Changing lanes

A roadmap for transport and future energy markets

February 2018

Cobalt crunch
From rare earths to lithium – tackling the new resources squeeze

Electric dreams
Technology, policy and regulation – Big Oil responds

Industry insights
Interviews with OPEC, Rio Tinto and Groupe PSA

China plugs in
Clean transport marks the future in the world’s largest EV market
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**February 2018**

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Foreword

Crossroads

It’s easy to get carried away with the hype surrounding electric vehicles (EVs). Sales of battery-powered cars may be surging, but the technology is still in its infancy and batteries are by no means the only low-carbon solution for global mobility.

What’s clear is that understanding the changing face of transport in whatever form it takes is one of the big challenges facing the energy and commodities industries. This special report — bringing together the very best of S&P Global Platts news and analytics insights — will help to shape the debate and provide decision makers with the key facts and information they require to future-proof their business models.

Like any disruptive technology, there will be winners and losers in the drive for more fuel-efficient internal combustion engines, or the development of cheaper and more usable EVs. Big oil companies are already adapting fast by investing heavily into the production of cleaner transportation fuels, such as liquefied natural gas, and by installing charging points into their service station networks. Some are going a step further by investing in power generation and distribution.

Despite these new business strategies, S&P Global Platts Analytics’ current projections are that oil production will have to increase in order to meet rising demand from road transport for years to come. EVs are likely to remain a small part of the overall global vehicle fleet unless the technology improves significantly and the cost of production falls. “It is important to emphasize that oil is expected to remain the most important fuel in the global energy mix for decades to come,” says OPEC Secretary General Mohammed Barkindo in the report.

If changes to mobility are a challenge for oil producers, they represent a new opportunity for the $800 billion global mining industry. Some battery resources such as lithium exist in abundance. Data from the US Geological Survey shows 400 years of supply at current production levels. However, other vital commodities face bottlenecks. Copper, nickel and aluminum could all see prices rise from growing EV demand. Cobalt—another key ingredient in batteries—is heavily dependent on high-risk areas such as the Democratic Republic of the Congo. The possible outcomes for metals producers are also explored in the report.

The growth of EVs in developed markets such as Europe is dependent on subsidies and policies designed to push consumers into battery-powered transport, especially in urban areas. How the market for this emerging form of passenger transport will hold up once these incentives are removed is uncertain.

Finally, we should recognize that EVs are also not the only solution for future mobility. Autonomous vehicles could transform the traditional model of car ownership, while hydrogen may eventually provide another alternative fuel, especially for larger commercial vehicles. The advantages of all these scenarios are considered in depth in the report, which I believe will be an indispensable guide for business to the future of mobility.
Introduction

Evolution not revolution

Revolution is a misused term when it comes to road transport. Advances in battery technology and a growing awareness of climate change issues are putting the traditional internal combustion engine (ICE) under pressure like never before but predictions of its sudden demise look overblown. Oil is likely to play a central role in powering mobility for decades to come.

Oil's advantages as a transport fuel are as applicable today as they were more than a century ago when the Model T Ford arguably triggered the last transport revolution because of its simplicity, reliability and economy. Rolling off some of the world’s first modern production lines the four-cylinder vehicle turned mass passenger-car ownership into a reality. The same refined products that fueled those early vehicles are still the most flexible and cost-effective ways for consumers to power their cars today despite volatile markets and alternative technologies.

Electric vehicles (EVs) may offer a glimpse of the future but for the time being their impact is limited. Despite improvements in battery technology range is limited even for the most expensive models, which still can't compete with ICE cars as a complete package.

S&P Global Platts Analytics forecasts that oil production will have to increase to meet rising demand for the next two decades. Meanwhile, demand for petrochemicals feedstock is expected to continue growing strongly, along with oil use in the marine and aviation sectors. Although vehicle manufacturers are increasingly investing in developing EV technology overall oil demand is still expected to exceed 100 million b/d this year, according to S&P Global Platts Analytics estimates.

Population growth and rapid expansion in emerging economies, especially in Asia, will continue to stoke consumption from vehicles in the medium term. But passenger-car oil use is expected to peak around 2030, along with a slowdown in commercial vehicle oil demand growth.

“There is a lot of talk about peak demand but this is far too early to be worrying about the demise of fossil fuels in the near term. Despite growth of EVs in double digits, overall sales amount to less than 2% of the total market,” said Chris Midgley, head of S&P Global Platts Analytics. “The current near-on 3 million EVs displaces less than around 60,000 b/d, or less than 0.06% of total global demand.”

Meanwhile, momentum is building around EVs and hybrid variants of the technology as viable alternatives to the future of mobility. Plug-in ranges are increasing and charging times are falling. Consumers are also becoming more concerned about emissions and the need to find alternatives to fossil fuels to meet their daily transport needs especially in urbanized areas. This has fed anxiety over the future of oil as the world’s primary source of transport fuel.

Professor Dieter Helm, an expert in transport and environmental issues at Oxford University and energy policy adviser to the British government, argues
that advances in EV technology will eat into oil's dominance as a transport fuel much sooner than the industry expects. Digitization of public transport and traffic management along with infrastructure improvements could also be catalysts for faster change. However, Helm who recently published the book *Burn Out: the endgame for fossil fuels* has taken a more radical view on the future of oil.

“The impact on oil demand will build up in the next decade, potentially much faster than the International Energy Agency and the oil companies predict,” Helm told S&P Global Platts. “There will be tipping points where motorists switch to electric, once they are confident that the electric charging infrastructure is in place, and as the costs of the vehicles fall.”

Although fuel demand for passenger transport could decline, demand could benefit in other areas such as petrochemicals and industrial consumption, which could both be boosted by EVs.

In reality, change will most likely be far slower than Helm would ideally like to see. Skeptics point out that while fast-charging stations are proliferating in parts of Europe such as the Netherlands, in many other European countries the vast majority of cars are more than 10 years old. Diesel remains a mainstay passenger car and haulage fuel, while the growth of EVs around the world is heavily incentivized by government subsidies and regulations.

Neither is the EV the only alternative to the domination of the ICE-powered car in mobility. Hydrogen especially in commercial transport and mass transportation could play an important role in the emerging energy mix as could natural gas. Fossil-fuel powered engines are also becoming more efficient, with manufacturers squeezing extra miles out of conventional valves and cylinders.

The most efficient petrol-driven cars are now capable of mileages close to 100 miles/gallon. According to BP the average car globally may have achieved less than 30 miles/gallon in 2015 but that is still more range efficient than the most expensive EVs. And engines are becoming more frugal. BP forecasts the average passenger car will achieve almost 50 miles/gallon by 2035. In its model, these efficiency gains could absorb most of the increases in the number of EVs expected on highways.

However, oil companies are still hedging their bets. Shell and Total have invested billions of dollars to expand liquefied natural gas (LNG) production, in part to feed expected increases in electricity demand, which could arise from EVs reaching a critical mass. Super majors — which have dominated highways and street corners with their refueling stations — are also investing to install recharging solutions into their networks. Electricity utilities are also looking for ways to tap the emerging market for recharging. Instead of revolution the changes currently underway in the world of mobility appear more evolutionary, with oil set to continue playing an important role as a primary transport fuel source for decades to come.
Fossil fuels have dominated transportation for the past century and are likely to continue to for the foreseeable future. However, new technologies and fuels, climate change policies and market drivers now threaten its dominance like never before.

Developments in batteries could make electric vehicles (EVs) cost competitive within a decade. Government policies and subsidies add to the pressure for change. Vehicle manufacturers are also investing tens of billions of dollars to prepare for a future that might see a growing share of EV sales.

Heavier duty vehicles, ranging from vans to long-distance trucks and buses, are also seeing a wider range of new cleaner fuel options. The transition is important for the downstream oil industry since both gasoline and diesel consumption may be threatened.

Electrification is not the only potential challenge for oil. Autonomous vehicles (AVs) could turn the world of transportation into a service industry with fewer cars on roads. Much higher utilization rates would have a wide ranging impact on fuel use, vehicle sales and even urban design. EVs are not necessarily the end game. Hydrogen could ultimately be better in terms of range and refueling, especially for heavy duty vehicles.

Europe is at the forefront of regulating the low-carbon transport revolution. The region’s policymakers are actively pushing manufacturers and consumers toward higher-efficiency lower-emissions vehicles.

China’s market is the most dynamic in terms of low-carbon transport. By almost any measure, China currently leads the world in road transport electrification. Moreover, EV growth offers China an opportunity to re-write the established order in both domestic and foreign markets, potentially benefiting as a world leading EV exporter.

Change isn’t guaranteed. Refueling and range are concerns for consumers. The overall performance of EVs is well below ICEs. Currently, the lack of widespread recharging stations is a key constraint on the market. The infrastructure is being built, but there is much to be done to give consumers the comfort level provided by gasoline and diesel.

The recharging impact on the electric grid is another factor that will have to be monitored carefully. Network management of EV demand is a critical factor in the transition to alternative transport.

Costs for EVs and battery packs must come down to the point where there is no significant premium over car ownership. Niche buyers may pay more for perceived environmental benefits, but the industry must still provide clear value for wider penetration to take off. That is not yet the case for EVs.

Costs are coming down. Lithium ion battery pack costs have dropped to below $300/kWh today, from $1,000/kWh in 2010. Expansive plans for additional battery manufacturing capacity should continue to drive the costs down, potentially toward $100/kWh, where it should achieve parity with ICE’s in markets with higher fuel prices.
EV demand is already proving disruptive for the metals industry, especially for lithium and cobalt prices. Sufficient minerals and metals exist in the earth’s crust to satisfy projected demand. However, more production and mine investment is essential to minimize the impact of what most analysts see as an impending supply deficit, and to keep prices steady, especially for lithium.

The oil industry has time to adapt. EVs first have to penetrate new car sales — currently less than 2% globally — and then slowly over time replace the entire fleet, which is 10 times the size of new car sales. This is a process that will occur over decades, not years. Despite EV growth, global road transportation demand for oil should continue to rise well beyond 2030. And even if conventional road transport turns negative in the future, there will be demand for petroleum for other uses such as petrochemicals, or air and marine transportation.

