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Decarbonization and Peak Oil Demand: The Role of Policy in the Transportation Sector

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EXECUTIVE SUMMARY

Policy initiatives associated with climate change and a low-carbon economy will impact the transportation sector and future oil demand. But which policies matter the most, and how impactful can they be? Understanding these policy dynamics is critical, as government intervention can accelerate transportation decarbonization (a transition to a low-carbon transportation sector) and peak oil demand scenarios that would otherwise evolve more slowly and would be based purely on market forces and technology adoption.

The transportation sector accounts for 56 percent of global oil demand[1] and has been the main driver of the significant increases in oil demand over the past two years.[2] However, ambitious transportation sector policies and plans, especially government programs to improve fuel efficiency, promote alternative fuels, and support electric vehicles (EVs) could have important consequences for oil demand destruction, leading to a plateau or even peak in global oil demand. This, in turn, could have serious geo-economic and geopolitical consequences for oil producing and consuming states. This paper will address the policies driving changes in transportation, as well as headwinds that policy makers are currently facing on this issue. Future work will address the geo-economic and geopolitical implications of various transportation and oil demand scenarios.

Today, lawmakers have a suite of policy options at their disposal to address emissions in the transportation sector. Popular policy options fall into four broad categories: (1) efficiency mandates, (2) lower- and zero-carbon fuels, (3) replacing the internal combustion engine (ICE), and (4) social engineering (through measures such as ride-sharing, smart cities, and the electrification of mass transit). Much of the focus today is on passenger vehicles and particularly the proliferation of electric vehicles. However, more attention should be paid to the transportation sector more broadly, inclusive of commercial vehicles, aviation, rail, marine shipping, and broader transportation issues such as a transformation of mass transit, city planning, and a "micro-mobility" revolution. The types, strengths, underlying motivations, and enforcement timelines of all of these transportation policies play an important role in the outlook for global oil demand as well as broader greenhouse gas reduction efforts.

There are key risks and challenges faced by lawmakers, however, that could undermine the transportation decarbonization effort. A key question is where and how these headwinds are playing out, as the variances among countries and regions will also be an important factor in the broader oil demand and decarbonization outlook. For example, several European countries are considered to be pushing the envelope on electric vehicles and shifting away from internal-combustion engines. However, the European market is not big enough to make a significantly negative dent in global demand as it represents about 15 percent of total oil consumption. On the other hand, significant decarbonization or clean transportation policy efforts in major Asian economies like China and India could have a major impact on the global market, as Asia accounted for about 60 percent of total oil demand growth in 2017.

Still, the risks and challenges faced by governments are significant and therefore an important factor in the broader peak oil demand debate. These include issues such as infrastructure constraints, costs (especially for the electric vehicles when compared to traditional fossil fueled power vehicles or in the case of retrofitting to cleaner fuels for marine shipping), political constraints including elections and legal challenges, questions about the regulation of emerging technologies, resource availability and environmental concerns for the critical minerals, and resistance from politically important and powerful groups such as the domestic auto industry in India or the agricultural/farm lobby in the United States. As a result, a major question remains: will governments be willing to put more political capital behind expensive initiatives, even in the face of the risk that the effort backfires and encourages rising energy and transportation prices? Or do governments instead prefer a more cautious approach that would signal a less disruptive outlook for global oil demand growth?

Evidently, there is a significant amount of uncertainty about the decarbonization transformation of the transportation sector, especially regarding how much

1 Andreas de Vries and Salman Ghouri, "Can We Expect Oil Demand To Slow Anytime Soon?," Energy-General, August 8, 2017, https://oilprice.com/Energy/Energy-General/Can-We-Expect-Oil-Demand-To-Slow-Anytime-Soon.html.

2 Alaric Nightingale and Grant Smith, "Planes, Trains and Trucks: Global Trade Boom Fires Up Oil Demand," Transport Topics, last updated March 7, 2018, http://www.ttnews.com/articles/planes-trains-and-trucks-global-trade-boom-fires-oil-demand.

policy-making will move the needle for the disruption of longer-term oil demand. However, despite the challenges, it is clear that policies, especially for ground transportation, are key in the broader decarbonization equation. Governments' willingness to put their weight beyond these types of measures needs to be closely watched as it will help signal major headwinds for global oil demand that would therefore inform a peak demand scenario.

INTRODUCTION

Ambitious transportation sector policy plans, especially government programs to improve fuel efficiency, promote alternative fuels, and support electric vehicles (EVs), could have important consequences for oil demand destruction, leading to a plateau or even peak in oil demand. About one-quarter of total global CO2 emissions come from the transportation sector and, therefore, addressing transportation emissions will strengthen countries' efforts to reduce total emissions as committed to under the Paris Agreement (climate accord).

Policies, however, are not solely motivated by a desire to address environmental concerns. In fact, decarbonization goals, air pollution concerns, industrial policy, and energy security are all key drivers of these policy plans. For example, governments globally are addressing worsening air pollution, particularly from the use of diesel vehicles, while some are developing industrial policy tools in a quest for global leadership in clean transportation and battery technologies. Meanwhile, governments are using a variety of technology and policy efforts to make cities more livable and efficient. Energy security also continues to be a factor particularly in higher growth markets in Asia.

The breadth of government activity and motivation in clean transportation shows that despite the recent hype about battery electric vehicles, the transportation sector greenhouse gas emissions (GHG) reduction efforts and policies that would accelerate a peak in oil demand are not solely an EV story. Along with policy tools and initiatives aimed at "clean" passenger vehicles, the broader transportation sector, including trucking, aviation, rail, and shipping must also be considered.

In addition to electrification, other technological advances will also impact oil demand, particularly outside the passenger and light-duty vehicle sector where energy density is a concern. Costs continue to fall for hydrogen, while advances are being made in natural gas (CNG and LNG)[3] and biofuels for use in both autos and in the transportation sector more broadly.

Another important factor is the shifting role of transportation, as autonomous vehicles, ride-sharing, and "micro-mobility" developments continue to demonstrate technological progress and declining costs in addition to being the subject of rising government interest. The design and proliferation of smart cities continue to evolve and the future of fleet ownership and the influence of market design on how consumers own, rent, or lease vehicles is also an important dynamic.

All of these dynamics pose a threat to oil's supreme role in transportation, particularly as government policies accelerate the adoption of clean transportation solutions or penalize the use of fossil fuels.

However, within the clean transportation and peak oil demand debate there is little consensus about the exact recipe of policy measures and implementation timeframes that will allow countries to meet commitments made under the Paris Agreement, especially regarding transportation sector decarbonization. Existing assessments from several leading government, academic, and private sector institutions have attempted to better understand the impact of various policy tools on decarbonization and promoting a clean transportation sector. Nonetheless, there remains a significant level of uncertainty in the analysis and forecasting on this issue particularly outside of the electric passenger vehicle domain.[4]

TWO APPROACHES TO GLOBAL CLIMATE CHANGE POLICY: "NATIONAL INTEREST" VS "CARBON BUDGET"

The Paris Agreement was designed to create an overarching climate framework, but at the same time allow for individual country-level approaches to achieve greenhouse gas emissions reduction targets through Intended Nationally Determined Contributions (INDCs). Though considered a more effective approach by allowing countries to consider national policy priorities and circumstances, the result has led to patchy decarbonization efforts and transportation emission reduction strategies across the world, largely owing to structural, technical, and politically complex challenges unique to countries and regions. Still, much of the existing research regarding clean transportation and peak oil demand scenarios does not consider the underlying dynamics that drive policy making and the

3 Compressed Natural Gas and Liquid Natural Gas, respectively

4 Please see figure 1 in the appendix of this report for a more detailed look at several examples of existing reports and analysis.

prioritization of national interests, especially when it comes to the environmental and climate change mitigation efforts.

Clean transportation policies are likely to be more effective when accounting for and influenced by other national interests. These include industrial policy motivations, air quality concerns, and energy security issues. These motivations are likely to drive support for policies aimed at decarbonizing transportation and therefore risks for future oil demand growth. For example, a policy framework developed with an industrial strategic goal might have more longevity than a purely climate agenda-based goal.

This "national interest" approach contrasts to current prominent theories regarding effective policy means to reduce emissions and limit the rise of global temperatures, which are based on the idea of a "carbon budget." According to the International Panel on Climate Change (IPCC), a carbon budget is the amount of carbon that can be emitted while still limiting global temperature rise below the target of 2 degrees Celsius above pre-industrial levels.[5] According to the World Resources Institute, half of the global carbon budget has already been spent, and as a result, the world is currently not on track to sufficiently limit warming.

A risk of relying purely on the carbon budget approach to motivate an aggressive policy push is that it is vague and does not take into account shifting realities, technological advancements,[6] and important political considerations. As a result, political interests that drive transportation policy change at a stronger level and within an earlier timeframe are cases that should be given the most attention when identifying the risks for future oil demand.

THE POLICY PORTFOLIO APPROACH

Lawmakers have a portfolio of policy options at their disposal to decarbonize the transportation sector (Figure 2). The types, strengths, underlying motivations, and enforcement timelines of these transportation policies all play an important role in the outlook for oil demand.

