Carbon Tracker Initiative

Adapt to Survive

Why oil companies must plan for net zero and avoid stranded assets

September 2021

About Carbon Tracker

Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's capital markets. Our research to date on unburnable 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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About the Authors

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Axel joined the oil, gas and mining team at Carbon Tracker in 2020. He has co-authored several reports and analyst notes on the oil and gas industry in the energy transition, including Beyond Petrostates (on country fiscal risk) and Pipe Dreams (on Canadian oil sands).

Prior to joining, Axel worked at Fitch Solutions as a senior country risk analyst focused on the Middle East. He holds an MSc in Comparative Politics from the London School of Economics.

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Mike joined Carbon Tracker in 2019, and now leads the oil, gas and mining research team, focussing on identifying transition risk within the oil and gas industry. He has authored reports on stranded asset risk at the company level, including *Breaking the Habit* and *Fault Lines* alongside writing on company climate ambitions in *Balancing the Budget* and the *Absolute Impact* series. Other research themes include country risk, explored in Beyond Petrostrates, and executive remuneration.

Prior to joining Carbon Tracker, Mike worked as a geologist for BP for 10 years on projects across the upstream value chain, from early access to development. Mike has experience working in petroleum basins across the world, including time spent working in Norway, with expertise in unconventional exploration and in leading technical project teams.

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Key Findings

- **1.5°C is fast becoming a seriously-considered benchmark for Paris alignment,** with major ramifications for stranded asset risk in oil and gas.
- **The IEA's Net Zero Emissions by 2050 Scenario - limiting warming to 1.5°C - means rapid production declines as a result of "no new projects".** For virtually all of the world's 40 largest listed companies, no further project sanctions results in rapidly declining production; for half of these companies, output from sanctioned assets falls at least 50% by the 2030s compared to today's levels.
- **Shale companies see the sharpest production declines.** However, more diversified producers such as Chevron, Shell and Equinor also face steep drops.
- **Even in a slower, "well below 2 degrees" pathway, asset stranding risk via unsanctioned assets is severe.** Using a least-cost model, we find that a majority of companies would see at least half of their business-as-usual investments on currently unsanctioned assets at risk of stranding under a low carbon scenario (SDS).
- **Large projects inconsistent even with a 2.7°C world appear to be on course for future sanction.** This includes major LNG projects like Pluto Train 2 (Woodside). Such projects carry even more severe stranding risks as the energy transition gathers pace.
- **The most exposed companies are among the world's largest,** including ExxonMobil, ConocoPhillips, Rosneft and Petrobras. These companies have significant exposure to relatively high-cost themes including deepwater offshore and shale oil. Other companies have high-cost project options in oil sands and LNG that could end up stranded if sanctioned.
- **Despite stranding risks to existing discoveries, companies continue to explore for more.** This goes against any notion of the need for a managed wind-down of production and reduced exposure to oil and gas through the energy transition.
- These issues emphasise the importance of investors continuing to pressure companies for more serious transition planning.

Executive Summary

Committing to net zero is not enough – the emissions reduction pathway is critical

The past 18 months have seen an avalanche of activity from companies and investors declaring their plans to reach "net zero" in alignment with the goals of the Paris Agreement. Clearly, the net zero challenge is especially difficult for the oil and gas industry.

Yet the real factor that determines the ultimate magnitude of global temperature rise, and the extent of each company's financial risk, is which net zero scenario investors choose to model against. As a result, investors must be keenly aware of the different implications of each scenario. That is the goal of this report: to quantify portfolio risk in the upstream oil and gas industry under different decarbonisation pathways.

In this report we primarily focus on modelling the International Energy Agency's Sustainable Development Scenario (SDS), associated with 1.65°C of warming. We also show the implications of the IEA's new, more stringent Net Zero Emissions by 2050 Scenario (NZE), which targets 1.5°C of warming. Both scenarios result in net zero emissions, but at different times and through different means. For comparison, we also include the Stated Policies Scenario (STEPS), which we use to represent a high-demand or business-as-usual pathway resulting in 2.7°C of warming.

Figure 1 shows global oil demand under these different scenarios, compared to future supply from sanctioned projects, meaning those currently producing or under development.

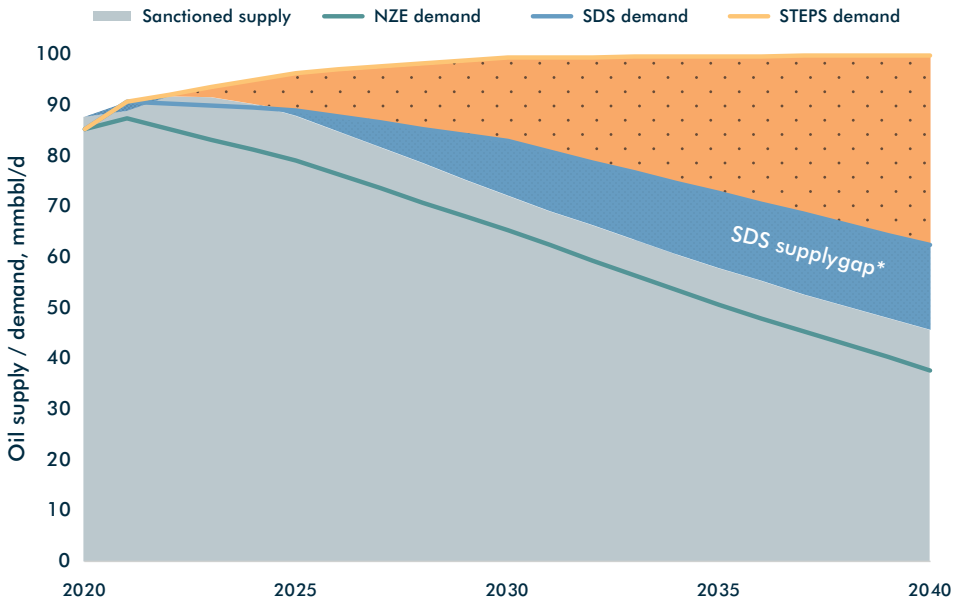
Under the stricter NZE scenario (green line) demand falls below supply from already sanctioned assets. This points in the same direction as the IEA's own conclusion: that "no new oil and natural gas fields are needed" after 2021 in the NZE.[1] In fact, it even suggests that some assets are already stranded and may close prematurely.

Under the less strict SDS scenario, there is a supply gap (represented in blue) with room for limited additional production from new oil fields – on average 5mmbbl/d over the next twenty years.

However, this is significantly smaller than the supply gap under STEPS; the orange area represents the supply from potentially future stranded assets.

1 https://www.iea.org/news/pathway-to-critical-and-formidable-goal-of-net-zero-emissions-by-2050-is-narrow-but-brings-huge-benefits

FIGURE 1 – GLOBAL OIL DEMAND UNDER DIFFERENT IEA SCENARIOS, AND FUTURE SUPPLY FROM SANCTIONED PROJECTS



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Note: Sanctioned = Producing and under-development assets.

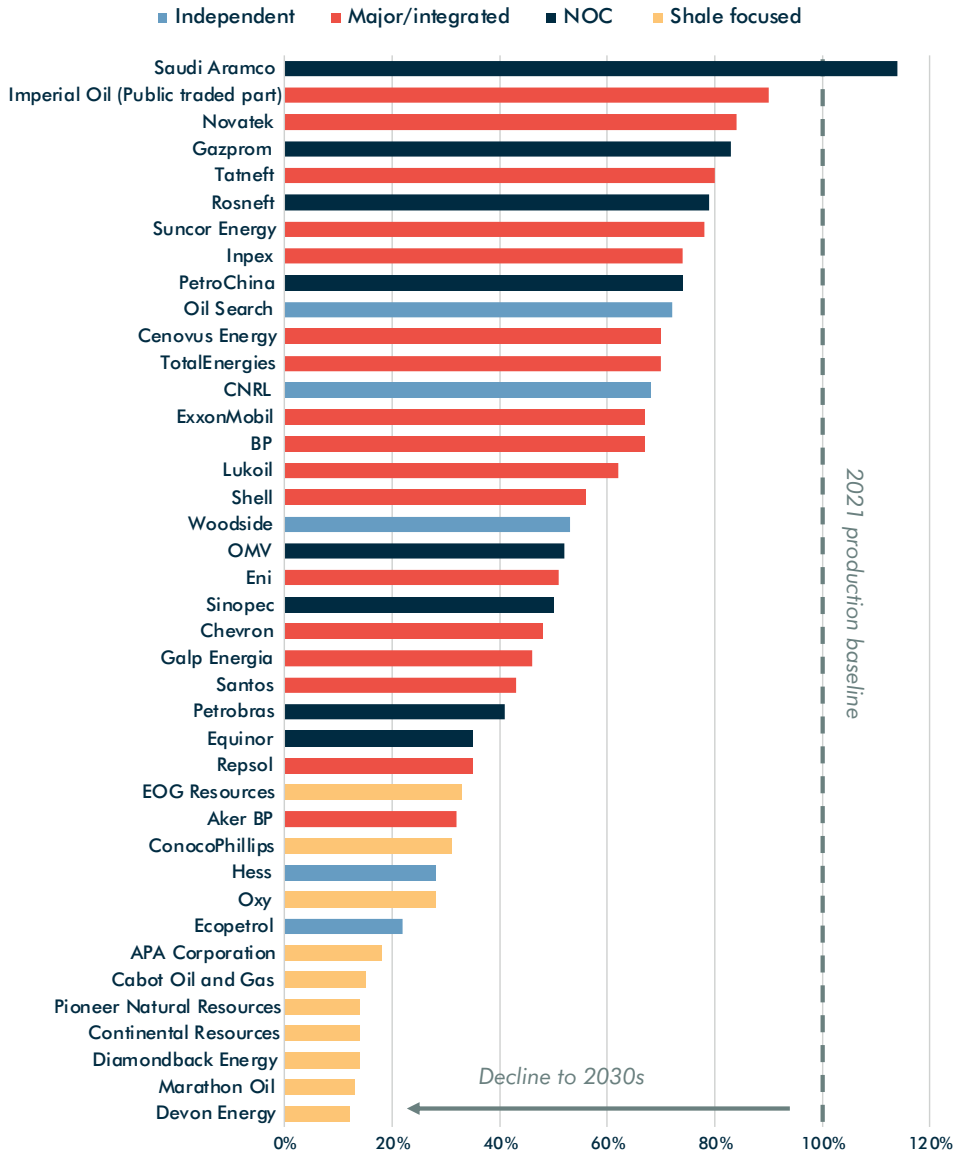
Net zero 2050 means a rapid wind-down of production; shale most at risk

Using Rystad Energy's base case forecasts, **Figure 2** visualises what happens to production levels in the 2030s under the NZE for the world's 40 largest listed oil and gas companies, compared to their production in 2021. It shows that for most companies – including majors like Shell, Chevron and Eni – production falls by at least half. Most shale companies see production fall by over 80%.

Investors looking to align with 1.5°C or net zero 2050 (NZE) may well find that this makes shale investments increasingly hard to defend.

2021 numbers represent Rystad projections as at March 2021, and include assumed sanctions for the year.

FIGURE 2 – IMPLICATION OF IEA NZE SCENARIO (NO NEW PROJECT SANCTIONS) ON OIL AND GAS PRODUCTION: AVERAGE 2030s PRODUCTION BY COMPANY VS 2021



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Notes: 2030s = 2030-2040 average. Oil and gas production in barrel of oil equivalent terms. Shale focused = Shale at least 50% of 2021-2040 production. Rystad base case volumes.

Even in other "well below 2°C" scenarios, asset stranding risks are severe

For those investors that choose not to align with the NZE (or other 1.5°C scenarios), we caution that asset stranding is still a major risk under slower transition pathways such as the SDS, albeit in the form of investment on unsanctioned assets.

To model this risk, we use a least-cost approach that assumes any supply gap is satisfied by the cheapest unsanctioned project options. Investment into more expensive project options will not earn a sufficient return, with those assets considered stranded.

