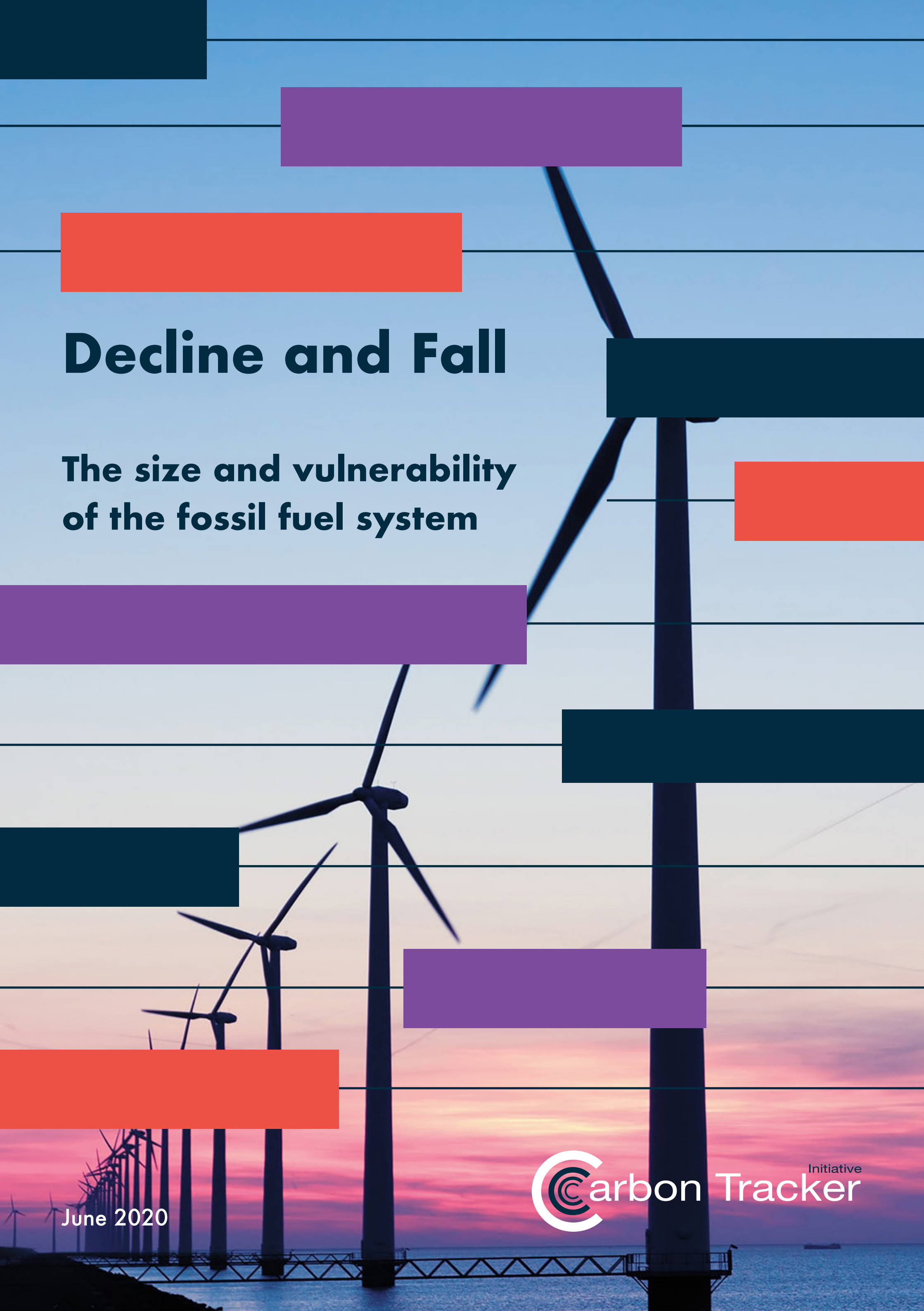

Decline and Fall

The size and vulnerability of the fossil fuel system

June 2020

Carbon Tracker Initiative

About Carbon Tracker

Carbon Tracker is a team of financial specialists making climate risk real in today's 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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Introduction

Renewable costs are below those of fossil fuels. Five years ago, fossil fuels were the cheapest baseload. The collapse in renewable costs means that for 85% of the world, renewable electricity is the cheapest source of new baseload. By the early 2020s it will be every major country. Because of the rise of cheap renewables, the fossil fuel system is ripe for disruption. This disruption will be have profound financial implications for investors as a quarter of equity markets and half of corporate bond markets are 'carbon entangled'.

Those responsible for our pension schemes should sit up and take notice; but even greater concern should be felt by financial regulators, as they grapple with finding the right tools to manage the risks of a deflating 'carbon bubble'.

The world faces two contrasting pathways. Either it can secure the 'trillion dollar green gigafall', the trillions that can be generated at low cost from the sun and the wind – particularly benefiting the poorest inhabitants of the world currently dependent upon high cost fossil fuel imports. Or it can stay locked into business as usual, tied into a declining industry that both threatens the global economy with the worst effects of a warming planet, and damages investors with losses, low returns and destabilised equity and credit markets.

In Carbon Tracker's first report, some ten years ago, entitled 'Unburnable Carbon – are the World's Financial Markets Carrying a Carbon Bubble' we highlighted that listed fossil fuel companies have the potential to develop enough reserves to take the world way beyond 3°C. Our second report, 'Unburnable Carbon – Wasted Capital and Stranded Assets', noted that if we can't burn what we have already found, why continue to invest in the fossil fuel industry's expansion? Yet today, we know that some $1 trillion is spent annually on expanding supply and this report goes more into these numbers. Before we wind down the fossil fuel system, we need to stop expanding it.

Some argue that 'fossil fuels will go away of their own accord' as the result of the rapid progress made by cleaner technologies and the collapse in demand for fossil fuels driven by the terrible COVID-19 epidemic. Unfortunately, as this report makes clear, financial markets are still heavily tied in to the fossil fuel system.

So what are our recommendations? In the same way that our first report was aimed at financial regulators, this one is also to be carefully read by those responsible for financial oversight. We advise now a rapid acceleration of disclosure and reporting systems around climate risk that allow investors to properly calculate risk. Thus analysis should be based on actual Paris alignment (which requires contraction of supply and demand), not models based on the neverland of 'we'll have it sorted out in 2040'. This requires companies to implement the appropriate accounting measures, particularly relating to asset write-downs and depreciation.

We believe companies will face major asset write downs as it becomes clear that high-cost fossil fuel supply and demand infrastructure has limited value. An example of this in 2019 was Repsol, which took €4.8bn of write-downs on its fossil fuel assets. Because of leverage, this was only 8% of assets, but 16% of equity.

To avoid the impacts of a disorderly wind down, we expect regulators to require companies to undertake tougher impairment tests. For example, by providing clear guidance frameworks for asset impairment, including goodwill, in line with the goals of the Paris climate agreement. This would include fossil fuel encumbered companies having to publish stress tests, consistent with the Paris goals, on the financial impact of changes in the useful life of assets; changes in the fair valuation of assets; the effects on impairment calculations because of increased costs or reduced demand and changes in provisions for onerous contracts because of increased costs or reduced demand. Running supply of fossil fuels down to meet what the science demands means rapid contraction of oil and gas supply and the closure of around one coal fired power station a day.

With proper risk disclosure, credit and equity analysts will be better able to test the resilience of individual fossil fuel companies to the financial storm. A storm which, as this report sets out, is fast descending upon us.

Mark Campanale, Founder & Executive Chair
Jon Grayson, CEO

Executive Summary

Decline and fall

The energy transition is disrupting the entire fossil fuel system, with profound consequences for financial markets and geopolitics. We calculate the size and vulnerability of the different parts of the system.

What's new

We take a wider definition of the whole fossil fuel system, looking at stocks and flows, supply and demand, fossil fuels, infrastructure and financial markets.

The assets are huge

The three main assets are the 900bn tonnes of coal, oil and gas, valued by the World Bank at $39tn; supply infrastructure of $10tn and demand infrastructure (electricity, transport and heavy industry) of $22tn; and financial markets with $18tn of equity (a quarter of the total), $8tn of traded bonds (half the total) and up to four times as much in unlisted debt.

Each asset has an annual flow

The key flows of the system are $1-3tn a year in economic rent to the petrostates from the fossil fuels; capital expenditure of $1tn on supply infrastructure and $3-4tn on demand infrastructure; and profits of $1-2tn.

The fossil fuel system is ripe for disruption

It is low growth, high fixed cost, low return and (incredibly) planning on expansion even as demand peaks.

The energy transition disrupts the system

The entire system is being disrupted by the forces of cheaper renewable technologies and more aggressive government policies. In one sector after another these are driving peak demand, which leads to lower prices, less profit, and stranded assets.

COVID-19 speeds up the process

The virus brings forward the timing of peak fossil fuel demand (possibly to 2019) and reveals the overcapacity and fragility of the fossil fuel system.

Flows and equity are vulnerable first

The flows of economic rents, capital expenditure and profit are damaged first. And these losses are anticipated by equity markets long before they show up in the write-down of physical assets.

Builders of new assets are especially vulnerable

Those companies involved in expanding the fossil fuel system are deeply exposed to the consequences of peaking demand. We identify $6tn of equity in sectors which are expanding the system, from oil exploration to gas turbines to diesel cars.

Subsectors close to peak demand are vulnerable

As sectors approach peak demand, so they are disrupted. The process started in European electricity, coal, and oil services, and is now spreading across the rest of the system.

High cost assets have no future

As demand peaks and starts to fall, high-cost assets are no longer required and become stranded. This is a structural shift, not another cycle.

The risk for the petrostates

Many petrostates have built their economic systems on the expectation of continued high flows of economic rents. In a world of declining demand, the flow of profits from fossil fuels will fall at the same time as the risks will rise. The size of the gap in expected fossil fuel wealth between the desires of the petrostates and the aspirations of the Paris Agreement is in the order of $100tn. The gap is a threat to the stability of some petrostates.

The opportunity for fossil fuel importers

Under the old system, fossil fuel importers financed an annual wealth transfer of $1-3tn to the petrostates. They have the opportunity to keep that wealth at home.

The implication for investors

There is far more risk inherent in the fossil fuel system than is conventionally priced into financial markets. Investors need to increase discount rates, reduce expected prices and volumes, curtail terminal values and account for the clean-up costs.

The implication for policymakers

The decline of the fossil fuel system is a significant threat to financial stability. $32tn in fixed assets, a quarter of the global equity market and half of the global corporate bond markets are in sectors linked to the fossil fuel system, and the banking sector is exposed to the very large amounts of unlisted debt. Now is the time to put in place an orderly wind-down of assets rather than trying to rebuild the unsustainable.

The fossil fuel system

Fossil fuels provide 80% of the world's primary energy, sustain the political economy of dozens of petrostates, and require a supply and demand infrastructure with a fixed asset value of over $30tn. The companies that supply and use fossil fuels make up a quarter of the global stock market and half the corporate bond market. So the system is complex, and the disruption now facing it will have profound consequences. We seek in this analysis to understand the broad contours of the change, recognising that much detailed work needs to be done in each of the areas.

There are four parts to this report:

- The size of the fossil fuel system
- The forces of disruption
- Which areas are most vulnerable
- The impact of disruption on the fossil fuel system

It is possible to simplify the fossil fuel system in two ways:

Areas (horizontals)

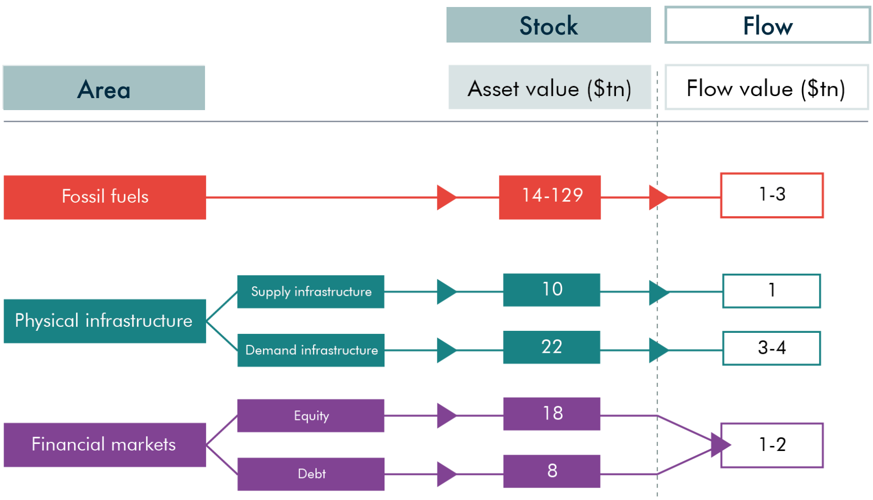
We can split the system into three main areas: the fossil fuels themselves; the infrastructure to get them out of the ground and to use them; and the financial markets which sustain them.

Stock and flow (verticals)

As so often in financial markets, it helps to distinguish between stocks (assets) and flows.

A stock is like a bathtub, and a flow is like the water flowing in from the tap and out from the plug.

FIGURE 1 – THE FOSSIL FUEL SYSTEM IN NUMBERS



Source: Bloomberg, IEA, Tong et al, Carbon Tracker

Assets (stocks)

The three main areas within the system are:

Fossil fuels

According to the IEA,[1] global fossil fuel reserves are 650bn tonnes of coal, 1,700bn barrels of oil and 220tn cubic metres (tcm) of gas. That adds up to 886bn tonnes of oil equivalent, more than 100 tonnes for each person on the planet.

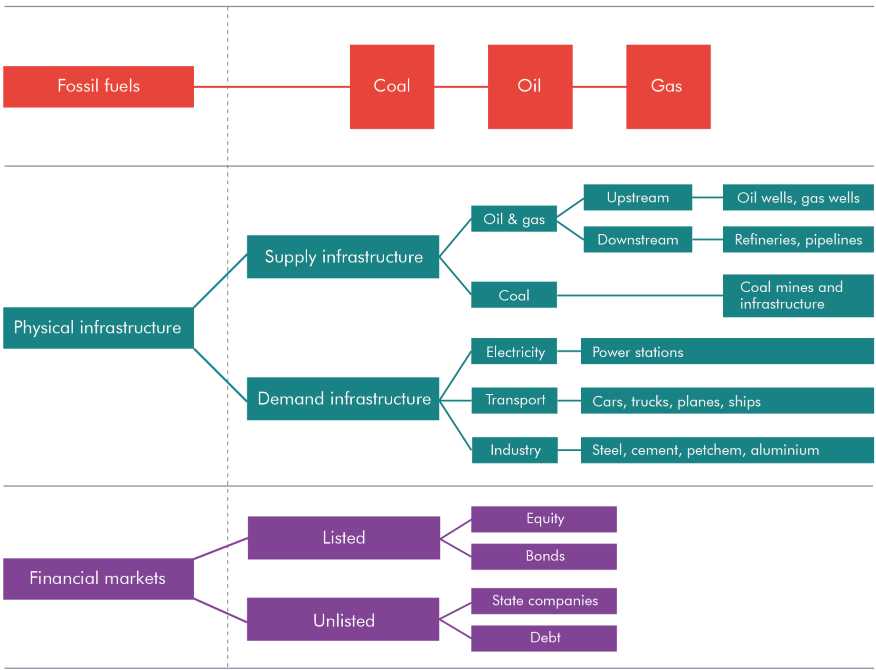
Physical infrastructure

There are two main parts to the physical infrastructure: supply infrastructure of $10tn to supply the fossil fuels; and demand infrastructure of $22tn to use them.

Financial markets

We can identify $18tn of listed equity and $8tn of corporate bonds issued by the companies that sustain the fossil fuel system. In addition to that, there is a large amount of unlisted debt linked to the banking sector.

FIGURE 2 – ASSETS OF THE FOSSIL FUEL SYSTEM



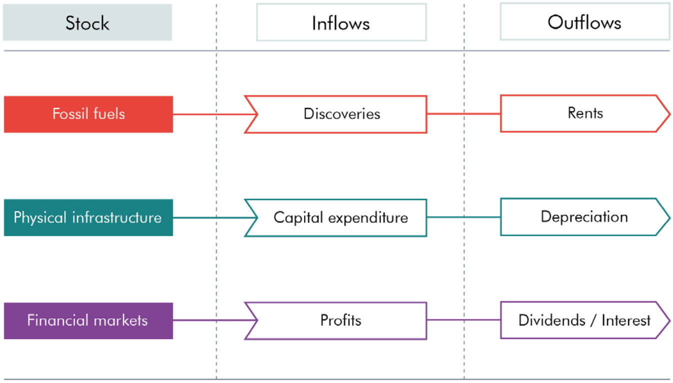
Source: Carbon Tracker

1 *Source: The oil and gas industry in energy transition, IEA, 2020.*

Flows

Each area has a primary inflow and an outflow as set out below. We set out what is the nature of the primary inflows and outflows, and then select one area of primary focus.

FIGURE 3 – INFLOWS AND OUTFLOWS OF THE FOSSIL FUEL SYSTEM



Source: Carbon Tracker

Fossil fuels

Inflow is whatever we discover or decide we can get out of the ground cheaply enough to classify as reserves.

Outflow is production of the fossil fuels. According to the BP database,[2] in 2018, the world produced 8,000 million tonnes of coal, 95 million barrels per day (mbpd) of oil, and 3,900 bcm of gas. That adds up to 11,700 million tonnes of oil equivalent. In turn, this production produces profits which can be quantified.