Large oil producers such as Saudi Arabia and OPEC are already adapting to the changing face of transport by investing in new technology and engaging with industry stakeholders. Major upstream projects are unlikely to be affected by growing EV penetration in the near term. Oil demand could also benefit from growing use of plastics and other petrochemicals products in the construction of lighter EVs.

EV developments may capture the headlines and the public’s imagination but the evidence suggests that even after a century of road domination the engine and fossil fuels both have a big role to play in the future of transport.
Mobility change: path and pace uncertain

After several generations of stability, we are entering a period of expanding transportation options that could have major impacts on oil, power and metals markets.

- The threat to internal combustion engines must be taken seriously this time.
- Perfect storm of technology, policy and behavior is expanding options for future mobility.
- Changes to the on-road fleet won’t happen overnight.
- Obstacles include vehicle costs – battery (lithium, cobalt) — range and refueling.
- Global oil demand still is likely to rise for at least another decade.

Global fleet and energy system

In many ways, our transportation system has changed very little over the past half century. Certainly cars, trucks, planes and vessels have improved substantially with greater efficiency and additional amenities ranging from greater horsepower to video screens. But the change has been evolutionary and the fuel choice – overwhelmingly oil products – is nearly the same as it was in the 1950s. Furthermore, the patterns established in the developed world, where higher incomes allowed the initial large expansion of personal vehicle penetration, trucking and air travel, have been broadly followed by the developing world with few exceptions.

From time to time over this period, there has been talk about alternative fuels for transportation, often driven by concerns about availability of supply, energy independence and high prices. With transportation accounting for 20% of global energy demand, potential shifts can have major consequences.

At one point in the 1980s methanol, manufactured from natural gas was put forward as a possible alternative. Natural gas, particularly as a long-distance trucking fuel, was perceived to be an emerging threat to oil within the past decade. LPG has made some inroads around the world, especially in taxi use. When the Toyota Prius hybrid was first introduced there was a view that hybrids would dominate the fleet within several decades.

Excitement over hydrogen fuel cells has come and gone several times and may return again down the road given fuel cell energy density advantages. But at least so far, use of the internal combustion engine (ICE) powered by oil-based fuels for transport has survived the challenges. For perspective, oil currently fuels about 97% of energy use...
in transport, while the transportation sector accounts for nearly 60% of total oil use. Demand from passenger cars has been growing and alone makes up 25% of the total draw on oil, with commercial transport a major contributor. Strong growth in oil demand for non-energy petchem feedstock and for bunkers is less directly impacted by such developments.

However, the challenge to ICEs this time around appears to be more serious. Hardly a day goes by without an automaker announcing a new electric model or a government announcing future goals to reduce the role of ICE vehicles.

We would expect to see major changes in the energy mix when multiple drivers, including policy, technology, and consumer behavior, work simultaneously, as appears to be the case now.

- Technology is allowing the costs of electric vehicles (EV) to fall to a point where they may be cost competitive with ICEs within a decade or so without giving up performance or other amenities. Technology is also progressing in the area of autonomous vehicles (AV).

- Policy is supporting EVs in many parts of the world either with direct subsidy support or via restrictions (so far mostly in the planning stage) on the use of ICEs. Taxation policy toward conventional fuels as well as electricity pricing will also play a role. The reasons for the policy support vary. In some cases it is driven by CO₂ emission concerns where the benefit will depend on the marginal source of electric power or hydrogen. In many cases it is driven by local air quality issues. In still other cases, such as in China, it is driven in part by industrial policy and national goals for vehicle and battery production. Energy security is still a concern in a number of regions.

- Consumer behavior will be driven in part by policy and technology, which will influence the relative cost of transportation options – both upfront capital costs and fuel costs. But there also will be a reciprocal impact on policy and technology by consumer concerns and preferences with regard to performance, storage space, refueling time and uncertainty, and other driving amenities. Electric vehicles may also see uplift from being perceived as “next generation transport”. Consumer comfort with autonomous vehicles as well as car and ride-sharing may play a role in the longer term as well. We also may find that future generations take a different view on the importance of car ownership.

All of these driving forces suggest that EV penetration in cars, as well as light and heavy trucks, may very well represent a real threat to ICE vehicles this time around. Certainly, automakers are concerned enough to be preparing more than 100 different models of EVs to come to the market over the next five years.

But while the direction of penetration is clear, the speed and the magnitude of that penetration are uncertain, with a wide range of opinions currently being put forward. Can automakers really move so quickly to offer new electric models? If the models are available, will consumers buy them? Some believe that EVs will remain a niche market. Others assume EVs will dominate new car sales within a decade.

We know with some certainty that the impact of EV penetration on fuel use will take time to emerge. (We define EVs here to include pure battery electric vehicles and plug-in hybrids.) Fuel use is determined by the entire on-road fleet of vehicles – both cars and trucks.

In the case of light duty models, the global fleet is approximately 1.1 billion vehicles. But annual sales of new cars are less than about 10% of that number. Currently, EV sales are only about 2% of new car sales and less than 0.2% of the existing fleet. Needless to say, there first must be a significant expansion of the EV share of new car sales before EVs eventually represent a significant share of the fleet and of fuel consumption.

We will not be caught by surprise if we are paying attention. We will observe the trends in new car sales and whether they disappoint or exceed expectations well before there is a meaningful impact on fuel use. This also clarifies the forecaster’s key question: What will determine the rate of penetration of new car sales?

**Consumer adoption dynamics**

Certainly the economic attractiveness of EVs versus alternatives will be the key factor for the vast majority of drivers.
While subsidies will play a role initially, it is unlikely that they will support the industry beyond the early years because subsidy costs to governments would rise dramatically with expanding sales volume. Ultimately the costs of EVs, and in particular their battery packs, must come down to the point where there is no significant premium in the total costs of ownership, taking into account capital and operating costs. The fuel portion of operating costs will be heavily influenced by oil product taxes and policies on electricity pricing. Countries with high oil taxes and duties, such as Japan and those in Europe, will see EVs become economically attractive first. However, economics also will depend on how electricity prices are set during times of peak recharging.

Consumers take resale value into account in their vehicle purchase decisions, and they will need to be convinced that the deterioration of battery packs will not dramatically depress the resale value of their electric vehicle. This concern has driven the majority of EV purchasers to date to lease rather than purchase vehicles since the battery accounts for more than one-third of the value of a typical electric car today.

When will this happen? Certainly there has been a major reduction in costs over the past decade. The costs of the lithium ion battery packs have come down from $1,000/kWh in 2010 to below $250/kWh today. While Tesla has built its first gigafactory, expansive plans for additional battery manufacturing capacity, particularly in China, should continue to drive battery costs down, potentially toward $100/kWh by the end of the next decade. At that level, EVs should achieve parity with ICES even in the lower fuel cost markets such as the US and China. But this assumes that costs of key material inputs to the battery pack, including lithium, cobalt, nickel, graphite and copper, will not increase significantly from current levels as battery production grows, perhaps by a factor of 100 or more. Metals availability and cost are discussed in greater detail elsewhere in this report, but it is clear that the materials component of cost will grow more important as other manufacturing costs are reduced.

The other key obstacles to wide-scale EV adoption involve refueling/charging, including frequency, availability and duration of the process. Frequency of refueling will of course be tied to vehicle range. The longest ranges for EVs today are more than 200 miles/321 km with Tesla’s Model 3 citing a range of just over 300 miles/482 km. The average range for ICES is more than 400 miles.

Currently the lack of widespread availability of recharging stations is a key constraint on consumer purchases. The infrastructure is being built out by a combination of players, including electric utilities, EV automakers, traditional fuel suppliers and governments, but there is much to be done to give consumers the comfort level that they currently have with the availability of gasoline and diesel.

The time required to recharge is also a major constraint. The fastest recharge today requires at least 30 minutes to get less than a complete charge. The slower recharging options (including most home systems) can take more than a day for a full charge, compared to a few minutes for filling up an ICE. Even with major vehicle cost reductions, we will probably need to see a continued reduction in recharge time. This will be difficult to accomplish via recharging technology improvements alone. Behavioral changes, such as swapping new for depleted batteries (as proposed in India),
ASEAN’s inevitable rise also should be considered, as well as potentially other changes, such as roads that facilitate recharging via induction.

As discussed in a later chapter, the recharging impact on both the local and wholesale electric grid is another factor that will have to be managed, and this will vary by region. These impacts will be minor while penetration is low, but will become significant over time. For instance, in a region with surplus solar power during mid-day, recharging of EVs while at work might be optimal. Where there is surplus baseload power, overnight recharging may be preferred. These choices will also influence the CO₂ benefits from a switch to EVs. Managing grid impacts will require some restrictions on the time and speed of charging, ultimately impacting the variable costs and the convenience of EVs.

This discussion thus far has focused primarily on personal vehicles, but EVs will be competing in the heavier vehicle space – both light and heavy trucks as well as buses. Globally, heavy duty vehicles have largely avoided the efficiency standard policies that are commonplace for passenger cars. Tesla already has received orders for its semi-truck model from both UPS and Pepsi. The list of municipalities that have taken steps to shift their bus fleet over to electric models spans the entire globe, from Santiago, to Geneva, to Shenzhen (though long-distance electric coaches face greater challenges) While there are far fewer trucks than cars on the road, the impact could be more significant than suggested by the vehicle numbers.

In the United States, Class 8 trucks, which include tractor trailers and dump trucks, typically are driven about 70,000 miles / 113,000 km per year, and the fuel efficiency is quite low – around 7 miles per gallon. Replacing one heavy duty truck can have the fuel impact of replacing about 20 cars. However, the cost and weight of batteries to support heavy trucks may prove to be a difficult obstacle. Fuels with greater energy density such as LNG or hydrogen may be a better fit. For certain classes of trucks (eg, delivery trucks) refueling time and availability could be less of a constraint, particularly if a fleet owner has the capability to refuel overnight at its own central station. In the case of city buses, fuel choice may be more easily influenced by government policy where government entities are often the owners of the vehicles. Electric buses would also be well suited to the benefits of regenerative breaking given their frequent stop/start nature. China in particular has put in place an aggressive program to electrify the city bus fleet.

Broadly speaking, batteries fare relatively poorly when compared to petroleum products in terms of specific and volumetric energy density. This poses particular problems for the penetration of electric vehicles in applications where compact space and low weight count for a premium for longer hauls.

