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# The future of oil: Between cooperation & competition

Jose A. Bolanos

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Cover picture: In a desert landscape, a pipeline is balanced on a concrete kerb stone and in the background stands a 'pumpjack' (also known as a nodding donkey) used for pumping oil from the ground. (BananaStock – Industry.)

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# A note of gratitude

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The reality of any macro-analysis of the kind presented here is that it will necessarily leave bits and pieces of reality out. I do trust that the choices made focus on the most important factors shaping the future of oil. However, standard caveats apply.

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## List of acronyms

**ISO** International Standard Organization

**IEC** International Electrotechnical Commission.

**IOGP** International Association of Oil & Gas Producers

**KTN** Knowledge Transfer Network

**CCSa** Carbon Capture & Storage Association

**CRF** Coal Research Forum

**APGTF** Advanced Power Generation Technology Forum

**UKCCSRC** UK Carbon Capture & Storage Research Centre

**R&D** Research & Development

**NIMBY** 'Not In My BackYard'.

**EU** European Union

**RSC** Royal Society of Chemistry

**NGV(s)** Natural Gas Vehicle(s)

**LNG** Liquefied Natural Gas

**IMF** International Monetary Fund

**GDP** Gross Domestic Product

**SIPA** School of International & Political Affairs [Columbia University]

**ESG** Environment, Social & Governance [Risks]

**UN** United Nations

**EIA** US Energy Information Administration

**BP** BP Plc. [commonly referred to as British Petroleum]

**APERC** Asia Pacific Energy Research Centre

**US** United States [of America]

**EUCERS** European Centre for Energy & Resource Security

**ISD** Institute for Strategic Dialogue

**KAS** Konrad Adenauer Stiftung

**SoCal** Standard Oil of California

**Socony** Standard Oil [Company] of New York

**Esso** Standard Oil (phonetic abbreviation of S.O) [of New Jersey]

**OPEC** Organization of Petroleum Exporting Countries

**BRICS** Brazil, Russia, India, China & South Africa

**WTI** West Texas Intermediate

**DUC(s)** Drilled and UnCompleted [Wells]

**CAPP** Canadian Association of Petroleum Exporters

**USGS** US Geological Survey

**IEA** International Energy Agency

**OECD** Organisation for Economic Co-operation & Development

**U.K.** United Kingdom

**CCS** Carbon Capture & Storage

**MDGs** Millenium Development Goals

**WEO** World Economic Outlook

**RST** Rentier State Theory

**NGO** Non-Governmental Organisation

**G7** Group of Seven (United States, Canada, France, Germany, Italy, Japan, United Kingdom)

**Bbl** Barrel

**Toe** Ton of oil equivalent

**BTU** British Thermal Unit

# Executive summary

This report takes a historical view of the path by which oil came to be the dominant fuel of our time. It becomes clear from this reading that oil became competitive by solving five key energy security challenges: availability, accessibility, acceptability, adaptability, and affordability (together: the '4A+A').

Booms in the oil industry have corresponded to events that led to synergies between the solutions given to the 4A+A. Crises have emerged from the incapacity to cope with the 4A+A. Specifically, oftentimes, the solutions given to one of the 'A's creates risk and uncertainty toward another 'A'. This report, then, assumes that oil's future is likely to continue to be related to the way in which it continues to 'solve' the 4A+A.

The problem nowadays is that imbalances in the '4A's side of the model are sources of risk and uncertainty toward the affordability of oil as an investment (the '+A'). This is addressed extensively in the second and third chapters. The second chapter describes how the current excess in supply (result of pre-existing accessibility and enhanced availability) is likely to develop into a long term crisis for the oil industry due to either protracted or seasonal low prices. The third chapter examines how the rejection of oil by some sectors of society (acceptability), and the increasing ability to use other fuels as replacement for oil (adaptability), point toward an ever-shrinking market for oil.

These challenges are not likely to resolve themselves. In fact, even if one is resolved, it is unrealistic to expect that all challenges will subside at once. Therefore, for the foreseeable future, the affordability of oil (as an investment) is likely to remain at a low.

This creates a complex paradox. To address affordability, the oil industry needs to either coordinate action to increase oil prices (cooperative track) or to find profits amidst low prices (competitive track).

## Cooperative track

Solving the problem of affordability politically (e.g. through production cut agreements such as OPEC's) is tempting when considering global security. But if cuts are decided politically rather than competitively, the world may end up favouring weak strategies. Moreover, the higher prices, the further the losses in acceptability and adaptability relative to other fuels. As both these realities would likely erode oil's competitiveness further, political solutions must be deemed short term.

There are, however, two actions that could compensate the long term consequences of pursuing cooperation.

1. Diversifying supply in oil producing countries could help producers to avoid facing an even greater challenge in the future.
2. Improving the industry's commitment to lowering net system emissions is necessary to avoid further losses of acceptability that could derive in significant demand effects.

## Competitive track

The report demonstrates throughout that the oil industry has faced extremely challenging times in the past. Each and every time, competition has allowed for the strongest players to emerge. If history is any indicator, letting the markets do their job enhances oil's competitiveness. Moreover, whilst OPEC showed it is possible to reach agreements to try and control prices, coordination in energy markets is extremely difficult to achieve and, most importantly, *sustain*.

If one is to encourage competition, however, four actions are needed to ensure a level-playing field and guarantee that social needs are taken into account.

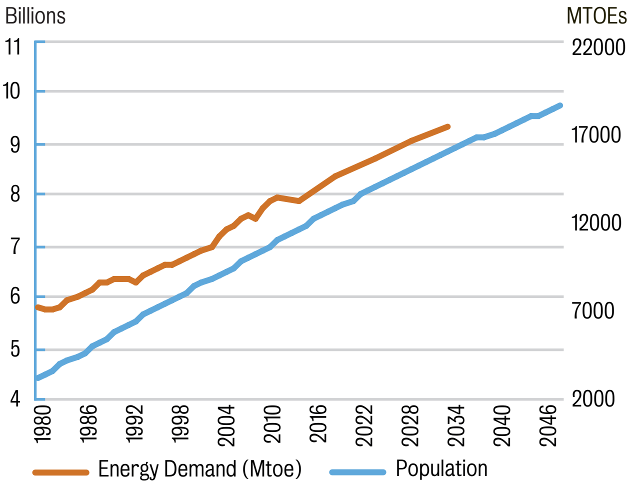
1. Eliminate subsidies to ensure that only the most competitive oil companies survive and that the period of crisis is as short as possible.
2. Foster long-term thinking to ensure that investments face the least risk of becoming stranded.
3. Elaborate risk indices that enable comparison of social preferences with the objective of ameliorating the lack of information with regard to oil's acceptability.
4. Improve access to financing in a way that fosters technological diversity, which could be done through goal-driven portfolios rather than by fuel-driven pools of resources.

Considerations about how to (and to what extent is it possible to) combine the recommendations from these two tracks are addressed in the last chapter.

# Introduction

The one consideration that best indicates the importance of discussing the future of oil is the contrast between population and energy demand projections. As of 2015, UN statistics forecast that the global population will go over the 9 billion mark within the next 20 to 25 years and will continue to grow to about 11 billion by 2100 (fig 1). Historically, demand for energy has grown along with population.

**Figure 1: Population & energy demand (1980-2050).**




*Sources: UN, EIA, BP.*[1]

Technology may diminish per capita energy consumption. Also, many regions have seen a 'decoupling' between growth and energy consumption – i.e. each unit of growth requires less energy than before.[2] Unfortunately, the world is still far from achieving universal access to energy. So far, as this report demonstrates, most evidence indicates that there will be continued growth in global energy demand for the foreseeable future.

The situation faced by oil then is not a question of whether there will be demand for energy, per se. There will be. The real question is whether oil will continue to be part of the solution and, if so, to what extent. This question currently preoccupies energy analysts and practitioners across the globe. For example, one of the most recent oil industry gatherings culminated in rather bleak forecasts about the future that oil will have to face, with some of the top actors in the industry forecasting a decade-long crisis.[3] Moreover, even if production cuts are agreed, it is dubious if cooperation in energy markets can be sustained. This was demonstrated by OPEC's 2016 production cut agreements, which, albeit successful in the end, was (and, at the time of sending this paper to press, still is) paved with significant skepticism.

Seeing into the future of oil is, nonetheless, particularly difficult. Admittedly, there is much that affects oil and oil markets. The oil industry faces what could fairly be described as a perfect storm of mixed and often contradictory forces. Prices have fluctuated wildly over the last decade, which means companies came into this crisis with significant wear. Geopolitical concerns are on the rise. These type of concerns can increase prices whilst at once further desire for diversification. Yet, diversification entails producing through methods that, such as deep-water for example, have higher costs than those of traditional suppliers – and/or in conflictive zones. Finally, awareness about the environment is increasing, which can be seen to fuel the quest for alternatives. These are only a selection of the forces being faced by oil on a daily basis. It would be impossible to consider each and every single force. There are just too many.

Very useful statistical forecasts about the short- and medium-term future of oil exist. These provide an extremely valuable insight. However, it is hard to establish how all the different variables will play out together on the long term. Often, even the short term and medium terms are impossible to predict. Not too long ago, for example, the world was obsessed with the advent of *peak oil*. To the surprise of many, this event never came. Instead, today's situation could fairly be described as a *great oil glut*. Indeed, the amount of oil available at the moment is such that BP recently estimated that current reserves would suffice for more than five decades of continued global production.[4]

As such, with the intention of trying to offer a longer-term insight this paper will avoid offering statistical projections. Instead, the report seeks to identify the key drivers behind the dominance that oil has in energy markets – i.e. the variables that define its competitiveness. If history is any indication, change will be related to these variables.

This will be achieved through a model that simplifies the explanation of how oil has remained competitive overtime

1 UN, "World Population Prospects: The 2015 Revision," DVD Edition (New York, NY: Department of Economic and Social Affairs, Population Division, United Nations (UN)., 2015); EIA, "Total Energy – Total Primary Energy Consumption (Quadrillion Btu)," *Washington, DC: U.S. Energy Information Administration (EIA)*, 2016, http://www.eia.gov/cfapps/ipdbproject/iedindex3.?tid=44&pid=44&aid=2&cid=ww,&syid=1980& eyid=2012&unit=QBTU; BP, "BP Energy Outlook 2016 Edition – Outlook to 2035 [Dataset]," Dataset (London, U.K.: BP plc, 2016).

2 Enerdata, "Global Energy Trends: Towards a Peak in Energy Demand and CO2 Emissions?" (Paris, France: Enerdata, 2016), 15.

3 A Hoffmann et al., "The Oil Industry Got Together and Agreed Things May Never Get Better," *New York, NY: Bloomberg.com,* 2016, http://www.bloomberg.com/news/articles/2016-02-12/the-oil-industry-got-together-and-agreed-things-may-never-get-better.

4 BP, *BP Statistical Review of World Energy – June 2013* (London, U.K.: BP plc, 2013), 7.

despite of the fact that there are so many individual forces, and that these forces change from time to time. Indeed, a model that simplifies the understanding of the most important factors driving the competitiveness of oil.

What is this model, and which are these factors? As evidenced in the first chapter, oil's competitiveness is grounded in its ability to solve five energy security challenges: availability, accessibility, acceptability, adaptability, and affordability. These five challenges will be referred to as the '4A+A' model for the remainder of the report. The 4A+A is based on a model proposed by the Asia Pacific Energy Research Centre (APERC) in 2007 known as the 4A.[5] The difference in the version proposed here is the inclusion of 'adaptability' as one of the first four 'A's and the symbolical separation of 'affordability' as a '+A'.

'Adaptability' is a factor that fell into disuse after oil became dominant. It is included as one of the 4As in here because it is impossible to compare oil with other fuels without considering how adaptable to modern production other technologies are. The idea of giving affordability a separate '+A' status derives from the fact that affordability is more easily affected by a myriad factors exogenous to the 4A+A than all other 'A's (for example, economic policy in countries such as the US). It is worth acknowledging the difference in kind between affordability and all other 'A's.

The key to understanding the usefulness of the 4A+A is to not focus in the challenges as isolated variables. At least when it comes to oil, it will be seen that the 4A+A highlights five entangled challenges that can be sources of risk and uncertainty toward each other. Take availability, for example. It will be shown that lack of availability has the immediate consequence making it hard to achieve the economies of scale needed to compete with other fuels. Too much availability, on the other hand, has the immediate consequence of cheapening a fuel to the point where profit may become inexistent. Ergo, both shortage and excess translate into negative consequences to the affordability of oil as an investment.

It is sometimes possible to calculate the likelihood and significance of these consequences (risks from a Knigthian perspective), but oftentimes, as it will be seen to be the case of many current trends, calculation is impossible (uncertainty from a Knigthian perspective).[6] Thereby, it should be clear that the core mechanism highlighted by the 4A+A is that each of the 'A's, that is, each of the challenges, can become source of risk and uncertainty toward any other 'A'. As it will become clear throughout the report, this reality is behind the problems faced by oil nowadays.

It is only fair to ask about the reasons why the specific factors considered in the 4A+A were chosen over other, different ones. Today, for example, variables such as 'market speculation' do affect the prices of oil and, by extension, its future. Likewise, OPEC's 2016 effort to cut supply, and similar ones that will no doubt arise in the future, may have some effect to the short term fate of oil.

As advanced above, however, this report is not a statistical outlook. This calls for concepts that, like those in the 4A+A, can explain the success of oil throughout history. Whilst variables other than those in the 4A+A could provide a certain ability to 'fine tune' the future of oil, the first chapter demonstrates that the 4A+A challenges have had a permanent and unparalleled role in oil's ability to remain competitive.

This means that the report follows an approach grounded in the belief that history can highlight the most important variables that will drive the future. Inevitably, there will be some who will be sceptical of it. Thus, it is worthwhile to highlight three other reasons that readers hesitant to look to the past could consider:

1. There is growing industry-wide recognition of the importance of the past. For example, BP even devotes a half-page graph in one of its latest Energy Outlooks to a structural examination of oil prices since 1861.[7] Additionally, the importance of learning from the past was emphasised by Paul Appleby, Head of Energy Economics at BP, in one of the EUCERS/ISD/KAS energy talks that run parallel to this fellowship.[8]
2. Energy and oil markets are incredibly complex. There is an inherent need for a diversity of inputs. There are plenty of rather robust oil and energy market outlooks driven by statistics. However, significantly less is written about the mechanisms that underlie the competitiveness of fuels.
3. There is a need for structural insights to offset a wicked problem of accuracy: the longer into the future an outlook goes, the less accurate it becomes. This is a reality fully acknowledged even by those who write the leading statistical outputs.[9]

Accordingly, this report's goal is not to statistically predict the future at a given time but to identify the most important sources of risk and uncertainty that are capable of significantly *altering* the future of oil.

A corollary of this objective is that this report is strategic rather than normative. It does not claim to know 'what we *should* do about oil'. It merely accepts that whilst many would like to stop using oil, oil is still being used and the length of the transition is uncertain. In the meantime,

5 APERC, *Quest for Energy Security in the 21st Century* (Tokyo, Japan: Institute of Energy Economics, Asia Pacific Energy Research Centre (APERC), 2007), 7–40.

6 Frank H Knight, *Risk, Uncertainty and Profit* (New York, NY: Augustus M. Kelley, 1921), Ch. VII-VIII.

7 BP, "BP Energy Outlook 2016 Edition – Outlook to 2035," Presentation (London, U.K.: BP plc, 2016), 14.

8 P Appleby, "Oil Prices – How Low? How Long?" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #2, London, U.K., April 20, 2016).

9 Cf. BP, "BP Energy Outlook 2016 Edition – Outlook to 2035," 1.

because of the importance of oil, its fate will continue to affect both those within and those outside the industry.

The need to suggest mechanisms through which its role can be managed is evident.

The report will continue as follows. An introductory chapter highlights the 4A+A model's ability to explain oil's dominance. A second chapter evaluates supply, showing that enhanced availability challenges the affordability of investment. A third chapter highlights the role of the context, specifically, losses of acceptability and adaptability vis-à-vis other fuels that also create risk and uncertainty towards affordability. A final chapter sums up findings and offers policy recommendations.

The main finding is a rather poignant conundrum: the policies needed to strengthen oil's competitiveness seem to be the opposite of the policies needed to manage global security. This is because global security may require the continuation of practices, or the realization of agreements, that could hinder oil's competitiveness on the long term. As such, recommendations are given separately for each of these two scenarios (denominated 'cooperative' and 'competitive' track).

A cooperative solution (most typically production cuts) could be attractive to those concerned about the effect that low oil prices may have on global security. However, if one is to opt for a political approach, one needs to be clear that if prices are managed via coordination, there is not guarantee about the winners being those with the strongest strategies. Moreover, if prices rise due to coordination rather than due to competitive improvement by producers, acceptability and adaptability of other fuels will increase relative to that of oil. It would be foolish for the industry to pursue coordination to improve prices (a big if) whilst ignoring these downsides.

However, addressing these downsides requires of undertaking two very challenging initiatives: diversification and offsetting net system emissions. Without diversification, the same regions that are facing security challenges nowadays will find themselves in similar or greater difficulties in a future where oil would be less competitive than it is today. Without offsetting emissions, oil basically relies on being cheap to continue being acceptable. Market share losses could be staggering if any other technology achieves price parity – and it seems likely that some will do.

Cooperation in global energy markets is difficult, particularly considering that it has been tried but ultimately shown either unviable or short-lived. OPEC's 2016 effort to cut production, for example, was paved with sufficient obstacles as to question its sustainability.[10] Moreover, as the first chapter shows, the most robust gains in the history of energy resulted from allowing producers to compete. Consequently, an alternative path of action would be to accept that oil is entering an era of increased competition and focus in ensuring that such process leads to a good outcome. Four recommendations are offered to this purpose.

Firstly, an argument against subsidies. Subsidies are shown to be akin to throwing gasoline onto an already-raging fire. Secondly, a call for addressing the present crisis with a long-term mind-set. Throughout history, it will be seen, the winners typically derive from strategies based on long-term thinking. Similarly, a long-term mentality can help reducing the number of stranded assets that will need management. Thirdly, a call for developing democratic risk acceptability indices. It will be seen that whilst oil is losing acceptability, it is impossible to establish the extent to which this is happening. Decisions about the future of energy would be improved by reducing the level of uncertainty in this regard. Fourthly, a call for furthering competition between different types of fuels through goal- rather than fuel-oriented financing. This would ensure that all fuels pursue some common goals whilst still competing against each other.

In real life, however, oil markets seem to eternally hesitate between cooperation and competition; between the two tracks. This naturally leads to the question of whether recommendations from the cooperative and competitive tracks can be combined. The answer is, yes, but at the same time, no.

A minimal level of cooperation could perhaps ameliorate security pressures whilst still allowing some competition to take place. Regardless, any type of coordination will restrain the scope for competitive strategies. Admittedly, the gravity of the effect depends on the level of coordination. Regardless, the choice of cooperation will inevitably have some effect on the ability to compete. Even if this effect is considered to be justified, it must be acknowledged for strategic purposes.

**&&&**

Many still think that oil is too ubiquitous to question its dominance. Clearly, this report disagrees. It highlights losses in competitiveness that have already taken place and warns against the possibility of further ones. Readers who ex-ante oppose the idea that oil can lose its dominance are invited to read the report with an open mind.

10 E.g. A Rascouet, "Saudi Arabia Faces Tough OPEC Equation with Mounting 'exemptions,'" *New York, NY: Bloomberg.com,* October 25, 2016, http://www.bloomberg.com/news/articles/2016-10-25/saudi-arabia-faces-worsening-opec-equation-as-exemptions-mount; S Wilkin, W Mahdi, and A Dipaola, "Iraq Balks at Joining OPEC Cuts, Making Output Deal Harder," *Bloomberg.com*, October 23, 2016, http://www.bloomberg.com/news/articles/2016-10-23/iraq-will-maintain-oil-output-while-opec-partners-discuss-cuts.

# A past full of struggles

If you ask Google about the history of oil it will tell you that oil was discovered in 1859 in northern Pennsylvania.[11] This is not true. 1859 marks the beginning of the modern history of oil. This event was the result of a complex partnership between New York investors George Bissell, Jonathan Eveleth and James Townsend, Yale chemistry professor Benjamin Silliman Jr., local rail man Edwin Drake, and salt driller William Smith. Their story will be addressed below.

Before doing that however, it is necessary to make one point clear: Bissell found the most successful way to solve the 4A+A. However, oil had encountered the 4A+A conundrum on numerous occasions prior to 1859. The discovery in 1859 was the culmination of a previous age of oil and the beginning of a new one rather than the beginning of oil, per se.

## Oil before Bissell

No one knows exactly when oil was discovered, but it was certainly thousands of years ago. For example, Yergin notes that oil seepages had been tapped as far back as 3000 B.C.[12] The Babylonians, Byzantines and Greeks all knew that oil could combust – there are myriad stories that show bitumen was used in weaponry in their time.

An interesting fact is that, at that point in history, oil was only used in weaponry, despite the fact that there was a need for fuel in other areas. Indeed, the biggest barrier to the development of lighting between the years 40,000 and 15,000 BCE was the procurement of fuel for lamps.[13] And yet, oil's first use in lighting dates only to 4,500 BCE.[14] Moreover, although lamps were widespread in Egypt by the Ptolemaic (beginning 305 BCE) and Roman (beginning 30 BCE) periods,[15] these were still mostly fuelled by olive oil.[16] This should make the critical mind wonder about the reasons why petroleum oil was useless for an energy-intensive technology such as lighting despite the fact that ancient civilisations knew it could combust.

The answer is that there were five challenges that oil had to overcome before becoming useful to humanity: the 4A+A (once again, availability, accessibility, acceptability, adaptability, +affordability).

There were two main problems regarding the use of oil in early lighting. Firstly, petroleum oil was less available than olive oil because the only way to obtain it was to wait for it to erupt from the ground. Basing a relatively widespread technology such as lighting on petroleum would have faced the very basic problem of simply not having enough fuel. Secondly, oil spurs from the ground as bitumen, a gooey tar rather than a liquid. One of the greatest advantages of liquid fuels is that they can be stored with relative ease – as opposed to gases, for example – and are also relatively easy to transfer from storage into usage.[17] Today's technology is based on hoses, pipes, furnaces, combustion engines and so forth. Lamps of the time used wicks. Bitumen is too thick for wicks. In other words, oil was adaptable for warmongering but not for lighting, or at least not as adaptable as other oils. The lesson is: if you cannot adapt a fuel to available technologies you might as well not have it.

About a thousand years later petroleum became adaptable to lighting thanks to distillation, developed by the Arab alchemist Muhammad ibn Zakariya Razi – Al-Razi – by the end of the 9th c. CE.

What is most interesting about Al-Razi's work is that it addresses both adaptability and acceptability at once. Indeed, Al-Razi described two processes that led to a "clear and 'safe to light'" substance that he called *kerosene*. Al-Razi was not only interested in making the fuel usable but also in making it safe for use. As the report will note later, safety is one of the main considerations that helped modern oil men like Rockefeller to increase the desire for oil vis-à-vis other fuels.[18]

By the 12th century CE, kerosene was such a basic commodity that it could be easily purchased in the streets of Damascus.[19] There is even evidence of trade between empires in the writings of Marco Polo:

> *To the north lies Zorzania [Georgia], near the confines of which there is a fountain of oil which discharges so great a quantity… In the neighbouring country no other is used in their lamps, and people come from distant parts to procure it.*[20]

11 Google, "Web Search for the Words 'history of Oil,'" *Mountain View, CA: Google*, 2015, https://www.google.co.uk/search?q=Google&ie=utf-8&oe=utf-8&gws_rd=cr&ei=sdR6Vp6ZJsiSaufst7AP#q=history+of+oil.

12 D Yergin, *The Prize: The Epic Quest for Oil, Money & Power*, 3rd ed. (New York, NY: Free Press, 2009), 7–8.

13 W Nordhaus, "Do Real-Output and Real-Wage Measures Capture Reality? The History of Lighting Suggests Not," in *The Economics of New Goods*, ed. T F Bresnahan and R J Gordon (Chicago, IL: University of Chicago Press, 1996), 27–70.