Figure 2. Transportation Sector Policy Portfolio

- Carbon policy
- Gasoline and fuel tax/de-subsidization
- Congestion management and tolling
- Licensing and driving restrictions
- Restrictions/bans on gasoline/diesel cars and trucks
- Incentives (tax credits, other financial incentives, rebates)
- Alternative engine subsidies and mandates
- Alternative fuel subsidies and mandates
- "Cash for clunkers"/scrapping incentives
- Efficiency mandates
- Mass transit versus highway spending
- Virtual work experiences versus commuting/flying
- Distance education
- Bicycles and walking

Currently, popular policy options fall into four broad categories: (1) efficiency mandates, (2) lower- and zero-carbon fuels, (3) replacing the internal combustion engine (ICE), and (4) social engineering.

Passenger Vehicles

Passenger vehicles account for just over 26 percent of global oil demand, the largest share of any sector. There is more opportunity for emissions reduction—and therefore oil demand destruction—in passenger

5 World Resources Institute, "World Resources Institute: The Carbon Budget," http://www.wri.org/sites/default/files/WRI13-IPCCinfographic-FINAL_web.png?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top-stories.

6 Andrew Freedman, "Rethinking the carbon budget message," Axios, May 15, 2018, https://www.axios.com/rethinking-the-carbon-budget-message-35c27974-1bc8-4148-b679-7cb18e35f605.html?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top-stories.

vehicles than in other sectors, and the technological challenges as well as costs and infrastructure issues, seem to be the easiest to target and overcome. As a result, the bulk of global transportation policy activity is focused on passenger vehicles. The range of policy measures aimed at fuel use and quality is a growing trend that will lend more insight into this debate.

Efficiency Mandates

Fuel-economy standards are the most common policy tool for increasing efficiency, and thus reducing oil consumption and greenhouse gas emissions, in transportation. In the United States, the federal Corporate Average Fuel Economy (CAFÉ) standards, enacted mainly in response to the 1970s Arab Oil Embargo, set an average fuel economy for manufacturers of new passenger vehicles and light-duty trucks. According to the Energy Information Administration (EIA), the policy is a footprint-based corporate average standard that uses the footprint of a vehicle (the wheelbase multiplied by average track width) to set GHG and fuel economy targets.[7] The Obama administration, which updated the rules in 2012, saw them as an important driver for reducing US oil consumption and encouraging automakers to offer more electric vehicle options. As light-duty vehicles account for about 60 percent of all US transportation-related GHG emissions and fuel consumption,[8] the Obama administration set rules for light-duty vehicles to achieve, in two phases, an emissions standard of 163 grams of CO2/mile for vehicles produced in model year (MY) 2025, equivalent to a fuel economy standard of 54.5 miles per gallon (mpg). According to the Obama EPA, the 2025 fuel standards would reduce oil consumption by 1.2 billion barrels and reduce about 540 million metric tons of greenhouse gas emissions over the lifetimes of MY 2022–2025 vehicles.[9] However, the Trump administration is in the process of weakening those standards, largely in response to push back from automakers claiming the MY 2022–2025 standards were too strict. Importantly, though, automakers have pushed back against the Trump administration's proposed changes that would significantly scale back federal fuel efficiency requirements by freezing model 2020 standards. Rather, automakers are asking for more flexibility in meeting the current rules, as well as to avoid a situation of legal uncertainty over clashes with California over the emissions standards. As a result, automakers will likely continue to increase the fuel economy for new vehicles given the political uncertainty about stricter future standards, and variance across the United States as well as globally.[10]

Another policy tool is the "cash for clunkers" program, whereby the government offers incentives to turn in older, less efficient vehicles. The Obama administration launched the $2.85 billion Car Allowance Rebate System (CARS) stimulus program in 2009 to boost efficient vehicle sales, reduce emissions, and create jobs amid the Great Recession. The program encouraged consumers to trade in older vehicles for a voucher of either $3,500 or $4,500 to be applied to more fuel efficient and newer vehicles.[11] According to the Brookings Institution, the average fuel economy of the vehicles traded in was 15.7 miles per gallon (mpg), while the average for new vehicles purchased was 24.9 mpg.[12] Still, the program resulted in a relatively minimal emissions reduction, approximately 8.58-28.28 million tons (the variances account for estimations of the "rebound effect," the net increase in new vehicle sales estimate and expected driven vehicle miles).[13] Brookings concluded that the program was not the most cost-effective policy for emissions reduction given the estimated cost per ton of CO2, and that it had an outsized impact on affluent and higher educated Americans.[14] Nonetheless, it is argued that the program was more cost effective when compared to other measures such as ethanol tax credits or various incentives for EVs at the time,[15] though varying opinions of the program raise the question of whether or not one-time offers such as vouchers and incentives are truly enough to change consumer behavior when it comes to purchasing vehicles.[16]

7 Energy Information Institute, "Today in Energy: Vehicle standards around the world aim to improve fuel economy and reduce emissions," Today In Energy, October 15, 2015, https://www.eia.gov/todayinenergy/detail.php?id=23572.

8 United States Department of Transportation, "Light Duty CAFÉ Midterm Evaluation: Model Years 2022-2025," https://www.nhtsa.gov/corporate-average-fuel-economy/light-duty-cafe-midterm-evaluation.

9 "Light Duty CAFÉ Midterm Evaluation: Model Years 2022-2025."

10 "Today in Energy: Vehicle standards around the world aim to improve fuel economy and reduce emissions."

11 Ted Gayer and Emily Parker, Cash for Clunkers: An Evaluation of the Car Allowance Rebate, Brookings Institution, October 31, 2013, https://www.brookings.edu/wp-content/uploads/2016/06/cash_for_clunkers_evaluation_paper_gayer.pdf.

12 Gayer and Parker, Cash for Clunkers.

13 Gayer and Parker, Cash for Clunkers.

14 Robillard, "Brookings: Cash for Clunkers failed," Politico, October 30, 2013, https://www.politico.com/story/2013/10/brookings-cash-for-clunkers-program-barack-obama-administration-cars-stimulus-099134.

15 Gayer and Parker, Cash for Clunkers.

16 Christopher Knittel, "Another argument for carbon tax: How car buyers behave," Soapbox, Sacramento Bee, December 12, 2017, http://www.sacbee.com/opinion/op-ed/soapbox/article189231719.html.

However, the cash for clunkers program could be an important policy tool outside of the United States to ensure that developing economies are not left behind in a lower carbon transportation future. By providing incentives to turn in older, less fuel-efficient vehicles, various governments could simply facilitate the removal of ICEs from the roads than would otherwise have been the case.

Lower- And Zero-Carbon Fuels in Internal Combustion Engines

Low Carbon Fuel Standards (LCFS) are also utilized by governments to address transportation sector emissions. California enacted an LCFS in 2011, which requires petroleum-based fuel producers to reduce the carbon intensity of their products or buy LCFS credits. According to the California Air Resources Board (CARB), the LCFS is fuel-neutral and performance-based, allowing the market to determine how to reduce the carbon intensity of fuels.[17] The program uses a lifecycle approach to greenhouse gas emissions, which assesses both the direct and indirect emissions associated with the use of fuels in the state. Ethanol makes up the largest share of alternative fuel used on a volume basis, though in 2016 over half of the LCFS credits were generated by non-ethanol fuels with lower carbon intensities such as electricity.[18] Moreover, according to the Natural Resources Defense Council (NRDC), California's LCFS increased clean fuels investment by $1.6 billion since it was implemented, and it has been a major factor in the 57 percent increase in alternative fuel consumption in the state.[19] Still, opponents of the program warn that along with rising costs and the pending legal battles, the LCFS could distort fuel markets, particularly if there is not a sufficient, readily available alternative fuels supply.

Elsewhere, Canada's federal government is in the process of proposing draft regulations to enact a Clean Fuel Standard. According to the Canadian government, the standard will apply to the full life cycle of all fuel types while remaining technology neutral.[20] Draft regulations are expected to be released in late 2018, though the effort is already receiving pushback, particularly from the oil industry.

The European Union (EU) has a Fuel Quality Directive, which requires reducing the greenhouse gas (GHG) intensity of transport fuels by at least 6 percent by 2020 from 2010 levels. The EU also has proposed ambitious targets to reduce CO2 emissions from passenger cars by 30 percent by 2030, as well as proposed levels of production for low emission vehicles, similar to the structure of the low emissions vehicles programs in California and China. Still, there are currently no active plans to develop the next phase of auto tailpipe emissions standards, the Euro 7 emissions standards. However, a stronger mandate to address climate change in the region signals that while European emissions standards have thus far focused on direct pollutants such as nitrogen oxide (NOX) and carbon monoxide, Euro 7 standards are more likely to directly address CO2 emissions as well.

Biofuels mandates, such as the Renewable Fuels Standard (RFS) in the US, Canada, and a planned ethanol mandate in China, represent another policy tool. In Canada, the provinces of Ontario, Quebec, Saskatchewan, Manitoba, and Alberta have implemented some sort of renewable fuels requirement, while British Columbia already has an LCFS in place that is based on California's standard. The Canadian government also implemented a renewable fuels standard in 2010 for gasoline requiring a minimum of 5 percent ethanol and in 2011 implemented a standard for diesel that requires blending 2 percent renewable distillate.

