Energy Transition Advisors
ETA

Summary for Policy Makers

Thermal Coal in Asia – Stopping the Juggernaut

The power sectors of China and India together combine to be one of the most significant sources of emissions on the planet due to the use of thermal coal plants. Indeed relative to other sources of carbon the potential unneeded carbon generated by these sectors relative to a 2°C scenario is the most significant of any source.

While in China coal consumption appears to have peaked already, in both China and India coal demand will still exceed IEA carbon budgets for thermal coal before 2050.

Indeed, the International Energy Agency (IEA)[1] carbon 'budgets' for their power sectors call for a near complete decarbonization by 2050. While this can help with air pollution and water stress too, carbon capture and storage plays a key part in that budget.

After a strong surge in 2015, the pipeline of all planned coal plants has fallen in India and China but the level remains unrealistically high relative to demand and the development of cleaner power sources.

Our analysis shows that in China in particular the current build out of coal plants under construction can cause an overshoot of the IEA thermal coal budget

Thermal Coal power plants under construction continue to rise in China at alarming levels. The amount of plants under construction in China (205GW) and India (65GW) are the numbers to watch. In the case of China, our analysis shows less than half of the capacity presently under construction would be sufficient to break the IEA annual thermal coal carbon budget by 2020 and the total budget by 2036. Stranded assets are likely to emerge as load factors continue to fall.

Thus, while growing renewable power plus falling coal power load factors have contributed to slowing or peaking emissions growth in China, further policy action in the power sector is still needed. Policies can complement positive trends in the relative cost of renewable energy, and reduce pressure on these sources from excess generating capacity, which is forcing curtailment.

Extending short-term moratoriums on new coal plant permits and new construction, accelerating retirements of old plants and Electricity Market Reform to prioritize low carbon dispatch are all on policy makers' radars in China and India.

Carbon capture and storage (CCS) needs to be implemented in government plans if it is to be taken seriously. As yet there is little evidence of action. Without CCS for coal plants, just deploying High Efficiency Low Emissions plants will not meet 2°C.

Reflecting the Paris Agreement, a cap on coal consumption and emissions in the power sector, tied to robust carbon markets, is a longer-term option. Looking at more granular caps through Performance Standards in the power sector with load factor management is also a viable pathway. Removing subsidies for coal production and consumption is consistent with all these policies. Promoting energy efficiency is highly effective and important too.

Editor: Mark Fulton ETA **October 2016**

[1] Interpolated from ETP 2016.

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by 2020 on an annual basis and use up the whole of the budget available till 2050 by 2036. India does so in the 2030s even with no new power plants developed post those under construction now.

Note that post initial publication, Greenpeace analysts see that the under construction pipeline has potentially fallen by around 8GW net and the preconstruction pipeline by even more, which is encouraging. However the magnitude of the emissions task remains high and even if only existing plants in China run at 50% capacity (load) factors and retirements and replacement by high efficiency plants are assumed, then the IEA budgets are exceeded before 2050.

India, in particular, believes it needs more room in carbon budgets for equity reasons - implying further cuts to OECD coal use - this paper looks at the power sector solutions that are both viable (renewable energy) and need further proving (Carbon Capture and Storage).

There is no doubt that both India and China have comprehensive policies to stimulate cleaner energy, efficiency and further policy changes would be highly desirable to support these trends by constraining unneeded thermal coal and developing green financing markets.

This summary is linked to the more detailed paper found at et-advisors.com

Co-Authors and Sources[2]:

- Ted Nace, Christine Shearer and Aiqun Yu from CoalSwarm provided underlying data and comments from Global Coal Plant Tracker.
- Carbon Tracker provided the Carbon Budget analysis.
- Lindee Wong from Ecofys prepared the High Efficiency Low Emissions Analysis.
- Shelagh Whitely at ODI provided the Subsidies' analysis.

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[2] The paper references and cites many sources, notably: Bloomberg New Energy Finance; EndCoal.org; Greenpeace.org: IEEFA.org; IEA.org; Regulatory Assistant Project ; The Oxford Martin School; EnergyInnovations.org; nrdc.org; edf.org.

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Editorial and Executive Summary

This study finds that China is perilously close to surpassing a crucial 'reference' carbon emission budget while India will do so over time as emissions continue to grow, throwing a focus on additional climate action where a critical choice is looming between carbon mitigation with or without large-scale carbon capture and storage (CCS). The International Energy Agency (IEA) has laid out carbon budgets, which represent the cumulative carbon emissions consistent with limiting global average warming to below 2°C at a 50% probability. There is no easy way to allocate such a budget between countries, given issues of equity and fairness, but the IEA is in many senses the key reference point starting from least cost and technology standpoints. On this standpoint, China is on course to surpass its annual thermal coal budget by 2020 and exhaust the whole budget by 2036, even if it proceeds only with coal power plants already under construction, disregarding many more in the planning pipeline. If it simply runs its current plants at 50% load (or capacity) factors and assuming retirements and conversions to high efficiency plants, the total budget is exceeded by 2040. These findings highlight how recent efforts to slow new permitting, and a peaking of coal-fired power generation and carbon emissions in China, are encouraging but need further effort. Even in India, with fewer power plants under construction, the coal sector will surpass its IEA budget in the 2030s – but again with no new power plants at all being built after the current batch. BNEF see the coal consumption IEA 450 ppm budget being overshot from 2020 by a large margin