14 IES, "A Brief History of Lighting," *Savannah, GA: Illuminating Engineering Society (IES)*, 2011, http://www.ies.org/lighting/history/timeline-of-lighting.cfm.

15 R Thomas, *Lamps in Terracotta and Bronze* (London, U.K.: The British Museum, 2015).

16 K Kimpe, P A Jacobs, and M Waelkens, "Analysis of Oil Used in Late Roman Oil Lamps with Different Mass Spectrometric Techniques Revealed the Presence of Predominantly Olive Oil Together with Traces of Animal Fat," *Journal of Chromatography A* 937, no. 1 (2001): 87–95.

17 Ministry of Power, *The Efficient Use of Fuel: A Text Book on Fuels and Their Efficient Utilization for the Use of Students and Technical Men in Industry* (London, U.K.: H.M. Stationery Office, 1958), 299–315.

18 Z Bilkadi, "The Oil Weapons," *Saudi Aramco World* 46, no. 1 (1995): 6.

19 Z Bilkadi, "Bitumen – A History," *Saudi Aramco World* 35, no. 6 (1984): 9.

20 M Polo, *The Travels of Marco Polo* (Middlesex, UK: Penguin Books, 1986), 21–22.

Although ancient oil trade was tiny in comparison to that of today, the Golden Age of Islam saw the emergence of a booming industry thanks to distillation. Do note that this means that an advancement in adaptability brought about an impact on acceptability. This time around, the impact was positive but if there is potential for a positive impact from one 'A' into another, there is also a chance of negative feedbacks.

Despite the existence of a thriving industry, however, kerosene lamps faded in parallel with the decline of science in the Middle East.[21] It would be ludicrous to suppose that European merchants never ran into kerosene lamps. Also, Al-Razi's work, whilst obscure, was within the reach of some elite Europeans.[22] Likewise, there are various examples of distillation having been achieved in Europe during the middle ages.[23] Moreover, oil was also known in China and the techniques were such that the Chinese were already drilling as deep as 600 metres by the 16th century CE.[24] So, why did the ancient oil industry die?

The easy answer is, accessibility. The demise of the early Islamic oil industry is the result of a combination of challenges to accessibility that increased transaction costs to the point that even the exchange of knowledge became unviable[25] – let alone the trade of oil.

But political accessibility alone does not explain why Europe did not develop its own oil industry. Because, as it turns out, Europe had oil. Oil seepages were mentioned in a book written by a polish Jesuit in 1721[26] in a way that evidences centuries-old knowledge of oil.[27] However, in Europe oil was harder to extract than in the Middle East. As a consequence, European oil was not an affordable investment at the time.

The unaffordability of these incipient European oil industries was not the result of a lack of desire to make them work. Many innovators tried extremely hard to make a profit out of oil. For example, in 1810, a Jewish man named Joseph Hecker found a promising source of oil in the Galician region – specifically in the town of Drohobycz (modern Western Ukraine). Hecker knew how to distil and found that he could convert 40% of this oil into kerosene. This enabled him to get a contract to provide the fuel for Prague's lighting in 1816.[28]

Unfortunately for Hecker, he was forced to default on his contract due to a combination of complications in the amount of oil his well yielded (availability) and transportation (accessibility).[29] But the most insightful part of this story is that Hecker's concession allowed for the digging of shafts,[30] meaning that he could have dug for more oil. At the time, however, digging was a sufficiently inefficient and manual process[31] to discourage Hecker from investing in further shafts. The end of Hecker's story is then that unforeseen costs related to availability and accessibility snowballed and had fatal consequences for the affordability of Hecker's enterprise.

The challenges faced by Hecker were different in nature to the accessibility challenges in the Middle East. The Middle East was inaccessible due to political reasons. Hecker saw the compounding of challenges to availability and technical obstacles to accessibility. But the effect was ultimately the same: a negative consequence toward the affordability of investing in oil. Hecker could not afford to dig for more oil due to the costs brought about by imbalances in two of the 'A's.

Whereas Al-Razi's story shows that synergy can be found between 'A's, Hecker's shows that the opposite can also happen. Imbalances between different 'A's can decrease the competitiveness of oil by means of creating risk and/or uncertainty that thereby prevent, or significantly challenge, the solution of the full 4A+A.

The situation started to turn around with the Galician re-discovery of distillation and the re-invention of the kerosene lamp. In 1852, Ignacy Lukasiewicz, a pharmacist from Lviv, a town neighbouring Drohobycz, perfected the process of distillation developed by his mentor Jan Zeh.[32] They recruited a local tinsmith, Adam Bratkowski, to help them build a kerosene lamp. The men soon got in touch with Lviv's hospital, where their kerosene lamp enabled the first night-time emergency surgery in history, in 1853.

A very significant part of Lukasiewicz's story is that he realised that refining was profitable in itself. He soon moved to the city of Bobrka, where in 1854 he built the first oil mine and refinery in the world, which was then followed by two other refineries in Kleçzani in 1859 and in

21 Bilkadi, "Bitumen – A History," 9.

22 R Briffault, *The Making of Humanity* (London, U.K.: George Allen & Unwin, 1919).

23 R J Forbes, *Bitumen and Petroleum in Antiquity* (Leiden, Netherlands: E. J. Brill, 1936), 35–38.

24 P Robinson, "Petroleum Processing Overview," in *Practical Advances in Petroleum Processing*, ed. C S Hsu and P Robinson, vol. 1 (New York, NY: Springer, 2006), 2.

25 Yergin, *The Prize*, 8.

26 G Rzaczynski, *Historia Naturalis Curiosa Regni Poloniae* (Sandomierz, Poland: Typis Collegii Societatis Jesu, 1721).

27 R J Forbes, *More Studies in Early Petroleum History* (Leiden, Netherlands: Brill Archive, 1959), 93.

28 J Hirszhaut, *The Jewish Oil Magnates of Galicia: A History, 1853-1945*, ed. V Schatzker, trans. M D Beckerman, vol. 1 (Montreal, Canada: McGill-Queen's University Press, 2015), 25.

29 Cf. Forbes, *More Studies in Early Petroleum History*, 93–94; A F Frank, *Oil Empire: Visions of Prosperity in Austrian Galicia*, vol. 149 (Cambridge, MA: Harvard University Press, 2009), 55–56; Hirszhaut, *The Jewish Oil Magnates of Galicia*, 1:25–26.

30 *Forbes, More Studies in Early Petroleum History*, 93.

31 Yergin, *The Prize*, 8.

32 Cf. Forbes, *More Studies in Early Petroleum History*, 94; Frank, *Oil Empire*, 149:56–57.

Polanka in 1861.[33] This gave him an unprecedented output capacity, over 55 tons of purified oil by 1859, thanks to a contract with one of Europe's largest railway companies.[34] Lukasiewicz's move into refining marks the separation of upstream and downstream.

Lukasiewicz's efforts represent the first time that synergy between the challenges in the 4A+A model had emerged since Al-Razi. His improved distillation technique improved adaptability and his focus on refining enabled economies of scale that led to an explosion of small shafts and thereby increased availability. "No less then [sic] 2,394 shafts were in production and over 3,000 abandoned altogether, producing some 9,000 tons of oil… about 25-45 metres deep and usually deepened when production began to fall".[35] The combined effect led to oil becoming, once again, an affordable investment.

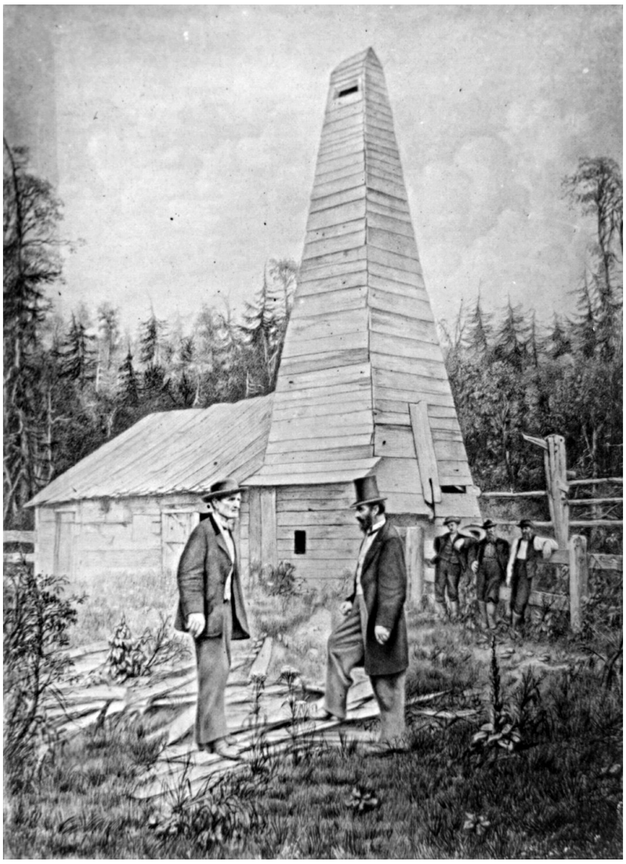
At the time, similar stories were unfolding elsewhere. The Absheron Peninsula, home to Baku and part of Tsarist Russia in the mid-1800s, saw the first attempts to drill for oil using earth augers – as soon to be seen these attempts were successful in terms of depth achieved but not sufficient to ignite the industry.[36] This should not come as a surprise given that testimonies evidence that locals had been digging for oil since the 14th century.[37] There is even an inscription that dates back to 1594 of a hand-dug well that reached a depth of 35 metres,[38] and wells of up to 20 metres were not uncommon at the time.[39]

Russians dug to a depth of 21 metres in Absheron in 1948, the same depth that Bissell and associates would reach a decade later in Pennsylvania. Nonetheless, the gains in availability were offset by the fact that long distances between supply and markets made transportation challenging (once again, accessibility). Additionally, stringent tax policies by the Tsar placed exogenous constrains to affordability.

## The Bissell effect

The definitive oil-meets-entrepreneurship event took place in Titusville, Pennsylvania, about a decade after Russians hit the 21-metre mark in Absheron.

**Figure 2: The first oil well.**



*Source: Library of Congress.*[40]

The traditional account of this story shows Bissell as a lawyer with a curious mind, who saw a bottle of oil at his alma-mater (Dartmouth University in Vermont) and questioned whether it could be used as fuel. He then ran into some posters about salt drilling and similarly pondered if they could be used to extract large quantities of oil. Bissell enrolled his partner Jonathan Eveleth as well as banker James Townsend to cover finances. In an almost serendipitous manner they asked Yale University chemistry professor Benjamin Silliman Jr. to conduct a study to investigate whether oil could be turned into an easy-to-use liquid fuel. Silliman was so impressed that he joined the other men in creating the Pennsylvania Rock Oil Company. They then hired local rail man Edwin Drake and local salt driller William Smith to drill for oil in land purchased in Titusville, Pennsylvania. Oil was struck at a depth of 69 feet (21 metres) on August 27, 1859. The well is said to have yielded somewhere between 20-35 barrels a day, which sold for about $20 per barrel.[41]

33 M Pabis-Braunstein, "Ignacy Lukasiewicz (1822-1882)," *American Institute of the History of Pharmacy* 31, no. 4 (1989): 176.

34 Forbes, *More Studies in Early Petroleum History,* 94.

35 Ibid., 97.

36 M S Vassiliou, *Historical Dictionary of the Petroleum Industry* (Lanham, MD: Scarecrow Press, 2009), 13; M Mau and H Edmundson, "Beginnings of the Oil and Gas Industry," *S.l.: Engineering and Technology History Wiki (ETHW)*, 2015, http://ethw.org/Beginnings_of_the_Oil_and_Gas_Industry.

37 V Alekperov, *Oil of Russia: Past, Present, & Future* (Minneapolis, MN: East View, 2011), 15.

38 Vassiliou, *Historical Dictionary of the Petroleum Industry*; M Mirbabayev, "Concise History of Azerbaijani Oil" (Baku, Azerbaijan, 2007), 8.

39 Alekperov, *Oil of Russia*, 54.

40 Library of Congress, "The First Oil Well," *Washington, DC: Library of Congress*, c1890, http://www.loc.gov/pictures/item/2010649522.

41 J Sherman, *Drake Well Museum and Park: Pennsylvania Trail of History Guide* (Mechanicsburg, PA: Stackpole Books, 2002), 13; I M Tarbell, *The History of the Standard Oil Company* (New York, NY: Cosimo, 2009), 10; Robinson, "Petroleum Processing Overview," 3.

While the above events have been confirmed historically, what is slightly unfair and perhaps exaggerated is the way in which Bissell comes out of the story as being the source behind each and every single idea. This is not to say that Bissell's actions were void of genius, but the context is important.

First of all, oil had been known to be available in the region for centuries already. It was also well known that oil could be found underground even in places without natural seepages, particularly in Pennsylvania, Kentucky, Ohio and West Virginia.[42] The ability to recover large quantities through salt-drilling technologies was widely known because salt wells had been periodically abandoned due to running into excessive amounts of oil.[43] One of these abandoned wells was the Magaw-Clark-Shryock salt well in Pennsylvania, where oil was struck at a depth of 300 feet (~91 metres) in 1815.[44] Geologists at the time were not even surprised by Bissell's finding.[45]

Secondly, many in the region were already trying to make oil affordable. Silliman himself had travelled to West New York to examine the commercial viability of oil flows in the years before Titusville.[46] Samuel M. Kier, a local salt-field owner, even managed to create a small oil operation by exploiting the oil that was struck as by-product of his salt operations. Whilst Kier never went fully into the business of oil, he is recorded as having sold up to a hundred gallons of purified oil at a price of 62.5 cents per gallon.[47] Some authors still see Kier, not Bissell, as the father of the modern oil industry.[48]

Thirdly, there had been a rising interest in exploring oil's adaptability and acceptability for the purposes of lighting. Crude oil was commonplace in rural Pennsylvania, but the undesirable odours and black smoke that resulted prevented wider usage. This catalysed interest in finding methods of reducing impurities.[49]

Fourthly, the need for a new fuel was evident. The supply of vegetable and animal oils was already falling short of market demand. Whale oil, which had replaced vegetable oils some centuries earlier, became scarce by the early 1800s. By the 1850s a gallon of whale oil was double the price of a gallon of lard oil ($1.77 per gallon versus $0.90).[50] This need for new fuels was behind the popularization of a liquid fuel distilled from coal, known as coal oil. Coal oil gained market traction in a relatively short span of time as it had been discovered as recently as 1846 by Canadian geologist Abraham Gesner.

In sum, by the time Bissell started his enterprise, all the 4A+A challenges had been solved by separate individuals. The notion of Bissell as someone who had ideas no one else did is not true.

But that was not Bissell's true genius, which was rather one of entrepreneurship: the ability to successfully combine all the 4A+A factors in a manner that the solutions given to each challenge reinforced each other. It took five thousand years, since the first documented uses of oil, for someone to bring all factors of the 4A+A model together.

Bissell soon found that the distillate of petroleum oil was a perfect alternative to coal oil. The liquids were so similar that they both were known as 'kerosene' for some years. As whale oil became increasingly scarce, more opportunities opened for coal and petroleum oils. This was furthered when the whaling industry came to a halt during the American Civil War between 1861 and 1865, which aided kerosene's ability to penetrate the market.

Since transportation was equally challenging at the time for all available oils, kerosene capitalized on having lower productions costs than vegetable oils. And, between the two types of kerosene available (rock- and coal-based), rock oil was easier to produce. In this way, petroleum-based kerosene soon became the most adaptable, available, accessible, acceptable and affordable oil of all time.

What followed the popularization of rock oil was the oil industry's very first glut. In the early 1860s derricks multiplied rapidly. The first flowing well was found in 1861 (all wells had required pumping before), which yielded 3000 barrels per day.[51] No less than three million barrels per year were being extracted by 1863.[52] The increased supply caused prices to fall to $0.10 per barrel,[53] which caused the bankruptcy of no few oil-men.

But demand rose steadily. This was partly due to a break in whale oil supply but also partly because of the increasing adaptability of oil as a lubricant and burner fuel oil. Prices soon reached up to $13.75 per barrel by the end of the Civil War.[54] Yet, a second glut soon drove the industry into

42 Tarbell, *The History of the Standard Oil Company*, 4.

43 Ibid., 5.

44 Pennsylvania Historical and Museum Commission, "PHMC Historical Markers: Search," *Harrisburg, PA: Pennsylvania Historical and Museum Commission*, 2015, http://www.portal.state.pa.us/portal/server.pt/community/pennsylvania_historical_marker_program/2539/search_for_historical_markers/300886.

45 E Owen, *Trek of the Oil Finders: A History of Exploration for Petroleum* (Tulsa, OK: American Association of Petroleum Geologists, 1975), 60.

46 P H Giddens, *The Birth of the Oil Industry* (New York, NY: The Macmillan Company, 1938), 2.

47 Tarbell, *The History of the Standard Oil Company*, 5–6.

48 W W Clark III and G Cooke, *The Green Industrial Revolution: Energy, Engineering and Economics* (Amsterdam, Netherlands: Elsevier, 2014), 37.

49 Sherman, *Drake Well Museum and Park*, 8.

50 Robinson, "Petroleum Processing Overview," 2.

51 Yergin, *The Prize*, 13.

52 C W Burleson, *Deep Challenge: Our Quest for Energy beneath the Sea* (Houston, TX: Gulf Professional Publishing, 1999), 22.

53 Cf. Tarbell, *The History of the Standard Oil Company*, 12; Yergin, *The Prize*, 14.

54 Yergin, *The Prize*, 14.

another depression – this time prices fell to $2.40 per barrel in 1867.[55]

These two first gluts mark the first time in history when oil investors were forced to face affordability challenges due to an excess of supply. Imbalances in some of the 'A's negatively affected the final affordability of oil. This time around, the imbalance was due to excessive availability and accessibility. The situation turned around when demand rose and, in addition, the weakest players exited the industry.

This goes to show that the future of oil is not necessarily the same thing as the future of each and every investor in the oil industry. Yes, oil as such has survived extreme price fluctuations ever since its inception. However, not everyone in the industry has survived the ups and downs. This is an industry that has always thrived through the rule that only the 'fittest' strategies survive.

## Rockefeller, Nobels and Sisters

It took about a century for oil to overtake coal as the dominant world fuel (table 1).

**Table 1: US oil & coal consumption (1910-1955).**

| Year | Oil (Trillion BTU) | Coal (Trillion BTU) |
|---|---|---|
| 1910 | 1007 | 12714 |
| 1915 | 1411 | 13294 |
| 1920 | 2634 | 15504 |
| 1925 | 4156 | 14706 |
| 1930 | 5652 | 13639 |
| 1935 | 5499 | 10634 |
| 1940 | 7487 | 12535 |
| 1945 | 9619 | 15972 |
| 1950 | 12706 | 12913 |
| 1955 | 16328 | 11703 |

*Source: Van der Linde.*[56]

Despite already being available, accessible, adaptable, acceptable and affordable by the 1870s, oil was second to coal throughout the second industrial revolution (1870-1914). In fact, books on energy still spoke of 'coal-equivalent' terms in 1950.[57]

This lengthy path to dominance included many and varied efforts to enhance the adaptability, availability, accessibility and acceptability (and therefore, ultimately, affordability) of oil. The most important of these was brought about by John Davison Rockefeller, who paid a great deal of attention to lowering the cost of overcoming all challenges in the 4A+A.

Rockefeller's most infamous tactic, one deemed illegal by the US Supreme Court in 1911,[58] aimed at lowering his accessibility costs relative to other competitors. He pursued rebates and drawbacks from the rail companies that transported his oil. This includes the discounts that any sensible business person would ask for but, also, under pressure from Rockefeller, a percentage of the earnings from other oil companies. Justified through the notion that the volume shipped by his company, Standard Oil, enabled efficiencies that reduced the price that other competitors would have to pay otherwise, rail companies paid Rockefeller a share of what they charged other customers.

However, Rockefeller's cost measures were part of a much wider strategy that ultimately allowed him to monopolize the market by 1985.[59] For instance, his financial position, largely a result of the relative gains in accessibility due to the rebates, enabled him to exploit the availability of oil in different regions, improving economies of scale and shortening distances to markets (accessibility).

Rockefeller was also ruthless in dealing with his competitors in the refining business. When unable to buy them outright, Rockefeller would drop prices in the markets they shared until they either sold or were forced out of business. This gave him the upper hand with regard to adaptability, which he used to secure enhanced acceptability for his oil. Indeed, the very name 'Standard Oil' intended to signal consistent quality amidst concern about the safety of other oils.[60]

Standard Oil was only rivalled when a Russian company called Branobel achieved similar linkages between the 4A+A factors.

Branobel, short for 'Nobel Brothers' (in Russian) was the result of the entrepreneurial genius of Robert and Ludwig Nobel. It was noted earlier that drilling techniques had already made their way to Russia by the end of the 1870s. This meant that at the time that the Russian oil boom began, availability was given. Acceptability could also be considered a given, because Russia had been importing kerosene from the US since the early 1860s.[61] The stringent tax policies of Tsarist times were also long gone by then. And yet, the Russian oil industry only saw a boom after Branobel. The main reason for the Russian sector's struggle at the time was that Russian production centres were extremely distant from markets (accessibility).

55 Ibid., 17.

56 C van der Linde, *Dynamic International Oil Markets: Oil Market Developments and Structure 1860-1990*, vol. 15 (Dordrecht, Netherlands: Springer Science & Business Media, 2013), Table 2.1

57 Ministry of Power, *The Efficient Use of Fuel: A Text Book on Fuels and Their Efficient Utilization for the Use of Students and Technical Men in Industry*, 1.

58 D A Crane, "Were Standard Oil's Rebates and Drawbacks Cost Justified," *Southern California Law Review* 85, no. 3 (2011): 559.

59 A A Fursenko, *The Battle for Oil: The Economics and Politics of International Corporate Conflict over Petroleum, 1860-1930*, vol. 12 (Greenwich, CT: JAI Press, 1990), 6.

60 Yergin, *The Prize*, 24.

61 Ibid., 41.

The Nobel brothers found a way to improve the accessibility of Russian oil by abandoning the use of animal-powered transportation for pipelines, storage and more efficient transportation vehicles, despite the scepticism of Russian oil oligarchs.[62] The Nobels even developed the world's first oil tanker fleet, starting in 1877 with *The Zoroaster*, and the world's first major system of pipelines – which surpassed 280 kilometres by 1890. By 1885, Branobel's capacity exceeded the combined output of the next five top competitors.[63]

The Nobels also paid a great deal of attention to adaptability. This was done by devising a way to make more money from oil by entering the business of residual oil fuels. Residual oil fuels are the fuels that can be derived from oil after distillation. Because coal was not available in Russia, residual oils had been used since the 1870s in oil burners for the propulsion of ships, including a Russian navy fleet stationed in the Caspian Sea.[64] To further the value of their residual products, the Nobel brothers designed and constructed improved fuel injectors that enhanced the efficiency of the burners. This soon ignited the market for fuel oils. Whilst less profitable than kerosene, fuel oil output surpassed kerosene by over 150% by the mid-1890s. This gave Branobel a strong financial security net that came in handy against Standard Oil.[65]

After the death of Ludwig Nobel in 1888, the company was taken over by Ludwig's eldest son, Emanuel Nobel. Emanuel continued pursuing fuel oils consistently and was even amongst the first in the world to secure a license for an invention that would soon change the world: the Diesel engine.[66]

The period between 1900 and 1970 would see a rather complex and convoluted tale of competition. This report will not go into a lot of details about this period for two reasons. Firstly, it would take an entire book. Secondly, there are already very good overviews of the topic.[67] A noteworthy fact, however, is that the seven most important companies in the oil industry during this time – Standard Oil of California (SoCal, later Chevron), Standard Oil of New York (Socony, later Mobil, now part of ExxonMobil), Standard Oil of New Jersey (Esso, renamed Exxon, now part of ExxonMobil), Gulf Oil, Texaco, Royal Dutch Shell, and the Anglo-Persian Oil Company (now BP) – were characterised by very strong strategies toward the 4A+A challenges.