Replacing the Internal Combustion Engine

California has been and continues to be a leader in enacting policy measures that encourage a switch from gasoline and diesel-powered vehicles to EVs. This is because the state is the largest passenger car and light-duty trucks market in the United States[21] and transportation accounted for about 37 percent of the state's GHG emissions in 2015, making addressing transportation emissions essential to the state's updated goal of cutting overall GHG emissions by 40 percent from 1990 levels by 2030.[22] California's EV market is the second largest in the world after China,[23] with over 300,000 battery-electric and hybrid vehicles on the

17 "Low Carbon Fuel Standard," California Air Resources Board, last updated May 22, 2018, https://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

18 "Low Carbon Fuel Standard."

19 Simon Mui, " New Progress Report Shows Low Carbon Fuel Standard Working," Expert Blog, Natural Resources Defense Council, June 22, 2017, https://www.nrdc.org/experts/new-progress-report-shows-low-carbon-fuel-standard-working.

20 Government of Canada, "Clean fuel standard," last updated January 1, 2018, https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html.

21 "Clean fuel standard."

22 Energy Information Institute, "Today in Energy: California plans to reduce greenhouse gasses by 40% by 2030," Today in Energy, February 2, 2018, https://www.eia.gov/todayinenergy/detail.php?id=23572.

23 Chris Busch, "California Wants More Than 4.2 Million Electric Vehicles by 2030; A New Plan Charts the Road Ahead," #PowerUp,

roads as of mid-2017.[24] In fact, China and California's markets are expected to account for 50 percent of global EV sales in 2018.[25]

In 2012, California also established a Zero Emissions Vehicle (ZEV) program, with a headline target to hit 1.5 million ZEVs on the roads by 2025. Under the program, automakers are required to meet an increasing ZEV credit percentage based on average annual sales, starting with 4.5 percent in 2018 and rising to 22 percent by 2025. Automakers earn credits for the sales, with value varying based on their proximity to zero emissions. Full electric or hydrogen vehicles earn more than hybrids, but full ZEVs must account for 16 percent of sales by 2025. Nine other states (Connecticut, Maine, Massachusetts, Rhode Island, Vermont, New Jersey, New York, Maryland, and Oregon) have also adopted the ZEV program. Additionally, California offers EV owners a $2,500 rebate (recently modified to favor lower income buyers) as well as benefits such as access to high occupancy vehicle (HOV) lanes.[26] The state also offers loan guarantees for fueling infrastructure and is building out charging stations.

On an even more aggressive end of the policy spectrum, several European countries such as the United Kingdom (UK), France, the Netherlands, and Norway have announced plans to ban the sale of new gasoline and diesel-powered vehicles. The UK's plan, announced in 2017 and scarce on details, will focus on enabling (and funding) local councils to limit diesel vehicle usage. Other measures will include the creation of Clean Air Zones, diesel car scrappage schemes, retrofitting buses, and funding for battery technology research and development.

European countries and cities are demonstrating a strong imperative to address climate change and are also motivated to address pollution concerns stemming from diesel. Moreover, the air quality issue has become more pronounced following the Volkswagen (VW) emissions testing cheating scandal, which prompted diesel cars to fall more out of favor among the public and governments. European cities in particular, are leading the charge against diesel vehicles, with Paris, Madrid, and Athens announcing plans to ban diesel vehicles from city centers by 2025, while London is planning to introduce a daily £10 charge on the oldest, dirtiest vehicles. This suggests that the policy trend toward electrification in the region will grow and therefore regulatory and political support will promote a rise of electric vehicle penetration along with other policies that address decarbonization in the transportation sector more broadly.

However, data thus far only partially support that theory. The region is seeing a rise in alternative fuel passenger vehicles, while the share of diesel in new passenger cars is declining. According to the European Automobile Manufacturers Association (ACEA), diesel's share of new passenger vehicles in Western Europe reached a peak in 2011 at about 56 percent of the total, which fell to 44 percent by 2017.[27] Meanwhile, the share of petrol-fueled new passenger vehicles grew from 43.7 percent in 2015 to 45.8 percent in 2016, while hybrid electric vehicles saw the most growth within the alternative fuel category, rising by .4 percent to 2.1 percent of Western Europe's new passenger vehicle registrations in 2016.[28]

Despite the fallout from the VW emissions test cheating scandal, even combined with national and local mandates, the transition to electric and hybrid vehicles has been relatively slow and diesel still remains the most popular fuel among Western European drivers, accounting for nearly 50 percent of total market share, followed closely by petrol, which, per the ACEA's latest data, continues to steadily grow. Battery costs and overall higher price tags for EVs as compared to internal combustion engine (ICE) cars, combined with inadequate charging infrastructure and low driving ranges continue to be major hurdles. For example, EVs only account for less than 5 percent of new car sales in the UK, held back by these very hurdles.

However, while EV deployment remains sluggish in some countries, others have taken the lead. Though a small market, Norway is by far the global leader on EV penetration due to a suite of incentives to motivate

Forbes, December 14, 2017, https://www.forbes.com/sites/energyinnovation/2017/12/14/california-wants-4-2-million-electric-vehicles-by-2030-a-new-state-plan-charts-the-road-ahead/#3cd0a9b64b44.

24 "Zero-Emission Vehicles and Infrastructure," California Energy Commission, last updated July 5, 2017, http://www.energy.ca.gov/renewables/tracking_progress/documents/electric_vehicle.pdf.

25 Mark Chediak, John Lippert and Ying Tian, " How California Taught China to Sell Electric Cars," Hyperdrive, Bloomberg, March 27, 2018, https://www.bloomberg.com/news/articles/2018-03-27/how-california-taught-china-to-sell-electric-cars.

26 "California Vehicle Rebate Program," California Climate Investments, Accessed June 13, 2018, https://www.arb.ca.gov/msprog/lct/cvrp.htm.

27 European Automobile Manufacturers Association, "Share of Diesel in New Passenger Cars," 2018, http://www.acea.be/statistics/tag/category/share-of-diesel-in-new-passenger-cars.

28 European Automobile Manufacturers Association, "Trends in fuel type of new cars between 2015 and 2016, by country," February 15, 2017, http://www.acea.be/statistics/article/trends-in-fuel-type-of-new-cars-between-2015-and-2016-by-country.

purchases of EVs, including a sales tax exemption that amounts to roughly $12,000, a 25 percent value-added tax (VAT) exemption, waivers on fees and tolls, access to bus lanes, and the largest per capita charging infrastructure in the world. Local governments also restrict diesel usage, and Norwegians are helped by their abundance of cheap hydro power for electricity. While considered a success in the broader EV dissemination story, Norway will still need to increase the use of all types of EVs rather than a current focus hybrid penetration in order to reach its 2025 target to phase out fossil fuel-powered vehicles. The costs of incentives are also increasingly an impediment for government, so these generous incentives are starting to be relaxed owing to budgetary constraints.

That said, even under the most aggressive electric and hybrid passenger vehicle dissemination growth scenario the European market is not big enough to have a dramatically negative impact on global oil demand, as it represented around 15 percent of global oil demand in 2017.

However, significant decarbonization or clean transportation policy efforts in major Asian economies like China and India could have a significant impact on the market, as Asia accounted for about 60 percent of global oil demand growth in 2017.

China is a good example of a country where national interests and current political realities are bolstering decarbonization in the transportation sector. In China, the motivation is less climate change than addressing growing air quality concerns and energy security goals, as well as motivating advanced domestic manufacturing of cars and batteries in an effort to be seen as a global leader in these sectors. Energy security goals are also an underlying factor, particularly reducing China's reliance on fossil fuel imports, especially from geopolitically risky exporters. While the effort in China is being driven centrally by the national government, there is also significant attention and advancement at the municipal level as well as advances in technology. The combination of these factors could have a large impact given the scale of both China's oil demand as well as its auto market.

The issue that gets the most attention is Chinese policies promoting electric vehicles (EVs). China has highly ambitious plans to increase EV penetration, with a target for new sales of EVs to reach 5 million by 2020 as part of the Thirteenth Five Year Plan. Beijing has a strong incentive to aggressively push EVs, given that its new-energy vehicle policy would benefit local electric vehicle manufacturers and is an opportunity to capture a competitive advantage in a still-developing industry lacking a clear global leader. The effort is in line with its Made in China 2025 strategy to foster the development of national champions in strategic sectors. As a result, government support for the development of new energy vehicles (NEVs) will not weaken, despite a risk of bottlenecks as well as a planned phase-out of subsidies.