We focus on the special type of profits known as rents that derive from this production, of between $1tn and $3tn a year.

Fossil fuel infrastructure

The inflow is capital expenditure on new infrastructure.

The outflow is deprecation and write-downs. We focus on the capital expenditure of $1tn a year for supply and $4tn a year for demand.

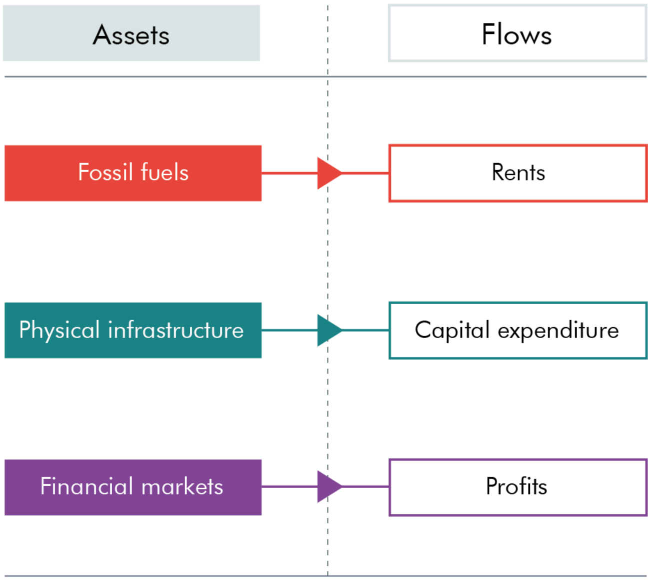
Financial markets

The inflow is capital raising and profits. The outflow is dividends and interest.

We focus on the profits that accrue to financial markets of $1-2tn a year.

2 *Source: BP Statistical Review 2019.*

FIGURE 4 – KEY FLOWS OF THE FOSSIL FUEL SYSTEM



Source: Carbon Tracker

Links to previous Carbon Tracker reports

Carbon Tracker has been writing for many years about which areas are most at risk from the energy transition. We have focussed on different areas of supply and demand for existing and new assets, over separate timescales, and the conclusions of that analysis are incorporated into this report. Here, we provide a framework within which to think about the energy transition so that the impact on each of the pieces can be better understood. Notable reports include:

- 'Unburnable carbon', released in 2011, looked at the threat to fossil fuel rents from lower volumes, and identified where these assets were listed.
- 'The $2tn stranded assets danger zone' in 2015 calculated the threat to fossil fuel supply capex.
- 'Margin call' in 2017 analysed the losses from lower prices resulting from overcapacity in the refinery sector.
- 'Mind the gap' in 2018 considered the threat to fossil fuel supply capex.
- 'Powering down coal' in 2018 looked at the threat to existing assets in the coal-fired electricity generation sector.
- 'Breaking the habit' in 2019 analysed on a stock level the gap between company capex plans and what was needed to achieve the goals of the Paris Agreement.
- 'How to waste over half a tn dollars' in 2020 quantified the threat to new capex in the coal generation sector.

What is there

The world has proven fossil fuel reserves of 886bn tonnes of oil equivalent. Countries and companies continue to add to this level every year.

The question is how to place a value upon these reserves. To state the obvious, a barrel of oil only has value insofar as it can be sold for more than the cost to extract it. The standard way used by the World Bank[3] is to capitalise the profits that flow from the reserves. The value of all these expected future profits is what they call fossil fuel wealth. Using a discount rate of 4%, and assuming that the profit per unit of the last five years will be maintained, they calculate the value of the world's fossil fuel wealth as $39tn in 2014. As we shall see below, it is possible to come up with very different valuations, depending on the assumptions.

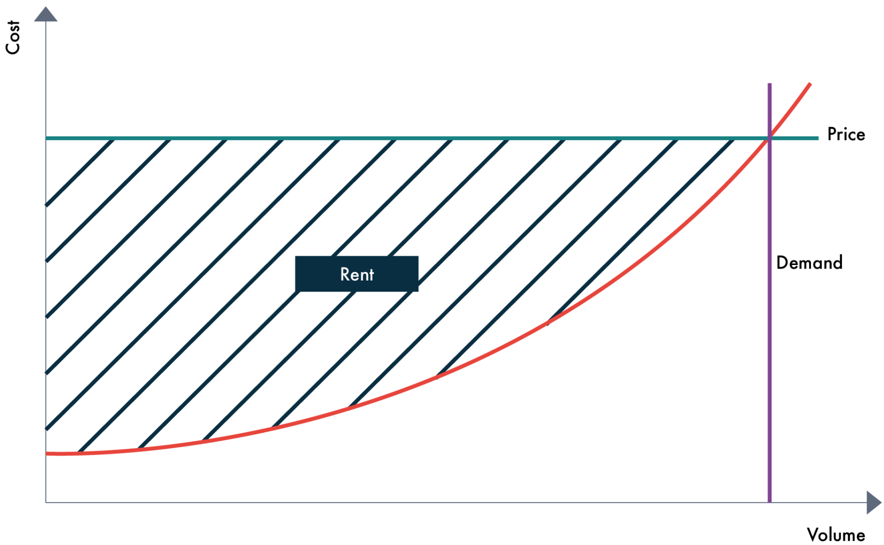
Rents

The World Bank defines some of the profits flowing from fossil fuels as rents, as explained below.

What is rent

Rent is a type of profit beyond the profit that accrues to pay for infrastructure. It is helpful to explain rent with a live example. To extract oil from the ground you need to pay operating costs of the workers and drill-bits and so on. And you need to pay for the capital costs of the infrastructure that makes all this possible. Assume that the operating

FIGURE 5 – THE SOURCE OF RENT



Source: Carbon Tracker

3 *Source: The changing wealth of nations, World Bank, 2018.*

costs are $5 a barrel and the infrastructure costs $10 a barrel, including a return for the capital used to make that infrastructure. So your total costs are $15 a barrel. If you sell the barrel of oil for $60, then you have generated rent of $45. Rent exists because the global price for fossil fuels has commonly been set by the highest cost producer, but the lowest cost producer is still paid the same amount. Rent exists in all markets, but as a rule, the forces of competition are able to compete it away. As Bressand notes, rent is far more pervasive, lasting and protected in energy markets than in most other markets.[4]

We demonstrate the process in the chart on the previous page.

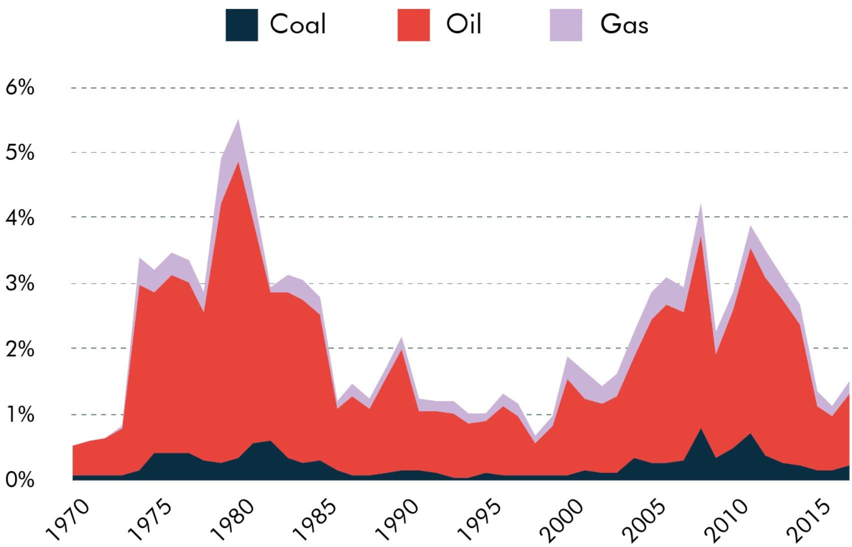
How much rent is generated

The World Bank also helpfully works out the amount of rent that is generated for each fuel and each country. The last year for which they have data is 2017.[5] The total amount of rent generated in 2017 was $1,214bn, of which $887bn came from oil, $155bn from gas and $172bn from coal. The world's largest recipient of fossil fuel rents is Saudi Arabia, followed by Russia, Iraq and Iran.

Rents fluctuate over time, reaching peaks of $2,700bn in 2008 and 2011. They have also shown the ability to keep pace with GDP, a characteristic of a real asset. We show the level of rent as a share of global GDP below.

Of the three fossil fuels, oil has always been the primary source of rent, and the total rents have varied between over 5% of GDP in the late 1980s and under 1% of GDP in the late 1990s.

FIGURE 6 – FOSSIL FUEL RENTS AS A SHARE OF GLOBAL GDP



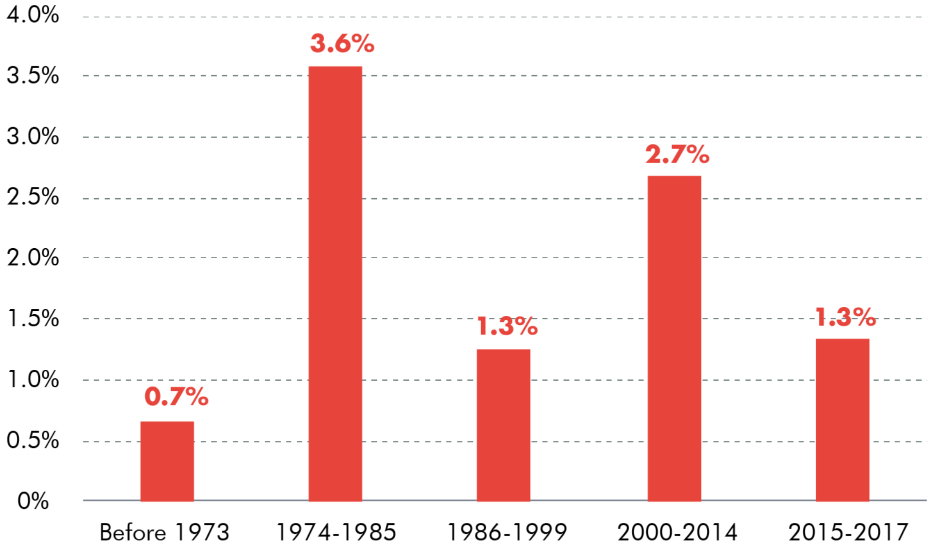
Source: World Bank

4 *Source: The role of markets and investment in global energy, Bressand, 2013.*
5 *Source: World Bank database.*

The key phases

It is possible to identify five distinct phases of the rental flows, as below.

FIGURE 7 – RENTS AS % OF GLOBAL GDP



Source: World Bank

In broad terms, there are two types of period: one when rents are high and one when they are low. In high rental periods, the rents average 3.1% of GDP. In low periods, they average 1.1% of GDP.

The periods of high rents are of course those where OPEC was able to enforce a successful cartel in 1973-85, and then the period between 2000-2014, where rising demand from China met limited supply capacity, itself the result of the lean period from 1986-99.[6]

The periods of low rents are before the formation of OPEC in 1973, when efficiency met new supply in the period after 1986, and more recently after 2015 when new supply from the US came into the market.

Who gets the rent

The World Bank notes that most of this rent ends up in the hands of the governments of the countries that control the fossil fuels. For example, they calculate that between 2010 and 2014, governments took on average 77% of available rents. Furthermore, they argue that in a well-designed system, governments would end up with all of the rents.

The reason for this is simple: governments control the land under which the fossil fuels sit. They can hire and fire production companies and take the majority of the rents for themselves.

6 *For more detail see, for example, Global Energy Politics, Van de Graaf, 2020.*

Fossil fuel infrastructure

There are two types of infrastructure within the fossil fuel system – supply and demand infrastructure.[7] It is of course right to consider them together because the energy transition will impact both supply and demand at the same time.

FIGURE 8 – FOSSIL FUEL INFRASTRUCTURE

Source: Carbon Tracker

The other useful split in infrastructure is to use our stock and flow framing. The stock is the existing assets and the flow is the capital expenditure on new assets.

In this section on infrastructure, we look specifically at the main supply and demand infrastructure, not at the suppliers of this infrastructure. For example, we calculate the value of the cars but not the car factories.

Supply infrastructure

What are the assets

In line with the IEA framing in its World Energy Investment (WEI)[8] report, we focus on three main groups of assets within the supply infrastructure.[9]

Upstream oil and gas

Extraction infrastructure such as oil wells or gas wells. There are said to be 65,000 oil fields in the world and there are 2 million oil wells covered by Rystad. The IEA covers capex on assets owned by states, oil and gas majors, and the oil services sector.

Downstream oil and gas processing and transportation

There are 740 refineries globally,[10] a capacity to handle over 100mbpd of oil, as well as over 500 gas processing facilities in the US alone. The world has 646,000 km of oil and oil product trunk pipelines, and 1,300,000 km of gas trunk pipelines.[11] There is 568mt of oil tanker capacity as well as 80bcm of gas transport capacity and 400mt of LNG liquefaction capacity.[12]

Coal mines and infrastructure

7 Note there is of course a difference between the fossil fuel system which we seek to describe here and the energy system as a whole.
8 Source: World Energy Investment, IEA, 2019. In 2018 real $ terms. Details available in the WEI 2019 methodology annex.
9 It is a moot point whether to include electricity generation as a supply side asset (because it makes electricity which is an energy carrier) or as a demand side asset (because it is a user of fossil fuels). In this report we classify it as a demand side asset.
10 Source: Wood Mackenzie 2017.
11 Source: Global Data 2020.
12 Source: World LNG Report, 2019.

The simplest way to value the supply infrastructure is to take the historic capital expenditure on physical assets and to depreciate it over time to give a depreciated asset value today.

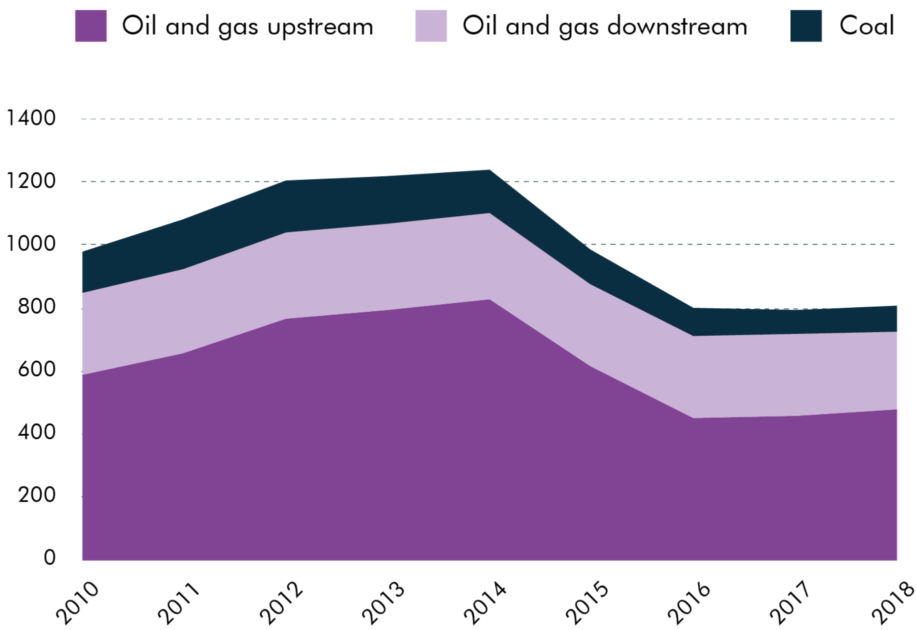
The WEI details the amount of capital expenditure on all fossil fuel supply infrastructure. In 2018 for example, capex on oil and gas upstream infrastructure was $477bn, on oil and gas downstream infrastructure was $249bn, and on coal mining and infrastructure was $80bn. So the total was $806bn.

The data goes back to 2005 (with more detail after 2010), and has been averaging in real terms $900bn a year since then.

In order to derive a valuation of this infrastructure in 2020, we need to decide over how many years to depreciate this capex. According to Bloomberg, the actual depreciation rate as a share of gross fixed assets of supply companies in general and the integrated oil sector specifically was 5% in 2019. If applied on a straight line basis, this would imply that capital expenditure is depreciated over 20 years. This seems quite aggressive, but we take it as a starting point.[13]

If we assume capex from 2000-2004 at 80% of 2005 levels (not a very important assumption as most of these assets are highly depreciated), that implies a total asset value for all fossil fuel supply infrastructure of $10tn. 62% is oil and gas upstream assets, 26% is oil and gas downstream assets, and 12% is coal assets.