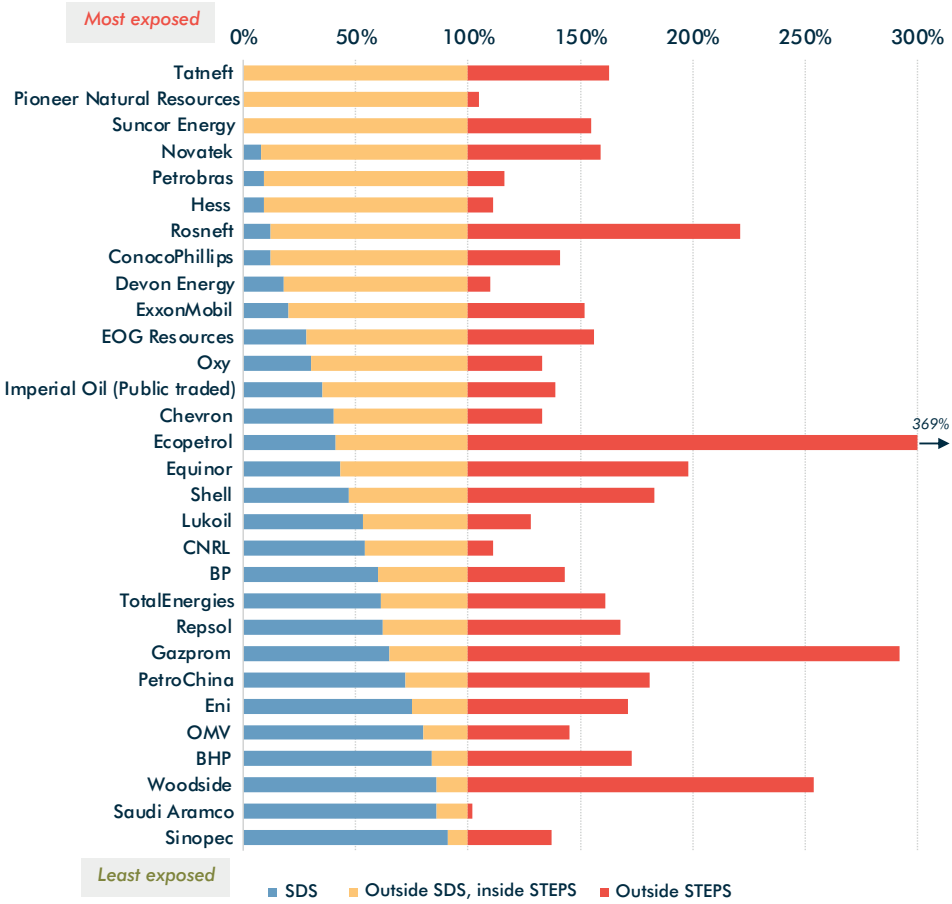
In **Figure 3** we show capex over the next decade on unsanctioned assets by company, using the business-as-usual level (STEPS) as a benchmark for what companies might reasonably look to sanction. As such, it represents the "surprise" gap between the high-demand future that companies may base sanctioning decisions on, and one where fossil fuel demand rapidly falls as the world pursues the goals of the Paris Agreement. In real dollar terms, globally this gap is equal to $1 trillion of investment over the next 20 years.

The blue bar represents the percentage of STEPS capex that aligns with the SDS. We find that in the SDS, more than half (33) of the world's 60 largest listed companies would see at least 50% of their business-as-usual project options become uncompetitive, and thus likely financially stranded; the 30 largest companies are shown below.

The poor competitiveness of certain themes clearly plays out in the relative placement of these companies. North American shale oil companies (e.g., Pioneer Natural Resources, Hess, ConocoPhillips) fare poorly, as do deepwater offshore specialists (Petrobras) and oil sands companies (Suncor Energy, Imperial Oil).

Other companies with large conventional resources or a focus on gas, like Saudi Aramco and Woodside, tend to rank better on this measure. However, using STEPS as the cut-off point for what companies are likely to develop can also hide important details. For instance, Woodside is preparing to sanction Pluto Train 2, a large project with breakeven costs high enough to not fit even within STEPS (represented by the red bar).

FIGURE 3 – 2021-2030 UNSANCTIONED CAPEX BY SCENARIO (% OF STEPS UNSANCTIONED CAPEX) – SELECTED COMPANIES



Source: Rystad Energy, IEA, Carbon Tracker analysis.

Despite risks, companies continue to explore and acquire high-cost reserves

Clearly, the industry has more project options than are needed in a low-carbon world – not just in very fast transition scenarios like the NZE, but in the SDS too. Despite this, companies continue to look for new resources, even in areas where the economics of identified assets are relatively poor.

Indeed, even European companies supposedly looking towards rapid decarbonisation and claiming to focus on their most "advantaged assets" are still paying for new acreage in the hope of finding more oil and gas. TotalEnergies, Equinor, Shell, Eni and OMV have all picked up new exploration licenses in frontier areas like Suriname and Norway's Barents Sea. Such moves call into question these companies' commitment to transitioning away from oil and gas.

Investors must continue to pressure companies for stronger transition planning

This report marks the fifth annual instalment of Carbon Tracker's analysis of upstream oil and gas capex risk, already an established benchmarking tool among large investors. This research is used by CA100+, the world's largest investor-led collaborative engagement initiative with more than 600 institutional investors collectively managing over $55tn, to benchmark companies and them towards better transition planning.

Investors have a crucial role to play in driving the changes to the oil and gas industry's behaviour necessary to steer it onto a more sustainable path. As recent climate-focused shareholder actions towards major companies have shown, the investor community is also growing more aware and organised in its pursuit of these objectives. Through our research, we look to inform and empower these efforts to ensure that the oil and gas industry walks the walk.

Introduction

Industry and investor sentiment around climate action is changing rapidly. Net zero 2050, a target often used synonymously with 1.5°C, has gone from being a best-case aim in the Paris Agreement to being part and parcel of many companies' transition plans. Equally, investors have started to shift the goal posts of what it means to be "Paris-aligned" while ramping up pressure on management boards to follow suit. Engine1's campaign to replace board members at ExxonMobil in pursuit of more serious transition planning is a wake-up call to executives that these organised investor initiatives have teeth.

Policymakers are also getting on board with net zero, at least in principle. According to BNEF, half of the world's emissions are now covered by some form of government net zero emissions target, including major emitters like the EU, China and Japan.[2] Combined with demand displacement through rapidly falling renewables costs, companies thus face transition risk from several different angles at once.

1.5 degrees means no new oil and gas projects

The International Energy Agency's (IEA) recent release of its Net Zero Emissions by 2050 Scenario (NZE) for the global energy system reflects these trends and has breathed fresh life into the 1.5°C debate. Most strikingly, the report concludes that to limit warming to 1.5°C by 2100, even with the use of carbon capture technology,[3] "no new oil and natural gas fields are needed" after 2021.[4] While this may not be surprising to readers of our previous reports – we've previously drawn the same conclusion from other 1.5°C scenarios (e.g. the IPCC's P1[5]) – it clearly has seismic implications for the oil and gas industry.

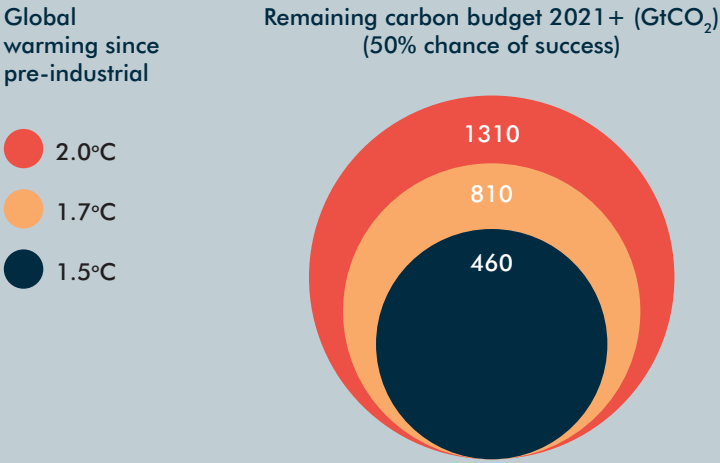
The reason is that the pace of change required is so much quicker. Simply striving for net zero in 2050 isn't in itself enough: it's the pathway towards net zero which is crucial in determining the warming outcome (see explainer box). As such, alignment with the Paris goals means conforming to a scenario that not only reaches net zero, but also does so rapidly enough to meet a temperature outcome of "well below 2 degrees Celsius" by 2100, without an over-reliance on as-yet-unproven negative emissions technologies.[6]

2 https://assets.bbhub.io/dotorg/sites/64/2021/07/BNEF-Climate-Policy-Factbook.pdf.
3 See methodology appendix for comparisons of CCUS use in different IEA scenarios.
4 https://www.iea.org/news/pathway-to-critical-and-formidable-goal-of-net-zero-emissions-by-2050-is-narrow-but-brings-huge-benefits.
5 See previous iteration of this research series, "Breaking the Habit", https://carbontracker.org/reports/breaking-the-habit/.
6 See our report "Absolute Impact 2021", https://carbontracker.org/reports/absolute-impact-2021/ .

Explainer: Carbon budgets

The idea of a carbon budget underpins our thinking at Carbon Tracker. It posits that each temperature target – 2°C, 1.5°C, etc – is associated with a set amount of cumulative greenhouse gas emissions from today's levels until the end of the century.

For a 50% chance of staying below 1.5°C, the carbon budget is roughly 450GtCO$_2$ – meaning it will be exhausted in about 11 years at the current rate of emissions (~40GtCO$_2$/year). For a 67% chance, it's just 9 years.



Source: *Global Carbon Project, IPCC, CTI analysis, April 2021.*

Carbon budgets feed into transition scenarios, which rely on the budgets to estimate the likely temperature outcome of a given decarbonisation pathway. It also works in reverse when trying to solve for a particular warming outcome, for instance scenarios that explicitly try to achieve 1.5°C.

Carbon budgets have obvious implications for the oil and gas industry as well. They clearly show that full life-cycle emissions, not just those that occur during extraction, are what matters for climate targets. This means that companies can't escape transition risk simply by decarbonising their own activities – if the world is to avert climate catastrophe, demand for fossil fuels must fall sharply too. All those with a stake in the industry are exposed.

Room for new oil and gas projects can only narrow as the world decarbonises

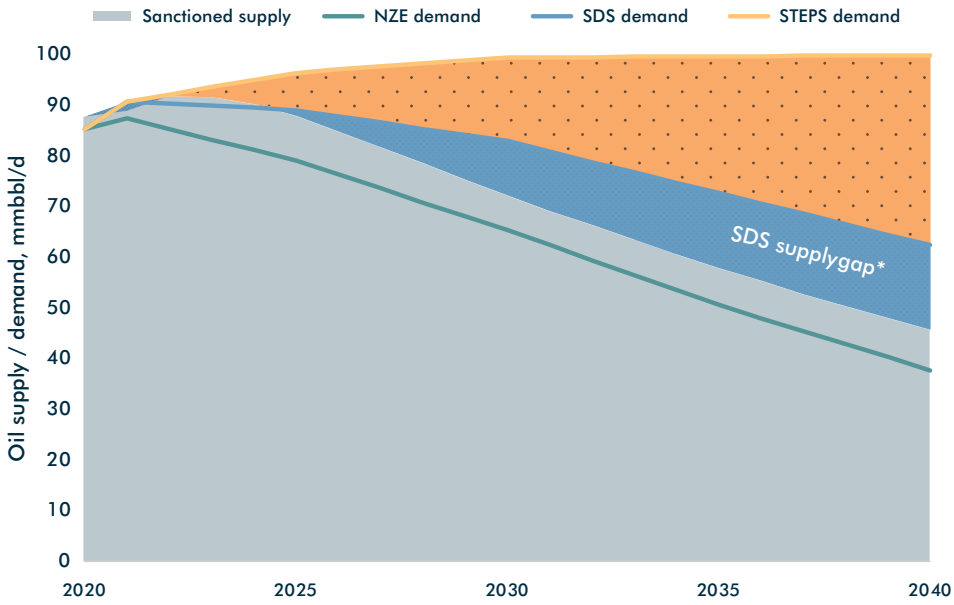
The upshot is, of course, that fossil fuel use must fall. Lower oil and gas demand means lower prices and greater competition for market share, in turn creating even less space to develop new projects while still earning a sufficient return. Accordingly, companies developing new assets in anticipation of a business-as-usual future of stable/rising demand will find themselves highly exposed to asset stranding if the world instead rapidly decarbonises, be it along the NZE, SDS or some other trajectory in between.

