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WILL COVID DRIVE AN EARLY PEAK IN TRANSPORTATION ACTIVITY AND OIL DEMAND?

BY MARIANNE KAH, LEW FULTON, AMY MYERS JAFFE, MARK SCHWARTZ, AND MARK FINLEY

JUNE 2021

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EXECUTIVE SUMMARY

A critical question to emerge from the oil demand crash in 2020 caused by the global pandemic is whether it marked the beginning of an inexorable decline in consumption of the fossil fuel that could significantly speed up government efforts to meet net zero carbon targets. The changes in government policy, technology, consumer behavior, and shipping during COVID-19 have been profound. Electric vehicle sales increased in a number of countries, while overall automobile sales declined. The use of digital technology accelerated with a sharp rise in telecommuting, teleshopping, and teleconferencing, cutting into transportation oil use primarily in passenger and air travel.

However, some aspects of the COVID experience increased oil use. There was significant substitution away from mass transit to greater use of personal vehicles and there is some evidence that people left large cities in the United States for the suburbs and smaller cities where there is less mass transit available and people drive more for non-commuting activities. There was also a large increase in e-commerce deliveries in the US and other nations that buoyed short-haul truck vehicle miles traveled. While unrelated to transportation, there was also an increase during COVID in petrochemicals used for personal protection equipment and packaging for take-out food and e-commerce deliveries.

Because of fossil fuels' greenhouse gas emissions, understanding how oil demand might return and when it could peak will be factors in governments' strategies for addressing climate change. In the summer and fall of 2020, Columbia University's Center on Global Energy Policy and the University of California, Davis Institute for Transportation Studies (ITS-Davis) conducted an oil demand scenario study out to 2030. The goal was to understand how COVID, in combination with other political, economic, social, and technological drivers, may impact long-term transportation activity and global oil demand and to try to determine whether oil demand has already peaked.

Forty-four leading energy and transportation experts developed four scenarios that varied by the pace of economic recovery, the level of government intervention in energy markets, and the stickiness in the mobility trends that were set in motion during the 2020 pandemic lockdowns. ITS-Davis then modeled the impacts of these scenarios on transportation energy and oil use. Other sectors less impacted by COVID were modeled with lesser detail.

Global oil demand grows through 2030 in three out of the report's four scenarios, which is generally in line with forecasts by agencies such as the International Energy Agency and others for that period. The one scenario that bucks the trend, named Forced Revitalization, is characterized by strong government intervention in green stimulus, acceleration of digital mobility technologies, and a slower economic recovery—the result being oil demand falling after 2025. The greater competitiveness of alternative fuels and the weaker economy in that scenario contribute to lower oil use overall.

The study finds that while great uncertainty remains about the speed and strength of the world's recovery from COVID, the current state of government climate policies and technology innovation are unlikely to reduce global oil demand fast enough to help the world keep within a 1.5°C temperature rise along the net zero carbon trajectory. Both government climate policies and technology innovation would need to move well beyond what was contemplated in this study's scenarios.

Other key takeaways include:

- COVID could drive a structural downshift in oil demand, even if economic growth in the short term brings about a recovery in oil use.
  - In some major markets, there appears to be a sense of fragility and greater acceptance of government policies that reduce greenhouse gas and air emissions, such as electrification of vehicles.
  - COVID accelerated digitalization via telecommuting, teleconferencing, teleshopping, 3D printing, etc., thereby cutting the need for oil to fuel as much mobility, which could permanently reduce oil demand.
- Despite relatively aggressive government policies aimed at reducing oil demand, such as within green stimulus packages enacted in several countries during the pandemic, global oil demand may not peak before 2030. This is primarily due to the time it takes to turn over large transportation fleets, growth in petrochemicals use, and the aspects of COVID that could drive an increase in vehicle miles traveled (VMT), such as greater use of personal vehicles over mass transit, migration outside large cities requiring people to drive more for non-commuting activities, and increasing truck delivery miles for e-commerce.
- The scenario analysis highlights the possibility that global light-duty-vehicle passenger oil demand may peak by 2025 or earlier. The combination of alternative vehicles and fuels as well as efficiency improvements tend to offset the increases in VMT.
- There are significant differences in trends between mature and developing countries. Across the four scenarios, all of the growth in transportation oil use occurs in China and other developing countries while there are declines in the US and Europe.

INTRODUCTION

Global oil demand declined by nearly nine million barrels per day in 2020 (a 9 percent drop from 2019) because of the COVID-19 pandemic and ensuing global economic decline.[1] A key feature characterizing COVID's impact in the transportation sector was a general downturn in mobility because of social distancing, avoidance of public transportation, and a sharp decline in air travel. There is great uncertainty about whether and when global oil demand will revert to its previous trend. The timing and pace of recovery from the pandemic will be an important feature of the trajectory of future oil use, but there are other uncertainties as well. Questions remain regarding whether aspects of the pandemic have permanently changed consumer behavior, accelerated the pace of technology adoption, or permanently altered the priorities of government policy in ways that will impact global oil demand.

This study, which was cosponsored by Columbia University's Center on Global Energy Policy and the University of California, Davis Institute for Transportation Studies (ITS-Davis), assesses potential drivers for discontinuous and permanent change in oil consumption arising out of the COVID pandemic. Using scenario analysis to envision possible futures, the study specifically examines if COVID will accelerate, slow, or have no lasting effect on the energy transition away from oil and to the electrification of the transportation sector. The study also addresses whether global oil demand has likely peaked already, or whether it will peak during the next decade. More important than the timing of the peak is what demand will do after it peaks. Will it drop precipitously, or will there be a gradual decline?

The COVID aftermath scenarios in this report are not an extended look at decadal trends, but rather represent an attempt to evaluate which new forces might be most influential to oil use over the next decade. The scenario study is informed by new trends seen in 2020 in light of the COVID pandemic and changes in the government's role in everyday life. The study extends the current literature by delivering four plausible scenarios focused on a "line of sight" time period rather than on the next 20–30 years, as forecasts by government agencies and companies generally do. The state of global greenhouse gas emissions in the year 2030 is critical to assessing the likelihood of achieving 2050 targets.

The study makes several other contributions to understanding the trajectory of global oil demand. The COVID pandemic intensified the debate over the timing of global peak oil demand, with some analysts indicating that oil demand has already peaked, while others have maintained that global oil demand will return to normal growth when COVID passes. Some of the voices in this debate also believe that global oil demand will fall precipitously over the next decade as a result of intensified government policies to achieve a net zero carbon position in 2050. This study assesses key indicators that could define the future global oil demand trajectory and places them into a scenario context. To build the scenarios, evidence was culled from data on governmental and consumer behavioral responses to COVID in 2020 (e.g., green stimulus, work from home, and reduced business travel). This data was assessed to determine the impact on oil demand in 2020 and consider the potential for longer-term structural changes in global oil demand.

Understanding the current trajectory of global oil demand is also useful for policy makers to craft more effective policies to achieve climate goals. To evaluate what specific policies and consumer actions are needed to achieve targeted greenhouse gas emissions reductions, an accurate understanding of demand trends is essential to sound policy making. Existing oil infrastructure and transportation fleets will tend to dampen abrupt changes in the trajectory of oil demand. Modeling of alternative scenarios can assist policy makers in formulating effective decarbonization strategies and policy approaches. The study considers the timescale required to achieve deep electrification or penetration of other non-oil energy in transportation. It also provides a sense of what policies are likely to be most effective at achieving decarbonization targets in the 2030 timeframe. Finally, the scenarios highlight the role that breakthroughs in key technologies could have for achieving climate goals.

Some policy makers, analysts, investors, and the environmental community think that new investment in oil production is undesirable. That begs the question of whether new oil-related investment could still be necessary for stable energy systems and, if so, in what geographies and segments of operations (e.g., upstream, midstream, and refining). In the face of very weak oil prices in recent years, poor historical returns on investment and deficient environmental performance (e.g., methane emissions and flaring), investor focus on ESG (environmental, social, governance) is making it more difficult and costly for the oil industry to attract capital. Government policies in some oil-producing countries may also play a role in slowing or stopping oil production growth.

One upshot of getting policies wrong is that energy price spikes related to a disorderly energy transition that improperly forecasts oil demand would increase risk to financial markets and potentially drive “pocketbook” political backlash from oil consumers to stringent environmental policy. Oil production from many maturing oil regions will decline without sustained investment. US shale production also requires a steady input of capital to sustain high production levels. While these issues are beyond the scope of this study, they point to the importance of understanding possible demand trajectories and timing of any peak in oil use. Given the longer lead times in oil field development in many parts of the world, a better handle on medium-term demand uncertainties is needed to forecast the amount of capital that could be deployed into the sector without creating surplus resources that could get stranded by falling oil prices or a lack of end use sales outlets.

METHODOLOGY FOR SCENARIO STUDY

This section lays out the study methodology, the scenario process and a description of the modeling of the global oil demand impacts of the scenarios. It also includes a discussion of the governance structure of the study.

It is important to note that the pandemic was still fully underway when the bulk of this study was undertaken, so the impacts of COVID will continue to evolve. Nevertheless, our scenarios are likely to cover the range of how the pandemic could evolve over the medium and long term. Furthermore, policy decisions are being made today, and the energy community should have access to the best analysis possible, even if it is preliminary.

Methods

The initial step was to understand how COVID has changed behaviors of consumers and how these new habits could impact global oil demand. Governments are also responding to the pandemic with policies that could have long-term ramifications for oil use. We considered whether these changes are likely to be temporary or more permanent in formulating scenario frameworks.

The second major part of the study was a scenario exercise. Over the past year, the COVID pandemic added an extreme level of uncertainty to business-as-usual forecasts. Past relationships between variables may be broken, so traditional forecasting methods aren't appropriate to understand the future. Scenarios are a commonly used tool for understanding what may happen in a complex and highly uncertain environment and assessing the possibility of discontinuous disruptive change. Scenario stories are an effective way of explaining a complex environment with multiple variables and understanding what happens in sufficient detail that the implications of the scenario are made clear. Scenario analysis is widely used among Fortune 500 companies and many government agencies. The Task Force on Climate-related Financial Disclosure (TCFD) recommends the use of scenarios to assess potential climate-related risks and uncertainties and the resiliency of the organization's strategy.[2]

To frame the scenarios, our five-person Steering Committee of forecasting experts (see section on Governance) held a brainstorming session to define which two critical uncertainties we would address in the study. We initially considered about six major uncertainties and narrowed it down to the two factors we agreed, after considerable debate, would have the largest impact on oil demand and were the most uncertain. We also made sure that the two critical uncertainties chosen were independent of each other. That is a standard step in the scenario development process. The two critical uncertainties chosen were the disruptive impact of pandemics to the global economy and mobility (including duration, recurrence, or new diseases), and the degree of policy intervention to accelerate technology adoption that speeds up the transition away from oil demand.

We then gathered 44 experts on energy and transportation forecasting to develop the scenarios. These experts came from governments, think tanks, academic institutions, the financial community, and energy and transportation companies. There was representation from the Americas, Europe, the Middle East, and Asia. Participation in the workshops was done under the Chatham House rule to allow for candid discussions. Thus, we do not list the names of the participants in this report outside of the Steering Committee.

The two critical uncertainties resulted in four different scenarios covering the potential for the high and low ranges of the critical uncertainties (the scenario logics are detailed in a matrix in The Four Scenarios section of this paper). The 44 experts were divided into four teams with a diversity of skills and backgrounds, and asked to develop one of the four scenarios with assigned boundaries related to the durability of disruptions by pandemics and the level of policy to accelerate the availability of technology innovation. Two virtual workshops were held for each of the four scenarios to develop the scenario stories, assess the implications for transportation activity and oil demand, and develop early warning signs for the scenario.

The scenario teams actively debated assumptions that should be used, such as the rate of EV penetration, to model alternative possibilities for oil demand impacts that may emanate from the post-COVID landscape. The Steering Committee was called upon to weigh in on less critical assumptions that needed to be made as each scenario was constructed and modeled. The key assumptions were reviewed by the Steering Committee and all of the scenario teams during a final workshop, which resembled a Delphi approach of getting experts to agree on how to best reflect the scenarios. The key assumptions are detailed in the section that describes the scenarios. Modeling the oil demand impacts of the scenarios used more sophisticated techniques for the sectors most impacted by COVID, while the International Energy Agency (IEA) assumptions were generally used for oil-using sectors that were less impacted by COVID. COVID had the largest impact on mobility and the transportation sector given the need for social distancing. Thus, Lew Fulton, one of the Steering Committee members, used a detailed model of the transportation sector calibrated to align with the IEA's Mobility Model to calculate the impacts on energy demand of the four scenarios.

COVID also had a significant impact on the petrochemical sector because of the increased use of plastics for personal protection equipment and packaging for e-commerce and take-out food. Existing demand elasticities were used to model petrochemical oil demand across the scenarios along with key assumptions about recycling, alternative feedstocks and bans on single-use plastic.

Other oil-using industrial sectors, such as non-chemical manufacturing, were temporarily impacted by COVID because of a lack of demand and a shutdown of industrial facilities. However, those impacts are viewed as temporary and are not expected to continue to influence longer-term oil demand. Oil use in the building sector has been in decline for years, and that decline is commonly projected to continue albeit with some with minimal impact from COVID. Modeling used IEA's forecasts to represent oil use in both the buildings and other industrial sectors. This modeling effort covered the sectors that are most likely to be impacted by COVID and included expert forecasts for the other sectors. In this way, outlooks were constructed across the entire landscape of oil use.

It is important to understand that the oil demand trajectories that are generated by this study should not be considered "forecasts." In scenario analysis, the aim is to define relatively extreme end points around the range of what could happen and study those end states in depth to understand better the factors that will influence outcomes. In reality, none of these four scenarios are likely to play out just as they are described. Rather, it will be possible to notice factors that indicate conditions are leaning toward one trajectory versus another. The purpose of this exercise is to tease out insights about the range of possible outcomes in the oil demand future and identify factors that will help policy makers recognize when there is a change in the trajectory.

A virtual workshop was held on September 26, 2020 with all of the participants, as well as other experts, to review all of the scenarios for consistency and plausibility and evaluate key assumptions and initial model results. This workshop was also run under the Chatham House Rule. Comments on the scenarios and model assumptions, such as the degree of electrification of trucks, were then incorporated, and the model was rerun.

Scenario Process

To develop the scenarios, workshop participants followed the classical eight-step process that has been used in military applications and by Royal Dutch Shell.[3] It contains the following elements:

1. Focal issue – Determine the focal issue. This report's focal issue is: How and to what degree will the COVID pandemic have long-term impacts on global oil demand, or are the changes witnessed in 2020 likely to be temporary?
2. Key factors – Assess the key factors that will impact the focal issue.
3. External forces – Assess the external forces that will impact the focal issue, including geopolitical, technological, social, and economic forces.
4. Critical uncertainties – Determine the two critical uncertainties that have a large impact on the focal issue and are most uncertain.
5. Scenario logics – Create a scenario matrix with the critical uncertainties and develop stories that describe the path and end points for each of the quadrants in the matrix. Two critical uncertainties result in a matrix with four quadrants or scenarios.
6. Scenarios – Flesh out the scenario stories, including key events and what happens with the different external forces (e.g., economic and political).
7. Implications – Assess the implications for each scenario for transportation and other oil-using activity and oil demand.
8. Early warning indicators – Develop early warning indicators that tell you when you are moving into each of the scenarios.

The time frame of the scenarios is from 2021 through 2030. The group did not develop the scenarios beyond 2030 because it assumed that whatever happened beyond that time period would likely have drivers unrelated to the pandemic. It is also possible that the scenarios would revert to a mean beyond 2030.

Modeling Energy Demand in the Transportation Sector

For the analysis of transportation energy use in the scenarios, on an international and global level, Lew Fulton used a global vehicle sales and stock model calibrated to align with the modeling framework used by the International Energy Agency (IEA) in its widely referenced Mobility Model (MoMo). This model includes all transportation modes and accounts for all transportation energy use around the world, broken into five regions (US, Europe, China, Other OECD and the rest of the world [ROW]). This report's modeling tool is informed by the methodology of the more complex and detailed MoMo model, which is described in Fulton et al, 2009.[4] The model tracks new vehicle and average stock technology types, in-use energy efficiency and typical travel levels. The approach aims to provide enough detail to understand how changes that occur in our various scenarios affect these factors and, ultimately, energy use and carbon dioxide (CO_2) emissions. The tracking of important vehicle technologies is an important aspect, including electric and hydrogen vehicles across various modes and sectors.

The scenario calculations in this report are, therefore, linked to and inform the projections of vehicle sales, stocks, drivetrain and energy technologies, efficiency, fuel use by fuel type, and CO_2 emissions. These calculations and projections are based on the "ASIF" methodology, which relates vehicle activity, stock, energy intensity and fuel carbon intensity with straightforward identities (Schipper et al., 1999). This relationship can be characterized as:

$$\mathbf{G} = \sum_{m,f} \mathbf{A}_{m,f}\,\mathbf{S}_{m,f}\,\mathbf{I}_{m,f}\,\mathbf{F}_{m,f}$$

where A is the travel activity (e.g., kilometers) per vehicle, S is the vehicle stock, I is the energy use per kilometers of driving for the average vehicle, and *F* is the CO_2 emissions per unit fuel use. These are assessed across all modes (*m*) or vehicle types, and all fuel types (*f*). The sum product of this equation is G, the total greenhouse gas emissions from all vehicles.

Using this framework, the authors calibrated to the IEA World Energy Outlook 2019 "Stated Policies Scenario" (SPS) as the "business as usual" case, with particular attention to the energy and oil use projections. The four scenarios were constructed relative to this one, including the changes in travel patterns and energy use in 2020 due to COVID (not in the IEA's 2019 Stated Policies Scenario).

Governance

In terms of study governance, a Steering Committee was established up front to guide the framework for developing the scenarios, review assumptions for modeling, and review a draft report. The Steering Committee included:

- **Marianne Kah**, Adjunct Senior Research Scholar, Columbia University Center on Global Energy Policy and Advisory Board member
- **Lew Fulton**, Director of the Sustainable Transportation Energy Pathways Program (STEPS+) at the University of California, Davis Institute of Transportation Studies (ITS- Davis)

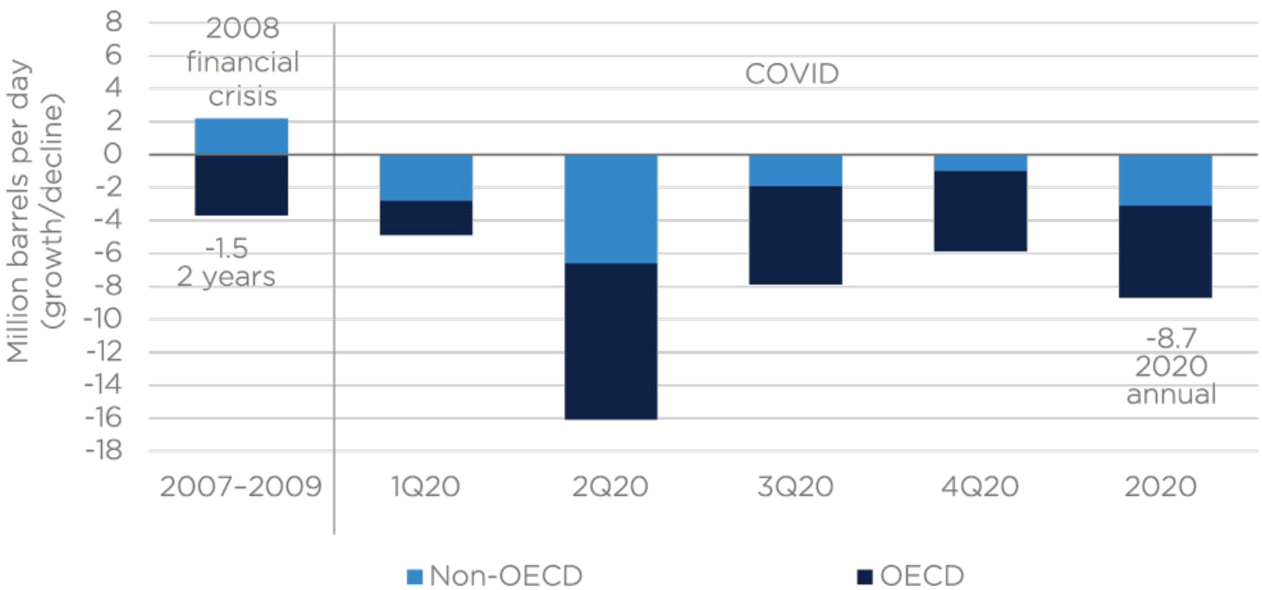
- **Amy Myers Jaffe**, Research Professor and Managing Director of the Climate Policy Lab at Tufts University's Fletcher School
- **Mark Schwartz**, Former Head of Analytics at S&P Global Platts
- **Mark Finley**, Fellow in Energy and Global Oil, Rice University's Baker Institute for Public Policy
- **Helen Currie**, Chief Economist, ConocoPhillips

It is important to note that the larger group of participants was not involved in any discussions about the oil price trajectory associated with each of the scenarios.