Where does this leave us? Pursuing energy efficiency is generally at the top of everyone's list to curb emissions. But if carbon is a priority, both countries must take urgent action to curb coal power growth, even if the OECD also steps up. First, they should extend or introduce moratoriums on coal power permits, and where feasible, halt current construction. Electricity market reforms, which dispatch renewables first in the merit order, are low hanging fruit. Second, additional action will be required to limit emissions from existing power plants. This study finds painfully slow progress towards deployment of CCS. In China, four large-scale CCS projects are awaiting final investment decisions. If these went ahead they would capture 6 million tonnes CO_2 annually, compared with IEA assumptions for 240MT CO_2 in China and India by 2030. Without CCS, however, China and eventually India will require equally urgent and radical action, if the world is to meet the 2°C target. This will include: potential caps on coal consumption being achieved through more specific caps on emissions in the power sector, early retirement of existing coal plants; and scrapping of fossil fuel subsidies. The potential for stranded assets and financial impacts remains substantial.

* * *

What happens to thermal coal in Asia, in terms of supply and demand and consumption, in many senses holds the key to global emissions and hence the climate. According to the IEA's *2°C Emissions from Fossil Fuel Combustion*, India and China electricity and heat sector emissions were near 5.3 gigatonnes ($GtCO_2$) in 2013, of a world total of 13.7Gt CO_2, which itself was a subset of combustion by all sectors of

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32.2GtCO_2, and around 50Gt of all global emissions.[3]. No other sector has such a concentrated impact as this**.** Coal dominates the power sector in China and India.

Section 1 in this study reviews how the past year has seen positive developments. China and India have sought to pull back the huge pipeline of planned coal fired power plants that drive demand for thermal coal, while continuing to push for scale up of renewable energy. Even so, this still leaves some 1,020 thermal coal plants in China and India which are planned, pre-permitted, permitted or under construction, with 566GW of potential capacity[4]. This is a massive pipeline still in place, which would result in cumulative emissions of 57Gt by 2050 at 50% load factors. The pipeline has to fall following a particularly strong rise in China in 2015, as the proposed plants simply are way beyond the electricity needs of China and India in the foreseeable future, and will therefore operate at lower, less economic run rates, while still giving rise to excess emissions.

The most important category is the 521 plants under construction, with a capacity of 270GW. These plants would lead to cumulative emissions of 30Gt, or some 3% of the global carbon budget outstanding. China dominates with 389 plants and 205GW capacity under construction, ahead of India's 132 plants with 65GW capacity. Indeed as we go to press, there have been further announcements of another 6GW approved in China[5]. This leaves a coal juggernaut operating and actually developing in Asia that in emission terms is sufficient to significantly affect the global carbon budget. In economic terms, load factors down at 46% in China raise the issue of stranded assets even before any carbon budget squeeze is considered. Only generous electricity tariffs are providing a buffer. A potential knock-on impact on those funding these stations makes the threat of systemic risk relevant. Estimates range up to $200bn of unneeded capex by 2020[6]. Importantly, choosing a low carbon pathway is still consistent with economic growth and development, and in the case of India solar is very much aligned with energy access.

The IEA in its recent World Energy Investment[7] publication said:

> *"With recent investment in renewables-based and nuclear power capacity now largely covering electricity demand growth, signs of overinvestment in coal-fired generation have emerged in China."*

Analysis from Bloomberg New Energy Finance (BNEF) in Chapter 2 shows that coal consumption in Asia overall would outstrip the IEA 450 PPM thermal budget for that region some two and a half times – indicating just how enormous the pressures are. India, in particular, is seen to be a huge source of

[3] http://edgar.jrc.ec.europa.eu/overview.php?v=GHGts1990-2012
[4] Coal Plant data source CoalSwarm, Emissions Ecofys
[5] http://news.bjx.com.cn/html/20161008/777915.shtml
[6] Greenpeace *Burning Money*
[7] https://www.iea.org/Textbase/npsum/WEI2016SUM.pdf

increased thermal coal use and emissions, as it accelerates to be the world's fastest growing consumer of thermal coal.

Section 3 sets out the IEA carbon budget for thermal coal in India and China in more detail, and looks at the role of carbon capture and storage (CCS). The number of coal plants assumed to be operating with CCS accelerates from 47GW in 2030 to 315GW in 2050. By 2050, that allows the Asian power sector to move towards being almost fully decarbonized. However, if those coal plants turned out to be only very efficient Ultra Super Critical (USC) plants without CCS, they would emit cumulatively 21Gt of emissions by 2050, and be running at 1.4Gt pa compared to the IEA budget of 0.19Gt pa.