A comparison of oil demand under both the NZE and SDS is shown in **Figure 4**, alongside the Stated Policies Scenario (STEPS, 2.7°C) which we believe represents a business-as-usual pathway for the industry. Additionally, Figure 4 shows the future production from sanctioned (producing and under-development) fields.[7]

Our findings clearly support that of the IEA's NZE – that no new projects are needed if we are to reach net zero by 2050 – as demand under the NZE falls well below the level of future supply expected from sanctioned fields.

Figure 4 also shows that under the SDS, there is significantly less space for new projects than under STEPS. Quantifying the differing transition risks faced by upstream oil and gas companies under this scenario is the focus of our modelling throughout this report.

FIGURE 4 – GLOBAL OIL DEMAND UNDER DIFFERENT IEA SCENARIOS, AND FUTURE SUPPLY FROM SANCTIONED (POST-FID) PROJECTS



Source: Rystad Energy, IEA, Carbon Tracker analysis.

7 *Gas is similar, but more complicated to plot due to demand being market-specific; see methodology appendix.*

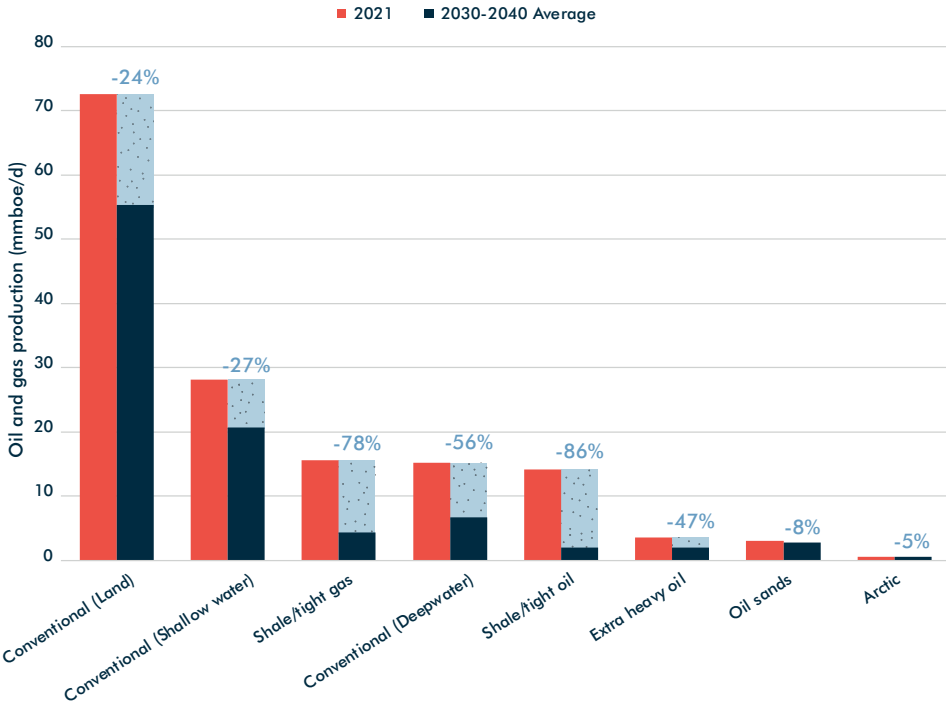
In our previous work, we have also used other scenarios from the IEA, including the Beyond 2 Degrees Scenario (B2DS, 1.6°C, net zero by 2060). Which of the SDS, NZE, or any other low-carbon scenario represents a "Paris-aligned" pathway, is ultimately up to individual investors to decide.

Regardless, in any low-carbon future, the overarching challenge for the oil and gas industry is that the space for new production narrows over time, while the risk of investing in assets that are not required increases, placing capital at risk.

"No new projects" hits shale the hardest

Under the NZE, future production amounts to running down sanctioned assets; since decline rates vary depending on resource theme, the impacts of this paradigm shift would disproportionately hit certain parts of the industry harder. **Figure 5** summarises this by comparing production from sanctioned assets under Rystad Energy's base case ($50s/barrel oil price long term) in the 2030s with today's levels.

FIGURE 5 - IMPLICATION OF IEA NZE (NO NEW PROJECT SANCTIONS): PRODUCTION DECLINES BY RESOURCE TYPE



Source: Rystad Energy, IEA, Carbon Tracker analysis.

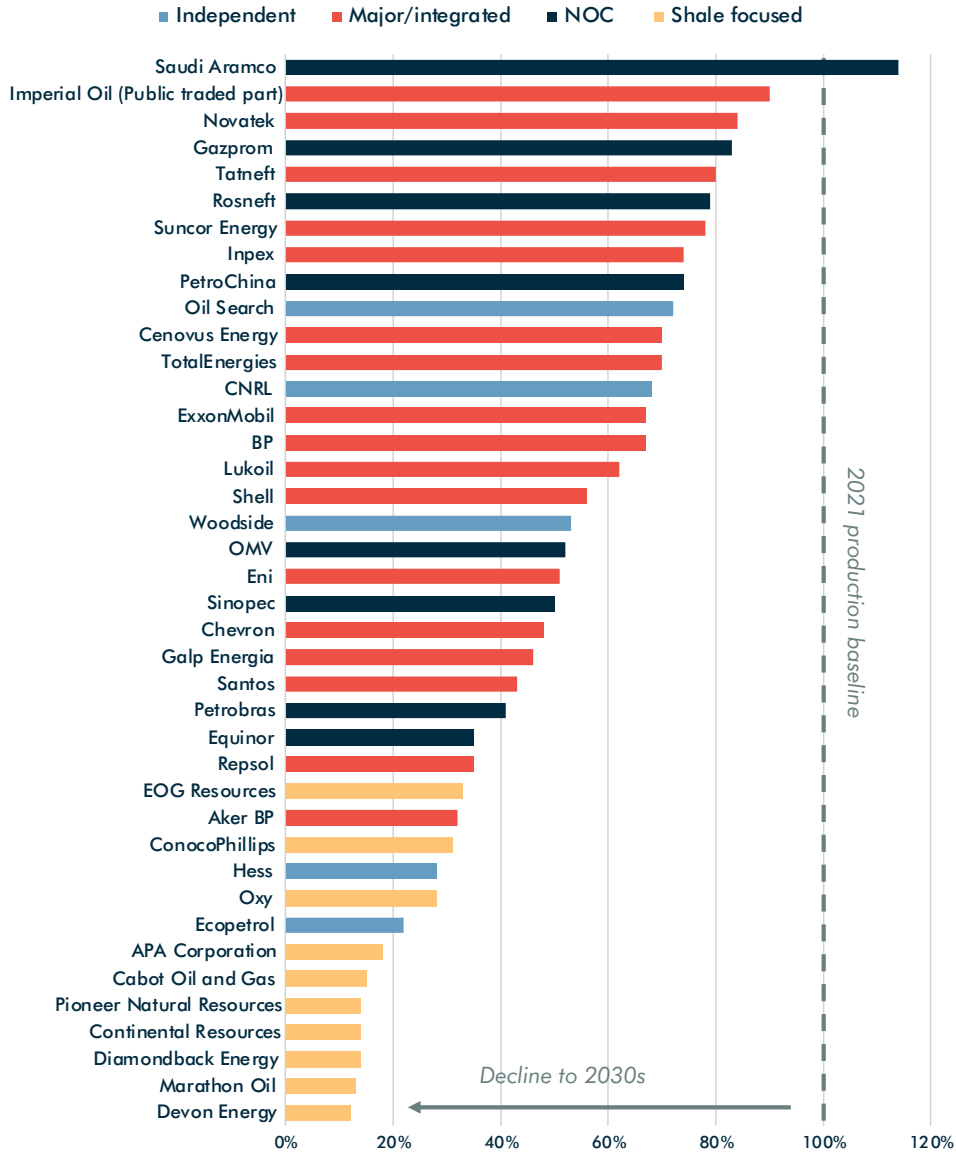
Shale wells generally have high decline rates, with companies relying heavily on continued new drilling to sustain production; as a result, it should come as no surprise that production from shale declines rapidly in a 1.5°C pathway. Shale and tight oil production from sanctioned assets fall by 86% between 2021 and the 2030s (Figure 5). Deepwater projects also face steeper decline rates than either onshore or shallow water.

Most large companies shrink significantly by the 2030s in the NZE

For most companies, halting new project sanctions would mean production levels fall significantly over the coming decades. **Figure 6** compares oil and gas production from sanctioned assets in the 2030s with that in 2021, both according to Rystad Energy's base case projections, for the 40 largest upstream and integrated entities by market cap in the S&P Global Oil Index, plus Saudi Aramco. Of these, more than half would shrink by at least 50% as their sanctioned assets are run down and no new assets are developed to replace them.

The differences between companies ultimately reflects the nature of their project portfolio. Given the results by resource theme in **Figure 5**, it's unsurprising to see that shale-focused companies are most impacted, clearly dominating the bottom quarter of **Figure 6** – including large companies like ConocoPhillips and Oxy. That said, other more diversified companies with significant shale exposures still face the same challenges, such as Exxon, Equinor and Repsol.

FIGURE 6 – IMPLICATION OF IEA NZE (NO NEW PROJECT SANCTIONS): PRODUCTION DECLINES TO 2030s BY COMPANY



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Notes: 2030s = 2030-2040 average. Shale focused = Shale at least 50% of 2021-2040 production. Rystad base case volumes.

The only exception to the general rule of rapid decline in Figure 6 is Saudi Aramco, which would see roughly 15% growth in total production from its sanctioned assets, driven mainly by increases at its Ghawar field – the world's largest oil field. This reflects Aramco's large spare capacity from mature fields. That said, this doesn't insulate Saudi Arabia from transition risk. The country's fiscal health is very much leveraged to oil prices and would face enormous challenges in a rapid transition scenario, as we have shown in our previous work focused on state oil and gas revenues in the SDS.[8]

Only a handful of companies recognise the need for production declines

Figure 6 stands in stark contrast to what most companies plan for. Only a handful of companies, like Shell, Eni, and BP have explicitly acknowledged that their oil production will fall over the coming years; BP is the only one to also include its gas business, which Shell and Eni still plan to grow.

The companies with ostensibly strong targets are not perfect, either. Although BP have pledged a 40% reduction by 2030, greater than the 33% implied by the data in Figure 6, this doesn't mean the company isn't planning new sanctions; rather, the focus is clearly on divestment, all while new "advantaged" assets are developed.[9]

Equally, while Shell's court-mandated 45% absolute emissions reduction by 2030 - a decision based on conforming to a global 1.5°C pathway - is in line with its 44% production decline under NZE in Figure 6, the court mandate carries no potential sanctions for non-compliance. The court's reduction target is far more ambitious than the company's own plans (a 45% emissions *intensity* reduction by 2035) and Shell still plans on significant growth in its gas business.

We recognise, of course, that these companies are still on the frontier of transition planning in that they accept that production levels will need to fall over time. Again, the vast majority of oil and gas companies have not done so, and we strongly urge them to follow suit.

Production declines have important implications for investors

The idea of rapid production declines raises some important questions around company valuations, which investors will want to consider carefully. Calling a halt to new sanctions would effectively make unsanctioned assets worthless and mean a permanent decline in future cashflows. Both would imply a serious shock to asset/equity valuations and leverage, in turn increasing the cost of capital and insolvency risks.

Companies may of course actively front run these issues, either by diversifying into new revenue streams (such as renewables) or by deleveraging and winding down, with capital returned to shareholders. From the perspective of oil and gas investors looking to align with net zero 2050 and/or 1.5°C, it's crucial that they only hold companies with strong transition plans of either persuasion.

8 https://carbontracker.org/reports/petrostates-energy-transition-report/.
9 https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/investors/bpweek/bpweek-resilient-focused-hydrocarbons-slides-and-script.pdf.

Falling demand will only make increase transition risk

Even if the transition to a low-carbon economy turns out to be slower than the NZE posits, it's hard to hide from the reality of the energy transition: lower fossil fuel prices, at least on average, and a smaller oil and gas industry. Companies and investors need to recognise now the risk of stranded assets that this creates. That's not a far-off concern for a future CEO, but a very real one right now – highlighted by mass asset impairments[10] and shareholder AGM interventions in 2020 and 2021. Yet despite the growing awareness of these risks, large companies such as ExxonMobil, Gazprom, Petrobras and Oxy continued to sanction large new assets even in 2020, a year of extremely weak demand.