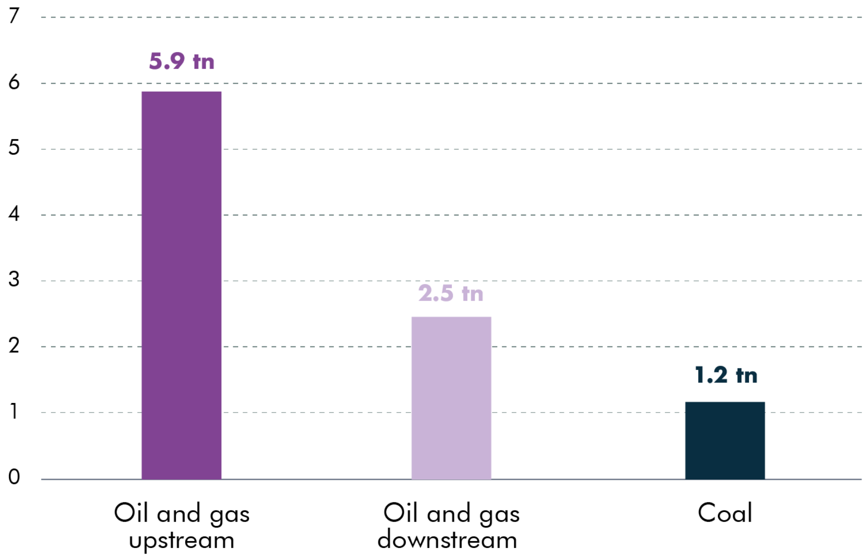
FIGURE 9 – ENERGY SECTOR INVESTMENT ($BN)



Source: IEA WEI 2019

13 *It is also possible to differentiate by sub-sector and to use other deprecation methodologies, but they produce a similar answer. Using Occam's razor, we prefer the simplest sensible solution.*

FIGURE 10 – FOSSIL FUEL SUPPLY INFRASTRUCTURE ASSET VALUE ($TN)



Source: IEA WEI 2019, Carbon Tracker

It is worth noting that this figure of $10tn is a minimum value to which it is worth applying some caveats:

It is an approximation of the balance sheet value, but does not capture the entire value of the fossil fuel supply system. The implicit assumption of flat-line depreciation over 20 years is that any asset built before the year 2000 has no value, which is clearly not the case. The fossil fuel system stands on the shoulders of huge amounts of infrastructure built over generations, not just that which is identifiable as fixed assets on company balance sheets. If we were to increase the depreciation level to 30 years for example, then the fixed asset value would be $12.5 tn.

We have not included within this number the assets of the companies which make machinery for the fossil fuel system.

We have not included any of the value of the ancillary infrastructure not built by the companies which own the fossil fuel system. The size of this can be rapidly appreciated by any visitor to the world's great oil cities, from Abu Dhabi in the Middle East to Astana in Kazakhstan.

Fossil fuel demand infrastructure

What are the demand sectors

Around 80% of global primary energy demand is for fossil fuels. Machines to use them are in every corner of the earth and in every sector. From cars to planes, fossil fuelled electricity generators to steel mills, we use fossil fuels in every area of our lives.

There are however, three sectors that account for nearly 80% of the usage – power generation, transport and industry.

Other analysis, for example by IRENA,[14] includes buildings in the list of assets that use fossil fuels and are at risk from an energy transition. However, the majority of direct fossil fuel usage in buildings is for heat and used in boilers. The value of a gas boiler is only a small fraction of the value of a house, and there are of course non-fossil sources of heating. Therefore, we did not include buildings in the calculation.

What is demand infrastructure

If we focus on these three sectors, it is possible to identify the main demand infrastructure assets.

Power generation

The assets of the power generation sector are relatively easy to identify. According to the IEA, the world at the end of 2018 had 4,300 GW of fossil fuel electricity generation assets. Of these, 2,100 GW are coal, 450 GW are oil, and 1,750 GW are gas.

Transport

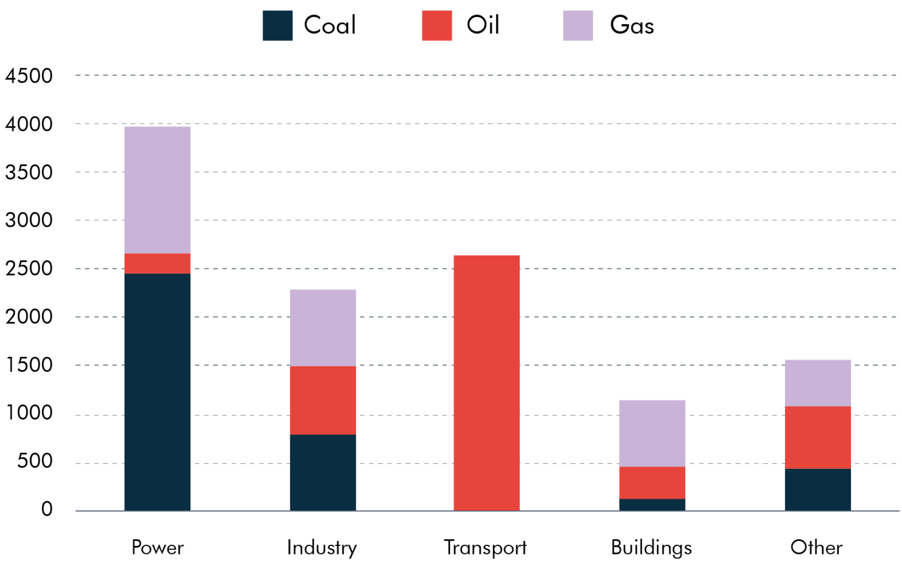
We consider the four largest areas of transport to be cars, trucks, planes and ships. According to Bernstein, the world had 1,100 million cars in 2015 as well as 380 million commercial vehicles. There are around 23,000 commercial planes according to Boeing and 2,000 million tonnes deadweight of shipping according to Clarkson's.

Industry

The four largest sectors for industrial usage of fossil fuels are steel, cement, petchem, (including plastics) and aluminium.

The world has 2,200mt of steel production capacity, 6,000mt of cement capacity,

FIGURE 11 – FOSSIL FUEL END USAGE (MTOE)



Source: IEA WEI 2019

14 *Source: IRENA Global energy transition prospects and the role of renewables, 2017.*

1,600mt of petchem capacity, and 65mt of aluminium capacity.

Asset value

In 2019, Tong et al released an excellent paper in Nature magazine[15] in which they calculated the size of the world's main fossil fuel demand assets at $22tn. They looked at the value of all the world's cars, planes and trucks, the power stations and generators, the steel, plastic, and other industrial plants with heavy fossil fuel usage. They used detailed country databases with asset lives in order to calculate the depreciated value of the assets.

The largest sector is road transport, with a total value of $11.9tn. Electricity is $2.6tn, other transport is $2.4tn and industry is nearly $1.9tn. Transport, electricity and industry make up 86% of the assets.

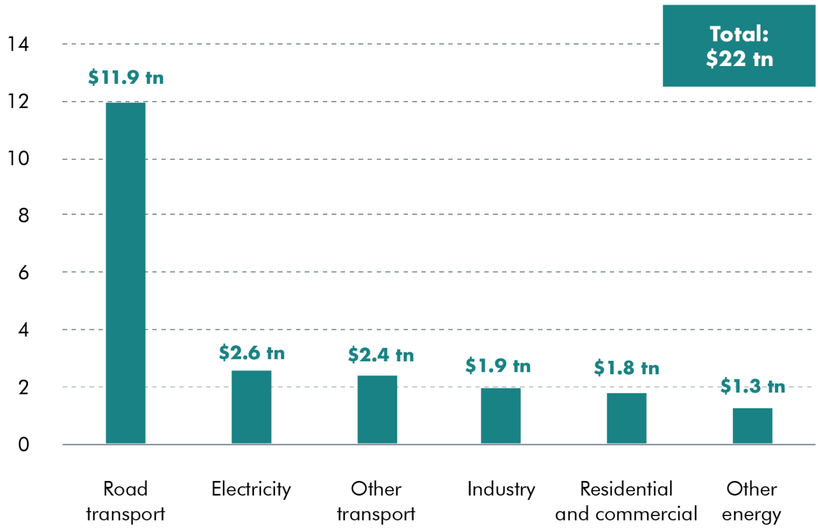
New fossil fuel infrastructure

The fossil fuel system has been expanding for over a century, and industry incumbents expect that the expansion will continue.

New supply infrastructure

The IEA's primary scenario for future energy supply and demand is the STEPS scenario.[16] This is commonly referenced by the fossil fuel industry as a base case. In this scenario, capex on supply infrastructure is forecast to run at just under $1tn a year, which is the same as it was in the 2014-18 period. The expectation under the STEPS scenario is for $21tn in capex in the period to 2040 on new supply side infrastructure. This is more than twice the asset value of existing infrastructure ($10tn) that we calculated above.

FIGURE 12 – FOSSIL FUEL USAGE INFRASTRUCTURE VALUE ($TN)



Source: Tong el al., Nature

15 *Source: Committed emissions from existing energy infrastructure, Tong et al, Nature magazine, 2019*

16 *Source: World Energy Outlook, IEA, 2019. This is associated with rising CO_2 emissions.*

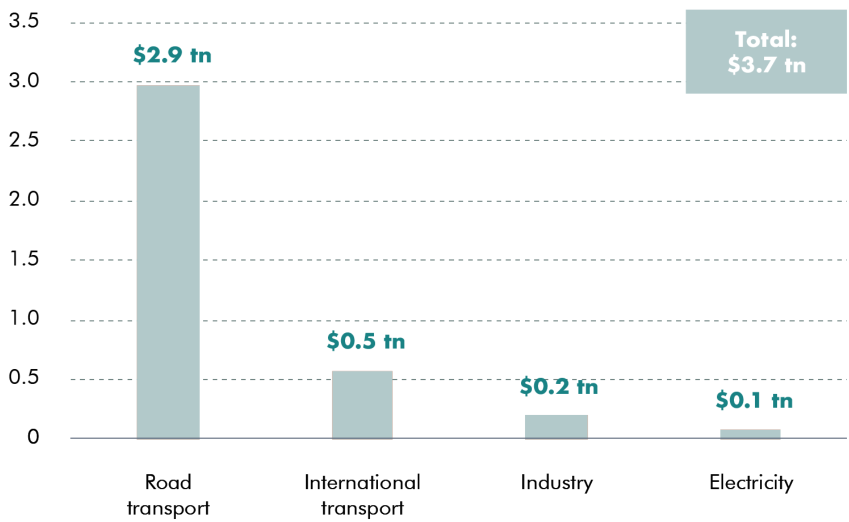
New demand infrastructure

We do not have the same level of forecast detail for each part of the fossil fuel demand system, and it is not clear how much is likely to be spent on fossil fuel based infrastructure versus non-fossil based. With regard to demand, it is also quite likely that, as we have started to see in the automotive sector, producers can shift their production rapidly from fossil fuel based infrastructure to green infrastructure. Over time, car makers can retool from ICE to EV, makers of ships can shift from diesel to ammonia, and electricity generators can move from gas turbines to wind turbines.

However, we can pull together some rough numbers for expected annual expenditure in the main areas of demand in the pre-COVID-19 era.[17] According to McKinsey,[18] expected spending on the automotive sector before the crisis was $2,800bn in 2020, and in addition to this they identify $170bn of spending on trucks. Before the impact of COVID-19, Boeing forecast an average of $340bn annual spending on aircraft and Clarkson's estimate of newbuild shipping catalogue stood at over $200bn in 2018.

Under the IEA STEPS scenario, spending on fossil fuel electricity generation capacity would be $80bn a year. And if we assume that the industrial sectors spend 10% of their asset value on capex (which is the norm in the steel sector), then industry capex would be in the order of $200bn a year.[19] So total capex was planned to be around $4tn a year on the main areas of demand side infrastructure.

FIGURE 13 – ANNUAL CAPEX ON NEW FOSSIL FUEL USAGE INFRASTRUCTURE ($BN)



Source: McKinsey, IEA, Clarkson's, Carbon Tracker estimates

17 To state the obvious, we do not yet have credible revised expectations for capex as there is still so much uncertainty.

18 Source: The future of mobility, McKinsey, 2019.

19 According to IHS for example, chemical sector expenditure alone has been running at around $100bn a year. So this number looks reasonable.

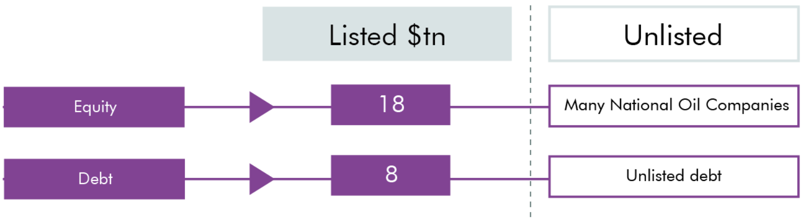
Financial markets provide the capital to build fossil fuel supply and demand infrastructure, and are rewarded with profits, dividends to investors and interest to their lenders. As we have noted, most of the rent goes to governments.

There is no fixed link between financial markets and infrastructure values, although the two are clearly connected.

The value of equity is the capitalised value of future profit expectations, while the value of debt is fixed and sometimes securitised by fixed assets.

We detail below the amounts of equity and debt that we are able to identify, and then examine the size of the other sources of capital which are dependent on the fossil fuel system. It is notable that the unlisted[20] debt capital is likely to be larger than all the listed capital.

FIGURE 14 – FOSSIL FUEL EQUITY AND DEBT SIZE ($TN)



Source: Bloomberg, Carbon Tracker

20 Technically of course all debt is unlisted. However, for the sake of simplicity we refer to debt which is followed by financial market data providers such as Bloomberg as 'listed'.

Equity

Total

Bloomberg calculates[21] that there is $74tn of listed equity in all sectors globally. As set out in detail in Appendix 1, we classify 41 of their 158 subsectors into one of four groups – supply, electricity, transport and industry. This enables us to identify $18tn of listed equities with a significant link[22] to fossil fuel supply and demand. To summarise the four groups:

Fossil fuel supply → $6.8tn

We identify 11 subsectors in this group. They range from the integrated oil and gas sector (with companies such as Saudi Aramco, Gazprom or Exxon) to oil and gas equipment and services (companies like Schlumberger and Halliburton) to construction and engineering (companies like Fluor).

Electricity → $2.9tn

We identify 5 subsectors in this group. From electric utilities with companies such as Enel or Iberdrola to industrial conglomerates with companies such as GE and Siemens.

Transport → $4.4tn

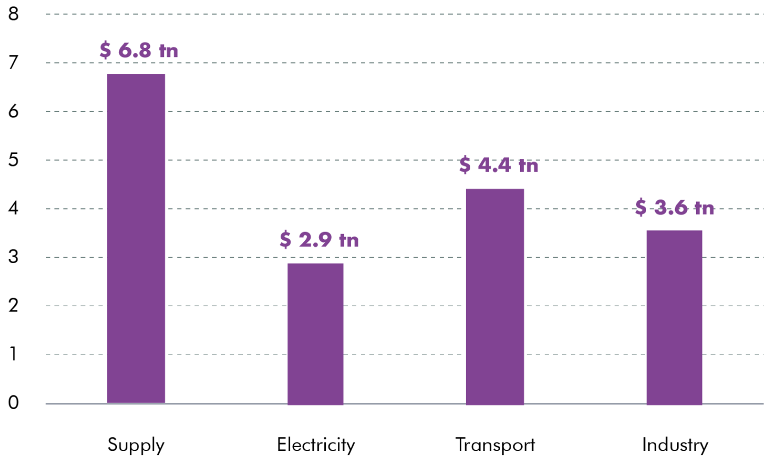
We identify 15 subsectors in this group. They range from automobile manufacturers such as Toyota and BMW to airlines such as EasyJet and auto parts companies such as Continental.

Industry → $3.6tn

We identify 10 subsectors in this group. They range from speciality chemicals such as Dupont, to commodity chemicals such as SABIC or Dow Chemicals, to steel companies such as Vale or Tata Steel.

$18tn in fossil fuel related sectors is 24% of listed equity.

FIGURE 15 – MARKET CAPITALISATION OF FOSSIL FUEL RELATED EQUITY ($TN)

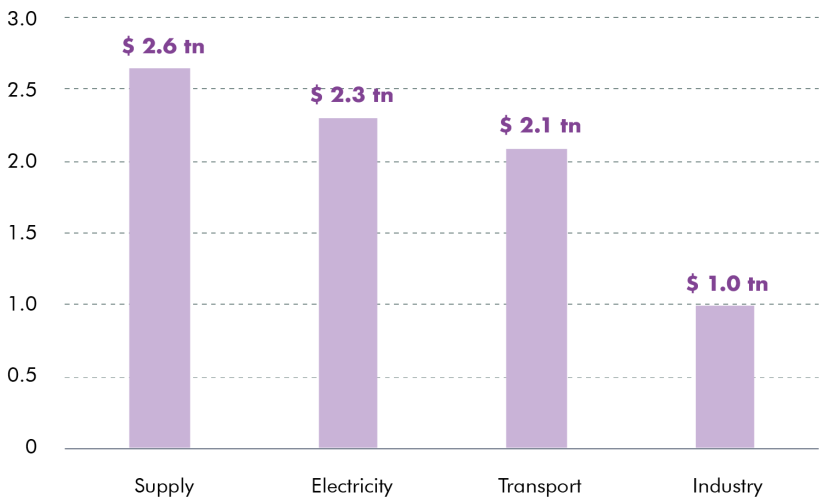


Source: Bloomberg, Carbon Tracker

21 Source: Bloomberg Terminal 24 March 2020. The valuation of the equity is of course very volatile at present. On 1 January 2020 for example fossil fuel related equity had a market capitalisation of $23tn. And on 22 May the equity was valued at $19tn.

22 The existence of a link of course does not mean complete dependency on the fossil fuel system. But it does enable us to quantify the size of the issue.

FIGURE 16 – SIZE OF FOSSIL FUEL RELATED CORPORATE BONDS ($TN)



Source: Bloomberg, Carbon Tracker

Bonds

Bloomberg is able to identify $15tn of non-financial corporate bonds issued by corporates in 9 subsectors. Most of these are issued by companies that have listed equity.

If we split this debt amongst the four fossil fuel groups, then it implies that $8tn is in the fossil fuel supply and demand groups.

$8tn of bonds is 53% of the total share of non-financial corporate bonds.

