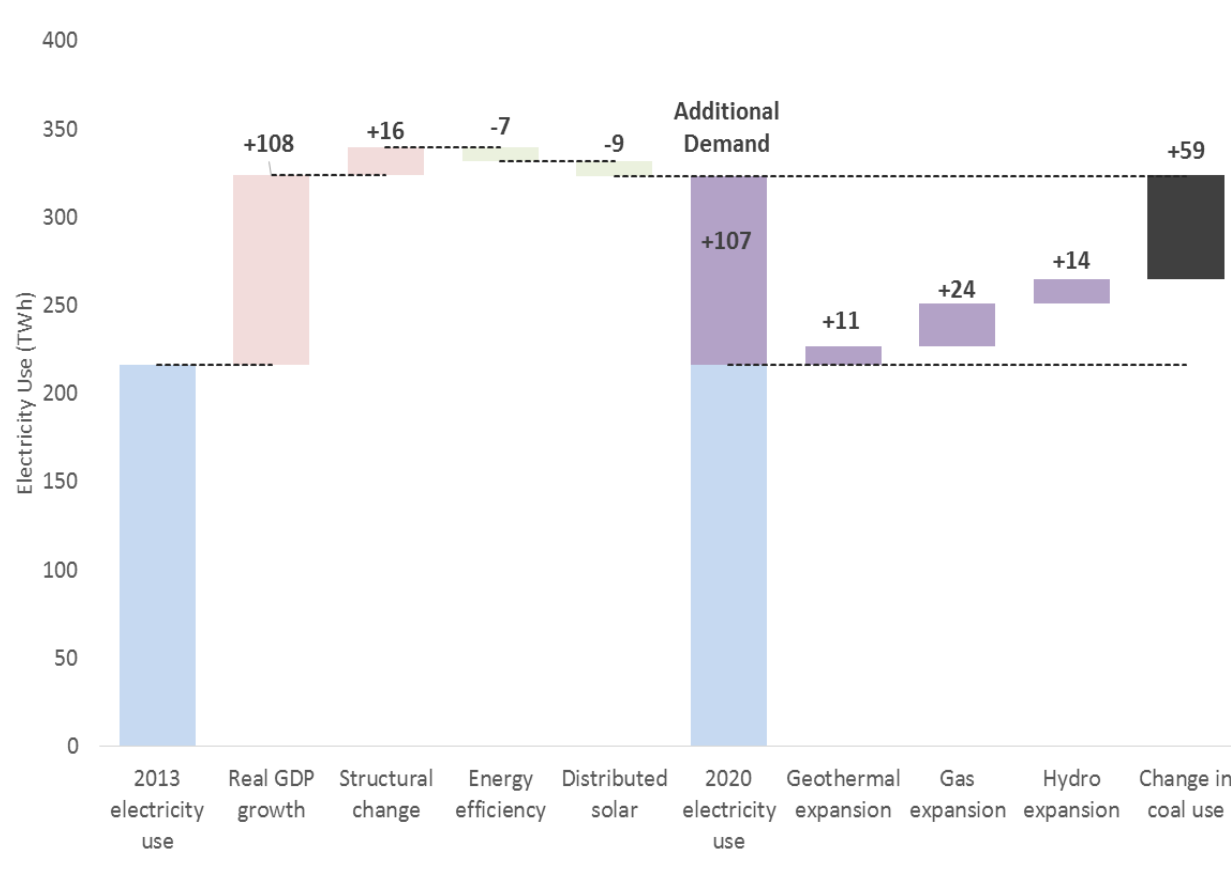
IEEFA forecasts that France's domestic thermal coal demand falls by a CAGR of 2.0% from 2013 to 11Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 1.0% over 2020-2035 as energy efficiency initiatives entirely offset real GDP growth, and on and offshore wind plus solar installs gradually displace the remaining coal-fired power generation. We assume a continued decline thereafter, with a CAGR of negative 2% for 2035-2050 as at some point France decommissions its final few coal-fired power plants at or before the end of their useful life as the carbon price combines with declining renewable electricity costs to make the coal-plants uncommercial.

3.11 Indonesia's coal demand

- Over 2005-2013, with real GDP growth of 5.9% pa, Indonesia's electricity demand has grown at an average of 6.8% annually. Thus electricity demand has grown at 115% of real GDP.
- Over 2013-2020, real GDP is forecast to grow at 6.0% annually, driving a 5.9% increase in net electricity demand as energy efficiency gains and distributed solar offset the greater electricity intensity of demand relative to GDP.
- The IEA New Policies Scenario expects a dramatic improvement in the impact of energy efficiency over the 2013-2035 period, driving gains of 2.3% pa. IEEFA does not see significant progress medium term, hence our forecast for a 0.5% annual saving through to 2020.
- Increased electricity supply is forecast from gas, geothermal and hydro with a significant step-up in wind installations beyond 2020.
- However, this is insufficient to provide adequate diversification of the Indonesian electricity grid and the sector is forecast to remain reliant on thermal coal, with domestic consumption to grow 5.0% pa to 91Mtpa by 2020.

Figure 55 details our forecast for changes to the Indonesian electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 55: Indonesia's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

In summary, the IMF forecasts 6.0% pa real GDP growth for Indonesia over the 2013-2020 period, expanding electricity demand by 124TWh (inclusive of the structural growth in demand beyond the rate of real GDP adding another 1% pa or 16TWh in total by 2020). With limited focus on energy efficiency to-date in Indonesia, this sector is forecast to reduce electricity demand by only 0.5% pa, resulting in a reduction in electricity demand of 7TWh by 2020 relative to 2013. Given the complexities of Indonesia's island structure for the electricity grid, we assume distributed solar with storage will have a 5GW penetration by 2020, taking electricity grid demand growth down by 0.6% pa or 9TWh. Expanded geothermal generation is forecast to add 11TWh, gas some 24TWh and hydro adding 14TWh of production by 2020.

Indonesia's domestic thermal coal demand is forecast to increase by 26Mtpa or 5% pa to 91Mtpa by 2020.

Indonesia's Electricity Market Structure

Coal-fired electricity generation capacity of 26.4GW represents 48.5% of Indonesia's total as at 31 Mar'2014. Gas-fired capacity of 15.7GW or 28.9% of the total is the main alternative, with oil third at 6.8GW of 12.4%. Hydro of 4.1GW and geothermal at 1.4% make up the balance – refer Figure 56. Indonesia to-date has no material exposure to wind farms nor utility scale solar.

Figure 56: Indonesia's Electricity Capacity (March 2014, GW)

As of 31 March 2014	Installed Capacity	
	GW	%
Coal	26.4	48.5%
Gas	15.7	28.9%
Oil	6.8	12.4%
Hydro	4.1	7.6%
Geothermal	1.4	2.5%
Other	0.0	0.0%
Total	54.4	100.0%

Source: PT PLN, Coaltrans Asia, 2 June 2014^{ccviii}

Electricity Demand Growth

Over the 2005-2013 period, with real GDP growth of 5.9% pa, Indonesia's electricity demand has grown at an average of 6.8% annually. Thus electricity demand has grown at 115% of real GDP. IEEFA assumes electricity demand will continue to grow at this rate, less 0.5% annually from new energy efficiency initiatives and a 0.6% annual reduction from increased use of distributed solar.

The net effect is that centralized grid-based electricity demand is forecast to grow at a CAGR of 5.9% from the 2013 base through to 2020.

Energy Efficiency

Energy efficiency has played little role in moderating electricity demand in Indonesia over the last decade. The IEA's New Policies Scenario projects a trebling in the rate of improvement in energy intensity to 2.3% pa through to 2035. Opportunities include a significant improvement in the thermal efficiency of coal use by phasing out or upgrading the existing low-efficiency subcritical coal-fired power plants from current levels of around 34% to upwards of 42% by 2035. Mandated energy management programs for major industrial users of electricity will provide a base framework for energy efficiency. The IEA also forecasts energy efficiency savings as a result of the increased urbanisation of the country and the increased use of appliance energy labeling and performance standards to. The IEA forecasts Indonesia's electricity growth moderates to a 4.2% CAGR over 2013-2035.^{ccix}

However, in the absence of strong current regulations and policy initiatives, IEEFA assumes this will only emerge a key priority post 2020.

Electrification and Reduced Energy Poverty

Distributed solar with storage is forecast to play an increased role in moderating grid reliance and solving the material energy access issues. PLN estimates that electrification rates will exceed 82% in 2014, but this still means 45 million Indonesians live without electricity. With a target of 97.8% electrification by 2022, this is a key government objective.

IEEFA forecasts additional distributed solar installs of 5GW by 2020, reducing grid electricity demand by 0.6% pa and providing a major solution to energy poverty across Indonesia.

Coal-Fired Generation is the Mainstay

The major Indonesian utility Negara forecasts domestic coal demand for power generation will rise to 151Mt by 2022, with 60GW of new coal-fired power plants in the pipeline. Negara's projections would see Indonesia's dependence on thermal coal as a power fuel source rise to 66% from 52% currently.^{ccx} This is predicated on electricity demand growing at some 8% pa. A Jun'2014 presentation by PLN forecast a lower but still substantial 38GW of additional coal-fired power generation capacity by 2022. PLN mapped out the location and development plans for much of this capacity, suggesting a major build-out is well underway. Given the availability and relatively low cost of domestic thermal coal in Indonesia (ignoring externalities), coal is expected to remain the mainstay of the Indonesian electricity sector for some time.

Geothermal Power

Indonesia has an installed geothermal base of 1.4GW at the start of 2014, and PLN forecasts 3.6GW of additional geothermal capacity will be brought on line by 2020.^{ccxi} Given the 200% uplift in capacity implied, IEEFA assumes some slippage on deployment timelines. IEEFA assumes 80% of this, or 2.9GW, of additional geothermal installs by 2020.

Hydroelectricity Power

Indonesia has an installed hydro base of 4.1GW at the start of 2014, and PLN forecasts 4.5GW of additional hydro capacity will be brought on line by 2020.^{ccxii} Again given the more than doubling in capacity implied, IEEFA assumes 20% slippage on deployment timelines given the limits imposed by the lack of a fully integrated electricity grid. This 3.6GW of additional capacity by 2020 adds 14TWh of additional electricity supply annually.

Gas-Fired Power Generation

Indonesia has an installed gas base of 15.7GW at the start of 2014, and PLN forecasts 8.4GW of additional gas capacity will be brought on line by 2020.^{ccxiii} IEEFA assumes 20% slippage on deployment timelines, implying 6.7GW of additional gas capacity by 2020.

Wind Power

Given no material penetration nor plans for wind power in Indonesia to-date, we assume that any deployment of wind will only occur post 2020. The expansion of the centralised electricity grid to join up the major island groups will certainly help prepare the Indonesian electricity grid to incorporate electricity from wind over the longer term.

Coal Demand in Indonesia Beyond 2020

IEEFA forecasts that Indonesia's domestic thermal coal demand will rise by a CAGR of 5.0% from 2013 to 91Mt in 2020. Beyond 2020, IEEFA forecasts that Indonesia's demand will slow to a CAGR growth of 3.6% through to a consumption level of 155Mtpa by 2035 as at some point distributed solar and onshore wind farm developments are accelerated post 2020.

3.12 Australia's coal demand

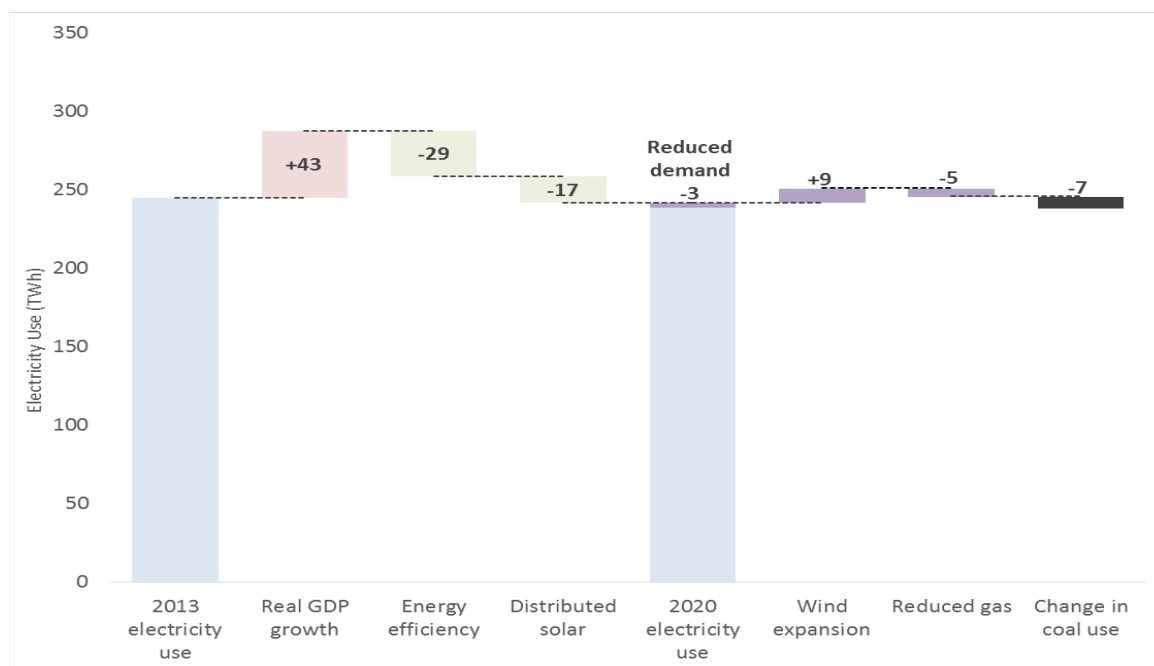
- IEEFA expects domestic demand for thermal coal in Australia to decrease over the short and long term.
- Between 2005-2014, Australia recorded a real reduction of 3.0% pa in electricity intensity relative to GDP, the second highest reduction of any major market behind only Japan.
- In the short term, decreased coal demand will be caused by falling demand for grid connected electricity, due to energy efficiency, distributed solar, the price elasticity of demand, more wind power and the progressive closure of Australia's aluminum industry.
- IEEFA forecasts that Australia's domestic thermal coal demand falls by a CAGR of 0.5% between 2013 and 2020, a total reduction of 7TWh. This will reduce coal demand from 57Mt in 2013 to 55Mt in 2020.
- IEEFA forecasts demand will continue to decline by a CAGR of negative 0.5% over 2020-2035. This will reduce coal demand to 51Mtpa by 2035.
- Despite wholesale power prices in Australia down at decade lows in 2014, the retail power price is at record highs, averaging A\$29c/kWh (US\$26c). This is in the top quartile of retail power prices globally. The normal economic theory of price-elasticity of demand is evident – the higher the government pushes up regulated prices, the more demand falls.
- High retail electricity prices combine with excellent solar radiation, plus low and flexible financing costs for capital improvements on residential housing (mortgage redraw facilities are common) and globally low solar installation costs of US\$2/kW. All of which means Australia has one of the highest penetrations of distributed rooftop solar globally.
- The antagonistic regulatory and utility positioning against retail customers means Australia is also likely to be one of the first markets where distributed solar with battery storage is commercially deployed on mass from 2018.
- Australia also has tremendous onshore wind resources. Despite the antagonistic policy position of the Australian government currently against wind, deployment of wind farms has and will continue to erode coal-fired power generation over the forecast period.