Against the backdrop outlined above, the present circumstances are particularly dangerous. As the world continues to emerge from the huge demand shock of Covid-19, and as OPEC keeps a tight grip on supply, oil prices remain tantalisingly high compared to last year. Simultaneously, growing concerns from parts of the industry about underinvestment – upstream capex in 2016-2020 was 40% lower than in 2011-2014 – could also lead companies to justify new sanctions in the hopes of cashing in on a new commodities "supercycle".

These short-term incentives ultimately stand in direct opposition to the goals of the Paris Agreement, which requires that oil and gas use significantly falls. In the face of this imperative, it's questionable how long a new cycle of higher oil prices, if it does occur, can really last. Given the long pay-back period of a typical oil or gas project, companies need to look beyond short-term signals if they are to guarantee lasting shareholder value.

This report seeks to bring clarity to this issue. By identifying which new assets are most at risk of stranding in a low-carbon world, and by extension which companies have the greatest transition risk, we give investors a tool with which to limit their own exposure to falling fossil fuel demand – all while keeping the oil and gas industry in check from pursuing short-term gains ahead of value preservation.

10 https://www.wsj.com/articles/2020-was-one-of-the-worst-ever-years-for-oil-write-downs-11609077600.

The Carbon Tracker Approach

This report is the fifth instalment in Carbon Tracker's Two Degrees of Separation series of reports which determine potential transition risk exposure by company for upstream oil and gas. It uses the same least cost methodology as the previous iteration, *Fault Lines* (published October 2020).

A brief summary of our approach is as follows:

- 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, detailed in the box overleaf.

- 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 on the basis of 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 which has 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, with a greater proportion of assets potentially at risk of becoming stranded if developed.

For the 2021 iteration of this analysis, we have updated the methodology to vary supply assumptions depending on the demand scenario used, to more accurately reflect future marginal prices under each one. This is to recognise the fact that under lower demand, long-term oil prices will likely fall, which will impact production levels, even from sanctioned projects. As such, lower-demand scenarios are modelled at lower production levels for both sanctioned and unsanctioned assets, using Rystad's alternate price-case production forecasts (see Appendix III for more detail).

IEA scenarios used in this report

Sustainable Development Scenario (SDS)[11]: This is our benchmark low carbon scenario. The 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.

Net Zero Emissions by 2050 Scenario (NZE)[12]: This scenario follows a pathway consistent with a 50% chance of limiting warming to 1.5°C without any overshoot – that is, without assuming global temperature rise can exceed 1.5°C before being pulled back down using carbon dioxide removal. Because the scenario doesn't include gas demand projections broken down by region – a necessary precondition of our model given the regionalised nature of gas markets – we haven't formally modelled the NZE for this report. As such, we present only the implications of the report's overall conclusion that no new oil and gas projects are required, which our data also broadly supports.

Beyond 2 Degrees Scenario (B2DS)[13]: An older scenario with a faster transition pathway than the SDS. It reaches net zero ten years before the SDS, in 2060, and we estimate it is consistent with a 50% chance of approximately 1.6°C warming by 2100. We have chosen to de-emphasise the B2DS in this iteration of our analysis, as it hasn't been updated in some years – however, we have included results for B2DS within Appendix I.

Stated Policies Scenario (STEPS)[14]: 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 but yet to be enacted, legislation on climate change is assumed to continue, but not be developed further.

Our modelling assumes that sanctioned projects (already producing or under development) continue to produce, as once capex is committed, projects are rarely stopped. Even if point-forward profitability is poor, companies will still want to recoup past investments as long as marginal revenue exceeds marginal cost. Accordingly, our approach focuses on identifying those new (unsanctioned) project options that fall outside a given climate scenario.

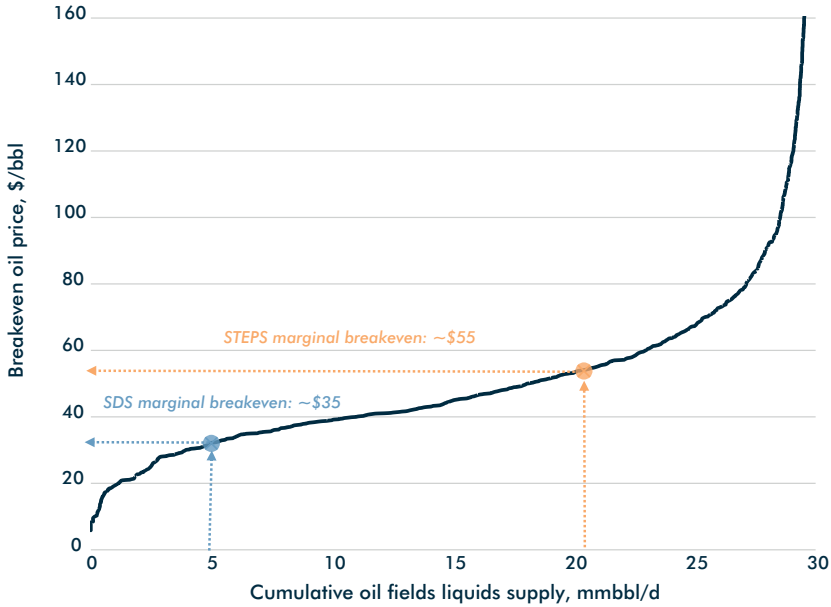
This approach is illustrated in **Figure 7**, which shows cost curves for the cumulative supply available from unsanctioned (pre-FID) oil projects, including potential expansion projects/phases to existing fields, under Rystad's base case volumes.[15] The vertical

11 *Published in the World Energy Outlook 2020.*
12 *Published in the Net Zero by 2050 report (May 2021).*
13 *Published in the Energy Technology Perspectives 2017.*
14 *Published in the World Energy Outlook 2020.*
15 *The main impact of using different Rystad price cases is a change in future production from already-sanctioned assets, and thus the supply gap. In our modelling of unsanctioned assets, we use cost curves at different price cases, however as the results are very similar at lower breakeven prices, for simplicity only the base case cost curve is shown in Figure 7 (see methodology appendix for more detail).*

arrows indicate the average demand for oil under each scenario in excess of future supply from existing fields – the supply gap as shown in **Figure 4**. The intersection of demand and potential supply determines the marginal breakeven prices under each scenario, as indicated by the horizontal arrows.

New oil fields that fall outside the SDS will have a breakeven oil price in excess of roughly $35/bbl at a 15% discount rate – but we stress that this marginal price is an output of the modelling, not an assumption. The true oil price in any scenario will inevitably fluctuate based on many other factors besides supply and demand.

FIGURE 7 – CUMULATIVE POTENTIAL OIL SUPPLY (2021-2040) FROM UNSANCTIONED OIL FIELDS - RYSTAD $BASE CURVE, SHOWING STEPS AND SDS SUPPLY GAPS



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Notes: Breakeven prices assume a 15% IRR. See Footnote 14 and methodology appendix for details on the use of different supply price cases.

We apply a similar logic for gas fields, although as gas demand is highly regionalised – transport happens primarily 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. For LNG projects, we match supply against the IEA's LNG trade demand figures.

Least Cost Modelling Results

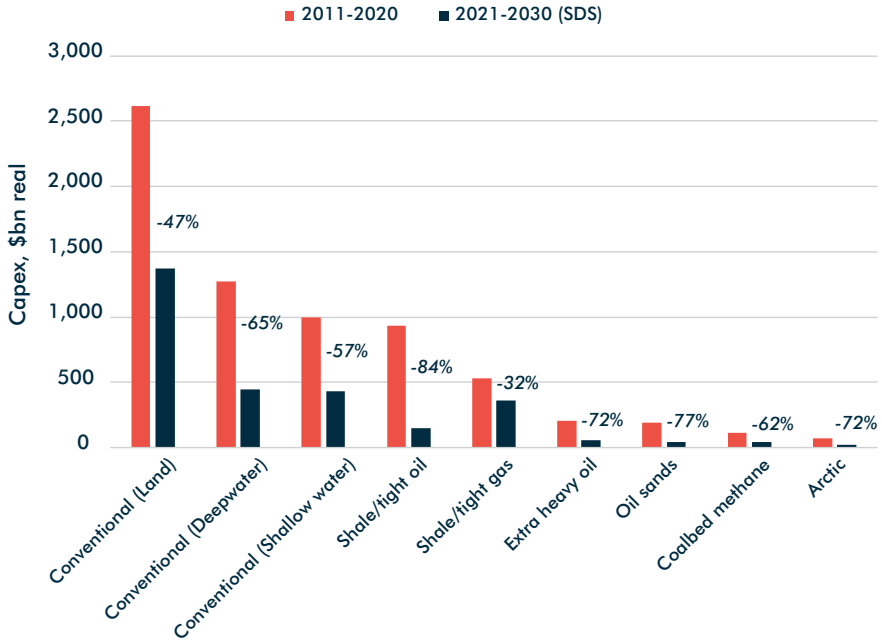
5.1 Thematic Insights

2020s cannot be a repeat of last decade

Our modelling results for the SDS clearly indicate that another wave of investment in response to a perceived supercycle is at odds with the realities of the Paris Agreement. Starting with total capex (sanctioned and unsanctioned), we see that global investment in the SDS over the next decade would be 58% lower than in the last decade (falling from $7tn to $3tn). In the NZE, where the industry invests only in sanctioned assets, the drop in total capex is 69%.

No resource theme is immune from decline, with investment falling across all categories **(Figure 8)**; nevertheless, certain resource themes, such as shale oil, oil sands, arctic drilling and extra heavy oil, are even more affected, with total capex falling by at least 70%.

FIGURE 8 – INVESTMENT DECLINES IN A LOW CARBON SCENARIO (SDS) BY RESOURCE THEME: SANCTIONED & UNSANCTIONED CAPEX IN THE 2020s VS LAST DECADE



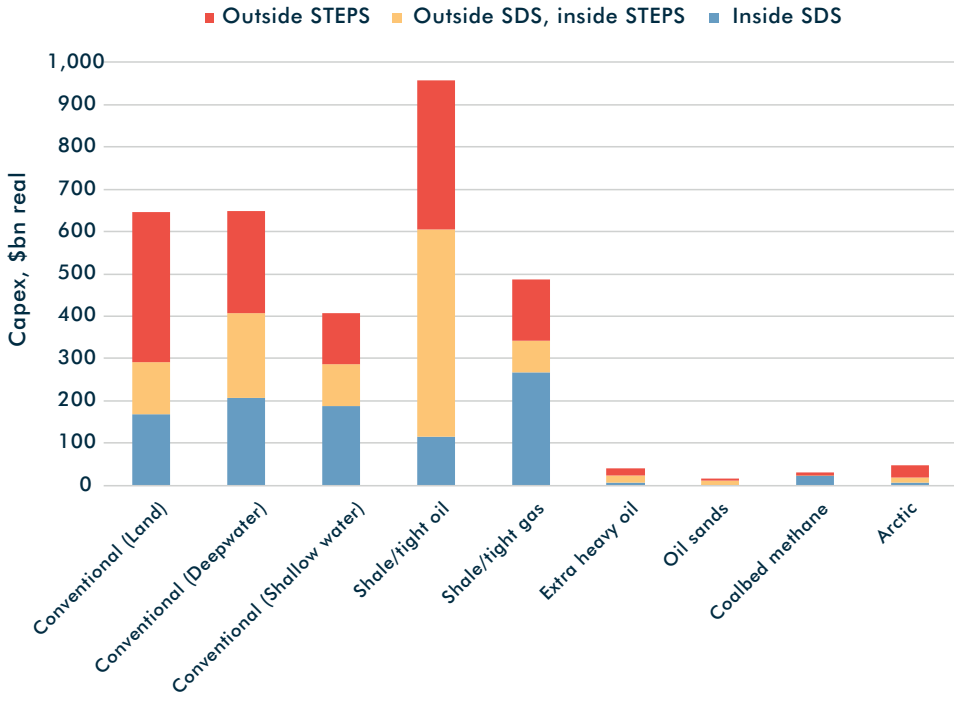
Source: Rystad Energy, IEA, Carbon Tracker analysis.

Shale prospects dim over the long-term

Moving onto unsanctioned capex – our primary measure of risk – we see again that shale finds itself in a challenging spot. Under business-as-usual (STEPS), capex on unsanctioned shale/tight oil projects is $600bn, yet just $110bn of this is inside our low-carbon scenario (SDS) – see **Figure 9**.

