Stranded Assets

What lies beneath

By Dr. Dinah A. Koehler and Bruno Bertocci
Oil and gas reserves are valued based on price, future expectations of supply and demand, and the cost of production. In the US, annual disclosure of oil and gas reserves is required for “those quantities of oil and gas, which, by analysis of geoscience and engineering data, can be estimated with reasonable certainty to be economically producible” using the SEC defined oil and gas prices. And according to some analysts, 80 percent of oil and gas reserves are likely to be stranded because the growing risks of climate change may render fossil fuels unburnable.

Convinced of this possibility, a growing number of asset owners are considering fossil fuel divestment, and many publicly known investors have already taken steps to divest from coal and some oil and gas stocks. One rationale for divestment is ethical; consumption of fossil fuels threatens the well-being of future generations on a warming planet. Others believe that a combination of rising public concern over the impact of climate change and political action after the COP 21 meetings in Paris in 2015 will increase the risk of economic loss to fossil fuel producers. Consequently, companies with a large portion of market value and future cash flows associated with these reserves may suffer declining returns and eventual asset impairments.

In this paper we examine the core of the stranded assets hypothesis: That publicly traded fossil fuel companies should be divested because they are mispriced and will lose value in the near future. We review the origins and basis for the stranded assets hypothesis and describe an analytical approach that can help inform investment decisions today. We focus on the publicly traded oil and gas companies that are in the MSCI World Index. Our analysis is motivated by the following question: Does the market today misprice oil and gas reserves, placing portfolios at risk?

Our analysis, informed by a net present value of cash flow calculation, reveals that many public oil and gas companies appear to be reasonably valued in several scenarios, even under a “strong form” of the stranded assets hypothesis. Our findings reinforce the need to conduct a thorough intrinsic value analysis to assess the merits of any fossil fuel divestment decision.

**Stranded assets math**

The starting point for the stranded assets hypothesis was a paper published in 2009 in Nature – a highly respected, peer-reviewed scientific journal. The authors of the paper estimated that only 886 to 900 gigatons of CO₂ (GT CO₂) could be emitted between the years 2000 and 2050 to ensure a high (80 percent) probability that global warming would remain within 2°C by 2100. The 2°C limit is believed by scientists to be the greatest amount that we can let the world warm without suffering from devastating social, environmental and economic damage.

The 2°C threshold limit is ambitious and increasingly crucial as climate change accelerates. The planet has already warmed by an estimated 1°C (1.8°F) since 1850 (the beginning of the industrial revolution), leaving behind a trail of increasingly greater damage to humans and the environment. According to the reinsurance industry, extreme weather cost the global economy USD 100 billion in 2015, part of a rising trend of weather-related economic damage. Of this total cost, only 30 percent was insured. Analysis of the historical relationship between temperature and economic productivity suggests that unabated global warming has the potential to reduce global economic production by 23 percent in 2100. New research finds that the unexpected speed at which Antarctica’s ice sheets are melting imply a rapid sea level rise of more than one meter by 2100.
In 2011, Carbon Tracker (an independent think tank) published an analysis of the implications of the *Nature* article for fossil fuel producers. To remain within the 2°C limit meant that only 565 GT CO₂ could be emitted from fossil fuel consumption between 2010 and 2050 – after subtracting emissions between 2000 and 2010 (about 321 GT CO₂). This estimate, in the view of the authors, has implications for the fossil fuel industry. Firstly, they point out that the carbon content of the world's fossil fuel proven recoverable reserves amounts to 2,795 GT CO₂, based on data from 2006 to 2007. Secondly, the majority (65 percent) of these GT CO₂ are embedded in the world's coal reserves, followed by 643 GT CO₂ (23 percent) in oil reserves and 335 GT CO₂ (12 percent) in natural gas reserves. Finally, when one compares the carbon emissions embedded in fossil fuel reserves (2,795 GT CO₂) with the allowable emissions budget to 2050 (565 GT CO₂) under the 2°C scenario (2DS), the conclusion, according to Carbon Tracker, is that 80 percent of fossil fuel reserves cannot be extracted – effectively stranding them. Carbon Tracker used a simplifying assumption that coal, oil and gas could each lose 80 percent of their reserves (see Figure 1).