IMPACT OF COVID ON GLOBAL OIL DEMAND IN 2020

As shown in Figure 1, global oil demand is estimated to have fallen by nearly nine million barrels per day in 2020. This is the largest annual decline since World War II and the Great Depression. Global oil demand was at its lowest in the second quarter of 2020. The 2020 demand decline is in sharp contrast to what happened to global oil demand during the 2008–2009 financial crisis, when demand fell by 1.5 million barrels per day during a two-year period.

Figure 1: Change in global oil demand: COVID vs. the 2008 financial crisis



Note: Year-over-year and quarter-over-quarter except where noted.

Source: International Energy Agency, Oil Market Report, May 12, 2021, and IEA Annual Statistical Supplemental 2007–09.

The global oil demand decline was much greater during COVID than in the financial crisis in part because of the greater global economic decline during COVID. According to the International Monetary Fund, real global GDP fell by 3.5 percent in 2020 versus a 0.1 percent decline in 2008–2009. The financial crisis wasn't as severe a downturn because it mostly impacted the industrialized world with developing nations continuing to grow. By contrast, in 2020, COVID adversely impacted the economies of both industrialized and developing nations. In fact, Figure 1 shows that oil demand declined in both OECD[5] (industrialized) and non-OECD developing nations in 2020. In 2008–2009, oil demand declined in OECD countries, but still grew in non-OECD countries.

Another significant difference between COVID and the financial crisis was that the pandemic had a particularly large impact on mobility and the transportation sector while the financial crisis focused on the financial and housing sectors. Because nearly 60 percent of global oil demand was used in the transportation sector, the 2020 crisis had a larger impact on oil demand.

Industrialized versus Developing Nations

The oil demand decline in 2020 was more severe in OECD nations (12 percent decline versus 2019) than non-OECD nations (6 percent decline versus 2019). OECD nations tended to have longer lockdowns and restrictions. In contrast with other developing nations, China's oil demand grew by nearly 2 percent in 2020. China's COVID pandemic started and ended earlier than the rest of the world's, and the government provided substantial investment and business-oriented stimulus to boost their economy.

Demand by Type of Fuel

There were large differences in the global demand loss for different refined oil products and sectors in 2020 even within the transportation sector.

Aviation was the hardest hit sector, with global revenue passenger kilometers falling by two-thirds in 2020 versus 2019 due to travel restrictions and increased passenger concerns about the COVID risk of air travel. International air travel, which experienced the most restrictions, was down by an even higher 76 percent versus 2019, compared with a loss of about 50 percent in domestic demand.[6] With the loss in passenger travel, global jet fuel demand declined by about 41 percent globally in 2020.[7]

Global gasoline demand was down by a much lower percentage in 2020 than jet fuel use. Global gasoline demand in 2020 was down by 11.5 percent.[8] In contrast, China's gasoline demand was estimated to be down by 1.6 percent in 2020 versus 2019.[9] Gasoline demand has been more buoyant than jet fuel demand because unlike flying, driving a personal vehicle is viewed as a safe, socially distanced activity. In addition, people are driving more as a substitute for public transportation and short (less than 500 miles) flights.

Global diesel demand was more resilient to COVID than either gasoline or jet fuel demand. Global diesel demand was down only 6 percent in 2020 versus 2019, with diesel demand rising in China by 2.6 percent.[10] Diesel demand is used primarily for trucking and agriculture, which were more robust activities during COVID than passenger car or air travel. Trucking activity and fuel demand were also helped by significant increases in e-commerce.

COVID IMPACTS ON GOVERNMENT POLICY, TECHNOLOGY, CONSUMER BEHAVIOR, AND SHIPPING IMPACTING OIL USE

Future oil demand will be shaped by the 2020 COVID pandemic. The core factors explored via the CGEP-ITS-Davis scenarios focus on government policies (particularly, climate-related policies), technology, consumer behavior, and shipping during the pandemic. The key elements within these four categories, which shape the oil demand scenarios, are detailed below.

Government COVID Recovery Stimulus and Climate Policies

Governments of major global economies are ramping up efforts to reduce global greenhouse gas emissions. One critical uncertainty that impacts oil demand in the scenarios is whether COVID accelerated government climate action or delayed it. Historically, environmental policies often advanced during periods of strong economic growth. The economic fallout associated with 2020's COVID shutdowns is deep. And governments are implementing unprecedented stimulus to restart activities. The timing presents an opportunity for stimulus to also accelerate climate-related policies. Major economies in the West, now including the US, are opting for "green" stimulus in response to the COVID-related economic crisis. It likely would not have been politically feasible to spend as much money on clean energy if it weren't for the need for economic stimulus. In terms of regulatory mandates, people may be more willing to accept regulation related to clean air because COVID increased concern about public health and environmental justice given the connection, described later in this paper, between air pollution and COVID deaths, particularly in low-income communities. The wildfires in the southwest of the United States and California greatly reduced air quality throughout the region during COVID, thereby connecting climate change and air quality. Western governments had already been moving toward more stringent climate regulation prior to COVID, but concerns about public health and air quality during COVID may have enhanced the acceptance of greater regulation. The sharp ramp-up in global EV sales in 2020, described later in this paper, is also indicative of stronger government policy drivers and greater consumer acceptance of electric vehicles (EVs) in some regions.

There is significant evidence that governments have increased green spending in response to COVID. Several countries in the world, including the United States, Europe, South Korea, China, and Canada, have announced major "green" stimulus spending in recent months.[11] But questions remain whether new stimulus will include clean technology investments at the same scale as made in 2009 outside of the European Union.[12] A recent report by the UN Environment Program and Oxford University indicated that through February 2021, only $341 billion—or about 18 percent—of the $2 trillion long-term COVID-19 economic recovery money is going to green spending and an inclusive recovery.[13]

In the United States, although the Trump administration continued to reverse Obama-era environmental rules during 2020, many states and cities have maintained momentum for climate policy. President Biden's recently rolled out $2.2 trillion infrastructure proposal includes major investments in clean energy. For example, it has a $174 billion plan to spur the development and adoption of electric vehicles including money to retool factories and boost domestic supply of materials, tax incentives for EV buyers, and grant and incentive programs for charging infrastructure.[14]

China's economic stimulus was focused on infrastructure with key drivers of jobs and stability in 2020. However, both EV charging and mass transit have been identified as new infrastructure that will receive priority stimulus investments. Still, China continues to spend on high-carbon infrastructure. Since the COVID epidemic began, nearly 10 gigawatts of coal power projects have been permitted by provincial and local governments.[15] Stimulus measures mentioned in recent Chinese provincial reports include both "green" and "brown" stimulus. Green stimulus measures include development of renewable power, hydrogen networks, energy storage and EV charging stations as well as the elimination of thermal power units. "Brown" stimulus includes fossil fuel redevelopment, oil and gas pipelines, and reserves.[16]

Another metric for China's climate policy is electric vehicle sales. In response to a rollback of subsidies and the pandemic, EV sales plummeted by over 50 percent in January 2020, and 77 percent in February 2020. To get to the target of EVs being 20 percent of auto sales by 2025, China subsequently extended subsidy support for two years. China's EV sales rebounded and likely reached 1.3 million units in 2020—up from the 1.1 million units sold in 2019.[17] This increase is especially notable considering Chinese overall car sales declined 6.8 percent in 2020 because of the pandemic and economic downturn.[18] This year, Chinese subsidies for new energy vehicles will be cut by 20 percent as part of a program to phase them out over time. Other policies to promote EVs remain in place, including EV requirements by car makers and a proposed ban on new sales of internal combustion engine cars by 2040. The phaseout of consumer subsidies is intended to force Chinese companies to make cars that are competitive with Western models. China's EV policy focus now is on increasing the numbers of charging stations, battery swapping, and battery recycling facilities.[19]

In September of 2020, President Xi Jinping announced that China would aim to become "carbon neutral" before 2060. China is also introducing a carbon emissions trading scheme this year and may impose nationwide emissions caps by 2025. These new policy developments portend a stricter attention to climate policy in the years to come in China.

The European Union has shown the most focus on "green stimulus" as part of its COVID recovery package. European Union lawmakers agreed to provide a $672 billion euro recovery fund with 37 percent of it dedicated to helping the climate. Germany's "Package for the Future" was the first to include widespread green measures, including funding for green infrastructure and R&D, particularly in the energy and transport sectors. In addition, thanks to new attractive models, promotions, and more stringent CO_2 emissions standards and government subsidies, nearly 1 in 10 cars sold in the European Union were electric vehicles in 2020. The main contributor to the EV boom has been Germany, thanks to generous government and manufacture purchase incentives.[20] Other nations in the EU have also had strong EV sales. In December 2020, 19 percent of automobile registrations in France were EVs, up 5.6 times from December 2019 levels.[21] Similarly in the Netherlands, one-quarter of new car sales were plug-ins in 2020.[22] By December 2020 for Europe as a whole, fully a quarter of auto deliveries were plug-ins (Plug-in hybrid or PHEV and EV combined).[23] Nearly 1.4 million battery-electric vehicles (BEVs) and PHEVs were registered in Europe during 2020, 137 percent more than in 2019, in a vehicle market that was down by 20 percent year-on-year.[24]

The European Green Deal also aspires to increase sixfold the capacity to produce renewable hydrogen by 2024, driving down the costs of the fuel. Scaling up the production of hydrogen could help offset oil use in aviation, shipping, cars, and trucks.

States and cities have also advanced numerous policies to decarbonize transportation and reduce local air emissions in 2020 during the pandemic. For example, in July 2020, 15 US states and the District of Columbia committed that 100 percent of medium and heavy-duty vehicle sales would be electric by 2050, with an interim goal of 30 percent of sales by 2030.[25] Another example of a US state taking action to lower greenhouse gas emissions and curb air pollution is that California environmental regulators recently ruled that ride-hailing companies must add electric vehicles to their fleets.[26]

Another example of a city focusing on clean air in response to COVID is Milan making 22 miles of city streets more pedestrian and cycling friendly at the expense of auto traffic.[27] A number of cities in the US also closed some city streets to traffic during COVID.[28]

Many climate-related policies were underway prior to COVID. However, instead of seeing a pause in these policies because of the public health and economic crisis in 2020, a continuation of climate policies and acceleration in some areas took place. The pandemic probably helped demonstrate the fragility of the planet and increased voter and policy maker focus on improving public health and the environment. People in urban areas have seen reduced pollution in 2020, and desire their cities remain that way. There is also increased concern about air quality given the recent studies that have linked deaths from COVID to air pollution.[29] The movement for environmental justice has also increased the focus on air pollution in low-income neighborhoods where people were especially vulnerable to COVID.

Looking forward, the success of government climate policy during an economic downturn will be measured by how well these policies create jobs. The scenarios in this report differ by how focused governments around the world are on climate solutions and whether climate actions are delayed or accelerated.

Technology

Technology enabled much of the global economy to continue working through the COVID shutdowns. Working from home and e-commerce became the norm in many regions, and could be permanent in some cases. Digitalization (software, internet connectivity) and innovation saw significant leaps forward as business and consumers adapted to working and holding business meetings from home and shopping from home. Because of the need for social distancing, COVID accelerated digitalization.

Electrification in transportation continued to advance amid COVID. Battery technology improved.[30] Charging infrastructure expanded.[31] Sales of EVs were significantly up in 2020, buffeted by government policies, to constitute 4 percent of global new automobile sales.[32]

The scenarios implemented different assumptions regarding advancement and adoption of technologies impacting oil demand.

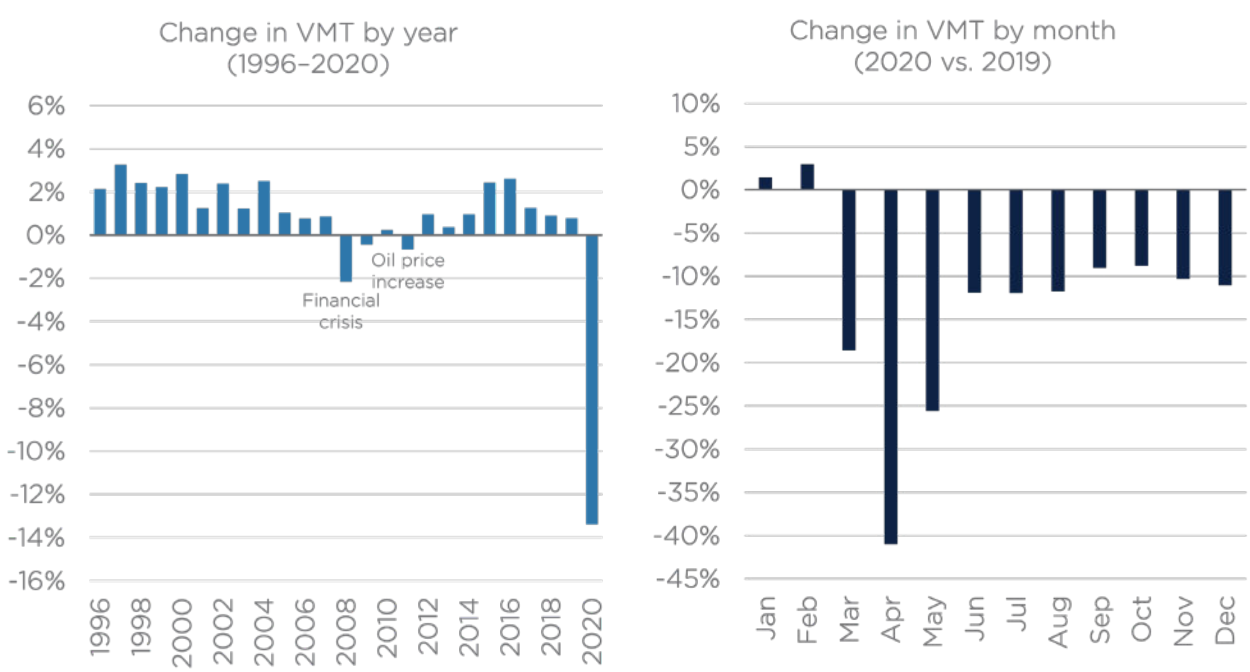
Consumer Behavior Changes

This section looks at what occurred in 2020 in the areas of passenger vehicle miles traveled (VMT), telecommuting, avoiding mass transit, ride-hailing, walking or biking, urban flight, passenger vehicle purchases, air travel, and petrochemical use.

Passenger Vehicle Miles Traveled (VMT)

COVID caused a sharp drop in passenger VMT in the US during 2020 because of massive telecommuting and high unemployment, as well as most other travel, coming to a halt because of the need for social distancing. As shown in Figure 2, the worst of it occurred in the spring of 2020, when COVID first became a problem in the US. While it is not shown in this chart, US VMT continued to decline in January and February of 2021 versus those months in 2020. Traffic rebounded significantly in March and April 2021 because of higher economic growth and a comparison with exceptionally weak levels in those months at the start of the COVID pandemic in 2020. Traffic is rebounding in some of the nation's largest cities, although more so on weekends than weekdays and not yet back to pre-pandemic levels.[33] Once there is an economic recovery that restores VMT, the question becomes whether aspects of COVID, such as the switch from mass transit to private cars, the increase in driving versus flying, and the movements out of the larger cities will accelerate automobile VMT growth. Alternatively, telecommuting could result in a permanent downshift in VMT growth.

Figure 2: Trends in US vehicle miles traveled



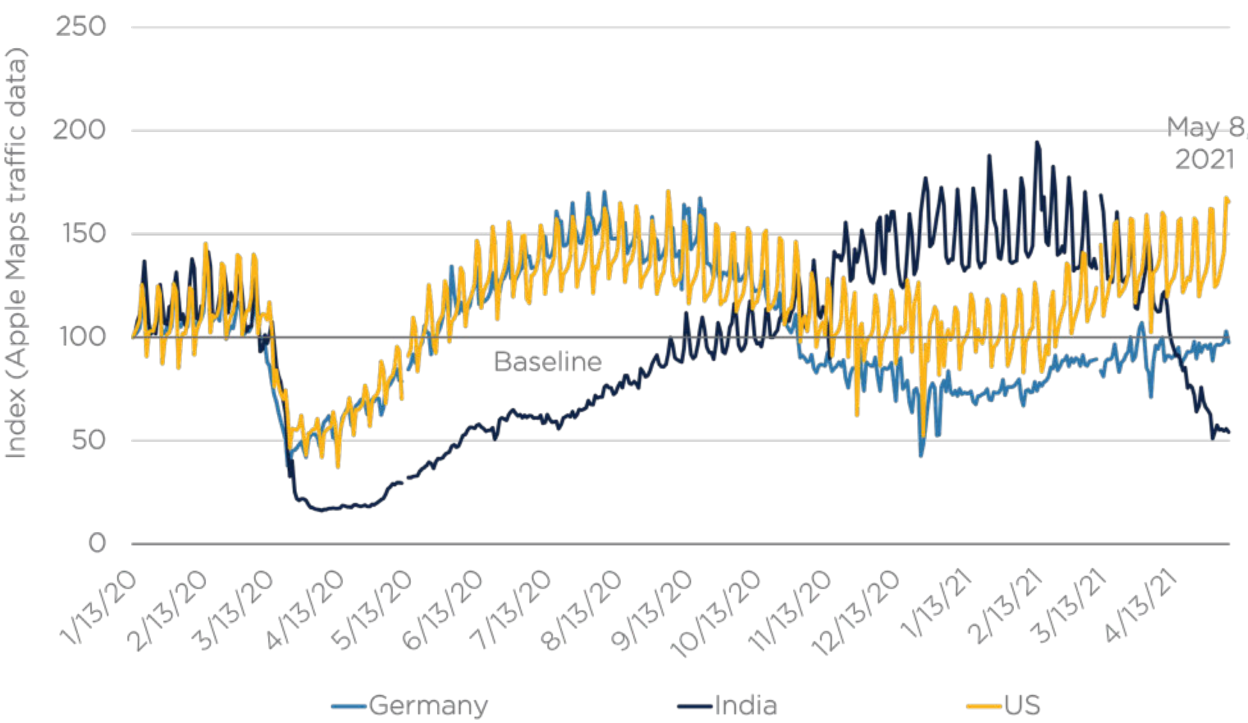
Note: Chart on the left notes 12-month moving average ending December 2020.

Source: US Department of Transportation, Federal Highway Administration, "Traffic Volume Trends," January 2021; all systems https://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm.

While driving was significantly impaired by COVID, it held up better than air travel in 2020. Driving in personal vehicles substituted for mass transit, ride-hailing, and short (under 500 miles) air flights. Telecommuting also enabled some employees to leave cities and move either temporarily or permanently to suburban or rural areas where there is a necessity to drive greater distances to get to grocery stores and other destinations (see section on Urban Flight).

