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USAEE Case Competition 2017

Case Competition Authors
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Sponsored by:

KAPSARC
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King Abdullah Petroleum Studies and Research Center

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TO: USAEE Case Competition Teams
FROM: Case Competition Committee
DATE: 15 July, 2017
SUBJECT: 2017 USAEE Case Competition Problem Packet

In this problem, your student team will act as a group of energy economics consultants. Your company has just received a request for a quick piece of analysis, which has been assigned to your team.

Prepare your response exactly as you would prepare it in the real world. The judges will evaluate the responses from the position of the fictional customer, so producing a piece of work that is valuable to the fictional customer should be your goal. The fictional customer has outlined their interests and goals in the following documents. You are permitted to respond however you like to the customer, but are advised to keep the customer's stated and implied objectives in mind as you work the problem.

Your main text is limited to 8,000 words (including captions, but excluding references), with each figure and table counting as 200 words (for a figure or table, you count the figure or table itself as 200 words and must also count the words in the caption towards the total of 8,000). Your References or Works Cited section does not count towards your 8,000 word limit. You may add an unlimited amount of appendices to the main document. These appendixes may be an appropriate place to go into greater detail about your modeling and assumptions. Note that the customers (and the judges) want a concise analysis and may not read the appendices.

If for some reason you feel compelled to explain why you have adopted a particular strategy in your analysis or presentation that you believe should not go in your written response, you may include a separate one-page explanatory memo. However, we do not anticipate that such a memo will be needed and you should not prepare one unless you believe it to be essential.

Some of the documents and data are invented. You are to treat them as real, but you may not invent facts or documents yourself.

We ask that you not discuss your solution with anyone outside your group during the project period. While it does require creative thinking, the problem does not require advanced methods (though such methods are allowed), and outside consultation shouldn't be necessary. You are allowed to ask me questions about the problem or case competition rules (parthv@cmu.edu). In general, additional information will not be provided for the problem itself. As in real life, the customer may not have provided you will all of the information that you want and you may need to calculate, estimate, or look up relevant data. Any responses that I provide to one group will be emailed out to all groups.

This document contains the most important materials, including documents from and relating to the fictional customer. The remainder of the packet consists of materials that may or may not be of use to you as you work on the problem. There is a significant amount of material, and it is meant to simulate a literature review that you might do when confronting this problem. Our advice is NOT to try to read all this material, but rather to quickly skim the abstracts and

then pick and choose to read things in greater depth as you need data and insights to frame and work through the problem in your own way. The collection of documents in this packet is meant to save you some trouble, but is not meant to be limiting: you may use any outside written and web resources or other materials that you find to be useful to your solution.

When your written response is complete, send copies in pdf to both parthv@cmu.edu and usaee@usaee.org. Your written response is due by August 6, 2017 at 11:59:59pm ET.

The panel of judges will be a mix of industry, academic, and consulting representatives and will select the top three teams based on the judging criteria described below. The top three teams will be informed by October 1 and must have at least one member attend the USAEE North American Conference in Houston, TX, to present their solution. Student teams are allowed to modify or improve their solutions in the period before the conference presentation. At the presentation, each team will be given 15 minutes to present their solution, followed by questions from the judges and audience.

Judging Criteria (as provided to the judges):

Judges should evaluate each response from the perspective of the fictional customer and should ask themselves to what degree the response improves the customer's understanding of the issue and to what degree the response helps the customer make decisions about the issue.

The student responses must meet a few minimum criteria to be considered for the top three positions: the student response must address each of the client's questions in some way, and the quality of presentation (writing, organization) must meet minimal standards for professional communication.

In a project as cohesive as a consultant report, it is difficult to separate the different factors that go into a successful response. To provide some structure to grading, judges will use the following weight ranges for each of the four general criteria.

Responsiveness to the customer need (recognition of the key issues and responsiveness to the stated questions) - 30-40%
Quality of analysis (did the right analysis, did the analysis right, provided support for arguments and conclusions) - 25-35%
Originality and insight (demonstrates creative thinking and extends understanding on the topic or presents a novel solution) - 15-25%
Presentation (quality of writing/figures, organization) - 10-20%

For each student response, judges should provide both a score (out of 100) and a few sentences of feedback focusing on the strengths and weaknesses of the response. Feedback will be shared with the teams after the case competition presentations, while the numerical scores will be used by the judges to select the top three teams. After assigning scores individually, the judges will meet to choose the top three responses based on individual scores and comments.

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Mobius Investments

NRG Economic Consultants
28790 Chagrin Blvd., Suite 350
Cleveland, OH 44122

July 14, 2017

Dear Mr. Estudiante,

We seek your assistance in helping us understand the potential consequences of climate change policy on the valuations of a number of international oil companies (IOCs) that we are invested in.

As you know, investors in large oil and gas companies have recently proposed that these companies more fully disclose the risks and opportunities that climate change poses for their businesses.[1]

We are primarily interested in the narrow question of whether climate policy will render some of these companies' reserves stranded,[2,3] and if that will affect their share price and valuation. Obviously, we would like to understand by how much the valuations would change in response to climate policy.

There are numerous emissions trajectories – each born of a different set of commercial and policy choices – that could stave off warming in excess of 2°C. The memo by Subi Natarajan of Petra Energy Insights describes demand forecasts for oil under various scenarios. We are interested in what would happen if one of the scenarios that envisage a relatively rapid shift away from oil were to be realized. Given the large volume of published work on scenarios that keep warming below 2°C (and the maximum atmospheric concentration of CO_2 at 430-530ppm), we do not see a need to re-invent the wheel. We believe it makes sense to simply pick an existing scenario for oil demand that is consistent with this target, and work out its consequences.

Of course, as Subi points out, another away of modeling climate policy is to simply assume a rising global carbon price. He suggests that modelling the effects of a global carbon price could be complicated, but it is certainly one way to approach the problem.