Converting the permissible CO₂ emissions (133 GT CO₂) from oil combustion into billion barrels of oil equivalent (bboe) means that approximately 310 bboe can be extracted and burned from 2010 to 2050, based on Carbon Tracker’s analysis. This leaves 1,185 bboe of oil “stranded.” When the Carbon Tracker analysis was published in 2011, the value of the estimated 1,185 bboe of stranded oil assets was the equivalent of USD 119 trillion at USD 100 oil, or USD 59 trillion at USD 50 oil at 2016 prices.

In accordance with the 2°C warming target (from a baseline year of 1850), the International Energy Agency (IEA) modeled several climate change scenarios to provide additional guidance. Their model suggests that under a 2DS, fossil fuel consumption needs to decline starting in 2020 – only four and a half years from now. They modeled two additional scenarios: a warming of 4°C (4DS) and 6°C (6DS) by 2100. The latter, 6DS, assumes no policy action to reduce greenhouse gas emissions combined with a steady increase in energy consumption to 2050 based on the historical business-as-usual trend. Under the 4DS, current political climate change policies are enacted, but overall energy consumption continues to rise to 2050.

The 2DS presents a very different future. The IEA projects that by 2050 the difference in oil consumption between a 6DS and 2DS scenario is 60.8 million boe per day. By comparison, in 2016 global oil consumption is estimated at 96 million boe per day (the equivalent of 35 bboe per year), of which 70 percent is used by the transport sector. At this rate of consumption it would take about 42 years to consume the entirety of the estimated 1,476 bboe in oil reserves. However, under the 2DS and assuming global oil consumption stays at 2016 levels, we will have used up the permissible oil budget of 310 bboe in about nine years.

**Figure 1: 80% of total fossil fuel reserves cannot be safely burned**

- Reserves
- Stranded assets

Using the 2DS as a guideline, the IEA and Carbon Tracker estimated the impact on oil price from 2013-2050 (see Figure 2). According to the IEA, a drop in consumption necessary to comply with 2DS would translate into a decrease in oil price from USD 97 per barrel in 2014 to USD 93 per barrel in 2050, punctuated by a dip in oil price due to recent oil price weakness. Carbon Tracker estimated that the 2DS scenario translates into a USD 60 per barrel break-even oil price. They conclude that this would put any oil production requiring a marginal cost to extract above USD 60 at risk in a future low price environment. In other words, deepwater, arctic, Canadian oil sands and some unconventional onshore US oil regions would become uneconomical for production. In conclusion, a 2DS poses a significant economic risk to investors according to Carbon Tracker and various similar analyses.

In summary, the key ingredients of stranded assets math are (see Figure 3):

1. An estimate of the total allowable carbon budget from 2000 to 2050 to remain within 2°C warming to 2100: 886 to 900 GT CO₂ based upon climate change models.  
2. An estimate of the carbon embedded in the estimated fossil fuel reserves (2,795 GT CO₂), of which an estimated 643 GT CO₂ are embedded in oil reserves and 335 GT CO₂ in gas reserves.  
3. An estimate of the amount of oil reserves. According to Carbon Tracker, these were 1,476 to 1,495 bboe using BP's Statistical Review of World Energy 2010 and estimates from the Nature article. Of this total, 80 percent, 1,185 bboe (510 GT CO₂), are considered stranded oil assets (2010–2050).  
4. An estimated reduction in oil consumption of 60.8 million boe/day by 2050 is required to stay within the 2DS carbon budget, according to the IEA.  
5. Finally, reduction in transportation sector consumption exerts downward pressure on the price of oil to USD 93 per barrel by 2050 according to IEA. In 2014, Carbon Tracker estimated that a 2DS implies a USD 60 per barrel break-even oil price.
What lies beneath the hypothesis
Market observers will have an immediate reaction to the scenarios proposed by IEA and Carbon Tracker. For example, in 2015 and 2016 the price of oil has averaged below USD 60 per barrel. Also, the world’s politicians may never agree to regulate carbon emissions by 2020. And so on.

