SUPPLY AND DEMAND IN A TIME OF CHANGING GEOPOLITICS AND A CHANGING CLIMATE

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EXECUTIVE SUMMARY

In some ways, much of the energy sector is in flux, yet much in the world of oil and gas remains relatively consistent. Concerns a decade ago were about peak oil supply, whereas discussions now are about the prospect of peak oil demand. The global natural gas market has been turned on its head due to the U.S. shale revolution. The United States is emerging as the largest oil and gas producer in the world, yet oil is still very much a global market subject to geopolitical developments in the Middle East and elsewhere. Renewable energy and battery prices are dropping, climate concerns are rising, and there is a narrative that exists about the inevitability of a clean energy transition – yet coal use, oil use, and global greenhouse gas emissions all rose last year. Energy policies are also experiencing rapid change, especially in the United States. Geopolitical uncertainty, the pace of policy change, and the pace of technological uncertainty are creating a complex and uncertain energy environment.

Over the next year or so, there are several big risk factors relevant to energy supply. These include what OPEC countries choose to prioritize, whether infrastructure bottlenecks (e.g., in the Permian) will hinder production, and whether sanctions, failing states, or other factors create supply disruptions. There are other risks as well, including geopolitics, trade restrictions, and the potential for a supply gap due to capex reductions for exploration and infrastructure over the past few years. The picture is not only about risks, though. Several technological trends are spurring continued improvements in the sector and driving changes in supply, including cost innovations in complex systems (e.g., increased standardization in deepwater), advanced analytics and big data, and automation and robotics. Although the actual pace of adoption in the North American industry for new technologies can be relatively slow, major energy companies see digitalization as an important trend and the next wave in improving operational efficiency. Still, more oil and gas resources exist in the world than will ever be used, raising the geopolitical question of where the next barrel of oil will come from. OPEC sets the bottom of the price, and North American shale sets the top. A lot of oil can be produced within that range. There will be big competition for where investment will go, and limits on production in one country are likely to just spur increased production in others.

Growth in overall energy demand has tended to mean that increased use of new energy sources has been in addition to, rather than instead of, existing sources.

Global energy demand, meanwhile, is expected to continue to grow, driven by an expanding middle class in developing countries. In light of this growing demand, it is important to recognize that, historically, there have been more energy additions than energy transitions; growth in overall energy demand has tended to mean that increased use of new energy sources has been in addition to, rather than instead of, existing sources. Global natural gas demand has been one of the key areas of recent growth, given a confluence of a supply push from the United States, demand pull from the rest of the world, and the rise of a more integrated and connected global market as gas moves from the pipeline to the water in the form of liquefied natural gas (LNG) exports. While LNG demand growth is increasing, there has been a lot of hesitation by buyers to sign long-term contracts, which has in turn led to a collapse in final investment decisions; investment is thus trailing projected demand. Looking ahead, there is a lot of uncertainty in the natural gas demand outlook. Europe, Japan, and emerging economies are expected to be sources of strong demand, and in many of these places, natural gas demand is intertwined with energy security issues. In Europe, for instance, being connected to a global gas market that is liquid provides energy alternatives for countries worried about reliance on Russian gas. Some question, though, whether the projected demand will actually materialize in light of cheap renewables, cheap coal, and questions about Chinese policy priorities.

With regard to oil demand, China again plays a big role, as its development has been very oil intensive. There are also sectors expected to provide significant oil demand growth going forward, including aviation, trucking, and petrochemicals (particularly plastics), though there are risk factors and technologies that could affect these sources of demand, such as hydrogen fuel cells, drop-in biofuels, and global efforts to rein in single-use plastics. Additional disruptions, such as artificial intelligence, digitization, and 3D printing, could also have implications for hydrocarbon demand – both positive and negative. Likewise, efforts to significantly reduce the limit for sulfur in fuel oil used on ships will hit both refining and shipping and will be very disruptive, though demand reductions in the shipping sector could lead to increases in diesel demand in other sectors. Perhaps the most discussed potential drivers of reduced oil demand are technological advances in road transport. In the near term, improved fuel efficiency standards will be more impactful, but electric vehicles (EVs) are expected to play a bigger role in displacing oil demand around 2030, spurred by significantly cheaper batteries and government policies (especially in China). That said, there is a risk of overemphasizing passenger vehicles as a disruptive factor, given that they only account for about a quarter of oil demand. Furthermore, vehicle ownership is still low for most of the world's population and will continue to rise, most of those cars will be second-hand conventional vehicles, and many developing countries have unreliable electricity systems that make EV penetration unrealistic. Still, while headlines proclaiming the end of oil or the end of the internal combustion engine may be hyperbolic, they have become part of the mainstream dialogue and are starting to affect investor behavior.

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Producing more oil and gas to satisfy demand will not matter if the midstream infrastructure is not there to move the oil and gas. Supply and takeaway are at a real imbalance at the moment, with midstream constraints across all U.S. basins – although it can be difficult to determine whether infrastructure is over- or under-built, as production volumes can ramp up far faster than processing plants or pipelines can get built. There is a need to be able to move fossil fuels – either to other places in the United States or to other countries – but companies are struggling to get infrastructure built (outside of places such as Texas and Louisiana). There has been a downward expansion in activism along the value chain, unleashed by the fight over the Keystone XL pipeline. Protestors are now fighting all infrastructure development, and some states are refusing to issue needed permits for pipelines. Regional planning regarding energy infrastructure might be a good idea, to minimize environmental impacts and address long-term climate and energy priorities. Beyond growing protest, other changes underway in the midstream market include a boom in private equity and a move by some companies to use real-time data to optimize midstream capacity and flow.

Those protesting fossil fuel infrastructure projects have made the Federal Energy Regulatory Commission (FERC) one of their primary targets, and there are a range of regulatory issues before FERC that could affect energy transport, particularly interstate gas pipelines. FERC has initiated a review of the policy statement that guides its determinations of the public convenience and necessity of new pipelines – a review that is raising complex issues related to eminent domain, landowners, project need, and climate change. FERC is also grappling with many other topics, such as whether and how to calculate indirect downstream greenhouse gas emissions impacts in its environmental analyses of new pipelines, issues around oil pipeline transaction structures and taxes (particularly regarding the use of affiliates), and the conflicting objectives arising at the intersection of federal and state regulations, organized wholesale power markets, and fossil fuel infrastructure (including a new docket on resilience).

Climate change is in many ways the elephant in the room for the oil and gas industry. Social license to operate used to be solely about local environmental and community responsibility – and improved, sustained stakeholder and community engagement processes are needed – but social license to operate now incorporates global elements too, as concern about climate change rises. Although scenarios projecting the global energy mix under a 2°C scenario still show a lot of oil and gas in the mix, there are activists of various types pushing for a future free of fossil fuels, including the

Keep it in the Ground movement, those seeking to stop all types of fossil fuel infrastructure projects, those pushing for divestment from fossil fuels, and some shareholder activists. Even those not seeking a complete end to fossil fuels are demanding action to address climate change. Some investors, for instance, are pushing for greater disclosure of climate risk – which puts the industry in a tough spot, as companies are asked to take the 2°C target seriously even without action from their governments. Until the industry becomes much more forthcoming about the climate issue, it will get killed in the public narrative – a narrative that is influencing investors, government funders, and policymakers. As the extremes in the debate move farther apart, it is getting harder to find common ground.

It may take a few brave leaders of companies to pull the right group together to move forward on climate policy, and leadership is starting to emerge.

Some industry leaders are trying to develop their businesses under the expectation that not only will they have to live with much tougher carbon constraints in the future, but also that their social license to operate will depend on having adequate responses to the climate challenge. Some companies, in addition to growing their natural gas resources, are looking for low-cost oil that has a smaller carbon footprint than some other oil sources, though this does not appear to be widespread. There are also efforts to deploy energy efficiency and renewable energy at company installations, reduce flaring, and advance carbon capture, utilization, and storage. In addition, there are voluntary initiatives underway to address the challenge of methane leakage, though these efforts do not have the same reach or impact as the federal methane regulations that are facing aggressive rollback efforts in the United States. Several companies also utilize internal carbon pricing to assess project risks, and there are debates about whether the industry should be proactive in supporting carbon pricing policies as well. Carbon pricing policies – like insurance policies – are a way that climate risks can be properly incorporated into economic signals, but some in the industry worry about unintended consequences, higher costs for oil and gas, unfair treatment of the industry in the political process, and how carbon pricing revenues would be used. It may take a few brave leaders of companies to pull the right group together to move forward on climate policy, and leadership is starting to emerge.

ENERGY SUPPLY

The world has moved from concern about peak oil and gas supplies to an era of energy abundance, largely due to the shale revolution. There are still significant risks to supply, though, as well as competition in global markets about where the next barrel will come from.

FORECASTS OF THE GLOBAL ENERGY MIX

To provide background and context: the global energy mix is projected to shift by 2040 because of policies (e.g., more stringent climate policies) and greater availability of various technologies. Forecasts suggest coal will lose market share, oil will generally maintain its market share, and gas will grow significantly, including dramatic growth in the global liquefied natural gas (LNG) trade. (Even under scenarios limiting global warming to 2°C, there is still a lot of oil and gas in the mix.) Nuclear, solar, and wind are all also projected to grow.