Figure 57 details our forecast for changes to the Australian electricity sector by 2020 relative to the 2013 base. Total electricity demand is forecast to continue declining gradually. This reflects 2.6% real GDP growth annually (which would add 43TWh of demand), less 1.8% pa lower electricity demand as a response to higher electricity prices, combined with energy efficiency savings (cutting demand an incremental 29TWh) such as the greater use of solar water heating, greater appliance performance labeling and home insulation standards, plus increased take-up of distributed solar.

Distributed rooftop solar take-up has been substantial over 2010-2014, and IEEFA forecasts that the commercial deployment of rooftop solar with battery storage from around 2018 will double the behind the meter self-generation by Australian residential and commercial consumers by 2020 (reducing demand 1% pa or a cumulative 17TWh by 2020).

New windfarms will continue to be installed, albeit at a slower rate than seen over 2009-2013 due to adverse government policy moves. We expect a net addition of 9TWh to be sourced from wind over 2013-2020. Incremental expansions of low carbon technology like Waste to Energy and end of the grid hybrid solar-gas are occurring, and will accelerate rapidly with any new policy support.^{CCXIV}

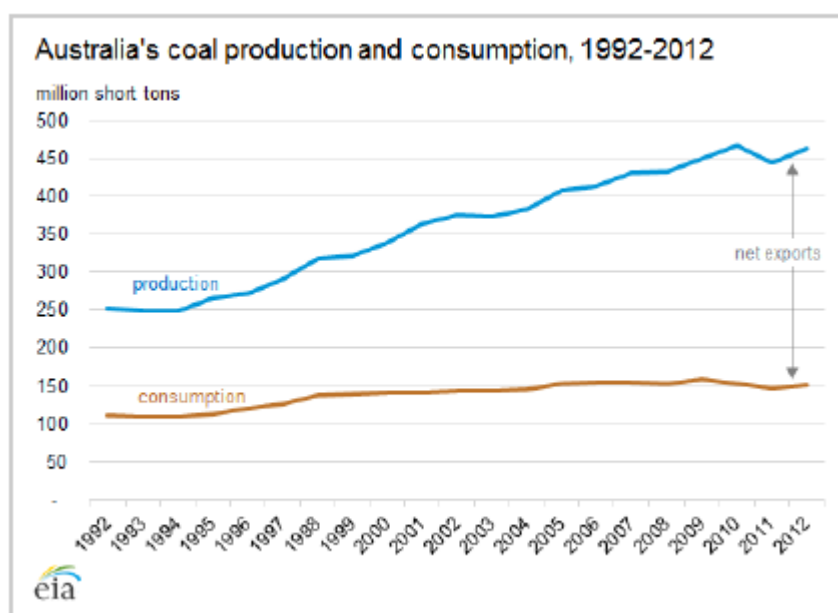
Figure 57: Australia's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

The Australian government decision to facilitate trebling Australian east coast gas production and move the market to export price parity saw wholesale natural gas prices treble into 2014. Having transitioned away from coal-fired power generation to gas over 2010-2013, much of this new gas-fired power generation has been financially stranded by higher gas prices and we see lower gas-fired power generation over the forecast period (-5TWh by 2020).

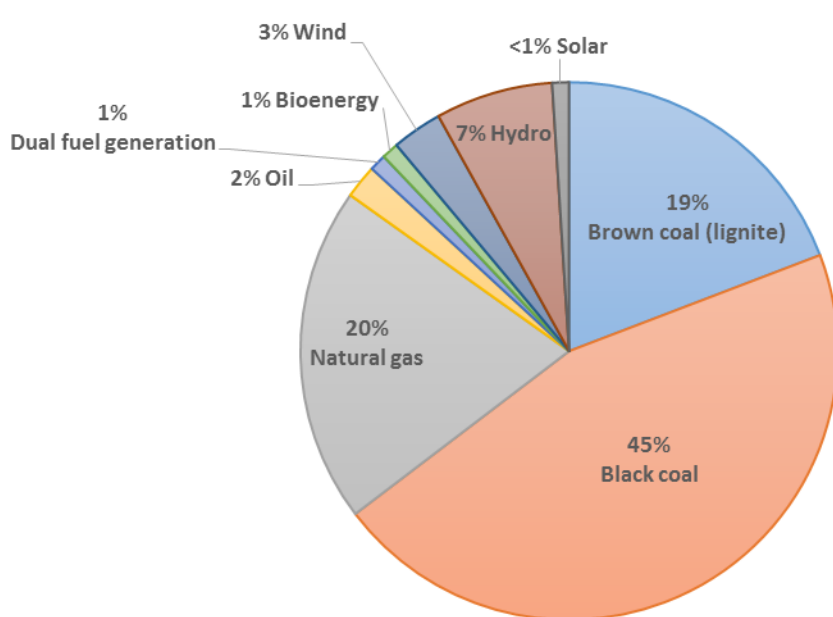
Figure 58: Australian Electricity Generation by Source, 2012/13



Source: US Energy Information Administration, Aug'2014^{CCXV}

Under current government policy initiatives, coal-fired power generation will remain steady and the mainstay of the Australian electricity sector, with domestic thermal coal use declining only marginally (7TWh) from current levels of 57Mtpa. In addition to thermal coal use, Australia remains one of the world's largest consumers of lignite coal and production is expected to remain at current levels of 73Mtpa –Figures 58 and 59.

Figure 59: Australian Electricity Generation by Source, 2012/13



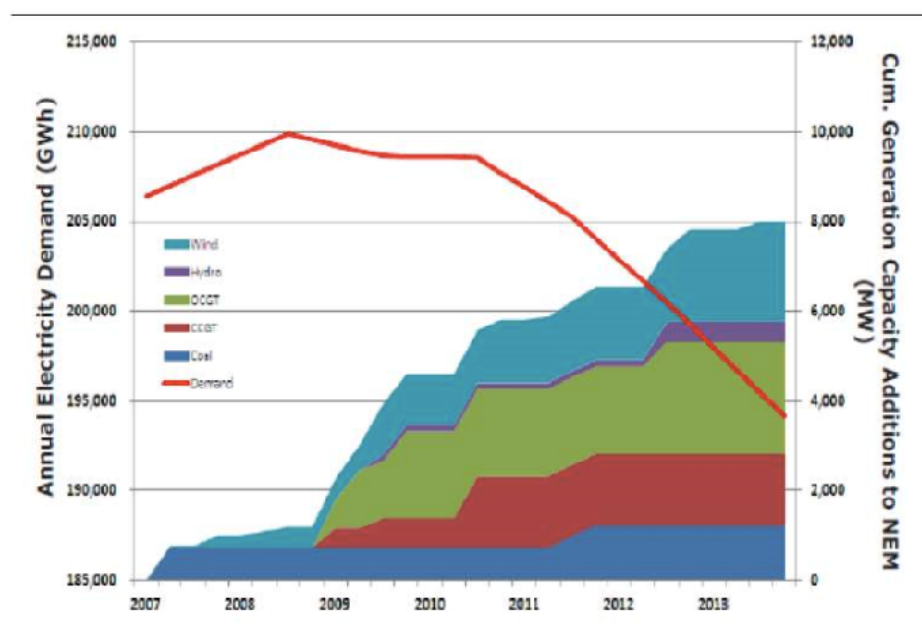
Source: EIA, Australian Bureau of Resources and Energy Economics

Australian Electricity Market Structure

With demand at 245TWh in 2013, this puts Australia as the 18th largest electricity market globally.

We have included Australia as a case study of how quickly a market can change, even without constructive policy settings. Two preconditions exist that have accelerated the transition of the Australian electricity sector are: i) close to world high peak power demand and prices; and ii) strong renewable resources. Once the right policy settings are implemented, the Australian electricity sector will transition very rapidly towards an inevitable low carbon future.^{CCXVI}

Figure 60: Generation Added vs Electricity Demand (NEM, 2007-2018)



Source: AEMO, Energy Australia^{ccxvii}

Australia has become a perfect lead market for the rise of distributed solar with storage, such that even with electricity demand falling for the last five years, it is inevitable that grid demand will continue to decline over the forecast period – refer Figure 60. The forecasts presented in Aug'2014 are from EnergyAustralia, one of the major electricity retailers and energy generators. Energy Australia is forecasting a continued decline, notwithstanding the repeal of the price on carbon pollution and the pending repeal of the Renewable Energy Target (RET).

Price Elasticity of Demand

High and rapidly increasing electricity prices have meant the end market for electricity has responded consistent with the expected 'price elasticity of demand', to the surprise of the Australian Energy Market Operator (AEMO) who has consistently forecast demand growth. With a CAGR for real GDP over 2005-2014 of 2.8%, electricity demand has declined 0.2%. This gives a real reduction of 3.0% pa in electricity intensity relative to GDP, the second highest reduction of any major market behind only Japan. This is not so much a function of increased energy efficiency as it is a response of reducing industrial and retail demand when retail electricity prices have increased by up to 20% pa.

The Australian market reflects an outcome of regulatory policies not responding to change. Where wholesale electricity prices are at a decade low of below US\$40/MWh, retail prices are at a record high of US\$260/MWh (US\$0.26/kWh). The wholesale price of energy makes up less than 20% of the retail price of electricity. Large investment in network infrastructure on the assumption of continued electricity demand growth has meant that network and other tax charges are now more than 70% of the retail price of electricity.

Distributed Solar

With retail electricity prices averaging A\$0.29/kWh (US\$26c) in 2014/15, distributed solar is competitive even with almost no subsidies even while for new systems where excess production is exported back into the grid with zero compensation from EnergyAustralia. Distributed solar is now in place on 1.2 million residential rooftops with a total capacity of 3.2GW. Distributed solar has recently started to expand into the industrial and commercial segments. Home energy management systems and battery storage solutions are likely to accelerate this trend post-2017. This could see total system installs double and the average size per installation double as well, such that distributed solar capacity installed could increase fourfold by 2020 to 12GW.

Stranded Assets

Australia continues to ignore the evidence presented by European utilities like RWE and E.ON over the last decade that has seen upwards of €500 billion of shareholder value destruction. The State governments have used the electricity sector as a source of excessive revenues for the last decade. The legacy is that Australia has some of the largest and worst polluting coal-fired power plants in the world. The New South Wales “privatisation” of their coal-fired power plants over 2014 has seen taxpayers suffer enormous financial losses, with the Government effectively giving AGL Energy the 2,000MW Liddell coal-fired power station for free in Aug’2014.^{ccxviii} The government earlier paid Origin Energy to take another power station to avoid the cost of massive site remediation and retrenchments.