We do not debate the scientific assessment of the allowable carbon budget to 2050. Nor do we debate the amount of carbon emissions embedded in a barrel of oil equivalent (estimated at 0.43 metric tons CO₂/boe).\(^\text{17}\) Should politicians agree to target a 2°C warming goal, we believe this will require reductions in demand for all fossil fuels and switching to cleaner fuels, effectively rendering some assets uneconomical. Carbon sequestration is thought to add only a small fraction to the permissible carbon budget (125 GT CO₂).\(^\text{18}\)

What we can (and should) ask is the following: How realistic is the conclusion that oil and gas assets will be stranded while taking into account current market expectations? Moreover, would all publicly traded oil and gas companies suffer equally? Which companies would prosper?

Our analysis: price to intrinsic value approach
To find an answer, we undertook scenario analysis. In fact, we constructed the most extreme of scenarios: Truncate all cash flows coming from production of the publicly traded oil and gas companies in the MSCI World benchmark at various time horizons. This exercise assumes that consumption of oil and gas drops to zero and that no more oil and gas reserves will be extracted. You might call this extreme tail-end stranded assets risk, a far cry from the gradual decline in consumption modeled by the IEA 2DS scenario. We call it a “cash flow cliff,” which sets in at 2020, 2025, 2030 and 2035 in our scenarios (see Figure 4). We assume that our sample companies do not adapt or make a strategic shift into renewables, effectively leaping over the cliff.

It is important to point out what we do not capture in our scenarios. We specifically exclude any global effects from coordinated policy action. Instead, we model four different time horizons within which action may be plausible. For example, the 2020 cliff is aligned with the recommendations of the IEA that consumption of oil and gas starts to decline. By 2025, China may reach peak carbon and start decreasing the carbon intensity of its economy.\(^\text{19}\) A reader who has a strong belief in a particular policy outcome can easily overlay it on our structure, which does not assume intervention.

Figure 4: Cash flow cliff
The stranded assets analysis from Carbon Tracker and others has estimated the economic impact of the 2DS by attempting to calculate the economic value of fossil fuel reserves that cannot be burned – a high level snapshot in time. But this is not easy to translate into a forward-looking investment strategy. It is worth recalling that a central element of the analysis is an assumed gradual decrease in fossil fuel consumption, as carbon regulations are adopted over time and alternative sources of energy gain market share. Given that this is a gradual process underway, over (at least) the next three decades to 2050, any stranded assets analysis should, at a minimum, consider the time value of money by using the discounting mechanism. Once discounted, the vast majority of the value of future cash flows generated by these reserves is captured in the first 5 to 10 years. This implies that a significant amount of the value is preserved even in our extreme cash flow cliff scenarios.

For our purposes, we calculate the value of reserves as the net present value (NPV) of future discounted cash flows from the exploration and commercial production of oil and gas reserves. Our reasoning is simple: the stranded assets hypothesis states that oil and gas (and coal) reserves cannot be extracted and produced, which will affect corporate valuations. We use the Q1 2016 Wood Mackenzie consensus upstream cash flow estimates for our analysis. These are bottom-up estimates that consider production costs, transport, processing and other expenses at a granular oil field level. Wood Mackenzie provides three cash flows scenarios for each company to reflect uncertainty in future oil prices (low, base, high); see Figure 5. It is notable that the low oil price scenario is most aligned with the Q1 2016 forward oil curve.

To assess the intrinsic value of these cash flows, we compare the NPV of cash flows for each company to its enterprise value (EV). EV represents all financial claims (equity and debt) on total cash flows as of this writing (end of the second quarter, June 30, 2016). However, EV captures cash flows from all operations of an oil and gas company, including upstream exploration and production (E&P) midstream transportation (by pipeline, rail, barge, oil tanker or truck), storage, and wholesale marketing), and downstream activities such as refining and transportation. These activities can account for a significant portion of oil and gas company revenue, especially for some of the large global companies.

To allow a cleaner comparison of these cash flows to EV, the EVs need to be adjusted to capture only the upstream revenues. Percentage of E&P-related revenue relative to total revenue is derived from Wood Mackenzie corporate data and Bloomberg data for each company in our sample. EVs are then adjusted by the percent of revenue related to finding, and eventually producing, hydrocarbons.

Figure 5: Forward future oil prices and scenarios

Source: Bloomberg Finance LP, Q1 2016; Wood Mackenzie, Q1 2016. Prices are in nominal terms, escalated at 2% after 2019. 2016 oil prices continue to hover around USD 45 per barrel.
Our sample includes 57 publicly traded oil and gas companies, of which the majority (35) are large cap companies (see Figure 6). Nineteen companies are classified as Focused US (with the majority of their upstream operations in the US) and 12 are Focused Canadian (primarily upstream with the majority of operations in Canada). Focused International companies have international upstream operations, Diversified Independents have both US and international operations and Majors include large global integrated companies with upstream E&P and downstream operations. Our total sample represents USD 1,796 billion in market capitalization at the end of Q2 2016.