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Storage is usually a rounding error in forecasts, but rising oil storage capacities could improve responsiveness to shifts in supply and demand. Storage ought to be included in the quantities of oil and gas that can come from different sources of supply, similar to Saudi spare capacity and the U.S. Strategic Petroleum Reserve. Knowledge of storage is also changing, with improved real-time awareness of stocks around the world; instant knowledge of inventories – whether they are rebounding or declining – will soon start driving supply and demand estimates.

It is also important to be aware that forecasts of energy prices can take very divergent approaches. Many institutional long-term forecasters tend to embrace gradualism – hugging the curve and not sticking their necks out. Sell-side research analysts sometimes take the opposite approach, pursuing contrarian, sensationalist outcomes that generate media headlines. There is a need for increased transparency about the assumptions and biases underlying various forecasts.

RISKS TO SUPPLY

The role of oil and gas has evolved in the global energy mix over the past year. In the oil market, excess inventory has been removed, capital discipline has come into play, global growth has driven oil demand (especially middle distillate demand), and a lot of managed money interests have invested in commodities as an inflation hedge. Looking ahead, there are several big risk factors through the end of 2019.

One involves what OPEC countries are focusing on – whether inventory metrics, resumption of the investment cycle, the state of the global economy, or the present geopolitical climate. The role of OPEC in forecasts is not easily

modeled. With regard to the investment cycle, there is a prevailing narrative that the big reduction in capex devoted to mature fields over the past couple of years will result in a supply gap in the near future; whether that gap is as big or comes as soon as forecasted is debatable, but the narrative nonetheless is repeated in the media and is influencing the decisions of producers. In the short term, OPEC is likely to try to reduce ambiguity about what its production level will be through the end of 2018.

A second risk factor in the short term is whether infrastructure bottlenecks will hinder production. As oil prices have improved, more severe bottlenecks have emerged, including due to Permian Basin infrastructure. It is an open question whether the Permian can handle significantly increased production.

A third risk factor is the risk of supply disruption. As inventory excesses have come down, even the prospect of supply disruptions is now starting to affect markets. Such disruptions are a particular risk in places such as Venezuela, Iran, Iraq, and Nigeria. In Venezuela, for instance, the conventional wisdom (which may not be right) is that the longer it takes for the state to collapse and a new government to be installed, the longer it will take for the turnaround in the oil sector to happen, given the damage to the fields, value destruction, and the flight of expertise. A couple of years ago, experts were more optimistic about a relatively quick turnaround, but lead times are now seen as much longer. If the current government falls, there could be a long period where it is unclear who is in charge and who to contract with. The lack of stability in the country could persist for a long time, and it is not clear how much interest the international community will have in revitalizing Venezuela's oil production (much less in revising governance systems and the role of the oil industry in the country's economy) at a time of global energy abundance, when its oil is not as essential as it once was. Furthermore, the expropriations that took place under Hugo Chavez will also deter some companies from ever going back into Venezuela; in addition to the physical deterioration of the oil infrastructure, there has been destruction of the trust needed to make long-term capital-intensive investments in that country. Companies have lots of places they can invest capital, and the geopolitical risk factor in Venezuela will be very high. On the other hand, some in the service sector are ready to quickly go back into Venezuela to put a lot of idle assets back to work.

Through a uniquely American story of technology, innovation, entrepreneurialism, capitalism, markets, property rights, and contract law, U.S. energy production – which was written off for dead a decade ago – has changed the landscape of the world's energy future.

Sanctions could also cause oil supply disruptions. U.S. sanctions currently apply to Russia, Iran, and Venezuela, and others may be coming. Some feel that the Russians might be further along in their development of their Arctic offshore resources if not for the imposition of sanctions, while others argue that the sanctions that apply to the Arctic, deepwater, and unconventionals have not had much impact yet and have in fact forced those markets in Russia to innovate and develop technologies in-house. The sanctions on Russia could have more impact further down the road. As for Iran, there are differing views about the potential impact of new sanctions under the Trump Administration. Major companies and buyers are already being cautious about purchasing Iranian oil, which could cause a sharp dip in exports. Some, however, think it likely that Iran will find a buyer for its oil somewhere (at a discount), as importers with little exposure to the United States could still import Iranian oil, and the kind of compliance seen last time (e.g., by China) seems unlikely. There is also an open question as to whether the Trump Administration is really ready to follow through on sanctions; it is unclear if the United States can have sanctions against Russia, Iran, and Venezuela and still keep gasoline prices low. Others think the impact of the new sanctions could be greater than doubters think, arguing, for instance, that China might comply because it is more reliant on U.S. crude now than before.

Beyond these short-term risks to supply, there are longer-term risks to consider as well, such as geopolitical risks. A lot of the forecasts are peace-and-prosperity forecasts. For example, if sanctions back Iran into a corner (whether

or not it is able to find markets for its oil in the short-term), it could have geopolitical implications over time, intensifying fault lines in the region and impacting oil supplies and prices. In the Middle East, the disconnect between maps and what people see as borders is playing out across the region, with deepening sectarian divides that are politicized at the state and sub-state levels. Many governments in the region are having trouble with unemployment, job creation, and economic mobility, which is exacerbating the existing fault lines, and the leadership vacuum (following the U.S. abdication of its traditional role) creates further questions in the region. What is happening in Saudi Arabia also merits attention, as the country is opening up but experiencing a disconnect between the design and the implementation of policy.

In addition to specific geopolitical disruptions, forecasts may be underestimating the impact of the partial retreat from free trade on the global energy system going forward. There are direct impacts, such as with the U.S. steel tariffs raising costs for energy infrastructure, but there are also more corrosive, long-term, indirect repercussions stemming from the undermining of the multilateral trade system, such as countries pivoting to new partners or investing more heavily in alternative energy sources in case of disruptions. Commodities such as oil and gas could see sharp corrections in prices as a result of trade and protectionism concerns. Nationalistic fervor in other countries and regions (e.g., Venezuela, the Middle East) creates the potential for closed borders, and that fervor is already a factor in driving oil prices to where they are today. Protectionist trade actions also undermine confidence in U.S. efforts to get long-term export contracts for LNG and other hydrocarbons.

Forecasts may be underestimating the impact of the partial retreat from free trade on the global energy system going forward.

There is also a long-term question about the role the financial channel plays in oil and gas production, such as whether the market has become more or less elastic. Now that producers are hedging more and there is a short-cycle dynamic in shale, it does not necessarily follow that U.S. shale will respond in the future the same way it did in 2013 and 2014. The change in price needed going forward could be more than was needed a few years ago.

In addition, there has been significant underinvestment recently, as upstream capex spending dropped after 2015. The huge reductions in capex budgets for investing in exploration and infrastructure the past few years could create and/or exacerbate a supply gap in a couple of ways. First, under pressure from investors, producers are touting their capital discipline, living within their cash flow, and focusing on returns. The next few years are a show-me time – whether discipline lasts and returns materialize. (Historically, capital discipline never lasts.) Industry investment today is directed at squeezing more out of existing wells and depleting them faster. There is not enough talk about that rate of decline. Actual decline rates are getting higher; it is not being observed today, but the real will become the observed within a few years. The external world cannot see underneath the hood of why field production levels are going up, but there is a limit to it. Second, there are concerns about who will invest in the necessary oil baseline, as so many investments now are in gas. Major companies are investing in gas instead of oil, partly because that is what activists want (reflecting the shift toward shorter-cycle investments) and partly due to investments in the energy transition. If there is underinvestment, there will be millions of barrels that would have been expected from sources such as bigger deepwater projects that will not actually be there in the early 2020s. This should mean a tightening of supply. Prices will thus go up, and the market will react – but managing the undersupply could involve permanently destroying demand (hastening the shift to fossil fuel alternatives) and could lead to a sharp recessionary environment. There is an inevitable cyclicality to oil prices in a market economy; the market will come into balance, but it is never a smooth ride.

IMPACT OF TECHNOLOGY

Technology is a key accelerator of value creation in the industry and throughout the full value chain. Technology has enabled increased liquids supply, including natural gas liquids (NGLs), tight oil, and deepwater supplies, which have been important in meeting growing demand. Several technological trends are spurring continued improvements in the sector and driving changes in supply, with implications for both companies and countries.

For example, cost innovations in complex systems have driven dramatic changes in industry productivity and efficiency over the past few years. When oil prices fell a few years ago, the industry was caught flat-footed, with projects that were only economic at $100/barrel. That is far from the case now, as people realize the need to compete with that marginal barrel of shale oil. In deepwater, for instance, breakeven costs have gone from near $100/barrel to about $40/barrel. At $100/barrel prices, it was important to get every last barrel of oil out, so there was a lot of deepwater customization that made economic sense at the time, but in a lower price world, the question became how much oil it was possible to get out in a way that drove costs down. The industry pursued real changes in how projects are conducted, including increased standardization of oil and gas projects and equipment, more modular and incremental approaches, and projects that are able to come online faster. Not all productivity gains are due to big technological advances. While the productivity of shale wells has increased markedly in just the past couple of years across basins, this is largely due to putting a lot more sand and water in the wells to break up the rock more.