All these companies, known as the 'Seven Sisters', addressed all 4A+A factors. However, all of them set benchmarks for specific 'A's, in a way that reinforced their approach to all other 'A's.

Three 'Sisters' (SoCal, Socony, Esso) emerged from the breakup of Standard Oil's monopoly brought about by the US Supreme Court in 1911.[68] Part of their success was grounded on the affordability enabled by existing economies of scale. But Standard Oil was broken up into 34 companies and only these three became 'Sisters'.

Socony (Mobil), based its strategy on furthering Standard Oil's marketing efforts and pursuing alternatives such as lubricants (acceptability / adaptability). Mobil is still one of the most visible brand names for lubricant oils (fig. 3).

**Figure 3: Mobil's logo.**

*Source: Hamilton.*[69]

Socal (Chevron) did it through a emphasising exploration, becoming the discoverer of Saudi Arabian oil (availability/ accessibility).[70] Esso was characterized by purchasing reserves rather than risking exploration,[71] which saved it resources that it then used in furthering efficiencies and finding new uses for oil (affordability/adaptability). Esso developed the process of 'fluid catalytic cracking', still core to the production of gasoline.[72] Esso can also be credited with a number of products that multiplied the uses of oil, such as butyl, which is used in tires and strong plastics.[73]

The other four Sisters also established benchmarks in aspects of the 4A+A. Gulf Oil had the lead on availability. It had so much oil that it was able to enter long-term contracts with other companies for as much as half their production.[74] Texaco followed a 'no waste' refining policy, "making all of every barrel into profitable products, rather than the standard practice of refining what salesmen could sell and discarding unwanted by-products like gasoline and asphalt".[75] Shell found its biggest strength in diversification into the production of gasoline, jet fuels, lubricants, and

62 Alekperov, *Oil of Russia*, 54.

63 Fursenko, *The Battle for Oil*, 12:9.

64 R W Tolf, *The Russian Rockefellers: The Saga of the Nobel Family and the Russian Oil Industry* (Stanford, CA: Hoover Press, 1976), 70.

65 Fursenko, *The Battle for Oil*, 12:11.

66 Tolf, *The Russian Rockefellers,* 169.

67 cf. W N Greene, *Strategies of the Major Oil Companies* (Ann Arbor, MI: UMI Press, 1984); Yergin, *The Prize*, 1–500.

68 US Supreme Court, "Standard Oil Co. of New Jersey v. United States 221 U.S. 1" (Washington, DC: US Supreme Court, 1911).

69 N Hamilton, "Flying Red Horse Logo," *Sunnyvale, CA: Flickr*, 2016, https://flic.kr/p/omU7d4.

70 Greene, *Strategies of the Major Oil Companies*, 159.

71 Ibid., 73.

72 ExxonMobil, "Our History," *Irving, TX: ExxonMobil*, 2016, http:/ corporate.exxonmobil.com/en/ company/about-us/history/overview.

73 Ibid.

74 Greene, *Strategies of the Major Oil Companies*, 89–90.

75 Ibid., 188–8.

specialty products, becoming the largest player in the business of petrochemicals.[76]

The conclusion is then rather definitive. Even the Seven Sisters, arguably the greatest stories of entrepreneurial success in the history of oil, were defined by the 4A+A challenge. Not only because they had to address all challenges but also because their very success came down to setting benchmarks in one or more of these areas.

All the above was, of course, accompanied by a number of events that furthered the demand for oil. For example, in the prologue of *The Prize*, Yergin tells how Winston Churchill converted the British navy from coal to oil prior to WWI.[77] The popularization of the automobile also had a huge effect on demand. Diesel and jet engines held (and hold) such importance for modern society that some authors credit them for having caused globalization.[78]

By 1960 oil was not only available and accessible across the world, it was fully adaptable, and had established itself as fully acceptable, even desirable. With thriving demand, the affordability of oil investments was at a high. To say that oil had emerged as a solution to the 4A+A challenge by the 1960s would be an understatement. At that time oil was *the* solution to the 4A+A challenge.

## The world after 1970

The Anglo-Persian Oil Company (currently BP) was left out of the previous section because it helps to explain the new challenge that appeared after the 1950s: political accessibility.

The Anglo-Persian Oil Company benefited from British colonial empire access to foreign resources, including the oil fields of Persia. The oil in the region has such quality and is so easy to extract that the company was able to ship it across the world and still profit.

Over time, however, countries in the Middle East started to grow unhappy at the share of profits they received from the oil in their land. Eventually, their dissatisfaction led to the creation of the Organization of Petroleum Exporting Countries (OPEC) in 1960. It was created by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela, who were later joined by Qatar, Libya, United Arab Emirates, Algeria, Nigeria, Angola, Gabon, Ecuador (membership interrupted between 1992 and 2007 due to dissatisfaction with the cost of being part of the cartel and the quotas allowed) and Indonesia (whose membership was suspended in 2009 due to no longer being a net exporter and who only recently re-joined in January 2016 despite still being a net importer, but ultimately excluded once again in OPEC's 2016 meeting due to being unwilling or unable to cut).[79]

It took almost a decade for OPEC to be in a position to challenge the Seven Sisters, but the OPEC countries ultimately managed to successfully assert their right to control access to the oil in their territories.

Two events were particularly important to this end. The first was the 'Declaratory Statement of Petroleum Policy in Member Countries' signed by OPEC members in 1968. This declaration made it clear that OPEC considered the use of the natural resources within their territories to be their inalienable right. Ten new members joined OPEC in the following year.

The second event was the practical application of this declaration by Libyan president Muammar al-Qaddafi, who moved to increase the profit derived from Libyan oil operations. Qaddafi was initially ignored by oil companies who thought he could not follow through with his threats. However, instead of going after the big companies, Qaddafi pressured a smaller company that relied entirely on Libyan oil until the company had no option but to accept his demands. This essentially caused a domino effect across the region. The outcome was the widespread nationalisation of oil in the region. Gone was the accessibility that the world had grown accustomed to.

The impact of the loss of accessibility would soon be manifested by the 1973 oil embargo imposed by OPEC. The embargo blocked the sale of oil to the United States and the Netherlands due to their support for Israel in the Yom Kippur War, but it was later expanded to include South Africa, Portugal and Rhodesia.[80] The embargo also included a five percent monthly cut in production[81] to avoid spare oil in the market being re-sold to those being embargoed.

Global oil prices quadrupled in just three months – from $3/barrel to $12.13. Chaos ensued in the United States, where consumers were queuing up in front of gas stations for fear of shortages. President Jimmy Carter later described the mood as follows:

> *We believed that our Nation's resources were limitless until 1973, when we had to face a growing dependence on foreign oil.*[82]

76 Ibid., 209.

77 Yergin, *The Prize*, xiii–xiv.

78 V Smil, *Prime Movers of Globalization: The History and Impact of Diesel Engines and Gas Turbines* (Cambridge, MA: MIT Press, 2010).

79 cf. NYT, "Ecuador Set to Leave OPEC," *New York, NY: New York Times (NYT)*, September 18, 1992, http://www.nytimes.com/1992/09/18/business/ecuador-set-to-leave-opec.html; BBC, "Indonesia to Withdraw from Opec," *London, U.K.: BBC*, May 28, 2008, http://news.bbc.co.uk/1/hi/business/7423008.stm; EIA, "Indonesia Rejoining OPEC despite Being a Net Importer of Petroleum," *Washington, DC: U.S. Energy Information Administration (EIA)*, 2015, http://www.eia.gov/todayinenergy/detail.cfm?id=23352; OPEC, "Brief History," *Vienna, Austria: Organization of Petroleum Exporting Countries (OPEC)*, 2016, http://www.opec.org/opec_web/en/about_us/24.htm.

80 B Rogers, "Southern Africa and the Oil Embargo," *Africa Today* 21, no. 2 (1974): 3–8.

81 R Licklider, "The Power of Oil: The Arab Oil Weapon and the Netherlands, the United Kingdom, Canada, Japan, and the United States," *International Studies Quarterly* 32, no. 2 (1988): 206.

82 J Carter, "Crisis of Confidence," *Atlanta, GA: The Carter Center*, 2016, http://www.cartercenter.org /news/editorials_speeches/crisis_of_confidence.html.

Whilst OPEC ended the embargo despite their conditions not having been met, the impact it had highlights the importance of accessibility.

A number of events would remind the world of the importance of accessibility. The Iranian revolution in 1979, for example. Before the revolution, Iran had been a close partner of the US. Iran even kept pumping oil during the 1973 embargo. This came to an end when the Shah of Iran was forced to flee the country and the opposition, led by Ayatollah Khomeini, took control of the government in 1979. In the process, the Iranian oil sector was brought to its knees. Despite concerns, markets held up until 1980, at which point prices soared to levels that, adjusted for inflation, would not be seen again until 2007.[83]

Oil prices gradually fell between 1981 and 1985, converging to about $30 per barrel ($60/bbl adjusted for inflation). Part of the credit goes to Saudi Arabia's interest in adapting production to protect prices. Despite, oil markets crashed in the second half of the decade after Saudis desisted in their efforts – greatly due to cheating by other OPEC members. By 1986, prices had fallen to under $20 per barrel ($40/bbl adjusted) and would remain in that range until Iraq's invasion of Kuwait in 1990.

By 1990 markets had matured sufficiently to even handle the biggest shift in consumption in the history of humanity: the switch in consumption growth from developed to emerging countries (table 2). Emerging countries represented 50% of global growth in energy consumption by 2010 and are forecast to represent 65% of total energy consumption by 2040. This was driven partly by development in Brazil, Russia, India, China and South Africa (BRICS) but is also partially a result of the fact that developing countries use less efficient technologies – requiring 3.4 barrels of oil for the same production that 1.1 barrels would cover in the developed world.[84]

**Table 2: Energy consumption by region (1990-2008).**

| Region | 1990 (%) | 2008 (%) |
|---|---|---|
| **Developed** | 48.6 | 42.2 |
| **Post-Socialist** | 19.7 | 10.7 |
| **Emerging** | 22.2 | 34.7 |
| **Developing** | 8.4 | 11.0 |

*Source: Bradshaw.*[85]

Despite such demand, prices remained relatively stable throughout the 90s. Admittedly, oil markets are extremely complex and numerous events other than the shift in demand from developed to developing worlds mattered. Both in favour and against price stability. To name just one example, US economic policy has a significant effect on the final price of oil.[86] However, the pressure of the shift in demand to the emerging world was unprecedented. The fact that prices remained stable through it is a testament to the efficiency of oil markets as a whole (which does include many more variables than this report could possibly cover).

Eventually, however, the combined effect of existing demand in the developed world, growing demand in the emerging world, and economic growth, were bound to have an effect. Prices began to rise in the early 2000s due to the acceleration of the economy and the exacerbation effect brought about by peak theorists who argued that oil would essentially run out.

The unprecedented increase in oil prices only came to an end during the 2008 financial crisis. This crisis began with the bursting of the housing bubble in the US and then spread to all other sectors, including energy. Put simply, the economy came to a halt and therefore required much less oil. Markets have seen unprecedented levels of volatility since.

The story does not end here. This report will enter into more detail about the current oil price collapse in the following chapter. However, this chapter shows that the most significant upturns in the industry resulted from situations where the challenges highlighted by the 4A+A were solved in a manner that the solution to one A reinforced the solution to another A, and that downturns coincide with imbalances that lead to some 4A+A factors creating risk and/or uncertainty toward other 4A+A factors.

Today, three components of the 4A+A (availability, acceptability, and adaptability) seem to be at the source of the risks and uncertainty that are currently hindering the affordability of oil as an investment. This will be addressed in the second and third chapters.

83 J Mouawad, "Oil Prices Pass Record Set in '80s, but Then Recede," *New York, NY: The New York Times*, 2008, http://www.nytimes.com/2008/03/03/business/worldbusiness/03cnd-oil.html?_r=0.

84 C Rühl, "Global Energy after the Crisis: Prospects and Priorities," *Foreign Affairs* 89, no. 2 (2010): 63.

85 M Bradshaw, "Sustainability, Climate Change and Transition," in *The Handbook of Global Energy Policy*, ed. A Goldthau (Hoboken, NJ: Wiley, 2013), 54.

86 e.g. K McElroy, "When the U.S. Dollar Goes Up, These Commodities Go down," *New York, NY: Seeking Alpha*, November 20, 2012, http://seekingalpha.com/article/1019611-when-the-u-s-dollar-goes-up-these-commodities-go-down; WSJ, "Winners and Losers When the Fed Raises Rates," *New York, NY: The Wall Street Journal (WSJ)*, 2015, http://blogs.wsj.com/moneybeat/2015/12/16/winners-and-losers-when-the-fed-raises-rates/.

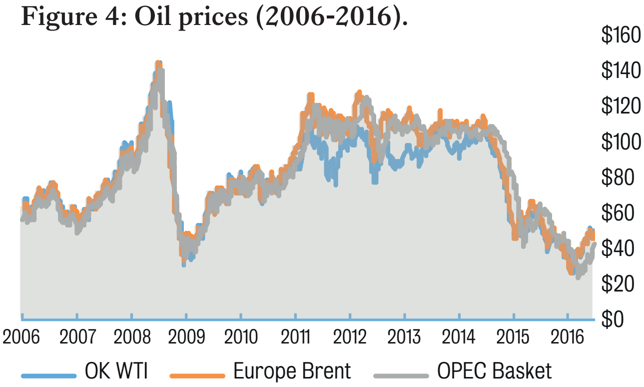
# Supply

The oil industry is currently in the midst of a perfect storm of structural challenges that are eroding its affordability. Of these challenges, excess supply in the market is the largest. BP describes the situation as follows:

> *Our industry remains focussed on the continuing weakness in the oil market. There are clear signs that the market is adjusting and that it will gradually rebalance. But the adjustment process is likely to be painful, and energy companies need to adapt to weather the storm.*[87]

The most evident sign of the magnitude of the 'storm' is current oil prices. Prices have hit levels that analysts did not even imagine were possible three years ago. In January 2016, for example, both WTI and Brent fell to under $27 per barrel. The last time that both WTI and Brent traded under $27 was in 2002, after a period of volatility triggered by a combination of events including the Asian financial crisis in 1998 and increased production in OPEC countries and Russia. At that time prices recovered in the build up to the 2007/08 financial crisis.

**Figure 4: Oil prices (2006-2016).**




*Source: EIA & OPEC.*[88]

## The causes

It is important to avoid the threat of 'exceptionalism' about the current situation. It is absolutely true that current prices are a challenge for the industry. However, it would be a mistake to think that the current low oil prices are the cause of the problems. If anything, they are further evidence of the rather tumultuous time that oil has experienced since the financial crisis.

Oil prices have fluctuated by over $100/barrel over the course of a decade: $50/bbl in January 2007, $147 in July 2008, $30 in December 2008, $123 in March 2013, $40 in August 2015 (fig. 4). In fact, prices were already falling prior to OPEC's decision not to cut production in November 2014. The industry did not move into the current era of low prices out of nowhere. By the time prices fell the industry was already battered by its past.

The answer as to why prices were falling before November 2014 has both a simple and complex explanation. The simple version is that there were too many actors pumping oil into the market, which led to an over-supply. The complex version requires explaining who these actors were and why they continued production.

For example, the United States played a significant role in fostering the supply of oil prior to 2014 thanks to what is now known as the 'shale revolution' (see box 2.1). In short, technological improvements increased the general availability of oil in the US by making it possible to extract oil from shale formations. The US oil industry is driven by profit, but also by a long-standing desire to become more self-sufficient. Shale oil is key to the latter objective so, as long as it is viable, the natural reaction is to produce as much as possible.

However, the US was not the only region from which oil was being pumped. Another prominent influence was the increasing viability of Canadian Oil Sands prior to 2014 (see box 2.2). Oil sands are the type of investment for which, once the upfront project costs have been paid, production costs are relatively low. By the time the glut became evident it was too late to halt the projects on the ground.

Another factor that further added to the glut was not supply per se, but the possibility of supply. Markets were aware of the possibility of acquiring yet more oil from new areas. The Arctic sea, where Shell had already begun exploration (see box 2.3), is the perfect example.

This is of course not a comprehensive list of all the actors that contributed to the glut. However, as elaborated in the respective boxes below, these areas do exemplify important trends that are likely to continue to affect the future of oil.

87 BP, "BP Energy Outlook 2016 Edition – Outlook to 2035," 4.

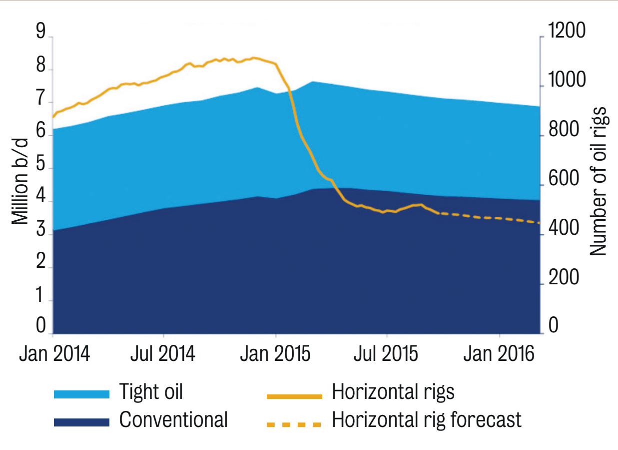
88 EIA, "Spot Prices for Crude Oil and Petroleum Products," Dataset (Washington, DC: Energy Information Agency (EIA), 2016); OPEC, "OPEC Basket Price," Dataset (Vienna, Austria: Organization of Petroleum Exporting Countries (OPEC), 2016).

## BOX 2.1: US SHALE

### Availability (+). Accessibility (+). Adaptability (+)

According to data from the EIA, US production fell from around 2.5 million thousand barrels per year during the 90s to little over 1.8 million thousand barrels by 2007/2008. This situation was reversed due to the 'shale revolution', which rapidly brought production up to almost 3.5 million thousand barrels in 2015 (3,442,205 thousand barrels).[89] The extent to which this newfound access to resources has changed the status of the US as a producer is such that on July 4th 2016 Rystad Energy published data showing that the US now has more oil reserves than Saudi Arabia.[90]

**Figure 5: US onshore production (2014-2015)**




*Source: Wood Mackenzie.*[91]

The EUCERS/KAS partnership has dealt extensively with the specifics of shale. Dr. Kuhn and Dr. Umbach have addressed shale's potential to be a game changer.[92] Jan-Justus Andreas, a previous KAS Fellow, examined the US shale revolution.[93] Both papers provide a detailed account of the phenomenon. As such, this report will limit itself to noting that the process consists of more than just drilling. Fracking involves liquefying rocks containing oil to separate the components. This allows the utilization of oil that would not be available otherwise. As such, shale oil is as much an improvement of availability as it is one of accessibility.

In addition, shale oil has a number of advantages that have helped it to be resilient:

- The shale industry is composed of many small producers rather than one big, inflexible company. This allows (and forces) shale companies to be very responsive to markets – as opposed to trying to control them – and thereby makes them innovators by definition.[94]
- Efficiency has improved by as much as 40% in the past few years.[95] This is likely due to the fact that shale is a relatively new technology. Efficiency improvements are amongst the factors helping shale to remain marginally viable despite low oil prices. At the time of writing, for example, break-even prices are around $60 per barrel, with a substantial share of the industry able to profit at $50 per barrel.[96] No other oil technology seems likely to match such a capacity for improvement in the short term.
- Other types of unconventional oil have similar break-even prices. For example, some deep-water operations are viable at $60/bbl. However, the cost of a shale well is vastly lower than that of deep-water wells. Shale wells range from around $6-10 million per well, whilst deep-water ones fall between $120 and $230 million.[97] Shale producers do need to drill many wells to achieve scale, but this can be done in stages so the full cost is not paid at once. The benefit is that shale oil's payback time is much shorter than that of other unconventional processes – as much as 6 to 8 years less.[98] This could become a financing advantage in volatile markets.
- There are about 4,000 drilled and uncompleted wells ('DUCs') waiting to be finished. All require less work than a new well. A large share of DUCs (~1,200) are located on the Permian Basin,[99] the most productive region for US shale. This is significant once it is considered that the total number of rigs at the height

89 EIA, "U.S. Field Production of Crude Oil (Thousand Barrels)," *Washington, DC: U.S. Energy Information Administration (EIA)*, 2016, https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=MCRFPUS1&f=A.

90 P M Nysveen, "United States Now Holds More Oil Reserves than Saudi Arabia," *Oslo, Norway: Rystad Energy*, 2016, http://communications.rystadenergy.com/acton/form/12327/0005:d-0001/0/index.htm.

91 S York, "Mourning Oil Prices: The Five Stages of Grief," *Edinburgh, U.K.: Wood Mackenzie*, 2015, http://www.woodmac.com/blog/mourning-oil-prices-the-five-stages-of-grief/.

92 M Kuhn and F Umbach, "Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU's Energy Security.," *EUCERS Strategy Paper* 1, no. 1 (2011): 1–52.

93 J J Andreas, "Fracking for Freedom: The Economic and Geopolitical Implications of the Shale Revolution," Strategy Paper (London, U.K.: European Centre for Energy and Resource Security, 2014).

94 Cf. A Halff, "OPEC's Policy Challenge in the Age of Shale Oil," *New York, NY: Columbia / SIPA Center on Global Energy Policy*, 2015, http://energypolicy.columbia.edu/publications/commentary/opec-s-policy-challenge-age-shale-oil.

95 S Williams, "Shale Drillers Adapting to Low Oil Prices, Report Finds," *New York, NY: The Wall Street Journal (WSJ)*, July 13, 2016, http://www.wsj.com/articles/shale-drillers-adapting-to-low-oil-prices-report-finds-1468396802.

96 Rystad, "The Oil Price Is Falling but so Is the Breakeven Price for Shale," *Rystad Energy "US Shale Newsletter"* 2, no. 1 (2015).

97 EIA, "Trends in U.S. Oil and Natural Gas Upstream Costs" (Washington, DC: U.S. Energy Information Administration (EIA), 2016), 4 & 26.

98 Rystad, "The Oil Price Is Falling but so Is the Breakeven Price for Shale."

99 A Abramov, "90% of DUCS Are Located within Permian, Eagle Ford, Bakken and Niobrara," *Oslo, Norway: Rystad Energy,* 2016, http://communications.rystadenergy.com/acton/form/12327/0005:d-0001/0/index.htm.

of the shale revolution was only slightly above 1,000.[100] In fact, some commentators have even ventured to say that the inventory of DUCs is sufficient to hold back any oil price rebound.[101]

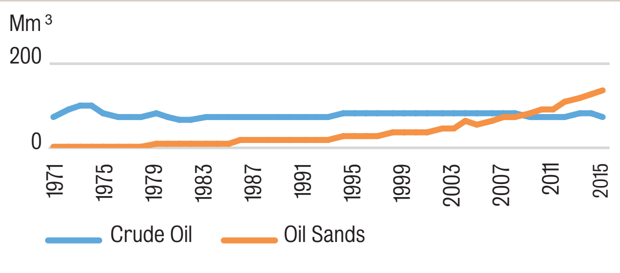
There is no point in denying that many shale companies are in a rather challenging situation. The fact remains that the sector is sitting on top of a $3 trillion pile of debt.[102] This may have dire economic consequences. However, shale producers are still able to operate despite this. This shows that, thanks partly to the reasons above, shale is resilient to very extreme circumstances, and, whilst the jury is still out on the extent to which shale will press supply upwards – which is itself tied to the price of oil – it is undeniable that it will do so to an extent.