The impact of China's EV target could have significant implications for automakers and oil demand given the sheer size of the market, as China is the largest market for EVs in the world, surpassing the United States in 2015.[29] In 2016, China accounted for the largest share of the 770,000 EVs sold worldwide by far, with 507,000

The Ten priority sectors of the Made in China 2025 industrial policy
1) New advanced information technology
2) Automated machine tools and robotics
3) Aerospace and aeronautical equipment
4) Maritime equipment and high-tech shipping
5) Modern rail transport equipment
6) New-energy vehicles and equipment
7) Power equipment
8) Agricultural equipment
9) New materials
10) Biopharma and advanced medical products

29 Bloomberg News, "Shakeup Looms for China's Electric-Vehicle Makers," Hyperdrive, Bloomberg, March 19, 2018, https://www.bloomberg.com/news/articles/2018-03-19/shakeup-looms-for-china-s-electric-vehicle-makers.

vehicles sold (compared to 159,000 in the US).[30] Beijing's EV strategy includes a requirement that automakers achieve a certain sales percentage of NEVs in 2020. China also has various incentives for new energy vehicles, is investing in public charging stations, provides sales and excise tax exemptions for EVs, and promotes other EV benefits like access to restricted lanes.

At the same time, as part of its industrial policy agenda, China has been moving aggressively to boost battery technology capabilities and there have been major policy developments and commitments to advance autonomous vehicle technology. Beijing has announced a policy to open city roads for the testing of self-driving vehicles, joining other major Chinese cities such as Shanghai and Shenzhen, which are also showing signs of commitment to developing autonomous vehicles and smart cars.

Finally, another important development is the growing use of hydrogen-powered fuel cell vehicles, both in China and across the world. Hydrogen fuel-celled electric vehicles (FCEVs) offer another important alternative-fuel vehicle option and have several advantages when compared to battery-powered electric vehicles such as the ability to drive for a longer range, a lower refueling time and heavy-duty capability.[31] According to the European Climate Foundation, fuel-cell passenger vehicles are expected to reach 10 percent of total sales by 2035, 19 percent by 2040 and 26 percent by 2050.[32]

Hydrogen for use as road transportation or for power consumption continues to make progress, especially given growing interest in coal-to-hydrogen projects. Earlier this year, Argus, an Australian utility, announced it was joining forces with Royal Dutch Shell and several Japanese companies in a coal-to-liquids joint venture pilot project.[33] If ramped up to reach a commercial scale, hydrogen produced from the project would be used for transportation fuel in Japan.

Still, the widespread dissemination of FCEVs has current limitations such as the availability of hydrogen, costs, and broader infrastructure challenges.[34]

Social Engineering

Another important facet of this debate is the potential for a public and private transportation transformation, particularly the way consumers think about mobility. Mass transit, ride-sharing, smart-cities, the electrification of mass transit, and other developments are changing traditional commutes and may be altering consumer behavior when it comes to purchasing vehicles. While still to be considered in a relatively early stage of development, ride-sharing and autonomous vehicles expansion holds particular stakeholder interest, and even Saudi Aramco, a skeptic of the peak demand debate, is more worried about the growth of ride-sharing than EVs.[35] According to the World Economic Forum, the growth of "mobility-as-a-service" and shared mobility could pose a threat to the number of vehicles on the road, particularly for urban and suburban consumers."[36]

China has also taken significant steps in the electrification of mass transport more broadly. Along with the electrification of railway, other significant policies include the promotion of ride-sharing and bicycle sharing, mass transit and smart cities policies, and support for advanced biofuels. Moreover, ninety-three Chinese cities have initiated smart-city pilot projects that include a focus on mobility services such as the proliferation of autonomous vehicles and shared-driving models.[37]

Commercial Vehicles

Commercial vehicles are the second largest source of oil demand at 18 percent, and thus represent a significant opportunity for emissions reduction and oil demand destruction. While focus and progress thus far has primarily

30 Nic Lutsey, "The rise of electric vehicles: The second million," The International Council on Clean Transportation, January 31, 2017, https://www.theicct.org/blogs/staff/second-million-electric-vehicles; China Association of Automobile Manufacturers, "中汽：2016年我国新能源汽 售50.7万 同比增 53%" Gasgoo, January 13, 2017, http://auto.gasgoo.com/News/2017/01/13062005205700050008C501.shtml..

31 Nicolas Stecher, "Our Hydrogen Future," Drive, October 25, 2017, http://www.thedrive.com/tech/14431/are-hydrogen-cars-the-next-big-thing-again.

32 Oliver Sachgau and Elisabeth Behrmann, "The Hydrogen-Powered Car's Big Setback," Hyperdrive, Bloomberg, March 23 2018, https://www.bloomberg.com/news/articles/2018-03-23/the-hydrogen-powered-car-s-big-setback.

33 "Japanese, Australian firms eye coal-to-hydrogen exports," Freight News, Hellenic Shipping News, April 12, 2018, https://www.hellenicshippingnews.com/japanese-australian-firms-eye-coal-to-hydrogen-exports/ .

34 Sachgau and Behrmann, "The Hydrogen-Powered Car's Big Setback," Bloomberg, March 23, 2018, https://www.bloomberg.com/news/articles/2018-03-23/the-hydrogen-powered-car-s-big-setback.

35 Camilla Hodgson, "Saudi Aramco execs see Uber as a bigger threat to oil demand than Tesla," Business Insider, December 11, 2017, http://www.businessinsider.com/saudi-aramco-ride-sharing-apps-than-electric-cars-2017-12.

36 Cheryl Martin, Fancesco Starace, Jean-Pascal Tricoire, "Electric Vehicles for Smarter Cities: The Future of Energy and Mobility," World Economic Forum, January 2018, http://www3.weforum.org/docs/WEF_2018_%20Electric_For_Smarter_Cities.pdf?utm_source=newsletter&utm_medium=email&utm_campaign=&stream=top-stories.

37 Karen Yeung and Eric Ng, "China to spearhead US$1 trillion autonomous driving revolution," South China Morning Post, December 13, 2018, http://www.scmp.com/business/china-business/article/2124042/china-spearhead-us1-trillion-autonomous-driving-revolution.

been in passenger vehicles, the International Energy Agency's (IEA's) most recent EV outlook found that the deployment of light-duty EVs will create significant opportunities and spur progress for the electrification of medium- and heavy-duty vehicles, with public busing and other municipal services as probable early targets.[38]

So far, though, the electrification of trucking more broadly has been limited to smaller demonstration and trial modules. These operations, though limited, are showing momentum particularly in California, Germany, Sweden, and the Netherlands where there is support from either the national or subnational policy makers, industry, and research groups.[39] Autonomous trucking is also gaining attention, particularly given growing interest from automakers such as Tesla. Cargo trucks will likely be early targets of the autonomous technology, though significant advances in this area are still limited by issues such as costs and battery sizes.[40]

The use of natural gas in trucking is also making headway, largely due to growing interest and investment from increasingly gas-focused oil majors. For example, Total recently announced a credit support agreement with Clean Energy Fuels Corp (CEF), which aims to launch a program incentivizing fuel switching from diesel to natural gas.[41] Still, higher costs and infrastructure constraints continue to impede on the proliferation of CNG- or LNG-fueled trucks more broadly, and according to NGV Global data, natural gas vehicles represent .06 percent of the total US fleet.[42] However, higher gasoline and diesel prices, along with steadily low natural gas prices and increasing support from companies and governments, could help bolster the adoption of natural gas in trucking and impact the broader oil demand displacement debate.

The use of lighter, lower cost materials in place of heavier steel and aluminum products is another important trend. While currently more focused on light-duty vehicles, progress and advancements could impact medium to heavy vehicles. For example, in Japan, researchers are testing the use of a wood pulp material called cellulose nanofibers in auto components given that it is much stronger and weighs one-fifth of steel.[43] These types of advanced materials will boost the fuel economy of automobiles, because it takes less energy to accelerate a lighter product. According to the US Department of Energy, a 10 percent reduction in vehicle weight can improve fuel economy 6–8 percent.[44]

Meanwhile, Chinese cities are making significant strides in electrifying public transportation. For example, the southeastern city of Shenzhen fully electrified its bus fleet, increasing the number of electric bus vehicles from 277 in 2012 to 16,359 in 2017, according to the World Resources Institute.[45] Shenzhen is the first city to deploy a 100 percent electrified bus fleet, which now is larger than the bus fleets (electrified and non-electrified) of New York, Los Angeles, New Jersey, Chicago, and Toronto combined.[46] Shenzhen's success in completely electrifying its bus fleet is due to a combination of factors, including national and local government support through measures such as subsidies, a build-out of necessary infrastructure (i.e. charging stations), and declining battery prices.

Aviation

While aviation currently accounts for slightly over 6 percent of global oil demand and about 2 percent of global carbon emissions,[47] demand for air travel is projected to double by 2040 and jet fuel demand will also increase,

38 "Global EV Outlook 2018," International Energy Agency, May 30, 2018, https://webstore.iea.org/login?ReturnUrl=%2fdownload%2fdirect%2f1045%3ffilename%3dglobal_ev_outlook_2018.pdf&filename=global_ev_outlook_2018.pdf.

39 "Global EV Outlook 2018."