Coal Demand in Australia Beyond 2020

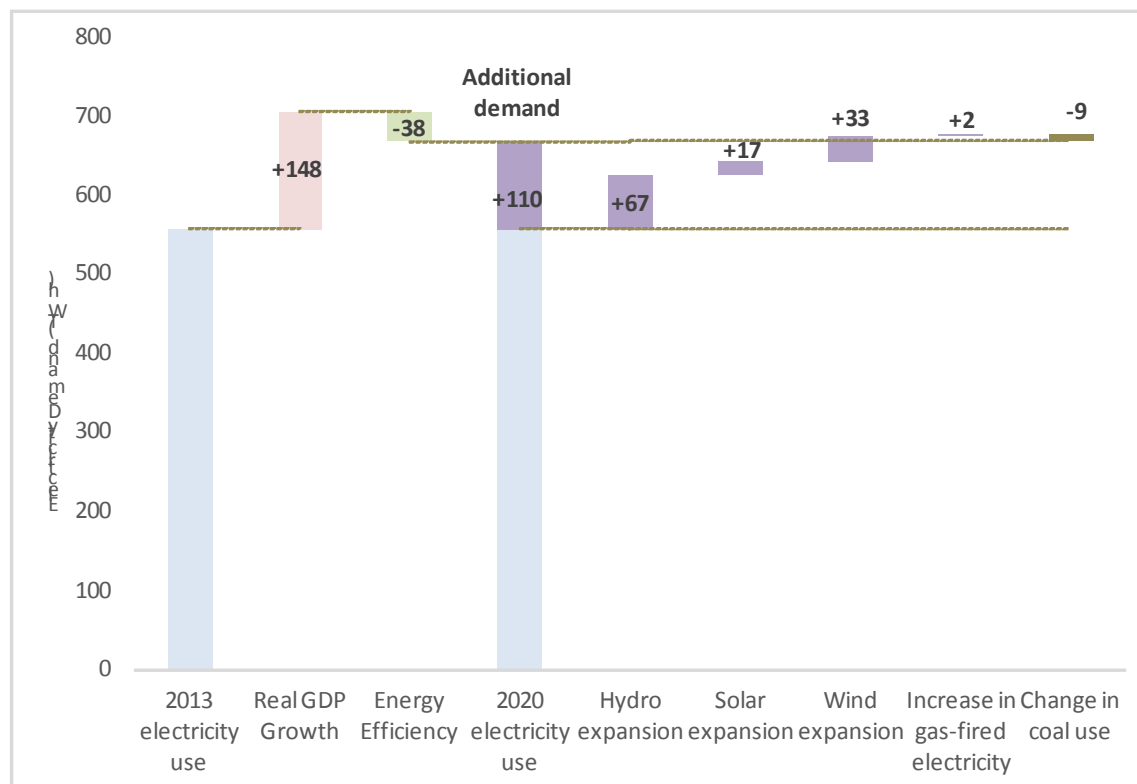
IEEFA forecasts that Australia’s domestic thermal coal demand falls by a CAGR of 0.5% between 2013 and 2020. This will reduce coal demand from 57Mt in 2013 to 55Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 0.5% over 2020-2035. Australia has high retail electricity prices relative to the OECD, such that at some point the Australian governments will progressively implement energy efficiency measures to rein in excessive electricity wastage or rooftop solar with storage will boom, driving down grid-based demand, leading to sustained falls in demand for coal. Australia also has an exceptional span of wind, solar and hydro resources, as well as significant geothermal and wave potential. As such, once we get a forward looking federal government we expect to see renewed expansion of renewables eroding coal-fired electricity generation. The various State governments of Australia are now questioning the logic of the Federal position, and the Victorian State election could be a turning point here. Key energy policy discussions relate to the closure of the archaic and highly polluting Anglesea power station and the reintroduction of the highly effective energy efficiency program that was closed for political expediency. The AEMO has acknowledged there remains 8GW of excess generating capacity in place as a result of falling demand, such that a progressive phase out of the aging lignite coal-fired power stations of Victoria are inevitable under any Australian energy policy that considers climate change real.

3.13 Brazil's coal demand

- Brazil has seen electricity growth of a 3.7% CAGR over 2000-2013, above real GDP growth of 3.3%. While this GDP growth is forecast to be sustained over the medium term, IEEFA expects energy efficiency to deliver a 1% annual improvement in electricity intensity of growth.
- Brazil is the 8th largest electricity market globally. With renewable energy providing 96% of Brazil's electricity, this illustrates how an electricity system is quite capable of developing without a reliance on coal, should sufficient renewable energy resources be available.
- Imported coal provides only 4% of Brazil's electricity needs. IEEFA forecasts a declining share for coal-fired power generation over the forecast period.
- IEEFA forecasts a major expansion of Brazil's installed base in both wind and solar over the forecast period, providing much needed energy system diversity. The Brazilian Energy Research Agency plans to add 17GW of wind this decade.

Figure 61 details our forecast for changes to the Brazil electricity sector by 2020 relative to the 2013 base. We explore this in more detail below.

Figure 61: Brazil's Electricity Market – Production Waterfall (2013-2020, TWh)



Source: IEEFA 2014 analysis

In summary, the IMF forecasts 3.6% pa real GDP growth for Brazil over the 2013-2020 period, expanding electricity demand by 148TWh. Energy efficiency is forecast to reduce electricity demand by 1% pa, resulting in a cumulative reduction in electricity demand of 38TWh by 2020 relative to

2013. Expanded large scale hydro electricity capacity is forecast to add 57TWh with an additional small scale run-of-river hydro adding another 10TWh of production by 2020. Brazil has seen a major investment in wind farms, and we expect an additional 32TWh of wind-generation. Solar capacity is forecast to see a step change from zero installed capacity to 8GW by 2020, adding 17TWh by 2020.

The combined impact is sufficient to underpin the economic growth of Brazil without any additional coal-fired power generation capacity. Brazil's thermal coal imports are forecast to fall marginally from the current level of 11Mtpa over the forecast period.

Current Electricity Market Structure

With a 2013 consumption of 557TWh, Brazil is the 8th largest electricity market in the world. Hydro provides 70-80% of total electricity generation, with wind producing 3%. Gas imports sourced from Bolivia fuel gas-fired generation as the main thermal capacity, with coal-fired power generation estimated to provide only 4% of Brazil's total. Electricity imports represent the balance.

Strong Economic Growth and a Limited Focus on Energy Efficiency

Brazil has seen electricity demand grow at a CAGR over 2000-2013 of 3.7% on the back of 3.3% real GDP growth over this period. Whilst the IMF forecasts 3.6% real GDP growth over 2011-2020, we expect a step-up in the application of energy efficiency initiatives, with electricity growth forecast at 1% below real GDP over the forecast period.

Renewable Energy – Hydro electricity

Brazil currently operates 82GW of hydro electricity capacity, with another 2GW of small scale run-of-river capacity. An additional 18GW of hydro capacity is proposed or already under construction, including the enormous 11.2GW Belo Monte dam. We assume 60% of this is commissioned by 2020. Combined with another 3GW of small scale hydro, this would add a combined 67TWh of annual electricity generation to the Brazilian system.

This has created a major energy security issue as a result of the lack of energy system diversity, and this has been particularly evident over the last decade with a series of drought years. As a result, the Brazilian government has provided a significant inducement for the development of alternative renewable energy sources. As Rob Grant, CEO of Pacific Hydro states about the opportunities for Brazil: "It is so big and it is really the homeland of renewable energy in the world in many respects. It is just integrated into their DNA, mainly because of the very large hydro history they have (Wind) is very complementary for their hydro system as well."^{CCXIX}

Renewable Energy – Wind

Brazil has an enormous wind generation capacity potential, and since 2010 Brazil has installed an average 0.7GW pa of new wind farms. Brazil currently has an existing pipeline of contracted wind projects of over 10 GW, contracted at world competitive rates of US\$50-60/MWh.^{CCXX} This reflects the exceptionally strong forecast operating rates of 35-45%, a government tender process that provides 20 year power purchase agreements and the provision of very low cost, long term project financing from the Brazilian Development Bank, BNDES. A new tender round is scheduled for Oct'2014, and over 17GW of new wind projects have been submitted for consideration.^{CCXXI}

The Brazilian Energy Research Agency plans to add 17GW of wind this decade to reach an installed wind capacity of 22GW by 2023, aiming to lift wind's share from 3% currently to 11.5% by 2023.^{ccxxii}

Renewable Energy – Solar

With such aggressive plans for the expansion of the onshore wind sector in Brazil, based on power purchase agreements that over 2011-2013 set records for the lowest wind costs globally (since beaten by PPAs in Texas as low as US\$30/MWH in 2014), the Brazilian government has held back on encouraging the development of the solar sector. However, the Sept'2014 electricity tender saw the submission of over 6.3GW of solar project proposals for consideration. In the interests of energy security through greater energy system diversity, we expect Brazil to award a significant number of solar projects in late 2014 and then step up Brazil's installation rate rapidly. Brazil expects to contract 3.5 GWs of solar power between 2014 and 2023, taking solar to 1.8% of the total system.^{ccxxiii}

High solar radiation and strong electricity sector demand growth underpins the need for significant solar investment. IEEFA forecasts an installed capacity of a cumulative 8GW by 2020, with a rapid escalation thereafter, particularly in distributed roof-top solar with storage.

Brazil's development bank BNDES is seeking to create a supply chain for solar manufacturing, just as it did for wind turbines in 2012. BNDES provides significant low cost project debt funding for projects utilising at least a minimum specified local content. The rules from BNDES and the country's Energy Research Agency have two phases. In the first phase, which runs through 2017, developers must use solar panels with locally produced frames and some electronic components. From 2018 through 2020, additional parts of the systems must be manufactured in Brazil.

Coal Demand in Brazil Beyond 2020

IEEFA forecasts that Brazil's domestic thermal coal demand falls by a CAGR of 1.0% from 2013 to 10Mt in 2020. Beyond 2020, IEEFA forecasts demand will continue to decline by a CAGR of negative 1.0% over 2020-2035 as energy efficiency initiatives and increased deployment of solar and wind more than offset real GDP growth.

Appendix A: Air pollution and coal combustion

The introduction of pollutants, such as particulate matter and biological molecules, into the atmosphere is harmful to both human health and the environment. A 2014 report from the World Health Organisation (WHO) estimates that in 2012, over seven million people died as a result of exposure to air pollution.⁸ Coal combustion is one of the most significant contributors to the release of hazardous air pollutants.

Human health implications of coal burning

A number of potentially hazardous pollutants are released when burning coal. Those most potent pollutants include sulphur dioxide (SO₂), nitrogen oxides (NO_x), particulate matter (PM), volatile organic compounds (VOCs), carbon dioxide (CO₂) and mercury.

Each hazardous pollutant released during coal combustion can have different implications for the health of humans and the environment, which will now be assessed.

Particulate matter

Particulate matter affects the health of more people than any other pollutant. Especially damaging are those particulates with a diameter of 10 microns or less, namely PM₁₀ and especially PM_{2.5} (those of 2.5 microns in diameter or less). These particulates are small enough to penetrate and lodge deep inside the lungs causing cardiovascular and respiratory diseases as well as lung cancer.

PM_{2.5} and PM₁₀ can be released directly from the smokestacks of coal-fired power plants (direct sources), but a larger proportion is supplied from secondary sources, in particular when SO₂, NO_x, ammonia or VOCs chemically react to create PM. For example, in China it is estimated that 55% of total PM_{2.5} is from secondary sources. Consequently, SO₂ and NO_x emissions are more hazardous than their direct impact alone suggests.

In many developing cities, 70µg/m³ is common, with some provinces in China reaching an average over 120µg/m³ in 2013. The WHO guidelines state that an annual mean of 10µg/m³ and 20µg/m³ for PM_{2.5} and PM₁₀ is a safe level. Exceeding this limit so drastically suggests huge ramifications for human health, which itself will incur significant economic costs that can be directly linked back to coal burning. The US EPA have estimated the cost savings due to Clean Air Act by avoiding the health implications of PM_{2.5} and ozone only – from 1990 to 2010 it is believed to be approximately \$12trn, from 2010 to 2020 this regulation is expected to add a further \$2trn in savings – refer Figure A-1.

⁸ <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

Figure A-1: Estimated benefits (\$) from the US EPA Clean Air Act⁹

Avoided Health Impacts (PM2.5 & Ozone Only)*	Pollutants	Year 2010	Year 2020	Estimated Cumulative Benefits 2010-2020 (NRDC)**
PM 2.5 Adult Mortality	PM	160,000	230,000	2,145,000
PM 2.5 Infant Mortality	PM	230	280	2,805
Ozone Mortality	Ozone	4,300	7,100	62,700
Chronic Bronchitis	PM	54,000	75,000	709,500
Acute Bronchitis	PM	130,000	180,000	1,705,000
Acute Myocardial Infarction	PM	130,000	200,000	1,815,000
Asthma Exacerbation	PM	1,700,000	2,400,000	22,550,000
Hospital Admissions	PM, Ozone	86,000	135,000	1,215,500
Emergency Room Visits	PM, Ozone	86,000	120,000	1,133,000
Restricted Activity Days	PM, Ozone	84,000,000	110,000,000	1,067,000,000
School Loss Days	Ozone	3,200,000	5,400,000	47,300,000
Lost Work Days	PM	13,000,000	17,000,000	165,000,000

Source: US EPA, 2011

Sulphur dioxide and nitrogen oxides

SO₂ can affect the respiratory system and the functioning of the lungs. The WHO recently lowered their guidelines from exposure to SO₂ from 125µg/m³ to 20µg/m³ as it was found that the health effects of SO₂ are more severe than previously thought. NO_x are also linked with reduced lung functioning.

Low level ozone

Low level ozone is not formed directly from coal burning, but as the result of a chemical reaction of sunlight and air containing NO_x and VOCs. Low level ozone is one of the primary ingredients of smog, a serious cause of respiratory illness in humans.

Mercury

Mercury exposure at high levels can harm the brain, heart, kidneys, lungs and immune systems of humans.

Figure A-2 summarises all the adverse impacts on human health from pollutants emitted in coal combustion.

