

## Carbon Tracker – Methodologies

Overview of methodologies and metrics for the alignment assessments which complement Indicator 6 of the Disclosure Framework within the Climate Action 100+ Net Zero Company Benchmark.

As a research partner to Climate Action 100+ (CA100+), Carbon Tracker Initiative conducts financial analysis and has developed a set of alignment assessments to help investors identify, quantify, and assess stranded asset risks for 69 focus companies, covering:

- 36 upstream oil & gas exploration and production companies' investment plans, and
- 33 utilities' announced retirement schedules of coal & gas fired electricity generation to assess their alignment with the goals of the Paris Climate Agreement.

Full details of Carbon Tracker Initiative's research and methodologies and full company-level engagement profiles are available on [www.carbontracker.org/company-profiles/](http://www.carbontracker.org/company-profiles/) and please direct questions and enquiries to [ca100@carbontracker.org](mailto:ca100@carbontracker.org).

## Carbon Tracker – Research and Analysis

We carry out scenario analysis to examine and understand how potential changes to supply and demand will impact the future of fossil fuel-exposed companies and projects. This analysis helps the investment community better understand the financial implications of tackling climate change.

- 1) Our analytical research identifies the highest cost, riskiest investments enabling greater scrutiny by analysts, asset owners, investors, policy makers and financial regulators.
- 2) Our regulatory research builds the case for reform of the financial regulatory system to improve transparency of climate-related financial risks and articulates the key changes to be made.
- 3) We provide expert insight for those engaging with energy companies around future strategy and capital expenditures.

Our research is grounded in conventional financial analysis and focuses on forward-looking material issues. As a not-for-profit research house, we are free from the constraints that would be imposed by a commercial financial research business model. This allows us to challenge business-as-usual approaches that we consider to be unsustainable in the face of the unprecedented challenge posed by climate change.

## The need to reduce emissions

Emissions of greenhouse gases will need to fall significantly if the world is to avoid catastrophic levels of global warming. Such constraints will have profound effects on the supply of and demand for fossil fuels, which account for the largest human source of greenhouse emissions.

For *existing assets*, our research can highlight those assets which are most at risk of becoming stranded through the energy transition, as society looks to restrict global warming to well below 2°C and strives to limit the warming to 1.5°C, as per the goals of the Paris Agreement.

There are already examples of coal mines, coal and gas power plants, and other hydrocarbon reserves which have become stranded by the low-carbon transition.

For *potential new investments*, our research aims to prevent stranded assets arising by identifying capital investments which may not yield the expected returns as the world decarbonizes. Our focus is therefore on advancing the energy transition through the stewardship of capital, with the intention of preventing it being wasted.

Our research publications are freely available on our website [www.carbontracker.org](http://www.carbontracker.org) as well as on research platforms such as Bloomberg, FactSet, Refinitiv and S&P Capital IQ.

## Carbon Tracker's least cost framework

Carbon Tracker's lens is that of the market – assessing which potential fossil fuel developments do not make economic sense and might destroy value in the energy transition, at the same time as taking the planet into a progressively more dangerous climate.

Underlying this analysis is the logic that in a world of limited demand, the lowest cost supply options will be most competitive and the higher cost options may fail to deliver economic returns – in other words, becoming economically “stranded”.

**Upstream oil & gas exploration and production capital expenditures (CAPEX).** In a series of reports since 2011<sup>1</sup>, Carbon Tracker has explored the financial implications for the oil & gas sector of the shift to a lower carbon economy in line with international climate commitments. We have examined the risks to fossil fuel capital expenditures, and hence to the investors that provide that capital.

By using classic supply and demand curves, we can illustrate what proportion of potential capex is on low-cost projects that would still be needed in a low carbon world, and what proportion is on high-cost projects that would not. Investment in the latter runs a greater risk of destroying value.

**Retirement of coal and gas-powered electricity power generation.** In a series of reports since 2017<sup>2</sup>, Carbon Tracker has explored the financial implications for the power and utility sector of the shift to a lower carbon economy in line with international carbon commitments. We have examined the risks to fossil fuel fired powered generation by assessing the volume and pace of retirements of unabated<sup>3</sup> coal and gas-fired electricity generation capacities that Paris Agreement aligned climate scenarios make clear must be wound down first.

By using classic supply and demand curves, we can illustrate the relative cost competitiveness of coal or gas-fired generation assets and hence which plants will be able to stay economic for longer in a low carbon world that require an almost complete phase-out of coal and gas-fired generation by 2040 and 2050 respectively. Investment in the higher cost generation runs a greater risk of stranding assets and destroying value.