We would appreciate it if you could get us a first cut of your analysis in the next three weeks (that is, on or before the end of the day on Aug 6). Given that time is short, we suggest that you pick a fossil fuel company or a major resource holder state, and run your analysis for them. We hope that your technique

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[1] Chasan, Emily. "Exxon Investors Rally to Back Climate Change Plan Board Opposes." Bloomberg.com, May 25, 2017. https://www.bloomberg.com/news/articles/2017-05-25/exxon-investors-amass-to-back-climate-change-plan-board-opposes.
[2] Matikainen, Sini. "What Are Stranded Assets? | Grantham Research Institute on Climate Change and the Environment," August 23, 2016. http://www.lse.ac.uk/GranthamInstitute/faqs/what-are-stranded-assets/.
[3] McGlade, Christophe, and Paul Ekins. "The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2 °C." Nature 517, no. 7533 (January 8, 2015): 187–90. doi:10.1038/nature14016.

and model will be general enough that it will be possible for you, in future projects, to quickly apply it to other companies or states.

We believe that it will likely be easiest for you to find the relevant data for large, publicly listed companies. These firms are required to make detailed disclosures of their reserves and finances in their financial filings (e.g., the 10-K filings with the SEC), and to disclose their strategic plans to investors (e.g., calls with and presentations to investors are often archived on their investor relations pages).

We recognize that many major fossil fuel companies produce significant quantities of both oil and gas. However, for now, we are mainly interested in learning whether the value of these companies' *oil* reserves will change due to climate policy, and by how much.

In addition to Subi's memo, I have attached a few others that might be helpful. Soon Kiat Wee of Sotong Analytics has sent me a few thoughts on the current supply curve for oil; that is, how much of the current resource base is economical to extract at what price. I have enclosed his memo. Combined with the information Subi's memo points to, these data ought to yield an estimate of how much of the current resource base we are likely to be produced. Supply curves will also give some information about the geographical location of different reserves. Company disclosures to investors contain information about where that *company's* resources are located, what they cost the company to find, and what the company expects them to cost to develop and produce. Based on this information, it should be possible to estimate the proportion of its resource base a company may not be able to produce. Geert van Reenen of Globus Economics has sent me some notes on how companies' portfolios are valued.

Finally, Horace Rothschild – our director of strategy – has raised a few broad questions, which we hope you will give us your thoughts on. How should we ask the companies we are invested in to respond to climate change and climate policy? For example, oil companies have started to invest in various low carbon energy technologies,[4,5] and nations with large hydrocarbon resources have sought to diversify their economies and sources of energy.[6]Should we encourage a similar shift in focus? We notice a number of scenarios require significant deployment of carbon capture and sequestration (CCS). If the policy environment makes CCS (at a few hundred dollars per tonne of CO_2) viable, will it also enable other low carbon technologies that reduce demand for hydrocarbons?
In summary, we are looking for two things.

- A quantitative, albeit approximate, assessment of how the valuation of oil companies might change if "2°C / 450ppm" climate policy were enacted. You can use the case of any company to illustrate your approach, but we would appreciate it if it were general enough that we could apply it to other oil companies in our portfolio. It would also be helpful if you could comment on what aspects of the model would change if we wanted to apply it to a national oil company rather than an investor-owned company.

[4] See, for example, slides 30-32 of this presentation: http://cdn.exxonmobil.com/~/media/global/files/investor-reports/2017/2017-05-30-presentation-deck-ams.pdf
[5] Anna Hirtenstein. "Shell Believes It Has the Expertise to Be a Clean-Energy Leader." Bloomberg.com, June 14, 2017. https://www.bloomberg.com/news/articles/2017-06-14/shell-sees-ability-to-manage-risk-giving-edge-in-offshore-wind.
[6] Ball, Jeffrey. "Why the Saudis Are Going Solar." The Atlantic, August 2015. https://www.theatlantic.com/magazine/archive/2015/07/saudis-solar-energy/395315/.

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- A qualitative assessment of what companies should do in response to a 2°C / 450ppm policy. Horace Rothschild's memo outlines the type of issues we are most concerned about.

We really look forward to your thoughts and analysis. We trust that your brief report, which we expect to receive in three weeks' time, will add some clarity to our decision-making in this area.

Sincerely,

Paulina Fischbach.

VP, Strategic Planning

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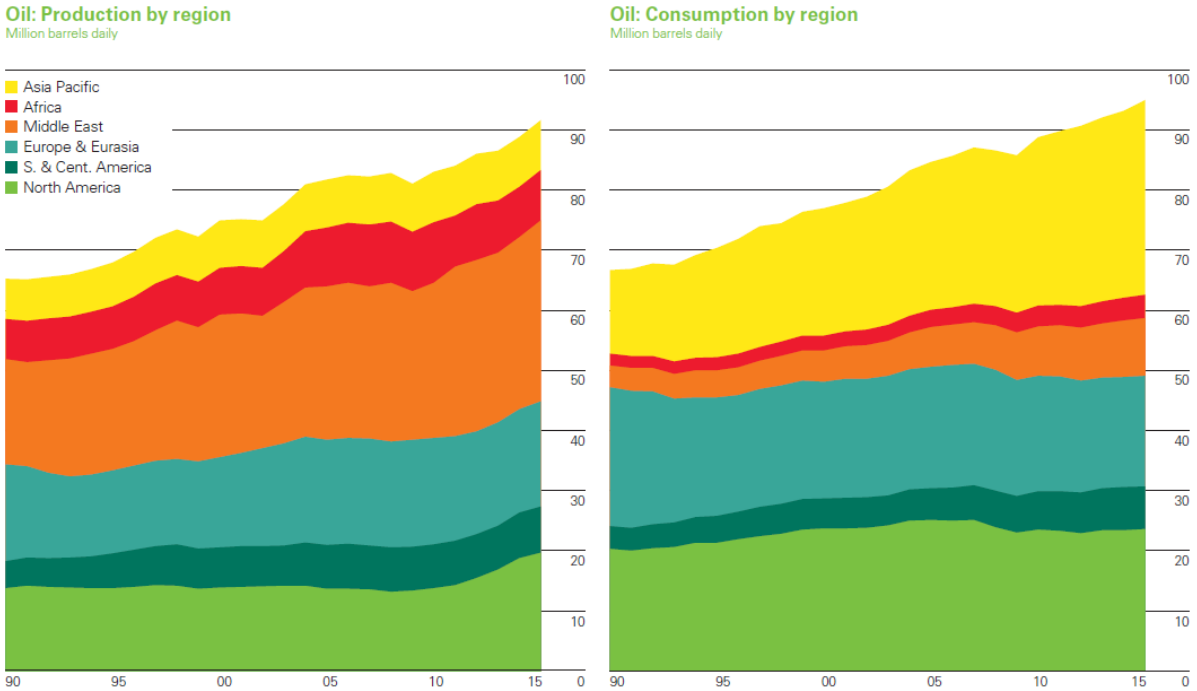
PETRA ENERGY INSIGHTS