## BOX 2.2: CANADIAN OIL SANDS

### Availability (+). Accessibility (+). Adaptability (-).

Another actor adding oil to the market is Canada. Canadian oil production increased from about 3 thousand barrels per day in 2005 to over 4 thousand barrels in 2014.[103] According to data from the Canadian Association of Petroleum Producers (CAPP), the bulk of that increase came from what is known as 'oil sands' (fig 6).[104]

**Figure 6: Canadian oil production (1971-2015)**




*Source: CAPP.*[105]

Oil sands are formations of minerals that are covered in bitumen. They can be mined and the bitumen can be separated through water and diluents. The final bitumen is then sold. Due to the very high viscosity of bitumen, these barrels are very hard to refine so the final price per barrel is quite low. Before the glut, prices rounded the $80/bbl mark but prices have been as low as $8.35/bbl since then. The extremely low prices of Canadian Oil Sands do not necessarily mean that operations are halted when prices seem uneconomical. Indeed, in the long term, the oil sands are only viable in a market where oil prices are above $70 per barrel. However, the investment pattern here is very different to that of shale oil. Oil sands have very high CAPEX costs but once they are running, it is relatively inexpensive to keep them running. Some estimate that oil sands have operating costs as low as ~$7.7/bbl.[106] As oil sands projects are thought to be able to run for decades, there is significant leeway with regard to how long an oil sand mine can run without making profits as losses can be recouped in times of high prices.

Oil sand miners could be in an even worse predicament if prices do fall to less than what is needed to run the mine. This is made worse by the fact that the bitumen obtained from oil sands is not as easy to refine as other oils available in the market so its price is bound to always be lower than the alternatives. That said, although it is uncertain whether new projects will be given the go-ahead, existing oil sands operations seem to be resilient.

## BOX 2.3: ARCTIC

### Availability (+). Accessibility (-). Adaptability (+).

The US Geological Survey (USGS) estimates that the Arctic holds 90 billion barrels of undiscovered and technically recoverable oil,[107] which amounts to circa 13% of the undiscovered oil in the world.[108] However, 'technically recoverable' oil is not the same as 'accessible'.

The same USGS assessment indicates that 84% of this oil is likely to be found offshore.[109]

Offshore exploration in the Arctic is so challenging – and therefore expensive – that companies have found it extremely hard to justify. The latest example is Shell, which recently pulled out of the region citing disappointing

100 York, "Mourning Oil Prices."

101 E Crooks, "Uncompleted Wells Could Hold Back Oil Price Rebound," *London, U.K.: Financial Times,* 2016, https://next.ft.com/content/2c82fe38-36bf-11e6-9a05-82a9b15a8ee7.

102 E Crooks, "Oil and Gas: Debt Fears Flare up," *London, U.K.: Financial Times,* 2016, http://www.ft.com/cms/s/0/d48b1922-eadd-11e5-bb79-2303682345c8.html.

103 BP, "BP Energy Outlook 2016 Edition – Outlook to 2035," 8.

104 M Vamburkar, "Crude at $10 Already a Reality for Canadian Oil-Sands Miners," *New York, NY: Bloomberg.com,* 2016, http://www.bloomberg.com/news/articles/2016-01-13/crude-at-10-already-a-reality-for-canadian-oil-sands-miners.

105 CAPP, "Canadian Crude Oil Production (1971 – 2009)," *Alberta, Canada: Canadian Association of Petroleum Producers (CAPP),* 2016, http://statshbnew.capp.ca/SHB/Sheet.asp?SectionID=3&SheetID=76; CAPP, "Canadian Crude Oil Production (2010-2015)," *Alberta, Canada: Canadian Association of Petroleum Producers (CAPP)*, 2016, http://statshbnew.capp.ca/SHB/Sheet.asp?SectionID=3&SheetID=321; CAPP, "Canadian Oil Sands Production (1967 – 2015)," *Alberta, Canada: Canadian Association of Petroleum Producers (CAPP),* 2016, http://statshbnew.capp.ca/SHB/Sheet.asp?SectionID=3&SheetID=85.

106 P Argiris, "Canadian Oil Sands: 170 Billion Barrels Can't Be Wrong," *Edinburgh, U.K.: Wood Mackenzie,* 2015, http://www.woodmac.com/blog/canadian-oil-sands-170-billion-barrels-cant-be-wrong/.

107 P Stauffer, ed., "Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle" (Menlo Park, CA: U.S. Geological Survey (USGS), 2008), 4, https://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf.

108 EIA, "Arctic Oil and Natural Gas Resources – Today in Energy," *Washington, DC: U.S. Energy Information Administration (EIA),* 2012, http://www.eia.gov/todayinenergy/detail.cfm?id=4650.

109 Stauffer, "Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle," 4.

results.[110] It is important to bear in mind that this move happened despite Shell having sunk somewhere between $5 and $7 billion into exploring the region. The decision took the world by surprise and there are conflicting narratives about the exact factors that precipitated the decision. Regardless, there is a general agreement that, had oil prices held, or had there been less regulatory concerns, Shell would have probably moved forward.

Shell's recent experience makes the Arctic a very good example of the importance that accessibility has even today. Simply put, whilst accessing the oil available in the region is plausible, it is so complicated, both from a technical and political perspective, that it becomes unaffordable at a time of low prices. However, interest in the region remains high. For example, Shell still holds the right to explore two hundred and seventy-five blocks in the region.[111] In fact, this latent interest in the region is not limited to companies. Governments are so keen on the region that some commentators have dubbed the struggle a "new cold war".[112] Russia went as far as to physically plant a flag on the seabed.

Given the latent interest in the region it seems almost impossible that new initiatives will not begin if prices rise sufficiently to justify the accessibility challenges. That said, the time that it takes to deploy a project in the region, added to the already long-term nature of an offshore project, needs to be considered. Even if prices do rebound sufficiently, market volatility and regulatory uncertainty may make it extremely risky to sink billions into exploration in the region. This may be less true for non-shareholder driven companies though.

110 T Macalister, "Shell Abandons Alaska Arctic Drilling," *London, U.K.: The Guardian,* September 28, 2015, https://www.theguardian.com/business/2015/sep/28/shell-ceases-alaska-arctic-drilling-exploratory-well-oil-gas-disappoints

111 Shell, "Shell Updates on Alaska Exploration," *The Hague, Netherlands: Shell,* 2015, http://www.shell.com/media/news-and-media-releases/2015/shell-updates-on-alaska-exploration.html.

112 J Holder et al., "The New Cold War: Drilling for Oil and Gas in the Arctic," *London, U.K.: The Guardian*, June 16, 2015, http://www.theguardian.com/environment/ng-interactive/2015/jun/16/drilling-oil-gas-arctic-alaska.

## The collapse

Given the effects all these actors were having on the market, by 2014 the sheer availability of oil in the market was already causing prices to converge downwards. In January prices stood at $95.14 (Oklahoma WTI), $107.94 (Europe Brent), and $103.82 (OPEC Basket). Prices fell slightly over the first semester but managed to hold over $90 per barrel until October 2014. By November 27th 2014, date of the now infamous OPEC meeting, WTI and Brent prices were already at $73.7 and $77.39 per barrel.

This left a very complex dilemma in the hands of OPEC. There were two broad possibilities. One was to slash production hoping to protect prices. The second was to accept an era of low prices. In a decision chiefly driven by Saudi Arabia, OPEC chose to dive 'head first' into an era of low oil prices. The official position was that the decision was taken to protect market share. However, 'protecting market share' is one of those terms that conceals the complexity of the decision. As addressed in this year's EUCERS/ISD/KAS energy talks, the decision had numerous drivers.[113]

The most commonly mentioned driver was OPEC's desire to force many non-OPEC producers out of the market. OPEC countries have much lower production costs than the rest of the world (table 3). Forcing low prices was an immediate way of putting pressure on the finances of competitors, even if this entailed putting pressure on their own finances.

Another reason that is believed to have played a role is the fact that Saudi Arabia had failed at trying to balance oil prices in the past. This failure dates back to the 80s when economic activity in the US slowed down as a result of the previous oil crises. The effect was a demand-driven oil glut. Prices gradually fell in between 1980 and 1985 despite of Saudi efforts to cut production. Saudi Arabia failed at gaining collaboration from other OPEC members so prices slipped from their hand little by little. Saudis finally gave up in 1985, and prices collapsed. The rest of the decade was marked by low prices – typically below $20.

Saudi Arabia tried to get a hold of the market by cutting supply but was unable to achieve its desired objective. The consequences were dire. Market share was lost to other producers and the very integrity of OPEC was brought into question due to internal divisions and cheating (by not abiding to quotas). This time around Saudis might have thought that it was better to be perceived as intentionally fostering the glut rather than as failing to control it.

These two considerations were the most important rationales behind the 'protect market share' justification. That said, many other related considerations had and will continue to have an influence.

113 EUCERS/ISD/KAS, "Oil Prices – How Low? How Long?" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #2, London, U.K., April 20, 2016); EUCERS/ISD/KAS, "The Gulf Region and the Future of Oil" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #3, London, U.K., May 23, 2016).

**Table 3: Production costs per barrel of oil**

| | CAPEX ($) | OPEX ($) | TOTAL ($) |
|---|---|---|---|
| U.K. | 21.80 | 30.70 | 52.50 |
| Brazil | 17.30 | 31.50 | 48.80 |
| Canada | 18.70 | 22.40 | 41.00 |
| U.S.A | 21.50 | 14.80 | 36.20 |
| Norway | 24.00 | 12.10 | 36.10 |
| Angola | 18.80 | 16.60 | 35.40 |
| Colombia | 15.50 | 19.80 | 35.30 |
| Nigeria | 16.20 | 15.30 | 31.60 |
| China | 15.60 | 14.30 | 29.90 |
| Mexico | 18.30 | 10.70 | 29.10 |
| Kazakhstan | 16.30 | 11.50 | 27.80 |
| Libya | 16.60 | 7.20 | 23.80 |
| Venezuela | 9.60 | 13.90 | 23.50 |
| Algeria | 13.20 | 7.20 | 20.40 |
| Russia | 8.90 | 8.40 | 17.20 |
| Iran | 6.90 | 5.70 | 12.60 |
| U.A.E | 6.60 | 5.70 | 12.30 |
| Iraq | 5.60 | 5.10 | 10.70 |
| S. Arabia | 4.50 | 5.40 | 9.90 |
| Kuwait | 3.70 | 4.80 | 8.50 |

*Source: CNN Money.*[114]

For example, analysts in our energy talks noted that the Saudi's desire to challenge Iran's re-entry into the market (Iran recently had its sanctions lifted and thus was able to restart oil sales to the West) seems to have been present in the background. Furthermore, there is another trend that seems to be emerging globally due to fear of climate change regulation by some producers. This is the decisiveness with which big oil producers are pumping oil out of the ground to avoid being left with stranded assets if climate change governance tightens. Saudi Arabia may indeed be under the impression that it has to sell as much oil as it can before legislation on the matter tightens and commercialization becomes harder. Regardless of the reasons, however, OPEC's decision had a decisive effect on the market.

Being a supply-driven phenomenon, the effect was similar to the one experienced by the industry after Bissell's first oil boom – which also caused a glut. Essentially, increased availability created a level of supply that soon glutted the market. Prices immediately collapsed to around $60 per barrel for most of December 2014 and to less than $50 per barrel throughout January 2015. Since then, oil prices remained low and only started to recuperate slightly in the first semester of 2016. At the time of sending this report to press, the price is back to the high $40s / low $50s, having recuperated (aided by OPEC's cuts) from a record low of less than $27 per barrel in January 2016.

## The immediate effects

It is advisable to give some thought to the level of oversupply faced by actors in the market, and the immediate consequences. This is key to understanding the magnitude of the challenge.

According to the EIA's 2016 short-term energy outlook, supply had already been intermittently exceeding demand since 2012. There were further increases in supply after 2014, with imbalances as high as 2 million barrels per day during 2015.[115] One way to picture what these numbers mean is to make an analogy with bath tubs. In the US, the standard bath tub holds a barrel of water (42 gallons). This means that during 2015, the additional oil put into markets per day was equivalent to what you would need to fill 2 million bath tubs.[116] Alternatively, you can think of the total amount as significantly higher than what either France or the UK consume (as per BP's statistics ~1.6 million barrels per day).[117]

The most immediate response was dramatic cut in CAPEX that has led to less exploration, less new wells, and so forth. According to the latest medium-term oil market report by the IEA, CAPEX expenditures fell by almost 50% in 2014, and 24% in 2015; 2016 is likely to see decreases of circa 17% (fig. 7).

CAPEX cuts have affected the whole industry, with offshore exploration being the sector that saw the largest share of cuts, and with shale and oil sands also reported to have been cut drastically. However, the report also mentions that the effect of oil prices was also deeply felt on the OPEX side, which affected many oil services companies due to major efforts to renegotiate contracts. It is partly because of the combined effects of increasing efficiency and CAPEX/ OPEX cuts that oil companies have coped with the glut.

The dramatic cuts to CAPEX are one of the main reasons behind analysts' expectations of a market rebalance[118] in the short to medium term. The rationale is simple; less investment today equals less supply in the near future.

114 Al Petroff and T Yellin, "What It Costs to Produce Oil," *Atlanta, GA: CNNMoney,* 2015, http://money.cnn.com/interactive/economy/the-cost-to-produce-a-barrel-of-oil/index.html.

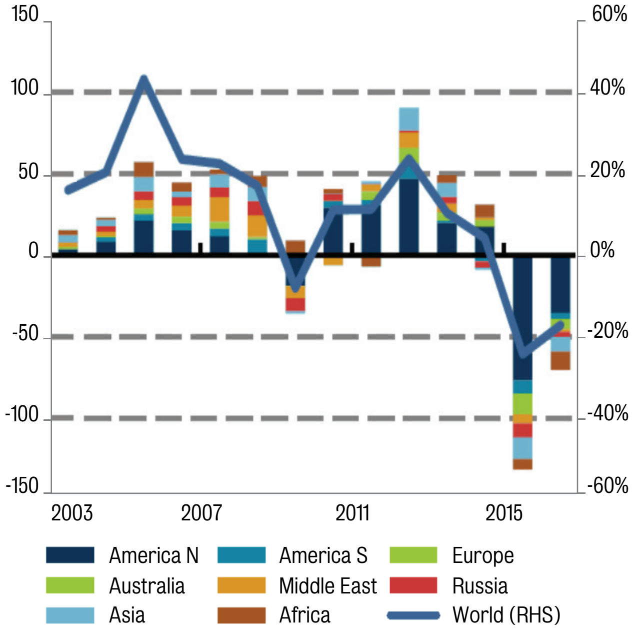
115 EIA, "Short-Term Energy Outlook (STEO) / Global Petroleum and Other Liquids," *Washington, DC: U.S. Energy Information Administration (EIA),* 2016, https://www.eia.gov/forecasts/steo/report/global_oil.cfm.

116 Cf. Reuters, "Factbox: How Much Is 60 Million Barrels of Oil?," *New York, NY: Reuters,* June 23, 2011, http://www.reuters.com/article/us-iea-oil-idUSTRE75M6S520110623.

117 BP, *BP Statistical Review of World Energy – June 2016* (London, U.K.: BP plc, 2016), 9.

118 Some authors use this word to imply that the current market status requires a 'better' balance. This reports takes a distance from such a flawed view of supply and demand considerations. Current prices reflect the right balance of current levels of supply and demand. If supply and/or demand change, prices will naturally adjust (rebalance).

**Figure 7: CAPEX expenditures (2003-2015).**




*Source: IEA.*[119]

Because of this, at the time of writing most analysts believe that prices will rebalance sooner rather than later.

Optimism should be taken with a note of caution though. Throughout the current glut analysts have generally been right with regard to what Marina Petroleka, Head of Oil and Gas at BMI Research and a participant in one of our energy talks, refers to as the 'direction of travel'.[120] However, analysts have found it harder to get the timing or the magnitudes right. This is understandable due to the level of complexity of modern oil markets. As has been shown thus far, the situation is driven by the combined actions of a wide number of actors involved in oil sub-industries that have very distinct characteristics – conventional onshore, shale, oil sands, conventional offshore, mid- and deep-water offshore.

As if this was not complex enough, there is the added analytical obstacle of the lack of reliable data about storage.

A corollary of the fact that oil is not perishable is an increase in the stocks of oil stored across the world. Problematically, it is extremely hard to know the exact amount of oil currently stored globally. As of July 2016, IEA estimated that OECD countries alone had accumulated as much as 3 billion barrels of oil,[121] but data about non-OECD storage is less transparent. China, for example, is a rather important actor for whom there are no reliable statistics.

Moreover, even if there were statistics about current storage capacity, there is a lot of uncertainty about the ceiling for the world's storage capacity. Evidence indicates that more and more oil storage is happening on an ad hoc basis and without any clear plan. For example, as reported by Bloomberg, the IEA estimates that, as of June 2016, 95 million barrels of oil are being stored at sea (in tankers).[122] As quoted by the FT, a broker in the business of tank leasing explained the situation as follows, "at the end of the day, you just never run out of storage. People just get clever about where they put the barrels".[123]

Storage is indeed one of the most unpredictable variables determining the speed and extent of any potential rebalancing – thus adding a significant level of uncertainty to any potential prediction of short term change in oil markets. Since storage capacity is both unknown and flexible, and since there is evidence of the fact that storage capacity is growing, chances are that it will take a significant while to burn through the oil stored. It is just impossible to know how long.

## The potential for a rebalance

Despite the uncertainty about when prices will go up, there is evidence to support the idea that prices will eventually have to rise, at least for a short while.

This is not to say that there will be a fast or even sustained price recovery (the following chapter will look into many factors that could reduce demand below current expectations). However, there is evidence to show that, to an extent, some level of rebalancing is already happening and may in fact be behind OPEC's recent interest in cutting production (announced September 2016 and agreed in their yearly meeting on late November 2016).

Firstly, Saudi Arabia's strategy may have already borne some fruit and thus Saudis may be less keen to force prices down. This is because low oil prices have at least halted the advance that was being made by other producers, particularly with regard to US shale. Indeed, as reported by Rystad Energy, production from shale-focused US companies decreased slightly in 2015 and, more importantly, investment in new projects fell substantially.[124]

119 IEA, "Oil Medium-Term Market Report 2016: Market Analysis and Forecasts to 2021" (Paris, France: International Energy Agency (IEA), 2016), 43.

120 M Petroleka, "Oil Prices – How Low? How Long?" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #2, London, U.K., April 20, 2016).

121 IEA, "OMR – OMR Public," *Paris, France: International Energy Agency (IEA),* 2016, https://www.iea.org/oilmarketreport/omrpublic/.

122 G Hurst and L Smith, "Traders Hoarding Most Oil since 2009 Amass North Sea Fleet," *New York, NY: Bloomberg.com, 2016,* http://www.bloomberg.com/news/articles/2016-07-13/oil-traders-hoarding-most-oil-since-2009-amass-north-sea-fleet.

123 G Meyer, "Demand for Oil Storage Soars amid Supply Glut," *London, U.K.: Financial Times,* 2016, https://next.ft.com/content/7a6ccb4a-1c63-11e6-a7bc-ee846770ec15.

124 P Nysveen and L Wei, "Shale's Response to Low Oil Price Environment – Summary of 2015 and Outlook of 2016," *Oslo, Norway: Rystad Energy,* 2016, http://communications.rystadenergy.com/acton/form/12327/0005:d-0001/0/index.htm.

Similar trends can be seen worldwide. Statistics from Baker Hughes show that, whilst there were over 3,500 rigs worldwide at the beginning of 2014, the number of rigs in June 2016 stood at 1,407.[125] Likewise, low oil prices have severely challenged competitor strategies, Iran included. All in all, Saudi Arabia may have successfully implemented the oldest trick in the oil man's book, the one Rockefeller used with competitors in the refining market: flooding the market to force competitors out. At least partially.

In consequence, although the 2016 cuts could face severe implementation challenges, insofar as OPEC does not increase production analysts believe that the glut should recede somewhere within a year or so[126] due to the severe underinvestment over the past few years.[127]

A second point is that many of the OPEC countries affected by the glut may not have the capacity to sustain low prices for much longer. At the level of prices seen throughout this glut, none of the countries that make up OPEC can be said to be making enough to cover their public finances. For example, as reported by the WSJ,[128] of all the OPEC countries, Kuwait is the one that can afford the lowest oil prices without having a public finance deficit. However, even Kuwait needs at least $51.80 per barrel. Other countries like Saudi Arabia, Oman, Bahrain and Venezuela need prices to be at around $100 per barrel to avoid holes in their public finances.

The pressure on the public finances of these countries is such that Saudi Arabia, for example, ran a $100 billion deficit in 2015. This led it to announce measures to modernize its economy. These measures include a very ambitious re-structuring plan known as Vision 2030.[129] Vision 2030 openly states diversification as a key objective:

> *Diversifying our economy is vital for its sustainability. Although oil and gas are essential pillars of our economy, we have begun expanding our investments into additional sectors. We understand that there are complicated challenges ahead but we have long-term plans to overcome them.* [130]

Moreover, although Vision 2030 promises that "there will be no taxes on citizens' income or wealth, nor on basic goods",[131] Saudi Arabia has already moved to impose the country's very first tax rate (5% VAT).[132] Whilst small if judged by average Western standards, taxes are an extremely bold move forward for Saudi Arabia. They may raise the expectations of the average Saudi citizen. It is, to put it shortly, a move that only makes sense if the Kingdom is absolutely determined to succeed in diversifying. Otherwise, if the leading elites fail in their objectives, the tax could easily be used to fuel arguments against the current leadership.

Despite this urgency, ambitiousness, and decisiveness, however, experts in this year's energy talks have expressed doubts over the sufficiency of these reforms. For example, Geir Westgaard, Statoil's VP of Political Analysis, noted that fiscal adjustments do not suffice and that deeper structural reform is necessary.[133] Similarly, Carole Nakhle, Director at Crystol Energy, expressed concern at the lack of a comprehensive energy policy in the region.[134] For her, this points to the fact that although there is desire for action, there is an immense void with regard to implementation. If this is true for Saudi Arabia, the richest of all OPEC countries, the effect that low prices have on the rest of producers across the world is all the more concerning.

A very clear example of the impact that low oil prices could have is Venezuela, where the world is currently witnessing a crisis that has led to Venezuelans flooding over the Colombian border to buy food.[135]

The general concern about the security of the world is shared by analysts across the globe, both in the fields of energy and geopolitics. For example, in a publication by Politico, Ian Bremmer, president of the Eurasia Group, expressed the following:

> *Geopolitically, the impact of low oil prices is concentrated in the Middle East, where political structures are brittle and based on oil wealth-supported patronage. Across the region, there are immediate and direct security threats without any social, political or economic reform processes in place to address the challenges these regimes face from the inside.*

125 Baker Hughes, "International Rig Count" (Houston, TX: Baker Hughes, 2016), http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9NjM4NzM3fENoaWxkSUQ9MzQzNjY3fFR5cGU9MQ==&t=1.

126 Although, to be entirely honest, the present author is extremely sceptical of an endogenous increase in prices within 2016/2017 (meaning one that happens naturally without voluntary cuts or political agreements).

127 J Stafford, "Why We Could See an Oil Price Shock in 2016," *Tysons Corner, VA: USA Today,* 2016, http://www.usatoday.com/story/money/markets/2016/03/27/why-we-could-see-oil-price-shock-2016/81336776/.

128 E Bentley, P Minczeski, and J Jovi, "Which Oil Producers Are Breaking Even?," *New York, NY: The Wall Street Journal (WSJ),* 2016, http://graphics.wsj.com/oil-producers-break-even-prices.

129 Kingdom of Saudi Arabia, "Saudi Arabia's Vision 2030 [English – Full Text]" (Riyadh: Kingdom of Saudi Arabia, 2016), http://vision2030.gov.sa/download/file/fid/417.

130 Ibid., 42.

131 Ibid., 65.

132 N Cunningham, "Low Oil Prices Forcing Saudi Arabia to Modernize Economy," *London, U.K.: OilPrice.com,* 2016, http://oilprice.com/Energy/Energy-General/Low-Oil-Prices-Forcing-Saudi-Arabia-To-Modernize-Economy.html.

133 G Westgaard, "The Gulf Region and the Future of Oil" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #3, London, U.K., May 23, 2016).

134 C Nakhle, "The Gulf Region and the Future of Oil" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #3, London, U.K., May 23, 2016).

135 A Hernandez and J Parkin, "120,000 Desperate Venezuelans Poured into Colombia to Buy Food but Now the Border Is Closed Again," *New York, NY: VICE News,* 2016, https://news.vice.com/article/120000-desperate-venezuelans-poured-into-colombia-to-buy-food-but-now-the-border-is-closed-again.