Other

It is also important to remember that financial markets do not capture the whole picture because not all sources of capital are listed. We note below three large additional areas of capital – unlisted debt, National Oil Company equity, and petrostate debt. Of these, unlisted debt is by far the largest.

Unlisted debt

According to the Institute of International Finance (IIF), the total amount of non-financial corporate debt is $75tn.[23] Meanwhile, Bloomberg tracks only $15tn of non-financial corporate bonds.[24] The implication of this is that syndicated loans and untracked bonds make up a further $60tn of debt, four times the level of the amount that is captured by Bloomberg or other data providers.

If we assume that half of this is in the fossil fuel supply and demand sectors (the same share as the non-financial corporate bond market), that would imply a further $30tn of fossil fuel sector related debt.

Since much of the debt will be owed to the banks, the implication is that the banks have a high level of exposure to the fossil fuel sector, and this is an issue we intend to address in a subsequent report. The risk is that the banking sector has not understood accurately the real risk of lending to fossil

23 Source: Global Debt Monitor, IIF, 2020.

24 Technically these bonds are also unlisted. What distinguishes them from other sources of corpore debt is simply the fact that they have been captured by the Blomberg analysis.

fuel projects if they are basing their risk assumptions on the experience of the last few decades of continuously rising demand. In a world of peaking demand, they would face two main risks: higher default rates and lower recovery rates than they expect; and a lack of buyers for the debt as other banks also seek to reduce exposure. This is commonly referred to as the Minsky moment for fossil fuel risk.

The likely high exposure of the banks is attested by two further pieces of evidence.

Dealogic analysed the sources of funding for the fossil fuel sector from 2010-2018.[25] They calculate that the total amount of new capital raised by the mining, oil and gas, and utility sectors over that period was $12tn. Half the total was from syndicated loans, which were larger than bond issuance. And the oil and gas sector alone raised syndicated loans of $3.2tn over that period. This compares with $1.9tn of outstanding corporate bonds issued by the energy sector according to Bloomberg in 2020.

Banking on Climate Change also looked[26] at the flow of capital raised by the banking sector for fossil fuel supply, and calculated that it was $2.7tn in the period 2016-19, over $600bn a year.

National Oil Company (NOC) equity

The IEA has pointed out that most oil and gas reserves and production are controlled by national oil companies rather than by private companies.[27] For example, in 2018, nearly 60% of production of oil and 50% of production of gas came from state-controlled oil companies.

Some of these companies are listed, such as Saudi Aramco and Gazprom. But many of them are not listed, such as the National Iranian Oil Company or the Abu Dhabi National Oil Company.

If we assume that perhaps half of the total assets are listed, then that implies another large amount of equity which is not captured by this analysis. The listed integrated oil and gas sector for example has a market capitalisation of $3tn.

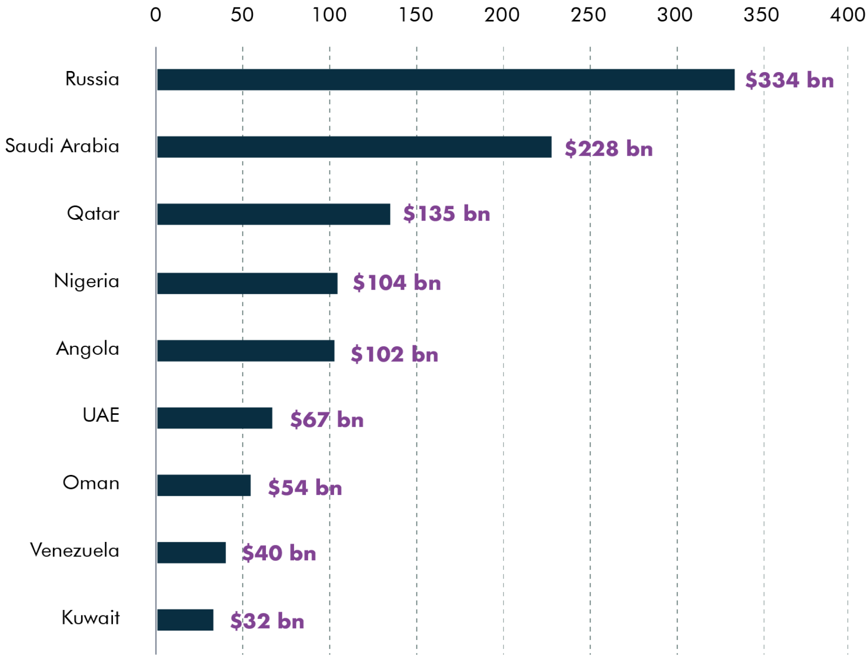
Petrostate debt

As the World Bank has noted,[28] there are many countries with a political economy highly dependent on the rents from fossil fuels. It follows that the debt of these counties is vulnerable to an energy transition.

We can identify $1.1tn of debt issued by major fossil fuel exporters.

25 Source: Dealogic quoted in 'Divestment – does it drive real change?, Schroders, 2019.
26 Source: Banking on Climate Change, Rainforest Action Network et al, 2019.
27 Source: The oil and gas industry in energy transitions, IEA, 2020.
28 Source: The carbon wealth of nations, from rents to risks, Word Bank, 2018. See also A new world, The geopolitics of the energy transformation, IRENA, 2019.

FIGURE 17 – GOVERNMENT DEBT OF MAJOR FOSSIL FUEL EXPORTERS ($BN)



Source: Bloomberg

The forces of disruption

What are the forces of disruption

Carbon Tracker has detailed the forces of disruption in many reports,[29] and we summarise them below. There are three key drivers of change – necessity, technology and policy.

Necessity

There are three aspects of necessity – climate change, pollution and energy security.

- **Climate Change.** In order to avoid catastrophic global warming, we are unable to burn all our fossil fuels. If we burnt all our proven reserves, we would release 3,000 Gt of CO_2.[30] Meanwhile, the global carbon budget to achieve net zero (with a 50% chance of 1.75 degrees centigrade) is around 1,000 Gt,[31] so we can burn only one third of them if we wish to achieve the goals of the Paris Agreement. We therefore need to have an energy transition from fossil fuels to green energy.

- **Clean air.** Pollution from fossil fuels makes the air of the great cities of Asia unbreathable, and outdoor air pollution from fossil fuels kills 4.5 million people a year.[32]

- **Energy security.** China and India lack oil and gas reserves, and are anxious to find alternative solutions. China imports 70% of its oil, and this would rise to 83% under the IEA STEPS scenario; India imports 83% of its oil and that would rise to 92% by 2040 under the IEA STEPS scenario.[33]

Technology

Technology covers many aspects of change. On the one hand, the well-known story of the rapidly falling costs of renewable energy, as detailed by Carbon Tracker[34] and Bloomberg NEF (BNEF). BNEF recently released the levelised cost of energy (LCOE) calculator for the first half of 2020,[35] and this indicated that the cheapest source of bulk electricity production in 85% of the world is renewables. Cheap renewable electricity disrupts supply sectors such as gas and coal as well as the demand sector of electricity generation.

A similar story is playing out in the battery sector, where costs are falling by nearly 20% for every doubling of capacity, and are reaching cost price parity with conventional car engines. At the same time, solar and wind are increasingly able to incorporate battery storage of two hours or more at a competitive price, to enable them to compete directly with fossil fuel based electricity generation.

29 Source: 2020 Vision, Carbon Tracker, 2018.
30 Source: The oil and gas industry in energy transitions, IEA, 2020.
31 Source: IPCC 1.5 degree report, 2018. The carbon budget from the start of 2018 was 1,170 Gt for a 66% chance of 2 degrees and 420 Gt for 1.5 degrees. See also: Carbon budgets where we are now, Carbon Tracker, 2020.
32 Source: Quantifying the economic costs of air pollution from fossil fuels, CREA, 2020.
33 Source: World Energy Outlook, IEA, 2019.
34 Source: How to waste over half a tn dollars, Carbon Tracker, 2020.
35 Source: LCOE of electricity H1 2020, BNEF, 2020.

Technology is evolving in a series of other areas, helped by the imperatives of necessity and policy action. Steel companies are investigating how to make steel with hydrogen instead of coal. Truck companies are looking at using electricity for smaller loads and hydrogen for heavier loads. Shipping companies are looking at ammonia as a propulsion tool. As Amory Lovins has noted,[36] engineers are improving efficiency levels of existing technology, backed by increasingly assertive government policy.

The implication of this technology revolution is felt across the supply and the demand side of the fossil fuel complex. And this is why the entire system is facing disruptive forces. In no part of the fossil fuel system can the suppliers or the users assume that they will not be disrupted by new ways of doing things.

Policy

As policymakers realise the necessity to speed up the energy transition, so they act to support renewables and to encourage fossil fuel users to pay for the externality that their usage imposes upon society.

Actions include the sticks, carrots and regulatory clarity. Sticks include charging for CO_2 and car bans; carrots include renewables subsidies and building renewable infrastructure; regulatory changes include auctions and changing the detail of electricity codes. This issue has been examined at length by David Victor and others.[37]

Why is the fossil fuel system so vulnerable

The fossil fuel system is especially vulnerable to these forces of disruption because it is low growth, does not pay for its externalities, low return and (incredibly) planning for more growth. Moreover, as change is set in motion, feedback loops make it happen more rapidly. We set out some of these features below, albeit cognisant that the fossil fuel system comprises very many subsectors, some of which are more exposed than others.

Low growth

The fossil fuel system as a whole, even at the best of times, has very low growth. Even before the recent crisis, fossil fuel demand growth was forecast to grow at under 1% a year. For example, the IEA's World Energy Outlook in 2019 forecast fossil fuel demand to rise from 11,660 mtoe in 2018 to 13,150 in 2040, a compound annual growth rate of 0.5%. If we accept that an industry is disrupted when demand starts to fall, it stands to reason that as a rule low growth industries are easier to disrupt than high growth industries.

36 *Source: How big is the energy efficiency resource, Lovins, IOP Science, 2018.*

37 *Source: Accelerating the low carbon transition, Brookings, 2019.*

Untaxed externalities

The externality cost to society from global warming and local pollution is at least €100 per tonne of CO_2 according to analysis from Stern,[38] CREA[39] and many others.

And yet the fossil fuel system as a whole has largely managed to avoid paying for these externalities.[40] The reason for this is a combination of the lobbying power of incumbents and a lack of global concern about the size of the externalities until recently.

Total taxes on fossil fuel use in 2018 were €520bn according to the OECD,[41] not much more than the $420bn paid out in the fossil fuel subsidies identified by the IEA.[42] Outside the road sector (which accounts for only 15% of total energy use), the average tax per tonne of CO_2 is just €3/tonne.

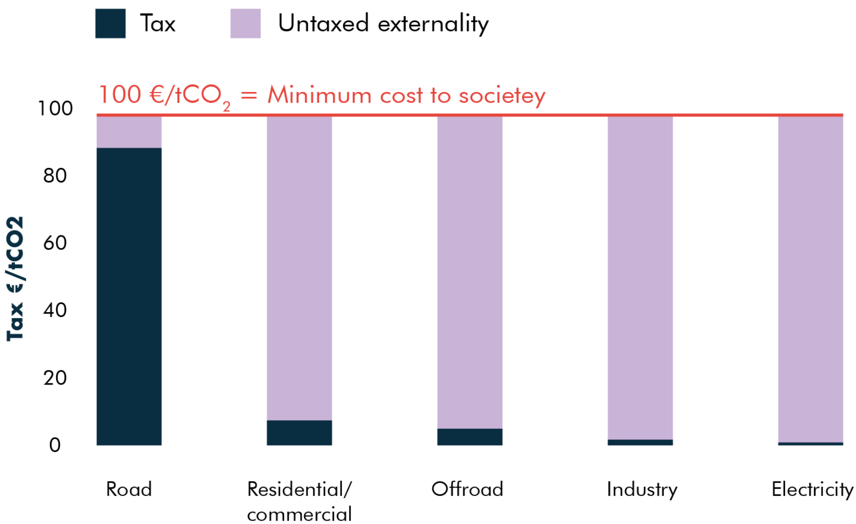
Low return

Certain parts of the fossil fuel system are especially capital intensive. One way to measure capital intensity is to look at fixed assets turnover, defined as sales divided by fixed assets. The average for the entire market is 2, and very capital intensive sectors tend to have a capital intensity of less than 1. Examples include the coal sector with a fixed asset turnover of 0.9, the utility sector where it is 0.5, or the E&P sector where it is 0.4.

The cost of maintaining and running these enormous infrastructure assets is high, and as a result large parts of the fossil fuel system generate relatively low returns.

According to Bloomberg,[43] the ROE of the integrated oil sector has been falling since 2005, and has not been above 10% on a consistent basis since 2015.

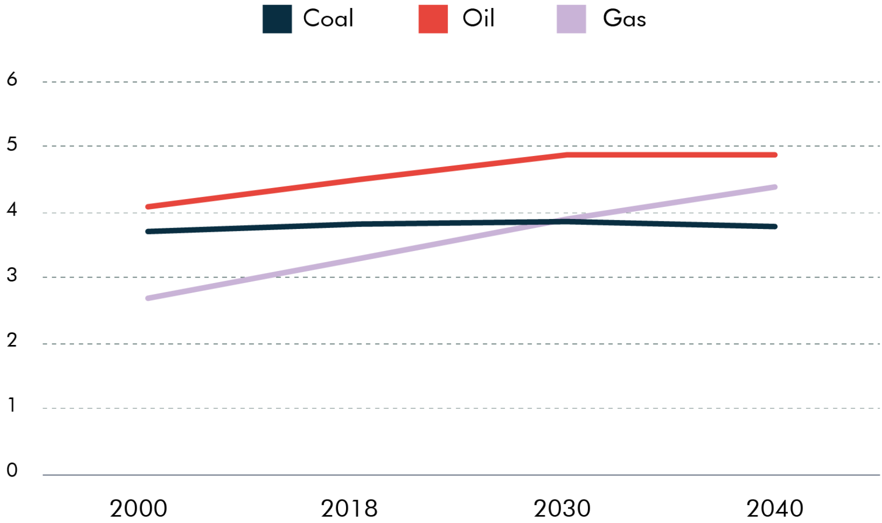
FIGURE 18 – EFFECTIVE TAX RATE PER TONNE ON CO2 USAGE



Source: OECD, Carbon Tracker

38 Source: The missing economic risks in assessment of climate change impact, Stern, 2019.
39 Source: Quantifying the economics costs of air pollution from fossil fuels, CREA, 2020.
40 Individual countries are of course different. But we look here at the system as a whole.
41 Source: Taxing energy use, OECD, 2019.
42 Source: Fossil fuel energy subsidies, IEA, 2019.
43 Source: Bloomberg Green, 2020.

FIGURE 19 – FORECAST SUPPLY OF FOSSIL FUELS (BN TONNES OF OIL EQUIVALENT)



Source: IEA WEO 2019, STEPS scenario

Planning for growth

Large parts of the fossil fuel system were planning for growth before the impact of COVID-19.

The IEA's STEPS scenario,[44] forecasts a rise in all areas of fossil fuel demand for the next 20 years. The published energy forecasts of companies from Exxon[45] to BP[46] see a bright future (for them) of ever rising growth in demand for fossil fuels.

On the supply side:

- Redburn noted in 2019[47] that the fossil fuel majors were planning to increase production of oil and gas to 2025 by a compound annual growth rate of 2%.
- In pipelines, Global Data in 2018 reported that the industry was planning on adding 160,000 km of gas pipelines by 2022 as well as 39,000 km of crude oil and 31,000 of oil product pipelines.
- In 2019, the LNG industry had liquefaction capacity of 365 mt, and according to Rystad the plan was to increase that to 700 mt in the next two decades. In 2015-2017, the industry took the final investment decision (FID) on under $20bn of liquefaction projects per annum, whilst in 2019 it was $70bn, and in 2020 it was planned before the virus to be $94bn.

The capex plans for the usage sector are a little more nuanced. The petrochemical industry had ambitious plans for a doubling in supply of plastics by 2040, and the manufacturers of aeroplanes expected continued high sales, before the coronavirus put their plan on ice.

44 *Source: World Energy Outlook, IEA, 2019.*
45 *Source: Outlook for energy, Exxon, 2019.*
46 *Source: Energy Outlook, BP, 2019.*
47 *Source: Lost in Transition, Redburn, 2019.*

However, elsewhere change was happening.

- The leaders of the electricity sector, from Enel to Iberdrola, are rapidly shifting into renewable energy. According to BNEF, nearly three quarters of new global electricity capacity is now non-fossil.[48] This is important because electricity is the largest share of fossil fuel consumption, accounting for over one third of the total.

- Many of the automotive manufactures are planning to shift new production into EV rather than ICE.[49] This is especially important because, as noted above, this is by far the largest area of capital expenditure, and also the largest area of oil demand.

- Industries such as cement[50] and steel[51] are searching for new solutions which use much less fossil fuels.

Facing feedback loops

There are various reinforcing feedback loops which make the process of change work faster. For example:

- **Technologies work together.** For example, cheaper batteries stimulate more EV demand. And then cars can act as a mobile battery for the electricity sector and in turn reduce the price of storage batteries, by adding to demand volumes and the learning curve. This in turn increases the level of penetration that renewables can have.

- **Write-downs.** Old assets move from being an asset to a liability and need to be written down.[52] The economic consequences of this shift are very profound and are the subject of a forthcoming report by Carbon Tracker. This weakens the ability of the incumbents to invest in new fossil fuel infrastructure.

