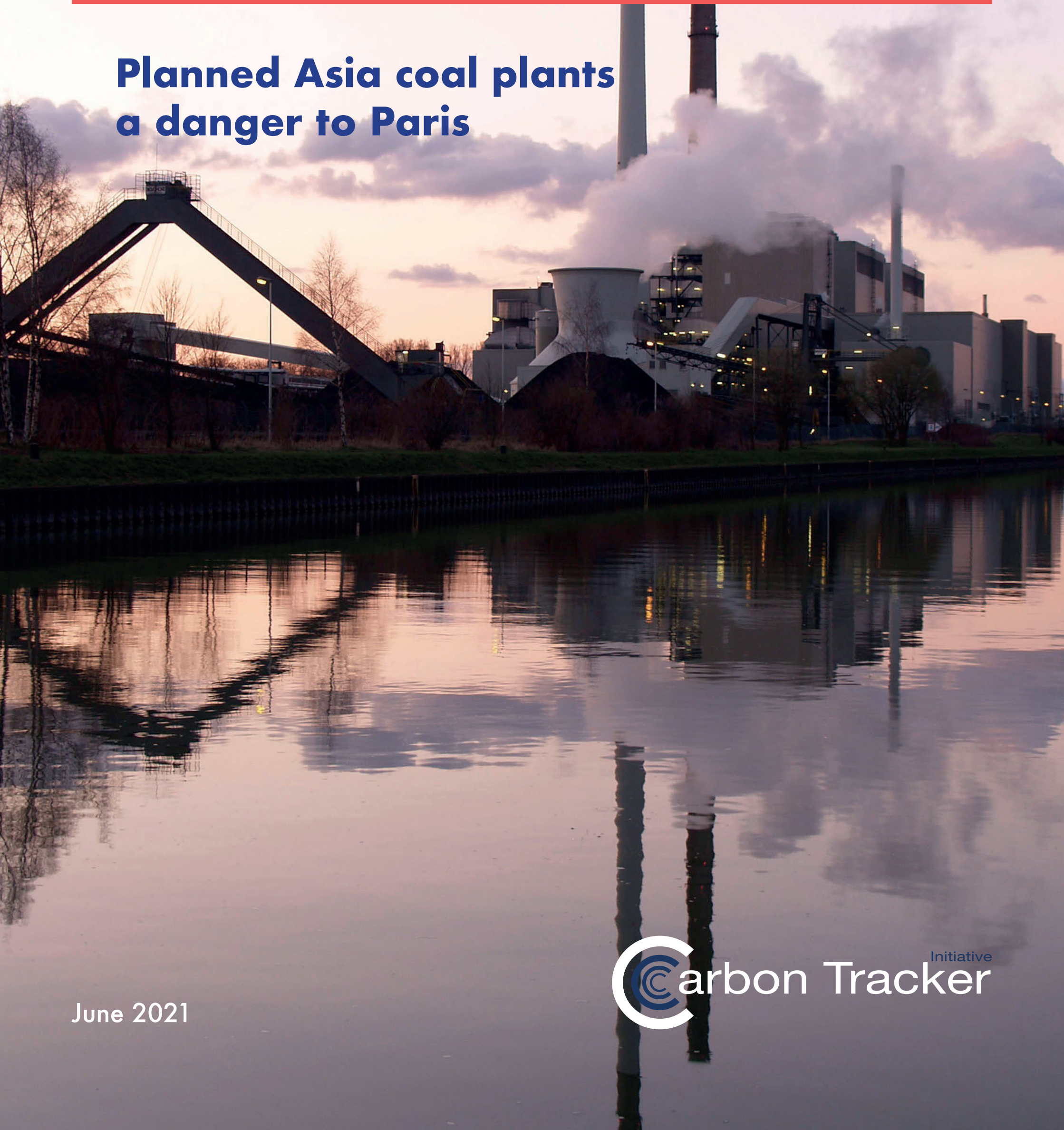
Do Not Revive Coal

Planned Asia coal plants a danger to Paris



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Carbon Tracker Initiative

About Carbon Tracker

The Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's capital markets. Our research to date on unboreable carbon and stranded assets has started a new debate on how to align the financial system in the transition to a low carbon economy.

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1. Key findings

The relative cost competitiveness of renewables versus coal is overwhelming. Investments in new renewables beat investments in new coal in all major markets today when comparing the levelized cost of energy (LCOE) for both.

Our analysis also shows that new renewables today beat 77% of operating coal when comparing the LCOE of renewables with the long run marginal cost (LRMC) of existing coal. By 2026 this will rise to almost 100%.

Progress in cutting coal generation further this decade to limit temperature rises rests almost entirely on developments in the regulated markets of Asia, especially China, India, and the ASEAN nations, which account for around 75% of global coal capacity and 80% of new projects.

27% of the global coal operating fleet is unprofitable today. We find around 70% of the global fleet relies to some degree on policy support and would likely be unprofitable in the absence of market distortions. We find the share of unprofitable plants will rise to 66% by 2040 based on current pollution regulations and climate policies.

The economics of coal are extremely fragile. We estimate that around 30% (600 GW) of the global coal fleet makes a profit of no more than $5/MWh. As capacity factors for coal plants continue to decline, especially in major coal countries like China and India, the economics of coal generation will deteriorate further. A five percent annual reduction in utilisation versus our base case would see global coal unprofitability almost double to 52% by 2030 and rise to 77% by 2040.

We model that under a beyond two degrees scenario (B2DS) $220 bn of operating coal assets would be stranded when compared to a business-as-usual (BAU) scenario. Ten companies alone account for around 40% of the stranding risk of which NTPC and the Adani Group in India, and PLN in Indonesia are by far the most exposed.

Our analysis also shows that new coal plants under construction or in planning are a very risky financial bet. We find a potential of $150 bn in value destruction even assuming BAU, which assumes far more coal use than climate-constrained pathways. These projects should be cancelled.

For new coal plants under B2DS we calculate that around $315 bn of debt, interest and undepreciated assets would remain outstanding. There is a major risk such balances would need to be written off, adversely impacting investors and lenders.

Coal is increasingly unviable both financially and environmentally, and is ceasing to make sense as an option for investors and governments. Instead, enabling market design with a level playing field will allow continued growth of renewables at least cost. Governments should use post-COVID stimulus as an opportunity to lay the foundations for a sustainable energy system.

2. Executive Summary

This report is the third annual report in Carbon Tracker's "Powering Down Coal" series. We have updated our global coal power economics model (GCPEM) which covers ~95% of operating, under construction, and planned coal capacity at boiler-level. We show that the favourable economics of clean renewables over coal continue to abound and that coal economics are extremely fragile. We also introduce our project finance model which builds on our global coal database and enables investors to clearly assess the viability of new coal projects[1] using traditional financial metrics such as net present value (NPV) and internal rate of return (IRR). This also allows a clear ranking of projects and sends an unequivocal message that investing in new coal is a bad bet without subsidies, such as various support structures in Asia.

It is apparent that the new normal for energy, which implies limited carbon budgets, the relative competitiveness of renewables versus coal gaining further ground, and more stringent pollution regulations, leaves little room for coal to play a future role. The COVID-19 pandemic saw a decline in coal generation thanks partly to renewables displacing coal, although expectations are for a partial bounce back in coal generation this year as a result of rising energy consumption. Even with a rebound in energy consumption capacity factors for coal plants continue to decline, owing to a combination of renewables displacing coal power and newly constructed coal plants contributing to oversupply. This is especially evident in major coal countries like China and India, meaning the economics of coal generation will deteriorate further. A number of economies directed a material portion of stimulus spending to clean energy, but still could not ignore the fossil fuel sector. As our report shows, this comes at a big economic and climate risk.

2.1 Pandemic kickstarted the final days of coal

The COVID-19 pandemic witnessed a record 4% (-346 TWh) decline in coal generation in 2020, with all countries apart from China, the biggest global user of coal, seeing falls[2]. Part of this decline was owing to lower electricity demand, but was partly attributable to coal being displaced by wind and solar, which grew by 15% (+314 TWh) year over year. We see the trend of renewables displacing coal as irreversible. In the UK, for example, renewables provided more of the country's electricity than fossil fuels[3]. Moreover, a significant portion of global stimulus spending has been earmarked for green projects.

Nevertheless, the International Energy Agency (IEA) in its most recent global energy outlook predicts 2021 to have the largest increase in energy-related carbon emissions since 2010, driven by a rebound in the use of coal in Asia, with demand expected to grow 4.6% and coming close to the 2014 peak. Much of the increase is down to a revival of coal being used for electricity generation in China. If the IEA's forecasts hold true, around 80% of the decline in 2020 would be reversed with emissions rebounding to just below 2019's peak[4,5]. The

1 New coal projects include plants under construction or in planning i.e., permitted or in the pre-permit phase

2 Global Electricity Review 2021 - Global Trends (ember-climate.org)

3 Renewables outstrip fossil fuels in UK in 2020 - reNews - Renewable Energy News

4 Coal and gas rebound puts carbon emissions on track for 2021 surge | Financial Times (ft.com) only available with subscription

5 Global Energy Review 2021 (iea.org)

silence from large polluting countries, including China and India, on more aggressive climate measures at the recent Leaders Summit on Climate spoke volumes and suggests they still have internal priorities that conflict with addressing climate change.

Progress in cutting coal generation further this decade to limit temperature rises rests almost entirely on developments in the regulated markets of Asia, especially China, India, and the ASEAN nations, which account for around 75% of global coal capacity and 80% of new projects. Indeed, capacity factors in China and India have declined over the last four years, with further declines over the medium-term likely as tighter pollution regulations come into force, low cost renewables continue to displace coal, and higher carbon prices take hold, most notably in China.

2.2 Vast majority of new coal will be value destructive

In *How to waste over half a trillion dollars*, published in March 2020, we found that thanks to declining costs, clean energy continued to displace coal as the low cost option for energy generation in all major markets, when comparing the LCOE for both. Cost reductions in renewable sources is a global trend which we expect to continue this decade as clean technologies are deployed along learning curves.

Some investors and policymakers are ignoring the risks of investing in new coal plants in light of both adverse economic and climate arguments. For example, Vietnam in its latest draft Power Development Plan still plans on building new coal plants this decade[6] and China in its 14th five-year plan referenced promoting the "clean and efficient" use of coal[7] underpinned by its large project pipeline. New coal plants are still being built and planned, which typically implies a commitment of at least 40 years. This is a risky bet as these coal plants are highly unlikely to generate a return above their cost of capital over the project lifetime as a cocktail of carbon pricing, lower cost renewables continuing to displace fossil fuels, and tight carbon budgets in the wake of net zero announcements leave limited space for running polluting coal plants and may lead to early closures driven by policy decisions.

2.3 $150 bn of negative NPV in new coal projects

We complement the data and analysis from Carbon Tracker's global coal database with our new project finance model for under-construction and planned coal plants. We look at the five countries with the biggest development pipelines. This incorporates over 600 projects[8] just over 300 GW and represents 80% of all global projects. Instead of simply focusing on the overnight investment costs of a project, we consider operating profits, debt financing obligations, and tax expenses. We use BAU as a reference scenario and B2DS as the climate-constrained alternative.

6 Vietnams-PDP8-Should-Be-a-Catalyst_Not-a-Barrier-to-Change_March-2021.pdf (ieefa.org) p.3
7 Three key points for power generation from China's five-year plan (power-technology.com)
8 Pipeline data provided by Global Energy Monitor (GEM)

PROJECT FINANCE MODEL

We calculate after-tax cashflows of each new under-construction and planned project for the five countries with the largest development pipelines: China, India, Japan, Indonesia, and Vietnam. Together, these countries account for over 600 projects totalling over 300 GW and representing 80% of total new coal projects globally. Data for under construction and planned projects was obtained from Global Energy Monitor (GEM).