Paulina Fischbach
VP, Strategic Planning
Mobius Investments
Singapore

RE: Demand for oil under stringent climate policy

Hello Paulina,

I've completed the background research on the future demand for oil, and have mixed and complicated results. Depending on who you ask, you can get any answer you want, from "oil will soon be rapidly phased out" to "the oil industry will enjoy many decades of continued growth". One thing I can say with confidence is that the supply is reliable for the foreseeable future, so the issue lies almost exclusively on the demand side. The complexity is basically that demand for transportation will continue to grow for the foreseeable future, but the effect of technological alternatives (electric vehicles, mainly) and policy constraints (related to climate change) are both uncertain. This puts projection of future prices as a function of social decisions more than physical supply or production.



World oil production growth in 2015 significantly exceeded the growth in oil consumption for a second consecutive year. Production grew by 2.8 million b/d, led by increases in the Middle East (+1.5 million b/d) and North America (+0.9 million b/d). Global oil consumption increased by 1.9 million b/d, nearly double the 10-year average, with above-average growth driven by OECD countries. The Asia Pacific region accounted for 74% of global growth, with China once again contributing the largest national increment to global oil consumption growth (+770,000 b/d).

Figure 1: Oil production/consumption since 1990 (from BP Statistical Review 2016)

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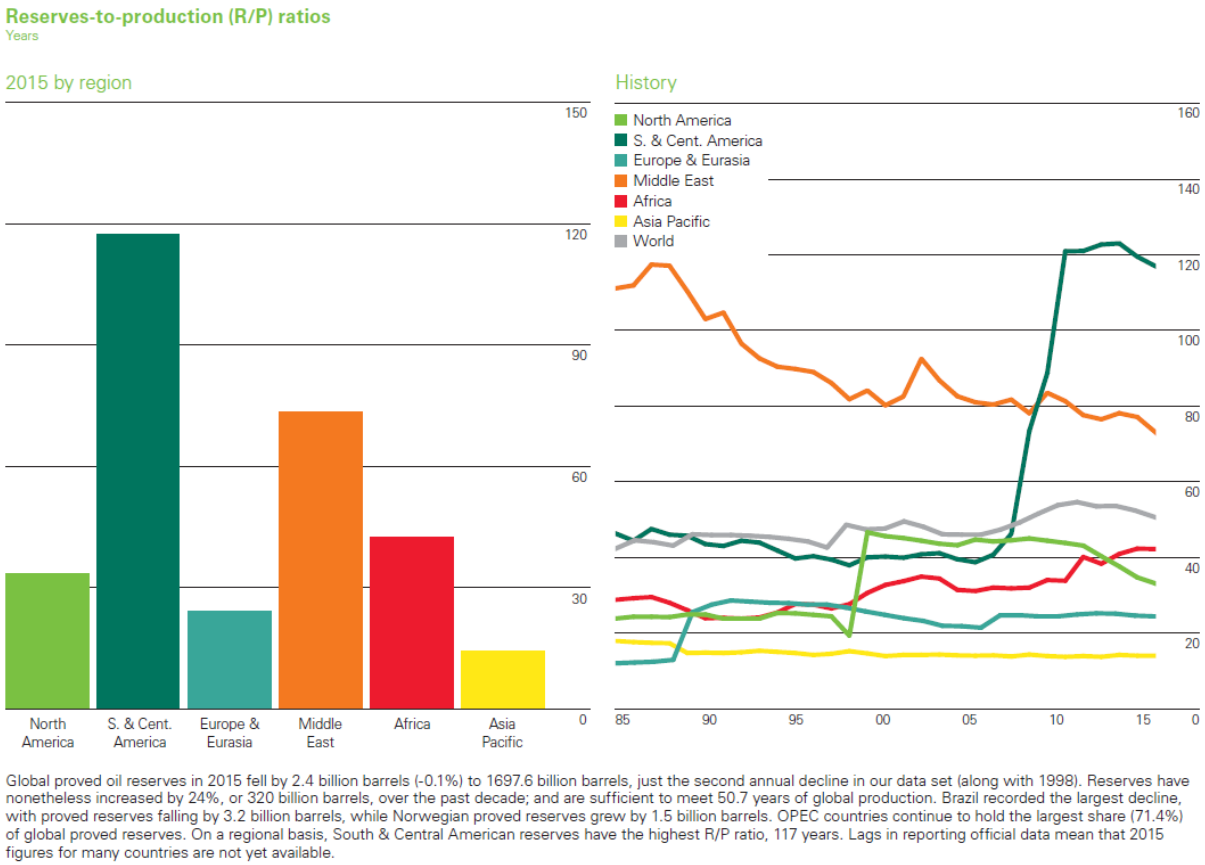
On the supply side of the equation, global oil reserves are strong. Discovery plus advances in extraction technology (such as hydraulic fracturing) have easily kept pace with continual increases in demand. In fact, we are now clearly in a period of oversupply, though it isn't obvious how long this will last. On supply, the short answer appears to be: if we are planning investments for the next 30 years or so, we should not be concerned about oil majors doing poorly on account of supply issues. Production volumes should be sustainable for several decades at least, and at reasonable production cost.



Global proved oil reserves in 2015 fell by 2.4 billion barrels (-0.1%) to 1697.6 billion barrels, just the second annual decline in our data set (along with 1998). Reserves have nonetheless increased by 24%, or 320 billion barrels, over the past decade; and are sufficient to meet 50.7 years of global production. Brazil recorded the largest decline, with proved reserves falling by 3.2 billion barrels, while Norwegian proved reserves grew by 1.5 billion barrels. OPEC countries continue to hold the largest share (71.4%) of global proved reserves. On a regional basis, South & Central American reserves have the highest R/P ratio, 117 years. Lags in reporting official data mean that 2015 figures for many countries are not yet available.

Figure 2: Reserves to production ratios (from BP Statistical Review 2016).