The question of equity in the carbon budget itself ultimately becomes moot as time goes on and the emissions cap declines dramatically. However, the amount of cumulative budget is important particularly to India where there is concern there is not enough room for growth. This might imply a further reduction in the OECD coal budget, or more help in funding a rapid build-up in cleaner energy. The connection to other pollution issues in air quality and water stress is not a focus of this paper, but is certainly another set of important issues.

The IEA has set out CCS potential in China – where it would be most needed – but this still requires major government involvement in transport and storage infrastructure, and so is risky until it is fully laid out and implemented. In effect, by 2020 'action is louder than words'. Renewable energy costs continue to fall, as demonstrated by CTI's recent paper[8], and flexible smart grids with storage are starting to emerge.

Section 4 of this document looks at the role that High Efficiency Low Emissions (HELE) power plants could play, combined with retirements, in replacing older, less efficient coal plants. Importantly, we assume operating load factors of coal plants at 50%, in line with BNEF expected global averages. Even then our, country coverage shows at best[9] emissions running at 3.3Gt per year in 2050. That compares with an annual total carbon budget by then of close to zero, and indeed is about 4% of the current 2015 budget.

In cumulative terms, according to our analysis, there are 161Gt of emissions on this most efficient pathway, around 18% of the total carbon budget of 900Gt. Under most scenarios tested, the IEA 2°C carbon budget is broken, in China by 2019[10], and by 2039 in India[11] even assuming no new coal plants are developed after the current 65GW. And if just exiting plants run at 50% load factors and assuming

[8] CarbonTracker, *End of the load for coal and gas?*
[9] Allows for retirements in China and replacement of older plants by Ultra Super Critical and only under construction in terms of new plants.
[10] Based on existing emissions plus impact from coal plants under construction at 50% load factors less 18-20GW of retirements a year and the remaining fleet evenly converted to Ultra Super Critical stations.
[11] Based on existing emissions plus impact from coal plants under construction at 50% load factors with older plants evenly converted into Ultra Super Critical stations.

retirements and conversions to high efficiency plants, then the carbon budget will be exhausted before 2050.

So what can be done? Section 5 looks at policy options in the face of such an enormous task. Many important policies are in place in China and India already. Specific to thermal coal, there is a moratorium of sorts in China on new permits and construction, which could be strengthened and extended. India is also seeing more push-back on plant construction. Electricity market reform is also a key policy area. Running low-cost, low-carbon energy first in electricity dispatch is a key priority that is often lacking in Asia. China could further enforce already existing laws, as a key focus for policy makers right now. Far more aggressive retirements of old plants could be carried out as well, to manage the stranding of those. Continuing to push for energy efficiency remains crucial in the whole equation.

In the longer term, the main priority measure remains to apply effective emissions caps that can be associated with a consumption cap on coal[12], in the power sector. Indeed China mentions caps, in its national contribution to the Paris Agreement. The political economy, with push-back from incumbents, will be a major factor in implementation. The most market-based response is around carbon markets that would allow both CCS in the most promising applications and regions, and renewable energy, in a flexible smart grid with storage to scale. China is establishing a national carbon market[13].

Another mandated option is to use Performance Standards to set emissions at the level of individual power plants. This forces technologies to prove themselves and accelerate: CCS; renewables; nuclear (with caveats on public acceptance); and energy efficiency. This fits more with recent moratoriums on new coal power permits and construction in China, and to some extent India, that could be extended and, where possible, current construction could be halted.

Finally, it is inconsistent with decarbonization to continue to subsidize fossil fuels, as set out in analysis which shows that support remains, through public finance for fossil fuels (domestic and international); support through state-owned enterprises (SOEs); links between production and consumption subsidies; and failure to price externalities.

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[12] See NRDC https://www.nrdc.org/experts/barbara-finamore/how-capping-coal-can-help-china-peak-its-co2-emissions-2025-and-contribute

[13] https://www.scientificamerican.com/article/china-will-start-the-world-s-largest-carbon-trading-market/
https://www.iea.org/publications/insights/insightpublications/emissions-trading-in-the-peoples-republic-of-china-a-simulation-for-the-power-sector.html
http://www.edf.org/sites/default/files/india-case-study-may2015.pdf

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Section Summaries of Research Document

Setting The Context:

The mismatch between their IEA ETP carbon budget and the combined potential emissions of existing and planned power plants in India and China (i.e. using coal supply in this case) is an order of magnitude greater than the corresponding mismatch for key sectors in potential oil supply/production, like deep water and oil sands. Only all global conventional oil combined comes close.