Digitalization can dramatically improve the economics and prevent projects from going over budget and falling behind schedule.

The industry is also using advanced analytics and big data to see what it can get out of datasets that enable it to avoid drilling a bunch of holes and help barrels get to market. Companies are using apps and real-time data to optimize operations, though many companies are still in pilot mode. The majors, for instance, are including seismic analytic algorithms as part of their strategies to improve efficiency. Another use of advanced analytics is predictive maintenance for equipment, which can prevent equipment breakdowns and improve up-time. One of the constraints around some of the analytic technologies, however, is that they require datasets that are large enough to allow algorithms to produce useful, impactful, predictive analytics – which could necessitate datasets from multiple companies and suppliers. There could be opportunities for producers in basins to share data, bring in data scientists, and produce basin wide industry solutions to challenges. Indeed, most new jobs coming into the industry will be data analysts instead of geologists.

Pilots involving automation and robotics are underway as well. For example, there are pilots testing the use of remote operations to run offshore fields, though these require increasing comfort with more workers being remotely located. It is possible for an overseas drilling program to be run remotely out of Houston while respecting local country laws about data residency, which could have significant risk mitigation benefits. Such technologies enable activity and production to ramp up with fewer employees, which will improve efficiency but have dramatic effects on the labor sector.

Major energy companies see digitalization as an important trend and the next wave in improving operational efficiency. Particularly in field development and operations, where the cost drivers really are, digitalization can dramatically improve the economics and prevent projects from going over budget and falling behind schedule. Taking advantage of the technologies in the space today can mean better project execution.

Still, although talk about technology in the sector is prevalent and pilots are ongoing, the actual adoption cycle in the North American industry for new technologies can be relatively lengthy. For example, there are models that can provide enhanced reservoir understanding and can help determine where and how to drill or frack, but these

models are not widely utilized. There are reasons for this. For one, there are internal constraints to adopting new technologies; business units are worried about meeting production targets and do not want to take risks, and they will not risk adopting new technologies unless companies change their incentives and reward systems to encourage them to do so. There are also lots of technology companies that want to come into the oil and gas space and save the industry, but while they have great ideas, they do not speak oil and gas and have trouble breaking through.

The industry also rarely applies technology to non-production issues, such as addressing community concerns. For decades, the pattern has been that when new areas of low-cost supply are found, producers rush in, disregard the environment (e.g., lots of flaring), produce lots of diesel emissions (e.g., from trucks), and create lots of noise pollution and other disruptions to communities. The industry needs to rethink how technology can apply to these issues. Technology can allow oil and gas operators to quantifiably reduce their impact, including use of natural resources, environmental footprint, and power and heat needs – but uptake of such technologies is slow.

Efforts such as the World Alliance for Efficient Solutions are looking to vet and accelerate adoption of energy efficient technology solutions by industry. In addition, efforts are needed to educate state regulators about the newest technologies so they allow the industry to use them.

THE NEXT BARREL OF OIL

More oil and gas exists in the world than will ever be used, raising the geopolitical question of who gets to produce – and where the next barrel of oil will come from. Fewer resources in capital budgets are going into exploration and production. The biggest potential prizes will still get explored, but there are a lot of barrels around the world, and there will be big competition for where investment will go. It is beneficial for each country to try to take market share from others – and get the jobs, royalties, taxes, etc. from production. The international majors have a number of opportunities around the world where there has been underinvestment, so limiting U.S. production (e.g., because of climate concerns or the Keep it in the Ground movement) will just push production elsewhere to meet demand – likely to places with fewer environmental controls on production.

Although a few countries (not major producers) are starting to declare ends to domestic fossil fuel production, there are lots of big investment opportunities in places looking to develop. In the oil space, in addition to the Permian, countries such as Brazil, Guyana, and Suriname represent huge exploration opportunities. In gas, Mozambique, Papua New Guinea, Argentina, Algeria, Qatar, and others represent big opportunities. There are a lot of resources in the ground that are slowly coming to life as fiscal terms, access to rigs, and skills are improving, but it is taking time.

North America is part of this equation too. Canada, for instance, will likely get its oil sands barrels to market, even if some companies divest from the oil sands. People own those resources, and Canada wants them produced. The Canadian government is even buying an oil sands pipeline from a private developer so it can actually get built, which shows the priority the government places on getting these barrels to market. As for the United States, there are smaller companies developing U.S. LNG in the Permian, with very low marginal costs, and it is those smaller, nimbler companies that are driving down costs, getting product to market, and making U.S. LNG capacity grow. Cheap gas and LNG are not just American strengths. Canada and Qatar, for example, also have extremely cheap gas, and Russia will be a player in LNG markets as well.

Countries looking to drive investment in their oil reserves should think about gaining a competitive advantage through their fiscal regimes. Even in the United States, analyses suggest that the tax cut improved the breakeven costs in the Gulf of Mexico by $2/barrel. Iraq is an example of a country with a poor fiscal regime, with terrible returns that make it hard for international majors to compete there.

The next barrel of oil may well come from areas where many barrels can be easily obtained at low cost. OPEC sets the bottom of the price, and North American shale sets the top. A lot of oil can be produced within that range. Given its improved costs and increased standardization of equipment, many investors believe that deepwater (with the exception of the Arctic) should have its day again and will be able to compete in some places. As for the Arctic, it is generally a higher-cost area of exploration and production, given cost factors related to remoteness, lack of infrastructure, operating environment, and operating season, but there are parts of the Arctic – more onshore than off – that are accessible and easier to operate in. Where there are major discoveries, economies of scale could be realized, and the Arctic could still be an interesting play.

ENERGY DEMAND

Global energy demand continues to grow, with natural gas, in particular, projected to see significant demand growth around the world given the destination flexibility of LNG. At the same time, discussions about peak oil supply have now become debates about the prospect of peak oil demand.

DEMAND FORECASTS

The big trend driving energy and petrochemical demand is the growing global middle class. In 2010, there were about 2 billion middle class consumers in the world, about half of whom were in OECD countries. Looking out to 2040, there will be about 3 billion more middle class consumers. The growth of the middle class globally is expected to peak around 2025, when 170 million people are added to the middle class that year. It is difficult to deny the energy demand generated by that middle-class growth, including increased air travel, the shift from two wheeled to four-wheeled vehicles, and more devices and appliances in homes. Demand in OECD countries is projected to be flat or declining; all the increase in demand is projected to come from the developing world. For example, India will spend trillions of dollars upgrading and expanding its energy infrastructure over the next couple of decades, which represents an opportunity for U.S. fossil fuel, renewables, and storage businesses to access that market.

Global primary energy demand out through 2040 is projected to rise 25% as GDP doubles, which means energy efficiency will have to play a central role.

All in all, global primary energy demand out through 2040 is projected to rise 25% as GDP doubles, which means energy efficiency will have to play a central role. Energy intensity in developed countries has already been declining, due in part to the shift of manufacturing to developing countries, but energy intensity is now expected to decline in developing economies as well, as they can grow with lower intensities and without following the inefficient pathways pursued by developed countries.

Forecasting demand is hard, however, and forecasts are usually wrong. Even measurements of current demand are of very poor quality, which in turn affects long-term forecasts. The range of forecasts has also really broadened, and they are sometimes hard to compare.

Forecasts of oil demand, for instance, used to be something that was just done by major oil companies and did not get a lot of attention, but there has since been a proliferation of forecasts, often by people not widely known within the industry. These forecasts show huge variance, creating lots of uncertainty. Some project contraction of oil demand by about 30% by mid-century, while others project growth of about 30%. The forecasts tend to fall into one of three categories. First, there are the traditional, data-intensive modeling exercises. Because these rely on time

series, they tend to miss disruptions. By definition, they tend to be conservative. Second, there are new people making headlines announcing the end of oil by 2030 or some other date. These forecasts use a different method. They do not look at the data or care about history, but rather look at disruption patterns in other industries (e.g., telecommunications, photography, the horse and buggy) and predict disruptive effects on the oil sector. These forecasts are explicitly looking for disruptions. The third category is more of a normative approach, asserting the need to limit warming to 1.5°C or 2°C and asking which big actions would move the needle. These three approaches use different methodologies and get different results – and all are probably wrong. Traditionalists, for instance, will miss disruptions, while disrupters will overstate disruption and miss the power of inertia. A truly disruptive outlook requires a lot of things – including consumer behavior, government regulations, and technologies – to come together, but they clearly have not come together yet.

While forecasts often project changes in shares of the energy mix, there has virtually never been an absolute reduction in any form of energy consumption globally.

In considering forecasts of growing energy demand, it is also important to recognize that, historically, there have been energy additions more than energy transitions. While forecasts often project changes in shares of the energy mix, there has virtually never been an absolute reduction in any form of energy consumption globally (perhaps with the exception of whale oil). Growth in overall energy demand has tended to dominate. Biomass use, for instance, has never declined, and then coal was added on top of it, which also has never declined. New energy sources have tended to be additive, rather than fundamentally replacing one energy source with another. Efforts to reduce fossil fuel demand are thus even more challenging than some might realize; it is not just about adding zero-carbon resources.