The far more interesting questions come on the demand side, and the three largest unknowns are alternative transportation options (biofuels, electric vehicles), demand in developing regions, and global responses to climate change. Electric vehicles (EVs) may pose a strong threat to oil demand, but face many obstacles, from capital cost to consumer perceptions. Even if they aren't adopted in existing markets, they may drive demand growth in emerging markets. And, there is some important interaction with government policy, which tends to see EVs as a tool for decarbonization. So, even if EVs are not naturally able to compete, government support may force a larger market share than would naturally occur.

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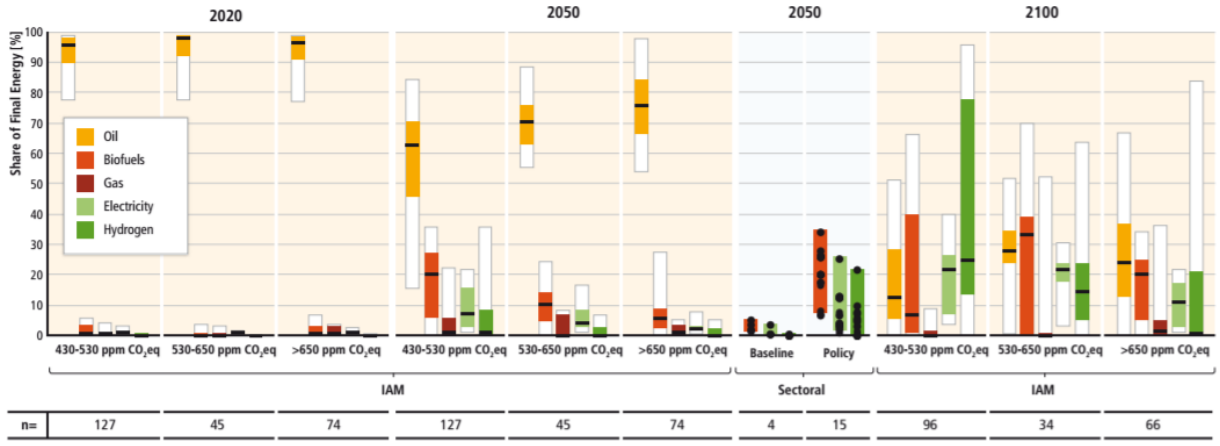

Figure 8.12 | Global shares of final fuel energy in the transport sector in 2020, 2050, and 2100 based on integrated models grouped by CO_2eq concentration levels by 2100 and compared with sectoral models (grouped by baseline and policies) in 2050. Box plots show minimum / maximum, 25th / 75th percentile and median. Source: *Integrated models*—WG III AR5 Scenario Database (Annex II.10). Sectoral models—IEA, 2012; IEA, 2011b; IEA, 2008; WEC, 2011a; EIA, 2011 and IEEJ, 2011.

Note: Interpretation is similar to that for Figs. 8.9 and 8.10, except that the boxes between the 75th and 25th percentiles for integrated model results have different colours to highlight the fuel type instead of GHG concentration categories. The specific observations from sectoral studies are shown as black dots

Figure 3: Projections of fuel shares in transportation (from IPCC AR5, Chapter 8 – Transport). Alternative fuels cut into the percent of transportation fueled by oil products, but oil remains the primary transport fuel through 2050 in all scenarios. The overall level of demand for transportation may actually mean that oil production continues to increase over time.

New demand for transportation will come as emerging markets (China, India, and other developing areas) adopt personal transportation. The mode and fuel of that transportation is yet unknown. Many hope that public transportation can fill most of the needs, but there is already evidence that both China and India are on the path to US-style personal transportation. Transport in these areas could be provided by EVs (or, less likely, fueled by biofuels), though that trajectory is hard to forecast.

	2015	2020	2025	2030	2035	2040
OECD	46.2	45.9	44.3	42.1	39.7	37.3
Developing countries	41.5	46.8	52.2	57.4	62.0	66.1
Eurasia	5.3	5.6	5.8	6.0	6.1	6.0
World	93.0	98.3	102.3	105.5	107.8	109.4

Figure 4: OPEC forecast of oil demand (mb/d) (from OPEC World Oil Outlook 2016).

Carbon policy is the third critical uncertainty, and the one that is most dependent on political will and social preferences. Liquid fuels are challenging to decarbonize – biofuels are still expensive, often have problematic indirect emissions, and are limited in scale. An affordable cellulosic method could cut into oil's share of the market, but the most promising method of decarbonizing transport appears to be electrification in the short term and perhaps

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hydrogen in the long term. But oil for transportation is relatively carbon efficient, and isn't an immediate target under likely carbon policies (unlike, for example, coal). More drastic decarbonization responses, however, would start to constrain oil use overall, though.

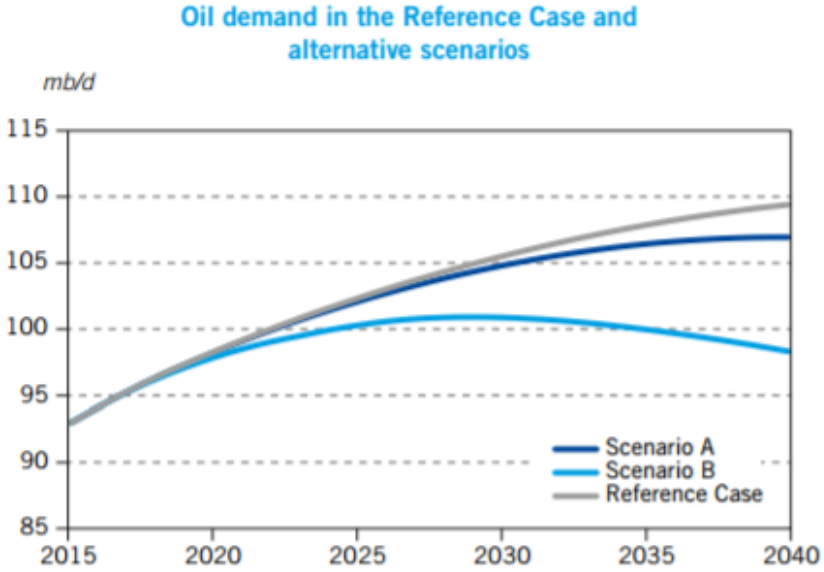

Figure 5: Future oil demand under three policy scenarios, representing business-as-usual, mild climate policy, and aggressive climate policy (from OPEC World Oil Outlook 2016).