We estimate overnight investment costs and forecast operating profits, debt financing obligations, and tax expenses to determine a project's viability.

Investment costs are dependent on boiler type and are taken from the IEA with the exception of China where a local source is used. Operating profit forecasts are based on the modelling assumptions used in our global coal power economics model. For example, in the case of China capacity factors and power tariffs are estimated at the provincial level whereas carbon prices are applied at the country level.

Interest rate assumptions were estimated at the country level and derived from specific country sources. Corporate tax rates were estimated at the country level and sourced from KPMG. We also assume a debt financing term of 20 years and a depreciation term of 40 years. Construction periods are assumed to be three years for China and Japan, and four years for India, Indonesia, and Vietnam.

We estimated a country weighted average cost of capital (WACC) assuming a split of debt-to-equity of 75/25. We did not calculate a project specific WACC because in many cases such granular data was not available or was extremely limited. To derive the WACC we filtered utility companies at a country level according to Bloomberg Industry Segments Classification (BICS) data. Where available we compared the WACC we calculated to industry WACC as calculated by Damodaran as a sense check.

Country	Total GW planned	Average size of project MW	Average capex per project $m	WACC	Interest rate on debt	Tax rate
Japan	8.5	608	1,614	2.6%	0.9%	31%
Indonesia	23.6	220	379	9.8%	3.5%	22%
India	59.8	650	981	7.2%	1.5%	30%
Vietnam	23.8	579	927	5.1%	1.5%	20%
China	187.1	508	195	4.5%	2.0%	25%

More detailed modelling assumptions and information on all sources are available in the coal methodology document which is included in section 5.1 of the appendix.

As shown in figure 1, 92% of projects under construction or in planning would have a negative NPV under BAU. We find that new projects are at risk of providing value destruction of around $150 bn under BAU. This is a relevant investment signal to investors to avoid committing capital to new coal projects with many likely to generate negative returns from the outset, even under the more optimistic BAU scenario. These new coal plants should be cancelled.

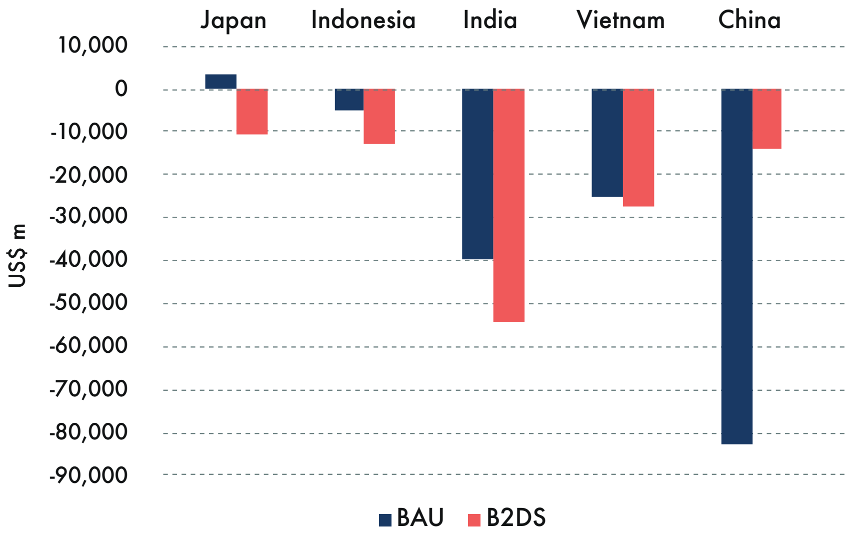
Figure 1 GLOBAL NEW COAL PROJECTS ECONOMICS

Country	Total NPV of Projects under BAU ($m)	Total GW planned	GW of Projects NPV negative BAU	% of Projects NPV negative BAU
Japan	3,402	8.5	1.1	12%
Indonesia	-4,731	23.6	15.2	64%
India	-39,752	59.8	51.7	86%
Vietnam	-24,919	23.8	23.4	99%
China	-82,937	187.1	186.7	100%
Total	**-148,937**	**302.7**	**278.1**	**92%**

Source: Carbon Tracker analysis

Under B2DS the NPV of projects would remain negative although marginally less than under BAU. This might seem counterintuitive but our modelling suggests that China in particular is susceptible to operating losses in the later years of new projects as capacity factors fall and rapidly rising carbon prices in late years mean revenues are insufficient to cover costs. Therefore, such a forecast would benefit from early closure under B2DS. A key modelling assumption is that unprofitable coal units would remain in operation under BAU as is the case with loss making operating units in China currently (we find around 30% of operating capacity in China is currently loss making). Nevertheless, it is possible that unless new projects receive financial aid from the government that they would close early under BAU anyway. This would be expected to be the case in non-regulated markets where market forces would prompt closures of unprofitable plants but may not happen in a regulated market like China. As can be seen in figure 2, for all other countries B2DS presents a more challenging scenario with 100% of projects in Japan and Vietnam, 89% in Indonesia, and 93% in India at risk of creating a more negative NPV.

Figure 2 NPV OF NEW COAL PROJECTS UNDER BAU AND B2DS

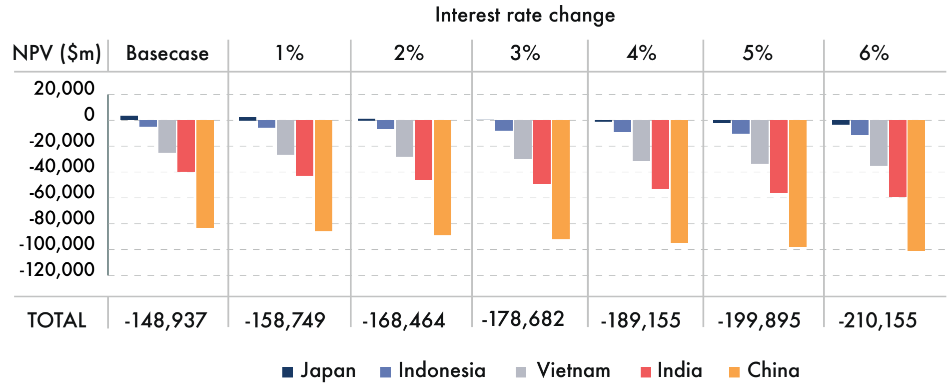


Source: Carbon Tracker analysis

As the world moves to limit carbon emissions and avoid the worst effects of climate change, continuing to invest in assets that do not fit within B2DS is a risk. B2DS generally represents an economic risk to investors and taxpayers being shouldered with greater project losses as well as a greater risk of default on outstanding debt and interest payments, and undepreciated asset balances, which would need to be written off owing to earlier-than-expected plant closures. We cover these points in detail in section 3.

Given the fragility of new coal economics, projects are very sensitive to changes in key inputs. We find that relatively small changes in debt costs often render new coal projects significantly less attractive. As can be seen in figure 3, every 1 percentage point (ppt) increase in the cost of debt over the base case would on average render an additional $10 bn in negative NPV. A modest 2 ppt increase in debt costs would see a total negative NPV of around $170 bn. We are already assuming comparatively low costs of debt across the five countries, ranging from 1% to no more than 3.5%. We believe as fewer lenders are willing or able to support coal financing, the scarcity of funding will drive up interest costs.

Figure 3 CHANGES IN NEW COAL ECONOMICS TO CHANGES IN DEBT COSTS



Source: Carbon Tracker analysis

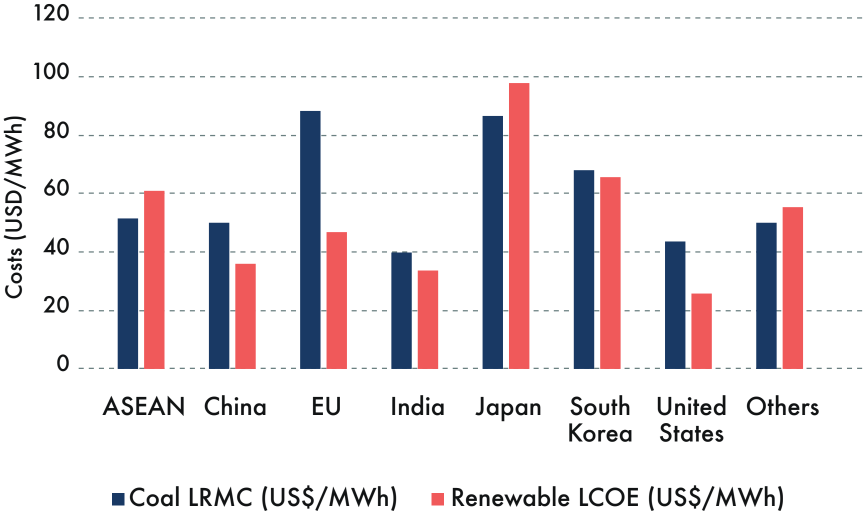
Although we do not assume carbon pricing in jurisdictions where it does not currently exist, project economics would be adversely impacted if a carbon price were to be introduced. When a project is sensitive to relatively small changes in key assumptions, the economics look increasingly shaky. A confluence of lower capacity factors, which has already been evinced in China and India as renewables crowd out coal, and higher debt costs, as the era of easy money ends at some point, would render even more of these projects a value destructive strategy, even assuming generous BAU timelines.

2.4 Economics of existing coal continue to deteriorate with stranding risk of $220 bn

2.4.1 Cost competitiveness

Existing coal continues to lose economic ground to low cost renewables. COVID-19 saw a record fall in coal power globally owing partly to the ongoing displacement of coal plants by renewable sources. We find that 77% of the global coal operating fleet is higher cost than new renewables today (1,600 GW) and this will rise to 98% by 2026 and 99% by 2030 (2,100 GW) based on current pollution regulations and climate policies when comparing the LCOE of new renewables to the LRMC of existing coal units as shown in figure 4.

Figure 4 LRMC OF COAL VERSUS LCOE OF RENEWABLES TODAY



Source: Carbon Tracker analysis

We cross-checked our LCOE estimates for solar photovoltaics (PV) and onshore wind with estimates from BloombergNEF (BNEF). Broadly speaking we find that the mid-range of our estimates are within the mid-to-low country ranges forecast by BNEF. For example, for onshore wind in China, our estimate is 11% lower than BNEF's mid-range and 15% higher than the low range. For Japan, we are 8% lower than BNEF's mid-range and 18% higher than the low range. For solar PV in Unites States our mid-range estimate is 24% and 8% below the mid- and low-range estimates of BNEF, respectively. Details of our modelling for LCOE and LRMC can be found in the coal methodology document which is included in section 5.1 of the appendix of the report. Charts showing a comparison of our country estimates versus BNEF for onshore wind and solar PV can be found in section 5.2 of the appendix.

2.4.2 Profitability

When assessing operating profitability[9], we find that 27%[10] of the global coal operating fleet is unprofitable today. This will rise to 66% by 2040 based on current pollution regulations and climate policies. It is worth highlighting that owing to market distortions[11] in regulated and semi-regulated market structures which benefit legacy coal operators, especially in Asia, existing coal plants are being propped-up by subsidies and policy-driven support. Such policies cause consumers to not benefit from the least cost and cleanest energy solution.

2.4.3 Net zero ambitions are incompatible with unabated coal power

Around two thirds of the global economy, including several major Asian coal users, have now announced net zero ambitions[12] which will require material declines in the use of fossil fuels. A number of net zero plans are lacking in short-term goal posts and some are vague in how a country will reach its long-term net zero goals. We think that net zero is incompatible with continuing to prop up coal plants, which is often the case in Asia, through market distortions and that coal phase outs are imminent as is already occurring in the UK and several EU countries. This means that many plants will not run for their full useful life as anticipated at project inception. This gives rise to potential stranding risk.