⁹ http://www.eenews.net/assets/2011/03/01/document_gw_03.pdf

Figure A-2: Coal's contribution to major health effects^{CCXXIV}

	Disease or condition	Symptom or result	Coal pollutants implicated
RESPIRATORY	Asthma exacerbations	Coughing, wheezing, shortness of breath, and breathlessness with a range of severity from mild to requiring hospitalization	NO ₂ Ozone Particulate Matter
	Asthma development	New cases of asthma, resulting in coughing, wheezing, shortness of breath, and breathlessness with a range of severity from mild to requiring hospitalization	Suspected but not confirmed: NO ₂ , Ozone, Particulate Matter
	Chronic Obstructive Pulmonary Disease (COPD)	Emphysema with chronic obstructive bronchitis; permanent narrowing of airways; breathlessness; chronic cough	NO ₂ PM
	Stunted lung development	Reductions in lung capacity; risk factor for Development of asthma and other respiratory diseases	NO ₂ PM
	Infant mortality	Death among infants age < 1 year	NO ₂ PM
	Lung cancer	Shortness of breath, wheezing, chronic cough, coughing up blood, pain, weight loss	PM
CARDIOVASCULAR	Cardiac arrhythmias	Abnormal rate or rhythm of the heart' palpitation or fluttering; may cause fatigue, dizziness, lightheadedness, fainting, rapid heartbeat, shortness of breath and chest pain	NO ₂ PM
	Acute myocardial infarction	Chest pain or discomfort; heart attack	PM2.5
	Congestive heart failure	Shortness of breath, fatigue, edema (swelling) due to impaired ability of heart to pump blood; can result from narrowed arteries, past heart attack, and high blood pressure; can lead to death	PM2.5
NEUROLOGICAL	Ischemic stroke	Artery supplying blood to the brain becomes blocked due to blood clot or narrowing; ⁶² may cause sudden numbness or weakness, especially on one side of body, confusion, trouble speaking, trouble seeing, trouble walking, dizziness, severe headache; ⁶³ effects can be transitory or persistent	NO ₂ PM2.5 PM10 SO ₂
	Developmental delay	Reduced IQ; mental retardation; clinical impairment on neurodevelopmental scales; permanent loss of intelligence	Mercury

Source: Physicians for Social Responsibility, 2009

How much does coal combustion emit?

How much coal burning specifically contributes to the global pool of each pollutant is highly difficult to determine due to variations in the polluting content of coal types, regional differences in the volume of each coal type consumed and the kinetic, amorphous nature of the global atmosphere making it very difficult to attribute pollutants to places. Estimates have been made at national levels, however.

The US EPA estimates coal burning contributes 87% of utility related NO_x and 94% of utility related SO₂, equivalent to approximately 63% of total SO₂ production in the US.¹⁰ Similarly, in China estimates suggest coal burning is the source of up to 60% of particulate matter and 80% of SO₂ emissions in some areas.

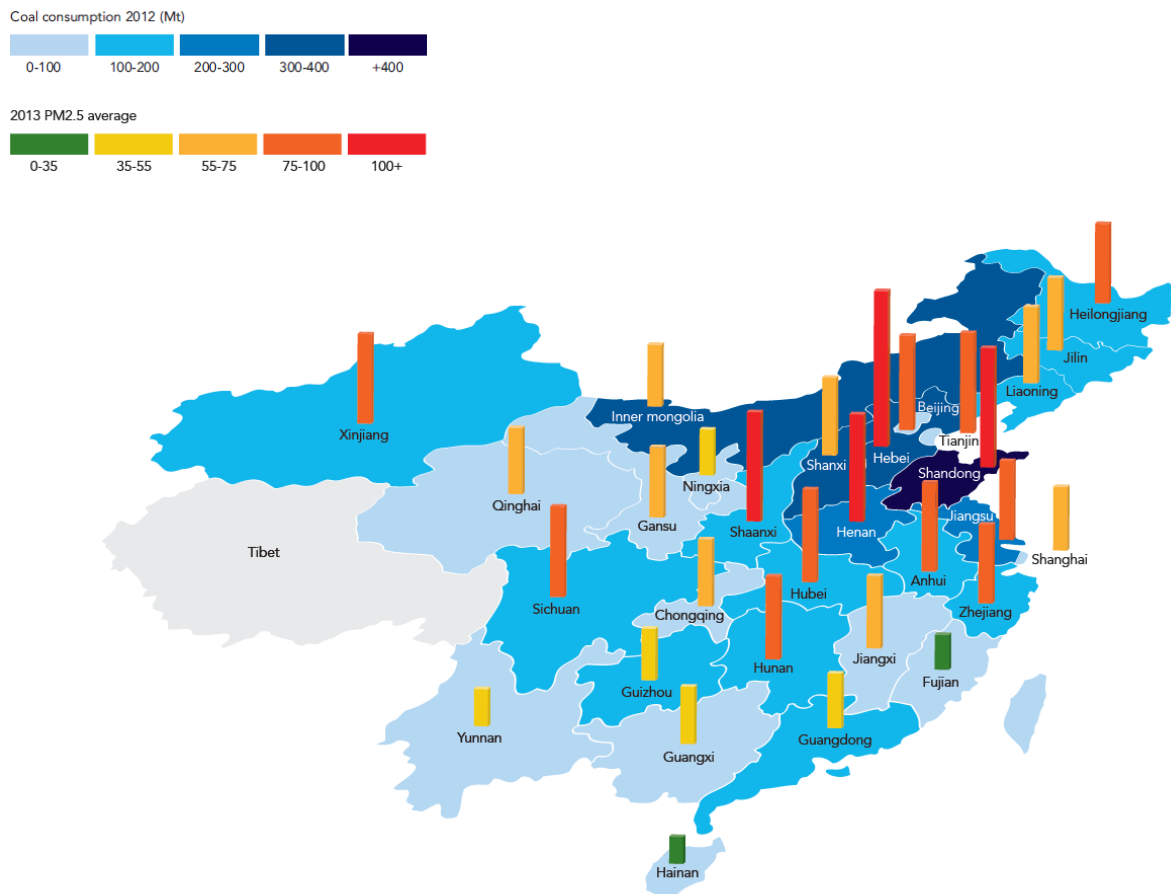
CASE STUDY: China's 'airpocalypse' and coal

It is no coincidence that China has the highest level of coal consumption and the highest density of regions approaching hazardous PM_{2.5} levels of 80µg/m³ of any single nation and, as such, will be examined in more detail.

In mid-January 2013, the air quality reading in Shijiazhuang City in Hebei province exceeded 1,000µg/m³, literally off the chart with most measuring devices only recording up to 755µg/m³ and far in excess of the WHO's 10µg/m³ recommended level. Deutsche Bank have estimated that 45% of the PM_{2.5} in Chinese cities derives from coal burning and its secondary sulphates and nitrates, by far the most of any single sector. Figure 1 further establishes a close relationship between high coal consuming provinces and high PM_{2.5} levels, whilst also emphasising the fact that only two Chinese provinces met the WHO's least stringent recommendation for PM_{2.5} levels of 35µg/m³.

¹⁰ <http://www.epa.gov/air/airtrends/aqtrnd03/>

Figure A-3: Average PM2.5 readings of the most polluted city in each province in 2013 against coal consumption in 2012



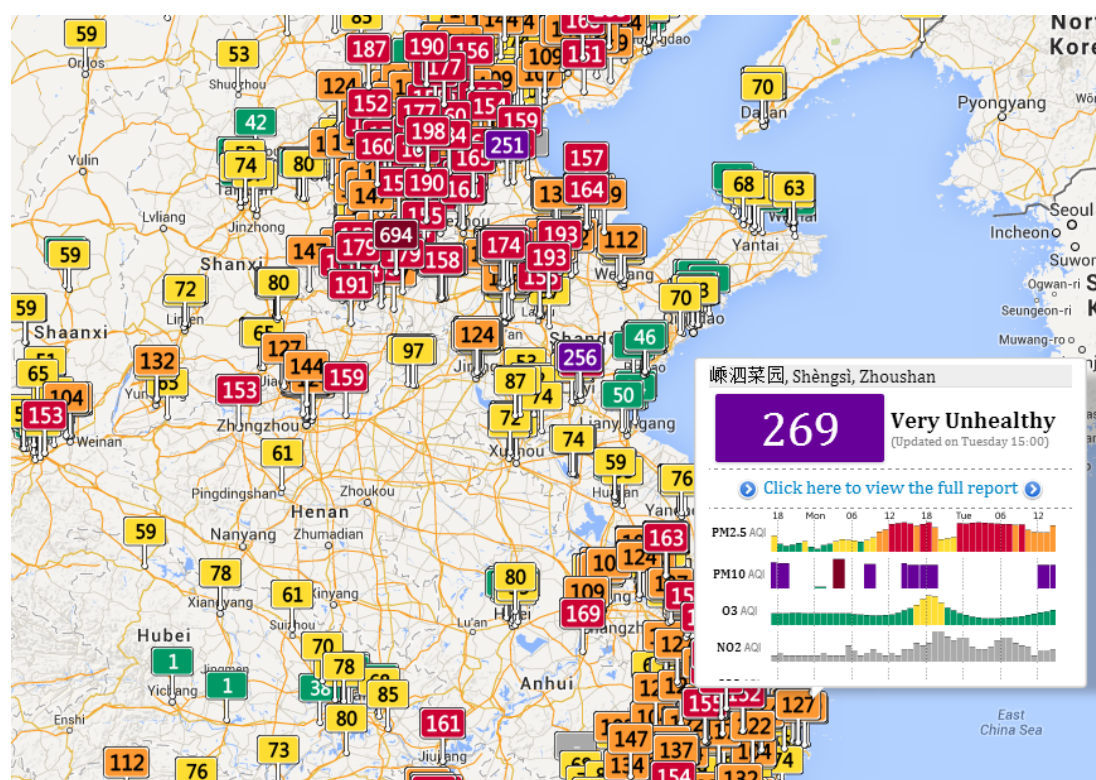
Source: China Year Book 2013

This dangerous level of air pollution has been compared to a ‘nuclear winter’ and deemed by the Shanghai Academy of Social Sciences as ‘uninhabitable for human beings’.¹¹ These air pollution crises have created an almost unprecedented level of public discontent towards the central government that shows few signs of waning until the issue is resolved.

Air pollution has become a political issue facilitated to a great extent by a vast increase in the volume and transparency of air quality information flows. The most popular mobile phone application in China is now an air quality meter allowing P2.5 readings, and other pollutants, to be obtained real-time at any moment. The same information is available globally on the internet, with Figure A-4 an example snapshot of coal consuming eastern provinces on September 2nd 2014. Detailed and readily available data like this has increased accountability on China’s central government and coal sector hugely.

¹¹ <http://www.theguardian.com/world/2014/feb/25/china-toxic-air-pollution-nuclear-winter-scientists>

Figure A-4: Air quality readings in eastern China 02/09/2014¹²



Consequently, the government has had no choice but to take action to fight air pollution. The Action Plan for Air Pollution Prevention and Control outlined a provincial level roadmap of pollution control targets that aims to reduce air pollution towards the National Ambient Air Quality Standard of $35\mu\text{g}/\text{m}^3$ by 2030.

This included targets to reduce PM2.5 by 20% across three key regions by 2017 – the Beijing-Tianjin-Hebei area, the Yangtze River Delta (Shanghai, Jiangsu and Zhejiang provinces) and the Pearl River Delta (Guangdong province) with the remaining provinces expected to reduce PM10 by at least 10% on 2012 levels.

Citi describe the air pollution issue as ‘the key driving force’ behind their prediction coal consumption will peak in China before 2020.¹³ Signs of the impact air pollution will have on coal consumption have begun to emerge. These three targeted regions, along with the Shandong, Chongqing and Shaanxi provinces, have specified coal consumption reduction targets as the primary method to meet these PM2.5 targets. Meeting these coal caps is estimated to result in a 10% reduction in coal demand across these provinces on 2012 consumption levels.

¹² <http://aqicn.org/map/china/>

¹³ Citi, 2013, The unimaginable: Peak coal in China

However, more drastic actions will need to take place if China is to meet the national target of PM_{2.5} at 35µg/m³ by 2030 – Tsinghua University research demonstrates that current measures will miss the target deadline.¹⁴ Consequently, downward pressures on China's coal sector are far from over. For example, Deutsche Bank have hypothesised a policy package to reduce average PM_{2.5} to 30µg/m³ by 2030. This scenario requires coal consumption to peak in 2016 and fall thereafter, equivalent to an absolute reduction of 22% from 2017-2030, whilst achieving 42% savings from energy efficiency measures.¹⁵

Environmental implications of coal burning

Climate change

The release of CO₂ from coal combustion presents one of the main drivers of the heating up of the Earth's climate and the risks this poses to the functioning of all aspects of human and environmental life. In their latest report, the thousands of scientists comprising the Intergovernmental Panel on Climate Change (IPCC) found that without additional efforts to reduce greenhouse gas emissions, of which CO₂ accounts for 76%, global mean surface temperature will increase by 3.7C-4.8C by 2100 compared to pre-industrial levels.¹⁶

In 2010 (the most recent year data available) the power and heat sector was responsible for 35% of total greenhouse gases, the most of any single sector. Again CO₂ was the most prominent GHG. The IEA estimate coal burning is the single largest source of these power and heat related emissions accounting for 44% of the total.