40 Steve LeVine, "Musk will unveil his electric, self-driving semi-truck tomorrow," Axios, November 15, 2017, https://www.axios.com/musk-will-unveil-his-electric-self-driving-semi-truck-tomorrow-1513306946-b2de5f0d-8172-4501-b9d3-50328204c057.html.

41 Ross McCracken, "Analysis: Total to provide credit support for US LNG truck purchases," S&P Global Platts, May 10 2018, https://www.platts.com/latest-news/natural-gas/london/analysis-total-to-provide-credit-support-for-10413418."

42 "Analysis: Total to provide credit support for US LNG truck purchases."

43 Naomi Tajitsu, Maki Shiraki, "Tougher than steel: Japan looks to wood pulp to make lighter auto parts," Reuters, August 14, 2017, https://www.reuters.com/article/us-autos-japan-wood/tougher-than-steel-japan-looks-to-wood-pulp-to-make-lighter-auto-parts-idUSKCN1AU2FX.

44 "Lightweight Materials for Cars and Trucks," United States Department of Energy Office of Energy Efficiency and Renewable Energy, 2018, https://www.energy.gov/eere/vehicles/lightweight-materials-cars-and-trucks.

45 Lu Lu, Lulu Xue and Weimin Zhou, "How Did Shenzhen, China Build World's Largest Electric Bus Fleet," World Resources Institute, April 4, 2018, http://www.wri.org/blog/2018/04/how-did-shenzhen-china-build-world-s-largest-electric-bus-fleet?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top-stories.

46 Nathaniel Bullard, "China Goes All In on the Transit Revolution," BloombergOpinion, Bloomberg, December 8, 2018, https://www-bloomberg-com.cdn.ampproject.org/c/s/www.bloomberg.com/amp/view/articles/2017-12-08/china-goes-all-in-on-the-transit-revolution?lipi=urn:li:page:d_flagship3_feed%3BWuGzbymyQs%2B7J%2BtmK0MEzQ%3D%3D&utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top-stories.

47 "Fact Sheet: Climate Change & CORSIA," IATA, May 2018, https://www.iata.org/pressroom/facts_figures/fact_sheets/Documents/

though increasing the efficiency of planes will likely keep the increased fuel demand to 50 percent.[48] The development of clean aviation technology is significantly further behind than that of ground transportation, with most advances coming from lighter, more efficient aircraft. Some manufacturers have been increasingly replacing heavier materials such as steel for lightweight and more energy-efficient materials such as carbon fiber, plastics, and aluminum. Plastics in particular are increasingly becoming a competitive alternative to aluminum in the aerospace industry, for both the interior and exterior of planes.[49] Along with delivering weight and manufacturing cost savings, the use of carbon fiber components has boosted fuel savings. For example, about half of the Boeing 787 Dreamliner's airframe is made of composites, reducing fuel consumption by up to 5 percent.[50]

There are also promising developments on drop-in "biojet" fuel. For example, a US Energy Department national lab announced in June that it had approved ethanol as a feedstock for aviation fuel use.[51] The fuel production process can use ethanol from any source, is thereby low cost, and can now be used by commercial airlines in up to 50 percent blends with conventional jet fuel.[52] Some of these decisions are being driven by the International Air Transport Association (IATA) pledge to reduce net aviation CO2 emissions by 50 percent by 2050, even as cost reduction and technological innovation continue to be key drivers. For example, Alaska Air has pioneered a technology called Required Navigation Performance, a performance-based navigation system,[53] which has led to a reduction in fuel consumption by over 518,000 gallons in 2016 and emissions reduction of over eleven million pounds. The company also attests that the installation of scimitar winglets on each aircraft wing has saved an additional 627,437 gallons of fuel and reduced emissions by over thirteen million pounds.[54]

Much like in the vehicle space, Norway is an early mover in the electrification of aviation. Earlier this year, Norway's airport operator, Avinor, announced all short-haul airliners (up to an hour and a half) in the country and to neighboring Scandinavian capitals would be fully electric by 2040.[55] Avinor recognizes that the road to deploying purely electric short-haul fleets will begin with the use of "intermediary" technologies such as hybrids and biofuels, and the move will make the country a leader when it comes to electrifying the transportation sector more broadly.

EasyJet has also embarked on an ambitious plan for developing short-distance, fully electric planes within the decade.[56] Additionally, a handful of companies are developing hybrid electric short-haul aircraft, which could be on the market in the next few years.

Rail

Advancements in rail are likewise an important dynamic, particularly in regard to competition with aviation. High-speed rail in Asia and Europe is challenging air travel in terms of cost competitiveness and trip duration.[57] Advancements in rail are especially evident in

fact-sheet-climate-change.pdf?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top.

48 Matt Piotrowski, "Strong Jet Fuel Demand to Have Long-Term Impacts on Global Market," Fuse, Saving America's Future Energy, February 13, 2018, http://energyfuse.org/strong-jet-fuel-demand-long-term-impacts-global-oil-market/.

49 Austin Weber, "The Growing Role of Plastics on Aerospace Assembly," Assembly Magazine, February 1, 2018, https://www.assemblymag.com/articles/94125-the-growing-role-of-plastics-in-aerospace-assembly.

50 Tim Bowler, "Carbon fibre planes: Lighter and stronger by design," BBC News, January 28, 2014, https://www.bbc.com/news/business-25833264.

51 Ben Geman, "Generate," Axios, June 13, 2018, https://www.axios.com/newsletters/axios-generate-0e80707b-ccbf-4c4a-9eec-f0bb64c53048.html?utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top.

52 Gregory Kunkel, "News Release: PNNL technology clears way for ethanol-derived jet fuel," Pacific Northwest National Laboratory, June 11, 2018, https://www.pnnl.gov/news/release.aspx?id=4511&utm_source=newsletter&utm_medium=email&utm_campaign=newsletter_axiosgenerate&stream=top.

53 Dan Ellis, Gary Limesand, Bill Syblon, "Equipping a Fleet for Required Navigation Performance," AeroQuarterly, Boeing, December 2011, https://www.boeing.com/commercial/aeromagazine/articles/2011_q4/pdfs/AERO_2011q4_article5.pdf.

54 Alaska Airlines, "2016 Sustainability Report: Building A Sustainable Future," January 2017, https://www.alaskaair.com/content/about-us/sustainability-report?lid=vanity-sustainability.

55 Agence France-Presse, "Norway aims for all short-haul flights to be 100% electric by 2040," Guardian, January 17, 2018, https://www.theguardian.com/world/2018/jan/18/norway-aims-for-all-short-haul-flights-to-be-100-electric-by-2040?CMP=share_btn_link.

56 Angela Monaghan, "EasyJet says it could be flying electric planes within a decade," Guardian, September 27, 2017, https://www.theguardian.com/business/2017/sep/27/easyjet-electric-planes-wright-electric-flights.

57 Justin Bachman, Richard Fan and Christopher Cannon, "Watch Out, Airlines. High Speed Rail Now Rivals Flying on Key Routes," Bloomberg, January 9, 2018 https://www.bloomberg.com/news/articles/2018-01-09/high-speed-rail-now-rivals-flying-on-key-global-routes?cmpid=BBD011018_BIZ&utm_medium=email&utm_source=newsletter&utm_term=180110&utm_campaign=bloombergdaily.

China, where in 2015, 910 million Chinese traveled by rail versus 415.4 who traveled by air.[58]

While the United States is seen as relatively behind the curve when it comes to rail advancements, some US states are making important strides. For example, in late 2017 the Florida East Coast Railway (FEC) became the first US railway to switch from diesel to run primarily on LNG.[59] The FEC's conversion to LNG, though, was facilitated by its shorter routes and the fact that it is a relatively small rail system. However, the switch could carry momentum for similar moves across the country, particularly given rising diesel prices and historically low natural gas prices.

Marine

Bunker fuels account for just over 5 percent of global oil demand, and policy slated to go into effect in 2020 is likely to keep this demand relatively constant[60] despite projected growth in international shipping.[61] According to the IMO, shipping accounts for about 3 percent of total global CO2 emissions, and emissions are expected to significantly increase by 2050 in line with growing global trade.[62]

The historic International Maritime Organization (IMO) agreement on April 13 2018, to reduce emissions from the global shipping industry by at least 50 percent of 2008 levels by 2050 was a major development in transportation. Shipping and airline emissions were not included as part of the Paris Agreement, however, the aviation industry agreed on an emissions reduction target soon after the signing of the climate accord. After years of debate, the IMO carbon reduction strategy joins another mandate to address shipping emissions, the controversial sulfur standard for bunker fuels that will go into effect in 2020. Nonetheless, the preliminary agreement was met with initial criticism that it was not strong enough, owing to concerns about the impact on exporters, fuel supply, and seaborne trade competitiveness.