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<sup>1</sup> This workstream and modeling started with “[The \\$2 trillion stranded assets danger zone: How fossil fuel firms risk destroying investor returns](#)” in 2015 and the methodology has continuously been updated in our five annual company level capex analyses starting with “[2 Degrees of Separation](#)” in 2017.

<sup>2</sup> This workstream and modeling were developed by Carbon Tracker's Power & Utilities team in 2016-2018 and have been continuously updated and enhanced. The model provides current and forward-looking estimates of the (short and long-run) marginal cost, gross profitability, relative competitiveness, phase-out year and stranded asset risk in a below 2°C scenario.

<sup>3</sup> Unabated power generation is without any use of carbon emission removal technologies.

## Carbon Tracker – Alignment Assessments

Carbon Tracker has developed eight alignment assessments to help investors identify, quantify, and assess stranded asset risks for 69 CA100+ focus companies.

- Four assessments focused on investment and capital allocation plans for 36 upstream oil & gas exploration and production companies in a carbon emission constrained world, and
- Two sets of two assessments (for a total of four) focused on whether announced retirement schedules of coal & gas fired electricity generation (respectively) for 33 utility companies are aligned with the goals and ambitions of the Paris Climate Agreement.

These assessments analyze companies' capital expenditures (CAPEX) and economic output from legacy fossil fuel-fired power generation and new prospective unsanctioned oil & gas exploration and production activities, hence, carbon-emitting assets relative to a range of climate change restricted scenarios. The analysis gives investors additional insights on the relative adequacy and alignment of company actions with the goals of the Paris Agreement.

These independent alignment assessments complement Indicator 6 of the Disclosure Framework within the CA100+ Net-Zero Company Benchmark to help investors assess oil & gas companies announced upstream capital expenditure plans and utility companies' asset retirement plans for their coal and gas generation capacity.

**Demand scenarios.** In our oil & gas and power & utility modeling, we use the following demand scenarios from the International Energy Agency (IEA) to proxy different levels of transition risk.

### International Energy Agency (IEA) demand scenarios used by Carbon Tracker

**Beyond 2 Degrees Scenario (B2DS):** A rapid-transition scenario that lands somewhere in-between SDS and NZE (see below), being equivalent to an estimated 1.6°C of global warming in this century with net zero emissions reached by 2060 with a 50% chance. *Source: IEA, Energy Technology Perspectives (2017).*

*This is our core carbon constrained demand scenario to model the alignment of company activities with a demand pathway consistent with the goals and ambitions of the Paris Climate Agreement.*

**Sustainable Development Scenario (SDS):** IEA models the SDS emissions trajectory to 2050 and notes that if this trajectory is extrapolated beyond this point, it would result in net zero emissions in 2070. If emissions are assumed to stay at zero thereafter, the IEA concludes this would result in a 66% chance of limiting warming to 1.8°C or a 50% chance of 1.65°C. *Source: IEA, World Energy Outlook 2020.*

**Stated Policies Scenario (STEPS):** Our business-as-usual proxy. STEPS is consistent with c.2.7°C warming (50% chance) and describes a projection of the future energy system whereby already enacted, and already announced yet to be enacted, legislation on climate change is assumed to continue, but not be developed further. *Source: IEA, World Energy Outlook 2020.*

**Net Zero Emissions By 2050 Scenario (NZE):** A faster decarbonization pathway, equivalent to 1.5°C of warming in this century with little overshoot (i.e., limited reliance on post-2050 negative emissions). As the name suggests, net zero is reached by 2050. *Source: IEA, Net Zero by 2050 (2021).*

*Source: 'Adapt to Survive' (Carbon Tracker, 2021)*

## Upstream Oil & Gas Exploration and Production Assessments

Carbon Tracker's four assessments in the CA100+ Net Zero Company Benchmark seek to help investors evaluate the alignment and resiliency of the capital allocation plans for 36 CA100+ focus companies with upstream oil & gas exploration and production activities if carbon emissions are aligned with the goals of the Paris Climate Agreement.