The role of emissions from coal combustion is complicated somewhat however, due to the secondary formation of aerosols – small particles formed through gas-to-particle conversion in the atmosphere. This conversion is largely driven by sulphur dioxide (and the resulting sulphuric acid) and ammonia, the stock of which are both contributed to by coal combustion. Aerosols impact our climate in two ways; directly by increasing the earth's albedo effect and reflecting sunlight back into space, and indirectly by modifying the size of cloud particles, thus changing how clouds reflect and absorb sunlight.

While the extent of the cooling from aerosols is still somewhat uncertain, the body of research on this topic is growing and the IPCC in their latest report were able to quantify that, while human aerosol emissions offset about one-third of the warming from human GHG emissions, human activity led by coal burning, remains the main cause of climate change over the past 60 years.¹⁷

¹⁴ Bernstein Research presentation, March 2014, Less, less, less... The beginning of the end of coal

¹⁵ Deutsche Bank, 2013, Big bang measures to fight air pollution (2nd edition)

¹⁶ http://report.mitigation2014.org/spm/ipcc_wg3_ar5_summary-for-policymakers_approved.pdf

¹⁷ <http://www.theguardian.com/environment/climate-consensus-97-per-cent/2013/sep/27/global-warming-ipcc-report-humans>

Climate change and health impacts

By furthering climate change, coal burning has impacts on human health additional to those highlighted above. Research by Kofi Annan's thinktank, Global Humanitarian Forum, estimate that climate change currently causes 300,000 deaths each year.¹⁸ Further studies have estimated that deaths due to climate change could total 100m by 2030 if government's fail to act.¹⁹

Aside from climate change, the CO₂ itself emitted during coal combustion is claimed to exacerbate the health-damaging impacts of air pollution. Research by Stanford University reveals that 'domes' created by higher levels of CO₂ concentrations can form above urban areas and cities which increase local temperatures. In doing so, higher levels of water vapour are created which increases the rate of chemical air pollution production such as ozone and particulate matter²⁰ – the ill-effects of which have already been displayed.

Acid rain and the contamination of ecosystems

Acid rain is caused when SO₂ and NO_x react with water molecules in the air to produce acids. Acid rain can lead to the contamination of forests, freshwaters and soils and those systems that rely on these ecosystems. In China, a country of high coal consumption currently, approximately 30% of the country now received acid rainfall.

¹⁸ <http://www.theguardian.com/environment/2009/may/29/1>

¹⁹ http://www.huffingtonpost.com/2012/09/26/climate-change-deaths_n_1915365.html

²⁰ <http://web.stanford.edu/group/efmh/jacobson/Articles/V/CO2loc0709EST.pdf>

Appendix B: Water use in coal burning

Water use in the extraction and consumption of coal is typically referred to through two classifications. Firstly, **withdrawals** refer to water resources extracted from the ground or surface-level water bodies before being discharged back into the environment. Alternatively, water can be **consumed** such that it is removed from the immediate water environment. In both cases, water availability is essential to the ongoing process of burning coal for power.

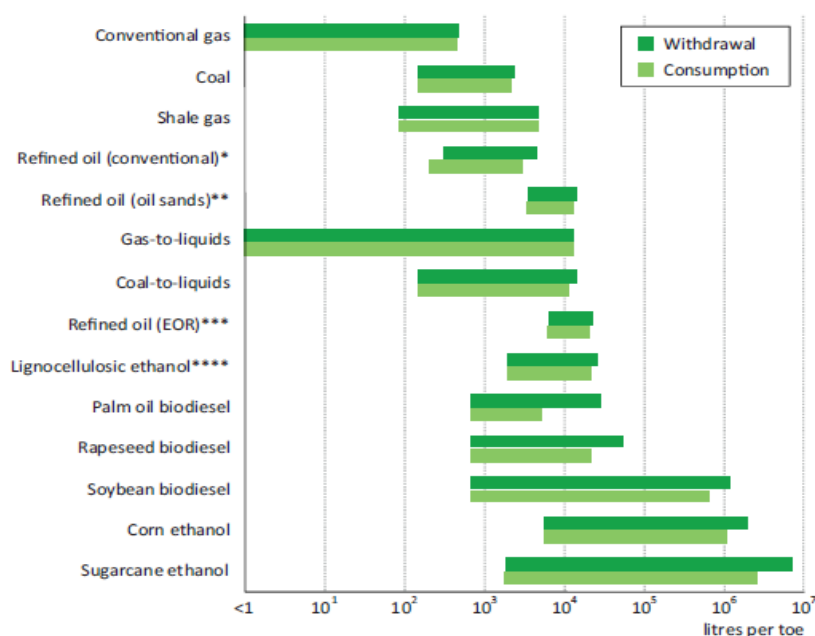
Primary coal production: Extraction, processing and transportation

In coal production, water is predominantly used for: i) cooling equipment; ii) dust suppression in mining and hauling; iii) washing tunnels; and iv) extinguishing fires. The amount of water needed depends on the characteristics of the mine, i.e. whether it is at the surface or underground.

Water is then used to varying degrees in the processing of coal, such as cutting and particularly in coal washing. Coal washing reduces the levels of ash and sulphur in the coal, improving its energy content before being burned, reducing desulphurisation costs and reducing its weight making transportation cheaper. Washing is presently undertaken mostly for export-quality grades of coal, but given the scope for washed coal burning to raise power plant efficiency, the practice could become more widespread, such as in India warn the IEA.

Finally, water can sometimes be required to transport coal by the slurry pipeline method, which involves pumping water with finely ground coal to its destination. Figure B-1 compares estimates for water use across these stages of primary energy production by fuel type.

Figure B-1: Minimum and maximum estimates for water use for primary energy production ^{CCXXV}



Source: IEA 2012

In terms of maximum potential water consumption during primary production processes, coal is the second most water-efficient fuel type detailed in Figure 1, but coal is many multiples more water intensive than renewable energy technologies – referred to in Table 1 below. Furthermore, the minimum-maximum ranges in Figure 1 are large, meaning significant uncertainty surrounds coal’s position compared to other fuel types. Illustratively, if coal mining in a particular location is at the maximum of the water use range and all other energy sources achieve their minimum water use, coal would be the 11th most efficient out of the 14 included.

Compared to its most competitive substitutes, Figure B-1 suggests coal is more water intensive than conventional gas and approximately equal with shale gas in terms of their median values.

Water use in coal power generation

Thermal coal power plants’ water consumption is determined in part by the plant’s efficiency, access to alternative heat sinks such as the atmosphere, and particularly, the cooling system employed.

There are three types of cooling systems that thermal power plants can employ, which have very different implications for the levels of water withdrawal and consumption.

- **Open-loop or once-through:** Water is withdrawn from a source, circulated to absorb heat and returned to the surface water body.
- **Tower, closed-loop or recirculating:** Water is withdrawn and recycled through the power system rather than discharged.
- **Dry cooling:** Uses air flows to remove heat, using no water. Can affect power plant performance, however, reducing average power generation by about 2-7% and raising the capital costs on installation.

Figure B-2: Median water withdrawal and consumption values by type and system^{ccxxvi}

Fuel	Cooling type	Median withdrawal (m ³ /MWh)	Median consumption (m ³ /MWh)
Coal	Once-through	85.5	0.4
Coal w/CCS	Tower (recirculating)	2.3	1.9
	Tower	4.3	3.2
Nuclear	Once-through	167.9	1.0
	Tower	4.2	2.5
Natural gas	Once-through	43.1	0.4
	Tower	1.0	0.7
Solar photovoltaic	n/a	0.1	0.1
Wind	n/a	0.0	0.0

Figure B-2 reveals that once-through cooling systems in coal-burning are a hugely water-intensive process, particularly with regards to the supply needed for withdrawal where the water required is 40 times higher than if tower cooling was used.

This makes coal-fired power facilities implementing this cooling system more vulnerable (as well as a major cause of) droughts and indirect changes in water resources. In turn, water scarcity poses reliability risks for coal-fired plants and can ‘influence the generation mix and [coal-fired] generating

costs', note the IEA.^{ccxxvii} For many countries, much of the coal-fired power generation capacity is located in water scarce regions. For example, HSBC found that in China, where a vast proportion of future coal demand is being forecasted, the majority of China's coal power generating centres are in the water-scarce north-east such that 30% of its coal consumption is located in provinces possessing only 5% of the nation's water.^{ccxxviii}

As well as being at risk to the physical constraints of water availability, coal-fired power plants that use once-through cooling systems are also exposed to potential water quality regulatory risk. Once water has been passed through a steam condenser it is returned to a nearby water body at a higher temperature than when sourced. This can be detrimental to aquatic life and nearby ecosystems. This has led to the implementation of increasingly stringent permitting requirements for these systems causing existing units to be gradually phased out, such as in the US.

Coal-burning requires approximately double the water supply than natural gas when using the once-through cooling system. Coal is far more competitive with natural gas in terms of water consumed (rather than withdrawn), but these volumes are negligible relative to those required for withdrawal supply such that the this decreased disadvantage does little to offset its exposure to water supply risks.

Table 1 also reveals that coal plants fitted with carbon capture and storage (CCS) require additional water than those without. This is to meet the higher cooling needs associated with reduced power plant efficiency and greater heat generation. This higher level of water stress on the surrounding resources must be factored in to CCS investment decisions.

Water consumption to grow significantly

Global water withdrawals for energy production were estimated in the IEA's World Energy Outlook 2012 at 583 billion cubic metres (bcm) in 2010.^{ccxxix} In the New Policies Scenario, global energy demand increases at 1.2% per year leading to withdrawals of water for energy production rising by 20% in 2035. However, withdrawals by coal-fired power plants globally decrease by 10% over this period. This is due to a reduction of power generation by subcritical coal plants using once-through cooling systems, particularly in the US, China and EU.

By 2035, water consumed in energy production is forecast by the IEA to increase 85% from the 66bcm consumed in 2010. Water consumed by coal-fired power plants increases over this period from approximately 38bcm to 48bcm, although the rate of growth slows between 2020 and 2035. This is a result of an increased proportion of supply coming from higher efficiency coal-fired power plants with more advanced cooling systems that increase water consumption per unit of electricity.

More water being consumed by energy production, and coal-fired power generation in particular, will serve to exacerbate the huge geographical variability in water availability that poses operational, financial and regulatory risks to the coal mining and coal-fired power generation industry – water resources are not distributed in proportion with coal mining and consumption activity. Consequently, the IEA warn that water scarcity could become a serious issue for coal power generation, particularly in China, the US and India, which will require 'deployment of better technology and greater integration of energy and water policies'.^{ccxxx}

Appendix C: US EPA Rules

The Clean Power Plan

Under President Obama's direction, the EPA in June 2014 proposed a raft of measures to achieve a combined 30% reduction in carbon emissions across America by 2030 from 2005 levels.^{ccxxxix} This equates to a 19% reduction by 2030 on 2012 levels. The plan impacts existing power plants, building on the MATS clean air regulations. A key recognition by the EPA is that the health benefits alone outweigh the costs of this proposal by a factor of 700%. President Obama expects health and climate benefits combined to total US\$55-93 billion in 2030.^{ccxxxix}

The EPA models "electricity bills down 8% in 2030". This is entirely consistent with our premise that renewables will exert a major deflationary impact on energy markets over time. In IEEFA's view, the combined impact of renewables and energy efficiency will be substantially greater than the 8% deflationary impact modelled by the EPA.

UBS Research^{ccxxxix} summarises the key impacts as being:

1. Coal-to-Gas switching, with the assumed rate of gas-generators forecast to rise from 40-50% currently to 70%, and an added incentive to build new gas generation capacity;
2. Maintain renewable energy installs, particularly post 2020 as the rules 'commit' states to follow through on their own RPS commitments;
3. Increased thermal heat rate efficiency of existing coal and gas-fired power generation by 6%;
4. A greater focus on energy efficiency improvements and demand response management.
5. Nuclear electricity generation policy remains very supportive, with an expectation of extending the useful life of existing facilities; and
6. Reduce the risk of stranded assets by giving flexibility and time to implement.

Mercury and Air Toxics Rule (MATS)

The introduction of MATS from 2015 combines with a number of other regulatory pressures and a significantly aging coal-fired power plant fleet to see a significant number of coal-fired power plants slated for closure over the 2015-2018 period. Estimates vary from 50-100GW.^{ccxxxix} Beyond this period, further closures are still expected, with additional costs and controls resulting from the natural Ambient air quality standards, including the soon to be revised Ozone Standard and the expected EPA rule to replace the CSAPR.

Bill Bumpers, an Environmental Partner of Baker Potts predicts: *"If we look forward through 2025, there is another significant block of gigawatts of coal fired power plants that won't survive beyond 2025."*^{ccxxxix}

Cross-State Air Pollution Rule (CSAPR)

The CSAPR replaces the old **Clean Air Interstate Rule**. CSAPR applies to 27 states, mostly in the eastern half of the US Issued in July 2011, the rule is designed to curb power plant emissions of nitrogen oxide and sulfur dioxide that degrade air quality in downwind states and impede the ability of those states to meet standards set for fine particulate matter (soot) and ground-level ozone (smog). The rule uses a cap-and-trade approach to emissions and creates four emissions trading

programs. Phase one limits would apply in 2015 and 2016, while phase two budgets would apply in 2017 and beyond.^{CCXXXVI}

Coal Ash Regulations

The US is reviewing coal ash regulations in light of several severe environmental disasters. This will result in an increased capital and operating cost for those coal-fired power plants that remain. We consider all of these regulatory changes internalise much of the currently external health, pollution, water and environmental costs of coal-fired power plants. However, in moving coal to a level playing field, it is pricing coal-fired power generation out of the market. Hence our conclusion of structural decline for thermal coal.