We model that under B2DS operating coal assets would be subject to $220 bn of stranding[13] when compared to a BAU scenario. Ten companies alone account for around 40% of the stranding risk of which NTPC and the Adani Group in India and PLN in Indonesia are by far the most exposed. This is a material risk which could transpire if a country phases out coal sooner than companies are currently planning for under a BAU scenario. A combination of limited carbon budgets under a Paris-aligned outcome and deteriorating economics for coal power means operating coal plants under BAU principles will not be sustainable and early closures will therefore likely be driven by a mix of economics and policy. This is a salient signal to investors: by committing money to operating coal assets there is a significant risk of either not recouping the investment or achieving an investment return below what was originally expected. We develop unit-level retirement schedules which are available on request.

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9 *We define profitability as revenues (in-market and out-of-market revenues) less long run marginal costs. We do not assume revenue or cost hedging in our modelling. Our methodology is covered in detail in the coal methodology document available in the appendix*

10 *In our report Political decisions, economic realities, published in April 2020, we found 41% of the global coal fleet was unprofitable in 2019 compared to our expectations of only 27% in 2021. The difference is down to a change in modelling methodology and better data*

11 *Market distortions are typically prevalent in regulated markets or semi-regulated markets where competition is often low or absent, especially from low-cost renewables, and reflect market inefficiencies. These markets are characterised by mechanisms such as fixed returns or cost pass-through structures via Power Purchase Agreements (PPAs). In addition, generous capacity payments are often available for coal generators in these markets. Therefore, unit profitability can be supported by such market distortions and those units which are loss making for extended periods may not necessarily close anyway as costs can be passed on to consumers or taxpayers*

12 *China, Japan, and South Korea have all announced net zero ambitions*

13 *We calculate stranding for operating units as the difference in the net present value of operating profits (revenues less long run marginal costs) between BAU and B2DS. Our calculation for operating units assumes there is no debt or asset balance outstanding, which may not be the case*

Our analysis also shows that under BAU, annual global emissions of CO_2 from coal plants are projected to be 8 bn tonnes by 2030 and around 7 bn tonnes by 2040, which compares to just over 9 bn tonnes projected this year. Under a B2DS pathway these emissions would halve by 2030 and by 2040 there would be annual net emissions savings of around 7 bn tonnes as 99% of unabated coal generation is phased out, roughly equivalent to emissions from the second (US) and third (India) largest polluting countries combined[14].

2.5 Weak coal economics highlighted by sensitivity to key factors

We estimate that around 30% (600 GW) of the global coal fleet makes a profit (revenues less costs) of no more than $5/MWh i.e., very close to break-even levels. To highlight the fragile state of existing coal economics we conducted a sensitivity analysis of coal plant profitability to changes in capacity factors. Capacity factors are the direct reflection of the structural demise of coal and globally continue to decline as clean energy displaces coal. Not surprisingly, those units operating close to break-even levels i.e. with revenues just about covering their costs are most susceptible to being pushed into loss-making territory. We find the biggest impact to global coal profitability occurs when capacity factors are 5% lower than our base case under BAU. In this scenario unprofitable units almost double to 52% from 28% by 2030. A reduction in capacity factors between 7.5% to 10% versus our base case results in negligible change in global coal profitability in 2030 and 2040. This serves to highlight that many coal plants are most sensitive to modest falls in utilisation, especially for those units hovering around break-even levels, something which could have an outsized effect on global coal profitability, underlining the comparatively weak economics.

2.6 High-level recommendations

Investors

- **Cancel all new coal projects or face $150 bn in value destruction for investors and tax payers.** New coal is an extremely risky investment. As our modelling shows, coal is not a least-cost option and operating periods will likely be cut short as tighter pollution regulations come into force to limit global warming. Even under BAU the vast majority of new projects do not look financially viable.

- **It is clear the debate around coal investment is not simply an Environmental, Social, and Governance (ESG) issue.** Fundamental reasons exist as to why new coal projects and majority coal generating power companies are risky investments over the medium-term. Investors need to understand the risks so that this is reflected in their activities.

14 bp Statistical Review of World Energy 2020) 2019 emissions data

Governments and Policy Makers

- **Governments should use post-COVID stimulus as an opportunity to lay the foundations for a sustainable energy system.** According to data from Energy Policy Tracker, 31 major economies and 8 multilateral development banks pledged $330 bn to fossil fuel-intensive sectors, which was 42% of the total, and more than the 36% directed to clean energy[15]. This imbalance risks end users getting a poorer deal in terms of higher energy prices and higher emissions than if the money was directed to clean resources.

- **Enabling market design with a level playing field allows continued growth of renewables at least cost.** Flexible, stable, and smart grids along with storage are both, from a technical and economic perspective, crucial to enable a transition away from coal towards renewables. A level playing field should also exist to enable renewables to compete fairly with fossil fuels. Policies which preference coal (and other fossil fuels) over clean energy need to be challenged and removed.

- **In many cases, especially in Asia, governments should resist the urge to switch from coal to liquefied natural gas (LNG).** This would not only fail to deliver the emissions savings needed to meet goals but also, in particular where capacity markets exist, push up electricity prices for consumers and/or increase government subsidies, e.g. Bangladesh and Pakistan. Moreover, shifting to LNG would see higher price volatility, e.g. Japan earlier this year[16]. Adopting renewables is typically not only the least cost solution but can also, when accompanied with adequate grid investments along with storage, lead to better financial, consumer, and environmental outcomes.

15 Energy Policy Tracker - Track funds for energy in recovery packages data as of 2 June 2021
16 LNG rally heralds more volatile gas prices to come | Financial Times (ft.com) only available with subscription

3. Vast majority of new coal will be value destructive

We complement the data and analysis from Carbon Tracker's global coal power economics model with our new project finance model for under-construction and planned coal plants. The purpose of the model is to assess the viability of a coal plant project over its lifetime by calculating each project's NPV and comparing the project WACC to the IRR. The NPV is the sum of the future cash flows of a project discounted at the WACC. The IRR is the discount rate (required return) when the NPV is equal to zero. When IRR is less than WACC this results in a negative NPV, which should be taken as a signal to cancel the project. We also show sensitivity to changes in debt costs and how these could impact project feasibility. For simplicity we aggregate project level data by country to reveal the big picture.

3.1 Using NPV and IRR shows investors that coal is a bad bet under any scenario

We use BAU as a reference scenario and B2DS as the climate-constrained alternative. Under a BAU scenario we assume that each coal plant will run for 40 years. We calculate the IRR[17] and NPV of each project under BAU and B2DS, which would see a sharp curtailment of the coal plant's operating life, more often than not when debt repayments still fall due and the coal plant is not fully depreciated. In many instances the comparison to B2DS is superfluous given how the vast majority of projects are NPV negative even under BAU.

The B2DS achieves net zero emissions by 2060, and we have previously estimated it is associated with an approximately 1.6 degree warming based on emissions to this point. In this scenario emissions will decline rapidly prior to 2040 meaning virtually all unabated coal plants will need to be phased out at the latest by 2040 and many much earlier. Our modelling identifies the year when a coal unit needs to be retired[18]. We select this scenario as it is one of the most ambitious (but achievable) of the IEA scenarios[19], for which detailed underlying data is available, and reflects the limited carbon budget available to achieve the Paris Agreement goals.

17 IRR is calculated via a finite iterative process i.e., via systemic trial and error. An IRR cannot always be calculated, for example where the project cash flows are all negative. In such instances we cross-check results with the NPV, which is not iterative and can thus be calculated, to determine whether the IRR would have been higher or lower than the WACC

18 More details on our B2DS modelling can be found in the coal methodology document in the appendix

19 The IEA Net Zero by 2050 report published in May 2021 came out after the writing of our report. Although we have not yet had the chance to incorporate the new information into our modelling, we note that key goalposts for the pathway to net zero and limiting the temperature rise to 1.5 degrees include no new unabated coal plants approved for development, phase-out of unabated coal in developed economies by 2030 and phase out of all unabated coal plants by 2040. If anything this renders BAU an even less realistic pathway and suggests B2DS should become a base case pathway

The NPV under these two scenarios offers investors and developers a quick tool for seeing how project economics change and whether, under either scenario, the project IRR would exceed the WACC, and thus be likely to generate positive value for investors or taxpayers. For simplicity we aggregate the project NPVs under BAU at a country level to highlight the level of potential value destruction. In many cases the NPV under BAU is negative, which is a signal that the project should not proceed in the first place let alone with anticipated future trends in renewables deployment and policy development.

Figure 5 GLOBAL NEW COAL PROJECT ECONOMICS UNDER BAU AND B2DS

Country	Total NPV of Projects under BAU ($m)	Total NPV of Projects under B2DS ($m)	Total GW planned	% of Projects NPV negative BAU	% of Projects NPV negative B2DS
Japan	3,402	-10,462	8.5	12%	100%
Indonesia	-4,731	-12,722	23.6	64%	89%
India	-39,752	-54,310	59.8	86%	93%
Vietnam	-24,919	-27,151	23.8	99%	100%
China	-82,937	-13,893	187.1	100%	69%
Total	**-148,937**	**-118,538**	**302.7**	**92%**	**78%**

Source: Carbon Tracker analysis

As can be seen in figure 5, 92% of all projects (278 GW) under a BAU scenario already generate a negative NPV meaning the return (IRR) is less than the hurdle rate (WACC). Even with very modest cost of debt and WACC assumptions only 25 GW (8% of total new capacity) of new projects have a positive NPV, of which India and Indonesia are the largest single countries (8 GW each). Indeed, most projects have a negative NPV. This offers a stark conclusion: the vast majority of new coal projects will be value destructive.

Under B2DS the NPV of projects would remain negative although less so than under BAU. This might seem counterintuitive but our modelling suggests that China in particular is susceptible to operating losses in the later years of projects as capacity factors fall and revenues are insufficient to cover costs, driven by higher carbon prices in later years. Therefore, such a forecast would benefit from early closure of plants under B2DS. A key modelling assumption is that unprofitable coal units would remain in operation under BAU as is the case with existing loss making units in China, which currently represent around 30% of Chinese capacity. Nevertheless, it is possible that unless these projects received financial aid from the government that they would close early under BAU anyway. This would be expected to be the case in non-regulated markets where market forces would prompt closures of unprofitable plants but may not happen in a regulated market like China. For all other countries B2DS presents a more challenging scenario with 100% of projects in Japan and Vietnam, 89% in Indonesia, and 93% in India at risk of stranding.

All new projects should be cancelled or risk significant value destruction.

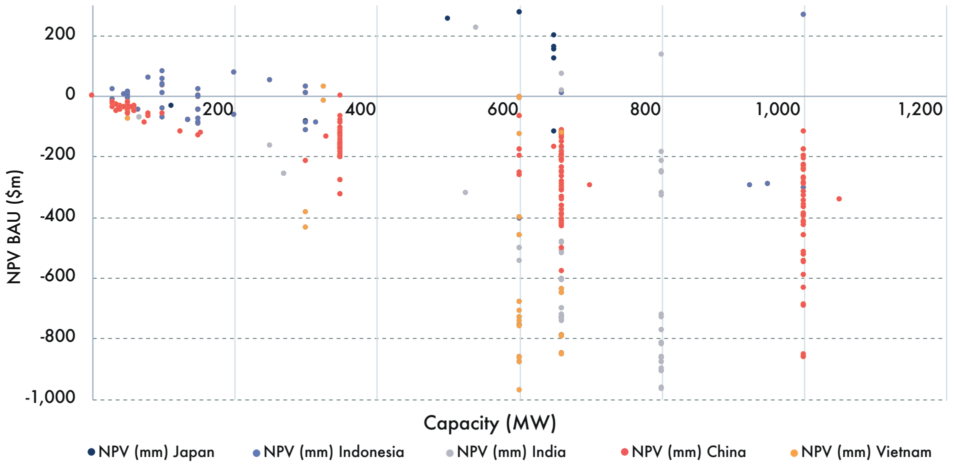
3.2 $150 bn of negative NPV in new coal projects under BAU

We assume that a developer and lender will only greenlight a project when the IRR is higher than the required hurdle rate (WACC) and therefore generates a positive net present value i.e., the decision to build is a rational economic decision rather than one based on non-financial reasons. Aside from this we do not assume that larger projects with lower IRRs but comparatively higher cash flows are more or less likely to proceed than smaller projects with higher IRRs but comparatively lower cash flows. All in we estimate $150 bn of potential value destruction if these projects proceed under a BAU scenario.