Alignment Assessments – upstream oil & gas exploration and production	Metrics	Traffic light – level of misalignment with Paris Climate Agreement goals
<p><b>COMPANY'S RECENT ACTIONS:</b> In the most recent full year (2020), were all the company's upstream oil and gas CAPEX projects consistent with the International Energy Agency's (IEA) Beyond 2°C Scenario (B2DS)?</p>	<p>Yes or No</p>	<p><b>Yes, represents alignment</b></p> <p><b>No, represents significant misalignment</b></p>
<p><b>CAPEX ANALYSIS:</b> What percentage of the company's potential future unsanctioned oil and gas CAPEX is inconsistent with the IEA's Beyond 2°C Scenario?</p>	<p>% of total future unsanctioned oil &amp; gas CAPEX opportunities inconsistent with IEA's Beyond 2°C Scenario</p>	<p><b>&gt;25% of unsanctioned CAPEX inconsistent represents significant misalignment</b></p> <p><b>0-25% of unsanctioned CAPEX inconsistent represents high misalignment</b></p> <p><b>0% of unsanctioned CAPEX inconsistent represents reduced misalignment</b></p>
<p><b>IMPAIRMENT PRICE Assessment:</b> (1) Are the company's commodity price forecasts increasing, decreasing, flat, or convex? and (2) what is the maximum price in the company's commodity price forecast? (shown in 2020 real terms Brent equivalent US\$ prices [and the year of maximum price]). N/A signifies that no impairment prices were identified.</p>	<p>Oil price in 2020 real terms brent equivalent US\$ (year of max)</p> <p>Increasing, decreasing, flat, or convex</p>	<p><b>Flat or increasing price deck with above average oil price as well as non-disclosure represents significant misalignment</b></p> <p><b>Flat or convex price deck with above average oil price represents high misalignment</b></p> <p><b>Flat or decreasing price deck with below average oil price indicates reduced misalignment</b></p>
<p><b>NET ZERO ANALYSIS:</b> What is the company's oil &amp; gas production level in the 2030s (against 2021 base line) assuming no new oil &amp; gas projects are sanctioned as stated by the IEA's Net Zero Emissions by 2050 Scenario?</p>	<p>Implied oil &amp; gas production level in 2030s assuming no new oil &amp; gas projects are allowed, expressed as a % of 2021 baseline production</p>	<p><b>25-100% decline in 2030s production relative to a 2021 baseline represents a significant challenge to the company's future operations</b></p> <p><b>10-25% decline in 2030s production relative to a 2021 baseline represents a large challenge to the company</b></p>

		<p><b>0-10% decline in 2030s production relative to a 2021 baseline represents a challenge to the company</b></p>
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The first two assessments use Carbon Tracker's least-cost of supply framework to identify the companies' investment plans and CAPEX exposure to upstream oil & gas projects based on data from Rystad Energy Group's UCube database and whether these are consistent with the demand constraints outlined in the IEA Beyond 2°C Scenario (B2DS).

The **first** assessment analyzes whether the company has sanctioned any new oil & gas projects inconsistent with B2DS in the most recent fiscal year for an indication of the company's current project approval process.

The **second** assessment shows the percentage of the company's potential CAPEX opportunities for the period 2021-2030 for unsanctioned upstream oil and gas projects inconsistent with B2DS according to Carbon Tracker's methodology. This analysis excludes consideration of projects so costly they are also inconsistent with the IEA's Stated Policies Scenario (STEPS) – the methodology is explained below. *The higher the percentage of inconsistent CAPEX opportunities, the more exposed the company is to invest in and create stranded upstream assets.*

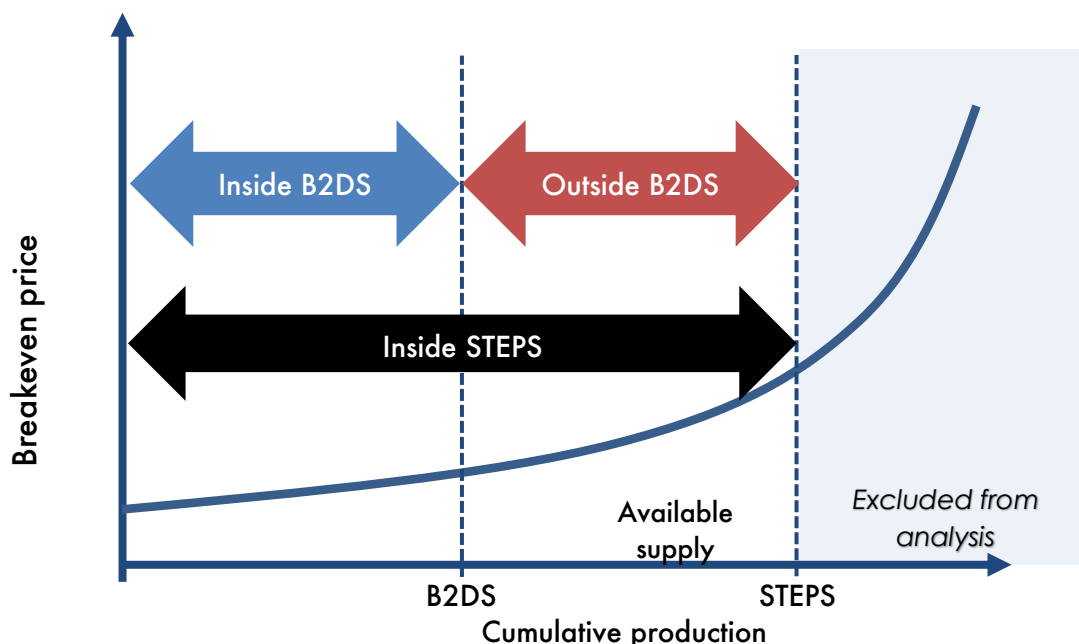
The **third** assessment analyzes the company's commodity price outlook to identify what commodity risks have been priced into its upstream asset base. From the most recent annual report, we collect the disclosed commodity pricing curve and absolute price assumptions used for impairment test of the company's fixed assets, which we use as a proxy for management's internal commodity price assumptions used for strategic planning. Oil prices have been converted to US Dollar 2020 real terms brent equivalent for comparability. *Companies with more aggressive commodity price assumptions (e.g., forecasting prolonged periods of high future oil and gas prices) are more likely to sanction projects at risk of becoming stranded in a carbon emission constrained world.*