Water Cooling Rules

The EPA is also reviewing its rules governing the use of water cooling by coal-fired power plants given the implications of water pollution and the billions of fish killed annually in the intake systems.^{CCXXXVII}

Appendix D: Tax Imposts on Coal Use

There is a gradual increase in the recognition of coal-fired power's externalities - including health, pollution, water and environmental costs. Particularly where countries have a significant trade deficits with respect to fossil fuels, we are seeing fossil fuels being less a fiscal drain in terms of subsidies but also a source of increased tax revenues.

Reform of the EU ETS

Ignacio Galan, CEO of Iberdrola SA has called for a major overhaul of the EU ETS: "We need a new energy policy framework. We need a real emissions trading system that works." Galan was one of 10 CEOs from some of Europe's largest power utilities including Iberdrola, Italy's Eni SpA, France's GDF Suez and Germany's E.ON SE, who sent a letter to EU leaders before their meeting in Brussels in June 2014 calling for changes to be made to policy. They said the EU should adopt a carbon target no later than October or risk uncertainty over the direction of policy that would unsettle power investments.^{ccxxxviii}

UK Carbon Tax

In order to underpin the regulatory impact of the EU ETS, the 2011 UK budget introduced a carbon price floor commencing April 2013. Initially set at £5/tonne of CO₂ for 2013/14, this steps up to £18/tonne of CO₂ for 2017/18, the equivalent to £43/tonne of thermal coal.^{ccxxxix}

China's Coal Tax

China's Finance Minister Lou Jiwei in July 2014 proposed a 5% tax of the value of coal, similar to that imposed on oil and natural gas in 2011. The tax is likely to be matched by a lift in the allowed electricity price, given the mechanism where the price of coal and electricity move in tandem.

This proposal is in addition to China's renewable energy electricity surcharge on coal-fired electricity generation of Rmb0.015 / kWh which is used to fund the investment in renewables.^{ccxl} This surcharge was introduced in 2010, doubled in 2011^{ccxli} and doubled again in 2013. It will raise an estimated US\$15bn in 2014 alone, up from US\$3bn in 2011.

China's National Emissions Trading Scheme

The National Development and Reform Commission (NDRC) in September 2014 outlined its initial plans for a nationwide market to slow down the rapid growth of greenhouse gas emissions in China.

The NDRC said it is likely to regulate 3-4 billion tonnes of carbon dioxide by 2020 and the market will cover 40% of its economy and be worth up to 400 billion yuan (US\$65 billion). This would make the market twice as big as the EU market, which is currently the world's biggest. China is proposing to bring forward plans to start a national market to 2016 from previous expectations of 2018.^{ccxlii}

Korean Coal US\$19/t Import Tax

From 1 July 2014 Korea implemented a US\$16-18/t coal import tax. The finance ministry said that a rate of 19 Korean won (US\$16-18/t) would be imposed per kilogram (kg) of coal with a minimum 5,000 kcal of net calorific value (NCV). For coal below 5,000 kcal/kg NCV, the rate will be 17 won per

kg.^{ccxliii} Given the lowering of import taxes on LNG at the same time, the initiative was clearly designed to lower carbon intensity of emissions:

"The government aims to lower power demand and boost demand for other fuels by hiking electricity fares or the taxes on coal for power generation."^{ccxliv}

Chile's Thermal Power Tax

In April 2014 Chile's government announced a proposal to implement a tax on carbon dioxide (CO₂) emissions. According to the proposal by Chile's President Michelle Bachelet, Chile will charge thermal power generators \$5 per tonne of CO₂ emitted.^{ccxlvccxlv} Having progressed substantially since then, this legislation is due to go to the House of Representatives in Sept'2014.^{ccxlvii}

Mexico's Coal Tax

In Jan'2014, Mexico imposed a tax on several types of fossil fuels, including gasoline, averaging US\$3/t of CO₂.^{ccxlviii}

India's Coal Tax

India's 2014/15 budget included the announcement of a doubling of the imported coal tax to Rs100/t^{ccxlix} (US\$1.70/t). This coal tax raised Rs25bn (US\$400m) in 2013/14. With increased coal usage, the tax will import 160-180Mtpa of coal and hence raise US\$250m pa from 2014/15 to assist in financing the commercialisation of Indian solar measures. The customs duty on thermal coal was also raised from 2.0% to 2.5%, and for coking coal from nil to 2.5%.^{cclcli}

Israel's fourfold hike in thermal coal import tax

Israel's finance ministry in Aug'2014 has proposed a fourfold hike in thermal coal import tax from 2015, which would raise the excise paid by the country's sole consumer Israel Electric Corp. to \$54/Mt from \$13/Mt. The proposal is part of the ministry's plan to cover the rise in expenses resulting from the current military operation in the Gaza Strip. The ministry said it expects the move would generate \$457m in additional revenue in 2015.^{cclii}

IMF recommends a 60% tax on coal

In a publication titled Promoting Responsible Energy Pricing, the International Monetary Fund (IMF) laid out its views on appropriate taxes on coal, natural gas and oil to factor in the fuels' overall costs, which include carbon dioxide emissions, air pollution, congestion and traffic accidents.^{ccliii}

In August 2014 IMF MD Christine Lagarde said:

"This means, for example, making sure that charges on different fuels are proportional to emissions from those fuels. That way, we get the relative prices of dirty, intermediate, and clean fuels right – and environmental damage is properly factored into energy prices, Using a single fiscal instrument targeted at a particular source of environmental harm is both effective and administratively simple. It is better than relying on a patchwork of uncoordinated policies".

“Take coal, for example. This is about the dirtiest of all fuels, yet almost no country imposes meaningful taxes on its use. Our work suggests that, to reflect the carbon damages alone, a reasonably-scaled charge would amount, on average, to around two-thirds of the current world price of coal. In countries where a lot of people are exposed to air pollution, the coal charge should be even higher—several times higher in some cases.”

Reduced subsidies for Indian Electricity

India has a pervasive suite of fossil fuel subsidies in place, despite the drain of a massive and growing fossil fuel based current account deficit. The subsidisation of kerosene, oil, diesel and electricity for the agricultural, fertilizer and retail markets were all introduced decades ago based on the flawed logic of trying to reduce energy poverty, but directly results in a quagmire of unfunded budget deficits across the State and Federal governments.

The State electricity Distribution Utilities collectively reported losses pre-subsidies of US\$15bn in 2011/12 (mostly unfunded), the last year combined results are available. This serves as a massive impediment to structural reform of the electricity market. With the rate of distribution company losses, there is almost no capital to fund the much needed upgrade of the electricity distribution system, meaning loss rates in electricity T&D of 23-27%. A circular spiral. The reform of the Indian electricity distribution sector is a key priority that involves a commitment to significantly raise retail electricity prices and reduce both indebtedness and borrowing costs by improving credit worthiness, all of which serves to improve profitability and facilitate reinvestment.

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- ❖

References

- ⁱ Bloomberg New Energy Finance, 10 September 2014, "China Premier Seeks to Reassure Investors Amid Antitrust Probes" <http://www.bloomberg.com/news/2014-09-10/china-premier-seeks-to-reassure-investors-amid-probes.html>
- ⁱⁱ http://www.riotinto.com/documents/Address_to_the_Australian_British_Chamber_of_Commerce.pdf
- ⁱⁱⁱ <http://www.iea.org/Textbase/npsum/MultipleBenefits2014SUM.pdf>
- ^{iv} http://www.businessspectator.com.au/article/2014/9/11/smart-energy/energy-efficiency-most-important-fuel-we-didnt-know-we-had?utm_source=exact&utm_medium=email&utm_content=903954&utm_campaign=cs_daily&modapt=
- ^v IEA, World Energy Outlook 2013, pp36; 645.
- ^{vi} Full details of coal consumption by type and then by sector can be found in the IEA's Coal Information 2013 report, page III.64. IEEFA has adjusted the IEA data to reclassify the data to include China's lignite production in the lignite figures, whereas the Chinese data reported in the IEA database includes this in thermal coal.
- ^{vii} IEA, Energy Technology Perspectives 2014, 2014, 29
- ^{viii} IEA, 2013, Technology Roadmap: Carbon capture and storage. Available at: <http://www.iea.org/publications/freepublications/publication/TechnologyRoadmapCarbonCaptureandStorage.pdf>
- ^{ix} Shell New Lens Scenarios, 2013. Available at: <http://www.shell.com/global/future-energy/scenarios/new-lens-scenarios.html>
- ^x ExxonMobil, The Outlook for Energy: A view to 2040, 2013. Available at: <http://corporate.exxonmobil.com/en/energy/energy-outlook>
- ^{xi} BP Energy Outlook to 2035, 2013. Available at: <http://www.bp.com/en/global/corporate/about-bp/energy-economics/energy-outlook/outlook-to-2035.html>
- ^{xii} EIA, International Energy Outlook 2013. Available at: <http://www.eia.gov/forecasts/ieo/coal.cfm>
- ^{xiii} To ensure consistency and readability of the graph, total coal demand data from 2000-2012 is from the IEA Coal Information 2013 publication.
- ^{xiv} ExxonMobil and the EIA forecast converted from quadrillion British thermal units (Qbtus) to Mtce using the EIA conversion factor: 27.778mbtu = 1.tce. Demand figure for 2020 estimated for consistency.
- ^{xv} Citi, 2013, Energy Darwinism: The evolution of the energy industry
- ^{xvi} Wood Mackenzie, 2013, Thermal trade coal market report
- ^{xvii} According to the IEA Coal Information 2013 report.
- ^{xviii} Deutsche Bank, 2012, *Coal at a crossroads*; Goldman Sachs, 2014, *The thermal coal paradox*; Citi, 2014, *When cyclical supply met structural demand*; Wood Mackenzie, 2013, *Thermal trade coal market report*; IEA, 2013, *World Energy Outlook*.
- ^{xix} Bernstein Research, 2013, Asian coal & power: Less, less, less...The beginning of the end of coal
- ^{xx} S&P, 2014, Carbon constraints cast a shadow over the future of the coal industry. Available at: http://www.carbontracker.org/wp-content/uploads/2014/07/2014-07-21-SP_Carbon-Constraints-Cast-A-Shadow-Over-The-Future-Of-The-Coal-Industry3.pdf
- ^{xxi} Deutsche Bank, 2013, Thermal coal: Coal at a crossroads
- ^{xxii} Morningstar, April 2014, Burned Out: China's Rebalancing Heralds the End of Coal's Growth Story
- ^{xxiii} IEA, 2013, World Energy Outlook 2013
- ^{xxiv} Citi, 2014, Global thermal coal: When cyclical supply met structural demand
- ^{xxv} Wood Mackenzie, 2014, Annapolis coal day presentation.
- ^{xxvi} <http://www.snl.com/InteractiveX/article.aspx?ID=28716124&KPLT=4>
- ^{xxvii} Citi, 2014, Global thermal coal: When cyclical supply met structural demand
- ^{xxviii} World Energy Model Documentation - page 21 section 4.1
- ^{xxix} <http://www.worldenergyoutlook.org/weomodel/investmentcosts/>
- ^{xxx} <http://www.worldenergyoutlook.org/weomodel/investmentcosts/>
- ^{xxxi} Ratle (2018) GVK, Alaknanda Hydro (2014) GVK, Subansiri Hydro (2018) NHPC, Parbati III (2014) NHPC and Kameng (2017) NEPCo.
- ^{xxxii} <http://www.worldbank.org/en/news/feature/2013/12/12/transforming-indias-future-with-solar-power>; ESMAP World Bank "Paving the Way for a Transformational Future" 12 Dec 2013 page 61
- ^{xxxiii} <http://reneweconomy.com.au/2014/graph-of-the-day-why-experts-get-it-wrong-on-wind-and-solar-58816>
- ^{xxxiv} http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf

- xxxv http://www.irena.org/rethinking/Rethinking_FullReport_web_view.pdf
- xxxvi <http://www2.epa.gov/carbon-pollution-standards/learn-about-carbon-pollution-power-plants#CAP>
- xxxvii World Energy Model Documentation - page 42 section 9.3.1
- xxxviii World Energy Model Documentation - page 42 section 9.3.1
- xxxix <http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy/statistical-review-downloads.html>
- xl <http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG>, <http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy/statistical-review-downloads.html>
- xli http://www.sourcewatch.org/index.php/European_Union_Large_Combustion_Plant_Directive_-_Coal_plants slated for closure
- xlii http://www.huffingtonpost.com/justin-guay/chinas-coal-imports-drop_b_5799552.html
- xliii <http://uk.reuters.com/article/2014/09/03/china-coal-imports-idUKL3NOR31GR20140903>
- xliv <http://in.reuters.com/article/2014/07/15/china-power-consumption-idINL4N0PQ15820140715>
- xlv <http://in.reuters.com/article/2014/06/13/china-economy-idINKBNOEOOI120140613?feedType=nl&feedName=inmoney>
- xlvi http://www.businessspectator.com.au/article/2014/6/16/china/china-readies-energy-revolution?utm_source=exact&utm_medium=email&utm_content=792325&utm_campaign=pm&modapt=
- xlvii <http://reneweconomy.com.au/2014/chinese-coal-consumption-just-fell-first-time-century-49062>
- xlviii <http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf>
- xlivx Morgan Stanley Research, China Coal & Power, Sara Chan, 5 August 2014, “Asia Insight: Burning Less, Burning Smarter”
- l <http://rhg.com/notes/chinas-2012-energy-report-card>
- li <http://www.bloomberg.com/news/2014-09-10/china-premier-seeks-to-reassure-investors-amid-probes.html>
- lii <http://www.bloomberg.com/news/2014-06-13/xi-calls-for-energy-revolution-to-ensure-china-s-demand-is-met.html>
- liii <http://www.smh.com.au/business/carbon-economy/chinas-national-carbon-market-to-start-in-2016-official-says-20140901-10arz1.html>
- liv http://www.businessspectator.com.au/news/2014/8/6/energy-markets/china-multiply-lng-fleet?utm_source=exact&utm_medium=email&utm_content=850270&utm_campaign=cs_daily&modapt=
- lv <http://www.eia.gov/todayinenergy/detail.cfm?id=17591>
- lvi <http://www.goldwindglobal.com/upload/files/201408/201408250901677.pdf>
- lvii <http://ir.mywind.com.cn/phoenix.zhtml?c=238508&p=irol-presentations>
- lviii <http://www.smh.com.au/business/carbon-economy/china-solar-energy-firms-rally-on-hopes-for-rising-demand-at-home-20140806-100usk.html#ixzz3CLX4UNL6>
- lix <http://www.bloomberg.com/news/2014-09-04/china-spurs-rooftop-solar-projects-with-call-for-higher-subsidy.html>
- lx <http://www.scmp.com/business/commodities/article/1586240/small-solar-farms-boosted-beijings-new-pricing-policy>
- lxi <http://www.reuters.com/article/2014/06/19/china-power-windpower-idUSL4N0P01YA20140619>
- lxii http://www.businessspectator.com.au/article/2014/7/1/energy-markets/middle-kingdom-masters-long-distance-grid?utm_source=exact&utm_medium=email&utm_content=809611&utm_campaign=cs_daily&modapt=
- lxiii <http://timesofindia.indiatimes.com/home/environment/pollution/china-suggests-cap-on-coal-use-import-curbs-in-draft-air-pollution-law/articleshow/42168590.cms>
- lxiv Morgan Stanley Research, China Coal & Power, Sara Chan, 5 August 2014, “Asia Insight: Burning Less, Burning Smarter”
- lxv Salva Report, 7 Aug’2014 (paywalled): <https://salvareport.com/>
- lxvi <http://www.adaro.com/publication/view/future-indonesia-asian-coal-markets/>
- lxvii <http://www.adaro.com/publication/view/future-indonesia-asian-coal-markets/>
- lxviii <http://www.adaro.com/publication/view/future-indonesia-asian-coal-markets/>
- lxix <http://www.reuters.com/article/2014/09/08/china-economy-trade-commodities-idUSL3NOR90ND20140908>
- lxx <http://www.eia.gov/coal/production/weekly/>
- lxxi <http://www.eia.gov/electricity/data.cfm#generation>
- lxxii <http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf>

- lxix <http://www.eia.gov/todayinenergy/detail.cfm?id=16071>
- lxxiv http://news.bna.com/clln/CLLNWB/split_display.adp?fedfid=50017272&vname=ccrnotallissues&jd=a0f3j9t4j4&split=0
- lxxv <http://www.eia.gov/totalenergy/data/monthly/index.cfm?src=email>
- lxxvi <http://www.eia.gov/todayinenergy/detail.cfm?id=17891&src=email>
- lxxvii <http://energy.gov/2013-wind-report>
- lxxviii <http://www.snl.com/InteractiveX/article.aspx?id=28970775&Printable=1&KPLT=4>
- lxxix <http://www.eia.gov/forecasts/steo/>
- lxxx <http://www.snl.com/InteractiveX/article.aspx?ID=29143444&KPLT=4>
- lxxxi <http://www.eia.gov/todayinenergy/detail.cfm?id=17051>
- lxxxii <http://www.eia.gov/todayinenergy/detail.cfm?id=17871&src=email>
- lxxxiii <http://www.snl.com/InteractiveX/article.aspx?ID=29029835&KPLT=4>
- lxxxiv <http://www.snl.com/InteractiveX/article.aspx?ID=28715159&KPLT=4>
- lxxxv <http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA--Nuclear-Power/>
- lxxxvi Citi Research, Shahriar (Shar) Pourreza, CFA, 12 May 2014, "The New Balance of "Power" Equity/Commodity View: Updating Coal Retirements, Quantifying Power Price Impact With Elements of Renewables"
- lxxxvii http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Michigan-Report.pdf
- lxxxviii <http://www.eia.gov/todayinenergy/detail.cfm?id=15031>
- lxxxix <http://www.greentechmedia.com/articles/read/eia-increases-short-term-coal-retirement-prediction-by-50>
- xc <http://content.sierraclub.org/press-releases/2014/08/agreement-brings-clean-energy-investments-cleaner-air-mississippi>
- xcI Julien Dumoulin-Smith, US Electric Utilities Analyst, UBS Research, "Post-MATS Era Shifts Focus to the West", 2 June 2014.
- xcii <http://www.snl.com/InteractiveX/article.aspx?ID=29146092&KPLT=4>
- xciii <http://www.snl.com/InteractiveX/article.aspx?ID=28713609&KPLT=4>
- xciv <http://www.greenpeace.org/usa/Global/usa/planet3/PDFs/media/Leasing%20Coal,%20Fueling%20Climate%20Change.pdf>
- xcv <http://www.ieefa.org/study-almost-30-billion-in-revenues-lost-to-taxpayers-by-giveaway-of-federally-owned-coal-in-powder-river-basin/>
- xcvi <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2010&subject=7-AEO2010&table=94-AEO2010®ion=0-0&cases=aeo2010r-d111809a>
- xcvii <http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=7-AEO2014&table=94-AEO2014®ion=0-0&cases=ref2014-d102413a>
- xcviii <http://www.bloomberg.com/news/2014-09-12/india-offshore-wind-policy-to-target-1-gigawatt-by-2020.html>
- xcix <http://www.bloomberg.com/news/2014-09-03/modi-vies-with-widodo-as-india-set-to-end-diesel-subsidy.html>
- c <http://www.adaro.com/publication/view/future-indonesia-asian-coal-markets/>
- ci <http://www.financialexpress.com/news/upgrade-power-plant-get-more-coal-supply/1274756/0>
- cii <http://www.hindustantimes.com/business-news/debt-trap-rs-4-5-lakh-cr-worth-of-power-projects-on-the-block/article1-1257677.aspx>
- ciii <http://economictimes.indiatimes.com/industry/energy/power/gautam-adani-plans-a-5000-mw-push-into-power-sector-in-talks-with-gmr-lanco-indiabulls-avantha/articleshow/39196166.cms>
- civ <http://www.livemint.com/Politics/XCsIFKlcYVITuRWDIHV7cO/Government-raises-concerns-over-power-project-loans-during-U.html>
- cv <http://www.thehindu.com/opinion/op-ed/germanys-great-green-gamble/article6388737.ece?homepage=true>
- cvi <http://cleantechnica.com/2014/08/21/can-india-achieve-100-renewable-energy-future/>
- cvi <http://about.bnef.com/bnef-news/india-invites-bids-for-8-billion-renewable-grid-upgrade/>
- cvi http://mospi.nic.in/mospi_new/upload/Energy_Statistics_2013.pdf?status=1&menu_id=216
- cix <http://indiabudget.nic.in/es2012-13/estat1.pdf>
- cx http://www.cea.nic.in/reports/yearly/lgbr_report.pdf

- ^{cx} http://zeenews.india.com/business/news/finance/power-stocks-surge-as-derc-approves-tariff-hike_104156.html
- ^{cxii} Goldman Sachs Global Equity Research, Pulkit Patni & Mohit Soni, “Energizing India: Reforms the bright spark, but regular tariff hikes key”, 19 January 2014.
- ^{cxiii} Deutsche Bank, Sanjeev Sanyal et al, 1 September 2014, “The Wide Angle, India 2020: The Road to East Asia”, page 35.
- ^{cxiv} <http://www.bloomberg.com/news/2014-06-25/suzlon-regains-top-position-in-india-wind-turbine-market.html>
- ^{cxv} http://www.business-standard.com/article/economy-policy/tax-benefit-scheme-restored-for-wind-energy-sector-114072501091_1.html
- ^{cxvi} <http://www.ieefa.org/press-release-the-beginning-of-the-end-of-imported-coal-in-india-report-exposes-economic-flaws/>
- ^{cxvii} <http://www.bloomberg.com/news/2014-08-31/suzlon-trauma-ending-as-modi-helps-double-turbines-india-credit.html>
- ^{cxviii} <http://cleantechnica.com/2014/07/27/india-lays-foundation-national-wind-energy-mission/>
- ^{cxix} <http://economictimes.indiatimes.com/industry/energy/power/government-aims-to-add-10000-mw-per-year-to-lift-wind-energy-sector/articleshow/40079023.cms>
- ^{cx} <http://www.bloomberg.com/news/2014-09-12/india-offshore-wind-policy-to-target-1-gigawatt-by-2020.html>
- ^{cxxi} Lanco Infratech Annual Report 2013/14, page 19 quoting Government of India, Ministry of New and Renewable Energy.
- ^{cxixii} <http://cleantechnica.com/2014/07/23/another-indian-state-joins-solar-power-race-1000-mw-pv-project/>
- ^{cxixiii} <http://reneweconomy.com.au/2014/worse-news-for-australia-as-india-taps-solar-beijing-bans-coal-66423>
- ^{cxixiv} <http://reneweconomy.com.au/2014/india-poised-to-be-world-solar-leader-adding-145gw-in-10-years-73146>
- ^{cxixv} http://www.nhpcindia.com/writereaddata/Images/pdf/presentation_30.06.13.pdf
- ^{cxixvi} http://www.cea.nic.in/reports/hydro/hydro_develop_12th_plan.pdf
- ^{cxixvii} http://www.afr.com/p/business/companies/india_burning_brighter_for_lng_exporters_HEBP7GNzeFbvpOiCfGC9qI
- ^{cxixviii} <http://in.reuters.com/article/2014/09/05/india-australia-nuclear-deal-idINKBN0H00MX20140905?feedType=nl&feedName=inmoney>
- ^{cxixix} <http://www.world-nuclear.org/info/country-profiles/countries-o-s/south-africa/>
- ^{cx} http://www.eskom.co.za/Whatweredoing/NewBuild/MedupiPowerStation/Pages/Medupi_Legacy_Programme.aspx
- ^{cxixxi} <http://www.gwec.net/publications/global-wind-report-2/>
- ^{cxixxii} <http://www.bloomberg.com/news/2014-01-31/south-africa-power-from-coal-may-fall-to-50-by-2050.html>
- ^{cxixxiii} <http://www.polity.org.za/article/sa-thembisile-majola-address-by-the-deputy-minister-of-energy-during-the-delivery-of-the-2014-budget-vote-speech-parliament-cape-town-21072014-2014-07-21>
- ^{cxixxiv} <http://www.africasmartgridforum2014.org/en/expert/sessionb2/minnesh-bipath-sg-vision-presentation-to-the-asgf-en.pdf>
- ^{cxixxv} http://www.esmap.org/sites/esmap.org/files/BN004-10_REISP-CD_South%20African%20Power%20Pool-Transmission%20&%20Trading.pdf
- ^{cxixxvi} <http://afkinsider.com/55209/africas-clean-energy-corridor-sparking-cross-border-cooperation/#sthash.fWA3xLLv.dpuf>
- ^{cxixxvii} http://www3.weforum.org/docs/WEF_AfricanStrategicInfrastructure_Report_2014.pdf
- ^{cxixxviii} <http://www.ipprenewables.co.za/#index.php>
- ^{cxixxix} <http://www.southafrica.info/news/business/2331733.htm#.U-cxltlCtZ4>
- ^{cx} <http://ir.suntech-power.com/phoenix.zhtml?c=192654&p=irol-newsArticle&ID=1765620&highlight=>
- ^{cxli} <http://www.gwec.net/publications/global-wind-report-2/>
- ^{cxlii} http://www.eskom.co.za/Whatweredoing/NewBuild/IngulaPumpedStorage/Pages/Ingula_Pumped_Storage_Scheme.aspx
- ^{cxliiii} <http://mg.co.za/article/2013-07-12-00-water-can-close-south-africas-electricity-gap>