### Figure 6: Market capitalization by peer group

<table>
<thead>
<tr>
<th>Market capitalization (USD billion)</th>
<th>Diversified Independent</th>
<th>Focused Canadian</th>
<th>Focused International</th>
<th>Focused US</th>
<th>Major</th>
<th>Total count</th>
<th>Total market capitalization USD billion 6/30/16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large cap (&gt;USD 7.5 billion)</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>35</td>
<td>USD 1,717.53</td>
</tr>
<tr>
<td>Mid cap (USD 2.5-7.5 billion)</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>15</td>
<td>USD 71.16</td>
</tr>
<tr>
<td>Small cap (&lt;USD 2.5 billion)</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>USD 7.36</td>
</tr>
<tr>
<td>Total count</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>19</td>
<td>7</td>
<td>57</td>
<td>USD 1,796.05</td>
</tr>
</tbody>
</table>


Scenario results
Figure 7 shows our results by peer group for all 12 scenarios (four time horizons, three price scenarios). Before diving into the results, let’s develop some intuition from an investor’s perspective. The present value of future cash flows reflects the intrinsic value of the stock. We can expect positive E&P cash flows until our cash flow cliffs materialize. Therefore, from today’s standpoint we should expect these stocks to have value even when faced with a cash flow cliff (at any moment in time). None of the reserves on the books of these companies should automatically be assumed to be stranded today because they still generate future cash flows until our sample goes over the cash flow cliff.

### Figure 7: NPV of cash flows as a percent of EV (Median) by peer group

![Figure 7: NPV of cash flows as a percent of EV (Median) by peer group](chart)

Indeed, our sample companies deliver positive NPV cash flows for almost every scenario. Figure 7 shows the median NPV/EV ratio for the entire 57 company sample across all 12 scenarios. Starting on the left hand side, under the most extreme case of a five-year cash flow cliff and low oil price, about USD 573 billion in market capitalization (dated June 30, 2016) is at risk because cash flows are less than or equal to zero. Several large cap Majors still perform well under this scenario. We might consider this the “strong form” of the stranded assets hypothesis, especially if a low oil price persists for a long period of time. As oil price scenarios increase, so do the number of companies with strong cash flow. Depending on time horizon and oil price assumptions, only a minority of companies are threatened with extremely depressed NPV of cash flows, even if all 57 companies were confronted by a cash flow cliff. The Majors and Diversified Independents generate the highest intrinsic value relative to today’s EV across all scenarios, followed by Focused International.

In some scenarios, the NPV of cash flows can exceed the EV of the stock, implying a favorable valuation today and potential excess returns in the future. Figures 8 and 9 show the percent of sample companies that have a ratio of NPV/EV greater than 100 percent (i.e. parity). In these cases the cash flows prior to truncation by a cash flow cliff are worth more than what investors would pay for the company today. The investment pays off, and this is particularly true with higher oil prices and longer time horizons. Our scenarios suggest that Majors and Diversified Independents are particularly attractively valued. We believe that in each scenario a solid investment case can be found for companies in each peer group and

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**Figure 8: Percent of oil/gas companies with NPV cash flows greater than EV by peer group**

![Bar chart showing the percentage of companies with NPV cash flows greater than EV by peer group across different price scenarios.]

at different market cap sizes. In the case of smaller market capitalization E&Ps, many of them are higher marginal cost producers which tend to have higher debt levels and leverage, which the market is discounting heavily today at current prices. Should oil prices increase, they will experience significant operating (profit) leverage and equity values will likely increase; these tend to be small Focused US operators.

Conversely, if the ratio is less than one, it is less likely that the investment today will pay off. The current observed market price of stock and debt are not justified by expected cash flows. In the low oil price scenario, almost no companies generate enough cash flow to justify current valuations. One plausible explanation is that the risk of stranded assets may already be in the market price of the company today. Alternatively, the market may be accounting for other factors that can push down expectations for a particular company.