Near real-time driving data is available today in countries and major cities around the world in mobility apps, such as the ones provided by Apple, Google and TomTom. Figure 3 is from Apple's mobility app based on requests for directions. While the "baseline" represents the second week in January 2020 (generally pre-COVID pandemic), the index doesn't represent the absolute change versus the baseline. The graph is just indicative of trends. The graph shows driving in the US, Germany, and India dropped substantially in March and April of 2020, when the global pandemic first developed, but recovered significantly over the summer. In the US and Germany, driving eroded in the fall with the second COVID wave. Since March 2021, driving in the United States has risen above the baseline because of higher vaccination rates and the economic recovery. In Germany, driving is just approaching the baseline. Driving in India has grown substantially since November 2020, but has fallen substantially since March 2021 with the sharp uptick in COVID cases.

Figure 3: Driving trends in selected countries



Note: This chart only has directional implications. It represents the change in volume of people driving in their communities, based on requests to Apple Maps for directions.

Source: Apple Mobility Trends Report, https://www.apple.com/covid19/mobility, accessed May 8, 2021.

Oil demand is greatly influenced by levels of transportation VMT. Projections of passenger VMT post-COVID will be highly influenced by how temporary or permanent behavioral changes are in (1) telecommuting, (2) substitution away from mass transit and ride-hailing, (3) increased walking and bicycling, (4) urban flight, and (5) growth in e-commerce (see section on E-commerce), and their combined net effect on driving. Our scenarios vary these assumptions around VMT, although the largest driver is the varying economic growth rates in the different scenarios.

Telecommuting

There is a high potential for a significant portion of telecommuting to become permanent, particularly with advances made in virtual meeting technology, increases in bandwidth, and findings that working at home in 2020 did not reduce productivity.[34] A recent University of Chicago study showed that nearly 40 percent of jobs in the US and Europe can plausibly be performed at home.[35] These jobs typically pay more than jobs that cannot be done at home and account for 46 percent of all US wages. Developing and emerging market nations with per capita GDP levels below one-third of US levels may only have half as many jobs that can be done from home.[36]

The pandemic informs projections of the extent telecommuting can occur, at least on a temporary basis. Prior to COVID, only 7 percent of employees in the US were able to telework[37] and 3–4 percent in Europe.[38] In April at the start of the pandemic, 51 percent of the workers surveyed in a Gallup poll in the US said they were always working from home. By October 2020, 33 percent of surveyed workers said they always worked at home, and another 25 percent said they sometimes worked from home.[39]

One key uncertainty about the future of telecommuting is the extent to which employees will continue to telecommute when the pandemic recedes. Companies may want to pursue a hybrid model with employees working some days at home and some days in the office. This could allow the company to reduce their commercial real estate and save money. Some companies have also made significant investments in technology to enable working at home (e.g., virtual meetings, enhanced cyber security). This investment makes them more likely to allow employees to continue to work at home.

Recent research indicates that generally speaking, telecommuting can increase productivity,[40] assuming workers have family situations that allow full time work at home. One important development is an increase in worker productivity by reducing hours of travel to office and back. From the point of view of employees, a recent Gallup poll showed that nearly two-thirds of US employees who have been working remotely during the pandemic would like to continue to do so.[41]

Over time, office space could be reserved for flexible conference rooms for in-person meetings that allow for cross-fertilization of ideas, rather than personal work spaces, and allow workers to avoid high congestion times for commuting. However, there is uncertainty over how much telecommuting will be maintained post COVID. One transportation expert specified some of the downsides of telecommuting, including lack of space at home, family distractions, and too little social interactions as things that may constrain the amount of telecommuting.[42]

A second key uncertainty is whether telecommuting will decrease or increase passenger VMT and, thus, oil demand. Commuting accounts for 17 percent of US daily vehicle trips, for example, opening the possibility that telecommuting could reduce VMT.[43] During the pandemic, people were not likely to use their freed-up commuting time to take daily trips to visit family or friends or go shopping. But historically when people telecommuted, they tended to use the freed-up time to drive for other reasons. In fact, one study concluded that telecommuters increase VMT by 20 percent because they spent saved commuting time on other work and non-work-related trips (e.g., visiting friends and family, shopping and recreation).[44] Another study, done in Switzerland, also found that telecommuters travel longer distances than non-telecommuters.[45]

Telecommuting may also allow people to move out of cities and work from the suburbs or rural areas where they will have to drive more to get to stores and other destinations. The Swiss study also found that telecommuters live further away from their workplaces than non-telecommuters. The scenarios developed for this study reflect different assumptions about telecommuting and its impact on VMT.

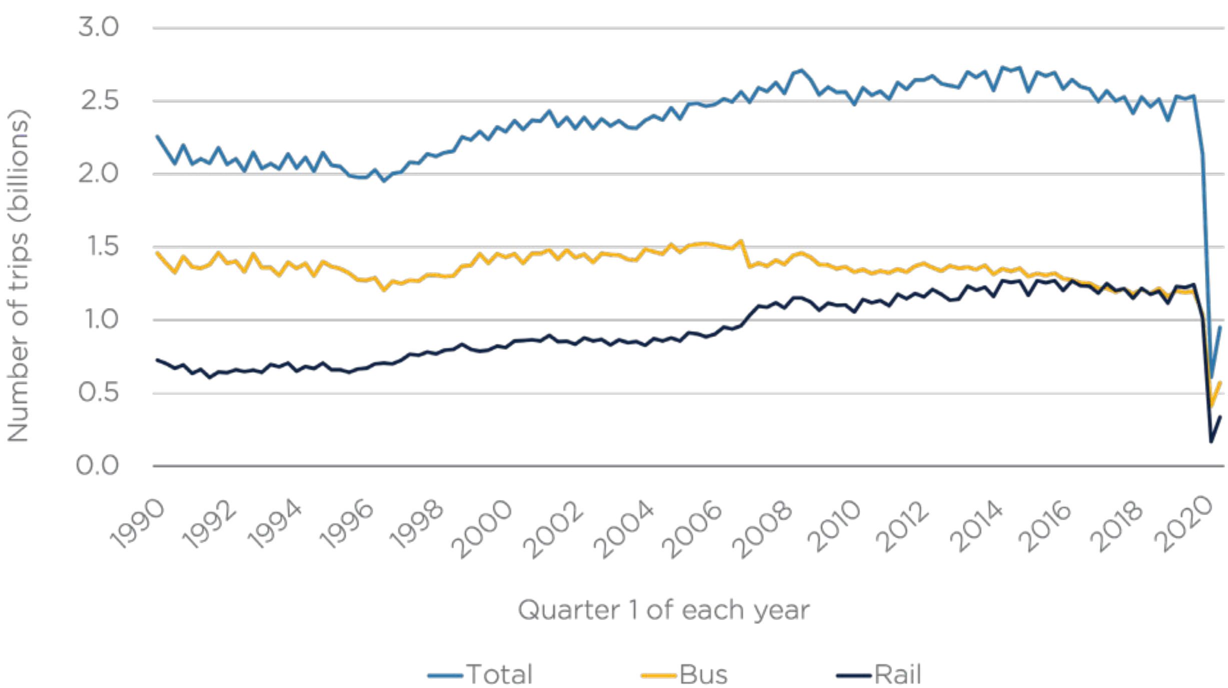
Substitution Away from Mass Transit

At the peak of the COVID scare in mid-April, public transit ridership fell 92 percent in major cities around the world.[46] Figure 4 shows that US and Canadian transit ridership in the third quarter of 2020 was still down by 62 percent versus the third quarter of 2019. Another social equity concern is that the decline in ridership has led to a decline in revenue and service, which may have disproportionately reduced transportation access for low-income people who can't afford to substitute private automobiles for mass transit service.

The decline in mass transit ridership is likely due to losses in employment, the substitution of private automobiles for those who can afford it, and telecommuting. It has been a factor that has buoyed oil demand.

Mass transit systems around the world are under severe financial distress because of the reduction in ridership. Depending on the length of the pandemic and government COVID subsidies, it will be challenging for cities to keep transit systems afloat. A key uncertainty addressed by the scenarios is whether there is a permanent loss in mass transit ridership and how quickly passenger confidence resumes after the pandemic recedes.

Figure 4: US and Canadian public transit ridership



Note: Bus includes trolleybuses; rail includes heavy, light, and commuter.

Source: American Public Transportation Association, https://www.apta.com/research-technical-resources/transit-statistics/ridership-report/.

Ride-Hailing

Before COVID, transportation network companies (TNCs) were increasing vehicle miles traveled in major cities around the world. Between 2012 and 2018, TNCs more than doubled the overall size of the for-hire ride services sector and put 2.8 new TNC vehicles miles on the road for each mile of personal driving removed.[47] Ride-hailing services were drawing customers away from non-auto modes of transit, such as public transportation, walking, and biking. Research shows that 60 percent of ride-hailing service users in large, dense cities in the United States would have taken public transit, walked, biked, or not made the trip at all if ride-hailing services were not available.[48] In addition to substitution away from more fuel-efficient transportation modes and inducing demand for travel that may have gone unmet, ride-hailing involves significant deadheading—the movement of vehicles in non-revenue mode for logistical reasons until the next passenger is found. Ride-hailing also contributes to urban congestion, which increases everyone's fuel use.

The fear of COVID infections greatly decreased ride-hailing in 2020. At the worst point in April 2020, demand for Uber riders was down by 80 percent from a year ago and Lyft reported a 75 percent drop. Even with Uber's food delivery service ramping up as people order in, the company is burning through cash. In the third quarter of 2020 versus 2019, Uber's ridership was down by 60 percent in the US and 36 percent in Europe, the Middle East, and Africa.[49] In the fourth quarter of 2020, Uber's worldwide ridership was still down by 24 percent versus the same quarter in 2019.[50]

A key uncertainty is the degree to which ride-hailing will bounce back when the pandemic recedes. In a CarGurus's survey of US shoppers, 11 percent of people said they would stop using ride-sharing services post-pandemic, and 28 percent expect to use it less.[51] A related question is whether autonomous vehicles or robo-taxis will restore the popularity of ride-hailing.

Increase in Walking and Bicycling

Another trend observed in 2020 was the increase in walking and bicycling. Biking has enjoyed a renaissance around the world as urbanites shun public transport for the relative safety of a two-wheeled commute. At the outset of the pandemic, retail sales for bikes were up 75 percent in the United States and 63 percent in the United Kingdom. Some cities created pop-up bike lanes. Others implemented 'slow streets' by erecting makeshift barriers and reducing speed limits so that walkers and bikers could safely share the road with necessary vehicles. Several US cities, including Houston and Los Angeles that historically have been primarily driving cities, saw significant year-over-year growth in both bike trips and cyclists in much of 2020. In Houston, for example, the total volume of cycling trips was 138 percent higher in May 2020 than in May 2019. New York City saw a steady rise in cycling post-COVID, with nearly 80 percent year-over-year growth in trips for July. While bikes are being used for commuting, users are increasingly logging trips to school, errands, health care facilities, and other essential destinations.[52]

In other international cities, government policies are helping to increase bicycling. Bogota, Colombia enacted one of the world's first plans to encourage bike travel, using cones to create 76 kilometers of temporary lanes.[53] In Europe, Paris fast-tracked a plan to create 650 kilometers of temporary and permanent bikeways. Globally, it is unclear whether low-income neighborhoods are sharing in the advantage of biking friendly infrastructure.

There has also been a boom in walking because of COVID and concerns about taking public transportation. With fewer cars on the road, some cities are making more space for walking that accommodates social distancing by closing roads to cars.

A key uncertainty is whether the trend for increased bicycling and walking in urban areas will continue after the pandemic recedes. Another question is whether neighborhoods in cities transform to allow people to walk or bike to all needed functions without leaving the neighborhood. This scenarios study did not address this type of urban transformation, which is difficult to model effectively.

Urban Flight

De-urbanization could increase oil demand because living in less dense areas could increase passenger VMT. According to the United Nations, more than one half of the world's population currently lives in urban areas, and the historical trend has been for virtually all countries of the world to become increasingly urbanized. The United Nations projects that 68 percent of the world population will live in urban areas by 2050.[54] However, people in the US were migrating out of the largest cities even before COVID. Population growth rates for urban core areas fell by 86 percent in 2015–2019, dropping from a growth rate around 0.8 percent to just over 0.1 percent.[55]

A key uncertainty is whether or not COVID changes the global urbanization trend and drives some degree of de-urbanization. According to the United Nations, cities have accounted for 90 percent of COVID infections.[56] Closures of restaurants, bars, and theaters have reduced the social vibrancy of cities, while telecommuting and job loss have choked off the economic vibrancy of cities. Telecommuters no longer need to live close to an office, and may move to a place that provides more space to work at home at a lower cost. In addition to fear of pandemics, rising social unrest with COVID exacerbating income inequality may be another reason some people are choosing to migrate out of large cities. Concerns about air pollution in cities have also increased given the connection of air pollution to COVID deaths. One recent study estimated that exposure to air pollution increases COVID deaths by 15 percent worldwide.[57]

There is some evidence that COVID has caused people to leave large cities in the US and move to the suburbs and smaller, less expensive cities. Analysis of spending activity by 100,000 credit card holders suggests 45 percent of Manhattan residents and 55 percent of San Franciscans have left their cities for some amount of time during COVID.[58] Another study indicates that 15 percent of working professionals in the San Francisco Bay Area have left the region since the pandemic began.[59] People leaving Manhattan tended to go to nearby suburbs or less dense outer boroughs, although a significant number went to Arizona, Colorado, and Southern California.[60]

It is uncertain whether or not the increase in urban flight that occurred during COVID is temporary. Lower real estate prices might entice some companies and workers to move into large cities when they couldn't afford to do so prior to COVID.

To gain a better understanding of what happens to mobility and oil use if some level of urban flight becomes permanent, one scenario in this report is about a prolonged pandemic with de-urbanization. It would likely increase driving VMT as people need to travel longer distances to get to stores and other destinations, and mass transit is less accessible outside of large cities. In fact, a study of millennials' driving behavior indicates that daily per capita VMT is 50 percent higher if they are located in the suburbs versus urban areas.[61]

Passenger Vehicle Purchases

In addition to VMT, oil demand in passenger vehicles is a function of the number of cars in the fleet and the type of fuel used and efficiency of the vehicle.

Automobile Sales

The pandemic and its adverse income and employment impacts lowered global automobile sales in 2020, thereby affecting the number of cars in the fleet and, thus, the oil demand associated with the vehicles. According to IHS Markit, global automobile sales in 2020 are expected to be down by 15 percent versus 2019. China's automobile demand fared better in 2020, with a loss of only 5 percent.[62] New cars are generally more fuel-efficient than similar class older cars. Thus, when a recession reduces fleet turnover, it reduces the improvement in the overall fleet fuel efficiency, which promotes oil demand growth.

Electric Vehicle (EV) Penetration

After the pandemic struck, some analysts believed that it would result in a lower penetration of EVs, despite continued reductions in the cost of batteries and the improved range of EVs. With weaker economic growth and concern about job loss, new vehicles sales were expected to drop and EVs sales were expected to be hard hit because of their higher cost and perceived risk. However, global electric vehicle sales were robust in 2020. Perhaps one reason was that white collar workers with higher incomes fared better in the recession than low-income workers, and higher-income people are the ones purchasing EVs today. According to preliminary data from the IEA, global EV sales rose 46 percent in 2020, climbing to over 3 million vehicles with their global market share increasing from 2.5 percent in 2019 to over 4 percent in 2020. EV sales growth occurred despite total car sales dropping by 14 percent in 2020.[63]

Most of the EV sales growth in 2020 occurred in Europe and China, where sales rose by 135 percent and 12 percent, respectively. The sharp growth in European EV sales was especially surprising given the decline in 2020 automobile sales of 20 percent year on year.[64] There were multiple possible explanations for this surge in EV sales, but it seemed to be caused primarily by more stringent CO_2 standards for vehicles (that EV sales can help meet) and large fines for automakers that miss the target.[65] A number of European governments, such as Germany and Italy, also provided significant new incentives to consumers to purchase EVs.[66] South Korea also experienced a boom with EV sales in 2020 rising by 54 percent.[67] EV sales in the US were up 4 percent in 2020, while total automobile sales were down by 15 percent. EV sales in the US were boosted by Tesla purchases, with most other brands experiencing declines.[68] The increase in EV sales is increasingly detracting from light-duty vehicle (LDV) oil demand growth. However, it is important to remember that global EV sales remain at roughly one-tenth the volume of conventional SUVs and, even with fast sales growth rates, will not represent a large share of the global LDV fleet by 2030.

Used Car Sales

The other significant car-buying trend observed in 2020 was the increase in used car sales due to their lower cost given concerns about unemployment as well as the need to acquire an alternative to mass transit for those who didn't own a car. In June 2020, franchised car dealers sold 1.2 million used cars and trucks in the US, according to Edmunds, up 22 percent from a year earlier. It was the highest monthly total since at least 2007.[69] Used cars reduce the fuel efficiency of the automotive fleet compared with adding new, more fuel-efficient cars to the fleet. Thus, they are likely to increase oil demand.

Looking forward, scenarios in this report differ by the degree of EV penetration and the pace of fuel efficiency improvement in conventional vehicles. New vehicle purchase is also highly sensitive to the different economic growth rates in the scenarios.

Air Travel

The aviation sector was the hardest hit sector in 2020 with global revenue passenger kilometers falling by two-thirds in 2020 versus 2019 because of travel restrictions and increased passenger concerns about the COVID risk of air travel. The passenger load factor on planes was about 65 percent in 2020 versus 81 percent in the previous five years.[70] And this was despite the reduction in capacity during the year. The path of the COVID recovery will be the largest driver of the recovery in air travel.

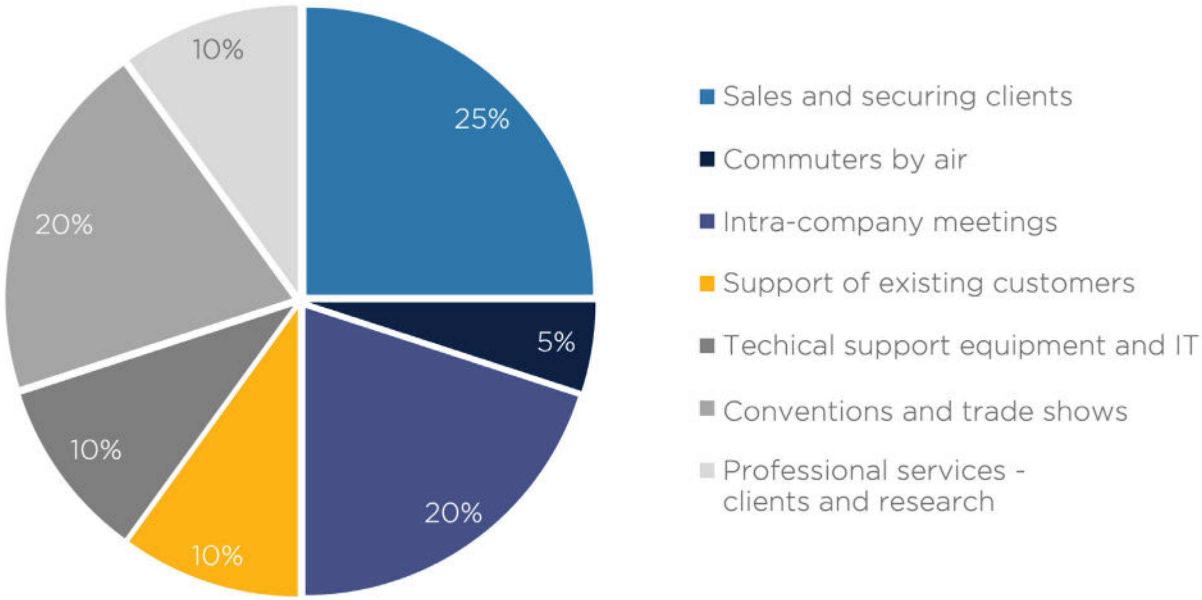
The area of greatest uncertainty is the degree to which business air travel will recover. While business travel ordinarily is slower to recover than leisure travel after an economic downturn, there is a question about whether improvements in virtual meetings will permanently reduce the demand for business travel. On a global basis, data from the World Travel and Tourism Council reveals business travel represents about 21 percent of total travel spending, with leisure comprising the remaining 79 percent in 2019.[71] However, business travel has a disproportionately large share of revenues for some of the major airlines. For example, Lufthansa Group in its 2019 Capital Market Presentation indicated that business revenues provide 50 percent of passenger revenues.[72]

Business travel has declined more than leisure travel in 2020. The Airlines Reporting Corporation indicates that in December 2020, corporate travel was down by 83 percent versus total travel down by a lesser 63 percent.[73] Communication in the business world has evolved from a mixture of in-person and digital interaction before COVID to one focused almost entirely on remote online contact. In addition, corporations have saved a large amount of money because of avoided business travel.