There may be some benefit to looking at specific policies or policy structures, such as a carbon price, but my perspective is that the policy mechanisms are less certain than the outcomes here. If a certain carbon trajectory is chosen as a target, different policy mechanisms will likely get you to a similar trajectory of oil consumption. In a sense, the policy is "baked into" the oil consumption projections that are made by different entities. I would advocate that the best method of considering policy constraints is to directly use a consumption trajectory that implicitly includes them. The OPEC forecast (above) and IPCC forecast (below) are two of the better references that I found, partly because both provide rigorous methodology and assumptions.

One could look at something like a carbon price trajectory into the future, starting at maybe $10/tonne today and increasing to $100/tonne by 2050 and examine how this affects profits of oil companies. But the modeling complexity grows quickly. One might assume that demand for transportation would not shift under these prices, but it would be hard to assume that demand for oil-based fuels would not shift. In that case, one would have to consider the costs and emissions of the alternatives, which would themselves shift around due to the assumed carbon price. Point being: a carbon tax covering most of the economy may have a different effect than a tax on oil products, even if they result in the same cost per gallon. This is because a carbon tax would also affect many other sectors of the economy, which would interact in unknown ways. Hence my suggestion that the best route may be to use an estimate of oil consumption that implicitly includes these interactions.

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When considering these future demand trends, I would suggest that the assumptions used are critical and should be considered. A variety of projections are available, but some obscure their assumptions and other use inputs that seem implausible. The best method is probably to examine several different reliable forecasts and run an analysis on either a single ensemble of them or on each individually as a form of sensitivity analysis. EIA, IEA, and IPCC are all solid, reliable sources for these forecasts, but an analyst should be cognizant of the assumptions that each uses (such as the EIA requirement to assume status quo policy into the future).

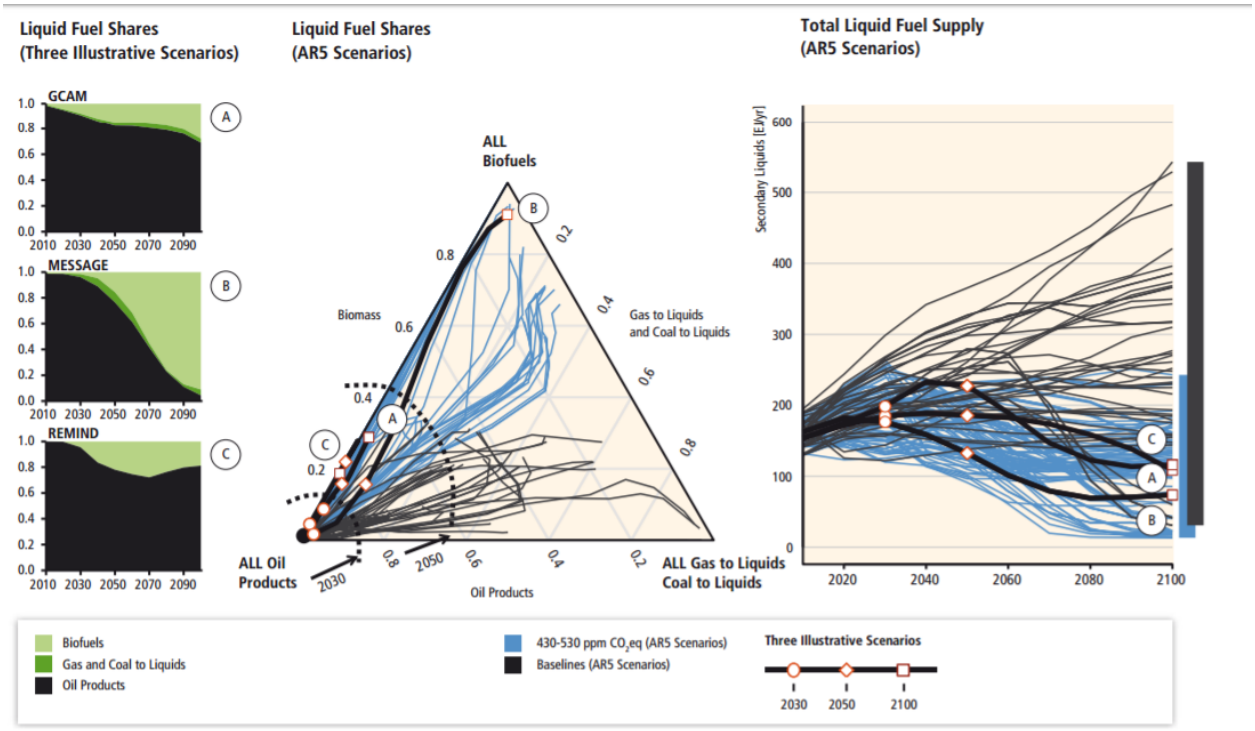

Figure 7.15 | Transition Pathways for the Aggregate Energy Supply Transformation System (a), Electricity Supply (b), and the Supply of Liquid Fuels (c): 2010 to 2100 for baseline and stringent mitigation scenarios (430–530 ppm CO_2eq). The pathways of three illustrative scenarios (cases A, B, and C) are highlighted for comparison. The illustrative pathways correspond to the same scenarios as shown in Figure 7.10. Dashed lines in the middle panels show the development to 2030 and 2050, and are indicative only for central trends across the majority of the scenarios. Source: WGIII AR5 Scenario Database (see Section 6.2.2 and Annex II.10) and three illustrative scenarios from ReMIND (Rose: Bauer et al., 2013); GCAM (AME: Calvin et al., 2012); and the MESSAGE model (GEA: Riahi et al., 2012).

Note: Scenarios assuming technology restrictions and scenarios with significant deviations for the base-year (2010) are excluded.

Figure 6: IPCC AR5 estimates of future liquid fuel supply (from Chapter 7 – Energy Systems of the IPCC AR5 report). Business-as-usual scenarios are in black lines, while scenarios keeping to 430-530 ppm CO2 are in blue. In short, BAU scenarios suggest that total liquid fuel demand will continue to increase and that it will mainly be met by oil products (though a few BAU scenarios imply adoption of alternatives). If the AR5 scenario (carbon constraint) is met, total fuels usage is expected to decline starting around 2030, and a growing share of that demand is met from alternative liquid fuels (biofuels, mainly). More details are in the IPCC report.