This is an important conclusion: not only does existing shale oil production decline rapidly (and thus shale-focused companies see the greatest declines in the NZE, see introduction), it is also one of the least competitive streams for developing new assets. This translates to a particularly severe sensitivity to demand outcomes, as we've shown in previous research.[16]

FIGURE 9 – 2021-2030 UNSANCTIONED CAPEX BY IEA SCENARIO AND RESOURCE THEME



Source: Rystad Energy, IEA, Carbon Tracker analysis.

16 *See Fault Lines (https://carbontracker.org/reports/fault-lines-stranded-asset/) for more data on this relationship.*

While **Figure 8** and **Figure 9** both show that shale gas fields are relatively more resilient in capex terms, this is partly a result of shale oil's weakness. With nearly 90% of shale oil investment excluded in the SDS – denoted as the yellow and red bars in Figure 9 – significant quantities of associated gas are also excluded as a result. This in turn implies a greater need to bring on dedicated gas fields to fill the gap in gas demand.

Still, this doesn't mean gas is a safe haven for growth. With every new iteration of the SDS, the IEA has assumed ever-steeper demand decline rates in North America for the period 2021-2040 – from 19% in the first release from 2017, to 43% in the latest release from 2020.[17] In the NZE, with no new gas assets sanctioned, North American gas production would fall by 75% over the next two decades.

Oil sands effectively a write-off

As in previous iterations of our analysis, oil sands remains one of the most uncompetitive themes in a low-carbon scenario. Oil sands investment in the SDS on both sanctioned and unsanctioned assets is around $50bn in 2021-2030, a quarter of what it was in the last decade (2011-2020) – see Figure 8 at the start of this chapter. The vast majority of SDS investment is on sanctioned assets, which our model assumes will continue to produce over their natural lives – investment on new (unsanctioned) assets is virtually nil. Most new investments would therefore immediately be at risk of stranding.

The oil sands industry's challenges became particularly apparent in 2020 as oil prices fell through the floor. TotalEnergies took a $7bn impairment on its oil sands assets, mirrored by write downs by several Canadian oil sands specialists (Imperial Oil ~$1bn; Suncor ~$1.6bn; Teck ~$900mn).[18] These impairments speak to the fundamentally high cost of developing oil sands assets, which translates into high stranding risks in our modelling framework. Promises of pursuing net zero operational emissions by 2050, the industry's most recent attempt at luring back investors, won't address these fundamental problems.[19]

Conventional resources more resilient, deepwater carries greater risk

While conventional resources tend to fare better than some other themes, not all are created equally: deepwater projects[20] have significantly higher stranding risk, with 50% of STEPS capex falling outside the SDS, compared to 30-40% for onshore and shallow water. The largest concentrations of deepwater capex risk, measured as the amount of STEPS investment that falls outside the SDS, sit in Brazil (in major fields such as Buzios) followed by the US Gulf of Mexico and Guyana.

17 *The same applies to global demand, where the first SDS assumed 8% growth, while the latest assumes a 13% decline.*
18 *Source: Financial disclosure via Bloomberg.*
19 *https://www.reuters.com/business/sustainable-business/canadas-oil-sands-producers-form-alliance-achieve-net-zero-emissions-by-2050-2021-06-09/.*
20 *In previous iterations of this analysis we distinguished between deepwater (150-1500m) and ultra-deepwater (greater than 1500m); here we treat them as a single theme, given their operational similarities.*

Deepwater's relative weakness stems from several factors. Projects tend to be both capital-intensive and feature significant technical risk compared to onshore or shallow water resources. In some cases, new deepwater basins are in countries without a long history of oil and gas production – notably Guyana. This in turn means less pre-existing infrastructure and more uncertain geological conditions, which drives up upfront development costs.

LNG won't be a saving grace

LNG continues to be a source of optimism in the oil and gas industry, with companies expecting it to benefit from the energy transition as a flexible transition fuel. For instance, BP, which plans to reduce oil and gas production by 40% over the next decade, still expects its LNG portfolio to grow by 50% over that same period. Eni, which we regard as having the most comprehensive climate targets of any major, similarly plans to grow its LNG business by 45% over the next three years. While accounting for a small fraction of the overall oil and gas industry – less than 4% of total capex in the last decade – LNG it is clearly viewed as a growth opportunity.

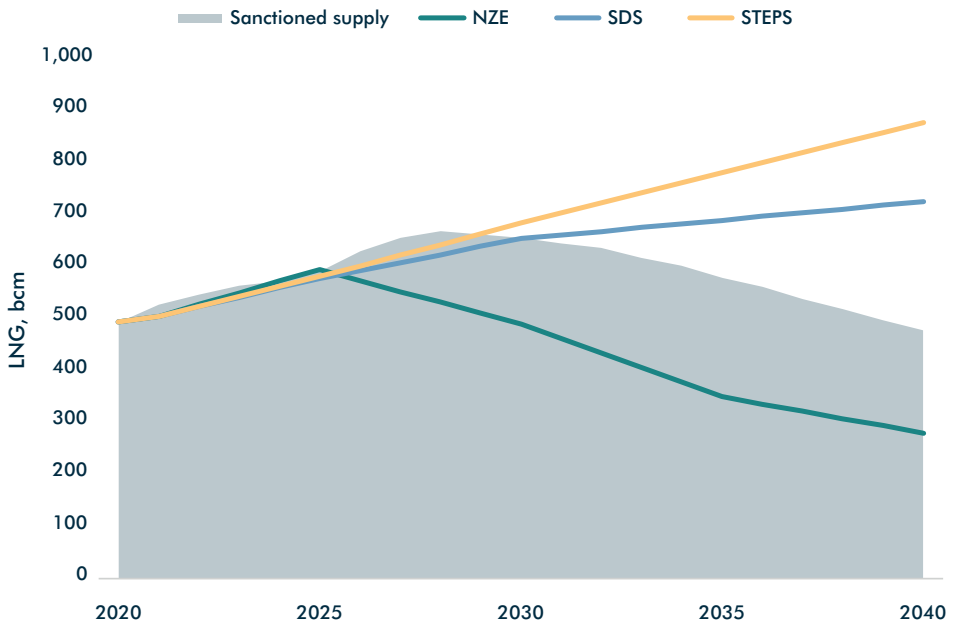
Under a 1.5°C scenario (NZE), where gas peaks earlier, we see future LNG trade[21] met by existing projects, and no new LNG projects would go ahead – see **Figure 10**. Since sanctioned supply exceeds demand by some 25%, some already-sanctioned projects would be at risk of being shut in early which would lead to significant losses – not to mention those from unsanctioned options.

In the SDS, LNG demand grows by >40% over 2021-2040 – a substantial amount, albeit considerably less than STEPS, which sees growth at >70%. That said, future LNG demand growth is predicated on major emerging economies, particularly in Asia, moving from coal to gas. That trend could well be challenged by countries leapfrogging directly to renewables, a possibility which seems to be underestimated by the industry at present.[22]

21 *In our assessment of LNG we use the IEA's interregional LNG trade demand figures, which are included in all their scenarios. We also add an allowance for intraregional trade.*

22 *For more on the emerging market electricity leapfrog, see https://carbontracker.org/reports/reach-for-the-sun/.*

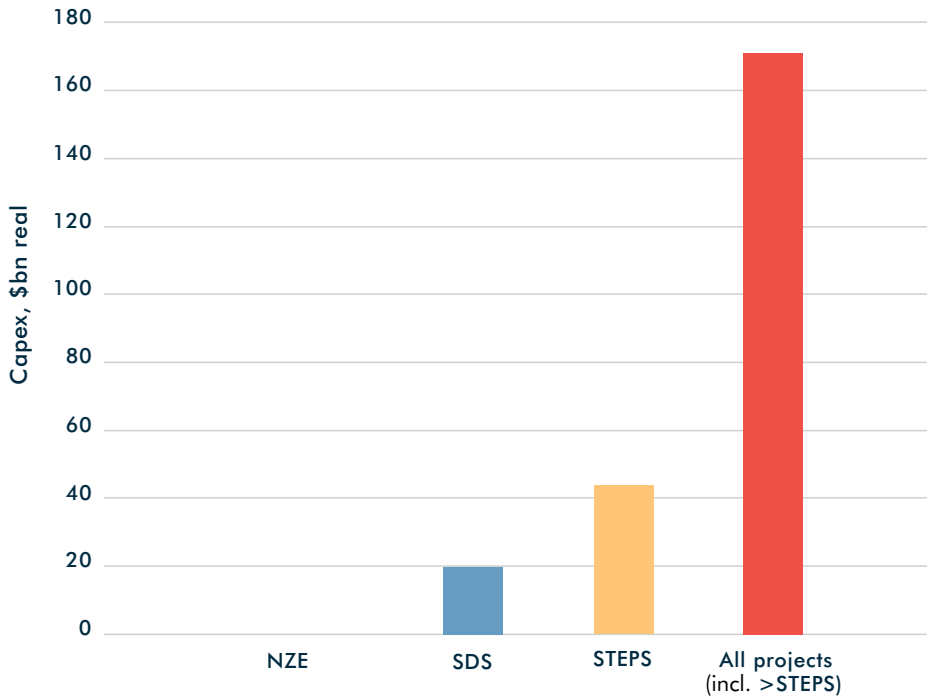
FIGURE 10 – GLOBAL LNG DEMAND UNDER DIFFERENT IEA SCENARIOS, AND FUTURE SUPPLY FROM SANCTIONED PROJECTS



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Note: The fact that the NZE outstrips both the SDS and STEPS in 2025 likely reflects that it is a newer scenario. We expect the latter two scenarios to catch up in the next iteration of the WEO.

Even with rising demand, the SDS still implies significant stranding risks if companies overshoot the mark by sanctioning based along the STEPS pathway (or something even more bullish). We find that 55% of capex on LNG projects in STEPS falls outside the SDS, with the vast majority of that slice concentrated in the US (some $14bn of unsanctioned capex) and Mozambique (about $9bn), with further significant amounts in Russia and Canada. That said, the capex overhang is considerably larger when we include project options that fall outside even STEPS – this portion represents 291% of the total STEPS amount. This is shown in **Figure 11**.

FIGURE 11 – LNG PROJECT OPTIONS: 2021-2030 UNSANCTIONED CAPEX ON LNG PROJECTS



Source: Rystad Energy, IEA, Carbon Tracker analysis.

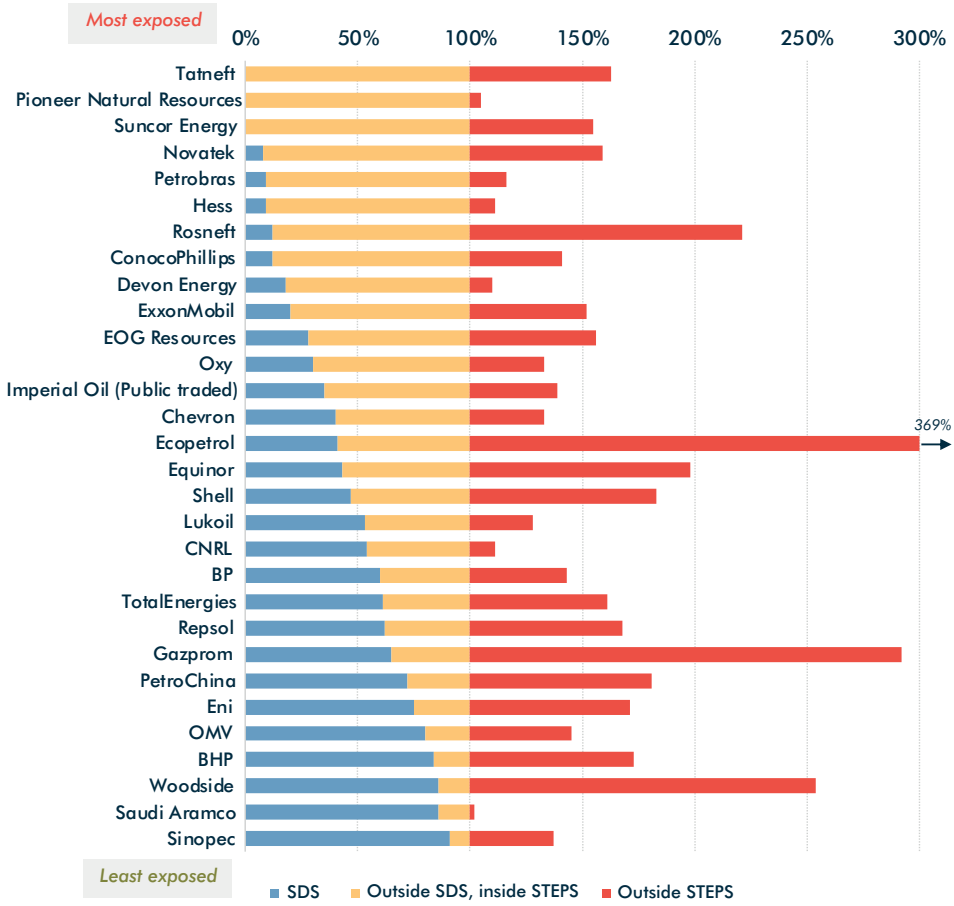
5.2 Company Risk – Relative Positioning

Company universe shows broad spectrum of risk

The conclusions drawn on a thematic level clearly extend down to the company level as well; companies' relative transition risk is heavily linked to the project development options in their portfolio. **Figure 12** shows company portfolio alignment for unsanctioned assets for both low carbon (SDS) and business-as-usual (STEPS) scenarios, focusing on the 30 largest companies in our 60-strong universe.[23] Those with large yellow bars – i.e., with large portions of future STEPS capex falling outside the SDS – are the most exposed to lower fossil fuel demand.