The default assumption most investors make is that the market is right (i.e. efficient) in assessing value most of the time. The market is cognizant of the likelihood that there can be some sudden change that might challenge future E&P cash flows, whether technological (e.g. better and more effective fuel cells) or regulatory action on climate change. It knows that at some point the global economy will need to transition to a different fuel source. Technological disruption can occur at any time, whether or not there has been regulatory intervention. We have seen this with the ongoing displacement of coal by cheaper natural gas for power generation in the US, which has been driven by advancements in drilling and completion technology. Market dynamics are shifting the playing field for US utilities more rapidly than decades of environmental regulation. Similarly, it is not a stretch to suggest that a cheaper source of energy can displace gasoline to power automobiles.
If the price of oil stays low (e.g. around USD 70) for the next 20 years, very few companies will be able to offer an attractive return on the investment from today’s present value of cash flow perspective. We show the effect of different oil price scenarios for the 15-year cash flow cliff (in 2030, Figures 10–12). Under the high oil price scenario more than half of our sample companies would deliver a NPV of cash flows greater than the current EV. These companies can return the entire value of the investment in cash flows over the next 15 years (to 2030). Under Wood Mackenzie’s base oil price scenario (benchmarked to USD 50 per barrel oil in 2016), most companies would generate 40 percent to 60 percent of the current EV by 2030. Several Focused US companies are attractively valued in this scenario. It is interesting to note that many companies, especially oil Majors, generate 40 percent to 50 percent of the price paid upfront in cash flows under the low oil price scenario. The low oil price scenario (at USD 38 per barrel) is most aligned with oil prices in the first half of 2016 and the futures strip, though market valuations at that time imply something closer to the base case oil price scenario, as we explain in more detail in the next section.

The conclusion for investment strategy seems clear. There are some publicly traded oil and gas companies that are unattractive from a long-term investment perspective regardless of the assumptions that are made.

Nevertheless, an investor can expect to get some value back under any one of these 12 cash flow cliff scenarios. This is as likely for the low oil price scenario and shorter
time horizons, as for a base oil price scenario, which can return 40 percent to 60 percent of the value of the investment in these 57 companies. Even if cash flows are truncated to simulate an abrupt stranded assets scenario, these reserves are not completely worthless. In many of our scenarios, oil and gas companies continue to be an attractive investment. This conclusion runs counter to the idea that all reserves are worthless under a scenario of reduced oil and gas consumption driven by regulatory efforts.

These conclusions are devoid of politics or ethical concerns. They are based only on cash flow economics. Furthermore, they raise questions about the conclusions of advocates of the stranded assets hypothesis, who argue that when oil prices fall below an estimated USD 60 per barrel break-even price, very few, if any, reserves can be extracted profitably. This brings us to today. Oil prices continue to hover around USD 45 per barrel, ranging from USD 34 to USD 55 in the past 12 months. And yet, oil and gas E&Ps continue to survive and attract capital.

2016: A major stress test for the industry

The business environment has been brutal for the oil and gas industry since the end of 2014. The target SEC oil price (i.e. SEC WTI) plummeted by 47 percent from USD 94.99 in 2014 to USD 50.13 in 2015. Since January 2015, there have been 86 oil and gas bankruptcies around the world, and of these 63 have been US E&Ps. In the same time period there have been 60 E&P takeovers. As the price of oil fell below USD 30 per barrel in January 2016 the pressure on oil and gas companies to cut their capital expenditure increased even more. Some companies announced capex cuts of up to 50 percent compared to 2015. At USD 35 per bbl, cuts to exploration and development (E&D) in 2016 could reach up to 70 percent below 2015 (see Figure 13).

E&D budgets are down for all peer groups, amounting to a reduction of more than USD 220 billion compared with 2014. Total industry capital expenditures are down 45 percent since 2014. Companies are adapting by cutting spending and reducing operating costs as much as possible, including rationalizing headcount. Others who have exhausted these options may need to sell assets to raise cash, or renegotiate and restructure debt. Only a few operators can self-fund at existing prices. Focused US companies have announced the highest E&D spend cuts, but others (e.g. Focused International, Diversified International and Focused Canadian) are close behind. Majors will increasingly be under pressure to cut dividends if oil prices linger at low levels. While their balance sheets are still strong, they have a higher rate of cash burn and longer lived projects.