To match the range of heavy duty Class 8 trucks traveling long distances, for example, electric truck batteries would need to take up valuable space and account for considerable weight – butting up against legal limits on truck weight.

Airplanes offer an extreme example of this, where aviation biofuels may offer a more feasible low carbon fuel option.
Impacts on oil demand

Of course for those in the downstream oil industry, it matters very much whether electrification and other alternative fuels hit cars or trucks earlier and harder. A greater penetration into cars (Europe aside) primarily will impact gasoline demand, while a greater penetration into trucking primarily will impact diesel demand.

What would it take for EV penetration to halt the growth in global oil demand? First off, we note that the growth in transportation oil demand will be slowed significantly by efficiency improvements in ICEs regardless of what happens with EVs. For instance we assume that the average efficiency of new vehicles will increase by 1.7%/year or nearly 50% between now and 2040. But with population and economic growth, that will not quite be sufficient to bring transport growth to a halt. If EVs were to grow to around 30% of new vehicles sales, that would lead to a plateau in road transportation use by ~ 2035. In order to force a major decline in transport oil use, we would need to see more aggressive penetration. If EVs become the vehicle of choice, say reaching 90% of new car sales by 2030, then we could see a decline in peak oil demand from road transportation between 2025 and 2030, and then a 5 million b/d drop in average daily oil demand from road transportation by 2040. But even in such a case, total global oil demand would still amount to more than 110 million b/d or about 10 million b/d more than today’s global demand.

Uncertainty around oil demand is substantial, posing difficult choices for large producers and long cycle investments. Short cycle shale is increasingly seen as a strategy, but without large capital projects, decline rates could leave the world short, even in an 80 million b/d world. Countries with large reserves, such as Saudi Arabia, must decide whether to support price or maximize production before demand weakens, while OPEC remains keen to keep prices in the sweet spot that balances budgets, stimulates demand and avoids substitution by other fuels/technologies.

Downstream refining is likely to face uncertainty, varying by geography, as refinery footprints are unlikely to match demand. A steady demand decline would likely result in consolidation, but rapid disruptive decline could also lead to weak margins, threatening many refineries.

The role of autonomous vehicles

Up until this point we have not addressed other related mobility issues, including those involving autonomous vehicles (AVs), car sharing or ride sharing. These may, or may not, have additional impacts on fuel choice although they could have far-reaching impacts on vehicle sales and even urban design.

The impact on fuel will be driven by the potential impacts on three variables:

- Distance driven;
Fuel efficiency; and

Fuel choice.

There is some evidence that widespread use of AVs could result in more driving if, for example, they proved to be substitutes for local public transportation or medium distance train and plane travel (e.g., a consumer may prefer to take an AV door to door for a trip of 300 km rather than taking a train or plane if the car can do the driving and provide additional convenience and privacy).

AVs also could be used by the elderly, young or disabled to increase their mobility and independence.

AVs should improve efficiency at the margin. To the extent that AV’s can be managed to avoid traffic, reduce drag, and maintain optimal speed, this should result in higher efficiency.

Also, if they operate more safely, with lower risk of collision, this could lead to the use of lighter-weight materials and an associated improvement in fuel efficiency.

Will AVs by necessity be EVs? While that does not necessarily have to be the case, at least so far there seems to be a preference by automakers to opt for EV drives. If AV utilization rates are higher, it would make sense to choose the vehicle with lower variable costs. If that proves to be the case, higher AV uptake will mean higher EV uptake. More intense car utilization could also lead to quicker fleet turnover, hastening ultimate efficiency gains.

What about ride sharing – will it further reduce oil product demand? This is certainly possible, but we should keep in mind that part of the drive for individuals to purchase a car has traditionally been the desire for privacy and greater control of their transportation.

Ride sharing schemes of the future, like carpooling schemes of the past, would have to overcome that tendency.

Car sharing might not result in a greater distance driven or a change in fuel choice, but it could result in average efficiency improvement if people chose vehicles suited to their needs, i.e., if a commuter used a small vehicle for daily commutes but a larger vehicle on weekends for family outings.

Again, this is a possibility, but we note that cars serve purposes beyond pure transport, including storage, and losing the ability to store personal items in a glove compartment or trunk, or infant seats, etc. may be a strong disincentive.

Hydrogen advantages

Of course EV’s are not necessarily the end game for transport technology. Reductions of GHG and conventional pollutants are also driving developments of natural gas (CNG, LNG, and renewable/biogas) and high-pressure direct injection (HPDI) vehicle options. However, it may be that hydrogen will ultimately allow better solutions to both range and refueling constraints. As mentioned earlier, hydrogen may provide a much better fit for heavy duty vehicles where higher energy density is key.

Hydrogen infrastructure build-out will be required but might be simpler given the ability to focus on highways initially rather than the broader network required for personal vehicles, which could follow. However, whether it is hydrogen or electricity that ultimately wins out, the impacts on conventional oil demand may be similar.

We should note that oil demand currently and in the future will be driven by more than road transport demand. Air and marine transport use of oil is likely to grow for decades to come with new technologies likely to be slower to penetrate. The growth in the use of petroleum as a petrochemical feed will continue even beyond that. But the oil market will look quite different to us all, upstream, downstream and midstream, if road transport is in decline rather than growing.

For that reason, it is imperative to keep a close eye on all of the emerging options with the potential to impact mobility.
Electric dreams

Manufacturers are pumping billions into better low-carbon vehicles but consumers still prefer the combustion engine for road transport despite growing environmental concerns.

- EVs sales could reach tipping point by 2025
- Range anxiety, battery cost and depreciation remain obstacles
- Automakers investing heavily in EV technology
- Sector still dependent on direct subsidies

Electric vehicles (EVs) are increasingly portrayed as the future of transport. Despite being limited in range and more expensive to buy than conventional fossil-fuel powered alternatives, EVs may still account for around a third of global passenger car sales by 2030, according to some estimates.

However, turning this electric dream into reality will require a technological leap by manufacturers in range, capability and their capacity to meet consumer demand.

But performance is improving quickly. For example, Nissan’s budget Leaf model — the world’s best-selling EV — could travel around 160 km (100 miles) when first launched in 2010.

The Japanese manufacturer plans to introduce a new version of the Leaf this year capable of travelling triple that distance on one charge. Up until now that kind of distance was only available from luxury brands such as Tesla Inc.

The company’s most basic Model S sedan costs around $70,000 and has redefined previous perceptions of EVs as underpowered niche vehicles. Even at the lower end the entry level in EVs is higher than conventional vehicle equivalents.

Range anxiety — a term used to describe a fear that an EV will run out of power before reaching a charge point — remains a significant worry for plenty of consumers.

Many conventional combustion engine powered cars can easily drive up to 800 km between refueling. Some of the more efficient diesel vehicles can even exceed ranges of 1,000 km (625 miles) on a standard 17 gallon (64 liter) tank, helping to reduce overall running costs.

The time taken to refuel is also a technological hurdle EVs must still overcome when compared with other conventional vehicles. Even the fastest charging points available in highway service stations require a 30-minute wait in order to deliver only an 80% battery top up.

That compares poorly with the convenience and speed of filling up at the pump, which explains why oil still accounts for 97% of energy use in cars and ground transport, according to figures compiled by S&P Global Platts Analytics.

Despite these technological challenges, traditional car manufacturers can see the writing on the wall for the
Electric dreams

Volvo Cars, part of the Chinese automotive group Zhejiang Geely Holding, in July 2017 said that every vehicle that it launches from 2019 will have an electric motor — either fully electric, or hybrid.

Volvo plans to introduce five fully electric cars between 2019 and 2021, and it is aiming to sell 1 million electrified vehicles by 2025. Of course, pure battery powered EVs are likely to represent a small proportion of the total with plug-in hybrid still the most commercially viable option for many consumers.

Volvo isn’t alone in re-gearing its entire business towards EVs. Ford Motor — which first perfected the mass production of the modern automobile with its groundbreaking Model T in 1908 — now plans for 70% of the cars it sells in China to be EVs, or hybrid, by 2025.

Toyota and Volkswagen Group — the world’s two largest manufacturers by volume — are both planning to roll out EV models across their range. Toyota plans to invest $10 billion into the segment from this year.

Eventually, these investments by the world-scale manufacturers should bring down purchase prices for consumers further eroding the combustion engine. However, electric mobility remains more expensive to acquire.

Batteries add €6,000 to €16,000 to the cost of a vehicle, estimates the European Automobile Manufacturers Association (ACEA). EV sales remain heavily dependent on financial incentives and subsidies in most markets.

For example, electric or hybrid vehicles accounted for more than 50% of all new cars sold in Norway in 2017, according to the Norwegian Road Federation. The country offers generous tax advantages to make electric vehicles more competitively priced, and owners enjoy other benefits such as exemption from tolls, free parking and recharging, and use of bus lanes. These incentives help to compensate for drawbacks in the technology and its deployment.

However, there are numerous examples of where sales fall when incentives are withdrawn. Hong Kong and Denmark are two examples where sudden policy changes, or withdrawal of government subsidies have had an immediate negative impact on EV sales.

Fleet operators such as car rental companies are also keen on the potential lower operating costs of EVs and autonomous vehicles.
Avis Budget Group Inc. — the largest general-use vehicle-rental company in the US — wants to play a leadership role in next-generation mobility and transportation, Arthur Orduna, vice president and chief innovation officer, said in an interview with S&P Global Market Intelligence in January. “That narrative has everything to do with not just working with customers today, but what they need and where they want to go tomorrow,” he said.

Avis — which owns car sharing network Zipcar — is pursuing a raft of mobility initiatives. The company is taking steps to make its fleet of vehicles connected, providing it with the means to monitor location, mileage, remaining fuel or charge, and management-system alerts all in real time, as well as giving it control over remote access to vehicles. Because the company is able to track this information, employees no longer need to spend time counting cars in their yards, said Orduna.

Tesla is looking to move into the truck space. The company is scheduled to begin production in 2019 of the Tesla Semi, an all-electric truck powered by four independent motors on rear axles that it said is capable of hauling loads of up to 80,000 lb up to 800 km (500 miles), according to the company’s website. However, battery size and weight will be limiting factors for EV technology in the commercial vehicle space unless addressed by new technology advances.