- **Reflexivity.**[53] Capital markets shift capital from dying sectors to growth sectors. This increases the cost of capital for the incumbent and reduces it for newcomers.[54]

- **Talent.** Talent shifts from dying areas to growth areas. This makes it harder for the laggards to recruit good people.

How disruption works

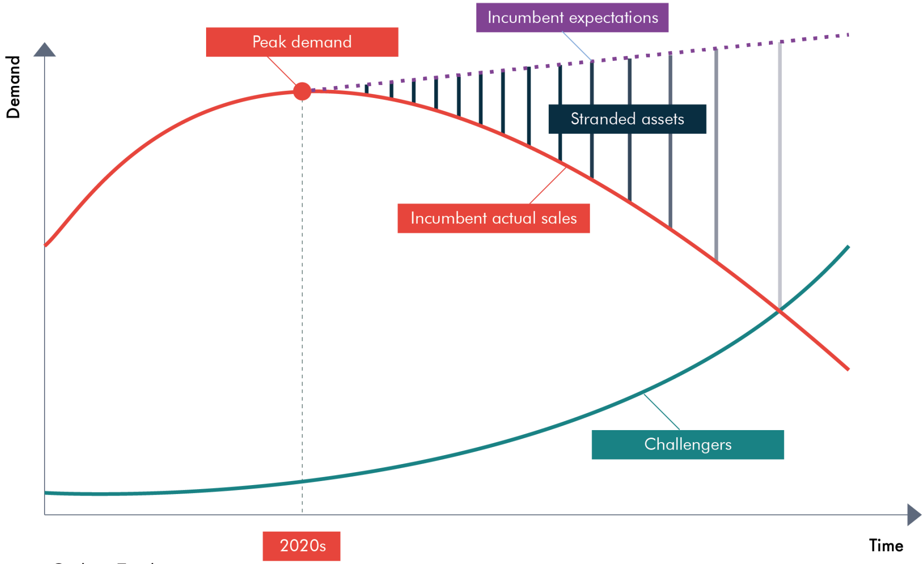
We set out below the mechanics of disruption, albeit this is an issue we have covered elsewhere.[55] The story is simple: new challengers on rapid cost learning curves lead to peak demand for incumbents and falling prices.[56] As price falls, so high cost assets become stranded, profits fall across the system, and even assets in the middle of the cost curve earn much lower returns. That causes lower profits and write-downs, and industry restructuring.

Peak demand

Technological innovation and policy support are driving peak demand in sector after sector and country after country. We may now have seen peak fossil fuel demand as a whole.[57]

48 *Source: Global trends in renewable energy investment, BNEF, 2019.*
49 *Source: EV Outlook, IEA, 2019.*
50 *Heidelberg Cement for example plans to produce net zero emission concrete by 2050.*
51 *Tata Steel for example has committed to net zero emissions steel by 2050. For more discussion of these topics see Mission Possible, Energy Transitions Commission, 2018.*
52 *The flip side: stranded assets and stranded liabilities, Carbon Tracker, 2020.*
53 *As popularised by George Soros in The Alchemy of Finance, 2003.*
54 *The IEA calculate that since 2010 the cost of equity for fossil fuel companies rose by 3% whilst that for renewable companies fell by 3%.*
55 *Source: 2020 Vision, Carbon Tracker, 2018.*
56 *Prices will of course retain their cyclicality. But with a falling mean over time.*
57 *Source: Was 2019 the peak of the fossil fuel era?, Carbon Tracker, 2020.*

FIGURE 20 – PEAK DEMAND AND STRANDED ASSETS



Source: Carbon Tracker

It is worthwhile to remember how to get to peak demand. As a challenger grows, so the challenger takes growth away from an incumbent. At the moment when they take all the growth, the challenger typically has a market share of under 5%.[58] And as soon as the challenger takes the growth, the incumbent, by definition, enters into terminal decline. And this means that peak demand happens early in transitions.

When the incumbent plans for more growth the picture is even worse. The gap between their plans and reality is a major source of stranded assets, overcapacity and lower prices.

Lower prices

It is worth recalling the basic economics of how prices react to disruption. There are three factors which drive down prices:

- Lower demand for existing fossil fuel infrastructure because some demand is being met by new sources of supply. For example, as solar and wind were introduced into the European electricity system, so demand for fossil fuels for electricity soon fell.[59] Peak fossil fuel demand for European electricity came in 2007 when solar and wind were just 4% of total electricity supply.
- Lower price because the new supply caps price at a certain level. For example, the price of gas is now being capped by the price of the renewable alternative in locations where renewables are plentiful such as parts of the US.[60]
- Lower price because of oversupply for the producer. Which means that producers are forced to sell not at their full cost but at their variable cost. This is what happened to the European

58 *Source: 2020 Vision, Carbon Tracker, 2018. The maths is pretty simple: if a challenger has a growth rate of 20% and a market share of 5%, then they make up 1 percentage point of growth. If the entire system is growing at just 1%, that is all the growth.*
59 *Source: Lessons from European electricity for global oil and gas, Carbon Tracker, 2018.*
60 *Source: Prospects for gas pipelines in the era of clean energy, RMI, 2019.*

electricity incumbents after 2008 and is happening at present to the oil industry.

In addition to this, as renewable costs fall, so the pressure only intensifies. Ramez Naam recently pointed out[61] that the learning rate of solar electricity costs has been understated. Moreover, as the learning rate continues to apply for the foreseeable future, so solar costs will become extremely cheap. Not only does this place more and more pressure on fossil fuel incumbents, but it also opens up new ways in which they can challenge fossil fuels. Very cheap solar opens up the possibility of cheap green hydrogen, and hydrogen is able to challenge fossil fuels in many areas.[62]

The impact of lower price

Instead of running incumbent fossil fuel companies to maximise profit and continuously expand, they are obliged to minimise costs and sell for whatever they can get. The effect is to move from the full cost curve towards the variable cost curve. A new equilibrium price is then reached, and at a lower level, as in the chart below.[63]

There are four main consequences of lower prices:

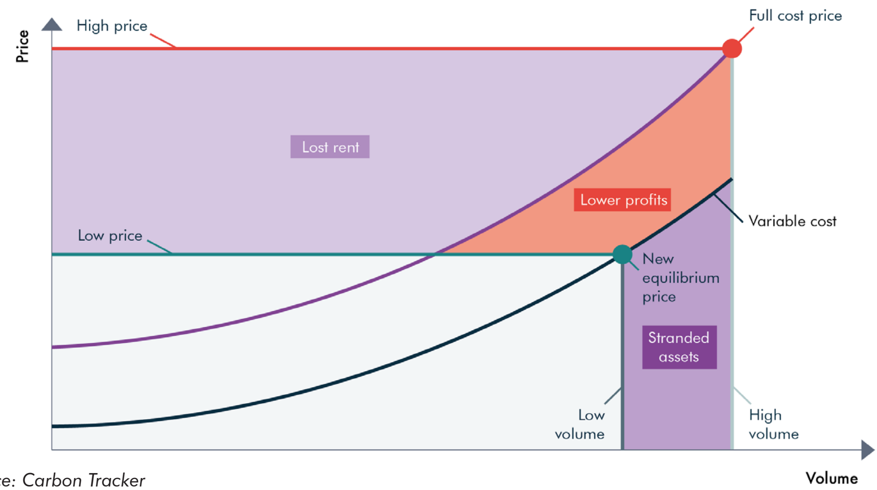
Lower rents. As the chart shows, the largest quantum of change is the fall in the amounts of rent. This means less money for the governments of petrostates.

Lower profits. Profits fall not just for the high cost companies, but right across the system.

Totally stranded assets.[64] When prices fall below variable costs, you have totally stranded assets.

Lower capex. As companies struggle to survive and figure out that growth is over, so they reduce their capex.

FIGURE 21 – THE IMPACT ON THE FOSSIL FUEL SYSTEM OF FALLING PRICES



Source: Carbon Tracker

61 Source: Solar's future is insanely cheap, Ramez Naam, 2020.
62 Source: Hydrogen economy outlook, Bloomberg NEF, 2020.
63 This is somewhat offset in upstream sectors by decline rates. Although the effect is commonly overstated by the industry.
64 Source: Terms list, Carbon Tracker 2020. Carbon Tracker defines stranded assets as those assets that at some time prior to the end of their economic life (as assumed at the investment decision point) are no longer able to earn an economic return as a result of changes associated with the transition to a low carbon economy. This definition covers both lower profits and totally stranded assets.

What determines vulnerability

If all areas of the fossil fuel system are at risk from the energy transition, the question then is which areas are most vulnerable. Sectors which have already been impacted by the energy transition include those across the supply and demand systems. From European electricity to US coal, from gas turbines to oil exploration.

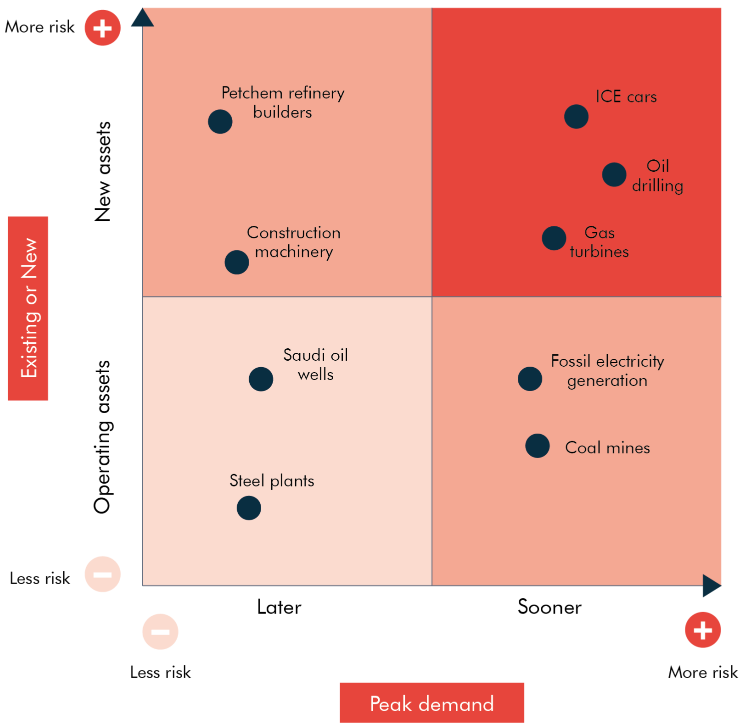
There is of course no single metric which can reveal vulnerability. Rather, we seek to identify the primary ways to work out which companies are most at risk.

In broad terms, we believe the best way to identify sector risk is to focus on the two metrics of companies building new assets and those at risk of peak demand, as explained in more detail below.

Once such a split has been made, the next issue of course is cost. The highest cost producers are the most at risk.

There are then some other factors that determine vulnerability. We consider location, duration, position in the supply chain, and type of fossil fuel.

FIGURE 22 – VULNERABILITY MATRIX



Source: Carbon Tracker

Builders of new assets

Existing supply and demand assets, as we have seen, have a value of over $30tn. However, before these are closed down, it will be necessary to stop the building of new assets. This fits into our stock/flow framework set out above. As we noted, incumbents are planning to build $1tn a year of extraction assets and $4tn of usage assets. Companies involved in these areas will be more vulnerable. A classic example is GE, manufacturers of gas turbines for electricity generation, which was derated after 2017. Or the European oil services companies, typically focussed on engineering and construction of greenfield infrastructure, whose share price peaked from 2011-2013. It is notable that companies in this grouping come from across the supply and demand sectors of the fossil fuel industry.

Peak demand

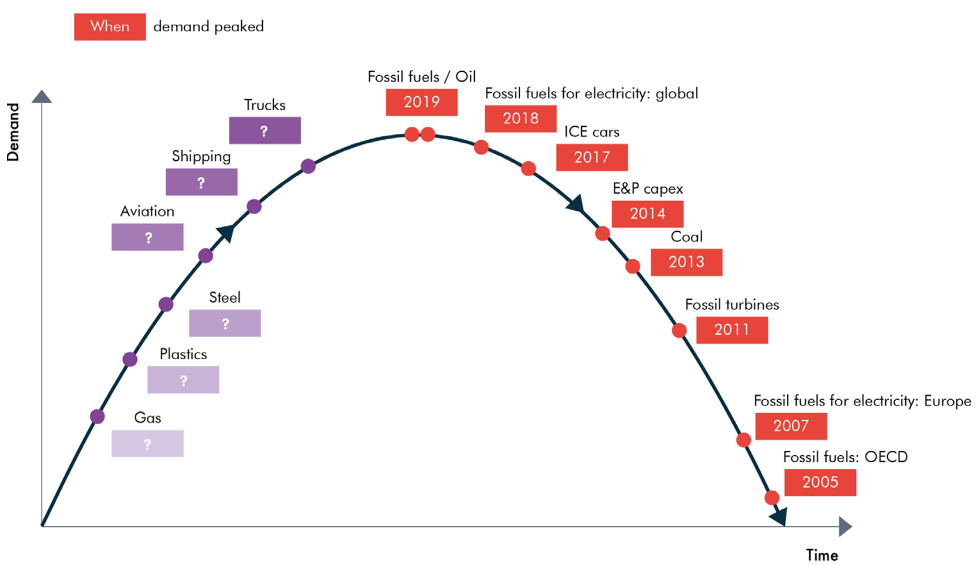
Those areas where disruptive challengers are able to take the growth are most at risk. That is to say, those areas where demand for incumbent technology peaks.

We show in the graph below the framework for how each sector, one after the other, sees demand peak and then starts down on the long curve of decline. For example, fossil fuel demand peaked in the OECD in 2005. Gas turbine demand peaked in 2011. E&P capex peaked in 2014. ICE car demand peaked in 2017. And global oil and global fossil fuel demand may have peaked in 2019.

High cost

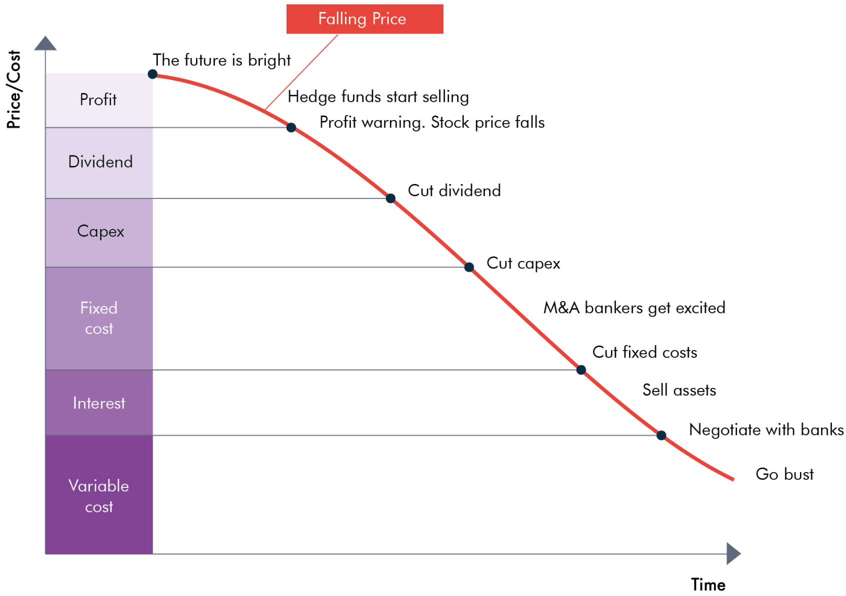
As every part of the fossil fuel sector faces new competition and lower prices, so it will be the highest-cost areas that are most vulnerable. This applies to countries, to sectors, and to stocks.

FIGURE 23 – PEAK DEMAND BY SECTOR



Source: Ember, RMI, BP, GE, BNEF, Carbon Tracker estimates. Note that there is still debate about whether or not peak fossil fuel and oil demand was in 2019

FIGURE 24 – THE IMPACT OF FALLING PRICE ON A COMPANY



Source: Carbon Tracker

- **Countries.** Those which, like Venezuela, built up a high social cost on the expectation of high fossil fuel rents. Political economist Thijs Van de Graaf notes that 'the situation looks particularly dire in Venezuela, Ecuador, Libya, Iraq, Algeria, Angola and Nigeria'.[65]

- **Sectors.** Deepwater oil and frontier oil and gas assets for example.

- **Companies.** Each segment of the fossil fuel system of course has companies that are at the top end of the cost curve. These companies live in hope that the fossil fuel downturn will turn out to be cyclical, and that they will have a chance to make profit again. If the downturn is structural, their banks will lose faith in them and they will have no future.

We show above how falling prices impact a company that is unable to transition its business model. This is of course stylised, and companies seek to reinvent themselves, but it nevertheless shows the process.

Other factors

There are other factors which can also matter.

Low in the supply chain

Each sector has a supply chain. For example, the OEMs sit at the centre of the car supply chain, and subcontract engine manufacturing to other companies. Or the oil majors contract work to the oil services companies.

And as a rule, the further down the supply chain, the more at risk companies will be. Moreover, as the system changes, so some companies may be able to change with it.

65 *Source: The coronavirus has changed oil markets forever, World Politics Review, 2020.*

For example, as demand shifts from ICE to EV, car manufacturers may be able to buy their engines from new suppliers. However, companies which are dedicated to the production of diesel engines will need to find a radically different business model.

Green policymakers

The two key drivers of the energy transition are technology and policy. As the mobile phone and internet revolutions showed us, superior technology innovations will eventually be adopted everywhere. However, policymakers can speed up or slow down the change very considerably. A classic example is the electricity sector in Europe, one of the early victims of the energy transition.