GLOBAL GAS DEMAND

Global natural gas demand is growing. It is an exciting time, with a confluence of a U.S. supply push and demand pull from the rest of the world. Gas transport, which used to be primarily by pipeline, has historically been much less flexible than oil transport, since pipelines have limited destination flexibility. The global natural gas market, however, is being completely transformed into a more integrated and connected global market as gas moves from the pipeline to the water. More than half of the gas traded in the world will soon be by ship rather than by pipeline, and floating storage and regasification units (FSRUs) could make a lot of markets available.

The United States is one of the main drivers of this transformation. When one looks at the projected growth in U.S. gas production and at how much can be consumed domestically and exported to Canada and Mexico, it is clear that additional LNG export capacity and export markets will be needed. From the Permian and elsewhere, about 20 bcf/day in production growth is expected by 2025; with 7 bcf/day export capacity under construction, far more is needed. Another $170 billion worth of infrastructure may be needed – $100 billion toward LNG export capacity and $70 billion toward pipelines – and that may be conservative. The outlook for the ramp-up of U.S. LNG export capacity is for 9 bcf/day of capacity by the end of the decade, creating a significant increase in export volumes with destination flexibility.

In some sense, there is a race between demand and how fast U.S. LNG export capacity grows, and the results of that race will show up in the spot price. If there is more demand than supply, prices will go up; if there is a gas glut, prices will be low. For the past few years, most analysts have been talking about the coming LNG supply glut, but that glut never arrived because demand came to the rescue. The first wave of U.S. exports went south and to Europe and then shifted over time to Asian markets in response to price signals. While some of the global demand has come from China, a lot has also come from adding up all of the smaller importers (e.g., Indonesia, Pakistan). These smaller importing countries are reflective of the much broader number of players stepping in on the buy side, bringing more demand for LNG into the global natural gas market. (The greater flexibility provided by ships versus pipelines means

distant reserves can serve smaller markets.) This is raising issues concerning the credit-worthiness of buyers, which is an area where entities such as the World Bank can help in terms of providing access to credit.

While LNG demand growth is increasing, there has been a lot of hesitation by buyers to sign long-term contracts. The average contract length has collapsed, and the average volume per contract is also down in light of uncertainty about what the market will look like. With a lot more gas on the water, it is available where and when buyers want it, reducing their interest in doing long-term contracts. As a result, there has been a collapse in final investment decisions while projections for LNG demand growth are being ratcheted up, which means investment is lagging projected demand. The markets are in a sort of holding pattern, waiting to see whether buyers, sellers, or financiers will blink first in figuring out a model to finance these investments. It is challenging to project finance a multi-billion-dollar project when customers will not sign long-term contracts. Some companies are going back to the joint venture approach, and some of the portfolio buyers now stepping into the market are willing to take some of the merchant risk. There is a great deal of experimentation going on with regard to business models, project financing, and contract terms.

U.S. shale has already had significant psychological and political impacts on how Europeans see their energy security situation.

In addition, there have been inadequate investments in gas storage to address the huge disparities in seasonal gas demand, with demand growth mostly coming from the northern hemisphere. Needed investments in storage may flow when price signals force the market to adjust to strong winter demand.

Looking ahead, there is a lot of uncertainty in the natural gas demand outlook, and some question whether the projected demand will actually materialize. In many OECD countries, zero-marginal-cost renewable energy (particularly with subsidies) is knocking natural gas off the curve, though Europe and Japan could both be sources of strong demand. As for emerging economies, most forecasts show significant growth in natural gas demand. India, for example, will likely have a lot more gas demand, and there might be another wave of small emerging importers as well. Emerging economy demand, however, is not a given either. In Southeast Asia, for instance, some countries are facing declining domestic reserves and are switching to other fuels such as coal and solar (including with storage), which can be cheaper than or competitive with gas. Chinese gas demand is a key question. A lot of China's existing demand represents the back end of a five-year plan to convert coal to gas, but that will shift going forward. If China's primary policy objective is dealing with local air pollution, that could increase gas demand. If China's objective is focused on reducing greenhouse gas emissions, that could have different implications for gas demand. Layering carbon goals on top of air pollution goals can push the outlook for gas in either direction. The strength of policy supporting various objectives could meaningfully change demand for natural gas, particularly in the power sector, though demand for it should still be strong in the industrial and perhaps commercial sectors. While China will be investing in LNG infrastructure, it will rely heavily on FSRUs.

Global natural gas demand is, in many places, intertwined with energy security issues. Europe provides the primary example of this, due to concerns about reliance on Russian gas. Energy security for Europe does not necessarily mean getting off of Russian gas; it means having alternatives due to being connected to a global market that is liquid. U.S. shale has already had significant psychological and political impacts on how Europeans see their energy security situation. While not many U.S. LNG cargoes have gone to Europe, the potential for U.S. gas to move into that market if price signals warrant has affected Russia's behavior and forced Gazprom to respond to the increased competition in the European market. The biggest geopolitical impact of the U.S. gas boom may be forcing Russia to engage as more of a market player. The ability to put large volumes of gas into the global market without destination restrictions has improved energy security. Countries that currently have no choice but to buy Russian gas, such as those in the Balkans, have much to gain from LNG. There is a reason that the Lithuanian LNG terminal is called Independence. (Russia and the United States are not the only powers in the geopolitical LNG equation, though; the Middle East, especially Saudi Arabia, has a clear strategy to shift demand from oil to gas.)

Although the general de-politicization of natural gas and the shift to reliance on liquid markets are advancing energy security, efforts by the Trump Administration to push the purchase of American LNG could re-politicize gas and could potentially backfire. It also is not clear that, under current circumstances, those outside of the United States view the country as such a valued trading partner. Furthermore, it would be better for the Trump Administration to have a proactive, holistic foreign policy into which energy dominance could fit, as opposed to leading with energy dominance. For instance, if the United States is not promoting more European solidarity, there will not be markets to send LNG to – or at least not a market-based system in which the United States can play well. The United States may be creating markets with LNG exports while at the same time undermining the potential of those markets with other foreign policy moves.

OIL DEMAND

A decade ago, the discussion was about whether peak oil supply was real. Now the discussion is about whether peak oil demand is real. It is important to note, though, that even if demand were to flatten, that would still represent a huge amount of oil demand.

China, again, plays a big role in the demand equation. Chinese oil imports passed 9 million barrels a day late in 2017 and could rise above 10 million barrels a day in the near future. China's development has been very oil-intensive. While its demand growth rate is coming down as it moves to a less energy-intensive economy, its huge import dependence is shaping its foreign policy and global geopolitics. China may have to drive its foreign policy increasingly into the Middle East, for instance, and Chinese oil companies have already been told to buy oil from the United States solely because of geopolitical relationships. Likewise, many producers are responding to the Chinese demand for imports, with Russia, Brazil, and the Saudis investing massively in both refining and petrochemicals to lock in long-term downstream market share in China.

Hydrogen has been held up as the perfect option for decades and yet the hydrogen economy never materializes.

There are also some sectors that are expected to provide a nearly unstoppable source of oil demand growth going forward. Demand from aviation, for instance, is projected to grow extremely fast for the next couple of decades. Planes sold today have a lifespan of 25 years – which means there is demand stickiness that will not disappear. Trucking will likewise be a big source of demand growth. Similarly, demand in petrochemicals, particularly plastics, is expected to show significant continued growth (though there is a paucity of good data on plastics demand). The U.S. abundance of hydrocarbons has transformed the chemical industry, bringing a wave of international investments into the U.S. industry and reinvigorating communities with good paying jobs. Plastics also sequester carbon and could replace other materials (e.g., metals) that are very energy intensive (although that does not appear to be particularly scalable in terms of relevant carbon sequestration.)

There are risk factors and technologies that could affect these sources of demand, however. Regarding aviation and trucking, low-carbon solutions could include hydrogen fuel cells and drop-in biofuels; these are currently expensive options, but they are potentially disruptive. (Batteries may not be good solutions for large vehicles.) Hydrogen could be particularly useful for commercial road transport; hydrogen could be made at every retail site from free electrons (i.e., spare electrons from renewable energy). Hydrogen in some ways allows for the perfect interaction between renewable energy, storability, and transport. On the other hand, hydrogen has been held up as the perfect option for decades and yet the hydrogen economy never materializes.

With regard to chemicals and plastics, there is a meaningful risk from efforts to rein in single-use plastics and to address climate change. Countries are discussing ways to address plastic pollution problems, with a focus on single-use plastics (which are a small part of the market), but these conversations have also included the idea of eliminating

fossil fuels from the cycle. While hydrocarbons will be used for plastics for decades, the industry could, within a few years, be in the position of defending the role of fossil fuels in making plastics – and by that point, it is unlikely to be a fact-based conversation. This is a perception issue; most people assume all fossil fuels are combusted when they are used, even though that is not the case in plastics. While there is skepticism that needed plastics and chemicals can be made other than from fossil fuels at a cost people will accept, the industry needs to be paying attention to this issue now.