With the exception of Japan, the majority of projects under BAU in all individual countries are NPV negative. In many cases the operating profitability or EBITDA (revenues less costs) is already relatively fragile. Once other costs are also included, such as taxes, loan repayments, and upfront capital costs, these projects are often unviable. We assume that some of these projects will proceed regardless and take this as an indication that forces other than economic and market rationales are at work in those countries.

We urge for such distortions to be removed and for all new projects to be cancelled.

Figure 6 NPV AND CAPACITY PROJECT SCATTERPLOT

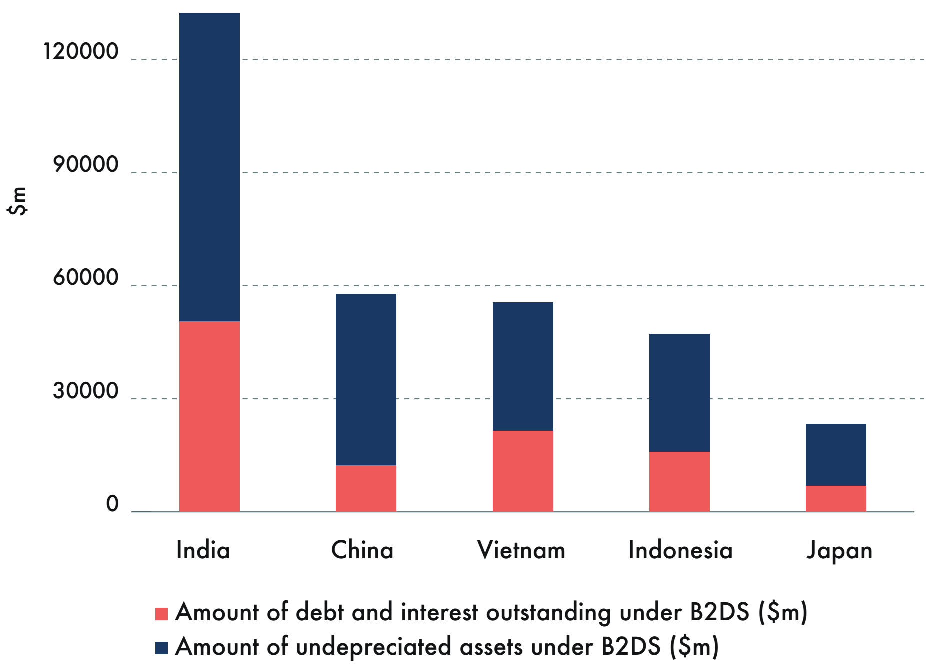


Source: Carbon Tracker analysis

As shown in figure 6, the overwhelming number of projects, regardless of project size, generate a negative NPV of anywhere up to -$1 bn.

3.3 $315 bn of debt, interest, and undepreciated assets outstanding under B2DS

Figure 7 DEBT, INTEREST, AND UNDEPRECIATED ASSET BALANCE UNDER B2DS



Source: Carbon Tracker analysis

As can be seen in figure 7 above, we find that under B2DS there would be material undepreciated asset balances for each country analysed. We calculate an aggregate undepreciated asset balance of around $210 bn, which would be at risk of write off if operations were cut short because of B2DS and assuming there had been no prior write downs. India and China account for over half of this amount and are most exposed under B2DS. Any write offs would have a negative impact on the balance sheet of the developing company and, in theory, would make it less valuable. We do not model write downs prior to the end of the project but note the possibility that write downs would occur prior to the end of the project life under both BAU and B2DS. Either way large write downs should be seen as a red flag by investors[20] as they reflect the poor decisions made by company management which destroys shareholder value. It is also the case that investors would need to anticipate such write downs well in advance of them happening and reduce exposure accordingly as equity markets tend to look ahead to such events well before they actually occur. For state-owned companies, and thus taxpayers, the losses are harder to avoid as the government will often step in and there is little the taxpayer can do about it.

20 Big Write-Downs Usually A Red Flag For Failed Management (forbes.com)

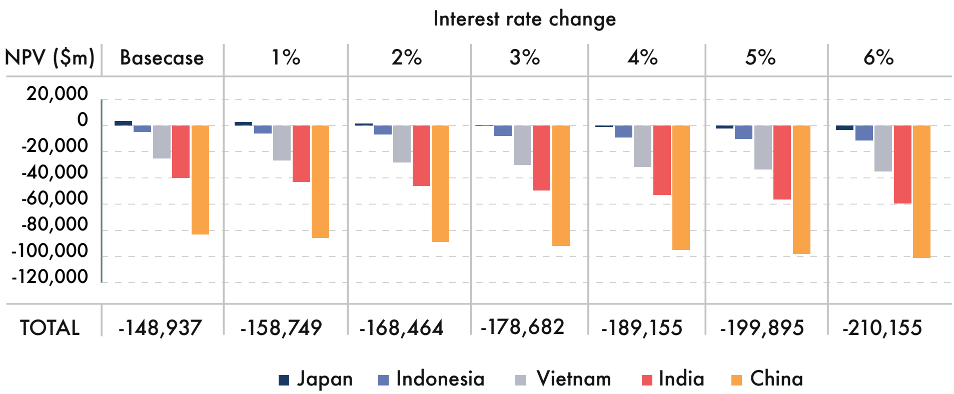
Our analysis also shows that around $105 bn of debt and interest would remain outstanding under B2DS. This means that once plants are closed early, there will be no cash flows to service the debt and interest payments. This is a wake-up call to lenders.

3.4 Projects are very sensitive to changes in debt costs

To illustrate how fragile the economics of new coal projects are, we conducted a sensitivity analysis of project NPV to changes in the cost of debt. We think the spread on debt for future coal projects will rise given the increasing scarcity of willing lenders owing to the risky economics of new coal projects[21], central bank tightening at some point, and pressure from bank shareholders to cease lending to new coal.

For ease of reference, we aggregate the findings at a country level. This should enable readers to assess the relative risk at a high level and rank countries accordingly. However, each project within a country will have its own dynamics (location, boiler efficiency, boiler type, etc) and any conclusion should be drawn with reference to the specific project in mind.

Figure 8 SENSITIVITY OF NPV TO CHANGES IN DEBT COSTS



Source: Carbon Tracker analysis

Our analysis shows that project economics are extremely sensitive to changes in interest costs. As shown in figure 8 above, every 1 percentage point (ppt) increase in the cost of debt over the base case would on average render an additional $10 bn in negative NPV. A modest 2 ppt increase in debt costs would see a total negative NPV of around $170 bn. We are already considering comparatively low costs of debt across the five countries ranging from 1% to no more than 3.5%.

Although we do not assume carbon pricing in jurisdictions where it does not currently exist, project economics would be adversely impacted if a carbon price were to be introduced. When a project is sensitive to relatively small changes in key assumptions, the economics look increasingly shaky. A confluence of lower capacity factors, which has already been evinced in China and India as renewables crowd out coal, and higher debt costs, as the era of easy money ends, would render even more of these projects a value destructive strategy, even assuming generous BAU timelines.

21 [Coal financing costs surge as investors opt for renewable energy | Coal | The Guardian]

3.5 Country economics shows limited variation and consistent value destruction

Below, we briefly highlight the key findings at a country level from our project finance analysis and break down the aggregate undiscounted cash flows to highlight the weak elements of new coal plant economics. We include a unit level case study, which provides project specific forecasts and key financial ratios, to illustrate the micro economics of an individual unit. This also shows how unit specifics drive NPVs and IRRs across the five countries. The aggregate totals at the country level (provided below) are the sum of the outputs at the individual project level.

CASE STUDY INDONESIA – 660 MW UNIT

The case study covers the second of two units, each with a capacity of 660 MW, for a coal power plant to be developed in Indonesia.

We assume a total investment cost of $1.2bn, a four year construction period starting in 2021 with the equity portion of the investment cost ($300m) spread evenly over the four years. The unit is expected to start operations in 2025 and run for 40 years under BAU. We assume a stable capacity factor of 62% and an average efficiency of the boiler of 41%. Fuel costs are estimated to average $16/MWh over the life of the project. There is currently no carbon pricing in Indonesia although a recent announcement by the government suggests carbon prices could be imposed in the future. Should this be the case, project economics would likely be even worse than our numbers below imply.

We calculate an IRR of 10% under BAU, slightly above the estimated WACC of 9.8%. The project is expected to generate a positive NPV of $7m under BAU. Over the life of the project the average EBITDA margin is expected to be 48% with an average debt service coverage ratio (DSCR) of 1.5x.

We think a BAU scenario is unlikely to prevail globally given a confluence of limited carbon budgets, tighter pollution restrictions, and low cost renewables continuing to displace coal plants. To reflect this we use B2DS as an alternative scenario. Under B2DS this unit would be forced to retire by 2042, giving it around 20 fewer years to recoup its original investment and leaving three years of loan repayments still to be made. Under B2DS we calculate the unit would generate an IRR and negative NPV of 4.1% and $103m, respectively.

Continues overleaf

Indonesia 660 MW Unit										
Financial Statements US$m	2024	2025	2026	2027	2028	2041	2061	2062	2063	2064
Revenues	0	219	219	219	219	219	219	219	219	219
Costs	0	-111	-111	-111	-111	-113	-115	-115	-115	-115
EBITDA	**0**	**108**	**108**	**107**	**107**	**106**	**104**	**104**	**104**	**104**
Depreciation	0	-30	-30	-30	-30	-30	-30	-30	-30	-30
EBIT	**0**	**78**	**78**	**77**	**77**	**76**	**74**	**74**	**74**	**74**
Interest	0	-30	-28	-27	-25	-5	0	0	0	0
EBT	**0**	**48**	**49**	**51**	**52**	**71**	**74**	**74**	**74**	**74**
Taxes	0	-12	-12	-13	-13	-18	-18	-18	-18	-18
Net Income	**0**	**36**	**37**	**38**	**39**	**53**	**55**	**55**	**55**	**55**
Loan installments	0	-45	-45	-45	-45	-45	0	0	0	0
Investment cost (equity portion)	-75	0	0	0	0	0	0	0	0	0
After-tax cash flow	**-75**	**21**	**22**	**23**	**24**	**38**	**85**	**85**	**85**	**85**
Net debt/EBITDA		8.1	7.7	7.3	6.9	1.6	-	-	-	-
EBITDA margin (%)		49.2	49.2	49.1	49.1	48.5	47.5	47.4	47.4	47.3
DSCR		1.3	1.3	1.3	1.3	1.8	-	-	-	-
Asset balance $m		1,172	1,142	1,112	1,082	691	90	60	30	-
Loan balance $m		857	812	766	721	135	-	-	-	-
WACC	9.8%									
IRR BAU	10.0%									
IRR B2DS	4.1%									
NPV BAU (US$m)	7									
NPV B2DS (US$m)	-103									

Under B2DS unit 2 would have an undepreciated asset balance of around $690m and total debt and interest outstanding of $135m. This would likely lead to a material asset write off (assuming no prior write downs) and debt and interest that would likely default as there would be no further cash flows to service the debt.