- cxliv <http://cleantechnica.com/2014/06/30/african-development-bank-supports-south-african-solar-thermal-power-project-142-million-loan/>
- cxlv <http://insidclimatenews.org/news/20140915/only-1-trillion-annual-investment-goal-puts-climate-solutions-within-reach>
- cxlvi <http://www.economist.com/news/asia/21586570-shadow-fukushima-worlds-worst-nuclear-disaster-after-chernobyl-hangs-over-japans-energy>
- cxlvii Compiled and calculated from Japan's Ministry of Energy, Technology and Industry (METI) Agency for Natural Resources and Energy (ENECHO): Energy Survey Statistics [in Japanese].
- cxlviii http://www.afr.com/p/business/companies/Ing_rally_slows_as_japan_prepares_7WHM8waTQYivhX5QkfE
- sAO
- cxlix http://www.enecho.meti.go.jp/en/category/others/basic_plan/pdf/4th_strategic_energy_plan.pdf
- cl Compiled and calculated from Japan's Ministry of Energy, Technology and Industry (METI) Agency for Natural Resources and Energy (ENECHO): Energy Survey Statistics [in Japanese].
- cli <http://www.bloomberg.com/news/2014-08-29/japan-plans-to-boost-budget-for-hydrogen-energy-saving-measures.html>
- clii <http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/download.aspx>
- cliii http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1399887558P.pdf
- cliv <http://www.eia.gov/countries/country-data.cfm?fips=JA>
- clv <https://www.eccj.or.jp/law/revised/10aug2005.pdf>
- clvi http://www.fepc.or.jp/english/news/generated_purchased/_icsFiles/afiedfile/2014/07/11/hatsuju_s_e_20140711.pdf
- clvii <http://www.bloomberg.com/news/2014-08-29/japan-plans-to-boost-budget-for-hydrogen-energy-saving-measures.html>
- clviii <http://www.bloomberg.com/news/2014-08-29/japan-plans-to-boost-budget-for-hydrogen-energy-saving-measures.html>
- clix <http://reneweconomy.com.au/2014/post-fukushima-japan-turns-offshore-wind-solar-25784>
- clx <http://www.reuters.com/article/2012/06/18/us-energy-renewables-japan-idUSBRE85H00Z20120618>
- clxi <http://about.bnef.com/bnef-news/japan-may-lower-solar-tariff-by-11-following-decline-in-costs/>
- clxii <http://www.recgroup.com/en/media/newsroom/PV-Japan-2014-REC-boosts-its-presence-on-the-Japanese-market-with-new-solar-panel-concepts-and-comprehensive-market-expertise/>
- clxiii <http://www.bloomberg.com/news/2014-09-04/china-spurs-rooftop-solar-projects-with-call-for-higher-subsidy.html>
- clxiv <http://www.bloomberg.com/news/2014-08-05/japan-may-pull-more-approvals-for-solar-projects-behind-schedule.html>
- clxv <http://www.bloomberg.com/news/2014-08-08/japan-solar-capacity-forecast-at-100gw-in-fy2030-by-lobby-group.html>
- clxvi <http://www.gwec.net/publications/global-wind-report-2/>
- clxvii <http://www.eia.gov/countries/country-data.cfm?fips=JA>
- clxviii <http://www.worldcoal.com/news/special-reports/articles/World-Coal-Regional-report-Japan-into-the-breach-coal1187.aspx#.U-mo5hCTJOA>
- clxix <http://www.eia.gov/countries/country-data.cfm?fips=JA>
- clxx <http://www.world-nuclear.org/info/Country-Profiles/Countries-O-S/South-Korea/>
- clxxi <http://www.gwec.net/publications/global-wind-report-2/>
- clxxii <http://in.reuters.com/article/2014/06/03/coal-southkorea-idINL3N0OK0XH20140603>
- clxxiii <http://reneweconomy.com.au/2014/german-coal-power-generation-10-year-low-august-69763>
- clxxiv <https://www.energy-charts.de/energy.htm>
- clxxv <http://www.germanenergyblog.de/?p=16179#more-16179>
- clxxvi https://www.enbw.com/company/press/press-releases/press-release-details_70016.html?sessionId=02BCE089537DC04B9EA5074D8437B943.nbwroot43
- clxxvii <http://www.bloomberg.com/news/2014-06-26/germany-s-new-coal-plants-push-power-glut-to-4-year-high.html>
- clxxviii <http://www.bloomberg.com/news/2014-06-26/germany-s-new-coal-plants-push-power-glut-to-4-year-high.html>
- clxxix <https://www.rwe.com/web/cms/mediablob/en/649048/data/2495606/76/rwe/investor-relations/presentations-videos/presentations/RWE-company-presentation-Focus-on-financial-strength-2014.pdf>

- clxxx http://news.bna.com/ieln/IELNWB/split_display.adp?fedfid=50244173&vname=inernotallissues&jd=a0f3p0k5c6&split=0
- clxxxi <http://www.theguardian.com/environment/2014/jul/23/eu-agrees-to-improve-energy-efficiency-30-by-2030>
- clxxxii <http://reneweconomy.com.au/2014/record-numbers-german-onshore-wind-68743>
- clxxxiii <http://www.gwec.net/publications/global-wind-report-2/>
- clxxxiv <http://www.theguardian.com/world/2011/may/30/germany-to-shut-nuclear-reactors>
- clxxxv <http://energytransition.de/2013/11/germany-to-shut-down-12-power-plants/>
- clxxxvi <http://www.rwe.com/web/cms/mediablob/en/649048/data/105818/76/rwe/investor-relations/RWE-company-presentation-Focus-on-financial-strength-2014.pdf>
- clxxxvii <http://www.bloomberg.com/news/2014-07-31/u-k-renewables-generated-14-9-percent-of-electricity.html>
- clxxxviii https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/338768/DUKES_2014_internet_content.pdf
- clxxxix https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322799/qep_June_2014.pdf
- cc <http://www.drax.com/media/41937/half-year-results-presentation-for-the-six-months-ended-30-june-2014.pdf>
- ccci <http://about.bnef.com/press-releases/uk-capacity-market-will-benefit-old-coal-new-gas/>
- ccii <http://www.drax.com/media/41937/half-year-results-presentation-for-the-six-months-ended-30-june-2014.pdf>
- cciii <http://www.drax.com/media/41937/half-year-results-presentation-for-the-six-months-ended-30-june-2014.pdf>
- cciv <http://drax.presscentre.com/News/Drax-set-to-become-largest-single-renewable-generator-in-the-UK-aff.aspx>
- ccv https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/338768/DUKES_2014_internet_content.pdf
- ccvi <http://www.drax.com/media/41937/half-year-results-presentation-for-the-six-months-ended-30-june-2014.pdf>
- ccvii http://www.businessspectator.com.au/news/2014/8/4/solar-energy/uk-set-pass-germany-solar-stakes?utm_source=exact&utm_medium=email&utm_content=847235&utm_campaign=cs_daily&modapt=
- ccviii <http://www.bloomberg.com/news/2014-08-18/u-k-wind-generated-record-22-of-electricity-yesterday.html>
- ccix <http://www.gwec.net/publications/global-wind-report-2/>
- cc <http://www.centrica.com/celticarray/>
- ccci <http://www.theguardian.com/environment/2014/jul/31/centrica-withdraws-from-irish-sea-offshore-windfarm-plan>
- ccii <http://www.bloomberg.com/news/2014-07-30/france-to-boost-efficiency-renewables-in-10-billion-euro-law.html>
- cciii <http://reneweconomy.com.au/2014/france-unveils-us13-4bn-energy-plan-to-focus-on-renewables-efficiency-26738>
- cciv <http://www.bloomberg.com/news/2014-06-23/french-state-bank-sets-aside-5-billion-euros-for-green-projects.html>
- ccv <http://www.businessgreen.com/bg/news/2358544/france-delivers-long-awaited-green-energy-bill>
- ccvi <http://www.imf.org/external/pubs/ft/weo/2014/01/weodata/download.aspx>
- ccvii <http://investors.itron.com/releaseDetail.cfm?ReleaseID=869355>
- ccviii PT PLN, Helmi Najamuddin, Head of Coal Division, Coaltrans Asia, 2 June 2014, "Powering Forward in Indonesia's Electrification Strategy".
- ccix IEA, World Energy Outlook Special Report, Sept'2013, "South East Asia Energy Outlook".
- ccx <http://www.thejakartaglobe.com/business/indonesia-power-station-coal-demand-seen-almost-doubling-2022/>
- ccxi PT PLN, Helmi Najamuddin, Head of Coal Division, Coaltrans Asia, 2 June 2014, "Powering Forward in Indonesia's Electrification Strategy".
- ccxii PT PLN, Helmi Najamuddin, Head of Coal Division, Coaltrans Asia, 2 June 2014, "Powering Forward in Indonesia's Electrification Strategy".

- ccxiii PT PLN, Helmi Najamuddin, Head of Coal Division, Coaltrans Asia, 2 June 2014, "Powering Forward in Indonesia's Electrification Strategy".
- ccxiv <http://reneweconomy.com.au/2014/australias-first-waste-to-energy-plant-set-to-open-in-wa-37560>
- ccxv <http://www.eia.gov/countries/country-data.cfm?fips=as>
- ccxvi <http://reneweconomy.com.au/2014/australias-solar-boom-has-only-just-begun-bloomberg-58987>
- ccxvii <http://reneweconomy.com.au/2014/can-coal-generators-fool-the-government-a-second-time-73580>
- ccxviii <http://reneweconomy.com.au/2014/the-2000mw-coal-generator-the-nsw-government-sold-for-0-59474>
- ccxix <http://www.businessspectator.com.au/article/2014/9/4/wind-power/pacific-hydro-its-not-easy-being-green>
- ccxx <http://www.gwec.net/publications/global-wind-report-2/>
- ccxxi <http://reneweconomy.com.au/2014/26-gw-wind-solar-power-capacity-offered-brazils-upcoming-auction-26113>
- ccxxii <http://www.bloomberg.com/news/2014-09-11/brazil-will-boost-wind-energy-as-drought-undermines-hydro.html>
- ccxxiii <http://www.bloomberg.com/news/2014-07-31/brazil-development-bank-will-allow-solar-cell-imports-to-2020.html>
- ccxxiv Available at: <http://www.psr.org/assets/pdfs/coals-assault-executive.pdf>
- ccxxv Data is for 'source to carrier' primary energy production, which includes withdrawals and consumption for extraction, processing and transport.
- ccxxvi CAN Analysis and Solutions, 2014, A clash of competing necessities: Water adequacy and electric reliability in China, India, France and Texas. Available at: <http://indiaenvironmentportal.org.in/content/397442/a-clash-of-competing-necessities-water-adequacy-and-electric-reliability-in-china-india-france-and-texas/>
- ccxxvii IEA, 2013, World Energy Outlook, 2013, 176
- ccxxviii HSBC, 2012, No water, no power: Is there enough water to fuel China's power expansion?
- ccxxix Water consumption in energy production was not covered in detail in the IEA's World Energy Outlook 2013, so the 2012 report reflects the best available data.
- ccxxx IEA, 2012, World Energy Outlook, 501
- ccxxxi <http://www2.epa.gov/carbon-pollution-standards/learn-about-carbon-pollution-power-plants#CAP>
- ccxxxii President Obama, 2 June 2014, "Clean Energy Plan", page 4. <http://www2.epa.gov/carbon-pollution-standards/fact-sheet-clean-power-plan-overview>
- ccxxxiii Julien Dumoulin-Smith, US Electric Utilities Analyst, UBS Research, "Clearing More Air on EPA's Carbon Regs", 12 June 2014.
- ccxxxiv http://www.ucsusa.org/assets/documents/clean_energy/Ripe-for-Retirement-Michigan-Report.pdf
- ccxxxv Julien Dumoulin-Smith, US Electric Utilities Analyst, UBS Research, "Clearing More Air on EPA's Carbon Regs", 12 June 2014.
- ccxxxvi <http://www.snl.com/InteractiveX/article.aspx?ID=28495211&KPLT=4>
- ccxxxvii <http://thinkprogress.org/climate/2014/05/20/3439437/epa-water-intake-power-plant-kill-fish-shrimp/>
- ccxxxviii <http://www.bloomberg.com/news/2014-06-27/eu-seen-curbing-coal-use-by-quadrupling-carbon-price.html>
- ccxxxix <http://www.drax.com/media/41937/half-year-results-presentation-for-the-six-months-ended-30-june-2014.pdf>
- ccxl <http://online.wsj.com/news/articles/SB10001424127887324324404579044592532822898>
- ccxli <http://www.reuters.com/article/2011/12/01/us-cleanenergy-shares-idUSTRE7B00FI20111201>
- ccxlii <http://reneweconomy.com.au/2014/china-plans-65bn-carbon-market-at-around-18tonne-48911>
- ccxliiii <http://in.reuters.com/article/2014/06/03/coal-southkorea-idINL3N0OKOXH20140603>
- ccxliv <http://uk.reuters.com/article/2014/01/23/korea-power-tax-idUKL3N0KW1AB20140123>
- ccxlv <http://www.businessspectator.com.au/news/2014/4/7/carbon-markets/chile-plans-carbon-tax>
- ccxlvi <http://www.globalpost.com/dispatch/news/regions/americas/chile/140513/chile-carbon-tax>
- ccxlvii <http://reneweconomy.com.au/2014/chile-poised-pass-south-americas-first-carbon-tax-38539>
- ccxlviii <http://www.businessspectator.com.au/news/2014/4/7/carbon-markets/chile-plans-carbon-tax>
- ccclix <http://reneweconomy.com.au/2014/modi-sows-seeds-solar-revolution-doubles-tax-coal-57890>
- cccl http://www.business-standard.com/article/companies/increase-in-clean-energy-cess-on-imported-coal-adani-gvk-and-tatas-to-redraw-foreign-assets-114071400060_1.html
- cccli http://coal.steelguru.com/india/16646/indian_govt_impose_duty_on_coking_coal_import
- ccclii <http://www.platts.com/latest-news/coal/jerusalem/israels-finance-ministry-seeks-fourfold-hike-26861080>
- cccliii <http://reneweconomy.com.au/2014/imf-calls-for-higher-taxes-on-dirty-fuels-to-fight-climate-change-48990>