There will not be a single disruption to oil demand, but rather many disruptions going on throughout the economy. For instance, disruptions such as artificial intelligence, digitization, and 3D printing could have implications for hydrocarbon demand – both positive and negative – throughout the supply chain, affecting manufacturing, petrochemicals, and U.S. competitiveness. With regard to petrochemicals, for example, companies manufacturing 3D printers of various kinds are working to create new formulations of chemicals that can be used in the printing, including to meet requirements (e.g., corporate sustainability goals) on what goes into those chemicals.

Oil will not exit the market, but it will be competing in a world of optionality with other fuel choices on a price basis.

Other factors could affect demand for oil as well. For example, the 2020 target set by the International Maritime Organization (IMO) to significantly reduce the limit for sulfur in fuel oil used on ships will hit both refining and shipping and will be very disruptive. Some project that it could affect the global economy, limiting economic growth and GDP – and perhaps, combined with high oil prices, contributing to a recession. Slowdowns in global GDP growth (even more than oil prices going up) have caused reductions in oil demand. On the other hand, there may also be some form of demand whack-a-mole that occurs, with demand getting hit it one sector but rising up in another. (This happens partly because of price; if demand declines in one area, prices go down, which creates demand elsewhere.) If the IMO 2020 target eventually drives residual fuel oil out of the marine market, that demand could then show up in the asphalt market and in some developing countries' power generation (i.e., the diesel that powers the backup generators that are ubiquitous in emerging markets).

Oil will not exit the market, but it will be competing in a world of optionality with other fuel choices on a price basis. Whether the transition is orderly or disorderly remains to be seen. An orderly transition assumes that new technologies and options gradually drive oil out of the market. A disorderly transition could involve peak demand, disincentivized investment, higher prices, bankrupt oil-producing countries, and damaged economic growth. The transition will involve lots of conflicting signals and mixed messages.

DEMAND FROM CARS

Technological advances in road transport are perhaps the main driver of conversations about peak oil demand. Global oil demand is expected to grow at a much slower pace – a slowing of pace not seen in decades – from 2020-2030 due to peaking of consumption for road transportation. Forecasts project little growth in passenger demand, particularly compared to freight, aviation, maritime, and chemicals. Oil demand in passenger transport could be even lower under 2°C scenarios.

Improved fuel efficiency and deployment of electric vehicles (EVs) are expected to reduce oil demand. In the medium term, there may well be more impact on oil demand from fuel efficiency gains in the drive train (including hybridization) than from EV penetration. While battery costs are falling, EVs are expected to remain a smaller driver of reduced oil demand than improved fuel efficiency standards until about 2030. By 2040, EVs could displace between 2.5 and 9 million barrels/day – and if penetrations of passenger and commercial EVs are greater than expected, future demand growth could be affected even more.

Although previous EV forecasts predicting significant penetration were always proven wrong, there are reasons to think the situation may be different now. On the technology front, battery pack costs have declined massively over the past decade, to around $200/kWh. Several models suggest that when they reach about $100/kWh, which is expected in the mid-2020s, they will be competitive with internal combustion engines. In other words, within about one cycle of automobile design, EVs could be competitive in ways that might be more attractive to people. Until then, government subsidies for EVs will be needed to spur consumer adoption (although there are criticisms that such subsidies are just giving money to the rich). That timeline may also get pushed back. While batteries have line of sight to $100/kWh, rising materials costs could act as a headwind and slow EVs in reaching competitiveness. Materials account for about 25% of battery costs, and the demand and prices for metals are rising. There are also serious geopolitical issues involved because so much cobalt production is in the Congo and so much of the refining capacity is in China. Likewise, the market for lithium is dominated by a very small number of companies that are all co-invested in each other and owned by China, which means it is not a real market or a real price.

The combination of reduced car ownership and autonomous electric vehicles could speed the EV transition.

Consumer interest, manufacturer interest, and government regulations may also be different now and will be key factors in the rate and scale of EV penetration. Assuming EVs are equal in cost, there are a lot of consumer advantages and value propositions to EVs that people will like and even pay a premium for, including lower variable fuel costs and maintenance costs. Some governments are looking to accelerate the transition. While fuel efficiency regulations around the world, the drive to meet carbon targets, and scandals around diesel vehicles will spur demand, the biggest driver of EV deployment may well be China, which is seeking to address air emissions, energy security, and industrial policy. China wants to be the world's biggest supplier of batteries and EVs. Since China announced its new policy on EVs, there have been a series of announcements of new EV models from manufacturers.

In addition, accelerated adoption of EVs will be very tied to the extent of car ownership, which is expected to be lower. Ridesharing companies with big fleets of autonomous vehicles could displace the need for vehicles for the next generation, potentially displacing even more oil demand. The effects of autonomous vehicles on oil demand, though, are rather unclear, with projections of their impact ranging from 100% greater energy demand to 50% less demand. If transport is less expensive and more convenient, then people will drive more instead of using alternatives like mass transit, and vehicle-miles traveled (VMT) will go up. On the other hand, autonomous fleets are likely to be electric, as developers of autonomous software find EVs a better fit, and most of the manufacturers working on autonomous vehicles are focused on EVs. The combination of reduced car ownership and autonomous electric vehicles could speed the EV transition.

That said, there is a risk in overemphasizing passenger vehicles as a factor in oil demand disruption, given that passenger vehicles only account for about a quarter of oil demand. Even in a 2°C scenario, oil demand remains relatively strong; while demand in personal transport will decline, there will still be growth in areas such as jet fuels (which have fewer substitutes).

In addition, forecasts of EV penetration and the impacts of passenger vehicles on oil demand vary widely. Such forecasts generally factor in VMT (which is tied to population growth and represents a big increase in demand), improved fuel efficiency in internal combustion engines (which could significantly reduce demand), and private and shared EVs. A lot of the disparities among and controversies about such forecasts are focused on the efficiency and population pieces. For instance, some forecasts rely on low population growth estimates, which yield lowball estimates of VMT growth and could thus overstate the impacts on reducing oil demand.

It is also important to keep the extent of EV penetration in perspective. Although vehicles per capita is high in developed countries, vehicle ownership is still low for most of the world's population and will continue to rise; there is a lot of momentum that will continue for years to come. In addition, lots of vehicles in these countries will be second-hand vehicles, which means they will not be EVs. Many developing countries also have poor and unreliable electricity systems, which makes EV penetration in these countries seem unrealistic. In addition, the vehicle fleet is getting older, and cars are lasting longer, which affects the oil demand trajectory. Even in developed countries, it is difficult for EVs to make up a meaningful portion of the overall fleet any time soon, given that they are starting from such a low base of penetration and the fleet turns over slowly.

Although headlines proclaiming the end of oil or the end of the internal combustion engine may therefore be hyperbolic, they have become part of the mainstream dialogue and are starting to affect investor behavior. Even before EV penetration actually gets high, cost-competitiveness and the EV narrative could quickly change investor perceptions of what is coming.

ENERGY INFRASTRUCTURE

Producing more hydrocarbon molecules to satisfy demand will not matter if the midstream infrastructure is not there to move the hydrocarbon molecules.

INFRASTRUCTURE CHALLENGES

Supply and takeaway are now at a real imbalance with midstream constraints across all U.S. basins. In the Permian, for instance, while NGL takeaway is sufficient, oil looks to be tight for a few years, and there is still a need for more gas takeaway. In the Northeast, there is a need for additional processing capacity. In the D-J Basin, there is excess oil capacity but an upcoming need for NGL takeaway. In the Bakken, production is way ahead of forecasts, and crude oil capacity may get tight next year.

Producing more hydrocarbon molecules to satisfy demand will not matter if the midstream infrastructure is not there to move the hydrocarbon molecules.

It can be difficult to determine whether infrastructure is over- or under-built. There is a Goldilocks element to it. Volumes can ramp up very quickly; it is possible to drill a well in a few months and get production online fast. Processing plants, though, take 18 months or more to build, and pipelines can take 2 years or more. These types of infrastructure are on different timeframes.

Whether the goal is energy independence or competitiveness of American companies, there is a need to be able to move fossil fuels – either within the United States or to other countries. Appropriate infrastructure needs to be in place to take advantage of the economic, geopolitical, and national security benefits of the U.S. shale boom, but companies are struggling to get that infrastructure built. Billions of dollars of investment in infrastructure are needed, but actually building infrastructure has gotten more and more difficult outside of places such as Texas and Louisiana. There has been a downward expansion in activism along the value chain. In some ways, the Keystone XL pipeline let the genie out of the bottle. Protestors are now fighting all infrastructure development, and their approaches are growing in sophistication; more than a million people checked into the Standing Rock protests on Facebook. The State of New York is refusing to issue needed water quality certificates under section 401 of the Clean Water Act to stop pipelines, and courts may have to tackle the federalism and interstate commerce question of whether states can block pipeline development by sitting on permit applications.

Some have suggested that regional planning regarding energy infrastructure needs would be a good idea. Efforts to do regional planning of multiple pipelines, particularly with regard to minimizing environmental impacts, may be stymied by the fact that such efforts run counter to the entrepreneurial way industry currently plans pipelines. It is possible that in some regions, if extra natural gas supplies are really only needed for short periods of time each year, it might be better to bring LNG cargo in as opposed to building new pipeline infrastructure with a 40-year lifespan, given that natural gas may need to be excised from the fuel supply (absent carbon capture and storage) within a de-

cade or two to meet climate goals. Each region of the country should come up with its own plans to force decisions like that one; regions face different challenges and should propose their own solutions.