> *What keeps these countries together – as well as those that rely on them for support – when the oil money runs out?*[136]

Furthermore, the concern about security seems to be shared by elites in producing countries both within and outside OPEC. This is evidenced, for example, by Russia's support to the 2016 OPEC cuts. This was a sign that the country is finding it increasingly hard to cope with low oil prices.

And of course, OPEC's ability to reach an agreement gave the final evidence of the generalized concern about low prices. Whilst the effect of these cuts will not be clear for a while due to the need to implement it, the deal does reflect Saudi Arabia's previous stated preference to keep prices above the $50 per barrel mark.[137]

The bottom line is that there may be no single player in the market with the capacity to survive a protracted 'war of attrition'. All producers may be aware of such reality and at least some are clearly and undeniably trying to foster agreements to avoid a longer crisis.

## Risk of protracted volatility

Even if prices increase, either organically or due to cuts, there is always the possibility of another decline lurking in the background. The main reason is that, although low prices do force producers out, many companies have been adapting. Indeed, even the biggest multinational oil companies, including BP and Shell, have faced staggering losses due to low oil prices. However, this same pressure is forcing them to improve efficiency.

This is most true of shale oil, as seen earlier in the report, but it is also true of other regions and technologies. For example, the North Sea has shown that companies can rely on existing investment to weather out crises (see box 2.4).

Whilst not the only factor that affects profitability, efficiency may help some companies to realise profits with low oil prices. This would eliminate OPEC's ability to force competitors out and thereby strengthen the case for cutting supply. However, it would also mean more actors able to operate at low prices, which could perpetuate the glut.

Thanks to the fact that OPEC announced cuts in September 2016 as tentative rather than final, markets had a brief glimpse of the way in which all these actors could respond to price increases.

In a nutshell, the very announcement of cuts seemed to re-ignite shale oil in the US. Goldman Sachs' summarized the reality with the term 'Wall of Supply', which they explained as the impossibility for oil to go past $55 per barrel given supply capacities around the world, particularly because a wide number of shale operations start being viable around that price.[138] However, the idea of a shale-induced price roof is not new. Prior to the glut, EUCERS' Research Director Frank Umbach, noted oil was heading to the below-$80 range due to shale's viability line ($75/bbl at the time), at a time where analysts were forecasting higher prices.[139] Dr Umbach has maintained his position throughout, periodically referring to an era of prices in the $30-$80 range.

It is important to understand very well why this idea of a price roof makes so much sense. This is because it is, to some extent, counter-intuitive: if supply goes down prices go up. You can also still find some arguments warning about the potential of substantial price hikes.[140] And truth be told, there are challenges that could ensure some actors do give up for good and thereby exit and not come back.

For example, analysts such as Julian Lee, who is a strategist at Bloomberg First World Oil and who also took part in our energy talks, see significant pressures against market re-entries, such as the loss of human capital to other industries or regions, and the impact that the current situation has had on the credit-worthiness of shale producers.[141]

The likelihood of significant affectation to credit-worthiness is particularly strong when you consider the vast amounts of oil stored across the globe are likely to keep prices low for a period of time. Since the clock is ticking for many producers, storage-related price increases delays could be the final nail in the coffin for many shale producers.

There is more. Many exogenous pressures could easily push other non-shale producers out of the market and thereby further reduce supply. For example, the likely appearance of diverse geopolitical disruptions across the world may hinder production in some places. In the words of Marina Petroleka, Head of Oil and Gas at BMI Research, oil prices are likely to increasingly correlate with geopolitical risks. The greater the risks, the higher the price.

136 POLITICO, "The Hidden Consequences of the Oil Crash," *Rosslyn, VA: POLITICO Magazine,* 2016, http://www.politico.com/magazine/story/2016/01/oil-crash-hidden-consequences-213550.7,14]

137 A Lawler, "OPEC Delegates Say Saudi Comments Show Higher Oil Price Desire," *London, U.K.: Reuters,* 2016, http://www.reuters.com/article/us-opec-oil-idUSKCN0ZT1EL.

138 Grant Smith, "'Wall of Supply' to Block Oil Rally at $55, Goldman Sachs Says," *New York, NY: Bloomberg.com,* October 5, 2016, http://www.bloomberg.com/news/articles/2016-10-05/-wall-of-supply-to-block-oil-rally-at-55-goldman-sachs-says.

139 F Umbach, "The Geopolitical Impact of Falling Oil Prices," *Vaduz, Liechtenstein: Geopolitical Intelligence Services (GIS)*, 2014, https://www.gisreportsonline.com/the-geopolitical-impact-of-falling-oil-prices,energy,1787,report.html; cf. F Umbach, "Rosneft and Russia Pay the Price of West's Energy Sanctions," V*aduz, Liechtenstein: Geopolitical Intelligence Services (GIS),* 2014, https://www.gisreportsonline.com/rosneft-and-russia-pay-the-price-of-wests-energy-sanctions,energy,394,report.html.

140 E.g. D Dicker, "$120 Oil As Soon As 2018?," London, U.K.: OilPrice.com, *OilPrice.com,* (2016), http://oilprice.com/Energy/Oil-Prices/120-Oil-As-Soon-As-2018.html.

141 J Lee, "The Gulf Region and the Future of Oil" (Conference participation, EUCERS/ISD/KAS Energy Talks 2016 #3, London, U.K., May 23, 2016).

## BOX 2.4: BRITISH NORTH SEA

### Availability (-). Accessibility (+). Adaptability (+).

The North Sea has been at the centre of European O&G strategies ever since the first two major oil discoveries in the region in 1969. The potential for profit, added to the securitisation of oil that resulted from OPEC's embargo in 1973 led the way for the rapid development of the region's potential. According to BP statistics, Norway and the United Kingdom (UK) developed an industry capable of a combined output of over 2,200 barrels per day over the course of a decade.[142] By the 80s, the British North Sea alone had already supplied more than 9 billion barrels of oil.[143] Unsurprisingly, the North Sea has continued to be an integral component of the UK and Europe's energy security. Today, the region faces a crisis centred on a poignant dilemma: availability is declining and affordability is being severely constrained. The region's production peaked in 1999/2000 and current oil prices are below the break-even mark of around $50-$60/bbl.[144]

The North Sea's O&G sector is not in crisis solely due to the recent oil price slump, though. Alarms were raised even before OPEC decided not to cut production in late 2014. For example, McKinsey has estimated that costs had increased yearly by as much as 10% OPEX and 16% CAPEX since 2003.[145] This was already seen to be constraining profitability across the region even at times of higher prices. The advent of low oil prices forced the industry into a cost-cutting effort but the overall situation has yet to improve. In fact, revenues have fallen so much that the industry reported a £39 million negative tax performance in the first semester of 2015.[146] This is very concerning because oil traded at over $50/bbl through most of that period.

The diminishing availability of oil in the region is an issue that highlights a number of trends:

- It is increasingly hard to extract oil from the North Sea, but this does not mean that the region holds less importance to global energy security strategies. It is actually the opposite. Concerns about availability highlight the need for action. For example, the industry has made a Herculean effort with regard to maximising production and has managed to halt the decline, after falling from a peak of around 6.3 million barrels in 1999/2000 to just shy of 3 million barrels in 2013.[147]
- The ability to tap into existing infrastructure highlights both positives and negatives. On the one hand, it shows that when faced with tough financial conditions, companies can make an extra effort to reduce costs and maximise return on previous investments with encouraging results. For example, PwC's Oil & Gas team lead, Alison Baker, considers that the opportunity to emerge stronger from the crisis is available to actors able to address costs and to properly identify the long-term possibilities.[148] Similarly, on top of the increase in production expected in 2016, cost reductions will likely bring some much needed relief. On the other hand, efficiency efforts highlight the very high social cost that low oil prices can have, even for developed societies, due to the resultant job losses. The region lost 5,500 direct jobs over the last year and some fear that 2016 could see many more.[149]
- The dire need to maintain viability may lead to a mismatch between over-optimistic planning and reality. For example, in its 2014 'Activity Survey', Oil & Gas UK found that capital investment in 2014 was £1.8 billion higher than forecasted, largely due to project slippages.[150] The fact that such a deviation from forecasts is possible is particularly concerning now that even forecasts paint a bleak picture.
- Decommissioning is a major issue for regions in decline. The level of decommissioning needed in the region is substantial, with 71% of contractors participating in the 2014 Aberdeen & Grampian Chamber of Commerce's Oil and Gas Survey stating that they are likely to be involved in decommissioning within five years.[151] It is very hard to forecast decommissioning costs. Low estimates fall somewhere around the £30 billion by 2040 mark,[152] whilst others go as high as $60 billion in a similar

142 BP, *BP Statistical Review of World Energy – June 2015* (London, U.K.: BP plc, 2015) [Dataset].

143 K W Glennie, *Petroleum Geology of the North Sea,* 4th ed. (Oxford, U.K.: Blackwell Science, 1998), 25.

144 E.g. M Gardham, "Falling Oil Price Could Hit Planned North Sea Projects, Analyst Warns," *Glasgow, Scotland: Herald Scotland,* 2014, http://www.heraldscotland.com/news/%2013193654.Falling_oil_price_could_hit_planned_North_Sea_projects__analyst_warns/

145 McKinsey, "Meeting the Challenge of Increasing North Sea Costs" (London, U.K.: McKinsey & Co., 2014), 5.

146 S Carrell, "North Sea Tax Revenues Plummet to Negative for the First Time in Sector's History," *London, U.K.: The Guardian,* 2015, https://www.theguardian.com/business/2015/oct/21/north-sea-tax-revenues-plummet-negative-first-time-history.

147 A Rascouet, R Katakey, and L Hurst, "North Sea Paradox Puts Pressure on International Oil Benchmark," *New York, NY: Bloomberg.com,* 2015, http://www.bloomberg.com/news/articles/2015-08-12/north-sea-oil-defies-price-slump-as-output-rises-a-second-year.

148 A Baker, North Sea oil industry at inflection point, says PwC's Baker, interview by ProactiveInvestors Stocktube, November 20, 2015, https://www.youtube.com/watch?v=Atvya3Y_SXU&feature=youtu.be.

149 K Stacey, "Oil Explorers Predict 10,000 More Job Losses in North Sea Sector," *London, U.K.: Financial Times,* 2015, http://www.ft.com/cms/s/0/555cd072-5c54-11e5-9846-de406ccb37f2.html#axzz3wlKU05Rw.

150 Oil & Gas UK, "Activity Survey 2015" (London, U.K.: Oil & Gas UK, 2015), 9

151 Fraser of Allander Institute, "Aberdeen & Grampian Chamber of Commerce's Oil and Gas Survey" (Glasgow, Scotland: Fraser of Allander Institute, 2014), 8.

152 A Jamieson, "Decommissioning in the North Sea: A Report of a Workshop Held to Discuss the Decommissioning of Oil and Gas Platforms in the North Sea" (London, U.K.: Royal Academy of Engineering, 2013), 10.

time frame.[153] This is a staggering amount of money that may not be feasible at times of low oil prices.

As described, the challenge faced by those in the region is dire. However, this is not necessarily a bad thing for oil per se. Many of the greatest achievements in the history of oil were during times of extreme pressure. Bissell's discovery came at a time when concerns about whale oil were at a high. Rockefeller managed to find success despite the situation being so bleak that even he was concerned. Whilst there is no way to know about the likelihood of their success, the North Sea region has fostered an important debate about alternatives. One such alternative is for it to serve as a hub for Carbon Capture and Storage (CCS) technologies. The lack of oil underground also means that there is space for the storage of carbon. In addition, the industry may also be able to offset risks through resources other than oil, both inside and outside the region. Gas is the most immediate possibility. The approval of the Culzean gas field may help the industry even if oil continues to be a dilemma. But gas is not the only possibility. Actors are keen to explore other potential lifelines such as offshore wind and potential business opportunities related to technical expertise in decommissioning through means of consulting and subcontracting.

153 A Banner, "Decommissioning: Estimations and Efficiencies [Presentation]" (London, U.K.: Department of Energy and Climate Change (DECC), 2015), 12.

That said, the key to a price roof lies in the number of avenues through which new supply could hit the market. Some shale producers may live through the current crisis. It would be rational for them to ramp up production as soon as prices increase. After all, they would need to make up for all the financial problems endured until that point.

Other producers could have left the market early on (or kept operations to a minimum) with the express intention of returning once prices go back up. These type of producers would have two advantages: better [or at least not as bad] financial standing than competitors and the know-how acquired throughout this time.

Moreover, it is dangerous to assume that absolutely everyone with the capacity to get into shale has already done so. As frequently mentioned by Dr Frank Umbach, Research Director at EUCERS, technologies cannot be bankrupted. Even if the viability of shale technologies were reduced, the technology will still be waiting to be implemented. Many investors could be waiting to enter the business with a 'second mover advantage' if prices increase. This is a strategy that avoids the risks of the initial period of consolidation that all technologies go through, before moving into the business once uncertainties are lower.

A 'second mover' phenomenon would not be too different from what Rockefeller did. He entered the business during the early gluts and thus endured some financial struggles himself. However, his initial operations were in refining rather than exploration, which enhanced his financial position relative to competitors. He then waited for the gluts to be over to 'step on the accelerator', capitalizing on the fact that competitors' finances had been ripped apart.

Altogether, what this situation leaves us with is a strong sensation of uncertainty with regard to the potential effect any production cuts could have. Indeed, lack of human capital, financial strain, the time it will take for the world to burn through stored oil, inter alia, may slow re-entries. But despite of not knowing the timing, it seems almost certain that, barring political agreements, someone, somewhere, may very well push production up to compensate for the time spent operating at a loss (prime mover not forced out of market), to re-enter the market (early exiter), or to enter the business for the first time (second mover). So, even if prices do go up, it would be seasonal at best.

But the story does not end here. Assume that shale does not keep prices down. A big assumption given what has already been noted. Even then, there is a final consideration about the potential for protracted volatility. One that, almost ironically, lies in the very mechanism that many hail as the solution: cuts.

Throughout the crisis some believed that voluntary cuts would come from the same actor who is furthering the glut at the moment: Saudi Arabia – a belief corroborated by OPECs' announcement. And it is true, maybe Saudis found that they cannot win a war of attrition. But it is also plausible (and a lot less patronizing) to think that Saudi

Arabia's final objective was to slow down investment rather than actually ensure the bankruptcy of anyone in particular. An alternative and less confrontational explanation is that Saudi elites may have also be interested in pushing prices down to legitimize their interest in reforming the economy.

From either of these perspectives, however, confirmation of global investment having fallen sufficiently so as to guarantee a good number of years of reduced supply could suffice to content the Saudis.[154] However, if either of these perspectives are the case – even if minimally, it would be rational to do such a thing seasonally. This would be to either ensure that the cost of capital remains as high as possible for any other producers – effectively making investment in the oil industry much harder by forcing a situation of protracted volatility, or to remind the country that reform is indeed necessary (or both).

All things considered, whilst it seems clear that the market has the potential to rebalance, perhaps aided by cuts, it does seem that for any rebalancing to be sustained, an extraordinary level of cooperation would be necessary. Otherwise, a) the desire of all actors to maintain market share, b) the ability to exploit efficiencies and delay investment at times of low oil prices, and c) the ability (and arguably the need) of some to reduce prices repeatedly via supply, will invariably lead to waves of cooperation followed by periods of increased and possibly brutal competition.

Without policy action and/or exogenous changes in demand, the future is likely to be one of either continued low prices or one of enhanced periods supply with sporadic pauses in investment of uncertain length. Indeed, one of either sustained low prices or protracted volatility. Either way, the affordability oil has as an investment is likely to continue under pressure.

Under these circumstances the most favourable types of oil investment are likely to be sweet, onshore oil (due to existing infrastructure and low operating costs) or shale oil (because it boasts short repayment periods and the flexibility to stop and start production).

The contradiction is that, if investments are made from the perspective of merely responding to low prices in the hope of better times – as opposed to a strategy that takes into account the long-term risks and uncertainties, the oil industry would be driven into a short-term mentality. As will be argued in the conclusion (policy recommendations), a short-term mentality is the exact opposite of what oil needs today.

154 J van den Beukel, "Why the New Saudi Oil Policy Is Likely to Succeed," *EnergyPost.eu,* January 25, 2016, http://www.energypost.eu/new-saudi-oil-policy-likely-succeed/.

# Context (demand)

Demand for energy around the world should theoretically continue to increase for the time being. This conclusion can be drawn largely from the state of current energy policy intentions: whilst economic growth seems to have slowed down significantly you would still be hard-pressed to find a policy agenda today that intends to decrease growth.[155] It is possible to see a decoupling of economic growth and energy demand growth in some areas of the world, which has led to a stagnation of energy demand in the past few years.[156] However, even if full decoupling were possible in the foreseeable future, existing statistics conceal humanity's failure to provide satisfactory access to energy to the world's poor (if seen from a perspective compatible with the UN's Millennium Development Goals).[157]

Forecasts do also support a view of increasing demand in the short and medium term. The consensus is that even if countries were to fully accomplish their climate change goals, all types of fuels will see an increase in total consumption from now until 2030, including oil. For example, in a recent report about energy and climate change, the IEA forecasts oil to grow to a peak consumption of 99 million barrels per day (9% above today) by 2030.[158]

Other reports agree. Some even suggest a more oil-intensive future. For example, the WEO 2015 projects demand to be around 103 to 117 million barrels per day by 2040, with the exception of the '450 scenario', which puts demand at around 74.1 million barrels per day by 2040. The 450 scenario is an aspirational guide that describes what the world would need to do to be consistent with the goal of limiting global warming to 2 degrees Celsius. It is more a hope than a projection. If one desires to achieve the 450 scenario, one needs to begin by truly understanding what the future is likely to be and only then offer policy recommendations that could alter said future. Otherwise, everything becomes a pointless exercise of offering unrealistic hopes as policy prescriptions.

Yes, there may be a technological breakthrough that is about to change the face of earth. This author would welcome such a thing. In fact, this chapter will soon address technologies that might trigger the type of innovation that could, perhaps, change the future. However, plans about the future cannot be made on the basis of unknowns.

But the fact that the future seems to be one in which there will be demand for energy should not be taken to mean that there will be certain demand for any given fuel, let alone oil. As will be seen in this chapter, demand for oil as such will be marked by an animosity toward oil that has already begun to increase, and by increased competition.

This is mainly due to two factors. The first is that people are starting to dislike oil due to the political, social, and environmental impacts typically linked to it. On the other hand, the adaptability of other sources of energy has been increasing relative to that of oil. Whilst it is wise to assume demand for oil will increase over the coming years, said demand is hanging from a thread. This effectively limits the room that oil has to manoeuvre itself out of the challenge it currently faces, as higher prices would incentivise both demand and supply of a myriad of other arguably more preferable options.

## Society and acceptability

The first chapter made only a passing reference to the Seven Sisters in order not to make this report too long to read. This meant the exclusion of many rather interesting stories. Amongst them, that of Enrico Mattei.

Mattei rose to prominence in the 1950s due to his role reconstructing the Italian oil sector via the state company 'Eni'. He is the one that coined the term 'Seven Sisters', which he used pejoratively to decry what he considered to be unfair oligopolistic dominance. His claims against the unfair dominance of the markets by the Seven Sisters helped him secure deals in different regions including Russia and Algeria, making Eni a very powerful company. Mattei's story shows how competitors can capitalize on the unacceptability of the way in which others do business.

This was, of course, a while ago and within the oil industry. After all, Mattei was also an oil man. However, concerns about the oil industry have only grown over time. In fact, nowadays, there are at least three major areas of dissatisfaction with the oil industry: geopolitical, humanitarian, and environmental.

### Geopolitical

Since OPEC's embargo in 1973 geopolitical concerns around oil have been significant. At that time, the concern was not around the usage of oil, per se, but around the potential consequences of heavy reliance on oil from any particular region. Consumer countries in the West responded to these concerns through a combination of two forms of diversification.

155 Barring man-made and/or natural catastrophes this author can only think of one trend that could be used to justify a future of diminished energy demand. It is a theory called 'de-growth' that advocates for a managed reduction of consumption across all spheres of human activity. However, at the moment it is an extremely marginal trend that is not driving any type of decision making.

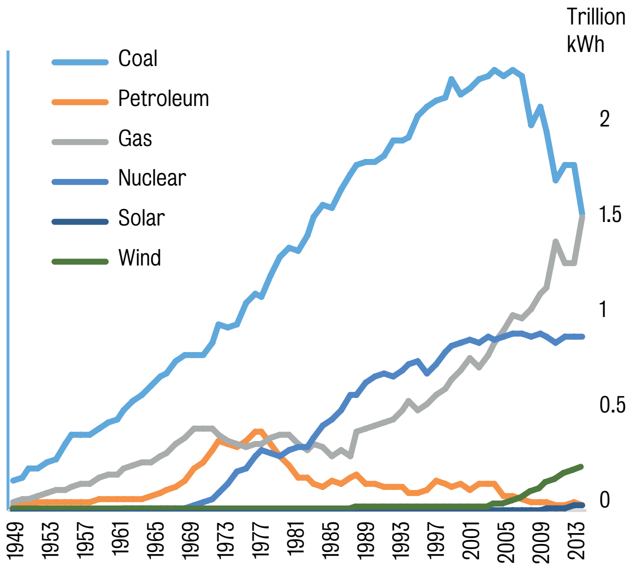
156 cf. Enerdata, "Global Energy Trends: Towards a Peak in Energy Demand and CO2 Emissions?," 15.

157 UN-Energy, "The Energy Challenge for Achieving the Millennium Development Goals," N*ew York, NY: UN-Energy Knowledge Network*, 2016, http://www.un-energy.org/publications/50-the-energy-challenge-for-achieving-the-millennium-development-goals.

158 IEA, "Energy Climate and Change (World Energy Outlook Special Report)" (Paris, France: International Energy Agency (IEA), 2015), 39.

The first was regional diversification. This looked to incentivise oil companies to re-balance the loss of accessibility to the Middle East by producing in regions such as the North Sea and the Gulf of Mexico. The second was fuel diversification. This aimed to explore other sources of energy such as nuclear, solar and wind.[159] The effect of fuel diversification is necessarily less significant than that of regional diversification because oil was used mainly in transportation rather than in electricity generation – and most fuel diversification has happened in the latter sector. However, the share of electricity being produced by petroleum fell significantly in the late 70s and early 80s (fig. 8) alongside efforts of fuel diversification.

**Figure 8: US energy production by fuel (1950-2016).**




*Source: EIA.*[160]

Now, recall that diversification efforts were introduced in the first chapter as responses to accessibility concerns. Fuelled by the oil embargo, political accessibility challenges ignited a desire for diversification. The success of these initiatives was such that today OPEC would not be able to, for example, embargo the US as effectively as it could back in 1973. The US would simply buy oil from a different producer such as West Africa. A major disruption, for instance, generalized instability in the Middle East, could still lead to a break down, but modern markets are considered to be resilient enough to survive localised disruptions.[161]

Even if this were not the case, the 'Carter Doctrine' states that the US (and allies) are willing to use force to ensure the continuity of the supply of energy resources. This has been noted to include "military deployment near exploitation sites and along shipping lanes, stockpiling of strategic resources, diplomatic support, 'gunboat' policies, [and] proxy wars or *coups d'état* to maintain allied regimes".[162]

Therefore, although once extremely important, accessibility has now become the norm. It is ensured by the market, and backed up by the Carter Doctrine.

There are, however, issues of acceptability attached to any geopolitical consideration. This is easiest to explain with a hypothetical example. Europe currently imports more than 30% of its oil from Russia.[163] Currently, only the dependency on Russian gas can be said to be a securitized issue within the EU, as there is no major concern about oil dependency from Russia. However, even if Russian oil continues to be fully accessible, if North Sea oil production does go down in the future, the EU will have to ponder whether to extend its dependency from Russian oil or source it from a different partner.

Imagine if such a decision needs to be taken amidst a political dispute between the EU and Russia. Would the public be happy to increase the amount of oil imported from Russia? Perhaps. However, geopolitical considerations may well be used to deem any further dependency from Russia as essentially unacceptable.