In every country there is now a political battle between those who wish to preserve the fossil fuel status quo and those who wish to move to a new green economy. Where fossil fuel interests are able to seize the reins of power, they are able to prevent or hold back change, subsidise fossil fuel production and persuade government to retard the growth of new energy.

How each country turns out depends on a complete range of factors,[66] and it is very notable for example that Norway, one of the largest fossil fuel exporters, is an advocate of a green transition; while Japan, which has almost no fossil fuels, has until recently been an advocate of continuity.

Nevertheless, counties which have major pollution problems, large fossil fuel imports and growing energy demand will tend to favour green transitions. In broad terms, this means that Europe, China and India will tend to enact policies more favourable to renewables while the Middle East and Russia will tend to be more supportive of fossil fuels.

The US under Trump has become a fossil fuel champion, but this is in fact anomalous because fossil fuel rents are less than 1% of US GDP.

Long duration

Long duration assets are generally[67] more vulnerable to change than short duration assets. The longest duration assets are:

- **Fossil fuels themselves.** As noted above, the world has a century of proven coal reserves and three times as much fossil fuels as it can burn without causing dangerous levels of climate change.

- **Electricity generation from fossil fuels.** Fossil fuel generation stations are designed for 40 years and can last much more than this.

- **Heavy industrial assets.** Industrial assets like steel mills or petrochemical plants are also designed for decades of fossil fuel usage.

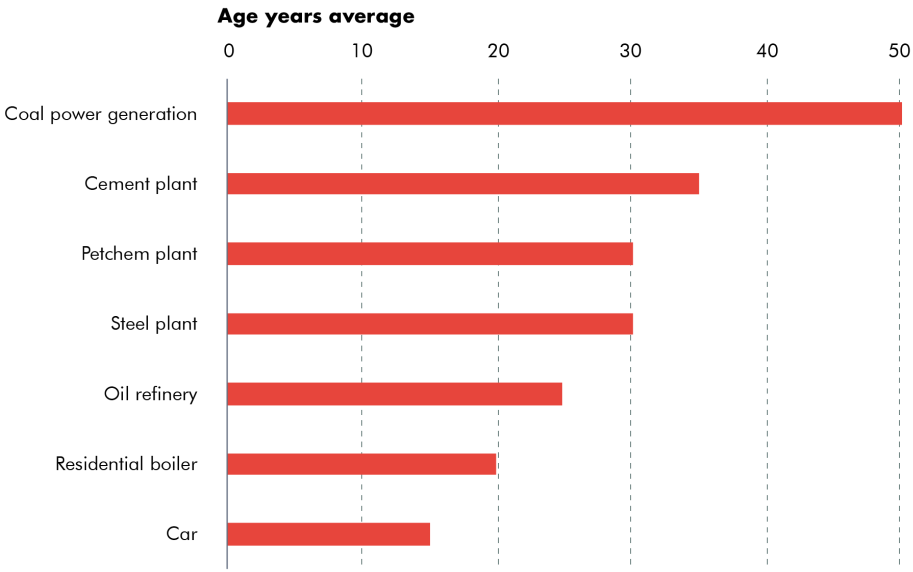
- **Pipelines.** There are typically designed for many decades of use.

Fossil fuel type

Vulnerability is typically split on the lines of which fossil fuel companies are linked to. The consensus view is that the most vulnerable area is coal, then oil then gas. Because that is the order in which demand is likely to peak in each area. However, oil is especially vulnerable as it has been protected for so long by a cartel, generates the highest rents, and 70% is exported.

66 *Source: The knowns and unknowns of the energy transition, WEF, 2020.*
67 *Not always of course. Some short duration shale assets have proven very vulnerable to disruption.*

FIGURE 25 – AVERAGE TECHNICAL LIFESPAN OF ENERGY RELATED CAPITAL STOCK



Source IEA WEO 2008

Factors that reduce vulnerability

There are also factors that reduce vulnerability. They include low cost, reusable infrastructure, and short duration assets – as well as high growth niches and companies able to handle incremental change.

Low cost

Low cost assets like Saudi oil wells will of course continue to operate long after high cost assets have ceased to exist. However, it is worth noting that their owners may nonetheless be vulnerable to lower prices, especially if they have built (as in the case of the petrostates) huge social costs on top of them which require a constant flow of high rents.

Reusable

Not all fossil fuel assets will be stranded by the energy transition. Some can find a new use in the renewable economy. An example would be North Sea infrastructure, some of which is moving from oil to wind. Another example would be gas pipelines, which hope to find a new life as hydrogen pipelines.

Short duration

As a rule, short duration assets are less vulnerable to change than long duration assets. So for example, cars (which last for around 15 years) are less at risk than coal fired power generation stations (with an expected asset life of at least 40 years).

High growth niches

Even within a sector that is facing a peak and decline, there can be specific areas that are still growing. The classic example of this is the building of the Cutty Sark, a sailing ship built in 1869, just at the moment when sailing ships were giving way to iron ships. However, for a few years sailing ships were still faster at getting tea back from China, and so the Cutty Sark was built.

So there may still be some high growth areas within the fossil fuel system. The higher the growth, the harder it is for the sector to be disrupted.

FIGURE 26 – SECTOR VULNERABILITY

Area	Average rents % GDP 2000-2017	Share of produce exported	Year of peak demand
Coal	0.3%	18%	2013
Oil	1.8%	70%	2019
Gas	0.3%	30%	TBC

Source: World Bank, Global Energy Politics, Van de Graaf, 2020, Carbon Tracker estimates. Peak oil demand in 2019 is still of course a matter of debate.

Incremental change

Clay Christensen, the writer of 'The Innovator's Dilemma,[68] distinguishes between incremental change (which companies can handle) and disruptive change (which they can't). In each area across the fossil fuel system, change is playing out. In most areas it is likely to prove disruptive, but in a few it may turn out to be incremental.

Decline rates

One of the primary arguments of fossil fuel suppliers is that decline rates will save the industry from low prices. The natural rate of decline of an oil well means that it is necessary to maintain high levels of investment, so prices will therefore stay at elevated levels (on the total cost curve) in order to stimulate new supply.

We do not believe that this argument is at all convincing, as laid out in our note 'The decline rate delusion.'[69] The counter argument is that the world has 50 years of oil, most of it in low-cost OPEC countries. As demand starts to fall, the high decline rate oil controlled by the IOCs will indeed be at risk, but not necessarily oil production itself.

Perhaps the right way to look at this is to note that the downstream sectors such as refining or petchem which do not have high decline or depreciation rates, are more vulnerable than the upstream sectors.

68 *The Innovator's Dilemma, Christensen 1997.*
69 *The decline rate delusion, Carbon Tracker, 2019.*

The impact by area

We summarise the impact of disruption below in our six main areas of focus, and then examine the consequences in more detail for a number of the key areas.

Fossil fuels

- Rents will be considerably lower as a result of lower prices.
- The value of fossil fuel assets is the capitalised value of rents, so the asset value will fall. The fall will be even higher as the discount rate rises to factor in higher risks and declining demand.

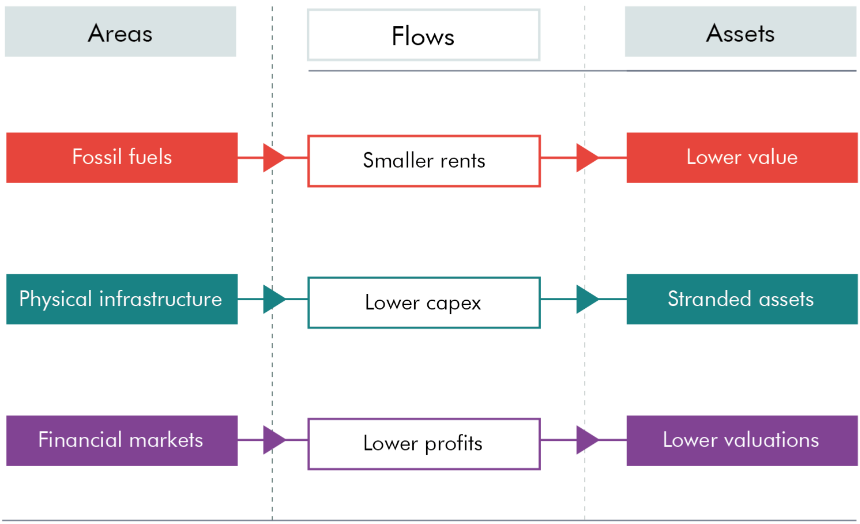
Physical infrastructure

- Capex will fall considerably as it becomes clear that expansion is not necessary.
- High cost infrastructure will no longer be needed and will have to be closed.

Financial markets

- Incumbent profits will fall as prices decline in the face of new competition.
- Dividends will reduce and some companies will struggle to make interest payments. The recent dividend cut by Shell is symptomatic of the changes to come.
- Equity performance will be weak as financial markets seek to price in less profit at higher risk.
- Some companies will be unable to pay debt and will go bust.

FIGURE 27 – DISRUPTION AND THE ENERGY SYSTEM



Source: Carbon Tracker

Timing

We set out below a standard template for how changes move through the system as a result of disruption leading to systemic change from growth to decline. Of course each area will be slightly different, but this is a useful way to think about the framing of change. The key point of course is that equity markets react early in the process, while asset write-downs typically come towards the end.

- **Strategy change.** Some management teams change strategy. Many companies employ PR and greenwashing and confuse this with strategy.
- **Equity markets decline.** Investors start to see the writing on the wall and reduce their exposure. As noted, this happens early.
- **Prices peak.** Another early indicator of trouble. The prices of commodities produced by incumbents peak and start to decline. Many commentators see this as a temporary issue.
- **Volumes peak.** Long after equity markets and prices have peaked, volumes peak.
- **Profit warnings.** Companies then start to issue profit warnings.
- **Cuts in dividends and capex.** And they start to cut discretionary capex and dividends.
- **M&A activity.** As change courses through the system, so M&A activity increases.
- **Assets written down.** Relatively late in the process, assets start to get written down. Markets typically have priced this in long before.

Fossil fuels

There is a large gap between the expected value of the fossil fuels under the expectations of incumbents and the aspirations of the Paris Agreement. As we detail below, the size of this gap is in the order of $100tn.

The framework

As we have seen, the value of fossil fuels is simply the capitalised rents that they can generate. This value is what the World Bank calls fossil fuel wealth.

In a standard model, the value of a flow of profit to perpetuity[70] is simply the annual flow divided by the discount rate. So if the annual rent is $2tn and the discount rate is 5%, then the fossil fuel wealth is $40tn.

Starting with a 2019 GDP level of $86tn, it is then possible to calculate the fossil fuel wealth based on just two variables:

- Rents as a share of global GDP.
- The discount rate.

We show this in the table 1 on the next page.

70 Technically of course the flows from fossil fuels do not continue into perpetuity. But as is well known, the net present value of flows after 50 years is very limited in any event. So we can use the perpetuity model as a simplifying assumption.

TABLE 1 – GLOBAL FOSSIL FUEL WEALTH $TN

Rent % GDP	Discount rate 1%	2%	3%	4%	5%	6%	7%
0.5%	43	22	14	11	9	7	6
1.0%	86	43	29	22	17	14	12
1.5%	129	65	43	32	26	22	18
2.0%	172	86	57	43	34	29	25
2.5%	215	108	72	54	43	36	31
3.0%	258	129	86	65	52	43	37
3.5%	301	151	100	75	60	50	43

Source: Carbon Tracker

Three ways to value the fossil fuel wealth

It is immediately apparent that there is a very large range of values that we can use to place a value on the fossil fuels. There are three main ways in which to value the wealth. The World Bank approach; the petrostate approach; and the Paris approach.

The World Bank approach

The World Bank[71] takes the average rent per unit for the last 5 years and multiplies by the forecast volume of sales in order to calculate a flow of rents for every year. They then use a discount rate of 4%. This leads them to a valuation for fossil fuel wealth of $39tn, which is similar to the number we show above of $43tn for a discount rate of 4% and a rent to GDP of 2%.

The petrostate approach

As we have seen above, the rents from fossil fuels were high from 1973-85 and 2000-2014. The average level was 3%, and this is perhaps the level to which the petrostates aspire. As an example of this approach, it is useful to look at the expected price of oil in the IEA's WEO; under the Current Policies and Stated Policies Scenarios, demand for oil rises until 2040 and prices move back to their previous peaks.

It is also useful to question the discount rate. Fossil fuel assets have been relatively successful at maintaining their real value over time, and even growing with GDP. If the value of a barrel of oil in the ground today is the same in real terms as the value of a barrel of oil in 20 years' time, that implies a very low discount rate. Furthermore, the risks faced by a government are much lower than those faced by a company. The case can certainly be made for a lower discount rate than the World Bank is using. Perhaps as low as 2%, in line with some long-term government bonds.

71 *Source: The changing wealth of nations, World Bank, 2018. This is a simplification of their methodology. For details see their Appendix A.*

If we combine rents of 3% of GDP and a 2% discount rate, we end up with a prospective level of fossil fuel wealth of $129tn. This is best seen as the level that the petrostates would like to achieve.

The Paris approach

The central objective of the Paris Agreement is its long-term temperature goal to hold global average temperature increase to well below 2°C above pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. The Agreement does not analyse what this means for oil demand, but there are many organisations which do this analysis and their work has been organised into a database by the IAMC (Integrated Assessment Modelling Coalition) and collated by the International Institute for Applied Systems Analysis (IIASA).[72] Accordiang to this database, the average 2°C scenario implies an annual decline in fossil fuel demand from 2020-2070 of 2%. This then sets up a very different dynamic for how to value the flows of rent.

The share of global GDP that fossil fuel rents would get will surely be lower in a world of falling demand and high existing capacity. We have in fact no experience of what this means,[73] so we can take as a starting point the level of rental flows that prevailed in the three low-rent periods. That is 1% of global GDP. In reality, it could be lower.

And there is also an important question on the size of the discount rate. Two factors combine to indicate that the discount rate should be higher. If demand declines by 2% a year, then that alone should add 2% to the discount rate in a perpetuity model. In addition to this, it is fair to say that the risks to expected returns from fossil fuel extraction are surely higher.

A market characterised by overcapacity and the threat of obsolescence is one which merits a higher level of risk.

For example, the IEA has noted that the oil sector saw an increase in the cost of equity of 3% in the period from 2010 to 2018.[74] We therefore argue that 2% would be a reasonable extra risk.

If we take 2% as our starting point (based on the petrostate approach) and then add 2% for decline and 2% for risk, the new discount rate would be 6%. This is 4 percentage points higher than the aspirational petrostate approach and two percentage points higher than the World Bank number.

If we combine a 6% discount rate with a share of 1% of GDP in rents, then we end up with a wealth value of only $14tn.

The wealth gap

The wealth gap between the petrostate aspiration and the Paris Agreement implications is therefore in the order of $100tn.

The gap largely represents a transfer of wealth from fossil fuel importing countries to fossil fuel exporting countries.[75]

The implications

The existence of this huge gap leads to two key conclusions:

- It is in the interests of some xpetrostates to resist change as long as they can.
- It is in the interest of fossil fuel importers to move to a Paris compliant world as quickly as they can.

As so often with technology transitions, there really is no question about which perspective

72 Source: Scenario Explorer, IIASA, 2020.
73 Oil demand fell briefly after the oil shock in 1973, but demand soon recovered.
74 Source: The oil and gas industry in energy transitions, IEA, 2020.
75 When there are no alternatives, fossil fuel importers are of course happy to pay for this. But when alternatives exist, they will not.

will prevail: the forces of progress will win.

There are two reason why the interests of the fossil fuel importers will prevail:

- **Size**. 80% of the world lives in countries that import fossil fuels. So the population of fossil fuel importers outnumbers the exporters by 4 to 1.
- **Technology**. As we have seen, renewable technologies just keep getting cheaper.

And as the forces of change do prevail, the implication for governments is that it makes less sense to develop their fossil fuel reserves. Lower prices, high risks, and greater uncertainty mean that fossil fuel assets near the top of the global cost curve do not merit development. They are a cost not an asset.

Fossil fuel infrastructure

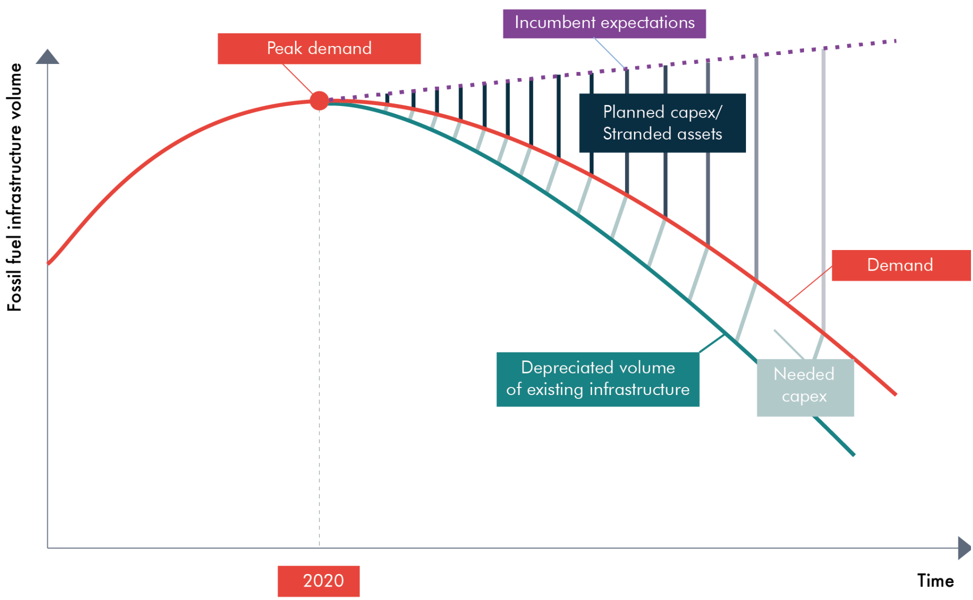
There are two parts of the fossil fuel infrastructure that are especially vulnerable – new infrastructure and long-life infrastructure.