Deutsche Post, which comprises the postal services of Deutsche Post and the international express operations of DHL, plans to test the Tesla Semi, but it also has been proactive in the development of its own mobility solutions. The company aims for 75% of its first and last-mile services to be met with vehicles generating zero emissions by 2025. In order to meet that target, it plans to replace 3,000 to 3,500 conventional vehicles annually with clean electric vehicles. Despite these goals, the company met 93% of its fuel needs for road transportation with diesel in 2016.

StreetScooter — a subsidiary of Deutsche Post — in collaboration with Ford is due to begin producing the Work XL, a bigger EV truck in 2018. The vehicle will be equipped with a modular battery system delivering 30 kWh to 90 kWh of power, giving it a range of up to 200 km.

The company’s CEO Frank Appel has high hopes for electric vehicles even though he acknowledges the limitations of the technology. “I believe that electric mobility even has the potential to become the new standard in mobility, especially in the logistics industry, but beyond logistics as well,” Appel wrote.
Hydrogen was once heralded as a game changing wonder fuel for low-carbon transport but the technology also has its critics.

Electric vehicles (EVs) may grab all the low-carbon headlines, but hydrogen power also has an important role to play in the future of transportation.

Although the hydrogen Fuel Cell Electric Vehicle (FCEV) currently has limitations as a personal road transport solution, the technology has huge potential to revolutionize trucks, buses, trains, and ships.

Despite Tesla Inc. CEO Elon Musk branding the technology “mind-bogglingly stupid” FCEVs have real benefits over battery EVs.

Hydrogen has a much higher energy density per weight than batteries, allowing FCEVs to travel longer distances and perform better for heavy, high-mileage vehicles. Hydrogen tanks and fuel cells weigh significantly less than batteries, allowing a truck to carry bigger payloads.

To longer range, add genuinely fast charging times akin to refilling a conventional vehicle. As range, mileage and payload requirements increase, so the costs of hydrogen FCEVs will start to undercut those of battery EVs — hence the technology is seen as complementary to, rather than competing with, battery EV cars.

Logistical, safety and cost concerns around hydrogen production, meanwhile, can be overcome by distributed...
production of hydrogen using electrolysis and surplus renewables during offpeak times. This power-to-gas process, incidentally, offers longer-term energy storage options that complement the short-term storage profile of batteries.

If commercial road transport starts to move towards hydrogen fuel cells, momentum could build quickly. The average age of a tractor unit for a long-distance truck is about four years. This in turn would drive investment in refuelling infrastructure.

The problem today is that, while several manufacturers have launched hydrogen fuel cell vehicles, numbers on the road remain vanishingly small and refuelling points are even scarcer. It is the classic chicken and egg conundrum. Without a refuelling point, why buy an FCEV? Without FCEVs on the road, why install a hydrogen pump?

Then there is the efficiency gap. Conversion of electricity to hydrogen via electrolysis is a complex, energy intensive process. Energy efficiency is pegged around 30% from the power grid to wheel if hydrogen is produced through electricity. Batteries charge straight from the network, with 60% efficiency when powered by green electricity. Nor are FCVs necessarily that clean, even if the only emission from the vehicle itself is water vapour. It depends how the hydrogen is made.

The vision, realized by Shell and ITM Power at Shell’s motorway station at Cobham on the M25 London orbital, is for green hydrogen produced by an on-site electrolyser using surplus renewables.

The reality is that most hydrogen is produced from natural gas reforming in large central plants. And while recharging is fast, you cannot re-charge an FCEV at home – a crucial element of flexibility in the emerging viability of battery EVs. In the meantime, battery EVs are making progress on range, payload and refuelling times flexibility.

With Cummins and Tesla launching battery trucks last year, the race is on to extend range. Cummins’ truck is designed for local deliveries with a 100 mile range, while Tesla is targeting regional haulage with a 200-300 mile range.

Just as significant, however, is LNGV’s November 2017 order for 14 Alstom-built fuel cell trains to ply routes in the northwest German state of Lower Saxony.

The trains, which will replace the current fleet of diesel units from late 2021, have a 1,000-km range on a single tank of hydrogen and can reach a maximum speed of 140 km/h.

On road, rail and sea, hydrogen has some powerful backers with deep pockets and extensive expertise.

The Hydrogen Council, whose mission is to see hydrogen technologies like FCEVs play a role in the global energy transition, counts Shell, Statoil, Total, Toyota, BMW, Daimler, GM, Alstom and Honda as members.

The council’s global goals include 10 to 15 million passenger cars and 500,000 trucks powered by hydrogen by 2030, with first deployment of hydrogen-powered trains and passenger ships.

By 2050 the numbers increase to 25% of the car market (400 million), 30% of the truck market (5 million) and 25% of the bus market (15 million, with the focus on long distance coaches as city buses are suited to battery units that benefit from regenerative braking).

These ambitious targets would replace some 20 million barrels of oil a day, removing 3.2 Gt CO2.

Hydrogen is one to watch, whatever Tesla’s Musk says.
Battery metals squeeze

Surging demand for metals used in electric vehicles batteries is disrupting the mining industry, pushing up prices for cobalt, copper, nickel, lithium, graphite and rare earths.

Diana Kinch
Editor-in-Chief, SBB Steel Markets Daily
S&P Global Platts

- Tight battery metals supplies and price pressures could slow EV boom
- Copper, nickel, cobalt, rare earths and graphite prices rose significantly in 2017
- Automakers and miners warn of deficits of cobalt and nickel from 2019
- Lithium may move into surplus from early 2020s following a flurry of new mine investments
- Mining activity could boost energy demand

Growing demand for electric vehicles (EVs) is proving disruptive for the metals industry. More production and mine investment is essential to minimize the impact of what most analysts see as an impending deficit of key battery metals cobalt, nickel and copper, and to keep lithium prices steady. And if mining companies fail to keep pace with demand EV sales could stall.

Bottlenecks are already emerging in the EV supply chain. Tesla Motors fell behind in its production targets last October. The lag is persisting partly because Panasonic has been unable to supply batteries quickly enough, due to insufficient metals supply available at the right price, according to metals consultancy Roskill. Likewise, Volkswagen has reportedly been unsuccessful in striking a deal with any mining company after issuing a tender in September for a minimum of five years’ supply of cobalt for batteries at a fixed price. Carmakers, including Toyota Motor Corp, Tesla Motors and China’s Sichuan Fulin Industrial Group, are now either committing to or eyeing equity stakes in key lithium miners in a move to guarantee offtake and lock-up supplies.

Forecasts vary but the trend points to major demand increases for the key battery metals. S&P Global Platts Analytics forecasts there will be 80 million passenger car EVs on the roads in 2030, and annual sales in that year of 13 million units, up from 3 million on the road last year, with sales of 1.17 million. Growth should snowball in the following decade to 280 million passenger EVs on the road in 2040, with annual sales of 40 million, it says.

This could result in a surge in demand for lithium, nickel and cobalt, as well as for copper, which is used in power generation, grid and charging infrastructure and in the cars themselves. According to a recent CRU study commissioned by mining giant Glencore, EVs could require 4.1 million mt of copper in 2030, equivalent to 18% of total 2016 supply.

How to manage battery metals demand growth has dominated recent metals industry events, as key battery metals start to account for an increasing percentage of battery costs, accentuating price volatility in the EVs supply chain.
Futures may help structure battery metals markets

Battery metals are set to transform into liquid markets, which will need new pricing solutions. The London Metal Exchange is looking to facilitate this growth by introducing battery metal contracts to capture demand.

The LME told S&P Global Platts that the exchange is “working closely with the battery metals industry, [and that] the LME will look to build out its suite of contracts with the addition of a chemical cobalt contract, lithium, and potentially a chemical nickel contract over the next 18 months to two years,” according to LME spokesman.

He added that “due to storage challenges and the non-standard user requirements for these battery metals, it is envisaged that we will offer cash-settled contracts.”

Lithium is difficult to store and is usually sold in chemical form such as lithium hydroxide or lithium carbonate powders. McKinsey analysts in a report on the future of nickel foresee potential for two distinct contracts: class 1 for high grade nickel powders or pellets, used to make nickel sulfate for batteries and class 2 for lower purity nickel for the steel industry.

McKinsey noted that class 1 nickel is priced up to around 35% over the current nickel LME reference price, while ferronickel is priced as a discount. Addition of a class 1 nickel contract would encourage suppliers to make new investments, according to the analysts.

— Sarah Jane Flaws
Battery metals in focus

Nickel
Nickel prices were boosted by about a fifth in 2017. The LME nickel cash settlement price closed the year at $12,260/mt, up from $10,205/mt. To put this into perspective this level was still below the market’s five-year average of $12,741/mt. Prices peaked at above $12,800/mt in early November as the annual LME Week gathering played up prospects of an EV revolution being a game-changer. However, batteries account for only 3% of the estimated 2.1 million mt/year of annual nickel consumption. By comparison stainless steel accounts for around 70% of nickel consumption. Analysts agree that battery demand should see substantial growth over the next few years, accounting for perhaps 12-15% of nickel consumption by the middle of the next decade.

The challenge is that not all forms of nickel currently produced — notably nickel pig iron (NPI) and ferronickel — are suitable for the production of nickel sulfate. This form is the principal feed chemical for battery cathode precursors. Growing battery demand could see higher volumes of “Class 1” nickel consumed by the EV sector, with the stainless industry increasingly reliant on NPI, ferronickel and reprocessed stainless scrap to cover its nickel requirements.

Lithium
Lithium has seen considerable price volatility since the beginning of the EV boom in late 2015 when prices for high-grade lithium carbonate more than doubled to some $21,000/mt. Not quoted on metals exchanges, lithium’s pricing is considered opaque, particularly in the Chinese spot market. Most is sold on short-term contracts, or bilateral deals due to volatility. This means perceptions of prices also vary. Four principal products are traded: lithium carbonate of 99.5% and 98.5% purity, lithium hydroxide and spodumene, the mined ore.