As a result of these adaptations, the oil price required for cash flow neutrality has plummeted by USD 40 per bbl.
(43 percent), from USD 93 per bbl in the beginning of 2015 to USD 53 per bbl Brent in the second quarter of 2016, according to Wood Mackenzie (see Figure 14). This is true for every peer group. The drop has been greatest for Diversified North Americans (53 percent) and Focused International (48 percent) due to their greater ability to cut spending. The Majors have the lowest average base-business break-even point. However, the peer group’s dividend payouts are higher than average, comprising USD 19 per bbl of their USD 58 per bbl weighted average cash flow break-even. Exposure to capital-intensive growth projects keeps break-evens relatively higher for Focused International companies.

At an average oil price of USD 50, about 44 percent of all oil and gas reserves are uneconomical without further adaptation, which may be increasingly difficult. As Figure 14 shows, many companies have to dip into their base business

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**Figure 14: Brent price required for cash flow neutrality (2016 vs. 2015)**

- **Dividends**
- **Exploration**
- **Base business**

- **Price required to be cash-flow neutral (USD bbl Brent)**
  - **2015**
  - **2016**

- **Diversified Independent**
- **Focused Canadian**
- **Focused US**
- **Focused International**
- **Major**

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**Figure 15: Total asset write-offs**

- **Focused International**
- **Focused Canadian**
- **Focused US**
- **Major**
- **Diversified Independent**

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Source: Wood Mackenzie Corporate Benchmarking Tool Q3 2015. Dividend and buybacks allocated in proportion between business segments; upstream share only shown. Assumes equity financing for all projects. Includes hedging where applicable.

for further cost cutting. In 2015, an estimated USD 220 billion of asset impairments had been reported by 48 publicly traded oil and gas firms (see Figure 15). Most reserves were written down by smaller companies with higher cost structures (such as oil sands) or by oil companies with high cost projects, such as tight oil.

About 645 bboe of global oil and gas reserves (estimated 277 GT CO₂) have been rendered uneconomical to produce at prevailing low prices (see Figure 16). This amounts to 44 percent of global oil and gas reserves at 1,157 bboe (493 bboe owned by National Oil Companies (NOC) and 664 bboe owned by the 50 largest publicly traded companies) according to Wood Mackenzie, based on 2015 data.²²

Only 512 bboe (345 bboe NOC, 167 bboe publicly traded companies) are economically producible at current low oil prices. Those 512 bboe are the equivalent of an estimated 220 GT CO₂. The estimated commercial reserves for the top 50 non-NOC companies amount to approximately 72 GT CO₂ (167 bboe). These reserves are well below the allowable 2DS oil budget of 310 bboe if we assume that only 20 percent of oil reserves can be burned as suggested by Carbon Tracker in Figure 3. Alternatively, nearly all NOC economically producible (commercial) reserves could be safely burned at today’s oil prices. We can foresee continued jockeying for position between NOCs and non-NOCs as social and political determination to control carbon emissions rises. However, while NOCs may be able to produce oil at uneconomical price levels longer than public companies, they cannot do so for long without significant negative national economic consequences.

Despite this dire situation, the market today continues to believe that there is value in oil and gas stocks. It believes that oil and gas companies are worth more than would be justified by the forward strip price (see Figure 17). In the beginning of 2016, the market (correctly) behaved as if the price of oil should be at and above USD 40 per bbl.²³ This has made it easier for oil and gas companies to raise money through equity markets.

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**Figure 16: Reserves rendered uneconomic in 2015 (bboe)**

<table>
<thead>
<tr>
<th>Oil &amp; gas reserves (bboe, GT CO₂)</th>
<th>Top 50 public companies</th>
<th>National oil companies (NOC)</th>
<th>Total global oil and gas reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total reserves (bboe)</td>
<td>664</td>
<td>493</td>
<td>1,157</td>
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<tr>
<td>GT CO₂</td>
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<tr>
<td>Commercial reserves (bboe)</td>
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<tr>
<td>GT CO₂</td>
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<td></td>
<td>72</td>
</tr>
<tr>
<td>Uneconomic reserves in 2015 (bboe)</td>
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<td></td>
<td>497</td>
</tr>
<tr>
<td>GT CO₂</td>
<td></td>
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<td>214</td>
</tr>
</tbody>
</table>


**Figure 17: Implied equity oil price versus oil price futures**

In the event that oil prices linger around USD 35 per bbl, the median years of remaining liquidity for all peer groups is below five years (see Figure 18). Some outliers will be able to survive 10 years or more at this low oil price, but overall such a scenario is dire for the industry – and unlikely given the dynamic of supply and demand.