The **fourth** assessment analyzes the company's production and operational exposure in a world aligned with the IEA's Net-Zero Emissions by 2050 scenario, i.e., where no new oil & gas projects are sanctioned after 2021. Hence, we compare the implied average oil & gas production volumes in the 2030s from currently sanctioned projects, based on Rystad Energy's forecast production decline rates, relative to 2021 oil & gas production. *The larger the decline in the company's current oil & gas production in a world transitioning to meet the goals and ambitions of the Paris Climate Agreement, the larger the strategic challenge for the company to replace earnings and cash flow generation.*

## Carbon Tracker's oil & gas project CAPEX analysis

*Core metric = Unsanctioned CAPEX inconsistent with demand constraints from B2DS as a % of total unsanctioned CAPEX inside the business-as-usual scenario of STEPS.*

- We use an economic model to link asset-level potential supply of oil and gas (from Rystad Energy) to demand pathways under different carbon-constrained scenarios from the IEA.
- The gap between the future production from sanctioned oil and gas projects and demand under any given scenario gives the additional production from unsanctioned projects that fits within that scenario.
- Using estimates of individual project economics from Rystad Energy, we then order these potential new supply options by breakeven cost and determine whether each project falls either inside or outside a given scenario based on its relative economic competitiveness.
- The CAPEX associated with the projects that fit within a given scenario can be aggregated by company and compared to potential project CAPEX under a business- as-usual scenario. This can be expressed as the % of business-as-usual CAPEX that either “fits” within, or falls outside, a given scenario.
- A company with a higher % of business-as-usual CAPEX associated with projects that fall outside a given scenario is relatively more exposed to transition risk than its peers, as a greater proportion of assets potentially at risk of stranding if developed.



Above is an illustrative example cost curve with the cumulative potential oil supply (2021-2040) from unsanctioned oil fields using Rystad Energy's base case supply curve, showing B2DS and STEPS supply gaps.

**Projects inconsistent with IEA's STEPS are excluded.** Following the recent years of oil price volatility, oil & gas companies have refocused on value rather than growth, and some

projects are now seen as less likely than they might have been previously. High-cost projects have therefore been excluded by reference to STEPS, the IEA's central scenario that assumes no further climate policy developments beyond those already enacted or announced and is consistent with a global temperature rise of 2.7°C with a 50% probability.

Any high-cost projects above the level required in this scenario have been assumed not to go ahead and therefore excluded from this analysis. This approach in effect assumes that companies are already aligned with the STEPS scenario and focuses on the "surprise" or "misread" differentials down to the SDS and B2DS demand levels. This shows the capital at risk if companies collectively (but not necessarily consciously) invest to deliver STEPS demand but are caught out by a lower level of demand.

**Focus on relative project positioning rather than the implicit absolute level of the oil or gas price.** We stress that for climate constrained scenario analyses the relative positioning of projects (and relative differences between companies) are more important than the absolute level of the marginal oil or gas price. As we have seen in recent years, the supply curve can move up and down, which would affect the marginal price, but not necessarily the order of whether projects are relatively high cost or low cost compared to each other.