Resource reliability and infrastructure constraints are also key factors when examining the transition to using cleaner fuels in global maritime shipping. Even if the target of a policy is an emission such as sulfur, the effort can translate to broader GHG reduction efforts and, therefore, peak demand effects. A key example is the current debate surrounding the IMO's move to implement a stricter sulfur emissions standard for global shipping at an earlier date than the shipping, refining, and broader oil and gas industries anticipated. Stakeholders' major concerns are that the regulations will lead to a shortage in low-sulfur fuels, or that there will not be enough readily available infrastructure, such as liquid natural gas (LNG) bunkering for shippers that choose to comply with the standards by switching to LNG for fuel. Governments' efforts will be a major factor in the increased use of LNG as bunker fuel, and some governments such as Japan, Singapore, and Europe are pursuing plans to increase LNG bunkering capacity through ports, LNG fueling, and storage capacity. While the IEA estimates that LNG will replace about 300,000 barrels per day (bpd) of oil-based bunker fuel by 2021, both high capital costs for retrofitting and limited infrastructure will remain a challenge for shippers. These lingering concerns have created uncertainty about how compliance will impact various industries and have raised additional concerns about how the IMO and flag states will enforce the standards once they go into effect in 2020.

HEADWINDS FOR AMBITIOUS TRANSPORTATION SECTOR DECARBONIZATION POLICIES

The role of policy will be key in the success of a transition to a lower carbon future, particularly for transportation; however, despite some of the previously explored efforts that governments are already taking, there are several key risks and challenges that could undermine the decarbonization effort. A key question is where and how these headwinds are playing out, and the variances among countries and regions will be an important factor in the broader oil demand and decarbonization outlook.

A recurring and nearly universally held theme among academics and policymakers is that early and robust policy

58 Bachman, "Watch Out, Airlines."

59 "Florida railway first in US to embrace LNG," Argus Media, November 10, 2017, https://www2.argusmedia.com/pt/news/1570353-florida-railway-first-in-us-to-embrace-lng?backToResults=true.

60 Andrew Wilson, "Medium-Term Outlook for Bunker Fuel Markets," (presentation at the International Energy Agency Oil Medium-Term Market Report Release, May 2016), International Energy Agency, http://www.platts.com/IM.Platts.Content/ProductsServices/ConferenceandEvents/emea/European-Bunker-Fuel/presentations/4%20-%20Andrew%20Wilson.pdf.

61 Peter Sand, "Macroeconomics: Economic Growth Around the World is Supporting Shipping," BIMCO, February 19, 2018, https://www.bimco.org/news/market_analysis/2018/20180219_macroeconomics_smoo_2018_01.

62 Costas Paris, "Shipping Regulators Reach Deal to Cut Carbon Emissions," Wall Street Journal, April 13, 2018, https://www.wsj.com/articles/shipping-regulators-reach-deal-to-cut-carbon-emissions-1523639309.

intervention is needed to feasibly limit the rise in global temperatures. The momentum generated by the signing of the Paris Agreement in late 2015 was real and did produce a significant amount of optimism about the global climate change effort and the outlook for the proliferation of ambitious environmental policy measures aimed at the transportation sector. However, US President Donald Trump's 2017 publicly announced intention to withdraw from the multilateral deal jeopardized that momentum. Not only has the potential US withdrawal complicated global decarbonization efforts, it has also raised questions about the strength and trajectory of global transportation sector emissions policies and targets.

While the announcement of a US withdrawal has not led to an unraveling of the Paris Agreement, it has created two diverging paths that threaten to stunt global momentum on climate change. On one side is a growing global consensus to strengthen emissions reduction strategies; on the other is the President Trump-led retreat from the aggressive environmental standards and global climate change leadership championed by former US President Barack Obama.

Along with uneven policy making, there is also a greater risk regarding the costs of many of these efforts. This risk is especially evident in some of the very aggressive EV proliferation scenarios, as it is generally accepted that EVs are expected to remain more expensive than fossil fuel powered vehicles for some time, a factor that would impede wider dissemination. Governments have used subsidies and tax incentives to help offset the higher cost, but the effort thus far has not significantly moved the needle for EV proliferation globally, at least not at a level noticeable in the oil market. Higher costs, when compared to traditional fossil fueled power vehicles, only increase consumer skepticism about EV ownership, and thus deter broad penetration. A major question remains: will governments be willing to put more political capital behind expensive initiatives that encourage EVs, such as quotas or ICE bans, even in the face of the risk that the effort backfires and encourages rising energy and transportation prices? Currently, it appears most governments are showing a degree of caution. For example, while the UK has announced a plan to ban the new sale of gasoline and diesel-powered vehicles, the plan avoids taxes or penalties on diesel car usage owing to a political sensitivity to enacting policies that target the average motorist. This demonstrates that political interests can, in turn, undermine decarbonization efforts.

China appears willing to invest a significant amount of political capital into its clean transportation sector, despite the costs. China's growing new energy vehicle industry (which includes battery-electric, plug-in hybrid, and fuel-cell cars), as part of its ambitious plans to increase EV penetration, are heavily reliant on government support, especially direct cash allowances. Consumers can currently purchase NEVs at a reduced price as automakers are later compensated through local or central government subsidies. Beijing has adjusted its subsidy regime since it was initially implemented, but it is not a signal of reduced support for the industry. Instead, the central government plans to shift support to areas such as charging facilities and technology, owing to significant momentum in NEV sales. There are risks facing China's policy push that will test Beijing and how much political capital the central government is willing to put behind expensive measures such as those previously mentioned. Nonetheless, President Xi Jinping's recent consolidation of power, as demonstrated during the Nineteenth Party Congress, has put the current administration in a stronger position to do so.

Other countries in the Asian region though have had difficulties advancing ambitious transportation sector measures owing to political and structural constraints. For example, despite aggressive initial policy promises about EVs, some countries are now backtracking after overestimating their ability to reach ambitious clean transportation targets. Last year, Indian officials announced plans to release a proposed policy ensuring only EVs are sold in the country by 2030. Nearly a year later, the Indian minister of road transport and highways revealed that no such electric vehicle policy would be announced. Despite being an important political initiative for Prime Minister Narendra Modi's government, the transition to electric vehicles faced numerous challenges from infrastructure constraints, technology issues, costs, and resistance from the domestic auto industry. While the Modi government will continue to prioritize a shift toward renewables more broadly, the decision to slow the adoption of electric vehicles will, at present, ensure a significant level of fossil fuel imports. The situation demonstrates the risks for lawmakers, where overly ambitious or unrealistic policies could have a "snap-back" effect and unintentionally harm the development of a clean transportation sector.

Moreover, headwinds for policy agendas in Southeast Asia are also impeding significant progress and action on clean transportation measures. According to the IEA, oil demand in the region is expected to rise steadily from about 3.1 million bpd in 2016 to reach 6.6 million bpd in 2040, driven in large part by growing mobility demand and a strong petrochemicals

sector.63 The transportation sector accounts for the lion's share of the region's total oil consumption, and will grow by about 1.1 million bpd as the proliferation of new light-duty passenger vehicles rises by 70 percent between now and 2040 to reach a stock of about 62 million. At the same time, the region is projected to add 1.6 million trucks to the total vehicle stock. The Southeast Asian region relies on oil imports owing to declining domestic supply and rising demand. Despite a focus by governments to ameliorate the energy security risk that this dynamic creates, policy action to curtail the use of oil in the transportation sector remains relatively limited. Still, according to the IEA, Thailand, Indonesia, the Philippines, and Brunei are currently in the early discussion phases of adopting fuel-economy standards, while Singapore and Thailand have already introduced fuel labeling and emissions schemes. The IEA acknowledges through its business-as-usual forecast scenario that a continuation of the policy action seen thus far in the region means Southeast Asian countries will lag behind a global trend of tightening the average fuel economy of passenger vehicles.64

Absent a more aggressive policy push, a similar trend will likely play out in the electrification of the transportation sector in Southeast Asia. Despite several Southeast Asian countries setting electric vehicle targets, the region will likely see limited EV growth due to a broader lack of policy support to boost sales or a buildout of infrastructure such as charging stations. In fact, the IEA forecasts that out of the total 62 million stock of light-duty passenger vehicles in 2040, EVs will account for about 6 percent, or 4 million and as a result electricity will only account for 1 percent of energy demand for the transportation sector.[65] At the same time, as air quality and traffic problems grow throughout the region, Southeast Asian governments will likely have to put more political capital into the clean transportation sector. The timing and degree to which they do, though, remains a key question.

Meanwhile, infrastructure issues will also remain challenging for governments. For EVs, related infrastructure such as charging stations, the impact on the grid and power demand, and better access to electricity more broadly in developing countries remain key concerns, though some markets are making more progress than others. Efforts to expand infrastructure for hydrogen are also underway, though they remain in the early stages, with Japan in phase one of its hydrogen energy target, which includes expanding the use of fuel cell vehicles and hydrogen stations.

Political constraints, including elections and legal challenges, especially in early movers such as the United States and Canada, also impact transportation policies. For example, elections have the potential to completely reverse course on issues such as environmental and carbon policy, especially in places like North America, where climate change and environmental policies remain highly partisan. The 2016 US election led to a massive U-turn from the Obama administration's environment- and climate-change-focused agenda to one that favors fossil fuels and the rejection of climate change science. In Canada, the recent victory of the Progressive Conservative Party, led by Doug Ford, in Ontario signals a stark shift in the direction that Canada's most populous province was taking on climate change and environmental policies such as a carbon tax. Ford has been very vocal about his opposition to the carbon tax implemented by the former Liberal provincial government and has vowed to reverse course as soon as possible. Canada is also facing an important election in 2019, where climate strategy and policy such as a nation-wide minimum carbon levy implemented by Prime Minister Justin Trudeau could be threatened—or at least more difficult to implement—especially following the election of Ford and likely election of the United Conservative Party, led by Jason Kenney, in Alberta in 2019.