According to Mining Journal, lithium carbonate equivalent (LCE) contract prices are rising in all markets and producer Orocobre expects to negotiate first half 2018 contract prices 25% higher than the second half of 2017. Canaccord Genuity and SP Angel see prices for 2018 in the $14,000/mt range. However, SP Angel also sees prices falling to $10,000/mt and $12,000/mt for carbonate and hydroxide respectively in the longer term as new projects and production come on stream. Many analysts see global consumption of lithium tripling or quadrupling over a 10-year period.

Most lithium production comes from four big producers: Albemarle, Sociedad Quimica y Minera de Chile (SQM), FMC and Sichuan Tianqi. Their mines are focused on the “lithium triangle” of salt lakes of Chile, Argentina and Bolivia. This is set to change. Rio Tinto’s Jadar project in Serbia is expected on stream in 2023. Industry sources expect oil companies to participate in lithium production in future.

Copper
LME copper prices jumped 28% last year as production failed to keep pace with demand growth due to insufficient investments. Falling metal grades in existing mines means that a deficit expected from the early 2020s could balloon to a shortage of 5.7 million mt/year by 2030, according to Robert Freidland, CEO of Ivanhoe Mines.

Latest production figures from the International Copper Study Group, for the first nine months of 2017, show world refined copper output up 0.5% year-on-year to 17.405 million mt. Among the few new mine projects being developed are Rio Tinto’s Oyu Tolgoi in Mongolia, Ivanhoe Mines’ Kamoaa-Kakula project in the Democratic Republic of the Congo (DRC) and Glencore’s doubling of output at its Katanga pit. Copper is used in EV batteries and motors along with cables needed for charging.

Cobalt
Cobalt is the metal most likely to delay EV production. Expectations of a tripling in demand by 2030 to more than 300,000 mt/year have led automakers and analysts to predict deficits. More than two thirds of supplies come from the DRC, where there are geopolitical risks. However, junior miners including Cobalt 27, Cobalt One and First Cobalt are seeking to exploit “pure-play” deposits, in Canada and Australia. Roskill notes that 60,000 mt/year of new cobalt refining capacity will come on stream during the next 5-10 years in China.

LME 3-months cobalt prices soared 129.8% last year to $75,250/mt in late December. “Without a primary mine supply side to speak of, cobalt has less of an elastic supply buffer than peers,” said BMO Capital Markets. Cobalt recycling is likely to take on more importance in future. One company with an initiative in this area is Eurasian Resources Group, with a tailings (mine rejects) processing project in the DRC.

— Diana Kinch and Andy Blamey
Metals account for around 40% of the active material costs of a lithium–ion battery, rising to around 50% including metal cell and copper wiring, according to consultancy Roskill. The total cost of $190/kWh of a Tesla NCA-C pack would be composed of $65/kWh cathode — comprising nickel, cobalt, lithium and alumina — and $10/kWh anode — comprising graphite, Roskill says.

Progress has been rapid in development of low-cobalt (low-Co) technology, moving from a 1:1:1 ratio of nickel-manganese-cobalt (Ni-Mn-Co) to a 8:1:1 Ni-Mn-Co ratio, Roskill notes. However, “it takes time for qualification (especially in automotive uses), so there will be a lag (1-2+ years) and it will change only on model launches,” say the consultancy’s analysts Robert Baylis and David Merriman. High cobalt prices currently impact battery costs more in portable devices than in the automotive sector, where batteries are less cobalt-intensive, they note. “Alternatives to nickel are also sought, but its price has been more stable so (this is) less of a rush,” the analysts say.

EV makers may start feeling the impact of a shortage of battery metals from early in the next decade as the cobalt and nickel markets slide into deficit, according to Catherine Girard, energy and raw materials expert leader at automaker Groupe Renault.

Cobalt, where pressure may be greatest, is forecast by the automaker to move into deficit between 2019 and 2025. However, analysts including BMO Capital Markets claim a deficit already exists. The shortfall caused a 130% price increase over the last year. Nickel is also seen in deficit from 2020, while automakers see a “big challenge” from increasing demand pressures on copper and aluminum in the next few years as demand from the EV and other sectors grow, according to Girard.

Meanwhile, lithium — currently in tight supply due to a recent explosion in demand — is forecast moving into surplus from 2021-22 as a flurry of new mine projects currently planned, or under construction come on stream, the Renault executive said.

Automotive battery demand is seen taking 39% of all lithium supplies by 2025, up from 14% in 2015. Renault took steps to significantly reduce the weight of rare earths used in its motor magnets to between 200 grams and 500 grams when prices shot up in 2010 due to the Chinese introducing export quotas, Girard said. Honda Motor Co and Daido Steel Co in 2016 reported they had developed a hybrid vehicle motor that didn’t use rare earths: a break with the norm in a move to control costs and supply uncertainties: independent research has put the typical weight of a rare earths-based magnet industry-wide in a single EV motor at around 1 kg.

On the bandwagon

In response to EV and energy storage demand, lithium-ion battery production capacity globally is forecast to increase to 372 GWh by 2021 from 33 factories. That compares with 70 GWh in 2015 produced from one factory, with the new capacity having already doubled the tonnage of cobalt and nickel consumed by battery production, according to Simon Moores of Benchmark Mineral Intelligence.

The lithium-ion battery market could grow annually by 16.6% between 2016 and 2022 to a value of $68.97 billion. Cobalt will probably track lithium-ion battery demand. “Lithium is the primary battery material but cobalt is the catalyst,” says David Weight, president of the UK-based Cobalt Institute. “It’s unlikely you’ll have a high-tech industry without cobalt in it.”
Some miners have been quick to jump on the EV bandwagon. But higher metals prices will be required to incentivize the next generation of projects to feed longer-term demand, Ivan Glasenberg, CEO of miner Glencore, told investors in December.

Sufficient minerals and metals exist in the earth’s crust to satisfy the burgeoning demand for lithium-ion batteries and the extra-strength magnets that EVs will use. According to the US Geological Survey, the world has sufficient lithium for 400 years supply at current levels.

However, concerns are growing over the pace of production increases and the cost of the infrastructure required to meet rising demand. It typically takes up to 10 years to bring a new mine on stream, and fears of deficits recently brought copper to a four-year high. Lithium and cobalt prices have more than doubled since the start of the boom. Spot prices for praseodymium (Pr) and neodymium (Nd) oxides — the rare earths most commonly used for permanent magnets in EV motors — skyrocketed to a three-year high in 2017, partly due to the imposition of Chinese production quotas. Aluminum — used to a smaller extent in EV batteries but also for the battery casing — is also set to benefit as carmakers seek to lighten vehicles.

**Clean sourcing and recycling**

Ethical sourcing for the EV industry is also a price factor. Opaque sourcing of materials may work out more expensive in future as pressures to improve social sustainability grow.

More than 60% of the world’s cobalt supplies currently derive from the DRC, where child labor issues have been highlighted by organizations including Greenpeace and the London Metal Exchange (LME). The Congolese parliament’s proposed hike in cobalt royalties from the existing 2% to 10% to boost revenues as part of a long-planned revamp of the mining code may also deter foreign investment, pushing producers elsewhere. Australia, Canada, Russia, Zambia and Finland have the potential to replace cobalt from the DRC, according to Marino Pieterse of Goldletter International.

Recycling metals is another significant challenge. EVs are being redesigned to be almost totally recyclable, including the metals used in their bodywork and in their batteries. Currently, there is only a low level of interest in battery recycling but interest is expected to grow as battery sizes increase. Batteries “will provide a huge recycling industry from 2020-21,” according to BMI’s Moores. Battery recycling could in future be made obligatory by governments. More than 90% of lead acid batteries are now recycled, he said.

Changes in preferred battery technology are another challenge for the industry to absorb. “Research continues apace on energy-dense alternatives that use less or no cobalt and nickel, but as yet materials matching NMC/NCA (Nickel Manganese Cobalt/Nickel Cobalt Aluminum) performance, importantly with a cost/benefit advantage, have not been found,” according to a recent Roskill report. Battery technology choices are not fixed and progress with new chemistry solutions is likely to remain slow. The popular Nissan Leaf EV — introduced in 2010 — originally used a Lithium Manganese Oxide (LMO) chemistry. The system used no cobalt. Another alternative is Lithium Iron Phosphate (LFP) technology. Both Roskill and SP Angel agree that metals availability and pricing pose risks to the EVs revolution.
“Without a primary mine supply side to speak of, cobalt has less of an elastic supply buffer than peers.”

BMO Capital Markets
From OPEC’s perspective how will members adapt to changes in mass-mobility such as the growth of electric vehicles (EVs) and hydrogen power units?

The road transportation sector currently accounts for 45% of global oil demand and the OPEC Secretariat constantly monitors developments in this sector.

This is highlighted by the fact that in OPEC’s last two World Oil Outlooks (WOOs), for 2016 and 2017, alternative scenarios focusing on the road transportation sector were considered.

The OPEC Secretariat will continue to monitor this vital sector, through further engagement with technology firms in the sector, via our international dialogues with main consuming nations and regions, such as the European Union, China and India, as well as by closely following energy policy developments and contributing to the overall energy debate.

However, it is important to emphasize that oil is expected to remain the most important fuel in the global energy mix for decades to come. In the WOO 2017, published last November, there is no peak oil demand in the forecast period to 2040. Moreover, oil will remain the main fuel in the transportation sector, although we do recognize that EVs and other alternative transport means will contribute to a deceleration in oil demand growth, especially in the long-term.

Recognizing these trends, member countries are taking steps forward to diversify their economy and increasing non-oil revenues. Some examples are Saudi Arabia with its Vision 2030 plan, the rapid development of renewables in the UAE, and fuel price adjustments in several member countries primarily aiming to foster more efficient use of oil products.

Some experts argue that EVs and other forms of electrified transport spell the end of the oil era, why would this not be the case?

Oil is a finite energy source, so one day we will see the end of the oil era. However, we do not see this happening anytime soon, and nor do any other major energy forecasters.

The OPEC Secretariat acknowledges that significant progress has been made in the development and promotion of EVs in recent years. Nonetheless, one should bear in mind that in 2016, EVs accounted for only 0.1% of the global passenger fleet. It is coming from a low base. However, in OPEC’s WOO 2017, it is underscored that EVs will
witness a further penetration of the passenger fleet market in the decades ahead. It is expected to account for around 16% of the market by 2040.