Similarly, while companies may contend that their projects are lower cost than the estimates in our data, the key is not the absolute cost level of those projects (even assuming an "apples-with-apples" basis of cost estimates for comparison) but where they stand relative to competitors. Not all companies can be winners; by using a third party, global database, enable projects to be compared on a similar basis, and hence derive relative company transition risk.

**Market segmentation.** Oil is reasonably approximated as a global market. Natural gas demand markets are highly regionalized with transport primarily happening by pipeline with LNG capacity more limited – we match supply and demand separately within five markets (Europe, North America, Russia, Australia, and the rest of the world) instead. LNG markets are assumed to be global; for these projects, we match supply against the IEA's LNG trade demand figures.

**Supply curve data.** Our stranded asset analysis is based on the global supply cost curve with underlying asset and project level data from Rystad Energy Group's UCube database<sup>4</sup> that covers more than 85,000 oil & gas assets owned by 3,000+ companies globally. We publish results for approx. 60-70 of the largest listed companies included in S&P Global Energy Index (sub-categories – Integrated and Exploration & Production) plus select CA100+ companies.

**15% hurdle rate.** Each company's results are derived from a full market supply curve showing the amount of potential production (including uncommercial assets) at each level of production cost. The measure of cost we use here is the breakeven price – the oil or gas price needed for each individual project's future cash flows to yield a NPV = 0 with a given discount rate of 15%. Alternatively, these could be seen as the oil or gas prices that give each project an internal rate of return (IRR) of 15%, an approximation of a minimum return required to justify sanction given risks such as cost overruns and delays, and the need to provide a minimum return to investors.

For further discussion about Carbon Tracker's methodology, please see [www.carbontracker.org](http://www.carbontracker.org) and most recent oil & gas capex and climate – '[Adapt to Survive](#)', Carbon Tracker (2021).

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<sup>4</sup> See more information on <https://www.rystadenergy.com/energy-themes/oil-gas/upstream/u-cube/>

## Power & Utilities' retirement of fossil-fuel powered electricity generation

Carbon Tracker's four assessments seek to help investors evaluate whether announced retirement schedules for coal and gas-fired electricity generation assets from 33 CA100+ utility focus companies are in alignment with the carbon emission constraints required to meet the goals and ambitions of the Paris Climate Agreement.

These assessments are based on Carbon Tracker's proprietary in-house modeling of Paris-aligned asset-level phase out schedules that identify the year when each coal and gas boiler can be retired in an economically efficient manner. Our modeling highlights the risk to investors of high-cost carbon-intensive projects and changing costs of renewable energies to help identify when building new renewables will be cheaper than operating existing coal and gas plants – methodology explained below.

To be Paris-aligned Carbon Tracker requires electric power & utility companies to publish:

- A coal and gas retirement schedule consistent with a credible climate scenario (such as IEA's Beyond 2°C Scenario (B2DS)); and
- A retirement date (year) assigned to each coal and gas unit respectively.

Carbon emissions from the utility sector are primarily driven by coal and gas-fired generation activities of which coal is by far the most significant and is responsible for about 80% of the sector's total carbon emissions and more than 90% when also including gas - hence both generation categories must be phased out to achieve climate targets.

Coal and gas-fired generation retirement schedules are vital to ensure companies collectively meet the global temperature goals in the Paris Agreement because:

- (i) climate change is about absolute emissions rather than emissions intensity,
- (ii) long-term retirement schedules will likely minimize out-of-market payments,
- (iii) growing clean generation capacity without retiring fossil capacity could create a negative investment signal in the future, and
- (iv) publicly announcing a retirement date is less likely to be reversed.

Our analysis assumes carbon capture and storage (CCS) technologies will not be available to extend the lifetimes of coal and gas capacity, as costs will likely be prohibitively expensive and only viable based on tax subsidies without a price on carbon emissions.

Hence, we analyze unabated (i.e., no CCS) coal and gas-fired generation where under IEA's Beyond 2°C Scenario (B2DS), unabated coal will be (~99%) phased-out globally by 2040 and ~94% of unabated gas-fired phased-out globally by 2050. However, different regions will have different phase-out dates and trajectories for coal and gas generation, which are accounted for in our modeling.

## Coal and gas-fired electricity generation retirement assessments

For the CA100+ Net Zero Company Benchmark, we have developed two sets of assessments (for a total of four) to evaluate the retirement schedules of coal and gas-fired power



capacity, respectively, and their alignment with demand constraints required to meet the goals and ambitions of the Paris Climate Agreement.