Today’s situation is a far cry from the 2DS oil price scenario modeled by the IEA or the estimated break-even price of USD 60 per bbl proposed by Carbon Tracker (May 2014) under a 2DS (stranded assets scenario). The last time we saw USD 60 per barrel oil was at the end of November 2014, close to the time when Carbon Tracker was conducting its analysis. It is tempting to conclude that we are experiencing a strong form of the stranded assets hypothesis in which reserves are “stranded” due to regulatory action. However, as is well known, current low oil prices are due to oversupply and weak demand, which is not a 2DS scenario. Nevertheless, today’s gas situation is illuminating in terms of how oil and gas companies fare under a low oil price.

What we have learned from recent developments is that USD 60 per bbl is no longer so onerous based on rapid adaptation by the oil and gas industry in 2015 and 2016. The market continues to see value in these companies even at a USD 45 per bbl oil price and expects future positive cash flows. Even if we were to truncate those cash flows with a cash flow cliff, there remains value in these companies, as they continue to generate cash flows from E&P operations until the cliff materializes. Finally, not all reserves are automatically rendered uneconomical under a USD 45 per bbl price, and once oil prices rise again many reserves will regain their value.

A revisionist view of the stranded assets hypothesis
According to the stranded assets hypothesis, the price of oil should drop because consumption of fossil fuels must drop to assure that we have a reasonable chance of staying within the 2DS, which can render reserves uneconomical. We take no issue with the hypothesis. Where we take issue is with the interpretation of a 2DS for oil and gas companies in the investment decision making process. The stranded assets hypothesis, as originally proposed, is easily misinterpreted for several fundamental reasons.

Firstly, if one wants to ascertain whether the market is taking the stranded assets hypothesis into account, one needs to appropriately model the market, which is a discounting machine. The present value mechanism that sets equity prices heavily discounts cash flows that are far in the future. Cash flows of more than 10 years out have little influence on the share price because they are too distant and inherently more uncertain. This leads to a simple conclusion: it is incorrect to assign a dollar per barrel value today to oil and gas reserves that might be lost at some future point when the market does not assign value to far distant cash flows associated with the consumption of those reserves.

![Figure 18: Years of remaining liquidity at 2015 spend levels](image-url)
Secondly, the stranded assets analysis to date has assumed that equity markets assign value to publicly traded oil companies based on the totality of global oil reserves. Specifically, a large percentage of all possible oil reserves can be uneconomical to produce at any moment in time due to oil price movement. In reality, the equity markets set the stock price of a public company based on an estimate of forward-looking cash flow that is driven by an implied estimate of the *economically recoverable reserves*, not total reserves. The market knows that not all reserves are equal. The price of oil determines whether or not reserves can be economically produced. The market fully understands that companies with reserves whose production costs are significantly higher than current and future oil prices are not economical. It therefore assigns them a zero or near zero value. This is why an oil sands company that needs USD 100 oil to be economic is punished severely by the market when oil prices are USD 30. The market can also see the company’s balance sheet, based upon which it estimates how long the company can stay in business in an unfavorable price environment before it needs to sell assets, dilute shareholders or declare bankruptcy. The market attempts at all times to figure out what portion of the world’s reserves can be produced economically. Companies are also required by regulators in most markets to evaluate and mark down their reserves at year-end based on the prevailing oil price, another significant market signal.

Finally, companies do not stand idle. They adapt to the market in which they operate. The severe pressure on companies exerted by low oil prices has forced extreme reductions in all expenses as companies lowered their production costs. The market responds to these actions by estimating the reduction in the break-even cost for each company and embeds a new set of future cash flows. It is easy to understand that an oil company with a break-even price of USD 100 per barrel will have relatively low or near-zero value in a USD 50 per barrel environment, but would suddenly have substantial value if it could reduce its production costs to USD 53 per barrel or lower, as is the case for some oil and gas companies. Companies unable to adjust to this environment have indeed gone bankrupt, but most of the failures have been in small to mid-size companies that lacked financial flexibility because they have assumed too much debt. Many larger companies have reduced costs, sold assets, raised capital and reduced dividend payments.