It is important to note that many uncertainties and constraints for EVs remain. The cost competitiveness of EVs is still questioned, particularly if generous subsidies are eliminated. In this regard, the cases of Estonia and Denmark where EV sales plunged significantly after governmental subsidies were slashed provide an interesting insight.

Moreover, the investment required to develop a reliable infrastructure for charging, as well as electricity generation, could also be seen as a constraint to further growth.

It is also quite revealing that in OPEC’s WOO 2017 a much more optimistic EV penetration scenario was presented. Under this extreme, and what could be viewed as a highly unlikely scenario, EV sales would almost triple compared to the Reference Case so that EVs would represent over 25% of the passenger fleet by 2040.

However, even under this scenario, the resulting impact on oil demand would not be dramatic and there would still be no peak oil demand by 2040.

Furthermore, we should be reminded that in addition to the passenger car segment – where the penetration of EVs is expected to be highest – there is the commercial vehicles segment.

The WOO’s projections indicate that oil demand growth in this segment of road transportation will be much stronger (compared to passenger cars) as sales are not anticipated to undergo electric diversification at anywhere near the level of passenger vehicles.

Moreover, significant future oil demand growth is also expected in petrochemicals, aviation, marine bunkers and other sectors, where options for shifting away from oil are not easy.

How can OPEC work with the automotive industry to extend the lifespan of oil as a primary fuel source in the transportation energy mix?

As mentioned, the OPEC Secretariat is engaging with many technology firms in the transportation sector through various channels, such as institutionalized dialogues, technical exchanges, workshops and research and development fora. Many member countries will also have their own platforms for engagement with the automotive industry.

We also acknowledge the challenges of emissions that come from burning fossil fuels. In this regard, we recognize the need to use energy efficiently and to continually look to develop and adopt cleaner energy technologies.

We believe that solutions can be found in technologies that reduce and ultimately eliminate these emissions. We welcome further coordinated action with the industry, as well as and through various research and development platforms.

Given the concerns over peak demand is the rapid growth of EV sales already being factored into OPEC’s decisions over production levels and capacity?
As I have already mentioned, the OPEC Secretariat does not see peak oil demand before 2040, and that oil will remain the main fuel source in transportation.

In the road transportation sector alone, in the WOO 2017 an additional 5.4 million barrels a day (mb/d) of demand is estimated up to 2040. This is mainly driven by the fact that the car fleet, both passenger and commercial, are forecast to double.

It is also important to consider that due to the relative low turnover rate of passenger vehicles, increasing EV sales will take a long time to be translated into a significant portion of the car fleet.

Moreover, and I do not hesitate to reiterate it again, significant demand growth is expected from other sectors such as petrochemicals and aviation, with an additional 3.9 mb/d and 2.9 mb/d, respectively between 2016 and 2040. In fact, oil demand is only anticipated to decline in the electricity generation sector during the WOO’s forecast period to 2040.

What is OPEC doing to be more engaged in the policy debate around alternative transportation technologies and not be perceived as a “dinosaur”?

As mentioned in a response to an earlier question, the OPEC Secretariat engages with many external parties, including technology firms, large consuming countries and regions, as well as through other institutionalized dialogues with other international organizations such as the International Energy Agency (IEA), the International Energy Forum (IEF) IEA and the OECD. This includes comparing projections and scenarios, including on technology and transportation.

We also closely monitor transportation-related developments in the energy and oil market, organize regular workshops to exchange knowledge with experts on the subject, and provide considerable commentary on transportation issues in the WOO.

We are actively involved in the policy debate, as are our member countries, and we are always ready and willing to engage further.

How is the growth in EVs and other changes to mobility such as hydrogen-powered shipping making it harder for OPEC Members to attract investment into their respective upstream and refining industries?

There is clear evidence that the oil industry has seen a drop off in investment in recent years, but we see little linkage between observed investment and potential changes in the transport sector.

The severe investment declines witnessed in both 2015 and 2016 were a result of the severe oil price cycle the industry was undergoing. Industry budgets were depleting and exploration and production spending was reduced by an enormous 27% in both years. In total, nearly one trillion dollars in investments were frozen or discontinued, and many thousands of industry staff were cut from payrolls.

The unprecedented industry downturn led OPEC member countries, in cooperation with some non-OPEC producers, to embark on a concerted effort, through the historic ‘Declaration of Cooperation’, to return balance to the
market, help the return of a sustainable stability, which in turn should be supportive for the return of investments.

I should point out that OPEC member countries have continued to invest in their industries throughout this volatile down-cycle. This has positioned them well to maintain their leading roles as reliable suppliers to growing economies around the world.

Looking ahead, given our projected future demand for oil, with the recent WOO 2017 expecting demand to reach over 111 mb/d by 2040, an increase of almost 16 mb/d, the world simply cannot afford a future supply crunch. The industry needs to continue to ensure that conditions are supportive for a sufficient level of investment to be in place in the years and decades to come.

In addition, the estimated share of OPEC liquids in total global liquids supply is expected to increase to 46% by 2040, from 40% in 2016. I am confident that our member countries will continue investing in the future to provide the required volumes. We do not envisage any major issues in attracting investment.

Will the growing demand for electricity arising from these changes in transportation will be OPEC looking more at gas and renewables such as solar in terms of policy formation?

OPEC believes in a balanced energy mix. There will be the need for all energies in the years to come otherwise we would be unable to meet the growing demand for energy, especially in developing countries. Of course, we can expect to see a further shift towards renewables in the coming decades. Let me stress that OPEC is greatly supportive of the development of renewables. Many of our countries have vast sources of solar and wind, and significant investments are being made in these fields.

Nevertheless, as indicated in OPEC's WOO 2017, oil and gas together are still expected to provide more than half of the world's energy needs by 2040, with their combined share relatively stable between 52–53% over the entire forecast period.

What is the future of oil and OPEC?

I have already answered in great detail about the future of oil. To put it simply, it will remain a core part of the overall energy mix in the coming decades.

In the industrialized world, we also need to remember how important oil and gas have been to our past. They have transformed our economies and our societies. They have provided heat, light and mobility. They have created and sustained economic growth and prosperity. The products derived from these precious natural resources are fundamental to our daily lives.

However, we should not forget that this has not been the story for everyone. When we start up our cars, switch on a light, turn on our mobile phones, we need to recognize that these everyday things are still unknown to billions of people across the world who continue to suffer from energy poverty.

These are people that need their voices heard. They need access to reliable, safe and secure modern energy services at scale. And oil will play a key part in helping deliver these essential modern energy services to all corners of the world.

As for OPEC, I think the last 18 months or so has shown that the organization is stronger, more committed and more purposeful than ever. The landmark agreements with our non-OPEC counterparts through the 'Declaration of Cooperation' were an incredible challenge, a mammoth undertaking, but through a shared vision and a resolute strength of purpose we were able to achieve something that many thought was beyond us.

I have been very happy to say that the consequences of our historic cooperation have exceeded even the most optimistic of expectations. The market rebalancing process is well underway, supported by historically high levels of conformity by participating countries. But let me add that we have not taken our eye off the goal of bringing stocks down to their five-year average, and helping ensure that a sustainable stability returns to the market.

Moreover, we are also looking at ways and means to institutionalise the 'Declaration of Cooperation' to ensure continuity in the framework and strategy that has built on this unparalleled global platform of stability. This would go beyond the short-term and look at some of the broader challenges, as well as opportunities, the oil industry is expected to face in the years and decades ahead.

We are positive about the future for OPEC and committed towards sustainable market stability with the broad participation of countries and major stakeholders.
Global electric vehicle trends

North America
- In the US, California is considering a bill to ban internal combustion engine (ICE) sales by 2040.
- Alternative transport incentives in other states include a $2,000 rebate in New York for the purchase of new EVs. The Oklahoma Supreme Court struck down a law imposing a tax on electric vehicles.
- Throughout all of Canada, EV purchasing incentives are currently only available at the provincial level in British Columbia, Quebec, and Ontario. Ontario intends to develop a province-wide EV sales target.

Latin America
- Some countries have adopted clean vehicle targets for state-owned fleets.

Africa and Middle East
- There are no major policy national initiatives related to alternative fuel transportation options.

Source: S&P Global Platts Analytics, Wards, OICA
Some countries have adopted clean vehicle targets for state-owned fleets.

**China**
The Chinese government is developing a timetable to ban ICE vehicles, but so far no target date has been set. In Beijing, Shanghai, and other major cities, EVs are exempt from license plate lotteries and registration fees.

**Other Asia**
The government of Indonesia has set a target of 20% EV market share by 2025 and plans to ban ICE vehicle sales by 2040. Vietnam has installed its first quick EV charging station.

**South Asia**
- India aims to have EVs account for 100 percent of new car sales by 2030 and expects 6 million EVs to be sold annually by 2020.
- Sri Lanka has proposed phasing out all ICE vehicles by 2040 and converting the entire government vehicle fleet to EVs or hybrids by 2025.

**Europe**
The European Commission (EC) has proposed regulations requiring a 15 percent fleet-wide reduction in GHG emissions for new cars by 2025 (below 2021 levels) and 30 percent by 2030. The EC has targeted a 60 percent reduction in GHG emissions below 1990 levels by 2050.

Countries where bans on ICE vehicles have been passed include The Netherlands (2025), Norway (2025), UK (2040), and France (2040).
China imports about 8 million b/d of crude oil

China accounted for half of global EV sales last year

EVs offering China an opportunity to rebrand industry

Chinese manufacturers competing on technology

By almost any measure, China leads the world in road transport electrification. It makes more, buys more and, with 75 different models available in 2017, offers consumers a wider choice of electric vehicle (EV) than any other country.

Chinese EV passenger car sales totaled 579,000 units last year. Add in about 20,000 imports and China accounted for around half of global EV sales. Chinese manufacturers also have a near total grip — about 90% — on the market for electric heavy-duty vehicles, selling 198,000 commercial EVs in 2017, about 85% of which were city buses.

The drivers of China’s EV boom are both political and economic, which guarantees continued state support. Industrial planners see a chance to change forever the country’s position in global auto manufacture and reduce growing dependence on imported crude.