Alignment assessments – coal and gas-fired electricity generation	Metrics and level of misalignment with the Paris Climate Agreement goals
<p><b>COAL PHASE-OUT:</b> Has the company announced a full phase-out of coal units by 2040 that is consistent with Carbon Tracker Initiative's interpretation of the IEA's Beyond 2°C Scenario?</p>	<ul style="list-style-type: none"> <li>▪ <b>Full retirement of coal fired generation fleet consistent with CTI's interpretation of a Paris-aligned pathway</b></li> <li>▪ <b>Full retirement of coal fired generation fleet, which is not yet consistent with CTI's interpretation of a Paris-aligned pathway</b></li> <li>▪ <b>Partial retirement</b></li> <li>▪ <b>Unannounced/ insufficient data on retirements</b></li> </ul>
<p><b>GAS PHASE-OUT:</b> Has the company announced a full phase-out of gas units by 2050 that is consistent with Carbon Tracker Initiative's interpretation of the IEA's Beyond 2°C Scenario?</p>	<ul style="list-style-type: none"> <li>▪ <b>Full retirement of gas fired generation fleet consistent with CTI's interpretation of a Paris-aligned pathway</b></li> <li>▪ <b>Full retirement of gas fired generation fleet, which is not yet consistent with CTI's interpretation of a Paris-aligned pathway</b></li> <li>▪ <b>Partial retirement</b></li> <li>▪ <b>Unannounced/ insufficient data on retirements</b></li> </ul>
<p><b>ALIGNMENT OF COAL PHASE-OUT:</b> The percentage of the company's operating and planned coal capacity that is aligned with Carbon Tracker Initiative's interpretation of IEA's Beyond 2°C Scenario. N/A signifies that no coal plants were identified.</p>	<p>% of unabated coal generation capacity (% of unabated coal generation units)</p> <p><b>0-75% of the company's operating and planned coal capacity is consistent with the Paris Agreement goals</b></p> <p><b>75-99% of the company's operating and planned coal capacity is consistent with the Paris Agreement goals</b></p> <p><b>100% of the company's operating and planned coal capacity is consistent with the Paris Agreement goals or the company has already phased out all coal capacity</b></p>
<p><b>ALIGNMENT OF GAS PHASE-OUT:</b> The percentage of the company's operating and planned gas capacity that is aligned with Carbon Tracker Initiative's interpretation of IEA's Beyond 2°C Scenario. N/A signifies that no gas plants were identified.</p>	<p>% of unabated gas generation capacity (% of unabated gas generation units)</p> <p><b>0-75% of the company's operating and planned gas capacity is consistent with the Paris Agreement goals</b></p> <p><b>75-99% of the company's operating and planned gas capacity is consistent with the Paris Agreement goals</b></p> <p><b>100% of the company's operating and planned gas capacity is consistent with the Paris Agreement goals or the company has already phased out all gas capacity</b></p>

The **first** set of assessments analyzes whether the goals and ambitions of the Paris Agreement are integrated into the company's power generation strategy. These assessments show the comprehensiveness of the company's announced coal and gas-fired generation capacity retirement schedules as an indication for the companies' preparedness for the transition to a low carbon power system.

We examine whether the companies have developed and disclosed:

- *a full phase-out retirement schedule for all coal / gas-fired generation capacities with assigned retirement years that are consistent with the demand constraints outlined in the IEA's Beyond 2°C Scenario (B2DS),*
- *a full retirement schedule with inconsistent retirement years,*
- *an only partial retirement schedule, or*
- *provided no or insufficient information to assess.*

The **second** set of assessments are based on Carbon Tracker's modeling and shows the share of companies' current and planned coal or gas-fired generation capacity retirements that are consistent with the goals and ambitions of the Paris Climate Agreement. The calculations are done for both capacity in megawatt (MW) terms and for the quantity of generation units. *The smaller the share of consistent coal or gas retirement schedules the higher the transition risk for the companies.*