China

China has 187 GW of new coal under construction or in planning, representing half of the global project pipeline. We find that 100% of projects (187 GW) are unviable on a BAU basis because their NPV is negative. This falls to 69% (128 GW) under B2DS as losses are for some projects are averted through early closure. We acknowledge that new coal projects may go ahead, even when the economics do not stack up, for non-financial reasons, which are outside the scope of our analysis.

FIGURE 9 CHINA AGGREGATE PROJECT LIFETIME CASH FLOWS BAU

Country	Years				
$m	**Pre-operation**	**to 2030**	**to 2040**	**to 2050**	**to end of project**
EBITDA (revenues less costs)		47,656	28,932	-71,910	-548,467
Debt payments (interest and principal)		-29,848	-30,136	-4,062	0
Taxes		-7,276	-4,852	-3,647	0
Investment cost (equity portion)	-17,941	0	0	0	0
Undiscounted cashflows	**-17,941**	**10,532**	**-6,057**	**-79,619**	**-548,467**
Total capex ($m)	**71,765**				

Source: Carbon Tracker analysis

As can be seen in figure 9, operating profitability sharply deteriorates from the 2040s but even in the 2030s profitability is unable to fully cover debt payments. This is driven by lower utilisation rates and higher costs (rising carbon prices[22]). This is the main driver of the weak economics of new projects under BAU. Under B2DS losses are averted through early closure, explaining why fewer projects generate a negative NPV. A key modelling assumption is that unprofitable coal units would remain in operation under BAU as is the case with existing loss making units in China currently (we estimate around 30% of operating capacity in China is currently loss making). Nevertheless, it is possible that unless new projects received financial aid from the government that they would close early under BAU anyway. This would be expected to be the case in non-regulated markets where market forces would prompt closures of unprofitable plants but may not happen in a regulated market like China.

22 We estimate carbon prices average $7/MWh in the 2030s, $21/MWh in the 2040s, $42/MWh in the 2050s and $76/MWh thereafter

India

India has 60 GW of new coal under construction or in planning, representing 15% of the global project pipeline. We find that 86% of projects (52 GW) are unviable on a BAU basis because their NPV is negative. This rises to 93% (56 GW) under B2DS. We acknowledge that new coal projects may go ahead, even when the economics do not stack up, for non-financial reasons, which are outside the scope of our analysis.

Figure 10 INDIA AGGREGATE PROJECT LIFETIME CASH FLOWS BAU

Country	Years				
$m	**Pre-operation**	**to 2030**	**to 2040**	**to 2050**	**to end of project**
EBITDA (revenues less costs)		19,475	20,768	11,025	-51,916
Debt payments (interest and principal)		-34,545	-37,204	-5,985	0
Taxes		-3,069	-3,522	-3,642	-4,125
Investment cost (equity portion)	-22,679	0	0	0	0
Undiscounted cashflows	**-22,679**	**-18,139**	**-19,959**	**1,398**	**-56,041**
Total capex ($m)	**90,717**				

Source: Carbon Tracker analysis

As can be seen in figure 10, operating profitability is insufficient to cover debt payments and deteriorates sharply from the 2050s which is when most power purchase agreements (PPAs) are assumed to end (25 years for new plants). This is the main driver of the weak economics of new projects under BAU. Under B2DS early closure of all unabated coal means some operating profits are foregone even when debt remains outstanding which pushes more projects into deeper negative territory. Although we model that plant closures under B2DS would be done on an economic basis i.e., loss making plants get closed ahead of profitable ones, all plants would need to close by 2040 under B2DS regardless of their economic situation to be consistent with the temperature goal in the Paris Agreement. We also highlight that if those plants with PPAs close early, the owner may be left with unfulfillable contractual obligations. The owner may or not get compensation for this. We see this as an additional risk under B2DS.

It may seem counterintuitive that projects go ahead in light of insufficient EBITDA to cover debt repayments and interest expenses, even in the early years. This begs the obvious question of why these projects would go ahead. We think some of these projects could proceed for non-economic reasons and/or because developer expectations are materially more optimistic than our own assumptions. The above table shows the big picture by aggregating the financials of each project, and serves to reinforce the message that many of these projects are dead in the water from the outset. However, there are some projects in India that buck this general trend. This is clear from the fact that only 10% of projects are viable under BAU per our analysis.

Japan

Japan has 8.5 W of new coal under construction or in planning. We find that only 12% of projects (1 GW) are unviable on a BAU basis because of negative NPV. This rises to 100% under B2DS. We acknowledge that new coal projects may go ahead, even when the economics do not stack up, for non-financial reasons, which are outside the scope of our analysis.

Figure 11 JAPAN AGGREGATE PROJECT LIFETIME CASH FLOWS BAU

Country	Years				
$m	**Pre-operation**	**to 2030**	**to 2040**	**to 2050**	**to end of project**
EBITDA (revenues less costs)		8,227	11,448	11,201	17,311
Debt payments (interest and principal)		-7,248	-9,002	-2,124	0
Taxes		-1,114	-1,714	-1,7694	-2,070
Investment cost (equity portion)	-5,648	0	0	0	0
Undiscounted cashflows	**-5,648**	**-136**	**722**	**7,308**	**15,241**
Total capex ($m)	**22,592**				

Source: Carbon Tracker analysis

As can be seen in figure 11, operating profitability remains strong throughout the lifetime of projects. This is driven by high capacity factors with minimal impact assumed from carbon taxes (we assume a flat carbon price of around $3/t which is the current level). Should carbon prices be materially higher compared to our assumptions then materially more projects would become unviable. For example, assuming a carbon price of $25/t by 2030 and $40/t by 2040 would render almost all projects unviable. Project economics are also supported by a low cost of debt (1%). Under B2DS early closure means operating profits are foregone even when debt remains outstanding which pushes all projects into negative territory.

Vietnam

Vietnam has 24 GW of new coal under construction or in planning. We find that 99% of projects (23 GW) are unviable on a BAU basis. This rises to 100% under B2DS. We acknowledge that new coal projects may go ahead, even when the economics do not stack up, for non-financial reasons, which are outside the scope of our analysis.

Figure 12 VIETNAM AGGREGATE PROJECT LIFETIME CASH FLOWS BAU

Country	Years				
$m	**Pre-operation**	**to 2030**	**to 2040**	**to 2050**	**to end of project**
EBITDA (revenues less costs)		2,459	813	-568	-3,075
Debt payments (interest and principal)		-9,949	-16,154	-6,469	0
Taxes		-126	-178	-166	-242
Investment cost (equity portion)	-9,503	0	0	0	0
Undiscounted cashflows	**-9,503**	**-7,616**	**-15,519**	**-7,203**	**-3,317**
Total capex ($m)	**38,012**				

Source: Carbon Tracker analysis

As can be seen in figure 12, operating profitability on average remains close to breakeven throughout the lifetime of projects. This is driven by the government's introduction of a carbon tax from the beginning of 2022. We estimate the carbon tax rises to $7/MWh by 2030 and $9/MWh by 2040. Operating profits are generally insufficient to cover debt and interest payments. Under B2DS early closure means some operating profits are foregone even when debt remains outstanding which pushes all projects into negative territory.

Similar to India, it may seem counterintuitive that projects go ahead in light of insufficient EBITDA to cover debt repayments and interest expenses even in the early years. We think some of these projects could proceed for policy-driven reasons and/or because developer expectations are materially more optimistic than our own assumptions. The above table shows the big picture by aggregating the financials of each project and serves to reinforce the message that many of these projects are dead in the water from the outset. However, there are a limited number of projects in Vietnam that buck this general trend. This is clear from the fact that only 4% of projects are viable under BAU per our analysis.

Indonesia

Indonesia has 24 GW of new coal under construction or in planning. We find that 64% of projects (15 GW) are unviable on a BAU basis. This rises to 89% (21 GW) under B2DS. We acknowledge that new coal projects may go ahead, even when the economics do not stack up, for non-financial reasons, which are outside the scope of our analysis. We highlight that the Indonesian government recently announced a ban on building new coal plants, only allowing those currently under construction or having reached their financial close to proceed[23].

Figure 13 INDONESIA AGGREGATE PROJECT LIFETIME CASH FLOWS BAU

Country	Years				
$m	**Pre-operation**	**to 2030**	**to 2040**	**to 2050**	**to end of project**
EBITDA (revenues less costs)		22,146	27,619	27,277	53,506
Debt payments (interest and principal)		-18,736	-18,622	-3,096	0
Taxes		-224	-3,741	-4,362	-5,193
Investment cost (equity portion)	-10,120	0	0	0	0
Undiscounted cashflows	**-10,120**	**3,186**	**5,256**	**19,820**	**48,312**
Total capex ($m)	**40,480**				

Source: Carbon Tracker analysis

As can be seen in figure 13, aggregate operating profitability remains strong throughout the lifetime of projects. This is driven by high margins on electricity tariffs and relatively high capacity factors. Nevertheless, later year cash flows are generally not sufficient to offset early years outflows when discounted. Under B2DS early closure means operating profits are foregone even when debt remains outstanding which pushes the vast majority of projects into negative territory.

23 No New Coal Plants in Indonesia in Another Bid to Cut Emissions - Bloomberg

4. Coal addiction for operating coal assets is more destructive than ever

Although 2020 and COVID-19 saw a fall in electricity demand and with it a reduction in coal power, many countries remain wedded to coal for their power needs. We have already shown that building new coal plants is extremely risky from a financial standpoint. Nevertheless, a number of countries continue to operate coal plants as a primary generation source, even though in most regions building renewables is lower cost than operating existing coal units. As can be seen in figure 14 below, only in Japan and the ASEAN region does coal retain a cost advantage and we estimate that will be competed away by 2022 and 2024, respectively, as the inexorable deflationary trend in renewables continues. By 2026 almost 100% of global coal capacity will be more expensive to run than building and operating new renewables from 77% today.

Figure 14 COST COMPETITIVENESS OF EXISTING COAL

Country/Region	2021e Coal Capacity (GW)	Percentage of Global Capacity	Coal Under Construction or in Planning (GW)	Year when Renewables cheaper than New Coal	Year when Renewables cheaper than Operating Coal	Percentage of Operating Coal which is more expensive than Renewables Today	Percentage of Operating Coal which is more expensive than Renewables by 2026
China	1,121	55%	187	Today	Today	86%	100%
India	248	12%	60	Today	Today	84%	100%
ASEAN	95	5%	55	Today	2024	12%	99%
Japan	45	2%	9	Today	2022	4%	100%
Germany	35	2%	-	Today	Today	100%	100%
South Korea	38	2%	7	Today	Today	43%	100%
Poland	29	1%	-	Today	Today	100%	100%
United States	228	11%	-	Today	Today	86%	100%
Others	211	10%	37			46%	73%
Total	**2,050**	**100%**	**356**			**77%**	**98%**

Source: Carbon Tracker analysis

4.1 Economics of existing coal continue to deteriorate with stranding risk of $220 bn

We calculate stranding for operating units as the difference in the net present value of operating profits (revenues less long run marginal costs) between BAU and B2DS. We do not assume revenue or cost hedging in our modelling. Our calculation for operating units assumes there is no debt or asset balance outstanding, which may not be the case and could imply potential writedowns on early closure. A positive stranded asset risk value means, based on existing market structures, investors and governments could lose money under B2DS as coal capacity is profitable. A negative stranded asset risk figure means, based on existing market structures, investors and governments could avoid losses under B2DS as coal capacity is unprofitable. Full details of our methodology are available in the coal methodology document in the appendix.