23 *By market cap; results for all 60 companies can be found in Appendix I.*

FIGURE 12 – 2021-2030 UNSANCTIONED CAPEX BY SCENARIO (% OF STEPS UNSANCTIONED CAPEX) – SELECTED COMPANIES



Source: Rystad Energy, IEA, Carbon Tracker analysis.
Note: CNOOC and Inpex have been replaced by BHP and Devon Energy since Fault Lines.

Among the most exposed are several companies focusing on shale oil (Pioneer, Hess, ConocoPhillips, Oxy), deepwater assets (Petrobras) and oil sands (Suncor), reflecting the thematic results shown in the previous section. Companies that are relative less exposed in this ranking tend to be those focused on conventional oil and gas (Saudi Aramco, OMV, PetroChina) or some mix of conventional and tight gas (Sinopec).[24]

24 *See Appendix II for commentary on year-on-year changes in companies' relative positioning.*

Majors' transition risk aligns with their climate ambitions

The majors display an equally wide range of transition risk as the wider company universe. Much as we saw in *Fault Lines*, there is a strong correlation between the quality of companies' emissions goals[25] – e.g., whether they cover scope 3 emissions and have interim targets – and their portfolio risk. In other words, companies that have more ambitious emissions targets tend to also have exposed portfolios. Eni and TotalEnergies come out on top in this group, echoing their high placement on our emissions ambitions rankings; US companies perform the worst, which again aligns with their position at the foot or our emissions ambitions.

This relationship makes some intuitive sense. Companies that set their emissions targets in a way that recognises the planet's finite limits may also be more conservative in their portfolio management, as both imply a fundamental caution about future demand and profitability. Equally, it's fair to assume that companies with weak emissions targets have looser assumptions about planetary boundaries and thus assume more robust future demand, which feeds into riskier sanctioning behaviour. Of course, this correlation is far from perfect – notably, many European majors still plan on growing LNG and/or wider gas production.

STEPS is the baseline – but projects above can still be major stranding risks

As we use STEPS as the proxy for business-as-usual company planning – an assumption we view as relatively conservative – some companies may appear relatively less exposed but still carry significant stranded asset risk if they have significant project options that fall outside even STEPS (large red bars on Figure 10). We ultimately think this is a reasonable trade-off, as not doing so could mean overstating the amount of capex at risk.

Nevertheless, we caution investors to query highly ranked companies with large portions of capex above the STEPS line. Examples of such companies which may appear fairly high in the relative rankings while still carrying significant asset stranding risk include Imperial Oil, the Canadian oil sands producer and Woodside, which is heavily focused on LNG.

And indeed, some projects that fall outside STEPS may still be actively considered for investment. If sanctioned, those projects would be at even greater risk of becoming stranded through the energy transition than those that only fall outside the SDS. For example, Woodside is still clearly intending to sanction Pluto Train 2, a large LNG project that falls outside STEPS – at the time of this report's publication, the company was preparing to sell a 49% stake in the project to help drive it forward.

With oil prices well above the STEPS marginal breakeven oil price (~$55/bbl) at the time of writing, the risk is elevated that companies sanction more of these projects that fall outside STEPS. This again highlights how our decision to use STEPS as the cut-off for what we consider business-as-usual makes for a conservative measure of capex at risk. It is also an important call to investors to ensure that companies demonstrate how any project sanctions are compatible with a low-demand world, not just short-term prices.

25 *For more on the majors' emissions targets, see "Absolute Impact 2021", https://carbontracker.org/reports/absolute-impact-2021/.*

2020 project sanctions outside the SDS

The outbreak of the Covid-19 pandemic, and in particular the restrictions on the world's major economies that followed, put immense pressure on energy markets in 2020. As oil prices collapsed, oil and gas companies reeled back expansion plans and cut dividends to keep balance sheets in shape. Despite these extremely challenging conditions, sanctioning activity did not stop - indeed, companies continued to greenlight assets that would not be compatible with the SDS under our modelling. The five largest (in capex terms) of these are shown in the table below.

Asset	Location	Field type	Ownership	Capex (2021-2030), $m
Payara (Prosperity)	Guyana	Oil field	ExxonMobil (45%); Hess (30%); CNOOC (25%)	5,500
Itapu (x-Florim) (P-71)	Brazil	Oil field	Petrobras (100%)	4,000
Sangomar Phase 1	Senegal	Oil field	Woodside (68.33%); Petrosen (18%); FAR Limited (13.67%)	3,900
Mero 3 (x-Libra NW) (Marechal Duque de Caxias)	Brazil	Oil field	Petrobras (40%); Shell (20%); Total (20%); CNOOC (10%); CNPC (parent) (10%)	2,700
Pacora	Guyana	Oil field	ExxonMobil (45%); Hess (30%); CNOOC (25%)	1,800

Existing discoveries not needed – yet companies still explore for more

Clearly, the industry has more project options than are needed in a low-carbon world, as evidenced by the large amounts of capex that falls outside the SDS and even STEPS for most companies. Despite this, companies continue to look for new resources, even in areas where the economics of identified assets are poor. Indeed, even European majors supposedly looking towards rapid decarbonisation and claiming to focus on their most "advantaged assets" are still paying for new acreage in the hope of finding more oil and gas.

For example, in June 2021, TotalEnergies, together with Chevron and Qatar Petroleum, acquired acreage in offshore Suriname – a relatively high-cost play where 70% of STEPS capex would fall outside the SDS. That same month Equinor, Shell, Vår Energi (Eni owned) and OMV all picked up stakes in Norway's Barents Sea. This area remains extremely unproven and, as shown earlier, Arctic projects are some of

the least resilient in our modelling. These decisions call into question the seriousness with which companies consider their long-term emissions goals, even those with strict interim targets (such as Eni).

Granted, companies are also selling at the same time as they explore; in the first half of 2021, the majors disposed of $6.9bn worth of assets, with BP and Shell accounting for the lion's share.[26] Still, this doesn't explain why companies are willing to take a risk on exploration at a time when some of them have pledged to reduce production. It's also completely at odds with the IEA's understanding of a net zero 2050 pathway, where no new projects are sanctioned past 2021 – let alone new acreage explored.

Companies claiming Paris alignment need to show serious planning

The growing emphasis on net zero 2050 and 1.5°C among investors and policymakers raises some existential questions for the oil and gas industry. If companies truly want to show that they are consistent with 1.5°C and net zero 2050, then sanctioning new projects ought to be extremely hard to justify. Putting a halt to new sanctions would in turn imply sharp production declines for most listed companies, especially in the shale segment, although extending to more diversified producers as well.

If companies are serious about aligning with the Paris goals and reaching net zero globally by mid-century, they need to be prepared for a rapid wind-down of their traditional business segments. Similarly, investors that want to be 1.5°C ready need to be aware of the serious implications that this has for the oil and gas companies they hold.

Even for those companies and investors who do not wish to align with a 1.5°C temperature goal, our modelling shows that many companies would come under severe stress even in a slower, if still ambitious, transition scenario like the SDS. Even with some room for new projects, the risk of asset stranding is severe unless management teams are very prudent about sanctioning decisions. The fact that majors with ostensibly strong transition plans are still exploring for new resources shows that this prudence may yet be elusive.

26 *According to analysis by Rystad Energy from 29 June 2021.*

Appendix I
Supplementary Company Results

TABLE 1 – UNSANCTIONED CAPEX (2021-2030) BY IEA SCENARIO – RANKED ALPHABETICALLY WITHIN SDS EXPOSURE QUARTILE

SDS quartile	Company	Upstream capex outside B2DS budget (% of STEPS)	Upstream capex outside SDS budget (% of STEPS)	Upstream capex outside STEPS budget (% of STEPS)
1	Antero Resources	0-10%	0-10%	0-10%
1	Arc Resources	20-30%	20-30%	0-10%
1	Beach Energy Limited	40-50%	10-20%	90-100%
1	BHP	20-30%	10-20%	70-80%
1	CNX Resources Corporation	0-10%	0-10%	90-100%
1	EQT Corporation	0-10%	0-10%	60-70%
1	OMV	50-60%	20-30%	40-50%
1	Origin Energy	0-10%	0-10%	90-100%
1	Range Resources	10-20%	10-20%	70-80%
1	Sasol	0-10%	0-10%	40-50%
1	Saudi Aramco	50-60%	10-20%	0-10%
1	Seven Generations Energy	0-10%	0-10%	0-10%
1	Sinopec	0-10%	0-10%	30-40%
1	Tourmaline Oil	10-20%	10-20%	0-10%
1	Woodside	40-50%	10-20%	90-100%
2	Aker BP	90-100%	30-40%	50-60%
2	BP	50-60%	40-50%	40-50%
2	Cimarex Energy	50-60%	50-60%	0-10%
2	CNRL	50-60%	40-50%	10-20%
2	Eni	30-40%	20-30%	70-80%
2	Gazprom	70-80%	30-40%	90-100%
2	Inpex	30-40%	20-30%	90-100%
2	Lukoil	80-90%	40-50%	20-30%
2	Lundin Energy	90-100%	40-50%	40-50%
2	Murphy Oil	50-60%	50-60%	70-80%

2	PetroChina	30-40%	20-30%	80-90%
2	Repsol	40-50%	30-40%	60-70%
2	Santos	70-80%	30-40%	90-100%
2	TotalEnergies	50-60%	30-40%	60-70%
2	Vermilion Energy	50-60%	50-60%	70-80%
3	APA Corporation	90-100%	70-80%	90-100%
3	Cenovus Energy	70-80%	70-80%	40-50%
3	Chevron	70-80%	60-70%	30-40%
3	Continental Resources	80-90%	70-80%	90-100%
3	Ecopetrol	50-60%	50-60%	90-100%
3	EOG Resources	90-100%	70-80%	50-60%
3	Equinor	80-90%	50-60%	90-100%
3	ExxonMobil	80-90%	80-90%	50-60%
3	Galp Energia SA	60-70%	60-70%	90-100%
3	Imperial Oil (Public traded part)	60-70%	60-70%	30-40%
3	Marathon Oil	70-80%	60-70%	20-30%
3	Oil Search	70-80%	60-70%	10-20%
3	Oxy	70-80%	70-80%	30-40%
3	Shell	60-70%	50-60%	80-90%
4	Cabot Oil and Gas	90-100%	90-100%	0-10%
4	ConocoPhillips	80-90%	80-90%	40-50%
4	Crescent Point Energy	90-100%	90-100%	50-60%
4	Devon Energy	80-90%	80-90%	10-20%
4	Diamondback Energy	90-100%	90-100%	10-20%
4	Hess	90-100%	90-100%	10-20%
4	Matador Resources	90-100%	90-100%	20-30%
4	Novatek	90-100%	90-100%	50-60%
4	Ovintiv	80-90%	80-90%	20-30%
4	Parex Resources	90-100%	90-100%	90-100%
4	PDC Energy	90-100%	90-100%	0-10%
4	Petrobras	90-100%	90-100%	10-20%
4	Pioneer Natural Resources	90-100%	90-100%	0-10%
4	Rosneft	90-100%	80-90%	90-100%
4	Suncor Energy	90-100%	90-100%	50-60%
4	Tatneft	90-100%	90-100%	60-70%