ETP Scenario: 2015-2035 and 2050 Carbon Emissions ($GtCO_2$)		
	Existing Plants Plus:	
India and China	All Planned	Under Construction
2035		
Needed	97	97
Emissions Level	119	108
Not Needed	22	11
2050		
Needed	108	108
Emissions Level	196	169
Not Needed	88	61

Source: IEA, CoalSwarm/CTI/ETA Analysis

450 Scenario: 2015-2035 Carbon Emissions ($GtCO_2$)			
Category	Needed	Not needed	Total
Oil	**221**	**28**	**249**
Arctic	1	1	3
Coalbed methane	0	0	0
Conventional (land/shelf)	144	13	157
Deep water	16	4	19
Extra heavy oil	7	1	8
Oil sands	11	3	14
Oil shale (kerogen)	0	0	0
Tight/shale liquids	30	3	34
Ultra deep water	12	2	14

Source: CTI Analysis

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Section 1: Recent Trends

In China, 2016 has seen a trend towards an increase in pre-construction power stations being shelved or cancelled, but also an increase in actual plants under construction. Meanwhile, evidence is growing that coal consumption may have peaked in the past two years, with the energy intensity of GDP falling as a result of the rebalancing of the economy.

Recent announcements, including a partial moratorium on new power plant permitting and construction, have been encouraging. Some 114GW of pre-construction coal power plant capacity has been cancelled or shelved this year. Nevertheless, 2015 saw a massive surge in permitted thermal coal fired stations at the local level in China, as permitting powers were passed to the provinces. That surge leaves 205GW still under construction today, even while the economics of the sector look challenging.

Low coal prices and supportive tariffs allow many coal plants to be profitable even at low load factors. However, tariffs are falling in China, as regulators send a signal to curtail new build, which leaves the sector increasingly vulnerable to economic stranding, given falling load factors that have already fallen to 46%. Estimates have put unneeded coal plant expenditures at around $200bn by 2020. Renewable energy continues to scale up but dispatch has been curtailed, a problem which needs to be addressed in dispatch reforms.

Indian developments remain ambivalent, reflecting an 'all of the above' energy policy approach that includes renewables, but also still seeks to develop coal aggressively with 65GW under construction, even after a reduction of the pre-construction in the pipeline of 40GW up to July this year. Indeed there have been announcements of cancellations of 'mega' projects, and local opposition around land use is evident in India. Renewable energy has seen strong gains and can go much further. However, longer-term demand for electricity remains high.

In both India and China, there is a tussle between domestic coal production and imported seaborne coal. China was reducing domestic production earlier in the year, while India has been trying to boost domestic production. Seaborne coal prices have been rising, but very recent announcements to increase domestic production in China again put this under pressure.

Global Coal Plant Tracker – Plant Capacity Comparison 1/16 vs 7/16 (MW)

Country	Announced	Pre-permit development	Permitted	Announced + Pre-permit + Permitted	Construction	Shelved	Cancelled 2010-2016
China (1/16)	247,160	217,294	54,960	519,414	193,179	61,735	164,495
China (7/16)	231,992	147,520	26,340	405,852	205,144	112,675	203,595
India (1/16)	64,630	95,595	58,244	218,469	72,200	85,065	305,272
India (7/16)	56,130	78,385	43,700	178,215	64,669	111,345	319,637

Source: CoalSwarm

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Section 2: The Outlook For Thermal Coal In Asia-Pacific, According to Bloomberg New Energy Finances' New Energy Outlook (NEO)

As a mainstream energy outlook but from a deep knowledge of renewables, we have been able to source Bloomberg New Energy Finances' New Energy Outlook (NEO) looking at Asia-Pacific overall and China and India within that.

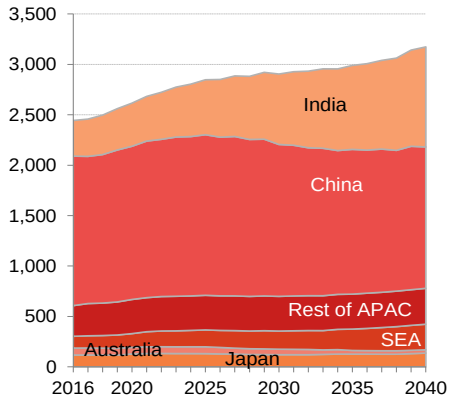
The Asia-Pacific region will drive global power demand growth over the next 25 years, requiring over 4TW of new capacity additions – more than the rest of the world combined. Renewables will provide the bulk of this new capacity, with both solar and wind technologies becoming largely competitive with fossil-fired generation on a levelized cost basis from 2020, and in all major markets by 2040.

As solar and wind LCOEs decline, coal and gas LCOEs remain relatively flat as higher penetrations of renewables eat into the run-hours of conventional plants. This conclusion holds even with the availability of CCS or high-efficiency coal technology, as neither will dispatch ahead of (or close to) zero marginal cost renewables. Lower realized load factors for coal plants already apparent in China point to the creation of stranded assets, if this trend continues.