This points us to the bottom line of acceptability: every actor prefers (i.e. finds more acceptable) oil from their own territory and/or allies. However, if every country deems its own oil more acceptable than that of others, all actors will continue to push production in their territories regardless of the consequences.

## Humanitarian

There are humanitarian considerations related to oil-producing regions. A reality that has two sides. In crude and practical terms, a political crisis in a producing country can have a similar effect to an embargo, making oil from the region inaccessible to markets. This would be a geopolitical issue and should thus be interpreted alongside considerations made previously.

On a more normative level, however, the idea that oil kindles political crises makes consumers in developed countries less keen on accepting oil. This idea can be traced back to a theory of energy security that became popular in the 80s, Rentier State Theory (RST). RST's rationale is simple: when a state receives large revenues from a single resource such as oil, it can avoid accountability and legitimacy demands from the public via patronage and coercion. This has the

159 R Dannreuther, "Energy Security and Shifting Modes of Governance," *International Politics* 52, no. 4 (2015): 472–73.

160 EIA, "Data – Table 7.2a: Electricity Net Generation: Total (All Sectors)," *Washington, DC: U.S. Energy Information Administration (EIA),* 2016, http://www.eia.gov/beta/MER/index.cfm?tbl=T07.02A#/?f=A.

161 Cf. E Gholz and D G Press, "Protecting 'the Prize': Oil and the US National Interest," *Security Studies* 19, no. 3 (2010): 453–485.

162 P Le Billon, "The Geopolitical Economy of 'resource Wars,'" *Geopolitics* 9, no. 1 (2004): 3.

163 EC, "In-Depth Study of European Energy Security – Accompanying the Document 'Communication from the Commission to the Council and the European Parliament: European Energy Security Strategy,'" Commission staff working document (Brussels, Belgium: European Commission (EC), 2014), 31–32.

potential to result in a lack of institutions, which can then lead to abhorrent conflicts such as those witnessed throughout Africa and the Middle East.[164]

It is true that oil needs to be bought from unstable regions because most major producers of oil have significant social and political problems. However, each of these situations is unique, which does make for differentials that may affect the value of any investment. The best contemporary example of this reality is West Africa (see box 3.1). Some years ago the US even hailed the region as the 'swing region' *par excellence* and devoted significant diplomatic efforts to it.[165] This came to an end with the increase in shale oil production in the US. Likewise, actors at all levels and from all over the world hesitate to engage with the region. For example, a very instructive interaction during this fellowship was a casual conversation with the CEO of a small oil services company in a conference in Amsterdam, who noted that concerns about corruption led them to withdraw from West Africa.[166]

In the US, the ability to exploit new resources provided the rationale to consider oil from the region undesirable; vis-à-vis shale but also vis-à-vis oil from other regions from where the US still imports. Likewise, some investors have found the region to be past their comfort zone. This highlights the need to gauge the acceptability of one region vis-à-vis all other regions. Given the opportunity provided by supply surpluses, differentials in acceptability do seem to matter.

### Environment

Environmental concerns are another major source of dissatisfaction with the oil industry. The world seems to be increasingly set on meeting (at least approximately) the goal of limiting global warming to under 2˚C. However, with existing technologies there is a limit to the amount of oil that can be burnt whilst still staying under this 2˚C target. Such a limit falls somewhere in between a third and a fourth of proven reserves.[167] This has led to a number of calls and initiatives that seek a move away from fossil fuels, including oil. As elaborated in the following paragraphs, this can be observed at different levels.

## States

On June 2015 the G7 declared that it aims to be free of fossil fuels by 2100. Whilst this is a rather long-term goal that leaves the responsibility to act to future generations, it does create a commitment that cannot be easily undone. To put it in more colloquial terms, it may be a tiny step, but it is one that could be considered to be in the right direction. And regardless of its normative value, it is a step that forces the G7 countries to at least start accepting the decarbonisation process as something that will happen, rather than as the desire of a few. Another very significant step in the direction of decarbonisation was the *Paris Agreement*. Thanks to the fellowship, the author had the opportunity to be present in Paris for the negotiations. As is well known, the meeting ended with the ratification of the Paris Agreement, which starts all countries on the path towards what should (in theory) be a process of decarbonisation. Many claimed at the time that it was all talk and that the agreement would soon lose potency. However, at the time of writing the Paris Agreement had already set a world record for the treaty with the most signatures on the day of opening (174 signatories on April 22nd, 2016) and managed to enter into force in less than a year (as oppose to the original goal of 2020) thanks to global interest in climate policies. This alone signals a rather overwhelming interest in the pursuit of its objectives. Furthermore, although the process has only begun, there were no significant relapses in the following round of negotiations in Marrakesh. Whilst Trump's victory in the US may indeed challenge the process, other countries seem to remain committed. Moreover, a 'Trump effect' would come alongside a bid to push US production up (which would refer the argument back to the previous chapter). As if this was not enough, it is also important to consider that even oil-producing countries, including Saudi Arabia, have also announced intentions to phase out fossil fuels.[168]

## Companies

The oil industry is becoming increasingly fragmented over the issue of climate change. Prior to the Paris meeting, some of the most important oil companies in the world voiced their support for carbon pricing in a letter to the UNFCCC Executive Secretary at the time, Christiana Figueres. This was an extraordinary event motivated by the fact that these companies would benefit from carbon pricing due to their investments in natural gas. However, the fact that they would benefit financially does not take away from the fact that the call can help to portray these companies as better for the environment than their competitors. There is no need to wait to see evidence of this. One of the companies that signed the letter, Total, recently launched a very engaging campaign entitled "Committed to Better Energy" in which it aims to differentiate itself from other oil companies by emphasising its involvement in natural gas and solar energy.[169] As those companies that exclusively dealt with oil now diversify their portfolios and claim to

164 Cf. Le Billon, "The Geopolitical Economy of 'resource Wars,'" 6–7; M Gray, "A Theory Of' late Rentierism' in the Arab States of the Gulf," Occasional Paper (Center for International and Regional Studies: Georgetown University School of Foreign Service in Qatar, 2011), 5.

165 Cf. H Clinton, "Energy Diplomacy in the 21st Century" (Speech, Georgetown University, Washington, DC, October 18, 2012).

166 Anonymous Source, "Informal Conversation" (Offshore Energy Forum 2015, Amsterdam, Netherlands, October 14, 2015).

167 E.g. B McKibben, "Global Warming's Terrifying New Math," *New York, NY: Rolling Stone,* 2012, http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719; C McGlade and P Ekins, "The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2 [Deg] C," *Nature* 517, no. 7533 (2015): 187–90.

168 P Clark, "Kingdom Built on Oil Foresees Fossil Fuel Phase-out This Century," *London, U.K.: Financial Times*, 2015, http://www.ft.com/cms/s/0/89260b8a-ffd4-11e4-bc30-00144feabdc0.html.

169 Total, "Committed to Better Energy: Our Corporate Campaign," *Paris, France: Total*, 2015, http://campaign-kit.total.com/en.

### BOX 3.1: WEST AFRICA

**Availability (+). Accessibility (+). Adaptability (+). Acceptability (–).**

According to BP's latest Statistical Review, Africa holds about 7.6% of proven global oil reserves. Whilst small when compared to the Middle East's 49%, this is only slightly less than the proven reserves in Europe and Eurasia. In addition, the region has a number of very significant advantages:

- West Africa presents the opportunity for continued growth in production, with production in some countries like Nigeria only expected to start bouncing back after 2020.
- Most of the oil in the region is a type of sweet oil known as 'Bonny Light' that is comparable in quality to the oil in the North Sea and thus compatible with existing refining infrastructure in the West.
- The region has the potential to serve as a swing provider due to its proximity to both the US and Europe. This would effectively allow American and European companies to offset risks present in other, more distant regions.

However, it is not easy to operate in West Africa. For example, Nigeria produces 40% of the region's oil and this is expected to grow to 60% by 2040.[170] However, operations in Nigeria are sporadically disrupted by up to 500 thousand barrels per day.[171] The social context is also challenging. The Niger Delta, for example, where most of the onshore rigs are, has been the site of violent struggles related to oil since the 90s. Moreover, companies can pay very high reputational costs by being associated with the region's problems. Shell, for example, is permanently under attack by global NGOs such as Amnesty International for its failure to address the spills in the Niger Delta.[172] Whilst Shell blames the spills on theft and illegal refining, the company also accepts some level of responsibility and has even agreed to settlements of $84 million with some of the communities affected by the spills.[173] These kinds of scandals can have a hefty cost to the value of traded oil companies like Shell.

A final consideration is that much of the potential in the region lies in deep waters off the West African coast. Whilst deep-water production could avoid many of the political problems associated with inland production, it also comes with higher break-even prices. Moreover, even if a company avoids running into one of these scandals, political risks in the region also threaten investment. For example, a territorial dispute between Ghana and Ivory Coast recently placed Tullow Oil at risk of losing investments.[174]

All in all, technical and political challenges significantly raise the risk factor attached to the region. As such, it was not particularly surprising to see that the region was amongst the first to be hit by low oil prices, with majors such as Shell and Total delaying projects totalling more than $13 billion as early as April 2015.[175]

170 IEA, "Africa Energy Outlook: A Focus on Energy Prospects in Sub-Saharan Africa" (Paris, France: International Energy Agency (IEA), 2014), 93.

171 EIA, "Country Analysis Brief: Nigeria" (Washington, DC: U.S. Energy Information Administration (EIA), 2016), 1.

172 Amnesty International, "Shell: #makethefuture – Clean up the Niger Delta!," *London, U.K.: Amnesty International,* 2016, https://www.amnesty.org/en/latest/campaigns/2015/11/shell-clean-up-oil-pollution-niger-delta/.

173 BBC, "Shell Agrees $84m Deal over Niger Delta Oil Spill," *London, U.K.: BBC News,* 2015, http://www.bbc.com/news/world-30699787.

174 cf. M Kavanagh, "Tullow Braced for Tribunal's Ruling over Key Ghana Oil Block," *London, U.K.: Financial Times,* 2015, https://www.ft.com/content/3fbb60ee-e841-11e4-baf0-00144feab7de; Tullow Oil, "Ghana and Côte d'Ivoire Maritime Boundary Arbitration Update," *London, U.K.: Tullow Oil,* 2015, http://www.tullowoil.com/media/press-releases/ghana-and-c%C3%B4te-d-ivoire-maritime-boundary-arbitration-update-April-2015.

175 C Adams and E Crooks, "Shell and Total Delay West Africa Projects after Oil Price Rout," *London, U.K.: Financial Times,* April 27, 2015, http://www.ft.com/cms/s/0/cf467788-ecbc-11e4-b82f-00144feab7de.html#axzz4FmsYbBlf.

be *better*, the world will face a growing need to compare producers on the basis of their environmental impacts. This will be key for the third policy recommendation offered in the following chapter.

## Society

A group that is keen to remind the world that fossil fuels are bad for the environment is the divestment movement. CarbonTracker, an organization that has become a strong supporter of the cause, notes that investment in fossil fuels is driven by "scenarios that assume business as usual and so there may be a risk assessment 'gap' between a management's view of the future and that which would result from action on climate change, technology developments and changing economic assumptions".[176] To the extent that uncertainty is indeed present, investors should be wary of fossil-driven portfolios. That said, strictly from a financial perspective, how much you invest in fossil fuels is a function of how good of an investor you (think you) are. It is ultimately your risk. But the divestment campaign goes further, calling for a shift of resources away from fossil fuels because they are inherently harmful for the planet:

> *Divestment is the opposite of an investment – it simply means getting rid of stocks, bonds, or investment funds that are unethical or morally ambiguous... Fossil fuel investments are a risk for both investors and the planet, so we're calling on institutions to divest from these companies.*[177]

The need to find workable agreements has led the divestment movement to favour selective divestment from the most harmful fossil fuels, typically fuel but lately also oil sands. For example, in a post entitled *'Norway will make (coal) history'*, the divestment movement hailed the decision by the Norwegian Parliament to divest Norway's Sovereign Fund from companies that produce energy using over 30% coal.[178] The Church of England's decision to divest from thermal coal and tar sands was received similarly.[179] In September 2015, the University of California joined the divestment cause by announcing the sale of two hundred million dollars of assets in coal and oil sands.[180] Finally, in one of the biggest symbolic hits that the oil industry has received in its history, two of the three biggest foundations associated with the Rockefeller family have announced their support for divestment. One of them, the Rockefeller Brothers Fund, is amongst the founders of the movement. And most significantly, the second foundation, the Rockefeller Family Fund, went as far as to single out ExxonMobil as morally reprehensible.[181] As was seen in the first chapter, ExxonMobil is the largest direct survivor of the breakup of Rockefeller's Standard Oil's monopoly.

### Efforts to regain acceptability

The oil industry is very aware of the losses in acceptability that they have incurred over time. It has tried to respond through different avenues.

## Standards

In the past few decades the industry has gone to great lengths to improve its social and environmental footprint. The driving force behind this phenomenon is standards.

It would be impossible to perform an extensive overview of all the technical standards used by the oil industry. A catalogue prepared by the International Association of Oil and Gas Producers – with its 129 pages of densely-packed tables – barely scratches the surface.[182] This is only a list of technical formal standards from the International Standard Organization (ISO) and the International Electrotechnical Commission (IEC), rather than a comprehensive list of all formal and non-formal standards currently driving the industry.

Most of these standards are very specific. They focus on improving aspects of daily operations to minimize risks, and are usually enforced in contracts. For example, in a conference about offshore oil, the owner of a medium-size oil services company explained that they would have no choice but to meet the standards required of them, even if they disagreed with them.[183] Because they are being enforced through contracts across the industry, the net effect is, *in theory*, a more efficient and less accident-prone oil industry.[184]

176 CarbonTracker, "The Fossil Fuel Transition Blueprint," *London, U.K.: CarbonTracker,* 2015, http://www.carbontracker.org/report/companyblueprint/.

177 Fossil Free, "What Is Fossil Fuel Divestment?," *Brooklyn, NY: 350.org,* 2015, http://gofossilfree.org/what-is-fossil-fuel-divestment/.

178 L Hazan, "Norway Will Make (Coal) History," *Brooklyn, NY: 350.org,* 2015, http://gofossilfree.org/norway-will-make-coal-history/.

179 M Mattauch, "Church of England Divests from Dirtiest Fossil Fuels," *Brooklyn, NY: 350.o*rg, 2015, http://gofossilfree.org/church-of-england-divests-from-dirtiest-fossil-fuels/.

180 L Gordon, "UC Sells off $200 Million in Coal and Oil Sands Investments," *Los Angeles, CA: LA Times,* 2015, http://www.latimes.com/local/education/la-me-ln-uc-coal-20150909-story.html.

181 T Wade and A Driver, "Rockefeller Family Fund Hits Exxon, Divests from Fossil Fuels," *London, U.K.: Reuters,* March 24, 2016, http://www.reuters.com/article/us-rockefeller-exxon-mobil-investments-idUSKCN0WP266.

182 IOGP, "Catalogue of International Standards Used in the Petroleum an Natural Gas Industries" (London, U.K.: International Association of Oil and Gas Producers (IOGP), 2012).

183 Anonymous Source, "Q&A Session | Panel: Risks and Rewards in Challenging Jurisdictions" (Offshore Energy Forum 2015, Amsterdam, Netherlands, October 14, 2015).

184 The actual net effect can be debated. Any regulatory framework, state or non-state, formal or informal, can be blamed for any accidents that occur. In this sense, standards are not less prone to blame-shifting than any other issue where human error is involved. It is always possible to blame the operator of a system for its failure – either by act or by omission they could have prevented failure at some point in time. The same is true of standards, they can always be blamed for not having been stronger or weaker. The corollary is that rather than looking at them as being the key to eliminate accidents, standards should be pursued under the idea that there is a balance between flexibility and strictness that minimizes accidents. The issue of whether the oil industry has achieved said balance is, however, a debate that is well beyond the scope of this report.

Since significant disapproval of the oil industry derives from unfortunate events such as oil spills, furthering and communicating improvement efforts in the use of standards could potentially aid the industry's acceptability.

## Carbon Capture & Storage (CCS)

A topic that usually comes up when you talk about fossil fuels and their role in climate change is CCS. This topic is most prominent when the discussion relates to coal and natural gas, or high-polluting industries such as cement. The idea of CCS becomes significantly less definite when the conversation moves to oil. The prospect of capturing carbon from the billion or so vehicles in the world is certainly a challenge. That said, the idea of implementing CCS in the oil industry, as means of compensating emissions as a whole, is not unheard of.

The basic logic is that of a carbon sink. CCS aims to offset the emissions generated by fossil fuels by storing these emissions underground. By storing tons of carbon, regardless of where they come from, the industry can offset emissions that are happening nonetheless. In theory, these offsets could be claimed against the potential impact of the oil being extracted, which would enable the oil industry to operate with net zero carbon footprint (or at least with much less impact). This could serve as counter-argument against groups that, like divestment, decry the effect that oil has to global warming.

Forecasts about the future of CCS are varied. One of the activities attended during this fellowship was a workshop about CCS organized conjointly by the Knowledge Transfer Network (KTN), the Carbon Capture and Storage Association (CCSa), the Coal Research Forum (CRF), the Advanced Power Generation Technology Forum (APGTF), and the UK Carbon Capture & Storage Research Centre (UKCCSRC). This activity was specifically about the "role for R&D in delivering cost-competitive CCS projects in the UK in the 2020s" and included CCS experts across different disciplines. Panels gave an overview of the technological developments thus far and the milestones that still need to be achieved. The challenges pending are significant. No one in the industry is underplaying the technological challenge. However, the general agreement was that cost-efficient CCS can be achieved given the necessary financial support during the current early stages.

However, that is indeed the very core of the problem. The level of investment that CCS seems to need to stand a fair chance is significant. In contrast, the mood for investing in CCS is not high. In November last year, for example, the UK government cancelled a £1bn CCS competition. The most concerning fact is that this was not an isolated event. The situation is similar across Europe. For example, whilst acknowledging that the climate change agenda cannot be realised without CCS, the European Commission acknowledges that the EU is far from meeting the goals agreed upon:[185]

> *In June 2008 the European Council, asked the Commission to propose as soon as possible an incentive mechanism for Member States and the private sector to ensure the construction and operation of up to 12 CCS demonstration plants by 2015 to contribute to mitigation of climate change. This target has not been reached and there are only two large scale CCS plants operating in Europe (both in Norway).*
>
> *The Commission's position on CCS has been confirmed in a number of policy communications. To reach the decarbonisation targets, CCS will need to be deployed from around 2030 onwards in the fossil fuel power sector. In the longer term, CCS may be the only option available to reduce direct emission from large scale industrial processes.*

When you take the difficulties of implementing a CCS research and development agenda into account, the mood changes. For example, Imperial College recently ran a CCS workshop entitled 'Is carbon capture and storage dead'?[186] In this workshop, available online through YouTube, most panellists, also experts in the field of CCS, agreed that the political narrative is indeed not favourable for CCS.

It is worth highlighting a comment made in this workshop by Dr Graeme Sweeney, Chairman of the Zero Emissions Platform coalition. He believes that the UK should in fact already be implementing CCS rather than looking for R&D funds.[187] Dr Sweeney's comment highlights a positive and a negative aspect of CCS. On the one hand, it shows that the technology is already capable of performing the required task – albeit perhaps not as efficiently as desired. On the other hand, however, the fact that the world is still unclear about how to fund research whilst the technology should already be being rolled out highlights that the political aspect of CCS is extremely challenging, perhaps too challenging.

As a whole then, it seems clear that, if it works, CCS could potentially enhance the industry's acceptability. What is uncertain is the extent of said effect. Many would still consider the industry less acceptable than non-emitting alternatives.

Moreover, there is evidence to indicate that CCS would likely be rejected at implementation stages even if there was money to fund its development. The reason is known as the 'not in my backyard' (NIMBY) phenomenon. Support for some technologies such as CCS may exist when thinking abstractly about them, but rejection skyrockets when people have to face the idea of allowing CCS operations nearby them.[188]

185 EC, "Annex 2: Report on Review of Directive 2009/31/EC on the Geological Storage of Carbon Dioxide," *Brussels, Belgium: European Commission (EC)*, 2015, 3, http://ec.europa.eu/clima/policies/strategies/progress/docs/com_2015_576_annex_2_en.pdf.

186 Energy Futures Lab, *Is CCS Dead And, If Not, How Do We Resuscitate It?* (London, U.K.: Energy Futures Lab, Imperial College London, 2016), https://www.youtube.com/watch?v=yJC-7hW1E18.

187 Ibid., min 22-23.

188 e.g. B W Terwel and D D Daamen, "Initial Public Reactions to Carbon Capture and Storage (CCS): Differentiating General and Local Views," *Climate Policy* 12, no. 3 (May 1, 2012): 288–300; R M Krause et al., "'Not in (or under) My Backyard': Geographic Proximity and Public Acceptance of Carbon Capture and Storage Facilities," *Risk Analysis* 34, no. 3 (March 2014): 529–40.

Perhaps most importantly, what is absolutely uncertain at this point in time is the source of the funds that could drive CCS. It may be unrealistic to expect governments to sponsor such an expensive research programme, particularly when companies themselves are not investing in it – at least not to the extent needed. If neither companies nor governments are willing to do the investment, who will?

### Other efforts

It seems evident that, at least in the short term, CCS will not be directly implemented in every car and truck on the planet. Ergo, the reasonable way to think of CCS is as a way through which the oil industry's net carbon contribution could be lowered. This is a concept that is not particularly different to emissions offsetting, which is typically done through carbon trading. This leads to the notion that the industry could also attempt to offset emissions through other mechanisms.

This author has heard, for example, of offsetting emissions through getting oil companies involved in large-scale forest management.[189] Whilst the idea could seem unnatural at first, and although this report is not endorsing it (which would require a full analysis of its viability from both an environmental and a financial perspective), the rationale is simple. The more trees there are in the world, the more emissions can be offset. Some of the emissions ultimately generated by the oil produced by oil industry could be offset through further forest coverage. Similarly, as was mentioned earlier, some companies are pushing for higher carbon prices in carbon trading.

Alternatives for offsetting emissions should be considered thoroughly. In the same way that the Seven Sisters built their brands, visionary oil companies could launch their own brands of transportation fuels attached to well-calibrated (and well-certified) carbon prices. As such, the point this section wants to make is not that any particular technology should be implemented but rather, that there is no shortage of ideas about how to minimize the net impact of the oil industry. These should be explored consciously.

## Technology and adaptability

Oil adaptability to modern human challenges is such that oil has become virtually ubiquitous to human activity. There is no simply no complete alternative to oil even today. This adaptability to modern challenges explains why, and how, oil has been able to maintain its dominance of energy markets despite having faced calls for diversification ever since the oil embargo in 1973.

However, as this section will show, oil is under pressure from myriad competitors, and these competitors have been gaining terrain with regards to their adaptability. As this report is focused on oil, there is no space for cross-category comparisons. However, it is worth noting some trends that could significantly affect the future of oil.

### Transportation

One of the latest World Energy Outlooks (WEO) by the IEA believes that even if countries stick to their declared objectives the world will need approximately 3,400 million tons of oil equivalent (MToe) by 2040 just for transportation – 85% of which will come from oil.[190] This is more or less equivalent to slightly over 50 million barrels per day (or between 50 and 60 percent of oil demand today). BP claims that the main source of demand growth in the following decades will come from the transport sector.[191]

These numbers alone help to evidence the importance that demand from the transport sector has. However, even better evidence can be found, once again, in history. As explained by Spencer Dale when presenting BP's latest Statistical Outlook in London, it took 40 years after reaching 1% market share for oil to go past the 10% market share threshold.[192] To be clear, Dale interpreted this as evidence of the fact that energy technologies take a substantial amount of time to gain popularity due to the slow pace of change in infrastructure. This is undeniable. However, it is also true that this market share hike emerged in tandem with the popularization of the automobile in the US during the inter-war period.

Nowadays automobiles are a relatively short-term investment, with many people changing cars on a regular basis. Ergo, the assumption that demand is as sticky as in the 1920s is weak. Without this assumption, however, one needs to accept that changes in transportation technologies could significantly affect demand at relatively short notice.