We model that under B2DS $220 bn of operating coal assets would be stranded when compared to a BAU scenario. This is a material risk which could transpire if a country decides to phase out coal sooner than companies are currently planning under a BAU scenario. India and ASEAN nations are most exposed to stranding risk under B2DS. The limited carbon budget under the Paris Agreement for the power sector means operating these coal plants under BAU principles will not be sustainable and early closures will likely be driven by a mix of economics and policy. This is a salient signal to investors: by committing money to operating coal assets there is a significant risk of not recouping the investment. We develop unit-level retirement schedules which are available on request.

We also find that $320 bn of operating losses could be avoided by early closure of loss-making coal plants under B2DS, which mainly affects China and Europe. This is low hanging fruit for companies who retire early as they can save shareholders and taxpayers money by curtailing loss making plants. This also corroborates our findings for new coal projects in China where NPVs are less negative under B2DS than BAU owing to early closure avoiding losses driven by lower capacity factors and higher carbon prices adversely impacting later year operating profits.

Figure 15 shows the ten companies most exposed to positive stranded asset risk under B2DS. The ten companies below represent around 40% of the total positive stranding risk calculated above. NTPC and the Adani Group in India and PLN in Indonesia are by far the most exposed accounting for over half of the total.

Figure 15 TEN COMPANIES MOST EXPOSED TO STRANDED ASSET RISK UNDER B2DS

Country/region	Parent Company	Operating Capacity (MW)	Stranded Asset Risk under B2DS ($m)
India	NTPC	73,470	19,077
Indonesia	PT PLN Persero	22,529	15,418
India	Adani Group	15,216	12,072
India	MAHAGENCO	10,690	7,409
Japan	TEPCO	18,126	6,869
India	Tata Group	8,703	6,572
India	Rajasthan RV Utpadan Nigam	7,830	6,524
South Africa	Eskom	44,726	5,269
India	TANGEDCO	10,020	5,079
India	NLC India	10,340	4,446
Total		**221,650**	**88,735**

Source: Carbon Tracker analysis, GEM

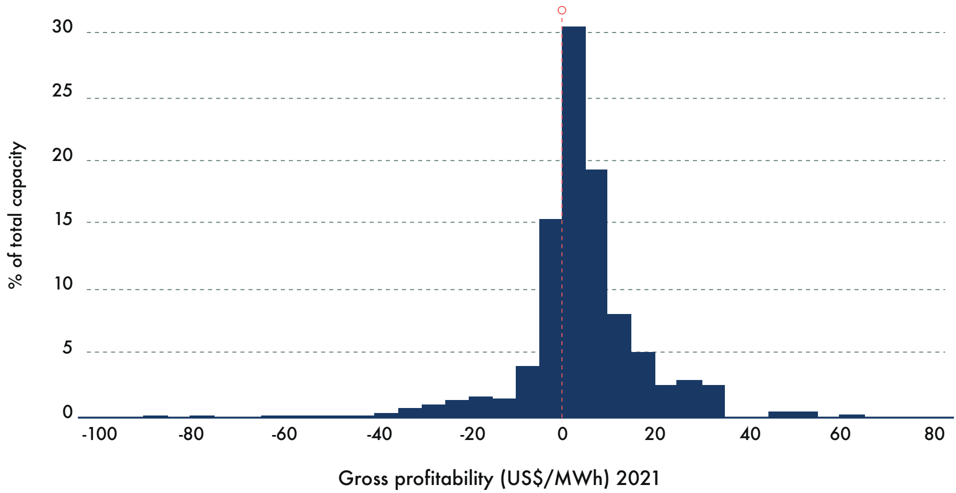
We highlight that according to our calculations the average size of an operating coal plant is currently around 330 MW. This equates to just over 6 coal plants every week until 2040 which need to be retired to be consistent with the B2DS scenario. The average age of the operating fleet is around 21 years, i.e. just halfway through the average anticipated operating life of 40 years. As can be seen above such closures are likely to result in significant stranding risk and potentially material asset impairments.

4.2 Weak coal economics highlighted by sensitivity to key factors

The state of existing coal economics is extremely fragile, with many coal plants only profitable owing to market regulations, absent which they would be loss making. Such support is often a cost to the consumer, through higher electricity prices, or the taxpayer, as the government is financing this.

Indeed, the ailing state of coal becomes evident when we consider even modest changes in key factors driving profitability. Not surprisingly, those units operating close to break-even levels i.e. with revenues just about covering their costs are most susceptible to being pushed into loss making territory. We estimate that around 30% (600 GW) of the global coal fleet makes an operating profit (revenues less costs) of no more than \$5/MWh i.e., very close to break-even levels. As can be seen in figure 16, a significant amount of global coal profitability is hovering around breakeven levels.

Figure 16 GLOBAL COAL PROFITABILITY (\$/MWH)

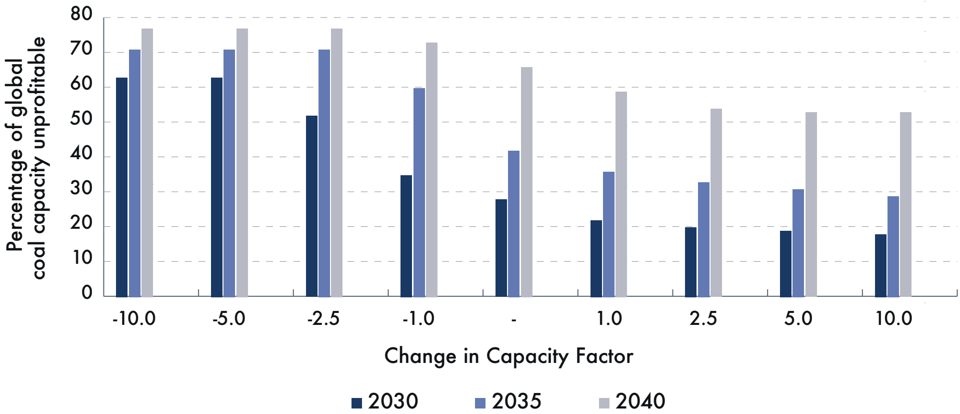


Source: Carbon Tracker analysis

Given declining usage of coal plants in recent years, most notably in key coal generating countries like China and India, we conducted a sensitivity of profitability to a percentage change in capacity factors of each year compared to our base case scenario. For example, a base case capacity factor of 60% with a 5% reduction in capacity would see 57% utilisation in year one (60% x 95%), 54% in year two (60% x 90%), etc.

As can be seen in figure 17, the biggest impact to global coal profitability is when capacity factors decline relatively by 5% annually compared to our base case. In this scenario unprofitable units almost double to 52% from 28% by 2030. A reduction in capacity factors of 2.5% versus our base case results in the largest change in global coal profitability in 2035 and 2040. This serves to highlight that even modest falls in utilisation could have an outsized effect on global coal profitability, because this would tip a large number of units hovering around break-even over the edge, underlining the comparatively weak economics.

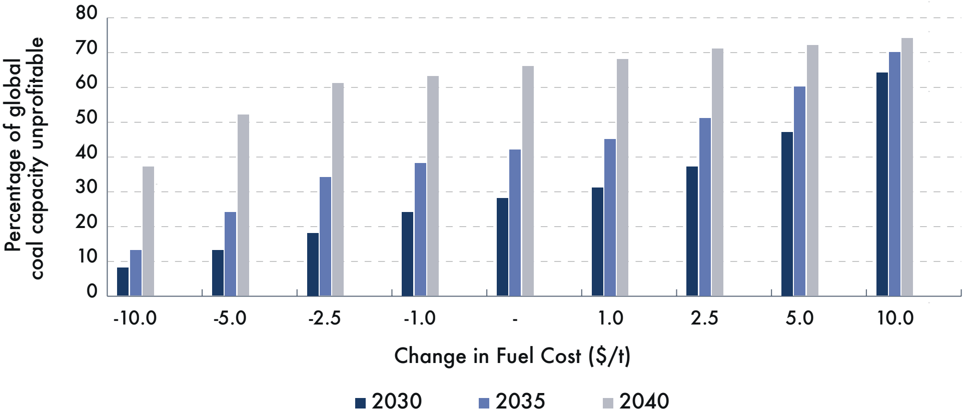
Figure 17 CHANGES IN GLOBAL COAL PROFITABILITY TO CHANGES IN CAPACITY FACTORS



Source: Carbon Tracker analysis

We also analysed how changes in fuel costs, often the largest single cost item of a coal power plant, and one that is irrelevant for near-zero marginal cost renewable sources, can quickly alter plant profitability. We assumed a permanent change to fuel prices versus our base case as shown in figure 18 below.

Figure 18 CHANGES IN GLOBAL COAL PROFITABILITY TO CHANGES IN FUEL COSTS



Source: Carbon Tracker analysis

As can be seen above, unlike changes in capacity factors, changes in volatile fuel costs continue to have a relevant impact on global coal profitability. By 2030 47% of coal would be unprofitable compared to our base case assuming a $5/t increase in fuel costs. This jumps to 64% assuming a $10/t increase in fuel costs. Even assuming a $2.5/t rise in fuel costs would result in over half of global coal capacity being unprofitable as soon as 2035 and 71% by 2040. We acknowledge that over the medium-to-long-term there may be a structural downtrend in coal prices owing to weakening demand but this is unlikely to manifest in a straight line. Indeed, during this period there is likely to be significant volatility with cyclical upswings causing economic distress to coal plants.

With most major countries signing up to net zero targets and capacity factors for coal plants on a generally declining trend, especially in the large economies of China and India, the days of operating coal are numbered. Volatile fuel prices make the economics of coal units even more unattractive when compared to near-zero marginal costs for clean renewables.

It is worth highlighting that coal units that remain profitable even in light of the scenarios above exist owing to market distortions. Market distortions are typically prevalent in regulated markets or semi-regulated markets where competition is often low or absent, especially from low-cost renewables, and reflect market inefficiencies. These markets are characterised by mechanisms such as fixed returns or cost pass-through structures via Power Purchase Agreements (PPAs). Therefore, unit profitability can be supported by such market distortions and those units which are loss making for extended periods may not necessarily close anyway as costs can be passed on to consumers or taxpayers.

However, this situation may not prevail as regulators and governments increasingly search for the least cost option. Regardless of this, with the exception of countries including Japan and ASEAN, close to 80% of the global coal fleet today could be switched to renewables with an immediate cost saving benefit given the comparative cost advantage of new renewables over existing coal. By 2026 almost all of the global coal fleet will be outcompeted by new renewables.

4.3 Country focus

We detail below the main markets in which coal is still relevant for energy generation and a way out of this uneconomic and polluting route. We also provide an asset-level coal phase out schedule for each country consistent with B2DS, which is available on request.