China imported about 8 million b/d of crude oil in 2017. The conversion of even a portion of transport to run on electricity reduces the country’s massive oil import bill, improves its trade balance and reduces its vulnerability to external shocks in the oil market. The same logic applies to natural gas. China’s pipeline gas and LNG imports are rising fast. They are being used to switch from coal use in heating and power generation and other city gas uses. There is less emphasis on gas-for-transport than on EVs because, as with oil, China faces a growing import bill and security of supply concerns.

The focus on EVs creates a more circular economic chain, with domestic manufacturers and power generators benefitting rather than foreign oil and gas producers.

Moreover, China’s industrial base can benefit. Labor costs are rising, leading to the loss of manufacturing investment. Auto production is a high value-added industry as dependent on engineering skills and technology as much as labor cost. China needs to move up the manufacturing value chain, and an auto industry in transition to electricity and automation fits the bill. Electrification and automation combined create a highly disruptive moment in the auto industry’s development, one which offers China an opportunity to re-write the established order in both domestic and foreign markets.
After a long period of rapid growth, China’s total vehicle market has reached a more mature phase as the stock of first-time buyers diminishes. It is characterized by slower sales growth, over-capacity and falling profit margins. However, new energy vehicles (NEVs), which include battery-only EVs, plug-in hybrid EVs and fuel cell EVs, are a market within a market.

The segment is also dominated by domestic Chinese manufacturers, which have traditionally struggled to compete with foreign brands. NEVs represented just 2.7% of 28.9 million locally-produced vehicles sold in 2017, a small proportion, but sales were up 53% year on year. In contrast, China’s vehicle market overall grew by 3% over the same period.

NEVs also address the extremely high levels of urban air pollution in China’s major cities. While measures have been taken to curb coal-fired generation in, or near urban areas, diesel and gasoline fumes from city traffic are a major contributor to poor air quality. At the same time, the greening of transport helps Beijing meet its commitments under the Paris Agreement on Climate Change. Being the market leader in NEVs builds on China’s rapid expansion of solar and wind generation to provide Beijing with a global leadership role on climate change.

The government has fostered NEV adoption by the provision of generous incentives, including sales subsidies of up to Yuan 55,000 ($8,590) for passenger EVs and reduced vehicle taxes. The sales incentive was reduced in 2017 and is expected to be phased out by 2020. This will be replaced from 2019 with a dual incentive scheme that imposes targets for NEV sales and average corporate fuel efficiency. In both areas, car makers earn tradable credits, while underperformers must buy credits.

Moreover, the credits are weighted according to vehicle quality in terms of range, a deliberate attempt to incentivize the development and deployment of better EV technology as China’s NEVs are generally smaller and perform less well than their Western competitors.

In Beijing and Shanghai, NEVs are also exempt from license plate auctions and registration fees. This is no mean giveaway: permanent license plates in Shanghai cost up to Yuan 80,000. In addition, more than 10,000 NEVs have been deployed in high mileage car sharing platforms. As a result, NEV penetration in China’s trend-setting tier 1 and 2 cities is much higher than elsewhere.

Subsidies are part of the government’s domestic industrial strategy. They are not evenly distributed and act as a barrier to foreign competition. ‘White lists’ are drawn up of eligible models by the Ministry of Industry and Information Technology, which heavily favor domestic manufacturers. There is also a list of approved domestic battery suppliers, from which Chinese NEV manufacturers source their batteries, although they are not specifically required to do so.

This favoritism is backed by a long-term state-supported R&D effort. It is notable that BYD — one of China’s principal NEV makers — uses its own lithium iron-phosphate technology, rather than the lithium nickel cobalt aluminum-oxide batteries developed by Tesla Inc. BYD, which has already commercialized e-buses and e-trucks ahead of Tesla, says it will reduce battery cell costs by 50% to $110/kWh within three to five years. In contrast, Tesla is targeting around $200/kWh when its Gigafactory ramps up to full production. BYD also claims to have equal, or superior, charging technologies as its more glamorous US rival.

But it is in e-HDVs where China’s lead is most impressive, both for domestic use and export. These include the manufacture of refuse trucks, light trucks and city buses for relatively short range, stop/start transportation tasks. Here, China dominates global production. E-buses, in particular, displace more fossil fuel than light-duty passenger EVs and remove more diesel fumes from city streets. As a result, the impact of EVs on oil demand is likely to be felt first and foremost in the Chinese diesel market.
Europe shifts gears

The low-carbon transport revolution is in its infancy. Europe's regulators are helping it to grow fast, creating a blueprint for other regions to follow.

- Low-carbon transport needs regulation until costs fall
- Europe targets recovery in global car market share
- EU wants to cut Eur1 billion/day fossil fuel import bill
- Auto industry wants regulation to boost new powertrains
- Disruptive technology could force pace of change

Europe is at the forefront of regulating the low-carbon transport revolution. The region's policymakers have put in place frameworks designed to gradually push manufacturers and consumers toward higher-efficiency lower-emissions passenger and commercial vehicles. But their capacity to sustain subsidies and lost tax revenues is open to question.

Behind this drive is the target to cut by at least 60% greenhouse gas emissions from transport by 2050, from 1990 levels. European policymakers also want to be “firmly on the path towards zero” by that date.

Regulators are working in tandem with automakers and infrastructure providers to clear the way for alternative drive trains, including electric vehicles (EVs) and others, to gradually phase out the fossil-fuel burning combustion engine.

Their challenge is achieving this historic transition while preserving economic growth, jobs and Europe's share of the global car market.

There are many examples around the world where uptake of EVs has fallen dramatically when government subsidies are withdrawn. This has been seen in areas such as the US state of Georgia, Hong Kong and Denmark, where sudden policy changes, or withdrawal of government incentives has seen an immediate negative impact on EV sales.

In some cases, the upcoming withdrawal of government subsidy has caused a temporary surge in uptake of EVs as consumers attempt to qualify for subsidies in a closing window, before sales numbers crash immediately following the withdrawal of support. This clearly illustrates the connection between government support mechanisms and consumers’ willingness to purchase lower emissions vehicles for the time being.

The obvious caveat to this scenario is that this situation may not remain the case indefinitely. If the unit cost of EVs and other low emissions vehicles falls far enough, this would enable governments to rein in the cost of supporting such technologies, with low carbon cars, vans and trucks competing directly with their internal combustion engine counterparts. For
fuel consumption in road transport, the largest contributor is in the heavy duty vehicle (HDV) segment. Countries with fuel efficiency and greenhouse gas emissions standards for HDVs include US, China, Europe, India, Japan and Canada.

Technology is playing catch up. But manufacturers are racing to produce more capable EVs and governments will eventually withdraw subsidies. Meanwhile, cost will probably remain a major consideration for consumers.

However, in cities concerns over urban air quality along with prohibitive legislation on conventional transport fuels such as diesel are of greater concern. Diesel may outperform gasoline on greenhouse gas emissions but it lags in terms of local air pollutants.

Diesel vehicles have become a target for policymakers across Europe. Engines powered by the fuel were lauded in the 1990s and 2000s as a way to reduce greenhouse gas emissions and improve efficiency.

Many European governments put incentives in place for consumers to switch to diesel from gasoline engines. However, this trend began to change, even before details of the Volkswagen engine emissions scandal emerged in 2015.

All mass-produced cars sold in the EU from September 2015 must meet the Euro 6 standard, which limits harmful air pollutant emissions from cars and vans and new rules seek to enforce real-world driving emissions standards.

France announced in July 2017 that it would ban sales of all gasoline and diesel cars by 2040, and the UK
followed suit later that month in announcing the same target and time-line. However, the delivery of such long-term targets would have to be achieved by future governments.

These goals have been driven in some cases by legal action against governments that have been failing to meet EU air quality targets, as well as a general growing awareness of the health impacts of toxic air in cities following the Volkswagen revelations. EVs are the obvious winners from these regulatory shifts.

Europe has been a self-styled global climate leader, pushing decarbonization policies since the mid-2000s, including an EU-wide carbon emissions cap-and-trade system since 2005. Other measures include the EU 2030 renewable energy and energy efficiency targets, and national energy policies to phase out coal from electricity generation. Of the total greenhouse gas emissions left unregulated by Europe’s carbon market, transport contributes 35%.

Passenger cars and light commercial vehicles have been subject to a CO₂ regulation in the EU since 2009. Initially, the target was set at an average of 130g CO₂/km for new passenger cars for 2015, and this was tightened to 95g CO₂/km for 2020. Many see transportation as a sector where further progress can be achieved on reducing greenhouse gas emissions, particularly in light of the 2015 Paris Agreement on climate change. The accord entails periodic stock-takes of global progress on meeting a two degrees Celsius limit on global temperature increase by 2100 from pre-industrial levels.

By comparison, the US EPA 2016 standards for light-duty vehicles require LDVs to meet an estimated combined average emissions level of 250g CO₂/
mile (about 153g CO₂/km). China has standards for air pollutants in LDVs similar to Euro 5 standards, but not greenhouse gases, which apply to new vehicles sold in China in January 2017 for gasoline and January 2018 for diesel. More stringent China 6 standards will apply in 2020 and 2023.

Industry bodies are also pushing for change. VDA, Germany’s automobile association, argues it will not be possible to maintain the speed of CO₂ reduction achieved in the past by further optimizing the internal combustion engine. A more fundamental shift to low-carbon forms of transport will be required, which could include EVs, fuel cells, compressed natural gas (CNG) and liquified natural gas (LNG).

“The legislators should encourage market penetration of vehicles with alternative powertrains. On the one hand, this has a positive impact on CO₂ emissions from road traffic, and on the other may generate faster economies of scale, which then makes vehicles with alternative powertrains competitive even sooner,” said the VDA in a recent report.

European leaders fear that the US and China have already taken the lead in developing new low-emissions car models. They may want to use legislation to protect the strategic industries and support vehicle manufacturers in the development of technology such as EVs, or hydrogen fuel cells.

Europe’s share of the global passenger vehicle market has been hit hard, falling to 20% in 2017 from 34% before 2008, according to the European Commission.

Cleaner air is a bonus of the transport revolution for Europe’s regulators. However, on CO₂ emissions, the contribution made by EVs is dependent on decarbonizing the electricity generation sector – a goal that has only partially been achieved so far.