Business travel that involves acquiring customers is likely to be restored. However, as shown in Figure 5, sales and securing clients represents only 25 percent of business travel. If intracompany in-person meetings disappeared along with conventions and in-person trade shows, this figure shows that 40 percent of business travel would be permanently lost. While it is unlikely that all of this travel will disappear, it is easy to see how one airline consultant estimated that a permanent loss of business travel between 19 percent and 36 percent is possible.[74]

The scenarios in this report vary by the year in which air travel returns to 2019 levels. In addition, they vary by the degree of the permanent loss in business travel. The scenarios also vary by the degree of fuel efficiency improvement and the penetration of low carbon fuels in aviation.

Figure 5: Airline business travel activity by trip purpose



Note: As the source explains, "Percentages based upon a review of reports from government, commercial, and academic sources with assessments made by a group of travel industry professionals coordinated by IdeaWorksCompany."

Source: Jay Sorenson, "The Journey Ahead: How the Pandemic and Technology Will Change Airline Business Travel," IdeaWorks Company, December 1, 2020, page 9, https://ideaworkscompany.com/wp-content/uploads/2020/12/Journey-Ahead-Airline-Business.pdf.

Petrochemical Use

In 2020, COVID hampered the demand for plastics in various applications around the world, including construction, automotive, electrical and electronics, and consumer goods, owing to a halt in manufacturing operations, restrictions on supply and transport, and the economic slowdown across the world. However, there was a significant increase in single-use plastic resin for personal protection equipment (PPE), protective barriers, medical supplies, and packaging for food (including take-out food), e-commerce, and cleaning products in 2020.[75] For example, in North America, consumer and packaging petrochemical demand increased by 8 percent in 2020 versus 2019 while there was a decline in other end use sectors.[76]

Unlike in 2019, when there was a major focus on recycling and reducing single-use plastics, 2020 has seen reductions in recycling and delayed or reduced bans on single-use plastic because of safety concerns about reusing plastic. During COVID, a number of single-use plastics bans were rolled back. In the UK, a much-heralded charge on plastic bags was suspended. A ban on such items has been put on hold in US states such as Maine, while retailers, including Starbucks, banned reusable cups to protect against the spread of COVID.[77]

In the US, industrial production fell by 6.9 percent for the year, while US chemical production fell by a lesser 3.6 percent in 2020.[78] While it was the largest decline since the Great Recession of 2008, the chemicals sector was one of the better performers within the manufacturing sector.

Looking forward, population growth and industrialization in the developing world should continue to result in strong growth in the demand for plastics. Rising construction spending by governments, particularly in China and India, will drive the demand for plastics in infrastructure and construction applications.

In many forecasts, petrochemical demand is projected to be the largest growth area for oil demand.[79] This study addresses differences in petrochemical demand in scenarios where pandemics remain an ongoing theme versus scenarios where pandemics are no longer a key driver. The study also addresses the key uncertainties of the strength of government policy in the areas of (1) mandated plastics recycling, (2) bans on single-use plastics, and (3) substitution of non-petroleum feedstock for petrochemical manufacturing.

Shipping Trends

Shipping trends detailed below include e-commerce, trucking, and marine.

E-commerce

COVID-19 accelerated the shift toward e-commerce that was already underway, with a recent study by IBM indicating the trend was accelerated by five years.[80] US e-commerce grew by 44 percent in 2020, the highest annual US e-commerce growth in at least two decades and triple the 15 percent jump in 2019.[81] Online sales in the US will account for 21 percent of total retail sales in 2020, up from about 16 percent in 2019.[82] The scope of e-commerce has also expanded including new firms, consumer segments (e.g., elderly) and products (e.g., groceries). While e-commerce could recede somewhat after the pandemic ends, people have grown used to the convenience, and it is likely to remain at a permanently higher level.

E-commerce has also increased internationally as a result of COVID. In many countries, online shopping had stalled because of underdeveloped infrastructure and the reluctance, or inability, of consumers to use banks and electronic payment. COVID forced rapid change. In Mexico, for example, fewer than half of adults had bank accounts and less than 5 percent of retail sales occurred online before the pandemic. Web sales in Mexico rose by 54 percent in 2020 as a result of COVID and store closures.[83] In 2020, there had also been booms in e-commerce in India, Russia, and Brazil, which also had been slow in adopting online shopping.

E-commerce substituting for individual shopping trips should reduce passenger VMT and fuel demand, particularly in rural areas. However, e-commerce could increase truck VMT and air pollution if consumers ship one item when shopping online with expedited shipping in a diesel truck.[84] There are strategies that logistics companies can employ to reduce e-commerce truck VMT and emissions if consumers and governments require it. They can allow less frequent deliveries or consolidate demand and delivery points, use cleaner vehicles or fuels (e.g., electric), or use alternative, less oil-intensive delivery modes (e.g., electric bicycles, robots, and drones). Some major e-commerce and logistics companies, such as Amazon and FedEx, are currently working to electrify their fleets.[85]

Trucking

COVID had a negative impact on trucking in the US overall because of lockdowns, supply chain disruptions and reduced international trade. Truck tonnage in the US declined by nearly 10 percent in each of April and May 2020, although was only down by 3.4 percent for the year.[86] Tonnage improvements after April were helped by increased consumption, retail inventory restocking, and robust single-family home construction.

Trends in tonnage impacted US truck VMT. Truck VMT declined year-over-year until the summer, and growth rates have been positive since then.[87] There has also been an increase in the number of intra-regional and last-mile truck trips, while the average length of the haul has declined in the United States. These trends are consistent with rising e-commerce and reduced international trade where long-haul trucks are required to move goods from ports to inland markets.

Looking forward, this report's scenarios address the following key questions around trucking activity:

- The strength of the economic recovery
- Whether or not the trend of deglobalization continues, including reduced trade and domestic economies building out their own supply chains
- The extent to which there are continued increases in e-commerce or whether consumers return to stores post COVID
- Whether there are logistical improvements in shipping that reduce truck VMT or alternative fuels used that reduce truck oil demand
- How 3D printing will impact shipping patterns
- The strength of government requirements for using lower carbon fuels or electricity for trucking

Marine

Even before the pandemic, growth in international maritime trade stalled in 2019—with trade volumes increasing by only 0.5 percent—because of protectionism and trade tensions. A recent report estimated that tariffs alone cut the volume of maritime trade by 0.5 percent in 2019.[88]

In 2020, the global pandemic and economic crisis further disrupted maritime transport and trade. The United Nations Conference on Trade and Development estimated that the volume of international maritime trade fell by 4.1 percent in 2020. In addition to demand contracting and lingering trade tensions, there were significant supply-chain disruptions due to COVID. The pandemic also elicited discussion among industry about shortening supply chains through nearshoring and reshoring, with less dependence on lean inventory models. The scenarios in this report differ by the rate of economic and trade growth, the degree of fuel efficiency improvement in ships, and the speed and penetration rates of lower carbon bunker fuels.

THE FOUR SCENARIOS

Critical Uncertainties

The Steering Committee for this report reviewed all the key drivers and external forces and chose the two critical uncertainties that had the largest impact on long-term oil demand and that were the most uncertain. The two critical uncertainties also had to be independent of each other so distinctive scenarios could be developed. The critical uncertainties chosen were:

- **Disruptive impact of pandemics** to the global economy and mobility (including duration, recurrence or new diseases)
- **The degree of policy intervention** to accelerate technology adoption that accelerates the transition away from oil demand

Scenario Logics

From the two critical uncertainties a matrix was developed with the end points defined for four scenarios, as shown in Figure 6.

Figure 6: Scenario logics

Degree of policy intervention to accelerate technology adoption that reduces oil demand	Low — **Disruptive impact of pandemics**	High
High	*Low pandemic disruption, high policy intervention* **Quadrant I** “Roaring Twenties”	*High pandemic disruption, high policy intervention* **Quadrant II** “Forced Revitalization”
Low	*Low pandemic disruption, low policy intervention* **Quadrant III** “Delayed Carbon Action”	*High pandemic disruption, low policy intervention* **Quadrant IV** “Survival”

Scenario quadrants II and IV assume the continued theme of pandemics during the next decade. In Quadrants I and III, the pandemic stops being disruptive to the world economy beyond 2021. In Quadrants I and II, there is strong government policy intervention to accelerate technology adoption that reduces oil demand.

In Quadrant I (Roaring Twenties), there is a strong economic recovery post pandemic that increases travel, congestion, air pollution, and greenhouse gas emissions. Governments around the world respond with strict climate change and environmental regulation.

In Quadrant II (Forced Revitalization), continued weak economic growth due to the pandemic causes governments to use green stimulus to revitalize their economies. Industrial policy driving investment in green technologies makes them competitive (e.g., electric vehicles and fuel cell vehicles), and there is a rapid uptake of them by consumers in the second half of the decade.

In Quadrant III (Delayed Carbon Action), governments delay their pursuit of reducing greenhouse gas emissions until there is a robust economic recovery. Some governments (e.g., EU) respond faster than others.

In Quadrant IV (Survival), continued disruption from pandemics overwhelms governments' ability to stimulate their economies. There is a focus on "brown" stimulus, and there is rising social unrest because of high unemployment and rising inequality.

Scenario Descriptions

This next section describes each of the scenarios in greater detail. A table comparing the detailed assumptions behind each scenario appears at the end of this section.

Roaring Twenties (Quadrant I) – Low Pandemic, High Policy Intervention

This scenario represents the quadrant that has low COVID disruption and high policy intervention to hasten a transition away from oil. In this scenario, the COVID vaccine is effective in ending the pandemic quickly. Additionally, government stimulus leads to a strong and rapid recovery in global economic growth. Hence, it is given the name "Roaring Twenties."

The mid-2020s are marked by rapidly rising global oil demand, congestion, pollution, and greenhouse gas emissions. Enabled by a swift global economic recovery, re-globalization shifts the focus of governments from domestic economic issues to global issues such as environmental sustainability and climate change. The US rejoins the Paris Agreement in 2021. The US and China work on carbon policies jointly, and there is a global carbon price of $50/metric ton in 2030. Stringent government policies to address climate change lower oil demand growth in the latter part of the decade as it takes time for regulations to be enacted and to change the vehicle stock.

There is strong government support for consumers to buy electric vehicles in this scenario. Governments subsidize the building of EV charging stations, and national subsidies to consumers are extended. EVs become 31 percent of new passenger vehicle sales in 2030 (shown in Table 1 at the end of this section). There are already 20 countries that have electrification targets or bans on internal combustion engine cars.[89] The EU's 750 billion euro stimulus package includes 20 billion euros to boost the sales of clean vehicles, and one million electric and hydrogen vehicle charging stations are to be installed by 2025.[90] President Biden's $2.2 trillion infrastructure plan has $174 billion to incentivize the purchase and charging of EVs.[91] In this scenario, national governments also adopt more stringent fuel efficiency standards and zero emissions vehicles (ZEV) policies. In the United States, for example, President Obama's fuel efficiency goals are restored, which implies a 5 percent per year improvement in fuel efficiency for passenger vehicles. Many nations also introduce regulatory programs to significantly improve the fuel efficiency of trucks. Light- and medium-duty trucks are also electrified to meet national low emissions truck standards, while ZEV programs incentivize the use of alternative fuels in heavy-duty trucks. Other transportation sectors are also subject to stringent regulations to reduce greenhouse gas emissions.

In this scenario, consumers accept increased regulations and requirements for EVs because they become more concerned about climate change and air pollution given the frequent extreme weather events and their positive experience with reduced air pollution during COVID, particularly with the correlation between air pollution and deaths from COVID. Strong global economic growth also leads to consumers accepting slightly higher cost technology. In this scenario, battery costs achieve parity with internal combustion engines in 2025, a consensus view reflected in a survey of forecasters done in 2019.[92]

Auto manufacturers are also making large investments in EVs and developing many new models, including popular SUVs and pickup trucks. Out of the world's top 20 vehicle manufacturers, which represented around 90 percent of new car registrations in 2020, 18 have stated plans to widen their portfolio of EV models and to rapidly scale up the production of light-duty EVs.[93] For example, General Motors announced a commitment to 30 new global electric vehicles by 2025. GM and EVgo plan to triple the size of the largest public fast charging network in the US, by adding more than 2700 new fast chargers over the next five years. Volvo has announced plans to become an all-EV company by 2030, while Volkswagen announced a mission of being the world's largest manufacturer of electric vehicles.[94]

VMT in the transportation sector is especially strong during the economic rebound over the next five years in the Roaring Twenties scenario, but slows with lower economic growth from 2025 to 2030. Air travel is restored to pre-COVID levels by 2024, and marine shipping is improved by re-globalization and improved trade.

Petrochemical demand is strong in this scenario because of a fast recovery from COVID and robust global economic growth. However, there is increasing pressure to reduce the amount of single-use plastic and increase recycling. Single-use plastic bans increase from 3 percent today to 6 percent by 2030, while recycling doubles from 12 percent globally today to 24 percent by 2030.

The real Brent oil price reaches $70 per barrel in 2025 with the strong oil demand recovery, but recedes to $55 per barrel in 2030 because of government regulations that reduce the growth rate in global oil demand.

Early Warning Signs of Roaring Twenties

The project team of experts who worked on this scenario developed the following early warning signs for this scenario:

- US presidential and senate election outcome: Democrats win
- Other elections around the world have globalist leaders win versus populists

- China's transportation and climate-related policies adopted are aimed at achieving net zero emissions
- Resurgence of international institutions (e.g., NATO, WTO, and WHO)
- US and China discuss climate and wider trade issues
- Consumer confidence returns globally
- Economic and trade growth increases
- Vaccine proves effective
- Willingness to fly returns
- Opening of offices
- Consumer acceptance of new regulatory policies in transport (e.g., consumers' willingness to purchase electric vehicles as mainstream vehicle)

Forced Revitalization (Quadrant II) – High Pandemic, High Policy Intervention

In this scenario, periodic outbreaks of COVID and other viruses continue over the next decade. Vaccines are not developed and distributed fast enough to eradicate the viruses. Successive waves of pandemics lower global economic growth. Various governments around the world view technology innovation as the key to economic recovery. There is a high-tech competition between the US, Europe, and China to accelerate R&D and investment in new technologies as a matter of economic and national security. The US and Europe also want to develop their own supply chains for strategic goods and for national and economic security, particularly in view of supply chains breaking down during the coronavirus. This aspect constrains China's exports and particularly lowers the nation's economic growth.

The US develops an industrial policy in its "space race" to jump-start its new economy. The nation prioritizes innovations in health care, biotechnology, and "green" industries. Governments around the world shift their focus to "green stimulus" because of rising concern about "well-being" as a result of pandemics and the climate crisis in this scenario.

R&D focused on clean technology in major markets around the world reduces the cost and increases the range of batteries and helps develop affordable low carbon fuels. By the mid-2020s, EVs and low carbon fuels become competitive with conventional vehicles and fuels, and penetration rates take off. Penetration rates of EVs exceed those of Roaring Twenties, where regulation is the primary driver versus cost as the primary driver in this scenario. Passenger car EVs capture nearly 40 percent of the new car sales by 2030. Consumer acceptance of EVs is high because technology innovation reduces EVs' cost, increases their range, and reduces charging time.

This scenario also assumes relatively rapid development of charging infrastructure. Both the EU Green Plan and President Biden's infrastructure proposal offer incentives for EV charging infrastructure, while China mandates utilities build them, so they are way ahead of other countries. The increase in electricity consumption is not a constraint on EV penetration in this scenario because real-time pricing moves EV charging away from peak consumption times where there is spare and renewable generation capacity available. The IEA estimates in its Sustainable Development scenario, which has similar EV penetration rates as this scenario, that EVs comprise only 2 percent to 5 percent of electricity consumption across major markets in 2030.[95]

Across all transportation modes, VMT and shipping are weak because of the continued pandemic and weak economic growth. Advances in 3D printing also shorten shipping distances. Air travel doesn't return to pre-COVID levels until 2027. In addition, slower economic growth in developing countries particularly slows petrochemical demand growth. However, that impact is partially offset by continued pandemics increasing the need for plastic personal protection equipment and packaging.

The scenario has high and rising government fiscal deficits. The US and other developed country governments get additional revenues by refocusing existing spending, raising taxes on higher income people, and making Social Security income-based. Income redistribution is an important objective in this scenario since the pandemic increased income inequality.

While oil demand growth is weak in this scenario, so is investment in new oil supply. The market tightens somewhat by 2025 because of the drop in investment in new oil supply and a supply disruption in an oil-producing nation as a result of a prolonged period of low oil prices. The real Brent oil price reaches $65 per barrel in 2025. However, demand is eroded quickly after 2025 because of high penetration of electric vehicles, and the oil price falls to $45 per barrel by 2030. Oil price volatility is greater in this scenario because low oil prices stimulate oil demand and could cause disruptions to supply in oil-producing nations.

Early Warning Signs of Forced Revitalization

- Large number of announcements of domestically focused "green stimulus" in various nations across the globe
- Announcements of cost reductions and density increases in batteries
- Signs of the US and Europe duplicating the supply chain of things currently imported from China
- Signs of financial challenges in China, such as large and growing government budget deficits
- The US developing an industrial policy and naming strategic industries, much like China does
- Increases in taxes on higher income people to deal with deficits and fund development of strategic industries
- Announced development and sales of fuel cell heavy-duty trucks
- Signs of investment in hydrogen and liquefied natural gas (LNG) infrastructure for

refueling heavy-duty trucks

- Advances in 3D printing
- Increases in R&D spending in the US subsidized by the federal government
- Consumer acceptance of new regulatory policies in transport (e.g., consumers' willingness to purchase electric vehicles as mainstream vehicle)

Delayed Climate Action (Quadrant III) – Low Pandemic, Low Policy Intervention

In this scenario, vaccines for COVID-19 are successful and the world regains confidence in avoiding the disease by 2022. However, the economic recovery is slow because of governments' lower spending to address high debt levels as well as lingering unemployment. Some key governments continue to be populist and protectionist, keeping world trade from recovering, which creates inefficiencies and detracts from global economic growth. Nevertheless, global economic growth is relatively robust: the second highest rate after the Roaring Twenties scenario.

Once the global economy recovers, transportation VMT and shipping growth are strong. For example, air travel is restored to pre-COVID levels by 2025.

Governments are focused on restoring economic growth and jobs, and they defer significant action on climate change. The US government is unsuccessful at passing a substantial amount of green stimulus, focusing instead on the perception that "brown" stimulus is more "shovel-ready." With a vacuum of policy at the national level regarding climate change, some state and local governments continue to enact policies to reduce greenhouse gas emissions. China has a three-year hiatus where the nation focuses on domestic economic growth and continues to reduce subsidies for buying electric vehicles. However, China still views batteries and EVs as strategic industries, so the nation will revert to other policies to increase the use of EVs. Europe slows down the implementation of the Green Deal by a couple of years. They also delay penalties on auto manufacturers for not meeting carbon standards because the auto sector is such a significant part of the economies in some of the countries. The rapid increase in EV penetration observed in 2020 slows because of limited government finances available to incentivize the continued consumer purchase of EVs or the building out of charging infrastructure. It takes longer to get the battery cost breakthroughs than expected, and countries do not share their technologies across borders.