New infrastructure

As fossil fuel demand peaks and then falls, it is clearly not necessary to build new supply or demand infrastructure. It follows that companies which are involved in the creation of this infrastructure are especially vulnerable.

The standard counterargument to this is to say that infrastructure is required to replace existing assets either because of deprecation or decline rates. This is of course a fair point, but this is often used to justify the buildout of additional infrastructure. The situation is set out in the chart below.

FIGURE 28 – FOSSIL FUEL INFRASTRUCTURE AND DEPRECIATION



Source: Carbon Tracker

If demand falls by less than depreciation (or decline rate), then it is indeed necessary to have some capex to maintain supply. But this is far less than the capex that is required to grow supply.

At present, the annual amount of capex being spent on new infrastructure is $1tn for new supply assets and $4tn for new demand assets. As we have seen, much of this capex, especially on the supply side, assumes rising demand for fossil fuels. The implication is that a lot of this capex is beyond that which is required to meet falling demand for fossil fuels.

It follows that companies involved in the creation of this infrastructure are at risk. We identify $6tn of equity in this area.

Long-life infrastructure

Until very recently, the fossil fuel supply and demand sectors assumed that nothing would change – that supply and demand for fossil fuels would continue to rise for the foreseeable future. As a result, they have built long-life infrastructure on the assumption of continued high and stable volumes and returns.

This assumptions will be challenged by the rise of alternative energy sources and by lower returns.

It follows that infrastructure with long lives such as petrochemical plants or oil pipelines are deeply at risk of generating lower returns than expected.

The areas with long infrastructure lives include electricity and industry with $4tn of identified assets and $6tn of equity capitalisation.

Financial markets

We summarise why equity markets are so vulnerable. We then consider the amount of equity in those areas we identified as being most at risk – builders of new assets and sectors near peak demand – and conclude with the impact of disruption on dividends.

Equity

The first impact on financial markets is of course on equity. As the great strategist Russell Napier said,[76] equity markets are the thin sliver of hope between assets and liabilities. In more prosaic terms, the value of an equity is the market expectation of the value of future profits. Two observations follow from this. First, that an asset with no profits (and no prospect of profits) has no value. And second, that the market can change its mind very quickly about the likely future profits of a sector.

As a result of this, equity markets tend to sell down at the first sign of trouble. As Larry Fink said in January 2020 with regard to the energy transition (and with extraordinary prescience),[77] financial markets bring future risk forward. And as they realise that the world is moving from one paradigm (constantly rising demand and price) to another (constantly falling demand and price), so they will seek to price it in.

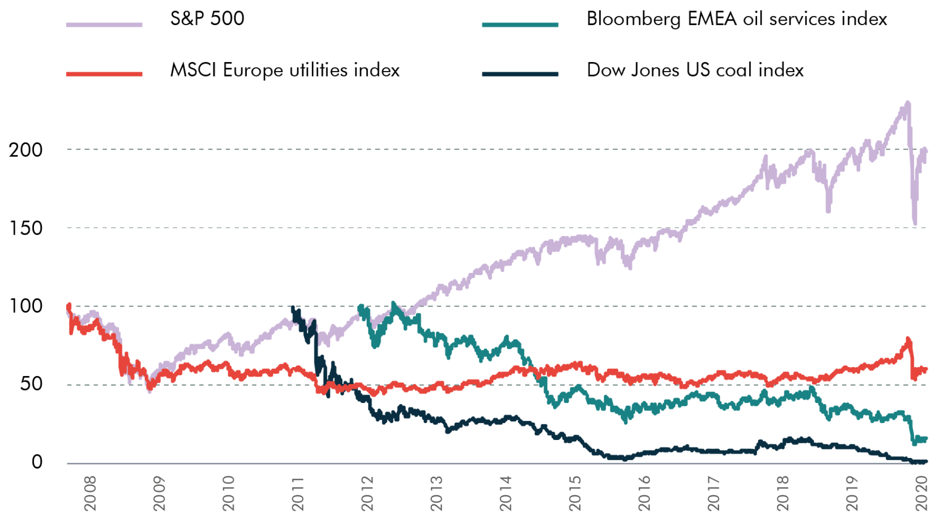
As we have seen, the impact on investors is felt very early in the process. The energy transition is likely to have a disproportionate impact on profits in capital intensive sectors. Stock prices will typically peak even before demand peaks. And by the time demand itself has peaked they will have already fallen a long way.

Examples of this include European electricity, coal or oil services in recent years. European electricity stock prices peaked in 2007, shortly before peak demand for fossil fuel for

76 *Source: Anatomy of the bear, Napier, 2005.*
77 *Larry Fink letter to investors, Blackrock, January 2020.*

electricity in Europe. US coal stocks peaked in 2011, a couple of years before peak global coal demand. And the oil services sector peaked from 2011-2013, the years preceding the peak of E&P capex in 2014.

FIGURE 29 – FOSSIL FUEL SUBSECTOR PERFORMANCE



Source: Bloomberg. Indexed from 2008 or from the peak year after 2008

FIGURE 30 – FINANCIAL MARKETS AND PEAK DEMAND

Source: Carbon Tracker

And from this we can derive a framework chart for how equity markets react to peak demand.

The COVID-19 crisis has brought forward peak demand for many areas of fossil fuels and had a profound market impact. Perhaps the right way to look at this is to take the framing of what happened to the European electricity sector in the wake of the 2008 crisis. When the rest of the market bounced, that sector did not.

Builders of new assets

Within equity markets, we calculate the builders of new assets have a market capitalisation of $6tn.

Sectors beyond or near the peak

We calculate that the market capitalisation of stocks in sectors like automotive or oil services which have passed the point of peak demand is $4tn, and in sectors like integrated oil where demand may be peaking is $6tn.

Dividends

As returns fall, so there will be less capital available to pay dividends and interest payments. This is an important issue for some stock indices. In the UK for example, 24% of dividends of the FTSE Index in 2019 came from the oil and gas sector.

How to analyse incumbents

It is not the purpose of this report to analyse in detail every one of dozens of complex sectors. However, we hope to question the prevailing orthodoxy of business as usual and to give investors and analysts tools with which they can identify the impact of transition on sectors. Disruptive change means that models should now assume:

New competition

In each area of the fossil fuel complex there are likely to be new competitors. Dozy industries undisturbed for decades will have to face the full flood of competition.

Lower prices

As the industry grapples with overcapacity and new competition, so prices are likely to fall over time. This does not of course mean that they lose their cyclicality, but it is likely to be cyclicality with a falling mean.

Higher taxes

Fossil fuel importing governments are likely to increase tax wedges to make fossil fuel users pay for the externality. Analysts should not make the mistake of thinking that all the profit from a sector will continue to accrue to companies.

Asset write-downs

Companies will face major asset write downs as as it becomes clear that high cost fossil fuel supply and demand infrastructure has limited value. An example of this in 2019 was Repsol, which took €4.8bn of write-downs on its fossil fuel assets. Because of leverage, this was only 8% of assets, but 16% of equity.

Higher discount rates

As financial markets exit sectors to which they have in the past allocated too much capital, the price of capital is highly likely to rise.

Lower terminal values

Many models include high terminal values. A typical analyst model might have a terminal value of 10-20 times expected profit. It is likely to be necessary to set these at much lower levels or even at zero.

Clean-up costs

It will be necessary to pay for clean-up costs as the industry realises that assets will never be used. As Carbon Tracker has pointed out,[78] these costs can be material. A detailed examination of this issue is the subject of forthcoming piece of analysis.

78 *The Flip Side, Carbon Tracker, 2020.*

Appendix 1: Equity market exposure

Equity markets do not of course overlap perfectly with the supply and demand fossil fuel infrastructure that we have identified above, and nor should we expect them to. Not all assets are listed, many companies have other areas of focus, and we are able to include the companies that make machinery for the fossil fuel system in our analysis of financial markets. Nevertheless, it is possible to do a broad-brush analysis of the subsectors and groups that are vulnerable to the energy transition.

How to identify the supply and demand groups

The MSCI global industry classification system (GICS) designates companies into 11 sectors, 24 market groups, 69 industries and 158 subsectors.

The supply and demand groups that we wish to identify do not correspond exactly with the 11 sectors that MSCI uses. Five MSCI sectors in particular merit attention – consumer discretionary, energy, industrials, materials, and utilities, and we reclassified most of their subsectors into the four groups. In total, we classified 41 of the 158 subsectors into one of four groups: Supply; Electricity; Transport; and Industry.

We are of course cognisant that there will be some stocks in these subsectors that are not unduly impacted by the transition, or even those which will benefit from the transition. Subsectors are always a blunt tool, and this is inherent within any attempt to simplify complexity. Nevertheless, change is happening, and it is important to work out where it is most concentrated.

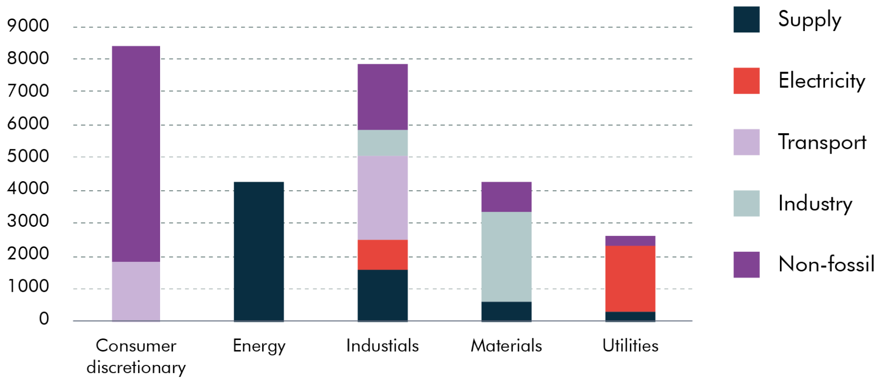
Companies like GE, with assets in many areas, were nevertheless deeply impacted by their exposure to the fossil fuel system. Thus we believe that this approach can shed some light on the subsectors where investors will find the greatest risks.

For the most part, our classifications are pretty standard. To summarise what we have done below, based on the 11 sectors:

- **Consumer discretionary.** We have classified the automobile subsectors under 'Transport'.
- **Energy.** All energy subsectors are classified under 'Supply'.
- **Industrials.** This is the sector that required most granular analysis. Some subsectors such as airlines were classified under 'Transport'. We classified the construction and engineering sector with stocks like Fluor under 'Supply'. We classified the construction machinery with stocks like CRRC under 'Industry'. And the industrial conglomerates with stocks like GE or Honeywell under 'Electricity'.[79]
- **Materials.** We focussed on the subsectors with 95% of GHG emissions. Most of these fitted nicely into our definition of 'Industry'. The diversified metals and mining sector with stocks like Glencore we allocated to 'Supply' because of the large coal exposure of these companies.
- **Utilities.** We classified most of these subsectors under 'Electricity'.

79 As noted above, we are well aware that not all of the business of these companies is linked to fossil fuels. This is a first order approximation to understand the size of the issue.

FIGURE 31 – LEVEL 1 MSCI SECTOR EXPOSURE TO FOSSIL FUEL GROUPS ($BN)



Source: Bloomberg, Carbon Tracker

The net impact of this is to include in our analysis all the energy sector, almost all the utility sector, three quarters of the industrials and materials sectors and 20% of the consumer discretionary sector.

How to identify capital goods providers

We use a relatively wide definition of 'capital goods provider' to cover any company involved in building new infrastructure for the fossil fuel system. The identification of a company as a capital goods provider was separate to its sector definition. We take the same group of 158 subsectors and for each of them we determine whether it can be classified as a capital goods provider to the fossil fuel supply or demand sectors. All other fossil fuel linked sectors are assumed to be operators of existing assets. We selected 13 subsectors in total.

So a company can be in the supply sector and a capital goods providers (like Fluor) or in the electricity sector and a provider (like GE) or in the transport sector and a provider (like VW).

Most capital goods companies are pretty easy to identify, and we go into more detail on them below. They include builders of cars or planes, oil drillers and equipment providers, equipment manufacturers and construction companies.

Again, it is hard to make a completely clear split, as there are some companies which span capital goods and operation. The oil and gas majors for example undertake a lot of capex, but have much larger existing assets and so do not merit specific inclusion as capital goods providers.

What subsectors are impacted

The subsectors that are impacted by the energy transition are in the most part easy to identify:

- **Oil, gas and coal producers.** But also the industrial companies that provide them with capital goods, like refinery builders or Korean shipbuilders.
- **Electricity companies.** But also the companies that provide machinery like GE.
- **Transport companies**. Both providers of capital goods (like cars or planes) and companies operating transport services (like airlines or shippers) that are likely to face the challenge of rising costs and new business models.

- **Heavy industry.** We focus on the main industries identified as major users of fossil fuels: steel, cement, petrochemicals, and aluminium, and also the companies that build their capital goods. These industries face the risk of being challenged by nimbler competition which is able to come up with new products which are much less carbon intensive. At the same time, policymakers are seeking to tax carbon intensive industries more heavily. They face the same risk as the electricity sector did ten years ago.

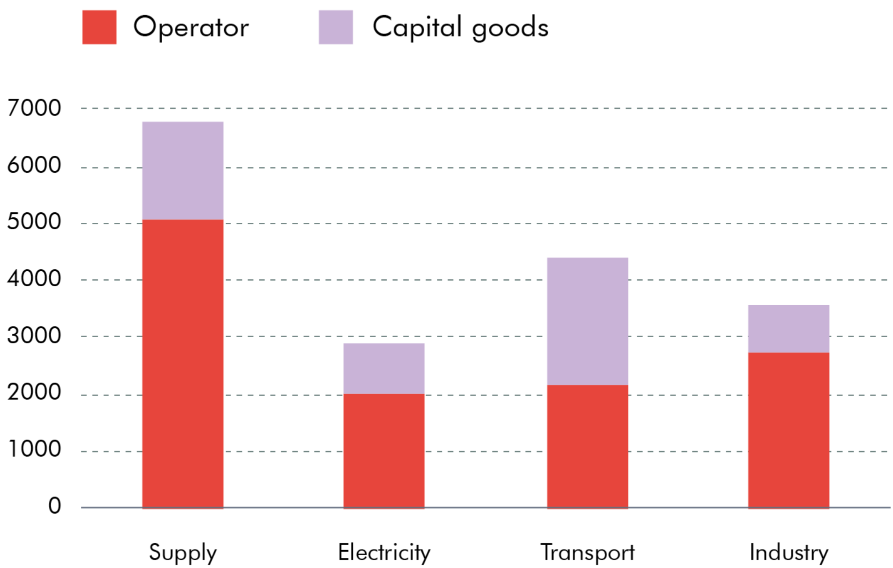
Key groups

The groups that we identify as being at risk have a market capitalisation of $18tn, as below. $7tn in supply and $11tn in the demand groups.

Valuation

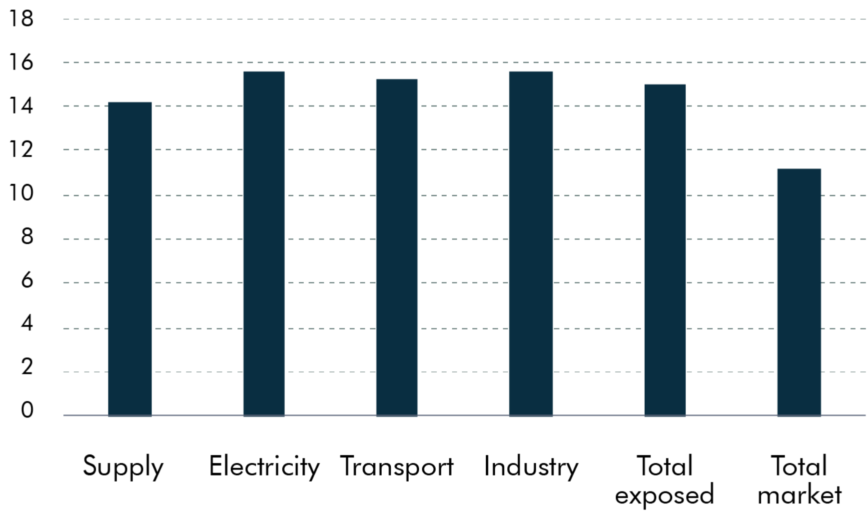
It is hard to price assets at a time of major market stress, such as at present, so we take trailing price to earnings (PE) and price to book (PB) ratios. Price to book ratios compare the equity value of a company with its book value, and levels of below 1 typically imply stressed stocks. These valuations show that the fossil fuel sectors are priced at a discount to the market in PB terms (1.3 v 1.8) but are not yet at the distressed levels we see in parts of the supply sector at present.