### Bio-fuels and other liquid fuels

It was mentioned earlier that both rock and coal oil shared the name 'kerosene' at the dawn of the oil industry. This should make it clear that oil is not the only substance in the world that can be converted into energy-intensive liquids. It was, however, the most efficient, which soon made it the dominant choice. But that was some time ago. A similar competition is emerging nowadays, not from coal oil but from a new wave of vegetable oils: bio-fuels.

189 e.g. E Bettelheim, "Fossil-Fuel Sector Can Save Itself by Saving Forests," *Washington, DC: Ecosystem Marketplace*, 2015, http://www.ecosystemmarketplace.com/articles/opinion-an-open-letter-to-fossil-industry-save-yourselves-by-saving-forests/; E Bettelheim, "How the Fossil Fuel Industry Could Redeem Itself: Save Forests," *Oakland, CA: GreenBiz*, January 27, 2016, https://www.greenbiz.com/article/how-fossil-fuel-industry-could-redeem-itself-save-forests.

190 IEA, "World Energy Outlook 2015" (Paris, France: International Energy Agency (IEA), 2015), 76.

191 BP, "BP Energy Outlook 2016 Edition – Outlook to 2035," 22.

192 S Dale, "Energy in 2015: A Year of Plenty" (BP Statistical Review of World Energy 2016 [Presentation], BP PLC., London, U.K., June 8, 2016), 18, http://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-spencer-dale-presentation.pdf.

Bio-fuels are not an entirely new phenomenon. The very first Diesel engines were said to run on peanut butter oil and Henry Ford's original vision was to use ethanol to power his cars.[193] Nowadays, however, some countries produce enormous amounts of bio-fuels. For example, the US and Brazil combined produce nearly 50 million tonnes of oil equivalent in bio-fuels (~60% of world bio-fuel production).[194] Whilst still miniscule if compared to global oil output, this amount of bio-fuels is an already sizeable contribution to global energy.

The most common type of bio-fuel is known as 'first-generation' bio-fuels. These are the bio-fuels derived from food crops such as sugar cane or palm oil. The problem with these is that scaling them would result in serious land availability challenges. As explained by Demirbas and Balat:[195]

> *A 5% displacement of gasoline in the EU requires about 5% of available crop land to produce ethanol, while in the USA, 8% is required. A 5% displacement of diesel requires 13% of USA crop land and 15% in the EU. Land requirements for bio-diesel are greater, primarily because average yields (liters of final fuel per hectare of crop land) are considerably lower than for ethanol. Land requirements to achieve 5% displacement of both gasoline and diesel would require the combined land total of 21% in the USA and 20% in the EU.*

This is partly a regulatory impossibility as initiatives, both at state and non-state levels, seek to guarantee that only land that has previously been used for crops is used for bio-fuels (to avoid deforestation). It is also a competitive and moral conundrum, as any hectare of land used for bio-fuels is necessarily one hectare less of crops for human consumption. That said, there are commentators and experts that believe that there is huge potential for bio-fuel production in other places in the world besides those currently producing bio-fuels.[196] But the general feeling is that there seems to be a ceiling on what conventional bio-fuels can produce.

Further competition from bio-fuels could come from second (non-food crops such as wood products), third (engineered crops such as algae), and fourth (bio-fuels with an additional carbon sequestration component) generation bio-fuels. The financial viability of these has been improving over time. For example, in a conference by the Royal Society of Chemistry in London, Mark Howard, BP's former Conversion Technology Centre VP, overviewed a number of technologies that have closed the price gap differential once measured in oil equivalent terms. At this very moment, however, many of these initiatives are still in their infancy.

This is not to say that consumption of bio-fuels will not grow. It will. According to the latest IEA estimate, bio-fuels are already forecast to grow from 3% of total transportation fuel today to 8% in 2040.[197] However, this forecast has already been considered in the calculations of market demand for oil. Analysts believe that it is unrealistic to expect bio-fuels to grow beyond what forecasts expect.[198] This report is un-eager to endorse expressions of impossibility – the history of oil shows that success lies in breaking through such barriers. Given the need for funds for R&D, however, it is undeniable that low oil prices do affect late generation bio-fuels capacity to change demand past forecasts.

### [e]Mobility

A potential game changer lies in the increasing popularity of electric vehicles, a trend known as eMobility. Some people doubt that electric vehicles will even become popular because they are much more expensive than regular cars, require significant infrastructure to charge, and provide relatively limited autonomy. Despite these warnings, electric vehicles are already increasing in popularity.

Electric vehicles are becoming cheaper, easier to charge, and their autonomy is improving. In fact, although there is still a relatively low number of electric vehicles on the street (>1 million),[199] it needs to be considered that they have only been available on the market less than a decade. Moreover, sales have been skyrocketing in the past few years, with the number of electric vehicles on the roads tripling between 2013 and 2015.[200]

To an extent then, the question of whether electric cars will or will not become popular has already been solved by reality. They are being bought by customers and there is no evidence to indicate that further improvements in efficiency and price will lead to anything other than more demand. Some very serious sources have run analyses that forecast price parity against conventional vehicles as soon as 2022.[201]

The real question is whether further popularization will weaken demand for oil beyond what is already expected.

193 Cf. National Geographic, "Biofuel Facts, Biofuel Information," *Washington, DC: U.S. National Geographic Society*, 2016, http://environment.nationalgeographic.com/environment/global-warming/biofuel-profile/.

194 BP, *BP Statistical Review of World Energy – June 2016, 39.*

195 M F Demirbas and M Balat, "Recent Advances on the Production and Utilization Trends of Bio-Fuels: A Global Perspective," *Energy Conversion and Management* 47, no. 15–16 (September 2006): 2375.

196 E.g. E Kirieieva, "Biofuels Production: World Experience and Possibility for Developing in Ukraine," Економіка. Фінанси. Менеджмент: Актуальні Питання Науки І Практики 4, no. 1 (2016): 7–14.

197 IEA, "World Energy Outlook 2015," 363.

198 Ibid.

199 S Yeo, "IEA: There Are Now More than One Million Electric Cars on the World's Roads," *London, U.K.: Carbon Brief*, June 2, 2016, https://www.carbonbrief.org/iea-there-are-now-more-than-one-million-electric-cars-on-the-worlds-roads.

200 B Plumer, "The Stunning Growth of Electric Cars, in Four Charts," *New York, NY: Vox*, June 6, 2016, http://www.vox.com/2016/6/6/11867894/electric-cars-global-sales.

201 T Randall, "Here's How Electric Cars Will Cause the next Oil Crisis," *New York, NY: Bloomberg.com*, 2016, http://www.bloomberg.com/features/2016-ev-oil-crisis/.

This is a rather uncomfortable question for oil and non-oil enthusiasts alike.

On the one hand, it is not necessarily true that electric cars are completely environmentally friendly. The share of total energy generated by solar and wind is still relatively low, between 1-2% when accounting for all sectors.[202] Assuming that electric cars do become popular and electricity demand grows at the expense of demand for oil derivatives such as gasoline and diesel, where will the required extra electricity generation for the vehicles come from?

If electric cars are not charged through renewables, their net impact on the environment may in fact be higher than conventional cars – once we account for generation, transmission and storage losses.

Of course, there is room for deliberation here. Better fossil fuels, overnight generation from existing renewables, better transmission networks, and better storage could improve the net benefit of electric vehicles. But existing infrastructure is simply not enough to cover a boom in electric vehicles. Investment will eventually be imperative. The inevitable question is whether investing in renewables will be more attractive than investing in fossil fuels if electric cars do take off. This is a question for which no one has an answer at the moment.

A secondary consideration in this regard is the issue of changes in acceptability of different technologies across time. The fact that one technology is currently acceptable should not be interpreted as a declaration of the continued acceptance of said technology. This is extremely important because there are no risk-free technologies. We may not be aware of the potential consequences of new technologies, but they do exist and may eventually increase in importance.[203] For example, electric cars depend on improvements in energy storage (batteries). However, the production of batteries entails significant environmental consequences.[204] Higher scrutiny of these consequences, which may arise alongside scale, may lead to the rejection of battery-based eMobility.

On the other hand, however, this is also an uncomfortable question for oil. The reason is that only a very small proportion of electricity generation comes from oil (~4% of global generation). As was mentioned earlier, however, oil was increasing in importance as a source of electricity generation prior to 1980. Moreover, it *is* possible to produce electricity with oil. This shows that oil has already been displaced from the electricity market. Any shift from transport-oriented liquid fuels to electricity-oriented non-liquids (batteries or else) will hurt demand for oil without much room for oil to strike back. One such shift may perhaps aid demand for other fossil fuels such as gas, but oil does not seem to be in a position to regain electricity-generating market share.

Accordingly, if electric cars proliferate at the expense of conventional cars, the only way oil could remain competitive would be to further slash prices. However, such a move would further a different kind of availability (inter-fuel availability – i.e. oversupply of many different types of fuel options for a similar purpose). This would likely snowball into an even worse affordability nightmare for the industry, and perhaps even beyond the industry.

eMobility could become a very significant exogenous pressure to demand for oil. This is true with or without the assistance of any technologies other than battery-powered electric vehicles. However, allow me to introduce a last consideration just for the sake of inviting the reader to imagine un-forecast, 'black swan' futures.

A clarification is necessary. This chapter begun by stating that plans cannot be made upon unknowns. It would be irresponsible to make policies that bet the future of humanity in any-one technology. We simply do not know the which(s), when(s), or how(s). However, we do know that there are many technologies besides those addressed thus far. Inasmuch as it would be irresponsible to plan on the basis of unknowns, it would be even more irresponsible to strategize as if these were inexistent or irrelevant. Currently there is no lack of technologies that could add further exogenous pressures to oil demand, or even find synergies between themselves.

Think of hydrogen cells, for example. In very basic terms, hydrogen cells convert hydrogen into electricity that can then be used to power an electric engine. A car powered both by batteries and hydrogen cells would be far too expensive to sell at the moment. However, there could be unimagined synergies available with regard to all the other components of electric vehicles that could further demand for electricity at the expense of oil derivatives.

Or think about gas, another fuel that is gaining ground in transportation at the expense of oil. Estimates by the US Department of Energy place the number of natural gas vehicles (NGVs) at about 15.2 million worldwide.[205] Major companies also seem to agree that there is potential to expand gas-powered transportation further. It is possible to find gas-powered ships and trucks from major manufacturers.[206] Likewise, Boeing has a project that

202 S Teske, S Sawyer, and O Schafer, *Energy [R]evolution: A Sustainable World Energy Outlook 2015* (Amsterdam, Netherlands: Greenpeace International, 2015), 39.

203 cf. U Beck, *Risk Society: Towards a New Modernity* (London, U.K.: SAGE, 1992).

204 cf. D A Notter et al., "Contribution of Li-Ion Batteries to the Environmental Impact of Electric Vehicles," *Environmental Science & Technology 44*, no. 17 (2010): 6550–6556; M C McManus, "Environmental Consequences of the Use of Batteries in Low Carbon Systems: The Impact of Battery Production," *Applied Energy* 93, no. 1 (2012): 288–295; E Behrmann, "Green Batteries' Graphite Adds to China Pollution," *New York, NY: Bloomberg.com*, 2014, http://www.bloomberg.com/news/articles/2014-03-14/teslas-in-california-help-bring-dirty-rain-to-china

205 US Dept. of Energy, "Alternative Fuels Data Center: Natural Gas Vehicles," *Washington, DC: United States Department of Energy*, 2016, http://www.afdc.energy.gov/vehicles/natural_gas.html.

206 e.g. Rolls-Royce, "LNG Fuelled Engines," *London, U.K.: Rolls-Royce*,

suggests LNG could soon be used in aircraft propulsion instead of kerosene.[207]

This is not to say that either battery-powered, hydrogen, and/or gas-powered transportation is ready to disrupt oil's dominance in transportation markets. Sales of gas-powered vehicles, arguably the largest of these three technologies, were struggling even prior to the drop in oil prices.[208] However, what this report wants to make clear is that competition for the transportation fuel market already exists. Whilst the pressure from each technology may be small when seen in isolation, market share losses could add up.

Moreover, just as some of these technologies could end up competing against each other, synergies between them could unravel. Some of these synergies are known. For example, hydrogen-gas mixtures can improve the efficiency of combustion engines.[209] Other synergies may yet be discovered. Regardless, given that the rate of innovation of all the alternatives to oil seems to be higher than within the oil industry, it is hard not to agree with the comment made recently by Jaffe and van der Veer:[210]

> *Eventually, players who remain competitive in the oil and gas industry will have to consider whether it can be more profitable to shareholders to develop profitable low-carbon sources of energy as supplement and ultimately replacements for oil and gas revenue sources.*

Even if someone is not ready to go as far as Jaffe and van der Veer and consider low-carbon sources of energy as full replacements for oil, to the extent that oil actors deny the extremely high pressure they could have on oil demand – including the risk of their impact being much greater than forecast – the response of the oil industry is likely to be deficient. For the mere fact that such thing would be akin to ignoring reality.

## The debate about subsidies

One of the latest trends in energy politics is the increasing frequency with which arguments against oil subsidies are raised. This is partially a result of the declining acceptability of oil – via the argument that the world should not subsidize what it does not desire, as well as partly a result of the fact that alternatives have been improving in their ability to cover our energy needs – via the argument that subsidies create unfair competition. As will be seen in the policy recommendations, this report also argues against subsidies. Before doing so, however, this section aims to briefly highlight the strength of the arguments against subsidies that have already been made by others.

Currently, the most disseminated publication about energy subsidies is the one published by the IMF about a year ago. In the words of the authors, "despite the sharp drop in international energy prices, post-tax subsidies have remained high, at 5.8 percent of global GDP ($4.2 trillion) in 2011, 6.5 percent ($4.9 trillion) in 2013, and also 6.5 percent ($5.3 trillion) in 2015".[211] Of these, about $1.6 trillion are used to subsidize oil.[212] The IMF's paper is, however, only the latest – although arguably the most accurate – estimate. Publications against subsidies for energy, and specifically for fossil fuels, have been mounting up.[213]

Another noteworthy report about energy subsidies reform, published just a couple months after the IMF study, was presented by Columbia University's School of International and Public Affair's (SIPA) Center on Global Energy Policy. SIPA's report holds that, far from being a reason to keep subsidies, low oil prices represent an opportunity to reform energy subsidies.

SIPA's report is particularly interesting because it addresses one of the main counter-arguments given by those who support energy subsidies: that the cost of not subsidizing the oil industry, particularly with regard to employment, is enormous. SIPA addresses this by highlighting the need to counterbalance losses:

> *To further mitigate the risk of public backlash, governments should rapidly replace fuel subsidies with social policies, cash transfers, and other productive investments that benefit the poor and other immediate losers from fuel subsidy reform.*[214]

The point of quoting this extract in the present report is not to say that energy subsidies should be replaced with other subsidies. That is a whole different debate outside the scope of this piece of research. However, the extract highlights that even authors friendly to the idea of subsidies are calling for *fuel subsidies* to be removed.

2016, http://www.rolls-royce.com/sustainability/performance/case-studies/lng-fuelled-engines.aspx; Freightliner, "114SD NG," *Portland, OR: Freightliner Trucks*, 2016, https://freightliner.com/why-freightliner/industry-leading-results/natural-gas/.

207 Boeing, "2014 Environment Report: Build a Better Planet > Future Flight," *Chicago, IL: Boeing*, 2014, http://www.boeing.com/aboutus/environment/environment_report_14/2.3_future_flight.html.

208 cf. B Tita, "Slow Going for Natural-Gas Powered Trucks," *New York, NY: The Wall Street Journal (WSJ)*, August 25, 2014, http://www.wsj.com/articles/natural-gas-trucks-struggle-to-gain-traction-1408995745.

209 S O Akansu et al., "Internal Combustion Engines Fueled by Natural Gas—hydrogen Mixtures," *International Journal of Hydrogen Energy* 29, no. 14 (November 2004): 1527–39.

210 A M Jaffe and J van der Veer, "What Happens When Oil Demand Peaks?," *S.l.: EnergyPost.eu*, May 23, 2016, http://www.energypost.eu/happens-demand-oil-peaks/.

211 D Coady et al., "How Large Are Global Energy Subsidies?," Working Paper (Washington, DC: International Monetary Fund (IMF), 2015), 18.

212 Ibid., 29.

213 E.g. UNEP, "Reforming Energy Subsidies: Opportunities to Contribute to the Climate Change Agenda" (Nairobi, Kenya: Division of Technology, Industry and Economics, United Nations Environment Programme (UNEP), 2008); J Arze del Granado, D Coady, and R Gillingham, "The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries," *World Development* 40, no. 11 (2012): 2234–2248; B Clements et al., "Energy Subsidies: How Large Are They and How Can They Be Reformed?," *Economics of Energy & Environmental Policy* 3, no. 1 (2014).

214 K Benes et al., "Low Oil Prices: An Opportunity for Fuel Subsidy Reform" (New York, NY: Columbia | SIPA Center on Global Energy Policy, 2015), 5.

# Conclusions and policy recommendations

In very broad terms, this report finds that the future of oil will be one of increased risks and uncertainty toward its affordability as an investment, often in contradictory manners. To address this, the industry, and the world indeed, will have to face a rather challenging dilemma of choosing between cooperation and competition. Why?

As we saw in the first chapter, oil's current market dominance is a result of its ability to 'solve' the 4A+A challenge (availability, accessibility, acceptability, adaptability, affordability). In a nutshell, little by little, oil found a way to set the benchmark approach to all these energy security challenges. A decline in oil's ability to meet any of these needs automatically reduces the competitiveness of oil.

The subsequent analysis of realities that could jeopardise oil's ability to meet the 4A+A challenge was approached from two perspectives: first, from a supply perspective (chapter 2) and then from a demand, or context, perspective (chapter 3). The chapter about supply showed that excessive availability is cause of significant risks and uncertainty toward affordability. The chapter about the context shows that the loss of acceptability and adaptability vis-à-vis competitors also raises risk and uncertainty with regard to the long term demand for oil, and by extension also its affordability.

Oil's position as the quintessential source of energy has become questionable. This does not mean that oil will disappear as a fuel. Barring unexpected events (that could, nonetheless, happen), there is no evidence for such a claim. However, there are far too many risks, and in particular a very high level of uncertainty about the impact that many variables (such as storage for example) can have, to think the oil industry can come out unscathed. There are also far too many competing technologies, and some of these could further lower demand for oil unexpectedly.

It is clear that some producers will be forced to lower their contribution to the market one way or another – via agreement or because they cannot withstand the pressure. Even if some of these later re-join, there will be a price to pay. This is how the industry has worked ever since its inception. Trying to avoid such a reality would be like swimming against the very powerful '4A+A' current that has determined the fate of oil for millennia.

At the same time however, and as oppose to prior crises, there is little prospect of unexpected increases in the uses or need for oil as to think the oil industry's affordability problem could be solved through demand. Moreover, even if some producers do exit, and even if many of them are unable to re-entry, the possibility of production raising yet again if prices increase is undeniable.

Thereby, the oil industry is looking at a substantial time of significant affordability challenges. This is either due to continued low prices (if re-entries are speedy), high levels of seasonal volatility (if there are delays to re-entries or if cuts are intentionally intermittent or simply not sustainable), and/or reduced demand (if other fuels capitalise on oil's relative losses in acceptability and adaptability).

The question is therefore not how to avoid this time of struggle but how to manage it. This question is as valid for the oil industry as it is for society. For the former, because it is a business reality. For the latter, because, in one way or another, the future of oil will greatly determine the future of society. This is the question that this chapter intends to address. How to manage the future of oil given the affordability crisis that it faces and the irreconcilable challenges beneath?

Speaking generally, two discernible approaches to managing oil's future can be seen to characterise oil markets. One is made by those who call for cooperation in energy markets, in particular through price management via production cuts. The other is to let markets thrive through competition.

A good rule of thumb to find out the group that you belong to is to ask yourself if you would welcome cuts from a given producer(s). If you think that OPEC should cut production (as announced days prior to the publication of this report), you are probably in the group of those amicable to the idea of fixing affordability via coordination (cooperative track). If, on the other hand, your reaction is to think that the least viable companies should just give up and leave the market, you are probably amongst those that would prefer to let markets do their job (competitive track).

Taking sides on this debate would be counterproductive for a study that aims to inform the long term, as oil markets have historically moved back and forth between cooperation and competition. Today, many hope cooperation can ameliorate challenges given that OPEC announced a cut agreement. But cuts (present or future) may or may not be delivered, and they may or may not be sustainable. Unequivocally, however, the pendulum eventually comes around.

Even more important is the fact that 4A+A will not suddenly become irrelevant in either the cooperative or the competitive scenario. Regardless of the choice, the 4A+A will continue to determine the future of oil. Thus, what this report will do is to highlight the policy recommendations that would help to minimize the impact of the crisis and improve the odds for a sustainable outcome in either scenario.

Before entering the recommendations for each of the 'tracks', it is fundamental to highlight that the two options are greatly incompatible. This will become clearest as the argument flows. In a nutshell, however, it can be said that the incompatibility comes down to a dissonance between the ideas driving each track. The cooperative track places faith in the ability to plan the future (thereby constrains action by design), the competitive track relies on each actor's capacity to respond to the future (thereby requires minimizing constrains to agency).

In such manner, it needs to be clear that the recommendations that seem compatible with the idea of ensuring global security via price coordination run against the recommendations that would improve the future competitiveness of oil as such. There are trade-offs between security and competitiveness.

## Cooperative Track

A lesson that can be extracted from the second chapter is that the world has yet to discover the speed with which oil production can re-enter the market if prices increase. This puts a question mark next to the issue of the duration through which the losing actors will have to bear the costs of the struggle. Similarly, it is still unknown if the future of oil, for the time being, will be one of continued low prices or one of cyclical volatility; not to forget that the challenge could be compounded by further un-forecasted losses in market share. This means that some losers may in fact never stop losing.

Those producers that most depend on the profits of oil, typically countries with intense political pressures, are likely to be hurt the most. This can be clearly seen in Venezuela today, and perhaps will be seen in other countries tomorrow. But since availability is unlikely to fall by itself, the only way for prices to reach a level that could ensure security in fragile regions would be via agreements and cooperation (such as production cuts).

This is an idea that is already far-fetched. Coordination of this kind would require an unprecedented level of collaboration between OPEC and non-OPEC countries. This is not to say that it cannot happen. Production cuts have been attempted in the past, to some success. Moreover, OPEC/non-OPEC dialogue seems to have been integral to OPEC's ability to deliver the 2016 cut agreement. More cuts, and/or other sorts of cooperation, will surely be suggested in the future.

One problem with cooperation, particularly with supply cuts, is that even if they do happen, they are extremely difficult to sustain – as Saudi Arabia found out back in the 80s. Moreover, even if they could indeed be sustained, the biggest contradiction is that, cooperation would most likely harm the long term competitiveness of oil.

This is partly because any kind of supply-reducing agreement would enhance global security by forcing some production out of the market by design (partially or fully). To become stronger, the industry needs to find out where the best practices are. But there is no way to know if the producers that would exit as result of political agreements would coincide with those that would have been eliminated by market competition (and thereby those who would have strengthened the industry).

What if the world ends up with the least efficient producers driving the future of oil instead? This may serve global security but it will definitely not improve the competitiveness of oil per se (I leave it to the reader to decide if this is positive or negative). It could also potentially harm the environment further by leaving in place the worst of the strategies that are already considered evil by some.

However, the dilemma exists also partly because being cheap is among the main reasons why people use oil. Agreements that foster high oil prices would enhance the acceptability and adaptability of other technologies relative to oil and thereby increase competitive pressures on oil (also for the reader to judge normatively). It is unlikely that oil would come out ahead of other sources of energy if consumers have to pay the same for oil as they would for other sources of energy. Moreover, it is also unlikely that the myriad technologies out there have reached their innovation plateau. Given that there are so many emerging alternatives to oil, the likelihood of a technological leap outside the industry is significant.