This scenario may occur because there are significant challenges to rapid EV penetration. AlixPartners estimates $300 billion will be needed to build out a global charging network to accommodate the expected growth of EVs by 2030, including $50 billion in the US alone.[96] Governments are focused on "brown" stimulus in this scenario rather than investing in EV charging infrastructure and in power transmission and distribution systems, all of which would enable EV penetration. Another reason why this scenario may occur is the enormous investment that would be required in clean sources of power generation to have electrification make sense from a climate viewpoint. To achieve net zero emissions in 2050, power sector investment needs to triple from 2019 to 2030 (from $760 billion to $2,200 billion), with a large portion spent on expanding, modernizing, and digitizing electricity networks along with investment in renewables.[97] Another reason why there is slow EV penetration in this scenario is that new mines that would be needed for sufficient battery metals are slow to be developed.

In this scenario, consumers have much lower adoption rates of EVs because these cars are more expensive than conventional ones given that technology breakthroughs haven't occurred as rapidly as expected, and governments aren't heavily mandating or incentivizing them.

As a result, global passenger car EV penetration only rises to 13 percent of new car sales by 2030 versus 2.6 percent in 2019. Governments also deferred additional bans on single-use plastics and increased mandates for plastics recycling in this scenario.

Oil demand growth in this scenario is relatively robust because of relatively robust global economic growth and temporarily weak policy drivers that would lower oil demand. The combination of moderately strong oil demand growth and the lack of investment in oil supply—due to low oil prices in the near-term and capital discipline—results in a much tighter oil market in the mid-2020s with a real $75 per barrel indicative oil price in 2025. The oil price could be higher in one or more years if OPEC capacity is not available to fill any supply gaps.

Early Warning Signs of Delayed Carbon Action

- Effective vaccine against new strains of virus
- US 2020 and midterm election results making it difficult to pass climate legislation and continuing trade restrictions
- US doesn't return to Obama era efficiency standards
- Governments around the world have a complete focus on jobs
- China strips away EV subsidies and lacks aggressive enforcement of EV mandates for a few years
- China's peak EV ambition turned out to be in 2019
- Stimulus ends up being less green than advertised in the EU and elsewhere
- EU backsliding on the timing of the green stimulus
- EU pushing back dates or fines for CO_2 standards for auto manufacturers
- Sharp drop-off in EV purchase rates in the EU in 2021 when they are no longer heavily subsidized
- EV sales rates continuing to fall elsewhere when subsidies are removed
- Government climate pronouncements are not backed up by specific policies and regulations

Survival (Quadrant IV) – High Pandemic, Low Policy Intervention

In this scenario, there is continued fear about infection because the vaccines aren't very effective against mutations, new viruses occur, or some people refuse to get the vaccine.[98] Continued weak global economic growth due to ongoing pandemics cause governments to focus on health and safety concerns and jobs rather than on climate change. National governments already have high debt levels and are failing to stimulate their economies. With ongoing pandemic concerns and limited policy options, this scenario has the weakest economic growth even as some new businesses continue to crop up (e.g., more digital businesses).

Income inequality increases because of the continued pandemic and weak policy environment, with low-income people less able to telecommute and, thus, more exposed to the virus, more likely to lose jobs that are in the service industry, and having worse access to health care. The continued pandemic, as well as rising income inequality and social unrest, cause people who can afford it to move out of big cities to suburbs or smaller towns.

The scenario assumes that cumulatively 10 percent of people move out of cities to suburbs and smaller cities by 2030 in the United States. In Europe, we assume that only 5 percent of the population leave large cities. In China, there are about 290 million migrant workers in cities, which could be about one-third of the urban population. Some of them could be forced out of cities if they lose employment because of a continued downturn.[99] However, many of these people are unlikely to own their own cars or drive more outside the city.

The combination of weak economic growth, massive telecommuting, and limited travel constrain oil demand. For example, air travel is not restored to 2019 seat miles until 2029. However, this decline in oil demand is partially offset by (1) the rise of the personal vehicle versus mass transit[100], (2) greater miles being driven by people who have moved out of major cities, (3) increased e-commerce with short delivery times, and (4) consumers under duress holding on to older cars and buying more used cars, which are less fuel-efficient than new cars. In addition, governments are less likely to enact policies that make energy and other household necessities more expensive. However, city governments adopt policies to improve air quality and make cities more attractive to stem the loss in population.

This scenario assumes that the real Brent oil price remains fairly low, standing at $45 per barrel in 2025 as it takes multiple years to draw down the high level of global oil inventories. The oil price is then assumed to rise to $50 per barrel by 2030 to elicit new US tight oil supply. Since those prices don't cover the social cost in OPEC countries, there may well be a supply disruption in a few oil-producing countries, giving rise to high oil price volatility.

In this scenario, consumers are slow to adopt EVs because there aren't significant technology breakthroughs or strong government policies supporting them, and lower incomes and high unemployment reduce interest in purchasing new, higher cost cars.

Early Warning Signs of Survival

- Any signs of vaccines being less effective against new coronavirus strains, new viruses or an unwillingness of segments of the population to take the vaccine

- Inability of national governments to agree on new fiscal stimulus
- Green stimulus packages failing
- Continued very high unemployment
- Continued or increased social unrest in cities
- Additional signs of people moving out of large cities
- Weak EV sales – steep drop in EU EV sales from 2020
- Continued weak new car sales and high used car sales
- Continued signs that telecommuters are not driving more in their leisure time, increasing overall VMT

Comparison of Scenarios

The scenarios differ by the length of the pandemic and their impact on economic growth. Roaring Twenties has the highest global economic growth rate of all the scenarios over the full time modeled: 2020–2030. However, that high rate is composed of a rapid initial recovery and significantly slowing growth beyond the mid-2020s. While Delayed Carbon Action's economic recovery is delayed, it ultimately has higher economic growth than Roaring Twenties toward the end of the decade. The two scenarios with the continued pandemics, Forced Revitalization and Survival, have the lowest economic growth.

Volumes of transportation VMT and tonnage shipped, the transportation activity levels that contribute to oil demand, generally follow the trend in economic growth. One exception is in the Marine sector, where the re-globalization in the Roaring Twenties scenario and increased international trade give it greater marine shipping than in the Delayed Carbon Action scenario, where protectionism continues. It is also important to note that VMT and shipping aren't as low in the pandemic scenarios as might be expected because the pandemic itself causes some offsetting increases in VMT and shipping (e.g., greater use of personal vehicles versus mass transit, greater e-commerce).

The scenarios also differ in the degree, timing, and nature of government action on climate change. Roaring Twenties is the only scenario with a global explicit carbon price and a stringent regulatory regime to reduce greenhouse gas emissions. Forced Revitalization is more about green stimulus and technology innovation than about regulation. However, the breakthroughs stemming from government R&D improve the competitiveness of batteries and alternative fuels such that the highest penetration of EVs and alternatives are found in the Forced Revitalization scenario. By definition, in the Delayed Carbon Action scenario, governments defer action on climate change for a few years. Even in the Survival scenario, local governments take actions to lower urban air emissions that reduce greenhouse gas emissions. All of the scenarios have a significant increase in passenger car and truck electrification, although it is highest in Forced Revitalization.

Table 1 summarizes the main indicators for each of the scenario:

Table 1: Scenario comparisons

	Roaring Twenties (I)	Forced Revitalization (II)	Delayed Carbon Action (III)	Survival (IV)
Real global economic growth (avg. 2020–2030)	3.9%	2.3%	3.3%	1.5%
Political	Re-globalization, climate-focused	Nationalist, redistribution of income	Nationalist	Nationalist
Main policy drivers	Climate, air quality	Industrial policy, green stimulus	Jobs, energy security	Health and safety, environmental justice
Real Brent oil price ($ 2020 per barrel)				
2025	$70	$65	$75	$45
2030	$55	$45	$65	$50
Global passenger vehicles				
Vehicle miles traveled growth rate through 2030	3.2%	2.1%	3.8%	1.6%
EV share of new car sales in 2030	31%	39%	13%	11%
Global trucks				
Light-duty % EVs of new truck sales in 2030	25%	30%	9%	5%
Medium-duty % EVs of new truck sales in 2030	22%	27%	8%	4%
Heavy-duty % alternatives of new truck sales in 2030 (e.g., electric, hydrogen, LNG)	20%	22%	10%	3%
Global air				
Year returning to 2019 seat miles	2024	2027	2025	2029
Lost business travel	15%	25%	10%	35%
International marine				
Mileage growth (annual % increase) through 2030	3.9%	1.2%	3.0%	1.2%
Alternative fuels share in 2030	17%	13%	9%	5%
Petrochemicals				
Ban on plastics (e.g., single use) (vs. 3% today)	6%	3%	0%	3%
Recycling in 2030 (vs. 12% today)	24%	20%	0%	9%
Low-carbon feedstock in 2030	5%	3%	0%	0%

Roaring Twenties appears to have the highest economic growth rate despite a significant increase in government regulation. The scenario has such high economic growth because of the quick recovery from COVID and the economic boom. Increased regulation follows in the mid-2020s. There is then a continuous decline in global economic growth rates, with Delayed Carbon Action's growth surpassing Roaring Twenties growth by the end of the forecast period. Delayed Carbon Action had slower initial economic growth, which is why governments opted for brown stimulus.

There are significantly higher EV penetration rates in the Roaring Twenties and Forced Revitalization scenarios than the other two scenarios that had much less government intervention. While more than 30 percent of new car sales in 2030 seems like a high number in light of the many challenges in ramping up EV penetration (e.g., consumer acceptance, improvements in battery cost and range, need for charging infrastructure), there were at least three forecasts made in 2020 that have similar rates of EV penetration. They include Bloomberg New Energy Finance's, the IEA's Sustainable Development scenario, and a forecast from Deloitte.[101] Our scenarios with high EV penetration assume penetration rates at least that high to fully capture the range of uncertainty.

MODEL RESULTS FOR THE TRANSPORTATION SECTOR

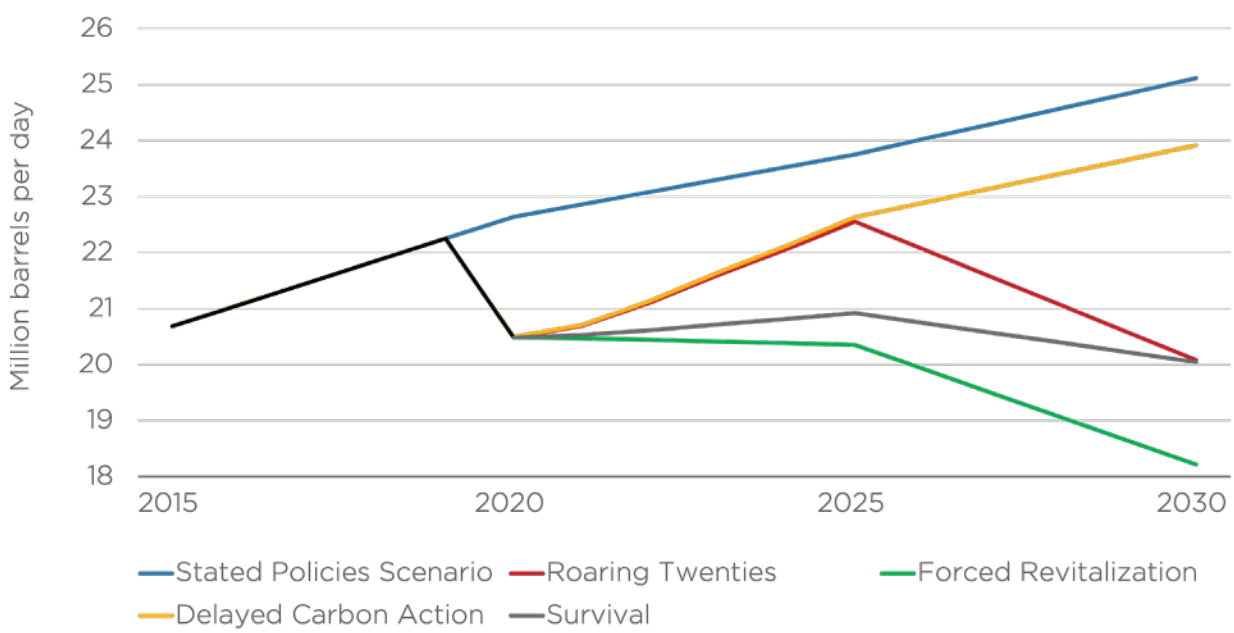
This section provides highlights of the transportation model results. Each of the figures provided presents results from the report's four scenarios along with the IEA Stated Policies Scenario (SPS) from 2019, which presents a pre-pandemic outlook. The same inputs for 2020 are used in all of the scenarios, based on the best estimates available for what changed in that year because of the pandemic.

Light-Duty Vehicles (LDVs)

As shown in Figure 7, passenger vehicle oil use peaks by 2025 in three of the four scenarios because government climate policies include electrification of the passenger vehicle sector. Vehicle electrification is a feature to varying degrees in all of the scenarios. In the two continued pandemic scenarios (Forced Revitalization and Survival), the peak in LDV oil demand was in 2019.

Also shown in Figure 7, oil use for LDVs is substantially below the IEA's 2019 SPS projection in all of the scenarios. The scenarios all had a loss of GDP because of COVID in 2020, which led to lower new car sales and lower passenger car VMT. In addition, all of the scenarios had significantly higher EV penetration than IEA's 2019 SPS case because of government policy or technology improvement or both.

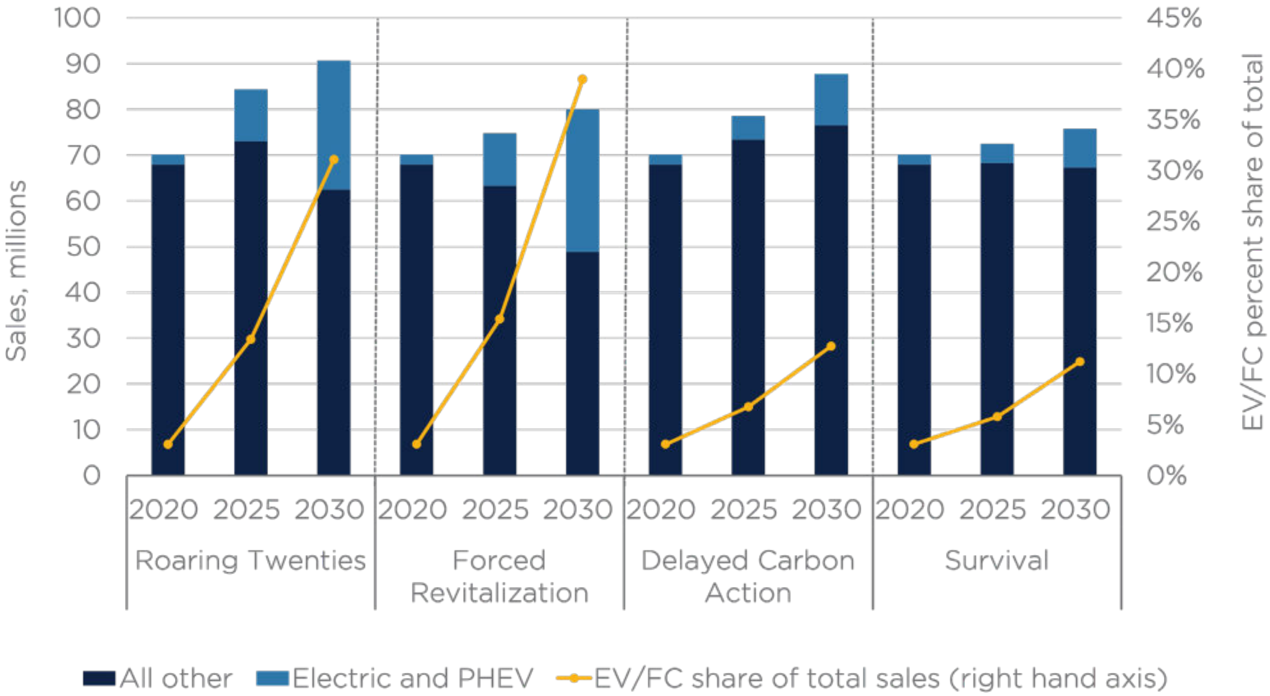
Figure 7: Global LDV oil use by scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

The Delayed Carbon Action scenario had the highest LDV oil use in 2030, bringing it closest to the IEA's SPS case. That resulted from the combination of higher global economic growth and deferred government climate policies. As shown in Figure 8, Delayed Carbon Action has lower EV penetration in 2030 than the two scenarios which had strong government climate actions (Roaring Twenties and Forced Revitalization).

Figure 8: Global LDV EV sales and shares by scenario



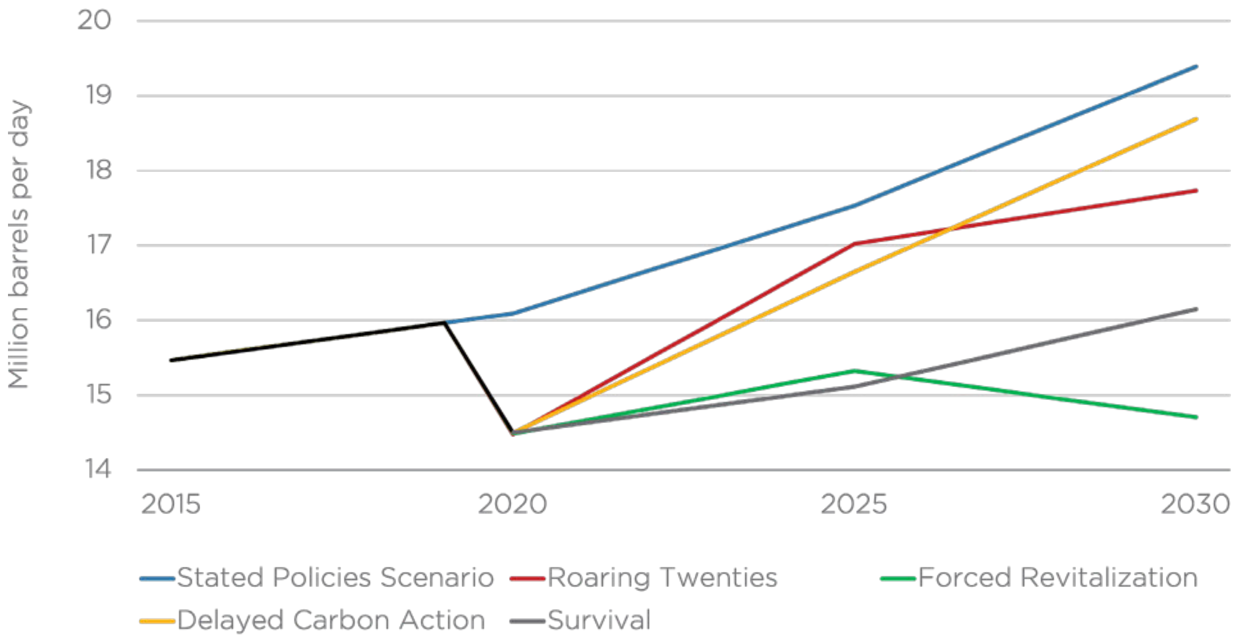
Given the policies to promote fuel economy and adopt electric vehicles in Roaring Twenties and Forced Revitalization, LDV oil use declines fairly significantly after 2025 in both of those scenarios. Forced Revitalization has the lowest oil use outlook because of the double whammy of weak economic growth from a continued pandemic and technology innovation policies that make electric vehicles competitive with conventional cars.

Survival has only a modest decline post 2025, but oil demand remains weak throughout the next decade since governments are not successful at stimulating their economies in this scenario. Oil demand would be even weaker if it weren't for the dominance of the personal vehicle versus mass transit and some urban flight resulting in increased driving.

Trucks[102]

As shown in Figure 9, none of the scenarios return to the 2019 SPS pre-COVID case throughout the forecast period. The Delayed Carbon Action scenario came closest to the SPS case by 2030 because of stronger economic growth and weaker government policies on truck fuel efficiency and electrification.