Beyond growing protest, other changes are underway in the midstream market as well. For instance, private equity is flooding the midstream market, part of a multi-year trend of common equity going down. This change in access to and sources of capital has implications, causing companies to shift their strategies and adopt different contractual stipulations. There could be some consolidation of companies in the future.

Technological changes are having an impact in midstream too. While there were not a lot of drivers for technological adoption in past decades, there are now competitive and pricing pressures that are driving fundamental changes in the way the midstream business is structured and operated. Some companies are moving to a model of full digitization, seeking to optimize and use real-time data to create tens of thousands of additional barrels of midstream capacity without any capital or infrastructure improvements – just by using real-time conditions, like a traffic flow engineer, to make sure flow is optimized every step of the way.

FERC

Those protesting fossil fuel infrastructure projects have made the Federal Energy Regulatory Commission (FERC) one of their primary targets, showing up at FERC meetings and at commissioners' homes. There are a range of regulatory issues before FERC that could affect energy transport, particularly related to interstate gas pipeline infrastructure. Themes involving climate change, efforts to decarbonize the power sector, and federalism run through many of these issues.

There are a range of regulatory issues before FERC that could affect energy transport, particularly related to interstate gas pipeline infrastructure.

For instance, FERC has initiated a Notice of Inquiry (NOI) into revising its Pipeline Certificate Policy Statement. The 1999 Statement provides a roadmap for FERC to determine the public convenience and necessity of a new pipeline. Projects are supposed to stand on their own economically (without subsidies), project need is based on market demand, and project benefits are balanced against adverse effects on other pipeline customers, competing pipelines, and affected communities and landowners along the route. Once FERC determines that the benefits exceed the adverse effects, the pipeline is determined to be in the public interest. At that point, analysis is conducted under the National Environmental Policy Act (NEPA) to assess the environmental effects of the pipeline. That is the existing policy. FERC released the NOI to examine the Policy Statement and see if changes are needed, in light of remarkable pipeline construction activity since the Statement was issued, controversy about new pipelines' effects on climate change, and industry concerns that the permitting process is too slow.

Given the successful track record of the Statement, it is unlikely that FERC will significantly change it; adjustments on the margins are more likely. FERC is looking at ways to make its reliable (though not easy or inexpensive) processes faster and more efficient without compromising safety or the environment. Some of the improvements needed may be low-profile process improvements. In the late 1990s, for instance, FERC added pre-filing and other measures that have worked well. The review of the Policy Statement should include a focus on what is working – and perhaps on how to expand it.

Many of the issues involved in the Statement review are quite complicated. For instance, pipeline companies are hoping for some improvements concerning eminent domain and landowner issues for new pipelines. Landowners, though, are not following FERC dockets and may not be fully aware of the timing of things, their options for engagement, and their rights regarding mitigation strategies and re-routing. Eminent domain is necessary for projects to get

built, but people are very uncomfortable with it. There are tree-sitters and other protestors blocking pipeline routes, which is at the very least bad for companies' brands and images.

The issues around project need are complex as well. Many are firm that the market should determine need. FERC has approved projects in the past that were never built because the market determined there was no need for them, and that should remain the market's decision. FERC seems unlikely to make changes around project need. Some opponents of pipeline infrastructure, though, argue that there is a difference between public need to meet domestic consumption and public need to facilitate export of a domestic resource; infrastructure to meet LNG export needs may face even greater opposition. There are also debates about whether climate change should be factored into the assessment, but FERC may lack statutory authority to make climate impacts part of the public convenience assessment.

Some of these issues, particularly the climate concerns, arise in other parts of FERC's work too. For instance, FERC is grappling with the Sabal Trail case and the question of whether FERC, as part of its NEPA analysis of a new pipeline to serve gas-fired power plants, has to consider the effects on climate change of the power plants' emissions. FERC determined it did not need to make that analysis, but a divided DC Circuit Court of Appeals panel held that if FERC has the authority to deny the pipeline because of environmental effects, then it must look at all the effects, both direct and indirect. Upon remand to FERC, the case has divided FERC along party lines, and the issue could go to the Supreme Court.

There are legitimate questions about the gap between the status quo and achieving a 2°C target, and pipelines will last 30-40 years and lock in emissions. Some climate advocates, seeing how far things are from a 2°C trajectory, are pursuing a supply-side strategy of throwing as much sand in the gears of fossil fuel infrastructure development as possible. However, some feel that asking FERC to calculate indirect downstream emissions impacts from pipelines is too dynamic and complex, may not actually add much climate value, and could create further inefficiencies in the process.

In addition, FERC is grappling with issues around oil pipeline transaction structures and taxes, particularly regarding the use of affiliates. FERC had issued a declaratory order to institute standards of conduct for pipeline companies and marketing affiliates, but that order brought forth a wave of industry concern and tax implications. The issue is before FERC again on rehearing.

Cheap gas and renewables are putting pressure on traditional "baseload" coal and nuclear power plants, several of which are retiring.

FERC is also dealing with the conflicting objectives arising at the intersection of federal and state regulations, organized wholesale power markets, and fossil fuel infrastructure. The ideal of competitive markets, state programs to subsidize particular forms of generation (e.g., renewables, nuclear), gas infrastructure bottlenecks, and the Trump Administration's desire to prop up economically struggling coal and nuclear plants are combining to create vexing challenges. Secretary of Energy Rick Perry had asked FERC to support coal and nuclear plants in the name of resilience, which, while unanimously rejected by the FERC commissioners (which reassured many people that the new commissioners will not cede FERC's independence), did raise a relevant question about grid resilience. Cheap gas and renewables are putting pressure on traditional "baseload" coal and nuclear power plants, several of which are retiring. FERC opened a docket on resilience and asked grid operators how they define it and what resilience challenges they face. Resilience means different things in different parts of the country. In the Northeast, resilience challenges are more about gas infrastructure and the inability to get gas into the region. Southern California has similar issues, with the unavailability of gas storage following the Aliso Canyon disaster. In Southern California and New England, it took luck over the past two seasons to avoid negative consequences from gas infrastructure limitations. PJM and the Mid-Atlantic face different issues, and many fuels and technologies (including storage) can play a role in boosting resilience there.

Details of the most recent Trump Administration proposal to bolster coal and nuclear plants remain very murky, and it is unclear if FERC would play a role in that process. One of the justifications for the latest proposal, though, is the assertion that gas pipelines are vulnerable to cyber and physical attacks. Whether this is justification for the Administration proposal or not, cyber vulnerability and physical attacks on infrastructure have indeed become far more relevant to the power sector today than they were a couple of decades ago. Multiple generators sometimes rely on a single pipeline, which means an attack could have definite consequences. Jurisdiction over that lies with the Transportation Security Administration (TSA), which already has a lot on its plate; overseeing the huge network of pipelines should perhaps be moved out of TSA and to a more appropriate body such as the Department of Energy.

COMMUNITY ENGAGEMENT, CLIMATE RISK, & SOCIAL LICENSE TO OPERATE

Social license to operate used to be solely about local environmental and community responsibility, but now global climate concerns are part of it too. These concerns pose challenges to the oil and gas industry moving forward, as it seeks to provide the energy the world needs while respecting community challenges and dealing with a transition to lower carbon resources.

SHALE GOVERNANCE

Distinct from global climate concerns, there are communities affected by production that have local concerns, and many of the local and community concerns related to the industry's social license to operate have focused on shale development. The Aspen Institute Energy & Environment Program has hosted a shale dialogue group that has come up with guidance for principled governance of shale resources, though the guidance could apply to governance of any topic, whether industries are in people's backyards for shale oil and gas, water, renewable energy resources, or something else.

Social license to operate used to be solely about local environmental and community responsibility, but now global climate concerns are part of it too.

The dialogue came up with three main recommendations for shale governance. One involves developing and maintaining reliable, use-inspired research. It is important that research questions are informed by the end users of that research, so that universities can focus their research on real-world problems for which regulators and industry have a pressing need for solutions. A second recommendation involves establishing demonstrable regulatory excellence, including having a proactive regulatory academy to get and keep regulators up to speed on the technological changes occurring so rapidly in the industry.

A third recommendation focused on creating effective and early engagement between the various actors and systems interested in and affected by shale development. Shale development is intensive, requiring huge numbers of trucks and other disruptive elements. Communities may or may not have seen this type of development before and may not appreciate the amount of noise, dust, and general nuisance that shale development entails. There are also other impacts, such as the earthquakes in Oklahoma that have been caused mostly by disposal of produced water, but also sometimes by fracking and completions. There is therefore a need for industry and regulators to change how community interactions occur. Community engagement cannot just be handing out t-shirts or sponsoring a scoreboard at a high school stadium. Companies must be willing to be changed in the process; otherwise their efforts are perceived as inauthentic platitudes.