The impact of subnational-level policies remains an important facet of this debate. In contrast to shifts by some Canadian provinces, several US states are enhancing environmental efforts amid absent federal leadership, particularly when it comes to the power sector and EVs. For example, California's Zero Emission Vehicle (ZEV) program requires 1.5 million ZEVs (about 15 percent of total new vehicle sales) to be on the roads by 2025, while nine other US states have followed California's lead and implemented ZEV standards.

While subnational policy frameworks can support broader national policies or make up for a policy absence at the national level, it can also create a messy regulatory environment that complicates operations and investments, particularly for automakers. This dynamic is currently playing out in the United States, where automakers fear an uneven regulatory landscape for fuel efficiency requirements may emerge given the

63 "Southeast Asia Energy Outlook," International Energy Agency, October 24, 2017, https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_SoutheastAsiaEnergyOutlook.pdf.

64 "Southeast Asia Energy Outlook."

65 "Southeast Asia Energy Outlook."

legal battle brewing between the Trump administration and California over the corporate average fuel economy (CAFE) standards.

As explored in the paper, ambitious low carbon fuel standards threaten to distort fuel markets where there is a lack of sufficient existing alternative fuel supply. In California, the lower carbon intensity assigned to sugarcane ethanol means that the bulk of compliance, especially in later years, will come from imported Brazilian ethanol rather than domestic corn ethanol—exposing refiners to the vagaries of Brazilian ethanol exports. The additional costs from the clean fuel standard imposed on refiners could result in the closure of existing refining capacity as compliance costs become too high or push exports over domestic sales. Existing fuel prices for consumers will likely go up to motivate the transition to cleaner burning vehicle fleets over time, including flex-fuel cars and electric vehicles.

Regulation of emerging technologies will pose challenges for governments, as underscored by the tragic accident in Arizona in which an autonomous vehicle operated by Uber crashed and killed a pedestrian. Regulations for self-driving technology are scant and generally considered more business-friendly, and prior to the accident, Arizona lawmakers boasted that there were limited regulations in place for autonomous vehicles in order to attract investment and testing.[66] This suggests that regulations will likely tighten in the near future, though governments will struggle with balancing how to tighten laws and restrictions without deterring investment and advancements in the technology. Another example is the emerging concerns among municipalities to regulate the emerging "micro-mobility" market.[67] Largely driven by the private sector at this point, shareable bikes and scooters used for shorter rides are challenging the business models from taxis to traditional motorcycle manufacturing. Yet, cities have been struggling with micro-mobility regulation, particularly as concerns rise about safety.

Courts could also derail or, in turn, support efforts to implement pro-EV measures such as bans of fossil fuel powered vehicles. For example, the highest federal administrative court in Germany ruled on February 27, 2018, that municipal governments could ban older diesel vehicles from city centers, based on a case brought by environmental activists. The heightened attention to air quality and the impact of the recent court ruling means it will become increasingly difficult to protect diesel cars, likely dealing a blow to diesel demand in Germany.

Developments in global biofuels markets are an important factor in the outlook for oil demand and are accordingly identified as significant policy tools in the assessed reports. The IEA forecasts in its Sustainable Development Scenario (SDS) that global biofuels demand will grow steadily over the next several decades to reach about 7.5 million bpd in 2040, up from just below 2 million bpd in 2016. Biofuels mandates in major markets such as the United States will be drivers of this growth. However, even the main biofuels policy tool, the Renewable Fuel Standard (RFS), continues to face political risks and challenges amid backlash from the US farming sector and refiners. The Trump administration is attempting to appease both sides of the debate by seeking ways to ease compliance burdens for the refining sector while also preventing backlash from farm states. However, the policy remains extremely complex politically given the political clout of the agriculture sector.

Resource availability and environmental concerns for the critical minerals used in many EVs, namely in batteries used to power them, is another key issue that could complicate transportation policies. The price of lithium has quadrupled, and the price of cobalt has doubled in recent years, owing to rising demand and tighter supply,[68] and the threat of a supply crunch would create major uncertainties about the wider dissemination of EVs and batteries more broadly.

In the long term, as resource constraints become more apparent, a system designed to reuse, recycle, and potentially substitute these materials is needed. Hydrogen and other clean energy technologies, such as natural gas in transportation, are less exposed to the risks of strategic minerals. By contrast, biofuels availability could be constrained by factors like land, fertilizer, and water availability.

Finally, another challenge for governments will be the problems associated with "stranded assets," in other words, what to do with devalued items such as oil infrastructure and ICE vehicles if and when the transition to clean technologies gets fully underway. According to the Carbon Tracker Initiative, standard assets, which

66 Daisuke Wakabayashi, "Self-Driving Uber Car Kills Pedestrian in Arizona, Where Robots Roam," New York Times, March 19 2018, https://www.nytimes.com/2018/03/19/technology/uber-driverless-fatality.html.

67 Molly McHugh, "Meet the New Urban Menace: The State of the E-scooter," Ringer, June 1, 2018, https://www.theringer.com/tech/2018/6/1/17417724/e-scooters-bird-lime-spin-micro-mobility-market-uber-lyft.

68 Melissa Lynes, "Plug-in electric vehicles: future market conditions and adoption rates," Issues in Focus, Energy Information Industry, October 23 2017, https://www.eia.gov/outlooks/ieo/pev.php.

are generally considered to be related to the generation and supply of fossil fuel, are no longer able to generate an economic return largely due to a political, technological, and even physical transition toward a lower-carbon future.[69] Stranded assets could add financial strain to government and company budgets, as well as logistical challenges from issues such as restructuring. More broadly, the stranded asset issue would pose even more meaningful risks to economies that rely heavily on revenues generated from vulnerable industries, creating winners and losers and potential geopolitical impacts.

69 "Stranded Assets" Carbon Tracker Initiative, August 23 2017, https://www.carbontracker.org/terms/stranded-assets/.

CONCLUSION

There is a significant amount of uncertainty about the transformation of the transportation sector, especially regarding efforts by governments and whether and how much policy will move the needle for longer-term oil demand. However, it is clear that policy making, especially for ground transportation, is key in the broader decarbonization equation, with the potential to have the greatest material impact on global oil demand, especially when combined with technological advancement. Similar to policy-driven shifts in the power sector, there are real developments in advancing clean technologies, improving efficiencies, and reducing emissions in the transportation sector, and it appears that growing support for these measures is driven by the momentum generated by the Paris Agreement.

Still, the level of patchwork policy making and continued instances of governments being unwilling or not sufficiently able to put their weight behind these measures, largely owing to a mismatch between national interest and political will, signals major headwinds for oil demand that would inform a peak demand scenario are unlikely in the foreseeable future unless more significant and cooperative efforts materialize. It remains important, however, to monitor the developments in key consumption growth markets like China and India, especially as they pertain to both governments' willingness to make politically complex decisions to prioritize oil demand destructing policies and the durability of the factors supporting those decisions, such as industrial policies and pollution concerns. Another important political question is whether governments will act even more aggressively in the future to make up for the current gaps of policy making.

Finally, a majority of existing outlooks (primarily base-cases and main scenarios) referenced in the appendix of this paper predict that it will take a convergence of aggressive policies and technological breakthroughs to see the most impactful shift in the global fuel mix where oil demand would be seriously threatened. Despite a relative lack of collective action thus far, the current political environment along with the wide degree of variance regarding oil demand forecasts (including the potential timing of a peak in demand), will increase uncertainty for the oil industry; further complicate the investment profile of high-cost, long-cycle oil projects; and generate questions about future geopolitical relations. The next issue brief will explore the impact of a "peak," or at least slowing, global oil demand on exporters and importers, and what it will mean for broader geopolitics.

APPENDIX I:

Robust Decarbonization Scenarios: What Transportation Sector Focused Policy Assumptions are Needed to Get to Zero Carbon Emissions and a Peak in Oil Demand?