Nevertheless, to meet expected demand, a significant level of new coal capacity will still be needed in Asia, particularly in India. The NEO forecast suggests that India will add 258GW of new coal capacity over the next 25 years (almost 1GW per month), with coal-fired power generation in the country trebling by 2040.

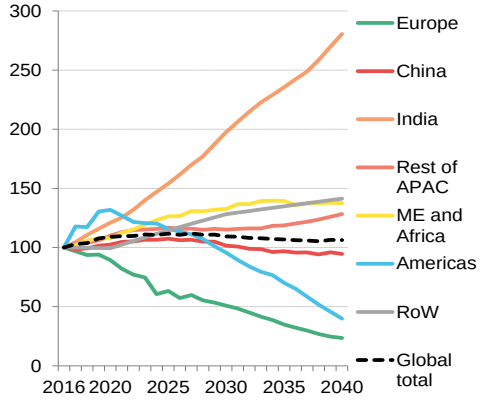
For the Asia-Pacific region as a whole, gross coal capacity additions are almost 700GW over the period 2016-40, or 0.5GW per week. Coal's share of the generation mix falls from 60% in 2015 to 42% in 2040, but in absolute terms it rises by a third to 8,400TWh/yr. over the same period. This translates into an additional 725Mt of coal consumption per year by 2040, the vast majority of which (650Mt) is in India.

Figure 1: Projected Power Sector Thermal Coal Consumption For APAC Region (Mt/Yr)



Source: Bloomberg New Energy Finance

Figure 2: Projected Power Sector Thermal Coal Consumption By Region, Rebased To 100



Source: Bloomberg New Energy Finance

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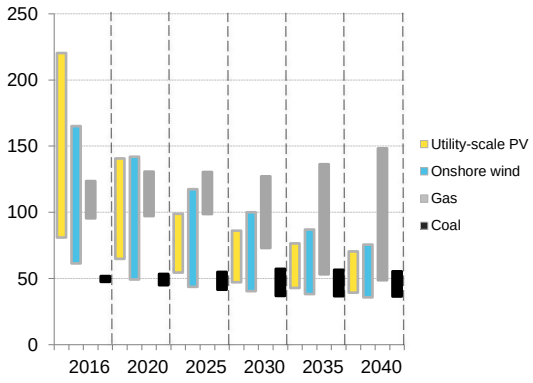
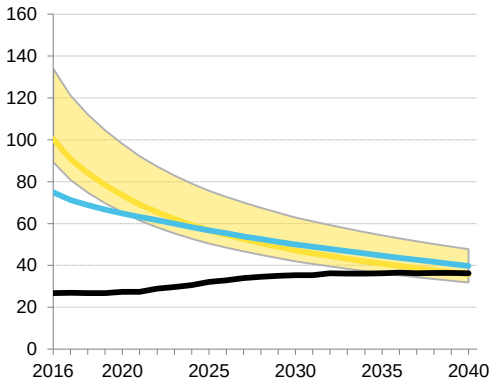
Largely, as a result of this growth in Asian coal consumption, by 2040 global power sector carbon emissions will be five times higher than the level consistent with a 2°C pathway.

Figure 1: Asia-Pacific LCOE based on, 2015-realised load factors, by technology, 2016-40 ($/MWh, 2015-real)



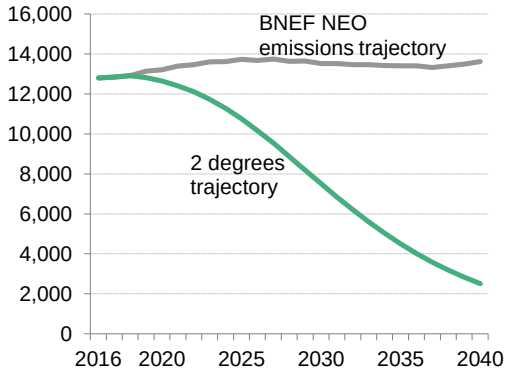
Source: Bloomberg New Energy Finance

Figure 2: China solar PV and onshore wind LCOE vs. coal marginal cost of generation ($/MWh,2015 real)



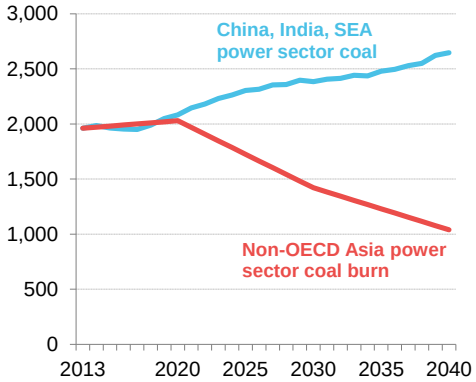
Source: Bloomberg New Energy Finance

Figure 3: NEO global power sector emissions projection vs. indicative 2°C trajectory (Mt CO_2e/yr.)