Figure 9: Global truck oil use by scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

In contrast with passenger vehicles, in only one scenario did oil demand for trucking peak by 2025, and the peak was actually in 2019 in that scenario. In Forced Revitalization, low economic growth rates constrained growth in tonnage shipped and there was a high level of alternative fuels used in trucks, as shown in Figure 10, including electricity, hydrogen, LNG, and biomass. For light-duty trucks, EVs represented 30 percent of new truck sales in 2030 in this scenario. Given the lag in turning over the entire truck fleet, a much deeper decline in demand would occur post 2030 if this scenario continued.

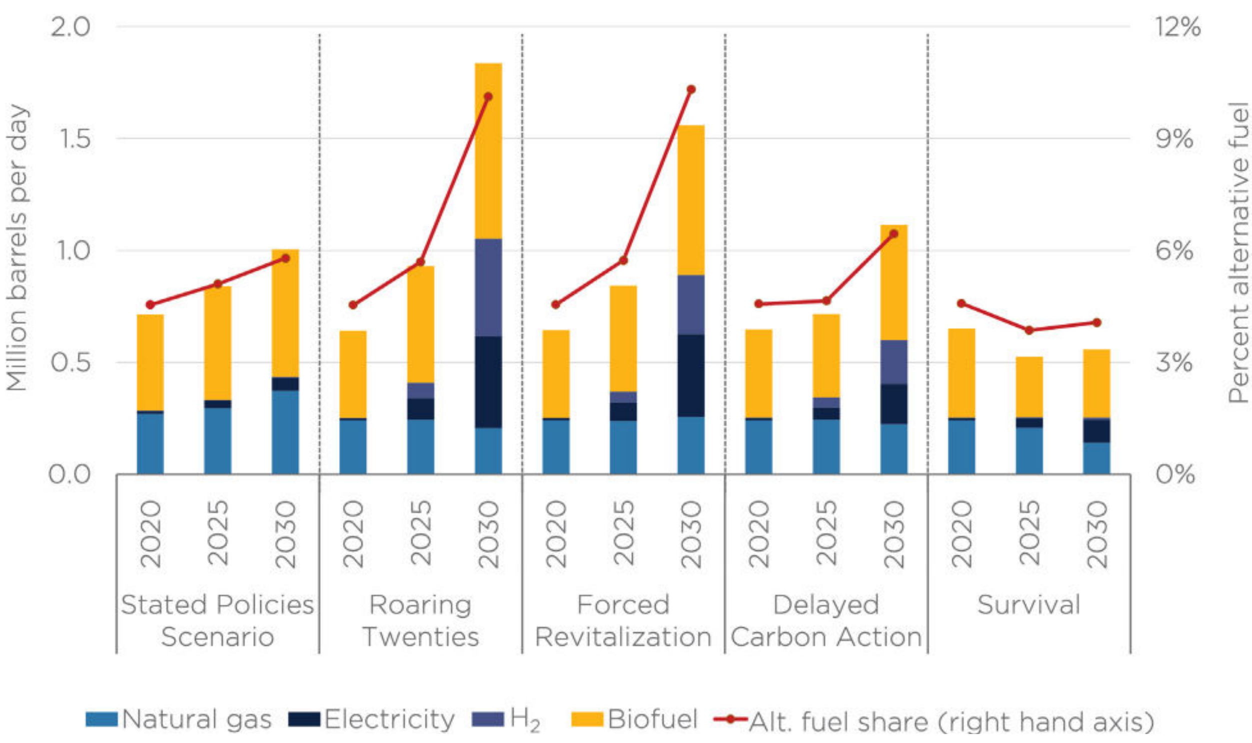
Electrification is a more difficult value proposition for heavy-duty trucks because the battery weight constrains cargo holding capacity given the weight limits on roads. Heavy-duty freight trucks contribute disproportionately to pollution and greenhouse gas emissions, representing less than one tenth of all vehicles, but about 40 percent of their carbon emissions,[103] which makes them an important target for government decarbonization policies. In the Forced Revitalization and Roaring Twenties scenarios, heavy-duty trucks also switched to fuel cells and LNG, with fuel cell trucks representing 12 percent to 14 percent of new heavy-duty truck sales by 2030. LNG truck sales were strongest in the US (given the large supply of shale gas) as well as in China (based on historical precedent), and weakest in Europe where numerous policy makers don't view natural gas as a sustainable fuel.

Trucking oil use didn't peak by 2030 in the Survival scenario despite weak economic growth and protectionism reducing shipping of imported goods from ports to inland destinations. Continued growth in e-commerce due to the ongoing pandemic buoyed short- and medium-haul shipping, and penetration rates for alternative fuels use in that scenario was low.

In Roaring Twenties, trucking oil use increased to a level close to the SPS case by 2025 as a result of a strong global economic recovery and increased international trade, causing a sharp rise in tonnage shipped. However, the pace of growth slows beyond 2025, when government regulations increasing fuel efficiency and the use of alternative fuels kick in.

In terms of geographic differences, most of the growth in trucking oil demand in most of the scenarios is anticipated to be in the developing world outside of China. The OECD countries tend to have lower economic growth and shipping requirements, and OECD nations and China are more likely to promote alternative fuels.

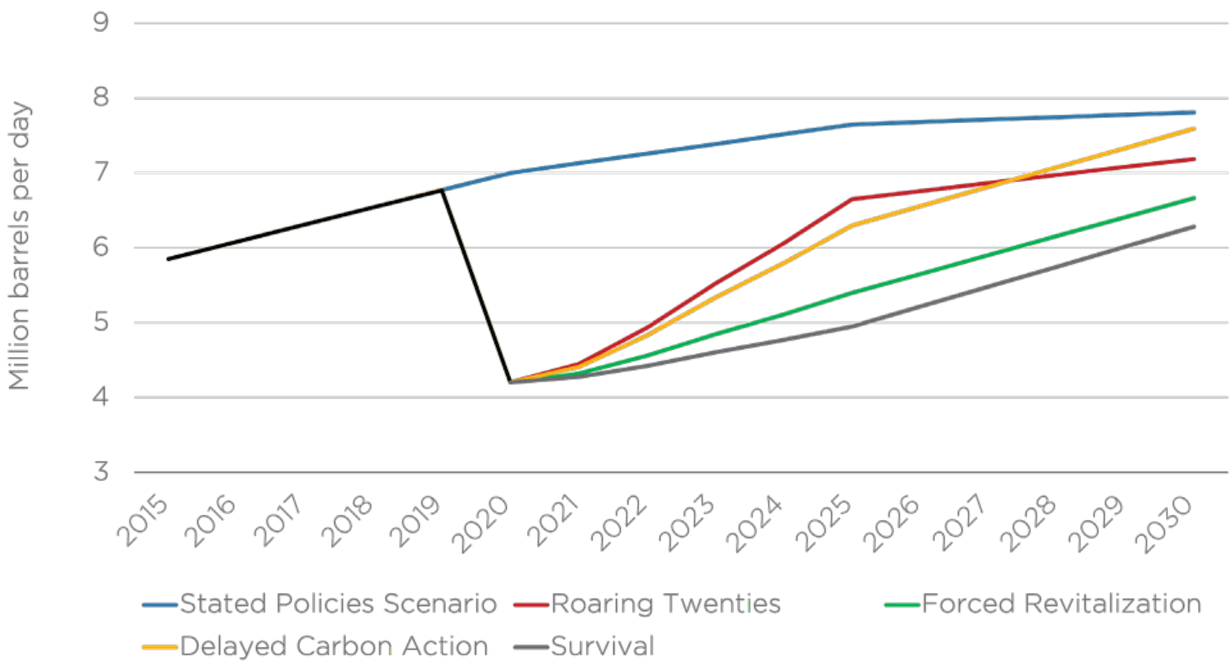
Figure 10: Trucking alternative fuel use by scenario



Air Travel[104]

As shown in Figure 11, global jet fuel oil use rises above 2020 levels in all of our scenarios through 2030. The biggest driver is strong travel growth in China and other developing countries. However, oil use does not get back to the SPS pre-COVID projection by 2030 in any of our scenarios because of delays in passenger travel restoration and a permanent loss in business travel to videoconferencing. In fact, in the two pandemic continuation scenarios, jet fuel oil use never returns to 2019 levels by 2030.

Figure 11: Global jet fuel oil use by scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

The Delayed Carbon Action scenario comes close to the SPS case by 2030 because of strong economic growth and a restoration of pre-COVID passenger travel by 2025, and less government pressure to improve the fuel efficiency of airplanes and use alternative fuels.

Roaring Twenties also had relatively strong jet fuel use growth because the economy and passenger miles recovered to pre-COVID levels by 2024. However, growth flattened after 2025 because of government regulations aimed at increasing fuel efficiency and using alternative fuels. The fuel efficiency of the air fleet also improved because of strong passenger demand requiring that new, more fuel-efficient planes be added to the fleet.

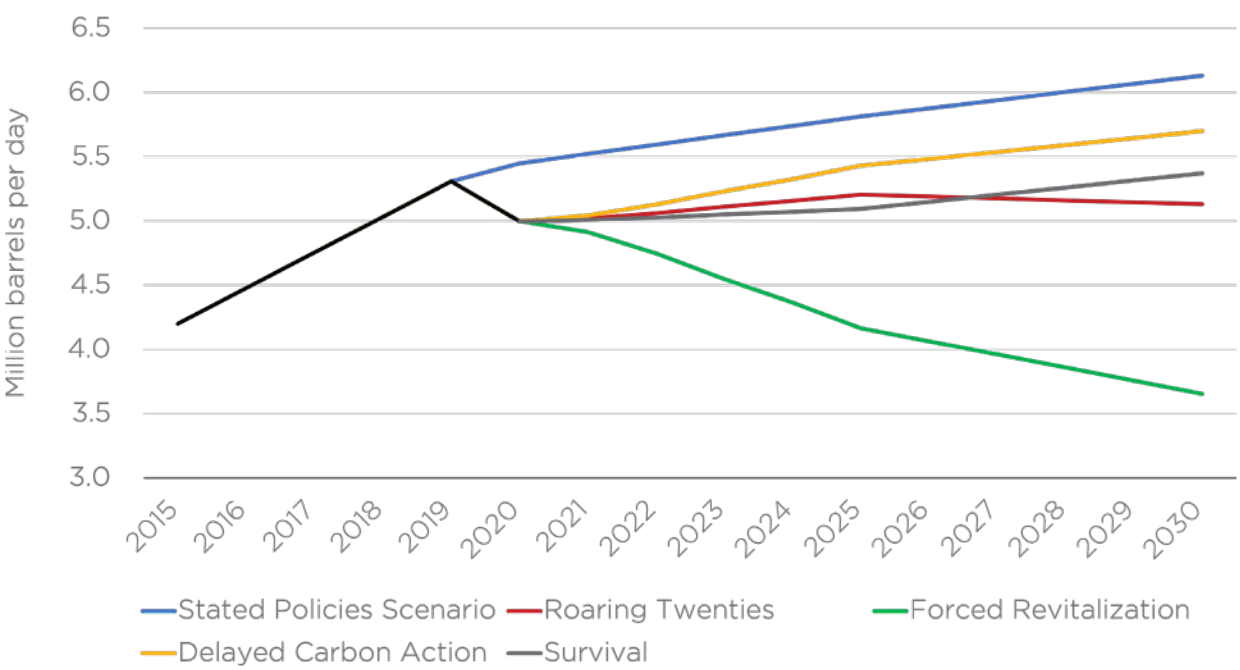
The scenarios with continued pandemics, Forced Revitalization and Survival, had a continued recovery in global jet fuel oil use through 2030 but at lower levels than the other scenarios because of much weaker economic growth, continued safety concerns about flying, and a greater permanent loss of business travel. Passenger travel wasn't returned to pre-COVID levels in these scenarios until the late 2020s. This impact was partially offset by lower fuel efficiency improvements versus the other scenarios since a reduced number of new, more fuel-efficient planes are required to meet travel demand in these scenarios. In addition, biojet use was limited.

Maritime Transport

Oil used in international ships increased in three out of four scenarios between 2020 and 2030, although it never was restored to the SPS pre-COVID projection. Also shown in Figure 12, the one scenario where oil use declined through 2030 (Forced Revitalization) had its peak in 2019.

Oil use is a function of shipping demand, oil intensity, and the use of alternative fuels to oil. International shipping rose from 2019 pre-COVID levels in all of the scenarios. However, fuel efficiency improvement and the use of alternative fuels constrained oil use, particularly in the Forced Revitalization and Roaring Twenties scenarios. In Forced Revitalization, for example, shipping growth was weak with lower economic growth because of the continued pandemic, and ships slow-steamed, which provided a significant reduction in fuel intensity. In Roaring Twenties, the International Marine Organization and national regulations drove a 17 percent penetration rate for alternative bunker fuel by 2030. That was composed of a combination of LNG, biofuels, and a small volume of other low carbon fuels such as green hydrogen.

Figure 12: International ships oil use by scenario



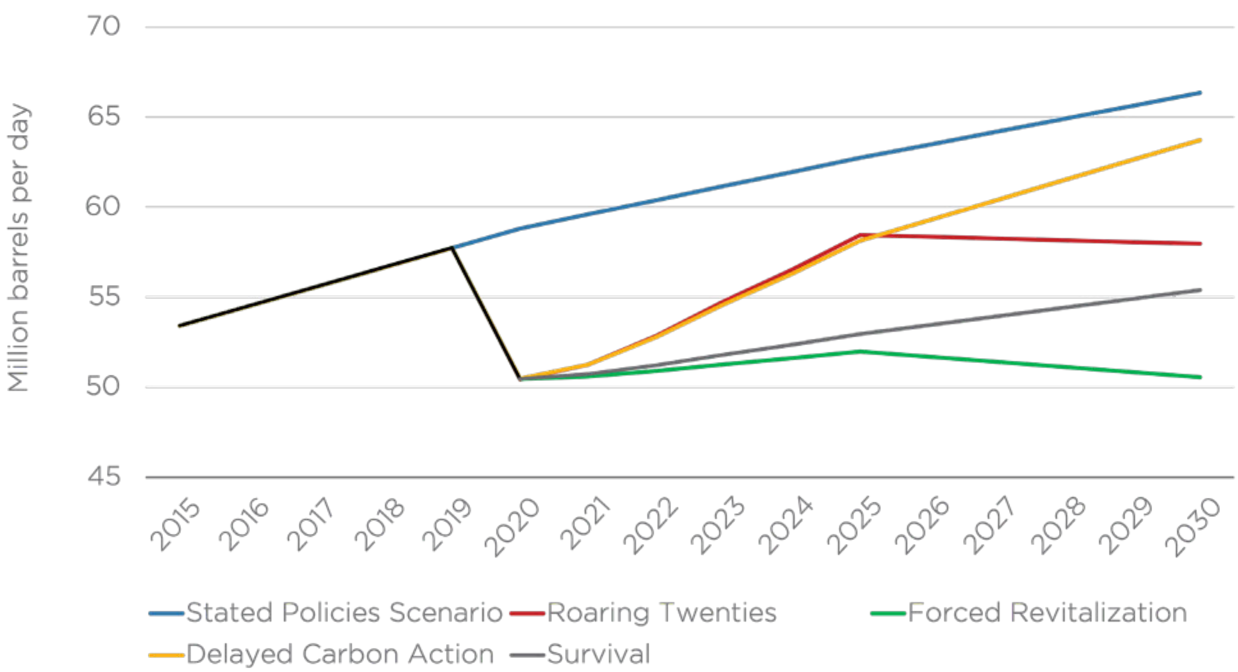
Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

Transportation Energy Use

Oil Use

Adding together the four major modes of transportation plus other modes, such as bus, two-wheeler, and domestic shipping, total transportation oil use is shown in Figure 13. Oil use in the scenarios with continued pandemics (Forced Revitalization and Survival) never returned to 2019 pre-COVID levels nor kept pace with the 2019 SPS projection. Furthermore, in the two scenarios with strong policy drivers to improve fuel efficiency and switch to electricity or other alternative fuels (Roaring Twenties and Forced Revitalization), transportation oil use recovers over the next four years, but then peaks in 2025. Roaring Twenties' oil use peaks at a higher level than Forced Revitalization's because of the former's higher economic growth and slightly lower rate of alternative fuel penetration. Transportation oil use in the other two scenarios (Delayed Carbon Action and Survival) continues to grow through 2030.

Figure 13: Global transportation oil use by scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

Alternative Energy Sources

Total energy use across the four major transportation sectors in 2030 is shown in Figure 14, reflecting the uptake of alternative energy sources. Despite aggressive penetration of alternative fuels in two of the scenarios (Roaring Twenties and Forced Revitalization), oil is still 87 percent of the transportation fuel mix in 2030. In the other two scenarios (Delayed Carbon

Action and Survival), oil is between 91 percent and 94 percent of the transportation fuel mix in 2030, similar to the 2019 SPS projection. Even with a large percentage of alternative fuel vehicle sales, it takes a long time to turn over the global vehicle fleet. Nevertheless, alternative fuels displace between 3 million barrels per day (MMBD) of oil demand by 2030 in the Survival scenario and 7 MMBD in the Roaring Twenties scenario. In the International Energy Agency's 2020 World Energy Outlook Stated Policies Scenario, global liquids demand is only expected to grow by 7 MMBD between 2019 and 2030. Thus, a greater percentage of alternative fuels than assumed in the IEA's latest SPS could significantly lessen oil demand growth. In the scenarios with high alternative fuel penetration, the impact on oil demand could increase substantially beyond 2030 as the fleet turns over, assuming the scenario continued.

As shown in Figure 15, the primary alternative fuels used in transportation are natural gas and biofuels. In 2030, they will still be the largest alternatives, but electricity will rise to over 20 percent of the alternatives in the two scenarios with strong policy drivers (Roaring Twenties and Forced Revitalization). Biofuels will rise to have a bigger share than natural gas in those two scenarios as well since natural gas is no longer viewed as a transition fuel in some regions such as Europe. Hydrogen has between 1 percent and 10 percent of the alternative fuels market in 2030, depending on which scenario has occurred.