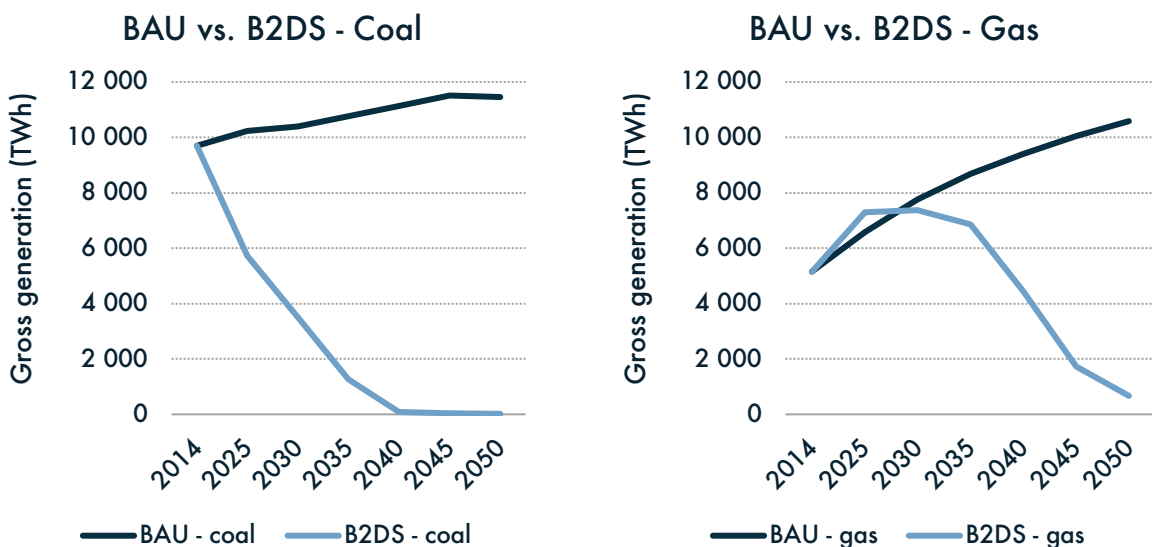
## Carbon Tracker's fossil fuel powered generation retirement analysis

The analytics are based on Carbon Tracker's techno-economic asset-level simulation coal and gas models that are using reasonable assumptions about commodity prices (fuel, power, and carbon), variable and fixed operations and maintenance costs (O&M) and policy outcomes (out-of-market revenues and control technologies costs):

- Global Coal Power Economics Model (GCPEM). GCPEM is a proprietary techno-economic simulation model which covers ~95% of global operating, under-construction, and planned coal-fired capacity<sup>5</sup>.
- Global Gas Power Economics Model (GGPEM). GGPEM is a proprietary techno-economic simulation model which covers ~40% of global operating, under-construction, and planned gas-fired capacity in the EU, United Kingdom and United States.<sup>6</sup> In Q2 2022, we will add gas modeling for several Asian countries.

Our B2DS modeling identifies the year when a coal or a gas unit needs to be retired and the amount of stranded asset risk associated with keeping the unit open. The primary asset-level inventory data builds on the Global Energy Monitor's (GEM) Global Coal Plant Tracker (GCPT) and Platts World Electric Power Plants (WEPP) databases<sup>7</sup>.

### POWER & UTILITIES - BUSINESS AS USUAL (BAU) VERSUS B2DS PATHWAYS FOR COAL AND GAS



Source: IEA scenario data, Carbon Tracker analysis

<sup>5</sup> The coal model, methodology, and assumptions are discussed in-depth in [https://carbontracker.org/wp-content/uploads/2021/06/Coal-Methodology-2021\\_June21.pdf](https://carbontracker.org/wp-content/uploads/2021/06/Coal-Methodology-2021_June21.pdf)

<sup>6</sup> The gas model, methodology, and assumptions are discussed in-depth in <https://carbontracker.org/wp-content/uploads/2021/10/Gas-Methodology-2021.pdf>

<sup>7</sup> For further information about the GPCT and WEPP see <https://endcoal.org/global-coal-plant-tracker/> and <https://www.spglobal.com/platts/en/products-services/electric-power/world-electric-power-plants-database>, respectively.

We define a stranded asset as the difference between the NPV of operating cashflows in a business as usual (BAU) scenario and a scenario, such as IEA's B2DS, that is consistent with the global temperature goals in the Paris Agreement.

- Firstly, we identify the amount of capacity that is required to fill the generation requirement in the B2DS. Under the B2DS, coal generation without carbon capture and storage (CCS) is phased out globally by 2040 (~99%) and gas generation will be almost entirely phased out by 2050 (~94%).
- Secondly, we rank the coal and gas-fired generation units to develop a retirement schedule, based on the authority, region, or grid responsible for maintaining security of supply. The units are ranked based on the Long Run Marginal Cost (LRMC) or operating cashflows.
  - **Coal:** The coal units with the highest LRMC or lowest operating cashflows are phased-out until the aggregated asset level generation reaches the limits set out in the B2DS.
  - **Gas:** Acknowledging that flexible gas turbine generation is necessary for fulfilling peak load electricity demand and other grid balancing services, units are also ranked by their turbine technology, capacity factor and operating cost to determine their potential to become a peaking power plant (peaker).
- Thirdly, we calculate the cash flow of every operating and under-construction unit in both the B2DS and BAU outcomes to understand stranded asset risk.
  - **Coal:** Stranded asset risk under the B2DS is defined as the difference between the NPV of operating cash flows in the BAU scenario (which includes announced retirements in company reports or otherwise assumes a minimum lifetime of 40 years) and the NPV of operating cash flows in the B2DS.
  - **Gas:** Stranded asset risk is then defined as the difference between the NPV of operating cash flows in the BAU scenario (which includes announced retirements in company reports or otherwise assumes a lifetime of 50 years for steam turbines, and 30 years for other technologies; or 25, whichever is later) and the NPV of operating cash flows in the B2DS.