Industry officials must be willing to meet community concerns genuinely and with an approach that is digestible to laymen; the industry speaks technocratic, but most people do not. It is time for the regulators and the regulated

to engage in sustained conversations that include the community and researchers. There is a need to build trust with stakeholders. These stakeholders fall into at least six general categories: resource owners, local communities, consumers, environmental interests, energy producers, and governments/regulators. Some of these stakeholders have obviously linked interests, such as resource owners who seek revenues, producers who seek profits, and consumers who seek low-cost, accessible energy. Bringing the range of stakeholders together to find common ground can yield progress.

Companies must be willing to be changed in the process; otherwise their efforts are perceived as inauthentic platitudes.

In Oklahoma, for instance, a seismicity coordinating council was formed that included all the relevant state agencies, operators, state universities, and a couple of legislators, which meets every month with great collaboration and has made significant progress in addressing the issue. While community participation is light, the council has reached out to communities to keep them advised of council progress, so communities know someone is listening to them and trying to solve the problems. A similar effort is beginning regarding nuisance and truck safety, including agencies, industry (including service companies and contractors), and communities; the effort is currently light on researchers. The various interests have to work together collaboratively to solve these challenges.

Sophisticated community engagement efforts, however, can be more challenging in some places than in others. For example, many of the developing countries that are largely at the heart of the energy transition in coming decades do not even have rule of law. Given that regulators will play far less of a role there, the companies doing business in those countries have even more significant responsibilities.

CLIMATE CHANGE & A SHIFTING NARRATIVE

Social license to operate now incorporates global elements too, as concern about climate change rises. There is good cause for this rising concern. The commitments made under the Paris Agreement do not limit warming to 2°C, though they do bend the curve from a business as-usual trajectory. Global emissions are still rising, and some project global CO2 emissions to peak in the 2030s. Coal's share of the global energy mix has not declined at all over the past 30 years. While taking the steps needed to achieve global climate targets will come with some costs, there are also very significant costs from not meeting those targets.

This is not to say there has been no progress. Europe and North America already peaked their emissions around 2008. Even with President Trump's plans for the United States to exit the Paris agreement and the Environmental Protection Agency's regulatory rollbacks, significant emission reductions are occurring in the U.S. power sector, and investors are very bullish on renewables because of smart economics (e.g., no fuel cost). There are more zero-carbon solutions in the power sector, though, than in the industrial, petrochemical, and other sectors. Also, in the EU, the disconnect between talk and action might go the other way. For instance, while there is talk in Europe about achieving total decarbonization by 2050 in a feasible and affordable way, construction of new fossil fuel pipelines is also occurring, and national governments are making decisions about energy mix and access to fossil fuel resources that may not align with EU rhetoric.

Scenarios projecting global energy demand and the global energy mix under a 2°C scenario vary widely, but in virtually all cases, there is still a lot of oil and gas in the mix. Oil and gas will likely be needed for another few decades at least, and there is strong optimism within the industry that technological solutions will emerge to the climate problem. There are opponents motivated by climate concerns, however, who are pushing for a future free of fossil fuels – a vision that most in the industry see as completely unrealistic (and unaffordable). While some environmental advocates are very pragmatic and seek to improve how oil and gas production is done, those opposed to fossil fuels include the Keep it in the Ground movement, those seeking to stop all types of fossil fuel infrastructure projects, those pushing for divestment from fossil fuels, and some shareholder activists.

Even those not seeking a complete end to fossil fuels are demanding action to address climate change. Until the industry becomes much more forthcoming about the climate issue, it will get killed in the public narrative. Even companies with sophisticated corporate messaging will fall short, as those messages are seen as platitudes that fail to deeply address the core issues, particularly if those companies are talking in a business-as-usual world instead of directly confronting the climate challenge. It is not yet clear what meaningful changes and messaging the public will believe. Companies need to play the slow game of building relationships and trust with policymakers, activists, and others. The industry has to be patient and show up at each conversation.

The narrative is shifting. A few years ago, natural gas was seen as a good thing, as a bridge to a clean energy future, but now industry has lost the narrative, and natural gas is under scrutiny. The climate-driven global narrative – which much of the public is increasingly believing – is moving towards a tipping point, influencing investors, government funders, and policymakers. There is a snowball effect occurring, creating an inevitability mentality. In Silicon Valley, for instance, climate change and the end of fossil fuels are both seen as givens. The Washington, D.C., public pension fund divested $6.4 billion of fossil fuel holdings. The World Bank last year announced no more upstream investments in oil and gas. It is now completely acceptable to see a future without fossil fuels. It has been normalized.

While taking the steps needed to achieve global climate targets will come with some costs, there are also very significant costs from not meeting those targets.

Opposition to upstream and midstream oil and gas investment is seen by a contingent of activists as supply-side climate policy, aiming to impact climate change by restricting fossil fuel supply. This is part of and feeds the narrative of a fossil-fuel-free future, which in turn makes conversation and compromise even more difficult. Climate debates have essentially become religious wars, on both extremes. Each side approaches the climate discussion from an extreme position, and the massive disconnect makes it easy to dismiss the other side. Even environmental NGOs are feeling this pressure, with some walking back their support for using captured carbon for enhanced oil recovery. The environmental movement has quickly shifted left, leaving even less of a center-left with whom the industry can try to find common ground. In addition, the wave of climate litigation underway is making companies paranoid about everything being discoverable and is seen as stifling conversations that need to be happening to find common ground and solutions moving forward. The industry's ideal would be for the lawsuits to go away, to stay away from causation debates, and to come together on how to address the problem. It is getting harder and harder, though, to find common ground, or even to bring folks together to have conversations.

Shareholder activism and the divest movement are also gaining strength. Investor pressure is aiming at lots of different elements. The big institutional investors have been thinking longer term about the oil and gas sector to figure out where it stands on climate change, in addition to reading about and anticipating big changes in fossil fuel demand. They are particularly focused on disclosure of climate risk – asking companies to disclose to shareholders what the impacts on the companies will be in a world that takes climate targets seriously. This puts the industry in a tough spot, as companies are being asked to disclose how resilient they are to the risk of stranded assets in a world that does not currently exist; they are asked to take the 2°C target seriously even though no country currently is acting as if it does, while at the same time responding to consumer demand. Oil and gas companies, at a leadership level, need to meaningfully address the climate issue, describing various climate change scenarios, the impacts on the companies, and the actions the companies are taking. Investors are also demanding corporate stewardship on environmental, social, and governance (ESG) issues, and that wave – which started in Europe and is coming to America – is unstoppable. Other investors are not looking for information but rather are focused on stigmatizing and demonizing the industry, turning it into the next tobacco; this effort started with coal and oil sands but is expanding its focus.

Shareholder initiatives have made rapid gains. What were once issues just for companies' public relations or investor relations departments are now more serious. Shareholder resolutions on climate change that got low votes just a couple of years ago have started to pass. While they could be dismissed as just requiring reports that are not actually relevant to company strategies or share prices, these resolutions reinforce the shifting narrative around fossil fuels. Big narratives, and government policies and investor actions driven by them, can have significant effects on allocation of capital. That is a real hazard for the industry, as it could impede its ability to deliver the products and services needed to meet growing energy demand in the developing world.

OPPORTUNITIES TO ADDRESS EMISSIONS WITHIN THE INDUSTRY

The industry as a whole has historically pivoted to other issues when asked about climate change, but now more is happening within the oil and gas majors. (A few European majors got together before the Paris agreement in 2014 to launch the Oil and Gas Climate Initiative but are just now beginning to engage with U.S. companies.) Some in the industry are trying to develop their businesses under the expectation that not only will they have to live with much tougher carbon constraints in the future, but also that their social license to operate will depend on having adequate responses to the climate challenge. Companies need to offer better solutions than just not liking the Keep it in the Ground movement. The industry needs to grapple seriously with climate as a problem while satisfying the continuing near-term need for oil and gas.

The industry needs to think not just about where the next barrel is coming from, but also where the cleanest barrel comes from.

For starters, the industry needs to think not just about where the next barrel is coming from, but also where the cleanest barrel comes from. Some companies, in addition to growing their natural gas resources, are looking for low-cost oil that has a smaller carbon footprint than some other oil sources; not all oil is equal in terms of the carbon footprint of the energy. Applying that kind of screen would raise serious questions about the Canadian oil sands and extra heavy oil from Venezuela, which could become stranded assets, and some companies are indeed restructuring their portfolios to exit those assets. On the other hand, while some majors are thinking about going after low-carbon barrels, it does not seem to be common in the industry globally. Also, most of the carbon comes from the combustion of the oil, and picking slightly less carbon-intensive barrels makes a pretty small difference given the scale of decarbonization needed.

The industry could also clean up its production from a climate perspective, such as by using solar arrays on oil fields for power. There are also efforts to electrify some company installations offshore, reduce flaring intensity and eventually eliminate flaring in upstream operations, address the challenge of methane leakage, achieve energy efficiency gains across company value chains, and invest in renewables. Offshore wind could be a good investment for companies with offshore drilling expertise.