TABLE 2 – ALL (SANCTIONED + UNSANCTIONED) CAPEX (2021-2030) BY IEA SCENARIO – RANKED ALPHABETICALLY WITHIN SDS EXPOSURE QUARTILE

SDS quartile	Company	Upstream capex outside B2DS budget (% of STEPS)	Upstream capex outside SDS budget (% of STEPS)	Upstream capex outside STEPS budget (% of STEPS)
1	Antero Resources	0-10%	0-10%	0-10%
1	Arc Resources	20-30%	20-30%	0-10%
1	Beach Energy Limited	40-50%	10-20%	90-100%
1	BHP	20-30%	10-20%	70-80%
1	CNX Resources Corporation	0-10%	0-10%	90-100%
1	EQT Corporation	0-10%	0-10%	60-70%
1	OMV	50-60%	20-30%	40-50%
1	Origin Energy	0-10%	0-10%	90-100%
1	Range Resources	10-20%	10-20%	70-80%
1	Sasol	0-10%	0-10%	40-50%
1	Saudi Aramco	50-60%	10-20%	0-10%
1	Seven Generations Energy	0-10%	0-10%	0-10%
1	Sinopec	0-10%	0-10%	30-40%
1	Tourmaline Oil	10-20%	10-20%	0-10%
1	Woodside	40-50%	10-20%	90-100%
2	Aker BP	90-100%	30-40%	50-60%
2	BP	50-60%	40-50%	40-50%
2	Cimarex Energy	50-60%	50-60%	0-10%
2	CNRL	50-60%	40-50%	10-20%
2	Eni	30-40%	20-30%	70-80%
2	Gazprom	70-80%	30-40%	90-100%
2	Inpex	30-40%	20-30%	90-100%
2	Lukoil	80-90%	40-50%	20-30%
2	Lundin Energy	90-100%	40-50%	40-50%
2	Murphy Oil	50-60%	50-60%	70-80%
2	PetroChina	30-40%	20-30%	80-90%
2	Repsol	40-50%	30-40%	60-70%
2	Santos	70-80%	30-40%	90-100%
2	TotalEnergies	50-60%	30-40%	60-70%
2	Vermilion Energy	50-60%	50-60%	70-80%

3	APA Corporation	90-100%	70-80%	90-100%
3	Cenovus Energy	70-80%	70-80%	40-50%
3	Chevron	70-80%	60-70%	30-40%
3	Continental Resources	80-90%	70-80%	90-100%
3	Ecopetrol	50-60%	50-60%	90-100%
3	EOG Resources	90-100%	70-80%	50-60%
3	Equinor	80-90%	50-60%	90-100%
3	ExxonMobil	80-90%	80-90%	50-60%
3	Galp Energia SA	60-70%	60-70%	90-100%
3	Imperial Oil (Public traded part)	60-70%	60-70%	30-40%
3	Marathon Oil	70-80%	60-70%	20-30%
3	Oil Search	70-80%	60-70%	10-20%
3	Oxy	70-80%	70-80%	30-40%
3	Shell	60-70%	50-60%	80-90%
4	Cabot Oil and Gas	90-100%	90-100%	0-10%
4	ConocoPhillips	80-90%	80-90%	40-50%
4	Crescent Point Energy	90-100%	90-100%	50-60%
4	Devon Energy	80-90%	80-90%	10-20%
4	Diamondback Energy	90-100%	90-100%	10-20%
4	Hess	90-100%	90-100%	10-20%
4	Matador Resources	90-100%	90-100%	20-30%
4	Novatek	90-100%	90-100%	50-60%
4	Ovintiv	80-90%	80-90%	20-30%
4	Parex Resources	90-100%	90-100%	90-100%
4	PDC Energy	90-100%	90-100%	0-10%
4	Petrobras	90-100%	90-100%	10-20%
4	Pioneer Natural Resources	90-100%	90-100%	0-10%
4	Rosneft	90-100%	80-90%	90-100%
4	Suncor Energy	90-100%	90-100%	50-60%
4	Tatneft	90-100%	90-100%	60-70%

Appendix II
Relative Changes in Company Positioning

Our methodological approach remains broadly similar in this report as in *Fault Lines*. That said, aggregate demand is slightly lower in this year's iteration of our model, partly because of a tighter demand outlook in the WEO 2020 than in the WEO 2019. This has compressed the supply gap somewhat, which impacts rankings of companies reliant on large assets with breakevens close to the marginal breakeven of the SDS. Moreover, a year of industry activity will inevitably mean some changes to company portfolios as well. These factors are summarised below:

CATEGORY	RELATIVE EXPOSURE IMPROVEMENT	RELATIVE EXPOSURE WORSENING
Corporate activity	**Asset divestment**, particularly of non-core positions	**Acquisition of new projects** outside budget
Data update	**Reduction in individual project breakeven costs**, sometimes related to improved resource estimates and/or project rationalisation, resulting in project moving inside the budget **Deferral of capex** on high-cost projects beyond 2030 timeframe **Reduction in capex** for projects outside budget	**Reduction in marginal industry breakeven cost** (demarcating in/out of budget) resulting in projects that were inside the budget now being outside **Upwards revision to breakeven cost estimates** **Increased capex outside B2DS but within STEPS**, either having previously been excluded as outside STEPS or through new acquisitions

In the interest of brevity and given the size of our company universe, below we list a few companies with the largest relative movements in our rankings and some significant drivers behind these moves. We mainly focus on companies' rankings with regards to unsanctioned SDS capex as a share of STEPS capex. These examples are drawn from the 30 largest companies in our 60-strong universe; smaller companies may also have seen their exposures shift but are not detailed here.

Improved relative positioning:

Imperial Oil: Syncrude Mildred Lake Extension sanctioned, reducing the amount of unsanctioned STEPS capex and increasing the relative share of unsanctioned SDS capex.

Equinor: Bacalhau Phase 1 (Brazil) now falls outside the SDS due to a lower marginal breakeven price for oil. Similarly, "Bakken/Three Forks Shale Rough Rider area" (US) now falls outside STEPS, increasing the relative share of SDS capex.

Ecopetrol: Reduced capex projections for Ecopetrol's largest project, an Oxy joint venture in the Permian, has reduced the amount of STEPS capex and thus increased the relative share of SDS capex. Orca and Santa Ana, two shallow water offshore gas fields inside the SDS, have seen their estimated approval years moved forward into the 2020s, increasing the amount of SDS capex in that timeframe.

TotalEnergies: Increased capex projections for Brulpadda gas field (South Africa), an SDS asset. New discovery in Kwaskwasi (Suriname), which is estimated to fall inside the SDS. North Platte oil project now falls outside STEPS, which has increased the relative share of SDS capex as well.

Worsened relative positioning:

Novatek: North Obskoye, Syadorskoye, Seyakhinskoye Zapadnoye (Russia) gas fields now fall outside of SDS due to a lower marginal breakeven price for Russian gas.

Chevron: Reduced capex projections for "Wolfcamp (Core Culberson)" (US), an SDS asset. The New Mexico portion of that same discovery has fallen outside the SDS due to a lower marginal breakeven price for oil. Moreover, most of the largest assets acquired via Noble Energy fall outside the SDS, which have also reduced the relative share of SDS capex.

ExxonMobil: Several large shale oil assets, for instance in the Wolfcamp portion of the Delaware basin, no longer fit in the SDS due to a lower marginal breakeven price for oil; as mentioned in Chapter 5, shale tends to be sensitive to even small variations in demand assumptions.

ConocoPhillips: Large Alaskan assets Narwhal and Willow now fall outside the SDS due to a combination of higher breakeven prices and a lower marginal breakeven price for oil. The same applies to assets in the Bakken Shale Formation.

Appendix III
Methodology

The methodology follows in large part those of the last two iterations of this analysis. The most detailed description can be found within the accompanying methodology document to *Breaking the Habit (September 2019)*.[27] This appendix focuses only on key elements of our approach as well as notable changes since the last iteration.

8.1 Data sources

The supply data that forms the basis of our analysis comes from Rystad Energy's UCube, which provides asset-level information on global upstream oil and gas. We make only minor adjustments to this data. For instance, we reclassify gas markets (i.e., Rystad's view on where each gas asset ships to) into broader regions that are consistent with our demand scenarios.

We also use Bloomberg to source our universe of 60 companies. This is drawn from the E&P and Integrated segments of the S&P Global Oil & Gas Index, with minor manual additions: Saudi Aramco, BHP and Sasol.

The vast majority of our data was collected in March 2021.

Notable changes: Due to M&A activity, a few companies have been dropped from our company universe: Concho Resources (acq. by ConocoPhillips); WPX Energy (merged with Devon Energy); Noble Energy (acq. by Chevron); Parsley Energy (acq. by Pioneer Natural Resources); Husky Energy (acq. by Cenovus).

8.2 Demand scenarios

We use IEA demand scenarios to proxy different levels of transition risk. These are:

- ***Stated Policies Scenario (STEPS):*** Our "business-as-usual" proxy, equivalent to an estimated 2.7°C of warming in this century. Source: World Energy Outlook 2020.

- ***Sustainable Development Scenario (SDS):*** Our main "Paris-aligned" scenario, equivalent to an estimated 1.65°C of warming in this century, with net zero emissions reached in 2070. Source: World Energy Outlook 2020.

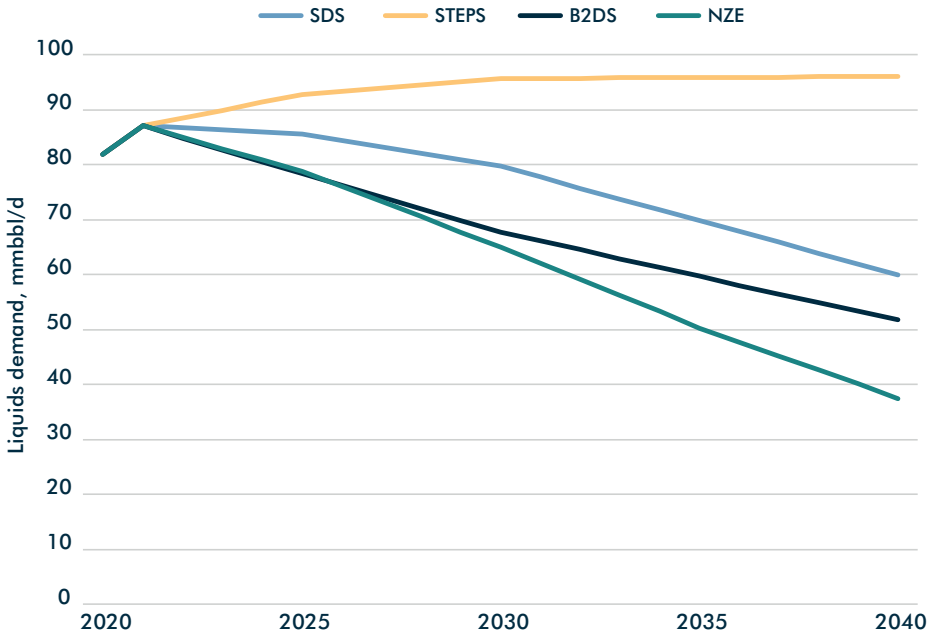
27 *Report available at https://carbontracker.org/reports/breaking-the-habit/. Methodology available at https://carbontransfer.wpengine.com/wp-content/uploads/2019/09/Breaking-the-Habit-Methodology-Final-1.pdf.*

- ***Net Zero Emissions By 2050 Scenario (NZE):*** A faster decarbonisation 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: Net Zero by 2050 (2021). N.b. we have not formally modelled supply under this scenario in this iteration of our analysis, in part due to a lack of detail on regional gas demand in the IEA's scenario data.

- ***Beyond 2 Degrees Scenario (B2DS):*** An older rapid-transition scenario that lands somewhere between the SDS and NZE, being equivalent to an estimated 1.6°C in this century with net zero reached by 2060. Source: Energy Technology Perspectives 2017.

A comparison of liquids demand is shown in **Figure 13**, which makes for a useful proxy of the relative pace of decarbonisation between these four scenarios.