From the reports that I have reviewed, there seems to be a consensus that oil demand is likely to continue to grow at a moderate rate for the foreseeable future (2040 and beyond) if global carbon policy is weak. If carbon policy is strong, oil demand does not get clobbered but does tend to level out and begin a slow decline starting around 2030. Those may be two reasonable base-case scenarios, but assessing the probability of each would be a challenge in light of the current shake-up in global climate accords. I've pulled some of the numbers from the IPCC AR5 scenarios for you in Tables 1 and 2. The data here are from the AR5 Scenario

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database[1], where other information about these scenarios can be gathered if needed. As a reminder, both the 450 and 550 ppm scenarios would be pretty aggressive and probably require negative emissions technologies and other expensive interventions. A realistic trajectory may be somewhere between these and the baseline BAU scenario.

I hope all of this helps your analysts get started.

Regards,

Subi Natarajan
Senior Analyst
Petra Energy Insights

[1] https://tntcat.iiasa.ac.at/AR5DB/dsd?Action=htmlpage&page=regions

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Table 1: Three "Business as usual" scenarios for primary oil production through 2090. These scenarios assume little to no effort to combat climate change and differ primarily in their assumptions about future oil availability and competition to oil from alternatives.

Model - Scenario	Unit	2005	2010	2020	2030	2040	2050	2060	2070	2080	2090
REMIND 1.5 - AMPERE3-Base	EJ/yr	167.2	177.6	211.1	227.5	220.4	199.8	173.3	143.3	141.5	144.8
GCAM 3.1 - LIMITS-Base	EJ/yr	167.8	169.6	191.5	201.6	206.7	208.1	224.8	242.6	262.3	279.7
MESSAGE V.4 - AMPERE3-Base	EJ/yr	169.3	170.5	228.7	272.9	313.5	329.4	319.4	288.2	248.7	220.7

Table 2: Primary oil production through 2090 in 450 and 550 ppm scenarios from IPC AR5. "450" and "550" refer to the target amount of CO2 in the atmosphere in the year 2100. 450 ppm is needed to constrain global warming to 2 degrees Celsius, but would be an aggressive global climate regime. 550 ppm would end up around 2.5 degrees of warming, but would still require strong global commitments.

Model - Scenario	Unit	2005	2010	2020	2030	2040	2050	2060	2070	2080	2090
REMIND 1.5 - AMPERE3-450	EJ/yr	167.15	177.5	207.3	228	221.2	187.8	141.2	93.48	63.169	46.07
REMIND 1.5 - AMPERE3-550	EJ/yr	167.15	177.5	207.3	227	225.9	211.9	182	136.5	107.98	88.02
GCAM 3.1 - LIMITS-450	EJ/yr	167.76	169.6	191.3	201	200.1	192.03	181	157.8	133.98	98.78
GCAM 3.1 - LIMITS-550	EJ/yr	167.76	169.6	191.8	204	206.2	201.75	196.9	177.5	155.57	120.1
MESSAGE V.4 - AMPERE3-450	EJ/yr	169.43	168.1	210.6	237	222.7	152.45	79.1	33.16	16.533	11.4
MESSAGE V.4 - AMPERE3-550	EJ/yr	169.43	168.1	217.9	260	279	247.5	176.4	117.3	48.344	23.15

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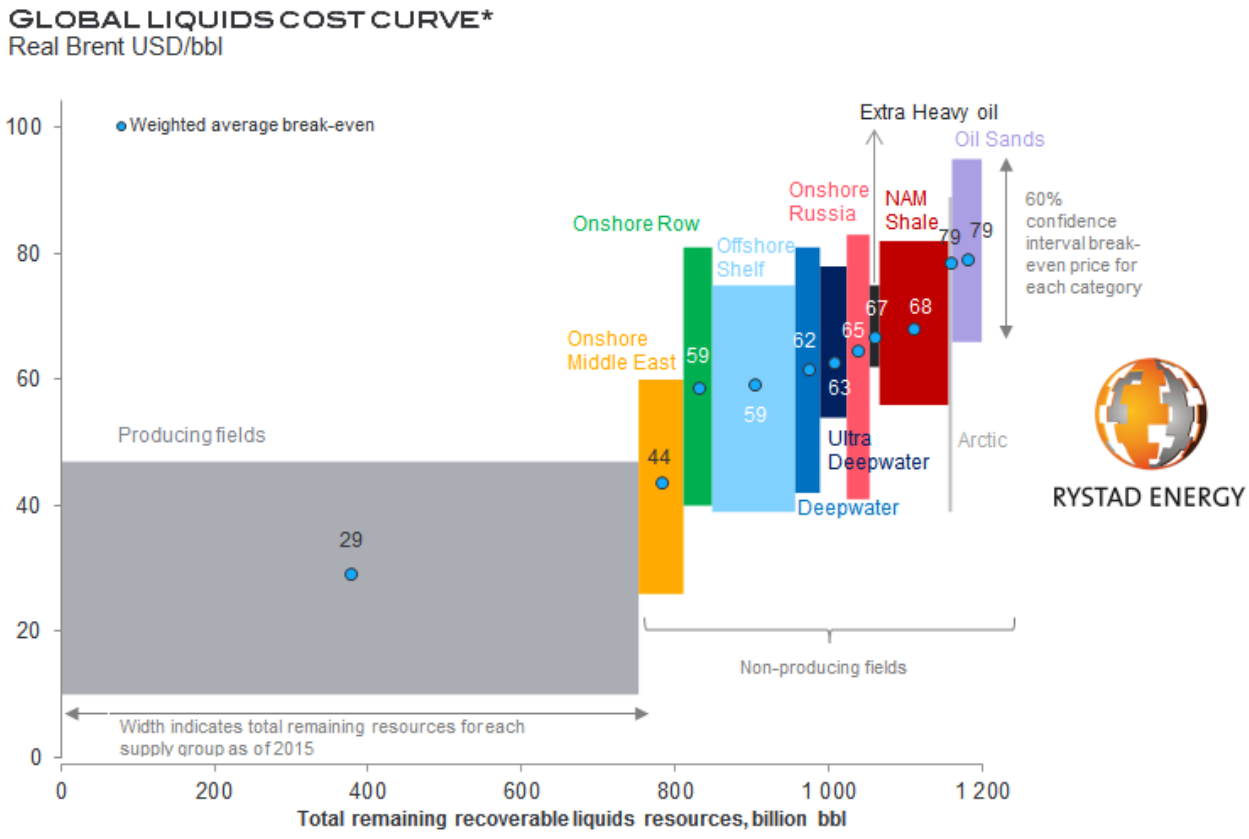
SOTONG ANALYTICS

Paulina Fischbach
VP, Strategic Planning
Mobius Investments
Singapore

RE: Notes on oil supply curves

Dear Ms. Fischbach:

We are delighted that Mr. Estudiente of NRG Economics is helping you figure out how climate policy might affect the evaluation of oil and gas firms, including private and national oil companies. I understand that you want some information on supply curves for oil.