We believe that a better way to test the stranded asset hypothesis is by replicating the market mechanism: calculate the NPV of the public companies’ cash flow under different scenarios and compare these to the market price (EV). This approach is specifically designed to reveal which scenario or set of scenarios are implicitly embedded in market prices. Our work shows very clearly that current share prices embed a difficult price environment for quite some time. Nevertheless, at current historically low oil prices there is still intrinsic value in the future cash flows associated with oil and gas reserves. Even in the most extreme cash flow cliff scenarios that we model, the present value of cash flows of these stocks still has intrinsic value for shareholders today.

From the investment standpoint it is thus plausible and likely that blanket divestment of the energy sector would mean sacrificing future returns. Investors should look at our scenarios and focus on which scenario is most likely to play out. In each scenario there are winners and losers – companies that are unable to adjust to the prevailing price of oil will fail or decline in value, and companies whose production costs are such that they will do well despite a relatively low oil price.
Postscript

In closing, a reality check is essential. Almost half of global carbon emissions come from coal combustion. Thus, it is crucial to reduce demand for coal to avert the worst climate change scenarios. Thermal coal has been under pressure around the globe. After an aggressive, highly leveraged expansion earlier this decade, weak and falling demand in the US and China has pushed many coal companies to the brink of bankruptcy. In the US, companies that produce 45 percent of the country's coal output are in bankruptcy proceedings as of this writing. The Chinese government is implementing policies to reduce deadly air pollution in urban areas and to push renewable energy. The seaborne thermal coal market is adjusting to a market size of around 880 million tons per annum (Mtpa) after two successive years of contraction. Chinese coal mine capacity is being cut and demand for coal imports this year is expected to be 19 Mtpa lower than in 2015. The transition to cleaner fuels (e.g. natural gas) is underway, driven by market forces.

As coal fades, we may be able to burn known oil and gas reserves and still meet the global carbon budget to 2050. Recent discussions have focused on the notion of peak oil by 2030 if market penetration of electric and autonomous cars continues along with a decline in individual car ownership. Rather than blanket divestment of fossil fuels, investors should consider various options that can reduce the carbon intensity of the global economy. These include advancements in battery technology and technologies that monitor and reduce energy use. The transition to cleaner fuels will take an additional estimated USD 840 billion annual investment over the next 15 years, according to the International Energy Agency (IEA).

Under the 2DS there will be no reprieve in the second half of this century. Carbon Tracker together with the Grantham Research Institute for Climate Change and the Environment at the London School of Economics and Political Science has determined that the world’s carbon emissions will have to be even more severely constrained after 2050 to achieve a 2DS. Without the use of negative emissions technologies, from 2050 to 2100 the carbon budget can only be 75 GT CO₂ to ensure an 80 percent probability of hitting the 2°C target. This is equivalent to just over two years of emissions at current consumption levels. Accordingly, Carbon Tracker and the Grantham Institute warn against the belief that there could be a fossil fuel renaissance post-2050. Thus, we need to continue to monitor the situation and actively manage investments in oil and gas stocks to reflect the current market dynamic and future climate change expectations.
Given only 20% of the total reserves can be used unabated. Investors are thus left exposed to the risk of unburnable carbon. If the 2°C target is rigorously applied, then only 149 of the 745 GT CO2 held by listed companies can be used unabated. Investors would be subject to impairment as these assets become stranded.

26 See Rystad Energy, “Petroleum Production under the two degree scenario,” 2013, for an analysis of different coal budgets on petroleum production.


30 Wood Mackenzie, email communication, July 7, 2016.

31 “Is the industry on track to generate free cash flow?” April, 2016, Wood Mackenzie.

32 1,157 bboe are equivalent to a 35-year reserve life at current consumption.

33 Historically, the market tends to diverge from the forward strip. At the peak and trough of an oil-price cycle, we tend to see the greatest divergence of forward strip versus implied equity oil price. In 2014, when oil was USD 105 per barrel, the implied equity price would lower. The market normalizes over a long period of time.


36 See Rystad Energy, “Petroleum Production under the two degree scenario,” 2013, for analysis of different coal budgets on petroleum production.


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