FIGURE 13 – LIQUIDS DEMAND (2020-2040) UNDER FOUR IEA SCENARIOS

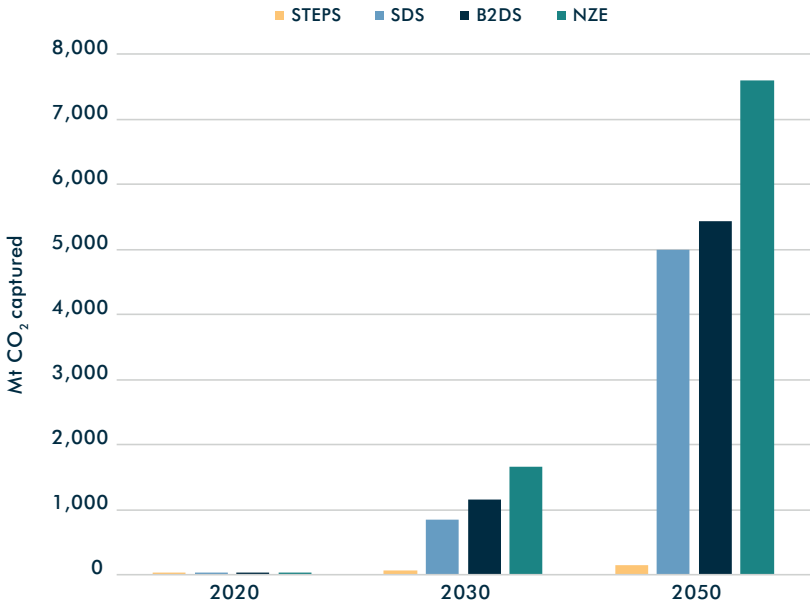


Source: IEA, Rystad Energy, Carbon Tracker analysis.

We commonly get asked about the degree to which our results factor in increased use of carbon capture, utilisation and/or storage (CCUS) and other potential negative emissions technologies (NETs) - this is summarised in **Figure 14**. For reference, global CCUS capacity was 40Mt CO_2/y in 2020.[28]

28 https://www.iea.org/reports/about-ccus.

FIGURE 14 – ANNUAL CARBON CAPTURE IN FOUR IEA SCENARIOS



Source: IEA, Rystad Energy, Carbon Tracker analysis.
Notes: STEPS data taken from WEO 2019; no updated figures were found in WEO 2020.

Notable changes: We have updated the SDS and STEPS to their WEO 2020 versions. Both scenarios have generally assumed steeper decline rates for both oil and gas demand in each of the last four iterations. We also added the NZE, although we don't formally model it due to a lack of regional gas demand data and because our model is designed to quantify unsanctioned asset stranding risk, which by default is 100% in the NZE. We also made ad hoc adjustments to allow for a brief demand resumption after the deep Covid-19-induced slump in 2020; as such, for 2021 demand we use the IEA's baseline forecasts from its Oil 2021 report and Q2-2021 Gas Market Report.

8.3 Modelling

As previously, our broad modelling approach is to find equilibrium supply for oil and LNG on a global market, and for dry gas on five regional markets (Europe, North America, Russia, Australia and the rest of the world), using supply cost in breakeven oil/gas price terms to determine the merit order of each unsanctioned oil and gas asset (sanctioned assets are assumed to continue producing over their natural lives). This is done on an aggregate 2021-2040 basis, using a 15% IRR to determine breakeven prices (the price at which an asset's net present value is zero).

The model then produces cut-off points for each scenario in the form of marginal breakeven prices, which delineate what we consider economic or uneconomic unsanctioned project options. These are shown for oil fields in **Table 3** below.

TABLE 3 – RESULTANT MARGINAL BREAKEVEN OIL PRICES AT 15% IRR FOR UNSANCTIONED OIL FIELDS IN THREE IEA SCENARIOS

SCENARIO	APPROXIMATE MARGINAL BREAKEVEN OIL PRICE, $/BARREL
STEPS	*$55*
SDS	*$35*
B2DS	$10

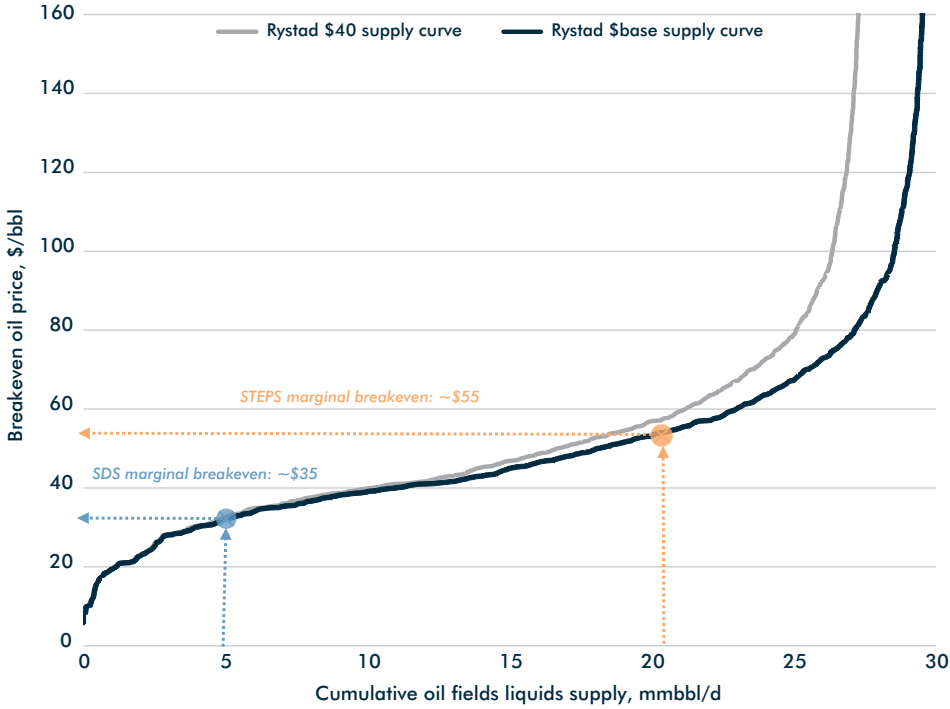
Notable changes: We have refined our approach this year by adjusting our supply assumptions based on the demand scenario used. In previous iterations, we assumed that companies would produce according to Rystad's base price case ($50s/barrel long term as of March 2021), and that lower demand would simply mean that some projects do not go ahead, while production from economic projects is unaffected. However, this may not square with reality – as prices fall, producers are likely to adjust output even on assets that go ahead to avoid squandering value.

Therefore, in this iteration we have modelled our low-carbon scenarios at a mixed price case. In the SDS we assume that oil fields produce at Rystad's $40/bbl price case, the option that aligned best with the marginal breakeven price (~$35) output from our modelling. For scenarios with even lower demand (B2DS, NZE), we used their $30/bbl price case, the lowest available in UCube.

Gas fields are modelled at Rystad's base price case regardless of scenario, based on our assumption that lower oil prices would not necessarily drive down gas production in a symmetrical fashion. Gas production would presumably be much more dependent on regional demand dynamics, which cannot be adjusted in UCube; therefore, it is more conservative to assume that they produce at "normal" levels.

STEPS is modelled entirely at base case prices as in previous reports. **Figure 15** shows how this plots against SDS for unsanctioned oil fields, which is modelled at the $40/barrel price case. The similarity of the two curves might at first glance seem to argue against the need to use different price cases in the first place, but note that price cases also affect sanctioned production, which in turn decides the remaining supply gap for unsanctioned projects. Sanctioned oil supply is around 1.5mmbbl/d less in the $40 price case. Modelling SDS at $base would mean removing that amount from the SDS supply gap, pushing the resultant marginal breakeven price down to around $29/bbl, leaving even less room for new oil fields.

FIGURE 15 - CUMULATIVE POTENTIAL OIL SUPPLY (2021-2040) FROM UNSANCTIONED OIL FIELDS - RYSTAD $BASE AND $40 CURVES, SHOWING STEPS AND SDS SUPPLY GAPS



A caveat to this approach is that Rystad only determines asset breakevens using its production volumes at base case prices – that is, breakevens do not dynamically change when the price assumption is lowered. This may introduce certain biases and could mean that the exact marginal breakevens are not fully accurate.

Accounting for these biases is difficult, however. All else being equal, lower production would mean an asset needs a higher breakeven price to reach NPV=0 at a given IRR, implying our numbers are biased to the downside. At the same time, lower prices and production also put strong downward pressure on drilling costs as suppliers compete for more scarce business; this can significantly reduce capital costs and therefore lower breakevens, which would imply our numbers are biased to the upside. Therefore, as in previous reports we encourage readers to view the marginal breakevens that result from our analysis as approximate.

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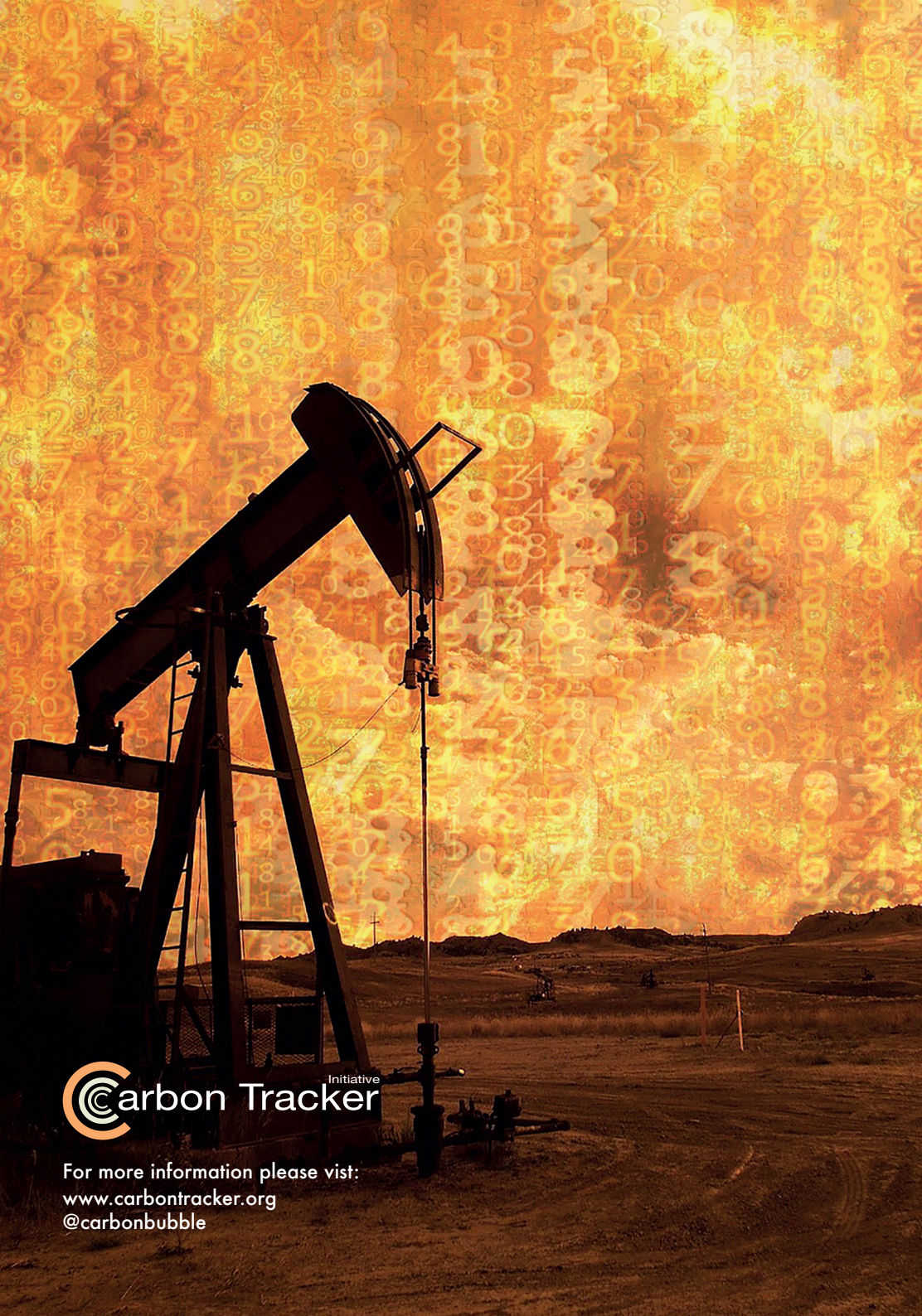

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