Source: Bloomberg New Energy Finance

Figure 4: NEO projection for coal consumption across China, India and SEA vs. IEA's 450 scenario for non-OECD Asia power sector coal burn (Mt/yr.)



Source: Bloomberg New Energy Finance, IEA

Section 3: Looking At The IEA's 2°C Carbon Budget And The Role CCS Is Expected To Play

The IEA carbon budget interpolated from the 2016 ETP for both the Chinese and Indian power sectors calls for a near complete decarbonization by 2050, with an accelerating profile for reductions from 2030 onwards. IEA scenarios for achieving this decarbonization include significant amounts of carbon capture and storage (CCS) technology retrofitted to existing power plants. The IEA assumes that 2.8 $GtCO_2$ of cumulative emissions come from CCS plants up to 2050. That would rise to 21$GtCO_2$, if these were all USC plants not eventually retrofitted with CCS.

For CCS to have any chance of success, there must be government-led strategies. These would first assess and develop storage potential. Second, they would price and fund transport networks based on the location of heavy industry and power. And third, they would subsidize actual projects. There is no evidence of this at present. Governments must lay out real policies targeting real opportunities.

The positive case for Chinese coal is laid out by an IEA paper[14] which cites 310GW of plants that could potentially be retrofitted. Nevertheless, trusting CCS before it is proven at scale is risky: the Chinese government first needs to lay out a comprehensive plan, for instance. It is important therefore also to move ahead with already proven and scaled zero carbon options, where these exist at a price at least as competitive as CCS. This opportunity indeed exists in the power sector, unlike in the cement and steel industries, where CCS has little alternative.

The output of Integrated Assessment Models can be counterproductive in this CCS policy context, as some models assume that without CCS the power sector simply cannot be decarbonized. We believe this is a dangerous outcome, and that it is more productive instead to analyze how decarbonization can be achieved. The falling relative cost of renewable energy shows one emerging, viable alternative. Similarly, scaling energy storage in a flexible smart grid is important, and starting to emerge. These issues are looked at in a policy context in Section 5.

Interpolated Carbon Budget From The IEA 2016 ETP

2 Degree Carbon Budget: Thermal Coal Only ($MtCO_2$)											
Country	Technology	2013	2015	2020	2025	2030	2035	2040	2045	2050	2015-2050
China	Unabated	4,188	4,149	4,050	3,748	3,007	1,786	518	14	0	**78,061**
China	Abated	0	0	0	7	32	62	113	158	144	**2,293**
China	Total	4,188	4,149	4,050	3,755	3,039	1,849	631	172	144	**80,356**
India	Unabated	887	1,014	1,330	1,319	1,244	769	147	1	1	**27,097**
India	Abated	0	0	0	1	6	16	23	34	45	**532**
India	Total	887	1,014	1,330	1,320	1,250	785	170	35	46	**27,630**
China + India	Unabated	5,075	5,460	5,380	5,067	4,251	2,555	665	15	1	**105,158**
China + India	Abated	0	0	0	8	38	78	136	192	189	**2,825**
China + India	Total	5,075	5,460	5,380	5,075	4,289	2,633	801	207	190	**107,983**

Source: IEA, CTI/ETA Analysis

[14] Ready for CCS retrofit: The potential for equipping China's existing coal fleet with carbon capture and storage.

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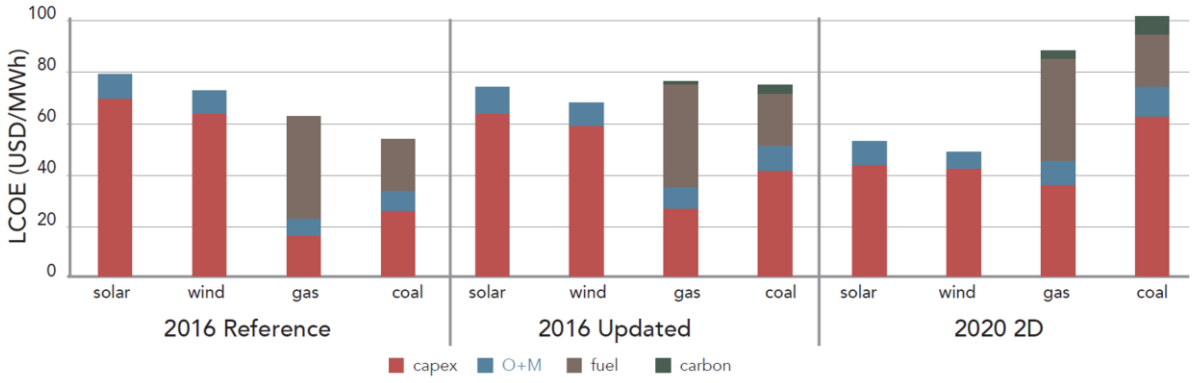
We note that the question of "equity" in carbon budgets is receiving more attention[15]. India particularly is concerned that carbon budgets are set too low for their development needs. The implications are that either the OECD reduces its carbon budget further, or financing flows are used to further help the ramp up of low carbon energy

As an illustration of the potential further scope for falls in renewable energy costs, the chart below shows a more aggressive estimate than BNEF from a recent Carbon Tracker study of the transition of relative average global costs from 2016 reference numbers through updated 2016 operational indicators to a post-2020 low carbon world.