Figure 14: Transportation fuel mix in 2030 by scenario

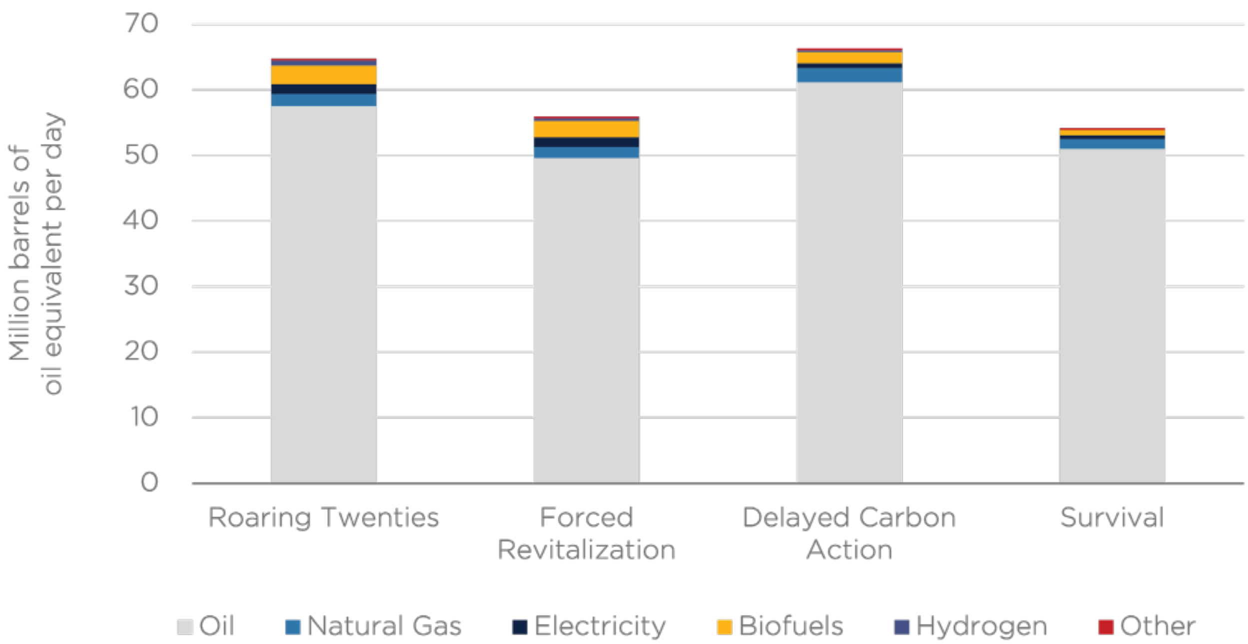
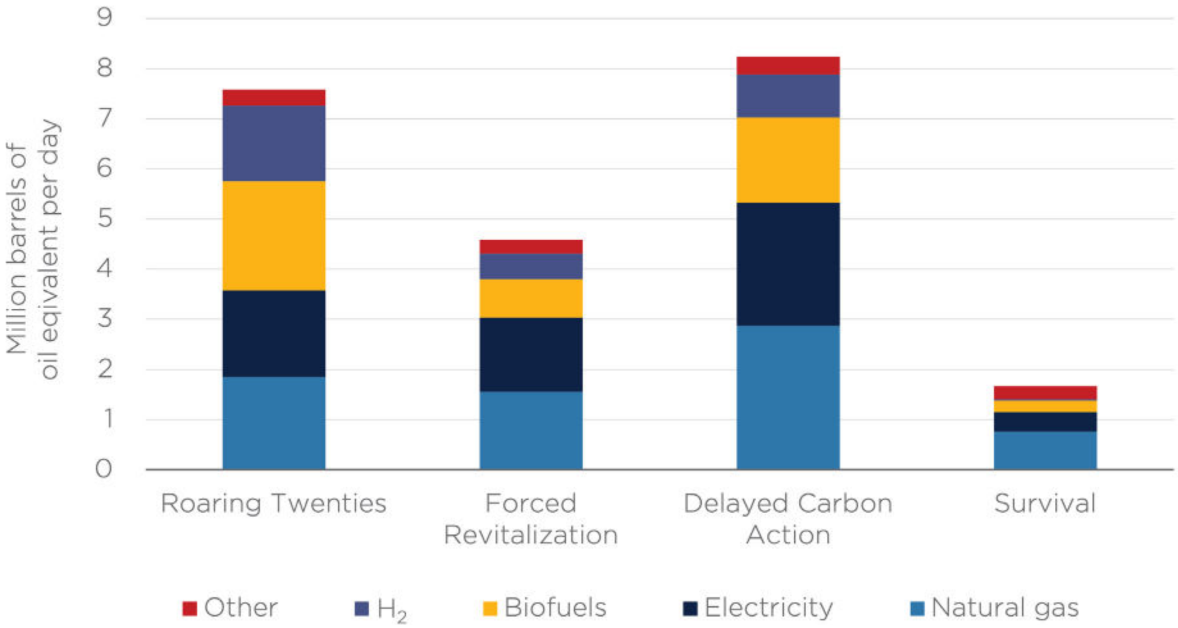


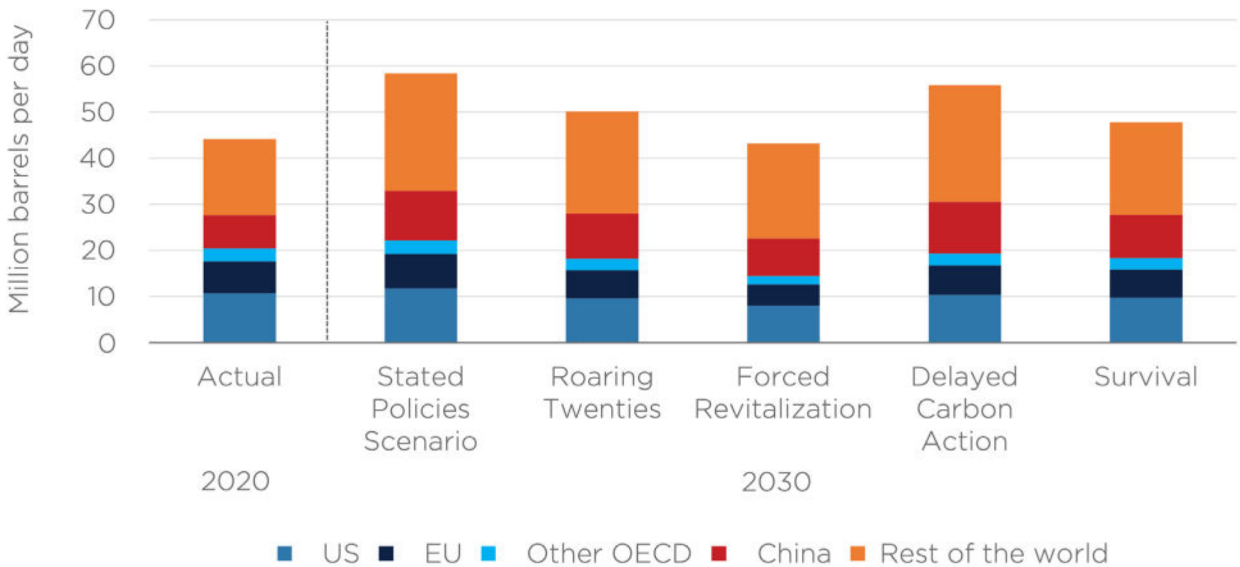
Figure 15: Transportation alternative fuel mix in 2030 by scenario



Oil Use by Region

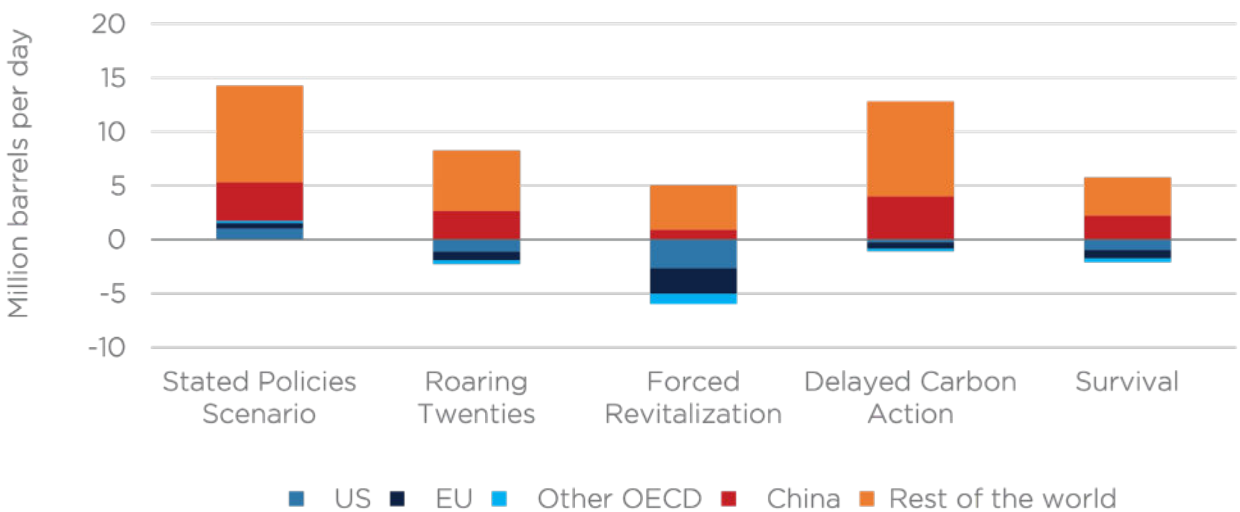
Figure 16 shows transportation oil use by region for 2020 and for all the scenarios in 2030. In 2020, OECD nations are nearly half of the global transportation oil demand. In 2030, OECD is only 33 percent to 38 percent of the demand, depending upon the scenario. Figure 17 shows the change in transportation oil use by region from 2020 to 2030. With the exception of IEA's Stated Policies scenario, all of the growth over the next decade in the report's four scenarios occur in non-OECD countries. Developing nations have greater population and economic growth driving transportation oil demand and they are less likely than the OECD to have strong policy drivers to reduce demand, with the noted exception of China. In all of our scenarios, OECD transportation oil demand declines.

Figure 16: Transportation oil use by region and scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

Figure 17: Change in transportation oil use by region, 2020–2030, by scenario



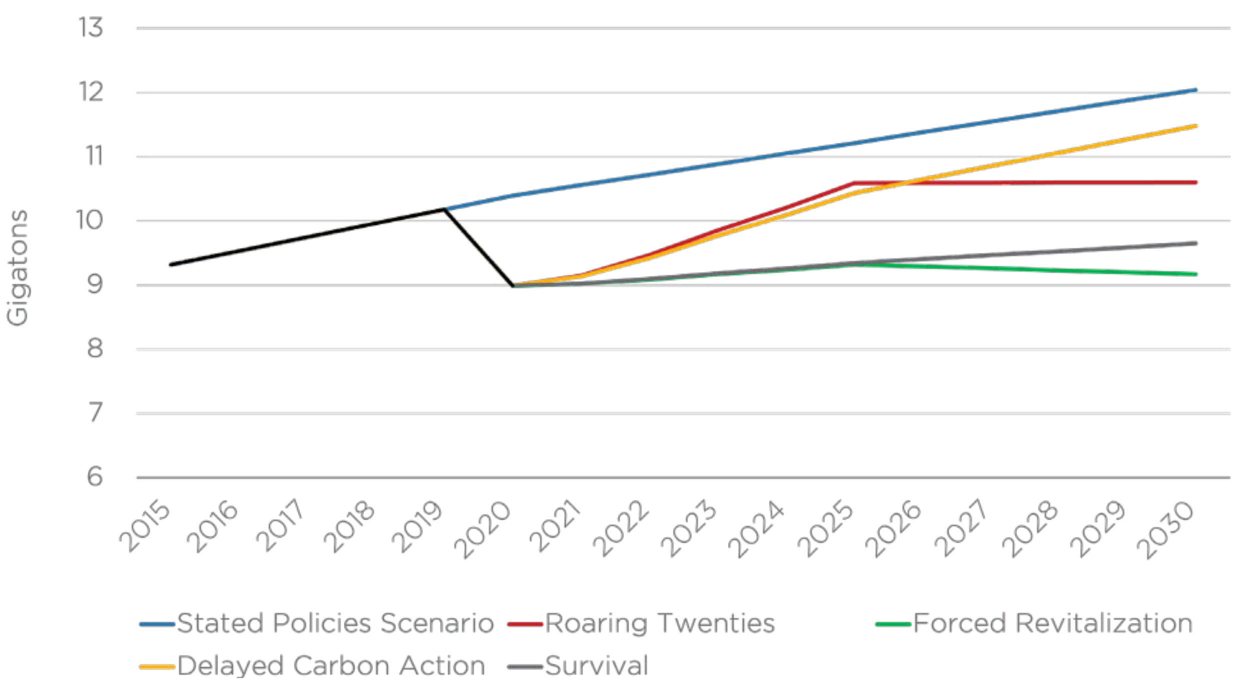
Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

Transportation CO_2 Emissions[105]

The impacts of the changes in energy use on transportation CO_2 emissions are shown in Figure 18. About one gigaton drop in CO_2 emissions, or about a 10 percent drop, occurred in 2020 compared to 2019. Looking forward, all of the scenarios have CO_2 emissions growth through 2025 in line with the recovery in transportation oil use. Delayed Carbon Action comes the closest to returning to the SPS trajectory. Emissions kink downwards in Roaring Twenties and Forced Revitalization after 2025, when policy-driven alternative fuel penetration and efficiency are higher and there are more years to incorporate the fleet turnover. In none of the scenarios do CO_2 emissions fall below the 2020 level by 2030. Clearly, the policies included in these scenarios are not sufficient to achieve a clear peaking and downward trajectory in transportation CO_2 emissions by 2030.

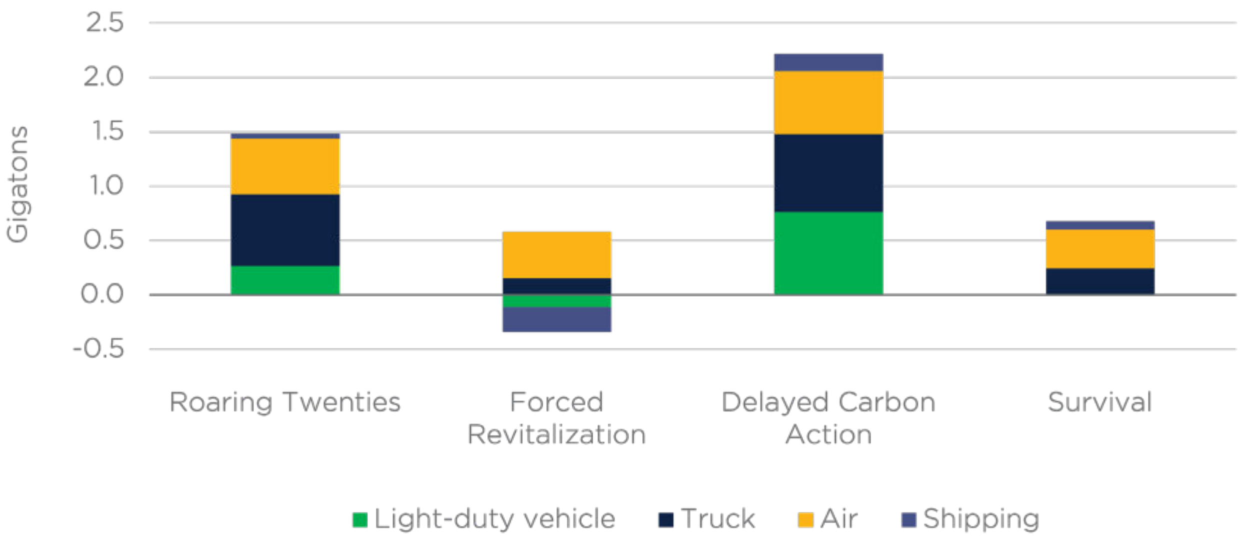
The net change in CO_2 emissions from 2020 to 2030 by mode and scenario is shown in Figure 19. In Roaring Twenties and Delayed Carbon Action, there is significant growth in emissions from light-duty vehicles, trucks and air travel, although in Roaring Twenties, the policies significantly slow the growth of light-duty vehicle CO_2 emissions and slow them more for passenger cars than for trucks or air. Shipping has fairly flat CO_2 emissions across the four scenarios. In Forced Revitalization and Survival, the rise of CO_2 emissions in the transportation sector is greatly slowed, but there is still growth in the truck and air sectors.

Figure 18: Transportation CO_2 emissions by scenario



Source: The Stated Policies Scenario refers to IEA's 2019 Outlook.

Figure 19: Change in transportation CO_2 emissions, 2020–2030, by scenario



CONCLUSIONS ON THE TRAJECTORY OF TOTAL GLOBAL OIL DEMAND

This section examines how the four scenarios impact total global oil demand, adding in the missing sectors such as petrochemicals, other industrials, and buildings. It also (1) compares the four scenarios with global oil demand forecasts by others for the next decade, (2) summarizes how COVID has changed the outlook, (3) assesses the timing of "peak" oil demand, which some analysts believe has already occurred, and (4) summarizes total oil demand growth by sector and region.

Total Oil Demand Projections

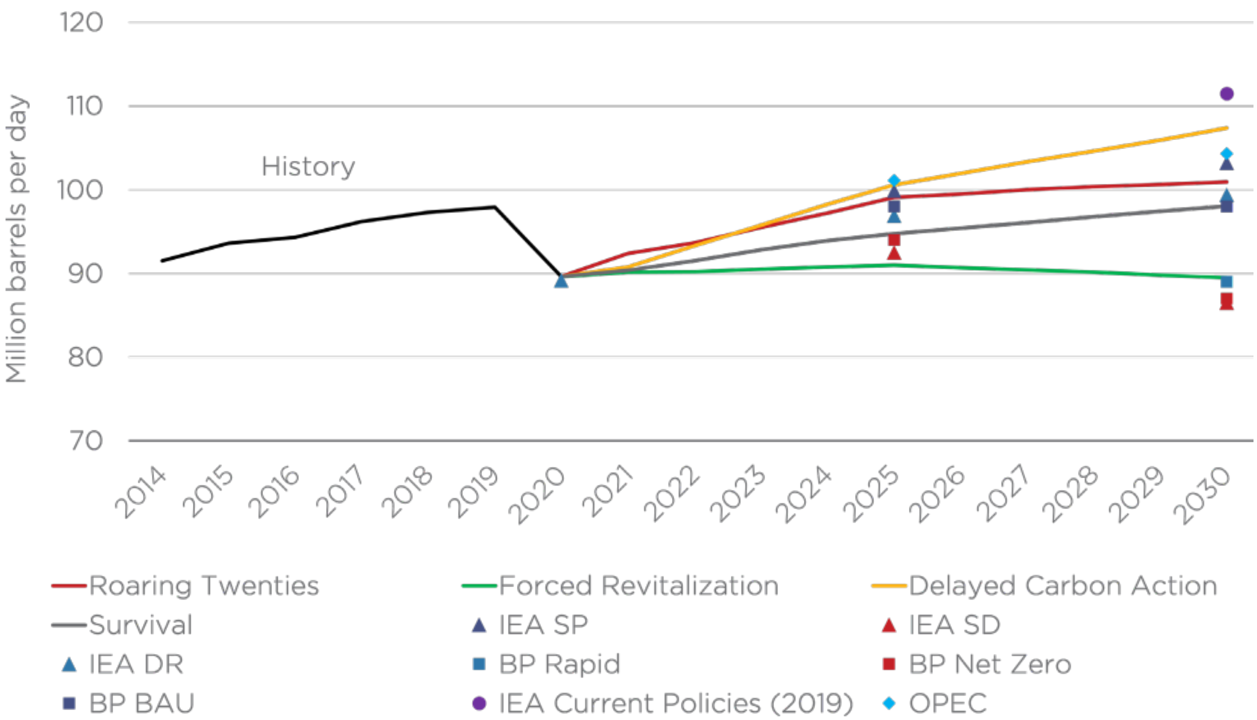
Figure 20 shows different total oil demand trajectories, excluding biofuels, for the four scenarios. Global oil demand grows from 2020 to 2025 in all scenarios, and growth continues through 2030 in three out of four scenarios. Global oil demand falls after 2025 in the Forced Revitalization scenario because of the greater competitiveness of alternative fuels and fuel efficiency improvements in the face of weak global economic growth and travel demand.

Comparison with Other Forecasts

Figure 20 also shows recent global oil demand projections through 2030 from the International Energy Agency, OPEC, and BP. It is important to note that this report's scenarios have somewhat different drivers than the BP net zero and IEA SD scenarios, in that this report is not trying to achieve a goal of "net zero," but rather is trying to depict how governments and consumers would respond to a prolonged pandemic.

The four scenarios generally encompass the range of forecasts through 2025 conducted by others. In 2030, the four scenarios are still within the range of forecasts, but demand from the forecasts with a 1.5-degree carbon pathway starts to diverge below this report's lowest scenario.

Figure 20: Global oil demand by scenario



Note: Global oil demand excludes biofuels.

Source: Historical data – IEA Oil Market Report: Annual Statistical Supplement 2020; IEA 2020 World Energy Outlook forecast, Stated Policies (SP), Sustainable Development (SD), and Delayed Recovery (DR) scenarios; IEA 2019 World Energy Outlook Current Policies scenario; BP Energy Outlook, 2020 Edition; OPEC World Oil Outlook 2020.

Delayed Carbon Action, this report's highest demand scenario in 2030, falls below the IEA's Current Policies scenario from 2019, which is now discontinued. As a reminder, in this scenario, governments postpone more stringent climate policies until their economies have recovered, but then introduce these policies later in the period. Thus, if this scenario was extended beyond 2030, global oil demand would probably flatten and, ultimately, decline.