Figure 1. Decarbonization scenarios and transportation sector policies

Scenario	Peak demand forecast	Transportation-aimed policy assumptions
International Energy Agency (IEA)'s Sustainable Development Scenario (SDS)	Around 2020	"The scenario assumes widespread use of existing technologies and policy practices to reduce air pollution emissions through the use of post-combustion treatment technologies." Major areas include an introduction of CO2 prices by sector and region, a strong push for efficiency in the transport sector, fuel switching to lower emissions fuels, improved fuel quality, higher road vehicle emissions standards, and increased support for low-carbon technologies.[1]
IEA's Faster Transition Scenario	Around 2020 (and falls thereafter at a faster rate than SDS)	Stronger and more ambitious policy intervention than assumed in the SDS that "further frontloads the low-carbon energy transition in the first half of the century," which would require introduction of carbon prices for power and industry in all countries in 2020, removal of fossil fuel subsidies by 2025, and further coordinated decarbonization policy efforts across all sectors (largest in end-use sectors such as trucking).[2]
Institute of Energy Economics, Japan (IEEJ) Peak Oil Demand Case	Around 2030	The scenario assumes policies that not only promote the integration of low-carbon technologies, but also aggressively promote zero emission vehicles.[3]
IEEJ Advanced Technologies Scenario	No peak	Assumes policies that seek to address climate change and energy security issues such as those that facilitate the widespread penetration of low-carbon technologies to reduce emissions, particularly in key energy-intensive sectors.[4]
Rocky Mountain Institute's Reinventing Fire Scenario	China's oil demand peaks by 2030	Policies focus on moving to increased use of non-fossil energy, while also pursuing smart technologies. There is also power sector and industrial reform through the increased integration of renewables and massive efficiency gains.[5]
Exxon Mobil's 2D Scenarios (2DS)	Doesn't forecast exact peak date	Outlook is heavily reliant on key policy requirements, such as the research and development of cost-effective efficiency gains to provide alternatives to high-cost carbon reduction options, and governments also pursue policies regarding price stimulation, in order to sway consumer preferences away from fuel-intensive technologies.[6]
Royal Dutch Shell's New Lens Scenarios	Varies by scenario	Shell assesses two scenarios (title "Oceans" and "Mountains") to look at future trends and the impact on the global energy mix. Along with assessing economic and social trends, the scenarios highlight areas where public policy has the greatest influence on the future energy mix. Both scenarios demonstrate that substantive, positive change will not evolve without national and international policies—which Shell concludes that "to date, seem beyond the bounds of plausibility."[7]
BP's Energy Outlook 2018, Evolving Transition scenario	Demand for oil does not plateau and peak until toward the end of the 2040-outlook	BP's main scenario (the Evolving Transition (ET) scenario) assumes that "government policies, technology, and social preferences continue to evolve in a manner and speed over the recent past." As a result, carbon emissions are not consistent with the Paris Agreement target, "highlighting the need for a more decisive break from the past."[8]

APPENDIX II:

Decarbonization Tools for Transportation: Drawing Lessons from the Scenarios

An abundance of analysis has already been dedicated to decarbonization and transportation emissions reduction efforts. In fact, the assessed reports in Figure 1 (above) barely scratch the surface in terms of the amount of existing research on the issue. The reports, however, take various approaches regarding the most effective and aggressive decarbonization policy tools for transportation.

Of these, the IEA's Sustainable Development Scenario offers the most detailed analysis into specific policy measures and timeframes that would result in a significant demand destruction for oil. The scenario assumes policy prioritization in areas such as:

- improving fuel quality by phasing out fuel with a high sulfur content and raising fuel-economy standards for passenger and commercial vehicles in addition to road freight trucks
- higher road vehicle emissions standards that include full on-road compliance by 2025
- bans on light-duty gasoline powered vehicles that do not have three-way catalysts or tight evaporative controls
- limits on light-duty vehicle emissions to 0.1 g/km NOX and 0.01 g/km PM
- significant growth in the share of electric vehicles to over 40 percent of the global auto stock in 2040
- phase-out of two-stroke engines for two- and three-wheelers; a reduction of fuel intensity in the aviation sector by 2.6 percent annually, along with an increase in the use of biofuels to reduce CO2 emissions by 50 percent below 2005 levels in 2050
- increased oil-to-gas switching and the use of low-sulfur fuels in the national and international maritime transportation sectors.

As a result, the implementation of these measures will help drive oil demand to peak in the early 2020s at around 95 million bpd while declining thereafter to reach 73 million bpd in 2040.

The IEA's Faster Transition Scenario (FTS) looks at an alternative scenario with even more robust government action that leads to an accelerated climate-focused pathway. Policy prioritizations under this scenario include: the introduction of carbon prices for the power and industry sectors in every country beginning in 2020, the phase-out of fossil fuel subsidies by 2025, and the implementation of ambitious mandates targeted at the end-user sector. For example, in FTS, 25 percent of the global truck fleet and over 50 percent of the global auto fleet would have to be electric by 2040.

The IEEJ's 2018 Outlook Peak Oil Demand Case (PODC) outlines a world where increased energy efficiency combined with a shift to renewable energy driven by climate change policies will lead to peak and decline in oil demand around 2030 at 98.2 million bpd. The PODC assumes policies that not only promote the integration of low-carbon technologies, but also aggressively promote zero emission vehicles (ZEVs). These ZEV promotion measures include banning internal combustion engines as well as providing subsidies for ZEV buyers.

In the Rocky Mountain Institute (RMI)'s Reinventing Fire Scenario (RFS), China's carbon emissions peak by 2030 and overall carbon intensity is reduced by 60-65 percent by 2050. As a result, oil's share in transportation is reduced to 45 percent from 73 percent in the RMI's reference case through four key pathways: activity reduction (from an "economic structural shift, improved layout of cities and industry, advanced logistics, and telecommuting/ teleconferencing"), mode shifting ("from trucks, airplanes, and private autos to more-efficient rail, water, highspeed rail, and public or non-motorized modes of transport"), increasing vehicle efficiency, and fuel switching ("to electricity, natural gas, and biofuels").

Exxon Mobil's Outlook for Energy describes a range of 2DS models relative to the 2018 Outlook that outline potential pathways to a world in which energy-related carbon emissions will go to zero and are potentially negative by the end of the century. The outlook contends that technology will play a critical role in determining the cost and effectiveness of the 2DS pathways, and while a heavy emphasis is placed on the role of policy requirements, the outlook offers limited details on exact policy measures. Instead, it is prescribed that governments invest heavily in research and development of low-cost solutions to decarbonization,

such as advanced biofuels and battery technologies. Furthermore, under this scenario, the assumption is that governments also pursue price stimulation policies in order to sway consumer preferences away from fuel-intensive technologies.

Royal Dutch Shell asses two outlooks (Oceans and Mountains) as part of its New Lens Scenarios report. In the Mountains scenario, the pace of energy demand is moderated owing to an economic slowdown, while government policies in large energy importers incentivize demand destructing measures such as compact-city development, vehicle fuel economy standards, transportation emission standards, and rebates for electric vehicle (both battery and hydrogen) purchases. As a result, liquid fuels for passenger road travel peaks in 2035 and declines slowing thereafter, until 2070, when the scenario predicts that the passenger-road market could be oil-free. In the Oceans scenario, liquid fuels continue to play a large role in the energy mix until the latter part of the century, driven by a prolonged period of structural economic and political reform that leads to a strong re-emergence of global energy demand. Oil demand grows until reaching a plateau in the 2040s. Meanwhile, biofuels make a breakthrough and meet about two-thirds of total global transport demand for liquids fuels, leading oil to mostly be used for petrochemical demand. Still, Shell contends that a zero-emission future would require an intense electrification of passenger road travel while long-distance freight, shipping, and aviation will depend on current technologies until substantial advancements in hydrogen are realized.

Finally, BP's 2018 Energy Outlook looks at a range of scenarios outlining the future energy mix. The main scenario, the Evolving Transition (ET) scenario, assumes a relatively status quo forecast of the evolution of government policies, social preferences, and technology. Demand for oil does not peak until later in the outlook as oil consumption accounts for 85 percent of total transport fuel demand (down from 94 percent today), despite an increasing number of electric cars and significant improvement in vehicle efficiency. BP also considers an Internal Combustion Engine Ban (ICE) scenario, a Faster Transition (FT), and an Even Faster Transition (EFT), which all see a higher rate of electric car sales driven by more aggressive policies, technology advancements, and faster evolution of consumer preferences. In the ICE ban scenario, liquid fuels demand is reduced by about 10 million bpd when compared to the ET scenario. However, oil demand is still at a higher level in 2040 than in 2016.

1 International Energy Agency, World Energy Outlook 2017 (Paris: International Energy Agency, 2017), https://www.iea.org/weo/.
2 Ibid.
3 The Institute of Energy Economics, Japan, IEEJ Outlook 2018 (Tokyo: The Institute of Energy Economics, Japan, 2017). https://eneken.ieej.or.jp/data/7570.pdf.
4 Ibid.
5 Energy Research Institute, Lawrence Berkeley National Laboratory, and Rocky Mountain Institute, Reinventing Fire: China (Beijing, Berkeley, Boulder: Energy Research Institute., Lawrence Berkeley National Laboratory., and Rocky Mountain Institute, 2016). https://www.rmi.org/insights/reinventing-fire/.
6 Exxon Mobil, 2018 Energy & Carbon Summary (Irving: Exxon Mobile Corporation, 2018), http://cdn.exxonmobil.com/~/media/global/files/energy-and-environment/2018-energy-and-carbon-summary.pdf.
7 Royal Dutch Shell, New Lens Scenarios (The Hague: Royal Dutch Shell, 2018), https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/new-lenses-on-the-future.html.
8 BP, 2018 BP Energy Outlook (London: BP, 2018), https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html.

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