FIGURE 32 – MARKET CAPITALISATION OF VULNERABLE GROUPS ($BN)



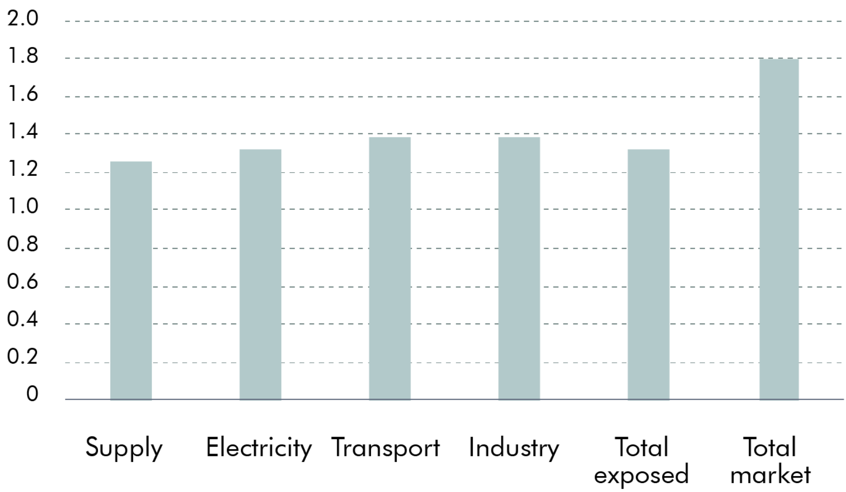
Source: Bloomberg, Carbon Tracker

FIGURE 33 – VALUATION BY GROUP – TRAILING PE



Source: Bloomberg

FIGURE 34 – VALUATION BY GROUP – TRAILING PB



Source: Bloomberg

The calculation of which groups are the most vulnerable to underperformance is made especially difficult given that markets have been significantly damaged by COVID-19, especially the deep cyclicals. The areas most vulnerable will of course prove to be those where expectation is most distant from reality, and we leave that to sector analysts. We tend to identify greatest risk in the capital goods companies (which are responsible for building new assets), but these are often the ones where performance has already been weakest.

Supply

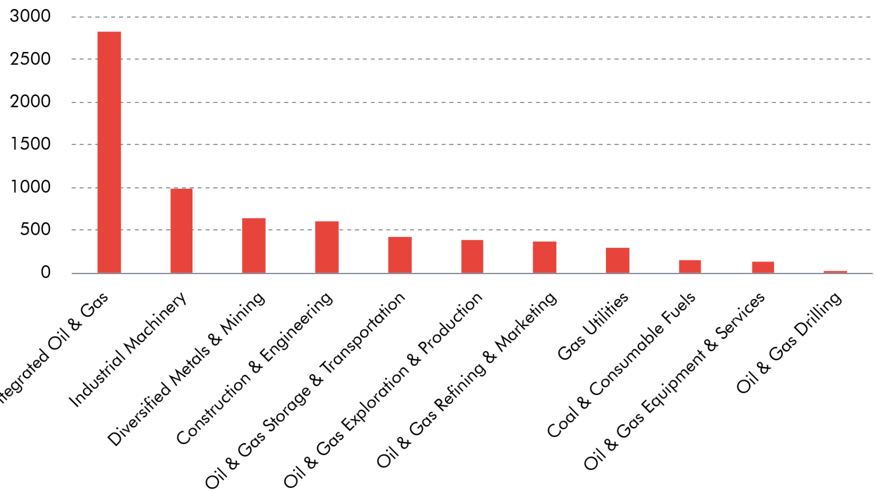
What are the assets

By supply assets we mean the whole range of infrastructure required to get fossil fuels from underground to the point where they can be used, both upstream and downstream: coal mines, oil and gas wells; oil and gas refineries and coal washing plants; pipelines, ports, and tankers.

Key listed subsectors

Integrated oil and gas is 42% of the total and industrial machinery a further 14%.

FIGURE 35 – SUPPLY SUBSECTORS – MARKET CAPITALISATION ($BN)



Source: Bloomberg

TABLE 2 – EXTRACTION SUBSECTOR VALUATION

Level 4 ID	S&P YTD perf	PE trailing	PB trailing
Oil & Gas Drilling	-69%	-2	0.2
Oil & Gas Equipment & Services	-67%	-5	0.8
Oil & Gas Refining & Marketing	-58%	11	1.1
Oil & Gas Exploration & Production	-55%	12	0.7
Oil & Gas Storage & Transportation	-47%	12	1.2
Integrated Oil & Gas	-46%	12	1.3
Industrial Machinery	-31%	23	2.2
Construction & Engineering	-16%	13	1.1
Gas Utilities	-15%	14	1.7
Coal & Consumable Fuels	NA	7	0.9
Diversified Metals & Mining	NA	14	1.5

Source: Bloomberg

Valuation and performance

The recent shocks have derated many of the sectors and the oil and gas drilling sector, for example, is now trading at only 0.2 times PB.

In the charts below we show the trailing PE and PB levels of each of the subsectors.

Furthermore, we show the year to date performance of the subsector within the US market as tracked by S&P. The global numbers are not available, and since the US market makes up around half the stocks it is a useful first approximation to see how markets are moving.

Electricity

What are the assets

The electricity group has two main parts within it – the generators and the companies that provide them with machinery.

Key listed subsectors

There are five listed subsectors.

FIGURE 36 – ELECTRICITY SUBSECTORS – MARKET CAPITALISATION ($BN)

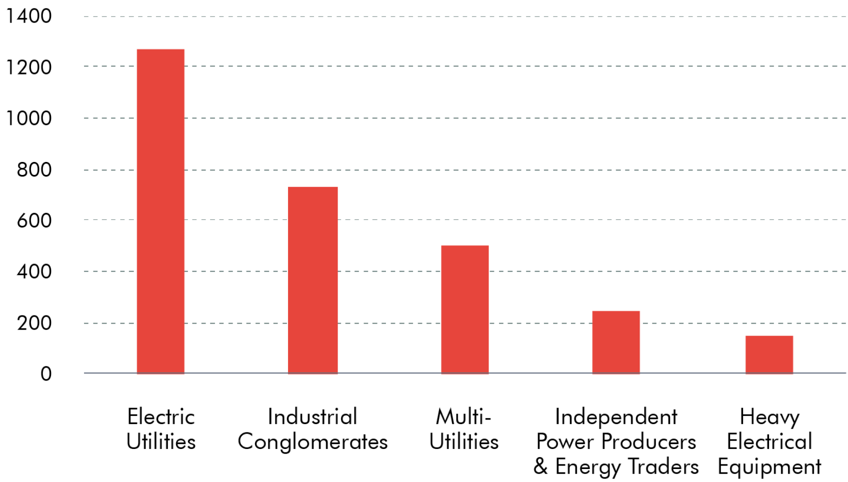


TABLE 3 – VALUATION OF ELECTRICITY SUBSECTORS

Level 4 ID	S&P YTD perf	PE trailing	PB trailing
Independent Power Producers & Energy Traders	-36%	14	1.0
Industrial Conglomerates	-27%	12	1.2
Multi-Utilities	-20%	15	1.7
Electric Utilities	-18%	16	1.3
Heavy Electrical Equipment	NA	50	1.4

Source: Bloomberg

Transport

What are the assets

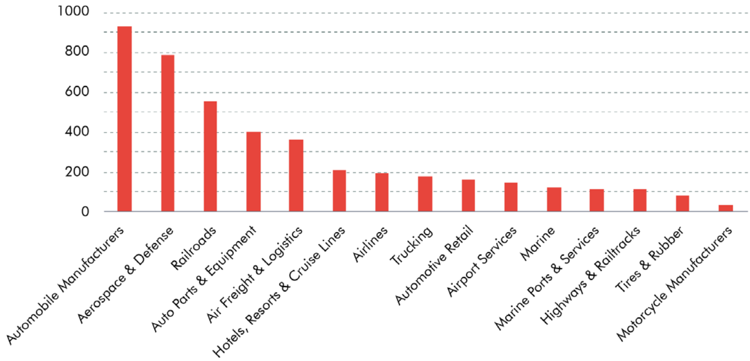
The transport subsectors include cars, trucks, planes and ships. Many of the companies in the space are responsible for producing new assets.

Valuation and performance

The most vulnerable year-to-dates have been have been the sectors impacted by the coronavirus, such as airlines and cruise lines.

Key listed subsector

FIGURE 37 – TRANSPORT SUBSECTORS – MARKET CAPITALISATION ($BN)



Source: Bloomberg

TABLE 4 – VALUATIONS OF TRANSPORT SUBSECTORS

Level 4 ID	S&P YTD perf	PE trailing	PB trailing
Hotels, Resorts & Cruise Lines	-59%	9	1.1
Airlines	-55%	15	1.0
Motorcycle Manufacturers	-54%	11	1.7
Auto Parts & Equipment	-51%	15	1.0
Automobile Manufacturers	-49%	10	0.9
Automotive Retail	-37%	17	2.6
Aerospace & Defense	-30%	25	3.5
Railroads	-25%	16	2.0
Air Freight & Logistics	-22%	19	2.8
Trucking	-11%	-48	1.7
Airport Services	NA	16	2.2
Highways & Railtracks	NA	14	1.5
Marine	NA	26	0.9
Marine Ports & Services	NA	11	1.0
Tires & Rubber	NA	11	1.0

Source: Bloomberg

Industry

What are the assets

Since all industries use fossil fuels, we selected the largest users – steel, cement, petchem and aluminium.

Key listed subsectors

Many of these subsectors are listed under the MSCI level 1 classification as materials.

FIGURE 38 – INDUSTRY SUBSECTORS – MARKET CAPITALISATION ($BN)

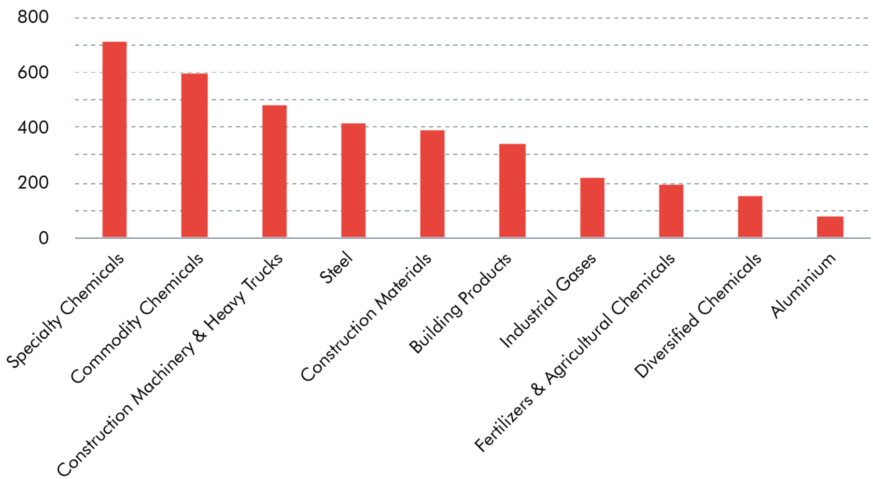


TABLE 5 – INDUSTRY SUBSECTOR VALUATIONS AND PERFORMANCE

Level 4 ID	S&P YTD perf	PE trailing	PB trailing
Commodity Chemicals	-51%	17	1.4
Diversified Chemicals	-43%	8	0.9
Steel	-36%	12	0.7
Specialty Chemicals	-32%	21	2.3
Building Products	-31%	14	1.7
Fertilizers & Agricultural Chemicals	-30%	23	1.3
Construction Materials	-29%	12	1.2
Construction Machinery & Heavy Trucks	-26%	14	1.6
Industrial Gases	-23%	28	2.4
Aluminium	NA	18	0.8

Source: Bloomberg

Capital goods

Although capital goods are part of each of the sectors identified above, we nevertheless consider them separately as they are an area of especial risk.

What are the assets

As noted, capital goods sectors span all four of the main areas on which we have focussed – supply, electricity, transport and industry. These are the companies that build and install the machinery of the fossil fuel era.

Key listed subsectors

Industrial machinery and automobile manufacturers are the largest subsectors.

Valuation and performance

The two most vulnerable subsectors so far have been oil and gas extraction and car manufacturing, both down year to date by over half.

FIGURE 39 – CAPITAL GOODS SUBSECTORS – MARKET CAPITALISATION ($BN)

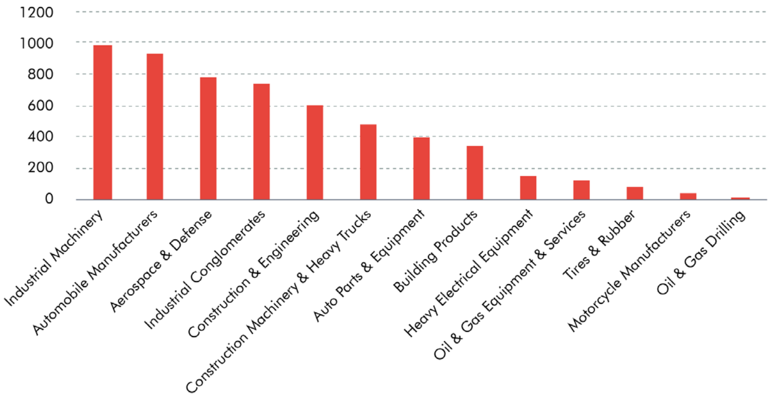


TABLE 6 – CAPITAL GOODS SUBSECTOR PERFORMANCE

Level 4 ID	S&P YTD perf	PE trailing	PB trailing
Oil & Gas Drilling	-69%	-2	0.2
Oil & Gas Equipment & Services	-67%	-5	0.9
Motorcycle Manufacturers	-54%	11	1.6
Auto Parts & Equipment	-51%	15	1.0
Automobile Manufacturers	-49%	10	0.8
Industrial Machinery	-31%	23	2.1
Building Products	-31%	14	1.7
Aerospace & Defense	-30%	24	3.3
Industrial Conglomerates	-27%	12	1.2
Construction Machinery & Heavy Trucks	-26%	14	1.6
Construction & Engineering	-16%	13	1.0
Heavy Electrical Equipment	NA	50	1.4
Tires & Rubber	NA	10	0.9

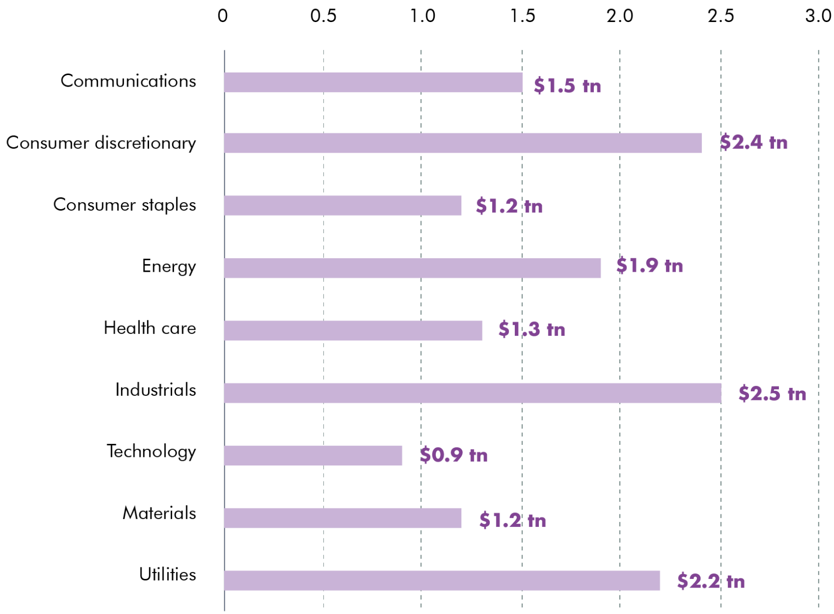
Source: Bloomberg

Appendix 2: Bond market exposure

We detail below how we calculated the size of the bond market exposure to fossil fuels.

The primary source of information is once again from Bloomberg, which categorises the $15tn of non-financial corporate bond debt into 11 sectors as below.

FIGURE 40 – CORPORATE BOND DEBT ($TN OUTSTANDING)

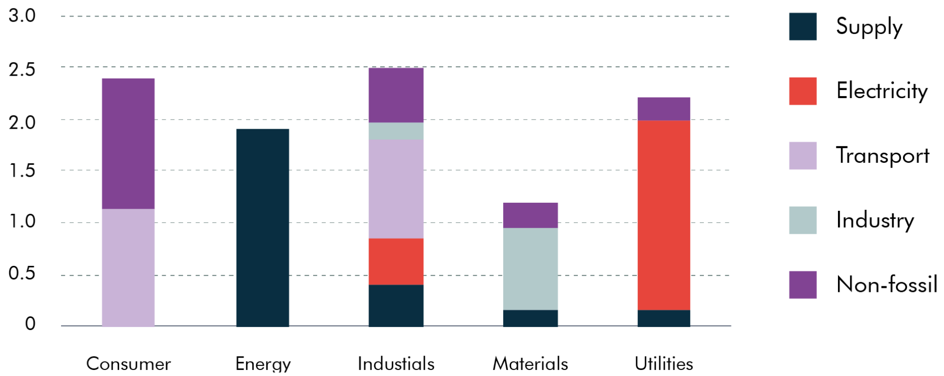


Source: Bloomberg

We then focus on the five sectors which have primary exposure to the fossil fuel system – consumer discretionary (which contains auto); energy; industrials; materials; and utilities. The question is how to allocate the debt to the groups of supply, electricity, transport and industry.

Our preferred solution is to divide up the $15tn of debt according to the split of long-term debt for each equity subsector, where we have more detailed information. We show below what this means for each of the sectors.

FIGURE 41 – CORPORATE BOND DEBT BY MSCI SECTOR $TN



Source: Bloomberg, Carbon Tracker

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