Comparison of LCOE Results Across All Scenarios



Source: CTI Analysis

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[15] https://climateequityreference.org

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Section 4: Asian Thermal Coal Plants And Emissions: High Efficiency Low Emission Plants Cannot Meet 2°C

There are presently some 1020 planned new thermal coal plants in China and India, whether pre-permitted, permitted or already under construction, corresponding to 566GW of potential capacity. Of this total, some 521 plants are under construction, with 270GW of capacity. China dominates, with 389 plants and 205GW under construction. India is presently building 132 plants, with 65GW capacity[16].

Our analysis uses these growth forecasts, and applies accepted emissions intensities and assumes a load factor of 50%, which is above China's recent 46%, but below BNEF's forecast rate in India. We add existing emissions, and a Business As Usual retirement schedule in China (18GW pa rising to 20GW), and compare the resulting emissions growth with China and India's annual and cumulative carbon budgets, interpolated from the IEA ETP 2016.

China dominates the overshoot. We make some generous assumptions: only plants under construction proceed; retirements run at 18GWpa of the subcritical fleet each year up to 2040, then 20GWpa of supercritical are retired up to 2050; and all remaining subcritical plants are converted to USC by 2040. Nevertheless, the annual budget is exceeded in China by 2019 emissions are running at around 4.6 $GtCO_2$ a year at the peak (which also implies some pick up in demand and further pressure on renewable dispatch). Looking at the cumulative budget each year, then that also is exceeded by 2019. The total carbon budget of 80 $GtCO_2$ is exceeded by 2036. This clearly points to the need for even faster retirements and/ or lower load factors of subcritical and eventually supercritical plants. If only existing plants are used as the starting point, the total budget is still exceeded by 2040.

In India, the annual carbon budget rises until 2020 when it starts to decline. If we were to assume that only those power plants under construction today proceeded, and that all subcritical were replaced by USC, then the carbon budget could last until the 2030s, but by the end of that decade would be exhausted. But that's with no new plants agreed after the current. However, India has suggested that OECD countries should bear a larger burden of the carbon budget from an equity stand point, given OECD historical emissions and India's need to grow.

So even using the most efficient power plants and replacing older ones with those over time does not meet the carbon budget.

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[16] Data is based on CoalSwarm, www.EndCoal.org

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High Efficiency Low Emissions Do Not Rescue The IEA Thermal Coal Carbon Budget

Scenario	Year when emissions first exceed annual budget	Year when cumulative emissions exceed cumulative carbon budget to date	Year when cumulative emissions exceed total cumulative carbon budget to 2050	Annual emissions in 2050 ($MtCO_2$)	TWh Produced in 2050
China existing plants only with retirement or replacement with USC	2031	2038	2040	1,553	2,098
India existing only with replacement by USC	2035	2045	2045	853	1,152
China all planned with retirements of existing plants	2019	2019	2033	3,069	3,702
China under construction with retirements of existing plants	2019	2019	2035	2,452	2,940
China all planned with existing plants retired or replaced by USC	2019	2019	2034	2,894	3,759
China under construction with existing plants retired or replaced by USC	2019	2019	2036	2,277	2,997
India all planned with replacement of existing plants with USC	2026	2031	2036	1,527	1,970
India under construction with replacement of existing plants with USC	2032	2039	2040	1,086	1,436

Source: CoalSwarm Ecofys/ETA Analysis

Summary for Policy Makers

Section 5: Meeting 2°C - Potential New Policy Options and Implications For Stranded Assets

The scientific and policy challenge for avoiding serious climate change is to limit global average warming to below 2°C. The analysis in previous sections indicates some hard choices in the energy sector, if the 2°C target is to be met, and the power sector to play a key role in decarbonizing, as is expected.

First, if CCS is to play a part, it must be deployed at scale with a full plan from government for situations where it is most suited. Second, renewable energy must take an increasing part of the energy mix, in a smart, flexible grid with storage. Third, if CCS is not deployed, then renewables and increased efficiency will have to carry the full load. This third scenario would also require much greater early retirement of coal power plants, with implications for asset stranding.

At present, there is no evidence of government planning to support CCS demonstration as a viable technology at scale and reasonable cost. An assumption of significant CCS deployment is therefore a leap of faith. It seems fair to expect IEA assumptions on CCS growth to decline over time, if no evidence of progress emerges.