**Carbon prices.** We only include carbon prices where they are implemented or have been approved and will be implemented in the future. In regions where stringent pollutant emission limits exist, we assume the installation of pollution control technologies and the relevant capital and operation costs across those plants that are non-compliant.

**Levelized Cost of Energy, but no system analysis.** For clarity, our modelling is based on Levelized Cost of Energy (LCOE) to compare power generation technologies. We have not conducted a systems analysis, which would require a detailed grid-by-grid analysis of the impact of removing, and potentially replacing, each asset over time. While the limitations of using LCOE analysis for understanding the economics of power generation have been well documented, this provides a simple proxy for when new investments in coal power no longer make economic sense and when investors and policymakers should plan and implement a coal or gas power phase-out. We would also note that many companies themselves conduct such analyses, including in their integrated resource plans, thus, it may be useful to ask the companies for their view on what is possible from a system point of view.

All together, we believe this work further tailors Carbon Tracker's approach to the economics of the low-carbon transition to the needs of the investors, providing both greater detail and granularity on individual plants, and big picture assessments of the pace at which

companies are transitioning by winding down their most carbon-intensive assets - coal and gas plants. It helps pose a simple question to companies: *if they in fact intend to meet emission reductions and/ or net zero targets, then they need to wind-down their coal and gas fleets, so can they now specify by how much, and when?*

**Metrics.** Carbon Tracker has developed the following metrics to track and monitor whether companies' announced retirements of coal and gas-fired generation capacity are in alignment with the pathways from a credible climate constraint scenario that meets the goals of the Paris-Alignment.

- **Absolute Unalignment (in Giga Watt, or GW)** - The yearly total capacity in GW unaligned with the energy demands of the B2DS. This is calculated by summing the difference between the company's annual coal capacity in a business-as-usual (BAU) scenario and in B2DS. This metric enables us to identify the companies with the largest unaligned generation capacity at risk for stranding and hence, where policy changes can be most impactful.
- **Relative Alignment (in percentage)** - The share of a company's future generation capacity (including retirements and new additions) that is aligned with the energy demands of the B2DS. *The lower the relative alignment, the higher the transition risk for the company.* This is calculated by summing total capacity aligned with B2DS between 2021 and 2040 for coal (2021 to 2050 for gas) divided by total capacity under a BAU scenario. A company's phase-out schedule can be either; in alignment with, behind or ahead of the B2DS schedule shown as *100% = perfect alignment, whereas <100% if behind the B2DS schedule and >100% if ahead of the B2DS.* This metric enables us to compare utilities of very different scales.
- **Share of analyzed units with announced retirement that is in alignment with B2DS (in percentage of all units)** - where the company has announced retirement year for its generation units, we show the share of the company's units where the retirement schedule is aligned with the goals of the Paris Climate Agreement.

For further discussion about Carbon Tracker's methodology, please see our most recent coal report "[Do Not Revive Coal: Planned Asia coal plants a danger to Paris](#)", and most recent gas report "[Put Gas on Standby](#)" – both authored by Carbon Tracker (2021).

See more information in the following Carbon Tracker reports:

### **Oil & Gas**

- [2 Degrees of Separation, Transition risk for oil and gas in a low carbon world, 2017](#)
- [2 Degrees of Separation, Company-level transition risks, 2018](#)
- [Breaking the Habit, 2019](#)
- [Fault Lines, 2020](#)
- [Adapt to Survive, 2021](#)

### **Power & Utilities**

- [Powering down coal: Navigating the economic and financial risks in the last years of coal power, 2018.](#)
- [Making it Mainstream, 2019](#)
- [Powering down Coal, 2019](#)
- [How to waste over half a trillion dollars: The economic implications of deflationary renewable energy for coal power investments, 2020](#)
- [Do Not Revive Coal: Planned Asia coal plants a danger to Paris, 2021](#)
- [Put Gas on Standby, 2021](#)