4.3.1 China

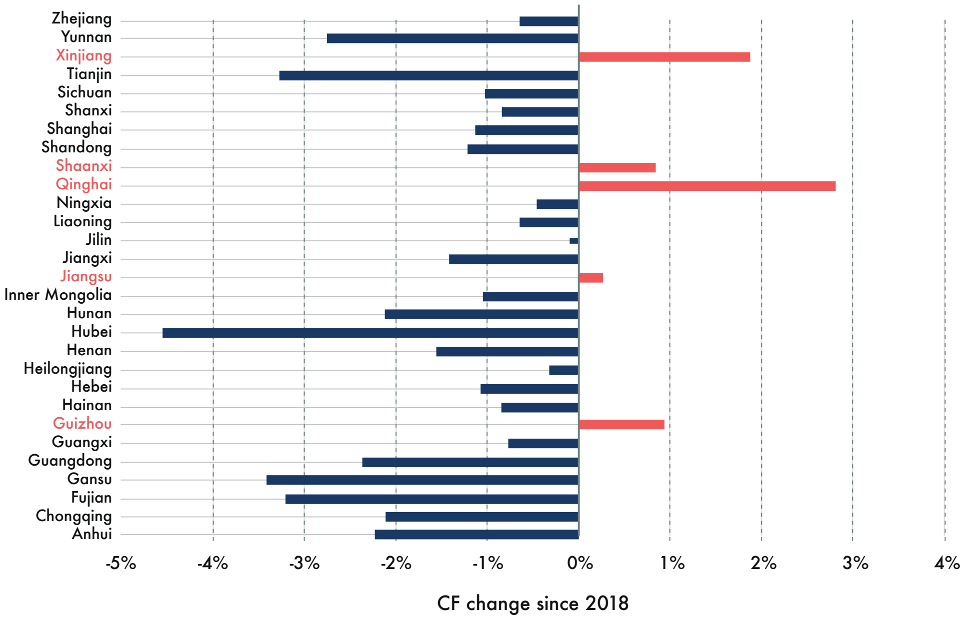
China is the world's largest coal power producer. It has around 1,100 GW of operating coal capacity and a pipeline of 187 GW. The scale of China's coal plant emissions is epic. Shandong alone, with 450 million tonnes of CO_2 emissions, is similar in scale to Mexico's total emissions, and renewables are already cheaper than coal plants in that province.

At the same time China has arguably led the build out in solar and onshore wind. In 2020, China installed almost 50 GW of solar capacity and around 70 GW of onshore wind capacity taking total installed capacity for solar and wind to 250 GW and 280 GW[24], respectively. China is targeting total installed capacity of wind and solar of 1,200 GW by 2030[25]. However, if China continued wind and solar build out at the 2020 rate this target would be achieved in around five and a half years and would imply installed wind and solar capacity of around 1,700 GW by 2030. And yet, China was the only major country with an increase in coal generation during 2020 as well as accounting for half of new coal projects globally. We think China is suffering from an overcapacity of coal which would imply further declines in coal plant utilisation.

As can be seen in figure 19, over the last few years China's operating coal fleet has already seen an overall fall in capacity factors in virtually every region.

24 Beijing: China installed 48.2 GW of solar in 2020 – pv magazine International (pv-magazine.com)
25 Cost of solar power soon lower than coal (www.gov.cn)

FIGURE 19 FALLS IN CAPACITY FACTORS IN CHINA SINCE 2018



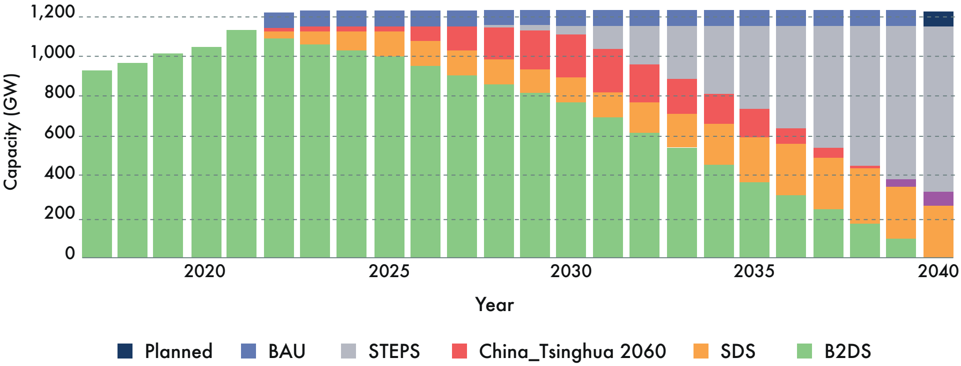
Source: Carbon Tracker analysis

The average capacity of China's coal fleet is expected to be 46% in 2021 and has fallen by 1% since 2018 and by 14% since 2011. Drops in utilisation have happened as a result of overcapacity, as more coal plants have come on line, with renewables displacing coal.

The cost of new renewables will soon be lower than operating existing coal plants in every region of China, with 86% of existing coal capacity already more expensive than building new renewables. By 2024, renewables will outcompete existing coal in all parts of China. We think the trend of falling capacity factors is set to worsen as more wind and solar displaces coal generation and any new coal projects entering the market this decade will exacerbate the overcapacity situation, especially as China enforces tighter pollution measures.

Local and central governments should work together to agree a phase out plan for coal plants. The government should invest in grid infrastructure and energy storage technologies to prepare the energy system for system peak load, rather than having coal plants running at a loss during these times, as well as integrating renewables sources. This would help China on the path to meeting its net zero targets by 2060, a detailed roadmap for which was notably lacking in the most recent five-year plan. We find under B2DS all coal plants would need to close in China by 2040, which would equate to an annual saving of around 4 billion tonnes of CO_2 emissions. As can be seen in figure 20, over 50% of China's coal capacity would close by 2035 with the remainder shut by 2040.

Figure 20 B2DS WOULD SEE 50% OF CHINA CAPACITY CLOSE BY 2033 AND 100% BY 2040



Source: Carbon Tracker analysis

4.3.2 India

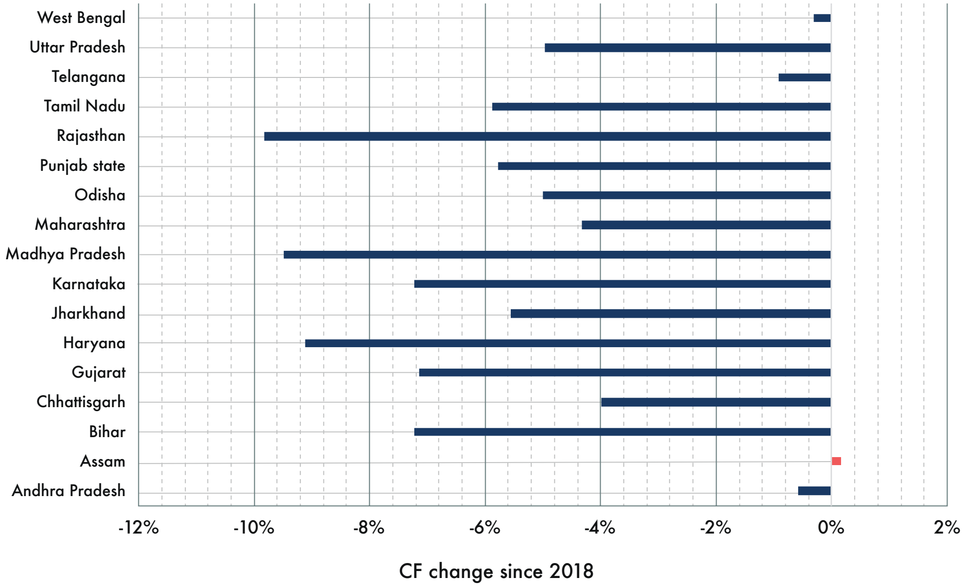
India is the second largest coal power producer with around 250 GW of capacity and a pipeline of 60 GW of under-construction and planned coal projects, many of which are expected to come on line over the next 5 years.

India has not yet committed to a net zero target although this is under discussion[26]. This will likely become a necessity in the near future as climate urgency increases and countries are forced to act to find sustainable pathways to net zero. Although India is reliant on operating coal for power, it has also set itself ambitious renewable targets given the high potential for solar and wind in the country.

Building new renewables already outcompetes 84% of operating coal in India. By 2024, renewables will outcompete existing coal in all parts of India. India announced a target of 450 GW of renewables by 2030, which will equate to 60% of energy from renewables[27]. This implies a more than fivefold increase from 2020 levels. As can be seen in figure 21 below, coal plant utilisation has fallen by 5% on average since 2018 as low-cost renewables displace coal. We think this trend is set to continue.

26 India Will Have to Leapfrog Every Major Economy to Reach Net Zero by 2050 - Bloomberg
27 India to have 60% renewable energy by 2030: Power minister R K Singh | Business Standard News (business-standard.com)

Figure 21 FALLS IN CAPACITY FACTORS IN INDIA SINCE 2018



Source: Carbon Tracker analysis

Since the start of the COVID-19 pandemic in early 2020 India has committed more money to the energy sector than any other major economy. However, of the $133bn of funds committed more than half is directed to "other" energy, which could find its way to fossil fuel financing among others, compared to $35bn earmarked for clean energy[28]. India should take this opportunity to direct more financing to clean energy and away from fossil fuels. This will better prepare the country for a sustainable grid, will enable an orderly coal phase out, and will be a lower cost alternative than continuing to subsidise fossil fuels. India should heed the warning from the already significant amount of stranded thermal power assets, estimated to be around $50 bn[29]. We find under B2DS all coal plants would need to close in India by 2040 and around 170 GW would need to be retired by 2030.

4.3.3 ASEAN

ASEAN[30] coal capacity is 95 GW with a further 55 GW under construction or in planning, much of which is attributable to Indonesia and Vietnam (see above). Regardless of the challenges of limited infrastructure to carry the power from source to users, lack of supportive regulatory policy, and complicated land rights[31], new renewables will soon outcompete existing coal on a cost basis. Policymakers, by committing to more coal now, risk shouldering consumers with higher electricity prices, value destruction for investors and taxpayers, and higher pollution.

28 India - Energy Policy Tracker data as of 2 June 2021
29 IEEFA: There's no way out for India's stranded thermal power assets - Institute for Energy Economics & Financial Analysis
30 Our analysis of ASEAN coal includes Indonesia, Malaysia, Philippines, and Vietnam
31 Renewable Energy Challenges In Southeast Asia | The ASEAN Post

ASEAN nations, because of their geography, are particularly susceptible to energy outages from climate-related events. This is compounded by the fact that they are heavily reliant on thermal fuels (mainly coal). These extreme weather events are becoming the norm and are directly linked to rising sea temperatures owing to climate change[32].

Extreme weather events are a global problem. When combined with an over-concentration of thermal energy and an isolated grid, the effects on energy generation can be exacerbated. IEEFA has pointed out that diversified energy sources matter[33] as supply chains are more at risk of breaking down when extreme weather hits. In the case of Indonesia, it is heavily reliant on thermal power most of which comes from coal (85% thermal power for 2019 of which 63% came from coal[34]). Severe flooding in February in key coal-producing regions forced the government to issue a warning about potential blackouts owing to coal supply chain disruption.

Another important lesson is that investment in the grid and interconnection should be a main priority. Indonesia should reconsider its heavy fossil fuels subsidies in favour of grid investments. As a dispersed island nation interconnection between key grids would strengthen the electricity system and would better connect renewable energy sources with end users. These arguments could equally apply to other ASEAN nations such as the Philippines (another geographically dispersed island nation) and Vietnam (also heavily reliant on thermal fuels as evinced in the most recent draft power development plan[35]).

New renewables will outcompete existing coal units in Vietnam by 2022, in the Philippines by 2023, with Indonesia and Malaysia following by 2024. More extreme and less predictable weather is here to stay as a result of climate change. The ASEAN nations in particular are exposed to such extreme weather events. Policymakers should pay heed to experience and focus on investing in a more diversified and robust grid and prioritise renewable resources in their long-term planning by levelling the playing field and not disproportionately favouring coal power with misguided subsidies. We find under B2DS all coal plants would need to close in ASEAN by 2040 and around 55 GW would need to be retired by 2030, equivalent to the current project pipeline.

4.3.4 Japan

Japan has 45 GW of operating coal capacity with 9 GW in the pipeline. Historically, Japanese banks have been willing lenders to coal projects most notably Mizuho, MUFG, and SMBC Group[36] but there are signs at the margin this is changing. For example, MUFG plans to halt all new financing for coal power[37] and the Japanese government has committed to no longer supporting foreign coal projects[38].