If current power plant construction proceeds, and CCS fails to be deployed, then meeting the 2°C target will require some forceful policy interventions. First, older subcritical plants could be retired more quickly, something that would be resisted by incumbents and may be very inefficient economically. Incumbents would likely call for subsidies and higher electricity tariffs. Second, all existing coal power stations would face lower load factors over time, and then retirement. Again, managing the economics of this process would be important, with incumbents likely to call for subsidies and higher electricity tariffs. Third, unless other sectors and the economy were to take the strain, then decarbonizing the power sector needs near-zero emissions technologies – renewables and nuclear (if costs and public acceptance improve). Fourth, 24/7 reliability considerations would require a smart, flexible grid with energy storage at scale. Storage is already available, but at relatively high cost. To assume a lower cost scale-up is reasonable, given current and past trends, where a manufacturing focus in China could do for storage what it did for Solar PV. Fifth, a program of Electricity Market Reform will be imperative. For example, in many Asian countries there is no merit curve approach to dispatch low marginal cost renewables first. Instead, coal plants are often guaranteed running hours, even at specific tariffs. China has significant reforms in proposal but policymakers are still pursuing successful implementation.

To conclude, meeting the 2°C target will require governments to show they can implement and perhaps help fund a massive scale-up of CCS transport and storage infrastructure, both for industry (most likely needed) and power sectors, as well as putting more resources into deploying renewable power. If CCS fails then renewables must carry the full load.

Summary for Policy Makers

Potential Policy Action

Given the effort required to meet the 2°C target, it is clear that a critical first policy step will be to extend or introduce moratoriums on new coal power permits and construction, and where feasible, to halt current construction. This first step would be consistent with electricity market reforms including adopting or enforcing least-cost merit order dispatch that favors renewables, and stopping the subsidizing of unneeded coal plants via electricity tariffs.

Implementing a full CCS rollout plan is an option particularly in China, with transport and storage funded where needed, and where applicable by government (potentially through carbon markets). Without such implementation, it is a high risk to assume that CCS will play an effective part in 2°C pathways.

In the longer term, effective emissions caps in the power sector will be key. These could be associated with consumption caps on coal, which are being implemented or looked at in a number of provinces already. Carbon markets could play a key role especially if a price over $100 per tonne could be achieved in the future. Rigorous Performance Standards, which mandate emissions limits per unit of power generation, can ensure a 2°C pathway with or without CCS. Such standards overlap with carbon markets. Annual emissions targets by plant or fleet would fit with load factor management to deliver a 2°C result. Meanwhile, a major scale-up in renewable would require supporting for reliability, through the roll-out of smart grid technologies and storage.

Green financing initiatives are also very helpful in the funding of cleaner energy. The UNEP Inquiry into Design of a Sustainable Financial system sets out many of the opportunities and issues, as does the Climate Bonds Initiative.

For consistency of policy approach, subsidies on fossil fuel consumption and production should be removed. And it will be critical to help exiting workers transition towards new industries, to drive social acceptance**.**

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Summary for Policy Makers

Section 6: Focus On Subsidies

Subsidies for fossil fuel production cause various inefficiencies related to climate change. First, by suppressing prices, they drive higher fossil fuel consumption and therefore carbon emissions, thus pushing the world towards exceeding safe climate limits. Second, they incentivize fossil fuel companies to carry out more risky and uneconomic production and exploration activities, thereby placing countries and companies at financial risk of stranded assets in a carbon-constrained world. Third, by straining treasuries, they divert public resources away from supporting low-carbon energy systems and universal energy access. And fourth, by supporting fossil fuels, they create unfair competition for low-carbon alternatives.

In looking at this topic, ODI argue that Phasing out fossil fuel subsidies is therefore a critical and necessary step to limit the impacts of climate change, reduce air pollution and facilitate the transition to low-carbon energy systems. Removing public support for fossil fuels would help rebalance energy markets, and force industry to operate on a more level playing field with emerging options to provide the same energy services. Ending these subsidies will also free up scarce government resources for development needs and social goods. Recognizing these inefficiencies which directly contradict climate policies, and the benefits from phasing out subsidies, governments led by G20 economies, can look at

- Adopt a 2020 deadline for the phase-out of fossil fuel subsidies with country-specific, measurable outcomes.
- Increase transparency through a publicly disclosed, consistent reporting scheme for all national subsidies for fossil fuels, strengthening the OECD inventory and expanding it to include all countries (using their model for tracking agricultural subsidies).
- Increase transparency of reporting on investment in and finance for fossil fuels by state-owned enterprises and majority publicly owned financial institutions.
- Work closely within international institutions and processes, such as the G20 and APEC, the OECD, the UNFCCC and the Sustainable Development Goals to ensure that any existing incentives for fossil fuel production are eliminated, and to monitor reforms so that no new incentives are established.
- Transfer subsidies from fossil fuel production to support wider public goods, including the transition to low-carbon energy systems and universal energy access.

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Summary for Policy Makers

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