In a nutshell then, the higher the price of oil, the less competitive the oil industry will be forced to be at a time when it needs to be so. Furthermore, the higher the price of oil, the more other technologies will be desired (at a time when oil is already being rejected by many), and the more funds will be available for R&D of other technologies (at a time when oil is losing ground vis-à-vis other fuels).

This is not to say that those who desire higher oil prices via cooperation are necessarily wrong. This report understands those who still think that agreements should be reached to ensure prices with which the world can live. Furthermore, sectors of society that are not typically in support of oil could potentially see price agreements positively, as they would increase the interest in developing alternative technologies. And the best argument in favour of coordination that this author has found, thus far, is that that the security of the world is likely more important than any one industry. Particularly as the consequences of protracted oil-related geopolitical instability could be catastrophic.

Regardless, it needs to be clear that the cooperation that seems to be compatible, perhaps necessary, with global security runs against the need for competition that seems necessary to improve the future of oil per se. With two potential caveats.

### Offsetting emissions

It seems unlikely that oil will regain acceptability on the environmental front without at least trying to do something to reduce net system emissions (offsetting). Thus, if the world is to pursue price coordination, the first policy recommendation follows.

**Cooperative Track Recommendation #1:**

*The oil industry needs to find a way to offset net system emissions.*

This is most true for those who are fond of the oil industry and would thus like to see it make part of the future. It is rational for a producer to suppose that oil has a future and invest in CCS, carbon trading, or an alternative offsetting framework.

Admittedly, it is less rational for a producer to suppose that there is no future in oil and still invest in offsetting technologies.[215] If actors are ready to abandon oil, partially or fully, they should focus on the following policy recommendation (a paragraph below). Regardless, what seems to be irrational and indeed massively risky is to continue pursuing oil as a long-term economic strategy without investing in some sort of offsetting effort. Particularly if, at the same time, prices are comparable to other technologies (which would result from artificially inflating prices via cooperation).

### Diversification

Some hope that the same funds that would come from high prices could be used to diversify the economies of producing countries, and the infrastructure of traded oil companies. This is an optimistic view that should be encouraged. Hence, the second policy recommended if the choice is to pursue a cooperative track.

**Cooperative Track Recommendation #2:**

*Producers need to diversify their sources of income.*

It is also important to be very frank about it. This is not a particularly novel recommendation. It would not be the first time that such a move has been attempted. Producing countries such as Saudi Arabia have been trying to diversify their economies for at least four decades.

It is true that plans such as Vision 2030 seem to have reasonable prospects of success. However, as it was dully elaborated in the second chapter, the obstacles to implementation are significant. Likewise, as it was highlighted in the 'info-box' about the North Sea, many traded companies are already diversifying into other business areas. Yet, these efforts are still in their infancy; declaring victory would be massively premature.

The point is not to be pessimistic about it though. This author has found no evidence whatsoever to reject the likelihood of success for current diversification strategies. Thus, diversification is considered to be plausible. But a healthy dose of realism is necessary. This time around it is imperative to succeed as, as explained, the cooperative way to high prices (and therefore the necessary funds for diversification) would risk oil's very competitiveness. This is like dismantling your house in the hopes of having enough wood to keep you warm through winter.

Because winter is coming.

## Competitive Track

There are indeed strong counter-arguments against calls for cooperation. The first is that such a strategy would be impossible to apply to all industries. It would lead to a generalized lack of competitiveness. It is then a very exceptional attitude to oil. The second, and arguably the most potent one, is that it is unrealistic. The idea of being able to coordinate such a complex market as that of oil may in fact be a chimera. Not because it is impossible to suggest or even agree to try. OPEC has shown you can try and achieve some results. However, time and again, sustaining cooperation has shown to be next to impossible. Also, even if sustained, OPEC may have already lost its ability to significantly influence prices due to the complexity of contemporaneous energy markets. If this is the case, agreements could end up being a face saving measure with only some minimal effect (sending markets into a competitive track regardless of whether it is acknowledged or not).

The alternative is to allow markets to do their job. Evidently, as history does show, there will be losers in the process. There will also be a cost to society. However, as the first chapter shows, competition has traditionally led to improved ways to solve the 4A+A. In turn, the way in which society's energy needs are addressed has improved each and every time.

This does not mean, however, to do nothing. For competition to happen, and to ensure that said competition responds to societal interests, there are challenges that need to be addressed.

### Stimulating agency

The first chapter told the stories of men such as Al-Razi, Bissell, Rockefeller, and the Nobels. They all devised synergies between the 4A+A factors.

Clearly, there is a very high level of entrepreneurial agency driving the fate of oil. Or, rather, the industry exists because of entrepreneurial agency. It is also the case that the greatest stories of entrepreneurial genius tend to appear in periods of struggle. The most striking evidence of this claim is that the very beginning of the modern oil industry was marked

215 It may still be morally justified. Then again, this report is strategic rather than normative.

by not one but two crises similar to today's glut. It is indeed rather revealing to learn that gluts have strengthened the oil industry by reducing the affordability of investment to the point that only the 'fittest' survive.

Without a doubt, the 'survival of the fittest' comes at a cost to individual entrepreneurs. In the very least, it is a source of unimaginable concern. Rockefeller himself was once rightfully worried about his ability to remain in business long enough for prices to come back up.[216] However, he survived and moved on to create the biggest oil empire the world has ever seen. So big that some of the most important energy companies today are still those that he set in motion.

This is how important it is to have the right agency in place. For the future of a fuel to be robust, the good ideas need to be separated from the bad.

Unfortunately, there is no *a priori* way of knowing what the right ideas are. On the contrary, visionaries like the Nobel brothers experienced rejection before success. If subsidies had existed back then, the Nobel brothers would have not been the likely recipients due to the dismissal of their strategies by contemporaneous elites.

Therefore, if one is to follow a competitive track the first policy recommendation, and indeed the most important, is as follows.

**Competitive Track Recommendation #1:**

***We need to stop subsidizing the oil industry.***

The present author is aware of the extremely high social cost (in particular, in terms of jobs) that this recommendation may have. However, the history of oil shows that the greatest stories of entrepreneurial achievement emerged during periods of difficulty. Oil is the dominant fuel of our time because it has been moulded to the needs of society rather than the other way around.

If the objective is to guarantee that the industry continues to be a source of innovation and solutions, and that the crisis be as short as possible, the actors within the industry need to be clear on the reality of the crisis as soon as possible. From a strategic perspective, subsidies only obscure this process. From a business perspective, it makes it harder for the fittest to show themselves. Only a world without subsidies can ensure that the most entrepreneurial and innovative agency survives.

This call for eliminating subsidies extends to all other sources of energy. This generalized call for ending subsidies is an argument that could be made from the perspective of avoiding moral hazards across all energy sectors. However, this report goes beyond this by noting that it is logically impossible to meet the 4A+A challenge whilst offsetting operating costs to society (which is what subsidies do). Wanting to dominate energy markets by avoiding the challenge of affordability is an oxymoron.

### The need for long-term thinking

The second chapter dealt directly with the dynamic between availability and affordability. The general message is that an excess of availability is currently creating risks and uncertainty toward, and thus directly hindering, the affordability of investment in the industry. That much is clear. What is not entirely clear is if the glut will recede, or when, or for how long.

The question of how long prices can stay high if there is a rebound is complex. There are many indications that some producers have the capacity to re-enter markets – particularly from US shale. Uncertainties about storage capacity, and the inherent unpredictability of global geopolitics add further sources of complexity in this regard.

Spencer Dale, BP's chief economist commented on this situation in a paper entitled "New Oil Economics":

> *Oil is not likely to be exhausted: As such, there shouldn't be a presumption that the relative price of oil will necessary [sic] increase over time…*
>
> *The supply characteristics of shale oil are different to conventional oil: shale oil is more responsive to oil prices, which should act to dampen price volatility.*[217]

This report agrees with Dale that oil is highly available and unlikely to be exhausted. Dale may also be right in noting that shale's flexibility has the potential to dampen volatility.

Further, as addressed earlier in the report, three different types of re-entries are plausible. First, it would be rational for shale producers that manage to stay in the market to push production up if prices increase. Secondly, producers that minimized losses by exiting early could come back with the advantage of having significant know-how. Thirdly, external investors could buy into the technology and enter with a second mover advantage. Therefore, the key consideration here refers not to whether there will be re-entries but rather, to the speed of re-entry.

If shale's ability to re-enter into the market is fast enough to avoid price volatility, low prices will become the norm. But if shale's flexibility is not sufficient to allow for speedy re-entries, seasonal volatility is likely to ensue due to delayed re-entries. The idea that oil producers will see non-volatile high prices in the foreseeable future is far too optimistic to use as a foundation for forming strategies.

216 Yergin, *The Prize*, 24.

217 S Dale, "New Economics of Oil," in *Society of Business Economists Annual Conference* (London, 2015), 19, http://www.chforum.org/library/new-economics-of-oil.pdf.

This is particularly concerning because it automatically means that there will be oil producers that are unable to continue doing business. This entails stranded assets.

It is not necessarily true that all fossil fuels will become stranded, however, it would be extremely naive to think that not a single oil operation will. There is a need to minimize the risk of ending up with an unmanageable quantity of stranded assets, and to plan ahead regarding how to manage those that do end up being stranded.

Accordingly, my second policy recommendation regards the attitude with which the current crisis should be tackled.

**Competitive Track Recommendation #2:**

*We need to avoid short-termism at both policy and industry levels.*

In times of crisis, many are tempted to 'kick the ball forward' and wait until things improve to act. This may be wise under certain circumstances – i.e. when an improvement in circumstances can be reasonably expected. However, all evidence seems to indicate that, one way or another, the affordability of oil will continue to be a challenge for the foreseeable future. A short-term mentality will only make it harder to act later. It would also make it harder to establish reasonable plans to deal with any stranded assets.

Moreover, if volatility does become cyclical and the trust in the business-making capacity of those in the industry is eroded, the very flow of investment into the industry could take a considerable hit. This would further the affordability challenge, perhaps even to yet unfathomable levels.

This does not mean that the industry should only undertake long-term projects. A sound long-term strategy could be to pursue projects with full knowledge of the fact that operations are likely to be forced into seasonal shut downs. Good financial planning on this basis could help guarantee the long-term viability of these kinds of projects. It would also serve as a pre-selection mechanism to filter out projects that could become a wicked kind of stranded assets – i.e. extremely hard to decommission.

Once again, however, the concern about subsidies need to be re-stated. There is a risk that those who defend subsidies will claim that well-planned subsidies could guarantee a managed transition. In this particular case, however, the market glut already exists and subsidies are helping inefficient producers to survive. Therefore, subsidies have the immediate effect of furthering the glut for everyone, which only cements the needs for further subsidies.

### Democratizing risk preferences

The third chapter is divided into three sections. The first highlights that the acceptability of oil has been falling. The second points to the fact that other technologies have been catching up in terms of adaptability. The third section shows how these two trends seem to have been cementing a very strong lobby against oil subsidies. As the issue of subsidies was already addressed, this third policy recommendation refers to acceptability (adaptability will be addressed in the next recommendation).

As we saw in the third chapter, there is a growing dissatisfaction with, and rejection of, oil.

Some of these concerns, such as the political challenges in West Africa, already fully and directly affect oil. Under conditions of excessive availability, it should become easier for markets and investors alike to discard regions from which oil is not desirable. Whilst for some this may improve their choices as customers, the rejection of some regions that, like West Africa and many places in the Middle East, are already experiencing political difficulties, could potentially worsen global security.

Other concerns like the divestment campaign are only partially affecting the oil industry, but may come to have a bigger impact in the short to medium term. This is an undeniable trend and no amount of disagreement with it will make it smaller. Indeed, as demonstrated by the divestment movement, a significant proportion of the public in Western countries is tired of the oil industry.

That said, even if someone is willing to reject oil due to believing that there are better alternatives – itself a comparative assessment, it is important to warn against framing oil as inherently evil. Oil should be credited with the fact that it fuelled the development of society ever since Bissell enabled synergies between all the components of the 4A+A. It is because of oil that the modern quality of life is possible – spectacular in comparison to any other age in the history of humanity. In a nutshell, oil would not be so dominant if it did not bring about significant benefits.

Accepting that oil does entail benefits – even if rejecting these benefits are comparatively better to those of other technologies, makes it clear that it is also important to avoid generalizing the rejection of oil as universal. Despite an undeniable trend towards it, oil is not yet unacceptable either. Greatly due to two considerations.

The first is that there are many who think that geopolitical risks are separate to, and more important than, environmental risks. The debate of whether this is a valid position falls well outside the scope of this report. It is undeniable, however, that those who think in this way are likely to be less critical of the environmental risks of oil. Moreover, the opinion that people in the Middle East have of oil is likely to be extremely different to that of Westerners. Thus, speaking democratically, the rejection of oil cannot be regarded as universal.

The second consideration are the prices of oil to customers. In the 4A+A model, affordability refers to the return on investment for those putting the money into a sector. Considerations about how cheap or expensive oil is compared to the alternatives fall within acceptability. When there is an excess of supply, acceptability increases because oil becomes cheaper to the final customer. There are, for example, reports that point to the fact that customers in the US are returning to bigger cars because they can now afford the bill.[218]

The reason this report did not go deeper into considerations of the desirability of oil given low prices is that it is unlikely that low prices will foster much additional demand. However, the reality is that the desire for cheap energy is there and can significantly help to sustain existing levels of demand.

Because attitudes to oil are a mixture of acceptance and rejection, it's important to remember that the actual challenge here is about establishing oil's comparative acceptability vis-à-vis other sources of energy. Oil has been losing ground in this sense. This is undeniable. However, nobody knows how much ground has been lost. Moreover, nobody knows how much ground oil can regain (if any) through better standards or even offsetting technologies such as CCS, or when other technologies face greater scrutiny.

It is particularly worrisome not to have tools to gain insight into the comparative acceptability of the risks associated with different energy technologies. This report mentioned two specific realities that would be benefited from such type of tools. One was the issue of batteries potentially becoming the object of scrutiny. Advocates of electric vehicles will surely minimize these claims; opponents will no doubt want to emphasize them. Only a democratic ranking of risk preferences would provide a tool to take society's point of view into account. The other reality is the competition that is starting to emerge between oil companies wanting to be perceived as better. In here, the problem is fundamental. What is a better oil company? Clearly, there is a need to rank them.

These are just two examples, however. It is also possible to imagine the need for tools of the sort for other situations. Just one more example. Changes in acceptability vis-à-vis other technologies can also be relevant to the development of gas due to its methane content (methane contributes significantly to global warming).

That said, this is not a report about the comparative environmental impact of different technologies. Rather, the point is that the acceptability of a fuel rests with society. The problem is that, in consequence, policies and strategies need to at least have an idea of what is society's actual preference toward the risks entailed by different fuel alternatives. This insight should ideally be able to gauge when there are changes in the acceptability of one or another fuel.

218 E.g. S Kyle, "America's Big Car Comeback and the Twilight of Pure Driving," *New York, NY: Bloomberg.com*, 2014, http://www.bloomberg.com/news/articles/2014-11-03/auto-sales-american-car-buyers-go-bigger-and-less-fun; J Golson, "As Gas Prices Fall, Americans Are Buying Thirstier Cars," *New York, NY: The Verge*, 2016, http://www.theverge.com/2016/1/7/10730398/lower-gas-prices-average-mpg-falls-transportation-research-institute-2016.

This leads to the third policy recommendation, a recommendation that is particularly important for a society that aspires to stay democratic.

**Competitive Track Recommendation #3:**

***We need democratic mechanisms to transparently signal societal risk preferences with regard to fuels.***

It is worth considering that many will claim that such risk tools already exist. They do not. Those rankings that do exist have clear biases that forbid a democratic comparison.

For example, environmentalists publish rankings of the most polluting companies. These clearly favour environmentalist mentalities. For better or worse, not everyone in the world is an environmentalist. Countries have energy security rankings. These are severely biased toward geopolitical risks. For better or worse, not everyone thinks geopolitical risks are so meaningful to their day to day reality. Companies have risk management frameworks. These are more multi-dimensional but still severely undervalue social and environmental concerns due to the need for financial performance. It is virtually unnecessary to point out that this financial focus is also not universal.

The mechanisms suggested in this report should be developed from a perspective that allows the comparison of financial and non-financial considerations based on democratic preferences. This necessarily begins by not grounding said mechanisms in pre-established preferences – as do the examples above.

A promising trend is what is called Environment, Social, and Governance (ESG) risk. This is a rising trend in the world of finance that aims at multi-dimensional risk analysis. ESG is a new trend and as such it is still to develop. However, some ESG tools could be used for effective comparisons, as it focuses specifically on evaluating risks. This reduces the challenge of finding a way to incorporate democratic preferences.

Incorporating risk preferences is, however, feasible. For example, one could imagine combining ESG indexes with geopolitical and financial rankings. One could also consider exploiting modern media technology and offering an interactive platform through which citizens could input their personal preferences, and then tie this to existing ESG rankings.

Whilst the potential is clear, this is an issue that requires further research.

### Furthering fuel diversity

The second part of the third chapter addressed the issue of the growing adaptability of other sources of energy vis-à-vis oil. This may be the key difference between today's glut and those that tested the industry in the past. In the past, demand grew *partly* due to increases in the adaptability of oil. The uses of oil effectively multiplied, thereby creating more channels for demand. Nowadays oil is already being used in virtually every human activity. Thus, rather than being on an increasing path with regard to adaptability, as was the case in previous supply driven crises, oil is losing adaptability relative to competitors. Furthermore, economic development seems to have stagnated. Therefore, it is unrealistic to expect that demand will grow much beyond forecasts. What could happen is that demand could be influenced downwards due to competition with other fuels.

At the moment, there is no technology that seems likely to affect oil demand sufficiently as to make current projections invalid. However, there are idealists who, like Bissell once did, continue to relentlessly seek ways of improving the adaptability of other sources of energy.

The first chapter showed how synergies between the solutions to the challenges highlighted by the 4A+A were found in the oil industry at times of struggle. For example, when whale oil was problematic. This was not an accident. The shortcomings of existing fuels necessarily raise interest in alternatives, and thereby directly push their affordability upwards. That said, as there is currently no clear leader among existing technologies, any policy recommendation needs to ensure all technologies have a fair chance.

This calls for being technology-agnostic and avoid 'picking winners'. That is, to give equal validity to technologies such as CCS, which may further the role that fossil fuels play in society, as to technologies like renewables, which may mean the end of fossil fuels.

This is an effort that begins with financing. If a new technology is viable, even if marginally, that technology should be able to access funds with the same ease as other, more established technologies. Which brings us to the fourth policy recommendation.

**Competitive Track**
**Recommendation #4:**

*We need to stimulate the diversity of technologies through non-technology-specific pools of financing.*

The main conceptual shift required for this policy recommendation is a move past the traditional mind-set of field-specific portfolios to solution-oriented pools of resources. So, for example, if the goal is to decarbonize, access to capital should be provided based on the potential for emission savings (as opposed to whether or not a given technology is fossil-based or renewable, for example) – given a minimum financial performance threshold to ensure that this does not in itself become a subsidy.

The problem with this conceptual shift is that it is a bitter pill to swallow for fossil and non-fossil fuel advocates alike.

Many environmentalists could reject the idea of sharing funds with fossil fuel technologies. The best response here is to refer back to the first policy recommendation: getting rid of subsidies. This would increase the amount of financing available in total, which should ease problems in developing a level financial playing field. Moreover, the Paris Agreement is compatible with this idea, as it focuses on net emissions rather than on non-emitting technologies, per se.

Fossil fuels advocates could feel that tying financing to any sort of environmental metrics puts their access to capital at risk. What can be said in this regard is that given the plethora of challenges faced by oil, the concern a bout sharing finances should rank very low in the list of priorities. Ultimately, the industry is struggling to develop its own technologies. Clearly, the current framework is not working.

## Policy links

The links between many of the policy recommendations are evident. Take the case of the call for financially stimulating a diversity of technologies and the argument against subsidies. To stimulate diversity, policy makers need to avoid choosing favourites. This is best achieved without subsidies.

However, it is important to realise that the policy recommendations are still independent of each other. Or, rather, that their effect can be decoupled in such a way that gains in one policy area are not compromised by shortcomings in another.

Yes, it would be ideal to stimulate diversity whilst also eliminating subsidies. However, it is not necessary to get rid of subsidies to stimulate technological diversity. This is because the argument against subsidies given here derives from the fact that subsidies erode the very competitiveness of oil as a business. In the long term, this will then lower the competitiveness of subsidized industries relative to those who dare to innovate without artificial funds.

As such, this report takes a strong stance against those who call for subsidies because 'others' have subsidies. As history shows, it is the ability to solve the 4A+A challenge that truly matters for a fuel to become dominant. Subsidies mask said challenge. There is literally no point in extending the disease to other energy sectors. As such, non-subsidized fuel industries should pursue competitive access to existing pools of capital, rather than call for limiting access to said pools of capital (which is what they do when they ask for subsidies for themselves).

Similar arguments can be made with regard to all policy recommendations. It would be easier to think on a long-term basis with a tool to signal societal risk preferences. However, industry actors and policy makers can devise ad-hoc ways of gauging preferences and still strategize in the long term.

All policy recommendations given in each of the 'tracks' would be best achieved in parallel. It is necessary to be realistic, however, and acknowledge that the likelihood of all these suggestions being implemented is rather low. Regardless, the slightest gain in any of them would decouple that particular area from the vices that pervade the rest of the industry.

The link between recommendations from the two different tracks is a different story. Here, the contradictions between global security and oil competitiveness seem to be impossible to decouple. The dilemma comes down to the fact that, in general, all policy recommendations given in the 'competitive track' acknowledge the need for competition. However, competition at a time when demand is unlikely to increase also means that there will be losers. This would, in all likelihood, worsen the challenge of ensuring security in some regions of the world. Then again, agreements to avoid security struggles by ensuring that prices remain at a certain level would also limit the scope for competition – in the very least by giving room to breathe to some producers that would otherwise be forced out of the market.

Regardless, recommendations from the competitive track can in theory be rolled out in a cooperative scenario and vice-versa. For example, diversification can be seen as a way to further competitiveness in a fully competitive environment – although it would need to be achieved with a lot less funds. Likewise, nothing forbids actors that choose to cooperate from also implementing some of the recommendations from the competitive track. The development of democratic risk indices, for example, would fit perfectly well within a cooperative context. It would allow policy makers to at least know the type of cooperation desired by society. That said, price agreements would at least partially mask the real acceptability of oil.

So, yes, additional hurdles considered, one can think of crossing recommendations over. Some more easily than others and in no case perfectly, but to some success.

It is also necessary to acknowledge the temptation of thinking that there can be *some* level of cooperation that still gives room for *some* competition to emerge. This is both true and not true at once. Minimal coordination will have a less detrimental effect to the long term competitiveness of oil than a fully coordinated framework would have. However, it would have some effect. That effect, as thoroughly evidenced by the 4A+A, would be negative. Necessary perhaps, but negative.

&&&

Since the stakes are so high, it is worth making a final note with regard to the leadership that drives energy policies and strategies. There is no doubt that the level of human capital related to the oil industry, at both policy and practitioner level, is high. But no group of human individuals is perfect nor free of biases.

There has been an undeniable level of miscalculation over the past decades. This miscalculation does not seem to derive from lack of technical expertise, nor from the knowledge of oil-specific aspects of the industry. In fact, the knowledge of the technical and financial specifics of oil is what seems to have allowed the industry to withstand volatility and low oil prices thus far.

The only conclusion available is that the energy community struggles to understand (and/or perhaps accept) the importance of contextual risks. That it is, as an epistemic community, biased towards discarding contextual risks as unlikely – possibly due to the sheer size and importance of oil.

It is then necessary to recommend paying more attention to contextual factors regardless of the choice of policies. To start acting upon them on the basis of what contextual pressures could be tomorrow rather than on what they are today. To interpret their likelihood upwards, rather than downwards. This is true both for those who want to see oil survive this crisis (by taking competing technologies more seriously) and for those who want oil gone (by believing and thereby investing in other technologies).

It is yet too early to know who the winner will be, but context has always been key to solving the challenges highlighted by the 4A+A model. Minimizing its role is indeed a wager against lessons drawn from the very history of oil.

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