*The break-even price is the Brent oil price at which NPV equals zero using a real discount rate of 7.5%. Resources are split into two life cycle categories: producing and non-producing (under development and discoveries). The latter is further split into several supply segment groups. The curve is made up of more than 20,000 unique assets based on each asset's break-even price and remaining liquids resources in 2015.
Source: Rystad Energy UCube September 2015

Figure 1: Cost curve for remaining recoverable liquid resources as of October 2015 (from https://www.rystadenergy.com/NewsEvents/PressReleases/global-liquids-supply-cost-curve)

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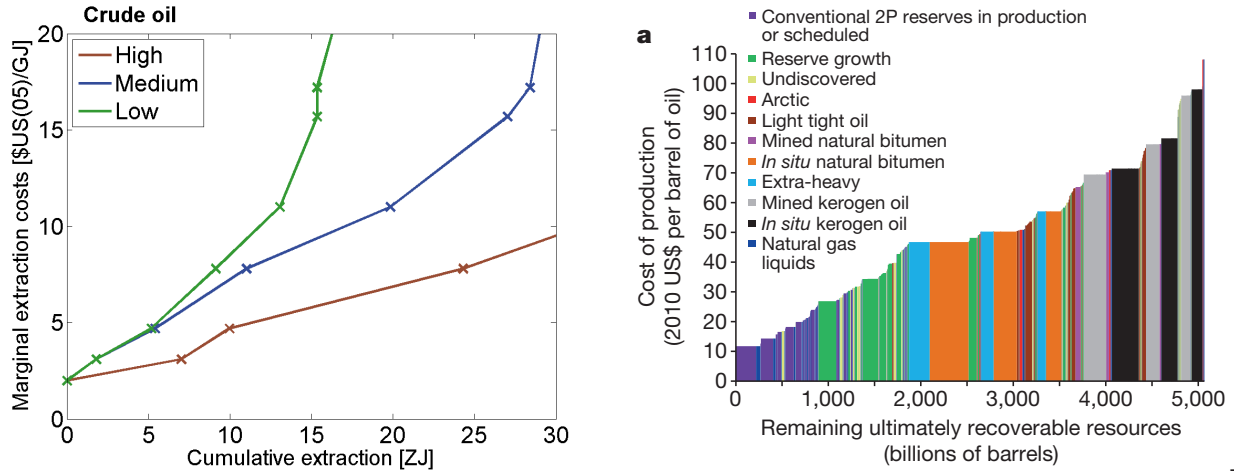
There are numerous such curves available; for example, the one from Rystad research, which is shown in Figure 1. Given the cumulative demand over the next 15-20 years, a curve like this ought to give you some sense of what the marginal cost of supply will be at the end of that period. While the prevailing price would likely depend on several factors, including the willingness of large producers to curtail supply, the cost of marginal supply is likely to be a factor.

Since you (and Mr. Estudiente) are interested in understanding how climate policies might affect the value of state and private fossil fuel portfolios, there are a couple of studies in the academic literature that you (and he) ought to look at closely.[1,2]Both studies contain a wealth of information in supplementary materials and appendices, which I have found very illuminating.



(a) (b)

Figure 2: Supply curves from (a) Bauer *et al.* (2016)[1] and (b) McGlade and Ekins (2015)[2] Note that one zeta-joule (ZJ) is approximately 160 billion barrels of oil.

The McGlade and Ekins study gets to the question of the geographical distribution of the fossil fuel reserves that must stay in the ground in order to meet a 2°C target. My understanding is that many oil majors report their hydrocarbon reserves in terms of the geographical distribution also (e.g., in the annual reports that they file).

Sincerely,

Wee Soon Kiat
Research Associate
Sotong Analytics

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[1] Bauer, Nico, Ioanna Mouratiadou, Gunnar Luderer, Lavinia Baumstark, Robert J. Brecha, Ottmar Edenhofer, and Elmar Kriegler. "Global Fossil Energy Markets and Climate Change Mitigation – an Analysis with REMIND." *Climatic Change* 136, no. 1 (May 1, 2016): 69–82. doi:10.1007/s10584-013-0901-6.

[2] McGlade, Christophe, and Paul Ekins. "The Geographical Distribution of Fossil Fuels Unused When Limiting Global Warming to 2 °C." Nature 517, no. 7533 (January 8, 2015): 187–90. doi:10.1038/nature14016.

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Mobius Investments

Paulina Fischbach
VP, Strategic Planning
Mobius Investments
Singapore

July 10, 2017

RE: Strategic Pathways for Oil Investments

Paulina:

When we discussed the NRG contract to provide a quick-turn look at oil-sector investments last week, I noted that while the focus of the analysis is to be a quantitative assessment of the effects of climate policy on valuation, we are also interested in strategic options to mitigate or respond to those risks. In other words, the risk analysis is only useful to us to the extent that it guides our decision making, and so we would like NRG to provide not only the valuation conclusions but a preliminary recommendation on how those conclusions bear on actions we could take. To that end, I've outlined a few questions below that merit consideration in the context of this analysis.