Roaring Twenties is the next highest global oil demand scenario in 2030 because of strong economic growth offset post 2025 by more stringent climate regulations. By 2030, demand in this scenario moves below OPEC's base case and IEA's Stated Policies Scenario.

The Survival scenario is close to BP's "Business-as-Usual" and IEA's "Delayed Recovery" scenarios. Similar to IEA's Delayed Recovery scenario, the Survival scenario has weak economic growth. BP's Business-as-Usual case is not a continued COVID scenario, but has a more aggressive path to decarbonization than Survival. In Survival, governments were less likely to enact policies that make energy and other household necessities more expensive for consumers.

Forced Revitalization comes closest to, but is higher than, BP's Rapid and Net Zero cases and the IEA's Sustainable Development case in 2030. Given the high debt levels and the concerns about massive fiscal spending, it was deemed unlikely that green stimulus in this scenario would be sufficient to move the world fully to a net zero, 1.5-degree centigrade carbon trajectory without significant global climate agreements, even with government spending in key countries pushing rapid acceleration of clean technologies.

In March 2021, the IEA published its medium-term global oil supply and demand outlook through 2026. The vaccine rollout has been more certain in the United States than contemplated when the authors designed this study in the summer and fall of 2020, although it is still highly uncertain internationally. IEA's latest forecast (not shown in this chart) has higher demand projections from 2021 to 2025 than this report's scenario projections as well as versus most of the other IEA and BP forecasts shown in this figure. Reflecting setbacks in Europe and India, in particular, this outcome is still highly uncertain. Assuming the vaccine rollout and economic recovery continue in the way the IMF is presently forecasting, the authors could see a faster global oil demand recovery in the short-term. However, the focus of this study is on the medium term (2025) and long term (2030), and there remains a great deal of uncertainty about the strength and timing of the recovery. The scenarios are designed to capture the full range of uncertainty.

The Impact of COVID on Global Oil Demand: Short-Term or Structural Change?

There are aspects of COVID that are likely temporary as well as aspects that may portend longer term structural change. Some of the experts assembled for this project reviewed the academic literature on technologies, behaviors, and policies and characterized the following elements currently influencing oil demand as temporary: (1) the economic downturn, (2) some percentage of the reduction in leisure travel both in passenger cars and air travel, (3) the increased dominance of the personal vehicle versus other forms of passenger travel such as mass transit and ride-hailing, (4) the sudden increase in consumption of single-use plastics resulting from greater use of personal protection equipment and the rapid rise in e-commerce, and (5) the decline in tonnage transported on ships and trucks. It is believed that some measure of these COVID-related phenomena could return to past trajectories as the pressures of the pandemic ease.

This scenario analysis shows that there are some circumstances where global oil demand could return to or exceed pre-COVID levels, but not likely before 2023 to 2025. In the Roaring Twenties and Delayed Carbon Action scenarios, a sharp recovery is considered, but even in these cases, a loss of oil demand growth lasts for at least four years, which could equal about five million barrels per day at the historical annual growth rate of 1.2 million barrels per day per year. In the scenarios where the pandemic lingers (Forced Revitalization and Survival), global oil demand may not get back to pre-COVID levels until 2030—if at all.

Among the changes that could create a lasting movement away from oil use is the sense of fragility COVID has created among populations in industrialized societies and the greater awareness of social and economic inequities worldwide. This new sense of vulnerability may be generating greater acceptance of government intervention into daily life, including policies that reduce greenhouse gas and air emissions. In this report's scenarios, the biggest manifestation of these policy changes was in electrification of road transport fleets and the use of alternative fuels.

A second feature from the pandemic, which experts believe will be more permanent, is the acceleration of digitalization reducing the need for mobility (e.g., telecommuting, teleconferencing, 3D printing, and more efficient shipping logistics). Digitalization primarily reduces commuting and passenger vehicle fuel use, business air travel and jet fuel use, shipping by trucks (because of 3D printing and more efficient logistics), and diesel use. The scenarios highlight the importance of the policy framework surrounding greater use of these digital mobility technologies, as some aspects of digitalization could actually increase oil demand and greenhouse gas emissions, such as ride-hailing and e-commerce with frequent deliveries. Lifestyle changes can swing both ways as well, since telecommuting might greatly reduce suburban rush hour commuting, but longer term could increase passenger VMT if populations shift out of large cities and to lifestyles that involve more recreational and other non-commuting driving.

The Timing of the Peak in Global Oil Demand

In three of the four scenarios, global oil demand does not peak before 2030. There are several reasons why an earlier peak is not achieved in most of the scenarios:

- Growth in petrochemicals and truck fuel demand offset declines in other transportation sectors.
- At about 1.2 billion vehicles for passenger cars today, it takes a long time to introduce new government programs and turn over the global transportation fleet. The economic weakness created by COVID lengthens this time span as a result of slower rates of new vehicle purchases. For example, in the US, the average age of vehicles has climbed to an all-time high of 11.9 years.[106] Older vehicles are sold several times before they are retired and may eventually move to developing countries. One example of how long it takes to change the global fleet is that in the Forced Revitalization scenario, where government support for EVs bring them to nearly 40 percent of new cars sold by 2030, but they still represent only 11 percent of the total global car stock fleet at that time.
- The scenarios that successfully end the COVID pandemic have strong economic recoveries, which are a large driver of global oil demand. Without strong policy drivers for an energy transition, oil demand finds support as governments focus on jobs and brown stimulus, as seen in the Delayed Carbon Action and Survival scenarios.
- Lower oil prices, supported by the large resource potential of US tight oil and ample global resources, tends to buoy global oil demand, even as new technologies come to the fore. It is possible that government intervention in the supply side of markets, however, could bring about higher sustained oil prices, leading to different outcomes.
- There are lingering aspects of COVID that are oil-intensive, such as: (1) the rise of the

personal vehicle versus mass transit; (2) greater miles being driven by people who have moved out of major cities; (3) greater purchases of used and less fuel-efficient cars; (4) increased e-commerce deliveries; and (5) greater use of single-use plastic for personal protection equipment and e-commerce packaging.

Only in Forced Revitalization does global oil demand peak before 2030, and the peak is in 2025. This scenario has a double whammy of very weak economic growth from the continued pandemic, as well as green stimulus lowering the cost of electric vehicles and alternative fuels leading to high penetration of alternatives. While global oil demand grows in this scenario through 2025, it never returns to the 2019 pre-COVID level.

Whether oil demand plateaus, decreases gradually or precipitously could make a larger difference to how much oil supply will be needed to satisfy demand in the coming years. It also has geopolitical consequences for countries whose revenues are tied in great measure to oil exports. Since it takes years to turn over transportation fleets, it would be worthwhile extending the timeline of the scenarios to understand the pace and oil demand impact of vehicle electrification as EVs become a substantial portion of the global vehicle fleet beyond 2030.

Sectoral Demand Changes

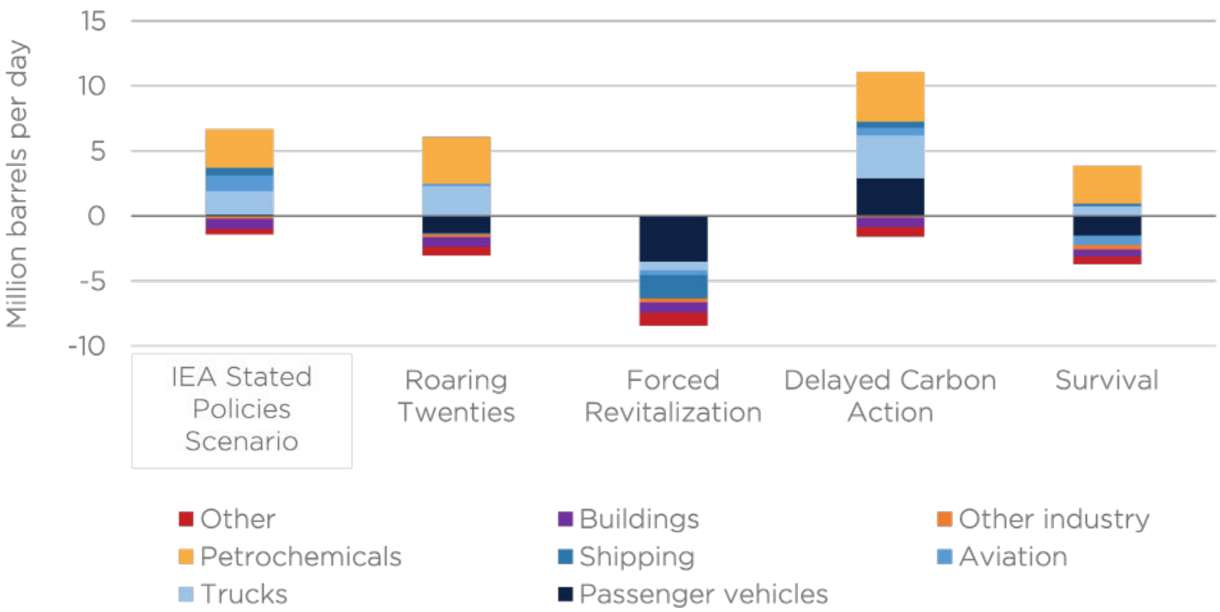
Global light-duty vehicle passenger oil demand peaks by 2025 or earlier in three of the four scenarios, although there is still some growth in two- and three-wheelers and buses. The combination of alternative vehicles and fuels as well as fuel efficiency improvements tends to offset the increases in VMT. Aspects of COVID, such as switching from mass transit to personal vehicles and substituting driving for flying on shorter trips, tend to increase VMT. This phenomenon is seen clearly in the scenarios where there is strong economic growth. The trend is masked in scenarios with weak economic growth.

The peak in light-duty vehicle passenger oil demand doesn't equate to a peak in total oil demand. As shown in Figure 21, growth in petrochemical feedstock and truck fuel demand offsets the decline in passenger vehicle demand in three of the four scenarios.

Petrochemical demand is sensitive to trends in the global economy and is generally linked with per capita income in energy modeling. In this study, aggressive government action to ban single-use plastics and require greater recycling in some of the scenarios is thwarted by the poor economics and potentially higher carbon footprints of some substitutes to plastics. Petrochemicals tend to be lower cost and lighter than substitutes (substitutes like bio-feedstocks are very expensive), and recycling has challenging economics in a low oil price environment. Another factor that could increase petrochemical demand in a decarbonizing world is the substitution of plastics in automobiles to reduce vehicle weight. However, this would also result in lower vehicle fuel use. In addition, there have been increases in the demand for single-use plastics because of the pandemic (e.g., personal protection equipment and packaging), leaving questions about longer term trends. Figure 21 also shows the IEA's 2020 Stated Policies case for petrochemical oil demand growth, which has even higher growth than all but one of this report's scenarios (Delayed Carbon Action).

As shown in Figure 21, two of the scenarios (Roaring Twenties and Delayed Carbon Action) have relatively robust truck fuel demand growth because strong economic growth and rising e-commerce partially offset the penetration of alternative trucks in these scenarios.

Figure 21: Global oil demand net growth by sector, 2019–2030, by scenario



Note: Global oil demand excludes biofuels.

Source: IEA 2020 World Energy Outlook forecast, Stated Policies (SP), scenarios from this study.

The next two sections discuss the oil market and policy implications of the scenario analysis. While it is beyond the scope of this study to address each of them in depth, they are all areas that would benefit from additional research.

OIL MARKET IMPLICATIONS

Difficulty in Reducing Oil Demand

One implication of the study results is that it isn't as easy to sustain a substantial reduction in oil demand even in light of new trends emerging during the COVID pandemic. It can take an extended number of years to put aggressive government regulations in place and to change out transportation fleets to lower carbon technologies. It is particularly difficult to lessen oil demand in a low oil price environment. Nevertheless, this analysis demonstrates that it is possible to limit the recovery in oil demand and ensure that it peaks before 2030 under the circumstances of weaker economic growth and strong government policies driving advancements and penetration of clean technology. Governments now have additional policy tools and technologies that could be used to lower the oil intensity of transportation mobility, trade and economic recovery.

Oil Balance Uncertainties

While analysis of oil supply pathways was beyond the scope of this study, a number of study participants were also oil supply-side experts. Investment in new oil supply is currently being challenged by poor historical returns, investor and lender concerns about ESG issues in the oil and gas sector, and expectations of lower oil demand during the energy transition. But even with governments focused on green stimulus, oil could easily remain the world's most used energy source for the coming decade, with the IEA indicating its 30 percent market will be roughly maintained in 2030, even in their Sustainable Development Scenario. This report's post-COVID scenarios show the chances of a new commodity boom cycle remains a distinct possibility in the 2020s and, with it, accompanying high oil prices. The question then becomes whether high oil prices would make government intervention to lower carbon emissions easier to accomplish and eventually promote a larger demise in oil demand in the long run.

Impact on the Refining Sector

The nine million barrels per day of demand loss in 2020 because of COVID reduced refining capacity utilization and challenged refineries to meet the altered fuel mix, particularly with plummeting air travel and historically low jet fuel demand. In the United States, refineries were operating at 79 percent capacity utilization in 2020 versus 91 percent utilization in the previous five years. Profitability of the sector has been greatly reduced. As a result of the weakened future demand outlook and challenges to profitability, global shutdowns of 3.6 million barrels per day have already been announced, but nearly double that amount would be required to allow refinery utilization rates to return to attractive levels, according to IEA analysis.[107]

To the extent that COVID-related trends lower long-term oil demand, it will have an even larger adverse impact on the refining sector than on upstream oil and gas exploration and production. Upstream oil production's natural geological declines and ongoing investment requirements to maintain production make the sector more responsive to possible downward changes in demand and prices. Refining's fixed costs, regardless of the rate of utilization, leave operators vulnerable to shifts in demand. Some developing countries that have the largest oil demand growth are adding their own refining capacity rather than continuing to import refined products from mature OECD markets. And these investment decisions may not be solely based on the project's economics, but rather include employment, self-sufficiency and other goals. Thus, there was a tendency toward global refining oversupply even before COVID accentuated the demand loss. Any permanent structural downshift in oil products' demand will exacerbate the current refining oversupply and potentially lead to more closures of Western refining assets where demand is likely to fall first. Rationalization of the global refining industry could have geopolitical ramifications as countries consider the need to secure their supply chains for jet fuel and marine and diesel fuel needed for military activities.

Energy Transition and the Minerals Supply Chain

If COVID accelerates the energy transition and vehicle electrification, then there will be increased pressures on the minerals supply chain for batteries. This has price implications as well as geopolitical risks given unequal access by countries to metals supply, and metals refining and processing capacity.

World Oil and Gas Trade

Since China and several other Asian countries recovered faster from COVID, their energy demand held up better than in the West. This accentuates and potentially has accelerated the long-term trend of Middle East and Russian energy exports increasingly flowing eastward.

Barriers to oil and gas trade were due to intensify during the energy transition, and COVID may have helped to accelerate this trend. US or Russian oil and gas exports could be hampered because of lingering trade disputes and new concerns about the carbon intensity of production. Middle East producers are already responding by trying to lower the carbon intensity of their exports and establishing carbon offsets. Europe may place border tariffs on energy intensive products, such as petrochemicals, to protect their domestic industry from imports from countries that don't regulate greenhouse gas emissions to the same degree. Bifurcated oil and gas markets could develop where products with low carbon footprints are priced and sold separately from higher carbon-footprint products.

Geopolitical Risks in Oil-Producing Countries

Weak or declining oil demand due to a prolonged pandemic or the energy transition would likely result in a sustained period of low oil prices, which will challenge the finances of oil-producing countries, particularly those who haven't been successful at diversifying their economies. While some producers in the Middle East have very low production costs and a low carbon footprint, the ones with large populations still have high fiscal break-even costs.

Over the medium term, it is unclear whether key producers will opt for higher oil prices as the global economy recovers or will maximize market share to avoid having stranded assets, if global oil demand peaks and then declines.

POLICY IMPLICATIONS

Achievability of Net Zero Climate Targets

This scenario analysis demonstrates that governments will need stronger and more comprehensive policy directives to move to a path of net zero greenhouse gas emissions by 2050. The participation in policy action by a larger number of governments will also be needed. By 2025, global oil demand would have to be significantly below the IEA's Sustainable Development scenario to allow the world to be on track to reach the net zero trajectory by 2050. In fact, a recently released IEA report indicates that passenger EVs would need to be more than 60 percent of vehicle sales by 2030 to move to a net zero carbon trajectory by 2050.[108] The most aggressive scenario in this report reached 40 percent of EV sales penetration by 2030. This finding implies that governments are not likely to achieve their climate targets without stronger policy action than is being contemplated today. In addition, some aspects of behavior change driven by COVID are likely to increase passenger and truck vehicle miles traveled such that they will increase oil demand unless policy actions are taken (e.g., single occupancy charges and VMT tax) to stop this increase from occurring.

Adoption of Alternative Vehicles and Fuels

The scenario in this report with the greatest success at driving the penetration of alternative vehicles was the one that focused on technological innovation to lower the cost of alternative vehicles and make them competitive with conventional vehicles (Forced Revitalization). That was a more successful approach than the regulatory approach in Roaring Twenties because it is difficult to coax consumers to buy alternative vehicles if they are more expensive than conventional vehicles.

It was also informative that the scenarios without strong national drivers still showed advancement in the penetration of alternative fuels. In Delayed Carbon Action, some governments (e.g., Europe) continued to advance alternatives sooner than others. That could increase the scale and improve the economics of alternatives, leading to faster adoption elsewhere. In Survival, state and city governments drove electrification of vehicles to reduce local air emissions and make cities more livable. While central policies are likely to be more efficient, incentivizing state and local policies is another potential path to achieve policy goals.

Rethinking Mass Transit

Mass transit usage took a severe hit during COVID, and people may be reluctant to return to it. Urban mass transit systems are also financially distressed. There is also a concern about reduced service arising out of COVID and whether low-income people will have sufficient transportation access to be able to retain jobs. Now is the time to rethink public transit systems—how to make them safer, more flexible, on sounder financial footing, while maintaining adequate service for low-income neighborhoods. This scenario analysis supports other research that indicates it will be harder to lower emissions and eliminate passenger miles traveled post-COVID without strong policy intervention, especially if populations shift to smaller cities and lower density lifestyles.

Need for Correct Balance of Oil Supply Investment during the Transition

The scenario analysis highlights the potential disconnect between government action and the timing for the transition away from oil use. Global climate negotiations need to consider energy finance in framing the energy transition and finding the right balance for investment to shift away from existing fossil fuel infrastructure while considering the investment required to provide oil supplies as well as equity issues for populations in energy producing states. The timing of policy implementation can have direct implications for continued investment uncertainty and potential stranded assets. It is unclear how to achieve the right balance of future economic development. Still, ending uncertainty about government policies and realistic guidance on the timing of the transition would help the private sector make sounder investment decisions and avoid extreme price uncertainty and volatility.

The Role of Economic Growth in Achieving Environmental Goals

There is a commonly held view based on past experience that progress on climate change cannot be made unless the world is experiencing strong economic growth. However, this report includes a plausible scenario (Forced Revitalization) about how progress could be made under weak economic conditions. In this scenario, governments focused on restoring economic growth through industrial policy that prioritized clean technologies. Governments will have to show that this approach is effective at creating new industries and jobs for this new paradigm to be accepted. It is clear that technology advancement is the key to moving climate goals forward, particularly during times of economic weakness.

Avoidance of Trade Protectionism

This report's scenario analysis included the potential impacts of protectionism slowing global economic recovery. COVID increased trade protectionism in three of four scenarios, as nations stimulated and protected their domestic industries. Protectionism may intensify during the energy transition, particularly if economies don't fully recover from COVID.

While great uncertainty remains about the speed and strength of the world's recovery from COVID, the current state of government climate policies and technology innovation are unlikely to reduce global oil demand fast enough to help the world move to a net zero carbon trajectory. Both government climate policies and technology innovation would need to move well beyond what was contemplated in this study's scenarios. This should be a wake-up call for policy makers.

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