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32 Climate Change - CNA (channelnewsasia.com)
33 IEEFA Indonesia: Lessons from Texas on extreme weather and power grid resilience - Institute for Energy Economics & Financial Analysis
34 content-handbook-of-energy-and-economic-statistics-of-indonesia-2019.pdf (esdm.go.id)
35 Vietnam: Key highlights of new draft of national power development plan (Draft PDP8) (globalcompliancenews.com)
36 Japan's Private Banks - No Coal Japan
37 Japan's SMFG likely to halt all new lending for coal power, sources say | Reuters
38 China, Japan, and South Korea aren't financing as many coal plants abroad anymore - Vox

Japan has plans to phase out 26 GW of coal this decade, focusing only on old and inefficient coal plants which would still leave around 30 GW in operation by 2030. This lack of political will is reflected in the current very low carbon price (¥289/t of CO_2 or around $3/t) although Japan recently committed to a more ambitious 2030 emissions reduction target (46% from 2013 levels versus 26% previously)[39]. The low carbon price and coal pipeline is at odds with Japan's net zero target by 2050.

Despite renewables being hampered by lack of land availability, capacity market payments favouring fossil fuels, and grid constraints owing to incumbent regional utilities[40] our analysis shows that renewables are already cheaper than new coal in Japan and will soon be cheaper than existing coal (by 2022). We also find that carbon taxes are too low to be effective as an emissions rationing mechanism given the large majority of operating coal units are currently profitable. We find a $60/tonne carbon tax (about the same as the EU's carbon price of €53/t[41]) would render around half of Japan's coal fleet unprofitable by 2030. At a carbon price of $110/t all of Japan's coal fleet would be unprofitable by 2030.

Japan needs to stop coal financing (domestically and globally). In addition, Japan needs to implement an accelerated coal phase out this decade, a revision of the too-low carbon price, and a level playing field in the capacity market so that renewables can compete on equal terms. Renewable sources such as wind and solar should be developed within the topographical constraints of the country and the lack of grid interconnections needs to be addressed, to better match supply and demand of electricity between regions. These actions should set Japan on the right path to achieving its net zero goals by 2050 and provide a least cost and clean energy solution for users. We find under B2DS all coal plants would need to close in Japan by 2039. Under B2DS around 30 GW would already be retired by 2030.

4.3.5 EU

The EU has led the charge in reducing reliance on coal power owing to a strong carbon pricing policy and supporting the build out in clean energy. It has set an ambitious emissions reductions target by 2030 (55% from 1990 levels[42]) on a pathway to achieving its net zero emissions target by 2050. Indeed, several major European countries have already announced a coal phase out this decade such as Italy, Denmark, Spain, the Netherlands, and France, which means half of the EU's coal plants are closed or set to retire by 2030[43]. However, two of the EU's biggest coal users are still struggling with their addiction. Both Germany and Poland are heavily reliant on a coal fix and are lagging behind other major economies in the EU by delaying their coal phase outs.

39 Biden: This will be 'decisive decade' for tackling climate change - BBC News
40 Japan lags as economies worldwide shift to renewable power - Nikkei Asia
41 Carbon Price Viewer - Ember (ember-climate.org) data as of 9 June 2021
42 State of the Union: Commission raises climate ambition (europa.eu)
43 Europe passes milestone with half of coal plants closed or set to retire by 2030 - Institute for Energy Economics & Financial Analysis (ieefa.org)

4.3.5.1 Germany

Germany has 35 GW of coal capacity. It has committed to a phase-out of its coal fleet by 2038, which is significantly behind other main EU states. The government has approved a competitive tender mechanism to incentivise and compensate early closure of coal-fired power plants in Germany such that no more than 9 GW of lignite and 8 GW of hard coal is expected to be in operation by 2030[44]. Regardless of this, our analysis finds that renewables already outcompete coal on a cost basis today and all coal units are unprofitable in Germany owing to the relatively high carbon cost. Germany should accelerate its coal phase out to minimise further losses and help reduce emissions by the 65% target by 2030 and help it reach its net zero target by 2045[45]. We find under B2DS that all coal plants in Germany would need to be decommissioned by 2030.

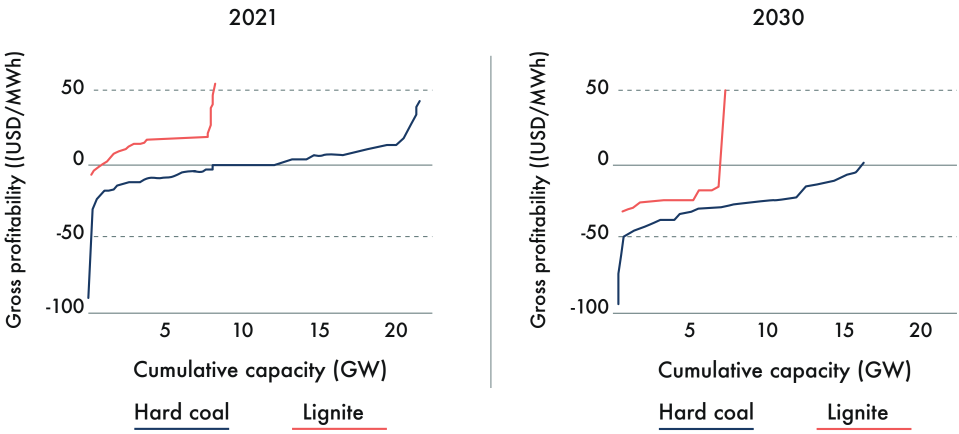
4.3.5.2 Poland

Poland has around 30 GW of coal capacity. Poland is seeking to buy existing coal assets from its three biggest utilities and merging them into a new state-owned energy company by 2022[46] in order to shield them from liabilities and free up utilities to build out natural gas and renewables projects. This proposal could amount to state aid to prop up its ailing coal industry in addition to a restructuring of its energy sector[47], but it will need the approval of the European Commission. This could result in some coal plants operating into the 2040s which would appear to be incompatible with the EU's ambitious climate targets.

Our analysis finds that similar to Germany (and other EU countries) renewables already outcompete coal on a cost basis today, but unlike in Germany, many of Poland's coal units are profitable owing to generous capacity market payments, until they expire in the early 2030s. As can be seen in figure 22, profitability deteriorates sharply in 2030 once these payments end. We estimate that around 50% of Poland's coal plants are unprofitable today. This rises to almost 100% by 2030 as profitability collapses on the end of capacity payments.

44 Spelling out the coal exit – Germany's phase-out plan | Clean Energy Wire
45 Germany sets tougher CO_2 emission reduction targets after top court ruling | Reuters
46 Poland to buy coal assets from utilities, create state energy company in 2022 | S&P Global Platts
47 Poland goes all out on coal rescue against EU's higher climate goal – EURACTIV.com

Figure 22 POLAND COAL PROFITABILITY DETERIORATES RAPIDLY BY 2030



Source: Carbon Tracker analysis

Poland should accelerate its coal phase out to reduce costs to consumers and keep coal generation at a minimum beyond 2028. We find under B2DS that all coal plants in Poland would need to be decommissioned by 2030.

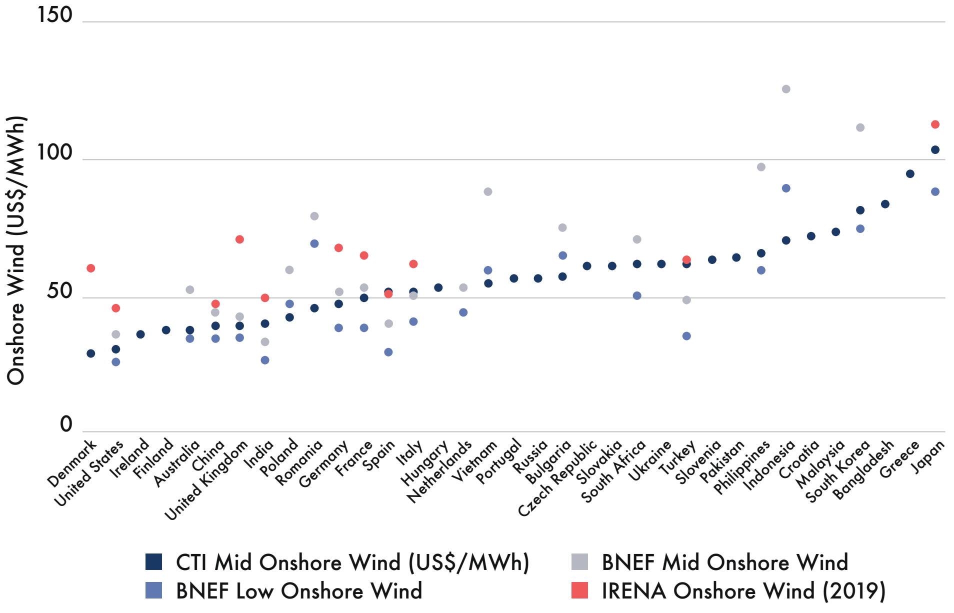
5 Appendix

5.1 Coal Methodology

Available at:
https://carbontracker.org/wp-content/uploads/2021/06/Coal-Methodology-2021_June21.pdf

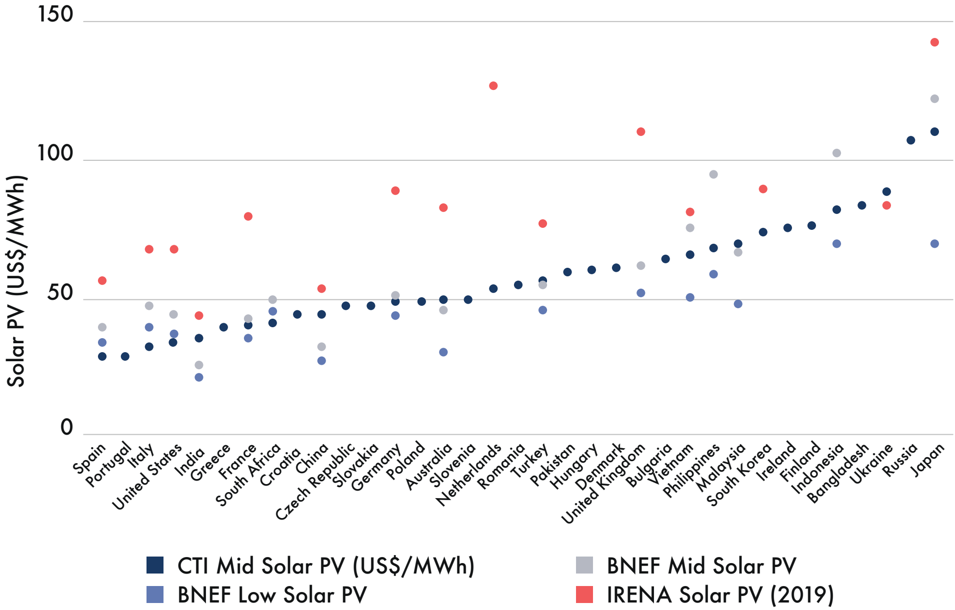
5.2 LCOE global estimates

Figure 23 ONSHORE WIND GLOBAL ESTIMATES: CARBON TRACKER, BNEF AND IRENA



Source: Carbon Tracker analysis, BNEF and IRENA
Note: BNEF data is from 2H20. IRENA data is from 2019

Figure 24 SOLAR PV GLOBAL ESTIMATES: CARBON TRACKER, BNEF AND IRENA



Source: Carbon Tracker analysis, BNEF and IRENA
Note: BNEF data is from 2H20. IRENA data is from 2019

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