As you know, a large portion of our business is managing investment portfolios of institutional investors—mostly large public pension funds. The institutional clients generally prefer a conservative approach, and, to date, we have not taken any major action with respect to the oil sector as a response to the climate change issue. The NRG analysis should help us determine whether we should maintain this status quo or do something else. There are two overarching questions that I would like to see addressed:

First, given the outcome of the valuation risk analysis, what is a prudent course of action? Options that come to mind (in no particular order) include:

- Divest from the oil sector. There have been a few high-profile instances of this for the coal industry, and some large shareholder groups and prominent stakeholders are now pushing for oil divestment.[1,2] A recommendation to divest should include guidance on and justification for which other industry sector(s) might be good replacement investments (e.g., with a similar risk profile) for these funds.
- Shift investments *within* the oil sector. NRG might, through its analysis, identify characteristics of oil companies (e.g., size, geographic location of reserves, diversification, technological advantages, corporate culture) that make some less risky than others. Given that many large funds have oil holdings, understanding these characteristics better would give us a strategic advantage in mitigating risk in our portfolio.

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[1] Volcovici, Valerie. "California lawpakers urge CalPERS to divest from Exxon." Reuters, March 30, 2016. http://www.reuters.com/article/us-calpers-climatechange-divestment-idUSKCN0WW252.

[2] http://www.divestnorway.org

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- Support shareholder resolutions in our oil holdings to encourage these companies to take action in such a way that mitigates risk. This recommendation should, of course, include a summary of what the resolutions should ask for and, if passed, what the effects would be.
- Join a shareholder group[3] to leverage our influence. What should the goals and identity of such a group be?

Of course, any other options the consultants come up with will be interesting to hear. I would not expect NRG to do a complete decision analysis of all these options given the timeframe of the study, but certainly their research and modeling should foster enough insight to allow them to develop one or two promising ideas for us to consider further.

Second, what are other institutional investors doing *vis a vis* this issue? If others are taking action, we need to be able to show our clients that we are being conservative but at the same time not running the risk of being late to the party. On the other hand, if the analysis points in a direction substantially different from that of other fund managers, we need to be able to clearly explain why that is the case. Again, the timeframe of the study will preclude an exhaustive analysis, but a general idea of where our peers our heading would be valuable.

I am looking forward to seeing the final report.

Regards,

Horace Rothschild
Director of Strategy

[3] E.g., https://www.ceres.org/networks/ceres-investor-network

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GLOBUS ECONOMICS

Paulina Fischbach
VP, Strategic Planning
Mobius Investments
Singapore

RE: Valuing energy companies

Dear Ms. Fischbach:

I understand that you have commissioned Mr. Estudiente of NRG Economics to advise you on how climate policy might affect your portfolio. You also wanted me to jot down a few ideas about how oil and gas companies are valued in general. I have done so below.

In theory, the value of a company is the present value of its future cash flows. Future cash flows should be discounted at at least the company's cost of capital; that is, the return that the company's investors expect or the interest rate that its creditors charge. In the case of companies that extract and sell a resource (such as oil), future cash flows clearly depend on the stock of that resource that the company owns at that time, as well as the price of that resource when it is eventually produced.

In the case of oil companies, a simple approach is valuing it is to correlate the value of different companies with certain critical operational parameters (e.g., their proven reserves of oil and gas, reserve-to-production ratios, etc.). There are couple of analyses by Mark Kaizer and Yunke Yu that could be useful.[1]These also have a good overview of the various ways in which resource holders classify their holdings (e.g., reserves vs resources). Of course, it is also possible to correlate a single company's performance over time on these parameters with changes in its market capitalization. Once the correlation is known, it is possible to predict the change in the value of the company if one of those parameters (e.g., their proven reserves) changed.

Using approaches that use current or past performance parameters without explicitly modeling the effect of price assumes that the current and past price (and therefore, supply and demand) environments will continue to prevail. If the balance between future supply and demand is going to be fundamentally different, then one must explicitly account for the effect of price. Aswath Damodaran[2], of the NYU Stern school, has demonstrated some straightforward ways of estimating the value of oil and gas companies that are subject to a volatile price environment. Of

[1] See, for example, Kaiser, Mark J., and Yunke Yu. "Part 1: Oil and Gas Company Valuation, Reserves, and Production." *Oil & Gas Finance Journal*. Accessed June 21, 2017. http://www.ogfj.com/articles/print/volume-9/issue-2/features/part-1-oil-and-gas-company.html.
and Kaiser, Mark J., and Yunke Yu. "Part II: Oil and Gas Company Valuation, Reserves, and Production." *Oil & Gas Finance Journal* Accessed June 21, 2017. http://www.ogfj.com/articles/print/volume-9/issue-3/features/oil-and-gas-company-valuation.html.

[2] Damodaran, Aswath. "Ups and Downs: Valuing Cyclical and Commodity Companies." SSRN Scholarly Paper. Rochester, NY: Social Science Research Network, September 1, 2009. https://papers.ssrn.com/abstract=1466041.

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course, Mr. Estudiente might want to carefully consider some of the assumptions that Prof. Damodaran makes (e.g., growth of 2% per year for the indefinite future).

I understand that Mr. Estudiente is also trying to figure out how demand might evolve with stringent climate policy environment, and how that might affect what part of the current reserve (and resource) base is produced. Company disclosures on the geographical distribution of reserves and resources might help – Mr. Estudiente would do well to study the 10-K and 20-F filings of whichever company he decides to look at in detail.

I trust you will find this useful.

Geert van Reenen
Globus Economics
The Hague, Netherlands.

P.S.: This is somewhat tangential to your original question, but maybe worth thinking about nonetheless. While the price environment for oil and gas is volatile, prices are self-correcting in the long term. If prices fall, companies' cash flows fall, and they have less money to invest in finding new resources. As a result, they produce less in the future. This creates scarcity and prices rise again, giving companies the funds to invest in finding new resources. In turn, they produce more, prices fall, and the cycle repeats itself. It is not clear that this mechanism would work quite as well in an environment of falling demand. If demand were falling, prices would not necessarily rise strongly in response to falling supply. Only low-cost producers – typically national oil companies (NOCs) – would be able to continue to operate in such an environment. However, in the absence of alternative revenue measures, NOCs may need to recover not only their capital and operating costs, but also fund the fiscal deficits of the governments that own them. As such, the "fiscal breakeven price" for the government can be considerably higher than the economic break-even price for the NOC.[3] This may give NOCs an incentive to curtail production to support prices provided that they believe others will coordinate with them in this undertaking.

[3] See the statistical appendix of the International Monetary Fund's *Regional Economic Outlook: Middle East and Central Asia,* here: http://www.imf.org/external/pubs/ft/reo/2016/mcd/eng/pdf/mreo1016st.pdf