Long-term, the industry may not have license to operate in a carbon-constrained world unless it finds a way of commercializing carbon capture, utilization, and storage. This could manifest in various ways. The industry could look to create its own zero-carbon disruptions that will benefit the industry, such as increasing storage efforts to inject enough CO2 to fully offset the lifecycle emissions of the oil, resulting in lower-carbon or carbon-negative oil. The industry could also take abundant supplies of methane, combined with direct air capture for CO2, to produce carbon black emissions-free. If methane could be turned into structural building materials, turning carbon into value and trapping it long-term, that could be a game changer. Capturing CO2 to make things is not a matter of technical possibility, but rather of commercialization and getting to scale and affordability.

METHANE

The issue of methane leakage from oil and gas production and transport has the potential to undermine the assertion that natural gas is a bridge to or part of a lower-carbon future. Companies are better off if methane stays in the pipe, and leaks from upstream production can be controlled fairly easily with money and technology. There are also leaks in gas distribution company pipes – the 80-year-old iron pipes under city streets – but data show that these are small sources of leakage in the chain compared to upstream. (Those old pipes are being replaced at the rate that regulators let utilities recover their costs.)

There have been aggressive efforts recently to roll back federal methane regulations in the United States; these rollbacks have primarily been based on ideology, as opposed to market conditions or engineering. The American Petroleum Institute (API) has put together a voluntary initiative that many major companies have signed onto in the absence of regulation – which could provide a model for methane regulation for whenever the Administration changes. Voluntary efforts are not making up the difference, though. The majors are all keenly aware of the methane issue and have stepped up with voluntary programs, but without federal regulations, it is difficult to bring along the thousands of small and mid-sized operators across the industry. Also, while the methane regulations are a competitive advantage for those who are already operating well, that has not translated into the majors pushing back on proposals to roll them back. The industry did not feel it had adequate input into the drafting of the regulations under the Obama Administration and felt there were so many regulations coming so quickly under that Administration that it could not keep up. As a result, API was suing to stop everything, which was not necessarily the right approach, but there was no visible path to come together to find solutions.

The methane leakage issue is not going away, though – in the United States or around the world – and it represents a vulnerability of the role of gas in the longer term. Natural gas companies working around the world need to pay attention to and address it.

BROADER CLIMATE POLICY

Carbon pricing could be a key aspect of bringing order to the energy transition. It is the most economically efficient way to address the challenge – and a way to properly price the risk more broadly in the economy. Several companies already utilize internal carbon pricing to assess project risks, and some feel the industry ought to be proactive on the public policy front as well – not just tolerating the policy idea but actively advocating for pricing the undesirable externality. To make progress around siting or permitting decisions, carbon pricing is essential; otherwise there is no normalized mechanism to address the challenges in an organized, rational way. It could also be good for the industry, at least with respect to the natural gas business. Some in the industry see carbon pricing as a key part of the answer. Some would support a carbon tax more if it involved getting rid of other inefficient clean energy subsidies and requirements (which are equivalent to much higher implied carbon prices).

Carbon pricing is essential; otherwise there is no normalized mechanism to address the challenges in an organized, rational way.

On the other hand, the industry has lots of small, private businesses that influence the trade associations and that are hostile to (or at least hesitant about) action on this issue. The industry associations will not provide leadership on this issue, given the disagreements within them. Until there is a real sense among a larger number within the industry that there is serious political attention being paid to carbon pricing, the trade associations will not come out and act proactively. There is little indication of such attention at the federal level, though some are hopeful that progress can be made, given that several members of the Senate feel there is nothing in budgets left to cut, so members of both parties are

looking at a carbon tax not for climate purposes but for revenue. In addition, even as carbon pricing seems to be on hold at the federal level, numerous states are exploring carbon pricing policies.

There are many concerns within the industry regarding carbon pricing. Some are wary of what is seen as a "central planning" solution and worry about unintended consequences from an overly simplistic policy. Others are concerned about further increasing the costs of oil and gas given that they are already highly taxed. In addition, the oil industry feels that participation in the political process will not yield a balanced result, will cause the industry to be treated unfairly, and will produce policies that are just cudgels as opposed to positive incentives for changes in the industry.

There are also concerns about how the revenues raised by carbon pricing would be used. There are many options. They could be used to pay for tax reform, cut other taxes, address deficits, pay for public projects (e.g., infrastructure), support additional investments to lower greenhouse gas emissions, offset the impacts of higher energy prices on low-income citizens, or provide people with regular dividends. These choices all have political, economic, and distributional aspects, but most (except for investing in additional emission reductions) do not affect the environmental impact of the carbon price.

It may take a few brave leaders of companies to pull the right group together to move forward on climate policy, help people in conservative oil-producing states understand, and engage the range of smaller companies. The CEOs of some of the majors are starting to speak out more on climate change now; leadership is starting to emerge. However, resurgent political support for and efforts to subsidize coal present a potential roadblock to the oil and gas industry engaging more on climate policy. Being lumped in with coal in the public mind is not where the oil and gas industry (or, for that matter, the nuclear industry) wants to be.

CLIMATE RISK & INSURANCE

Just as carbon pricing is meant to properly price climate risks into the broader economy, so too is insurance meant to provide a pure economic signal of what risks are – and climate risk factors should be incorporated into insurance prices. Insurance and reinsurance companies are seeing rising losses from extreme weather events, which, while due in part to more buildings and infrastructure being built along the coasts, are also driven by climate change. The insurance industry needs to be able to properly price the risk and charge risk-adequate prices. In the competitive U.S. marketplace, however, any insurers that step out ahead to charge such prices will lose market share, as competitors will charge lower prices. The risk-adequate price is thus not reflected in the marketplace, which means people and businesses are not receiving the proper signals about climate risks. Flood insurance is a particularly notable manifestation of this problem, as the National Flood Insurance Program controls the market and is not adequately reflecting the risks in the price.

Insurance and reinsurance companies are seeing rising losses from extreme weather events.

Some in the insurance industry are hoping to have an impact on improving the climate resilience of buildings and infrastructure, much as the industry did on improving car safety. At the moment, there is little financial incentive for most people to adopt such practices. An improved method of incorporating the value of resiliency – the value of keeping people safe and enabling communities to withstand extreme weather events – could provide a better incentive. A resilient mortgage, for instance, could recognize the value of resilient properties; if a house is built stronger – beyond building codes – then the default risk as the result of an event is less, so the mortgage rate in the market should also be lower.

APPENDICES: AGENDA

WEDNESDAY, JUNE 6

Opening Session

Introduction — **David Monsma**, Vice President, Aspen Institute; Executive Director, Energy and Environment Program

Welcome — **Jason Bordoff**, Founding Director of the Center on Global Energy Policy at Columbia University

Janet Clark, Director of EOG Resources and Former EVP and CFO of Marathon Oil Corporation

SESSION I: **Data Room – The Global Energy System**

In a world where the energy system is in transition, where are we going and how do we get there… and what are barriers that we should keep our eyes out for on the horizon?

Moderator: Janet Clark

Discussants:

Pete Trelenberg, ExxonMobil
Michael Cohen, Barclays
Kassia Yanosek, McKinsey & Company
Jay Costan, Dentons

SESSION II: **Discussion with FERC Commissioner Neil Chatterjee**

A discussion with FERC Commissioner Chatterjee on the future regulatory framework and energy policy, pipelines, and electricity.

Moderator: Jason Bordoff

Discussant:

Neil Chatterjee, Federal Energy Regulatory Commission

SESSION III: **Markets: Global Natural Gas Markets**

Natural gas is projected to be the largest demand growth fuel over the coming decade, and LNG has been increasingly sold on spot markets rather than fixed contracts. What is the short and mid- term outlook for natural gas and LNG and where will future supplies be coming from and going to?

Moderator: Janet Clark

Discussants:

Jason Bordoff
Adrian Reed, Tellurian, Inc.
Heather Cykoski, ABB Inc.

THURSDAY, JUNE 7

SESSION IV: **Oil Upstream and Midstream**

Where will the next barrel of oil come from? Will new ultra-deepwater technology, soon to be opened offshore space open to drilling in the US, and melting ice opening up areas of the Arctic to exploration or will efficiencies in shale production reduce exploration?

Moderator: Janet Clark

Discussants:

John Mingé, BP America, Inc.
Claire Farley, KKR
Michael Teague, State of Oklahoma
Sarah Sandberg, DCP Midstream

SESSION V: **The Future of Petroleum Demand**

There is much talk about the future of petroleum demand. What are the factors that go into increasing or decreasing demand for petroleum? What segments are growing and what are at risk of shrinking?

Moderator: Jason Bordoff

Discussants:

Chris Midgley, S&P Global Platts
Antoine Halff, Columbia University Center on Global Energy Policy
Marianne Kah, Columbia University Center on Global Energy Policy
Paula Gant, Former US Department of Energy

FRIDAY, JUNE 8

SESSION VI: **Considering and Planning for Climate Risk**

Climate change is increasingly impacting a wide range of economic sectors, including energy, infrastructure, natural resources, agriculture, and the environment. As the impacts amplify, companies are beginning to build climate change into their risk analysis. How can companies better prepare for an uncertain future?

Moderator: Jason Bordoff

Discussants:

Jean-François Poupeau, Schlumberger
Geir Westgaard, Equinor
Carl Hedde, Munich Re, US
Tisha Schuller, Adamantine Energy

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