The European Commission (EC) released the EU’s Clean Mobility Package in November 2017, which includes new targets for EU fleet-wide CO₂ emissions of new passenger cars and vans that will apply from 2025 and 2030, respectively. For both new cars and vans, the average CO₂ emissions will have to be 30% lower in 2030 than in 2021, according to the proposed regulations.

The proposals will be boosted by financial instruments to ensure swift deployment, and the package includes the Clean Vehicles Directive, which seeks to promote clean mobility solutions in public procurement tenders, providing a boost to demand and deployment, according to the EC. In addition, the EU in December informally agreed rules on energy use in buildings that require EV charging points to be installed in car parks.

European transport regulators have also signaled they are open to fuel cell and hydrogen vehicles, and EU officials are working on ways to allow the market to pick the best technology for each case. Helping to reduce the region’s Eur1 billion/day fossil fuel bill is another incentive.

As is the case in all regions, there are limits to the extent governments will be prepared to fund the uptake of low-emissions vehicles, bearing in mind the need to control public expenditure and maintain tax revenue streams from the use of liquid fuels. If the cost of EVs and other clean vehicles falls far enough to compete directly with combustion engines, it is reasonable to expect governments to scale back financial support mechanisms for them.

Low emissions vehicles could eventually upend the market for internal combustion engines, but they will only be a game-changer if the cost of EVs and other alternatives comes down to a point where they can compete directly. Until then, uptake of low-emissions vehicles looks set to be determined by government support frameworks and policies.

However, EVs still hold the potential to transform the energy sector, according to Professor Paul Stevens, a senior research fellow and international oil markets expert at the Royal Institute of International Affairs at Chatham House in London.

“I’m a great believer in the potential for EVs. Transport is only one part of a much bigger transition to a low carbon economy. But it’s a big part, with major implications,” said Stevens in an interview with S&P Global Platts.
Thought leaders: Bold Baatar, Rio Tinto

The global mining view from Rio Tinto

S&P Global Platts interviewed Bold Baatar, chief executive, energy and minerals, Rio Tinto about how the transport evolution is creating opportunities and challenges for global miners.

By Andy Critchlow and Diana Kinch

What does the growth of EV transport and alternative forms of mobility mean for global mining companies such as Rio Tinto?

When you unravel the numbers on a global scale, the fleet is 1 billion cars so by 2030 we’re assuming about 1.2 billion to 1.3 billion cars. There are annual sales of about 100 million cars per year so that potentially grows to about 120 million by 2030 and that’s not far off. It’s going to come around really fast. Of the new sales that are going to occur per year over that time, the range of estimates for electrical vehicles is anything from between 10 to 30 million so the penetration of the global total is anything between 15% and 25%.

In the mining space that’s very important context. Iron ore is globally about a $120 billion industry. Copper is about another $120 billion industry. There is gold, which is probably another $100 billion. Then the next is probably aluminum, which is a little less than $100 billion. So these are four mega products. The next material is nickel and that’s only $20 billion so when you think about the global mining wallet share those four big commodities take such a big space in an $800 billion total industry.

Then you look at lithium today and it’s probably only worth around $2 billion.

I know there is a lot of excitement around lithium but in the global mining space even if lithium quadruples it’s only going to be $10 billion of an $800 billion industry. So the largest growth is probably going to be in copper. Electric vehicles are going to take on 90 kilograms of additional copper compared to an internal combustion engine car. What is an additional driver are the recharging stations, which could add another potential 50 kg. Electric vehicles are actually more about copper.

What are the dangers of shortages in supply of key battery and EV materials such as cobalt, lithium, rare earths and copper for prices and investment?

Copper prices will be volatile. The challenge with copper unlike iron ore is that you have to invest in drilling to prove out the reserves. In iron ore you already know the largest formations in the world. In copper it’s harder and is a bit like looking for a needle in a hay stack so the supply in copper in the future is a question. The other one is aluminum. Batteries themselves will take an additional 40 kg of aluminum because the casing and the light structuring of EVs will mean it has more of the metal than cars today.
Will growing demand for these minerals trigger a new super-cycle in metals commodities?

It’s very difficult to see. There is a certain demand upswing coming for sure for copper but is it a super-cycle coming for some of the other commodities? I just don’t know. If you look at what happened in the previous super-cycle it was the mass urbanization of China and we don’t see another China scenario emerging. Electric vehicles are more about a very special group of commodities rather than a broader mining super-cycle that you saw across all commodities previously.

How is Rio Tinto positioned to meet rising demand from EV production and how will these new forms of transport inform the company’s strategy going forward?

Our strategy is very consistent. It’s low cost, long life and expandable. Lithium is the second most common element in the earth, it’s like iron ore. We’re the leader in iron ore because we’re the lowest cost. So our strategy is very simple. It’s not about deficits of the actual commodity, it is about the cost position of that commodity verses the demand fluctuations. So it’s very important in lithium for Rio to be the lowest cost producer.

We do have an initiative within Rio Tinto Venture where we’re looking at the low carbon future for metals and minerals and what will be in high demand. Of course that includes lithium, which is an extension of our existing portfolio. The other types of metals are high-purity nickel, and then of course there is demand for cobalt, but reliance on DRC (Democratic Republic of the Congo) is a risk for the industry. However, having said that there are other battery technologies that are looking to reduce cobalt not completely but reducing the average graded content. We’re looking at a number of areas but again it has to be consistent with our overall strategy and create value for our shareholders. We want to be in the long life, low cost and expandable category in any scenario.

How important a role will coal play in meeting energy requirements for EVs through to 2040?

We have exited our thermal coal business so it’s not part of our portfolio currently and we don’t have any particular insight into its future as part of the energy solution. But the reality is that you probably can’t completely replace it in the energy mix. However, a lot of people talk about battery recycling. Before it gets recycled after being taken off your car it becomes a storage unit and goes into a recharging station. In theory, when you drive up in your EV you’re not going to be drawing power from the grid at peak rates; you are going to be drawing power from the storage units. So the lithium-ion batteries have a second life in storage, which creates a new source of power in that mix. It could help to manage the peak to trough volatility of power generation and hopefully reduce the volatility we have today.

What other investment opportunities do you see opening up for mining companies to meet rising demand from EVs?

We have products like monazite which we’re selling out of Madagascar. It’s a bi-product of our mineral sands. Monazite contains neodymium which is a heavy magnet component that’s used in EVs. So suddenly we have a portfolio of smaller minerals that currently are already in our existing mining operations which we need to make sure we see through to capture the full value.

What are the risks the EV industry poses for conventional metals such as iron ore?

For steel I think it’s going to have some impact but steel is also always growing with population growth. We’re not seeing any kind of structural decline. Two things will offset any possibility of decline. One is the total number of vehicles on the road. Secondly, the penetration of electric vehicles will still be pretty low at 25% of the global fleet and the rest are still going to have heavy steel components, and then the other part of it is that the world will need infrastructure.

Will growing EV mineral demand see changes to the way some commodities are traded?

The pricing of nickel could definitely change. The way it’s priced today, there is a heavy pig-iron component that is more of a steel pricing mechanism and obviously it’s heavily influenced by the steel industry. Battery nickel though is absolutely high-purity nickel and at some point there will be a bifurcation of high-purity nickel in pricing verses nickel pig-iron because you’re pricing the same something that is 18% nickel as something that is 99% pure and these are really two different products.

Will there be new greenfield projects to meet demand from next year?

The board is going to be approving Jadad, our potential lithium project in Serbia, next year so I think at some point that could be fully up and running in five years. So greenfield projects are certainly going to come in that space. But we have to finish the feasibility study first which determines the size of the operation. We hope it could be up to 50,000 tonnes of lithium carbonates in a world of currently 200,000 tonnes that potentially grows to 500,000 tonnes or 800,000 tonnes. It’s not a small operation so in lithium we’re going to have to make a decision but there is no question about the reserves.
Disruptive forces

EVs will have widespread impacts on multiple industries. Disruption will extend from automotive to utilities, oil and gas, refining and metals.

Electric vehicles (EVs) clearly qualify as a disruptive force, but what is most interesting is how many industries could be roiled by greater penetration of EVs over the next decade. At a minimum, the regulated power, metals, oil and gas, and automotive sectors will face significant credit consequences from an increased number of EVs on the road, and, to be sure, the impacts could vary widely based on geography.

Oil and gas

At first sight, companies in the oil and gas industry look like the biggest losers from the shift to EVs. In a world without internal combustion engines, demand for oil products such as gasoline and diesel could evaporate. But while the adoption of EVs is a growing reality, in the next few years global oil demand also looks likely to continue growing, potentially above 1%. The rate at which EVs are adopted in the coming years and decades is absolutely critical — and highly uncertain — but it’s not the only factor.

For oil producers, growth in demand from emerging markets for transport remains the larger factor in the near term, as 47% of crude oil is currently used in road transportation. The 1 million EVs sold in 2017 compare with total global car sales of 80 million. S&P Global Platts Analytics has pointed to oil demand loss of 20,000 b/d for each additional million EVs. Even if assuming a growth to annual sales of 11 million cars in 2025, the total impact is going to be about 220,000 b/d, compared with current production of about 95 million b/d.

We see oil focused producers with reserves at the high end of the cost curve as most exposed. While producers have focused on shorter cycle developments, including shale, in recent years of low prices, the investment profile is also important. A high cost development could still be economically attractive, if the costs are front loaded and the long-term investment needs to maintain production are low. As demand and potential returns wane and companies pull back on investment, free cash flow generation could actually increase. Such a lack of reinvestment can’t ultimately support a sustainable business model, however.

In our view, the long lead time until EVs take over will allow the oil majors to look for alternative growth routes, with more focus on gas and renewables. These two energy sources are well placed to meet some of the increased demand for electricity from power producers as a result of EVs. Gas makes up about half of the reserves and production of the five supermajors.

Oil refineries also face a potentially painful transition over time as both demand for their oil products softens and declines, and as the mix of products
changes over time. Many refineries can only make relatively modest changes to their product slate. Changing their configurations to produce, at first, less gasoline, then also likely less diesel, even where possible could involve material investment, which might not be economic. We note that, over time, the age of many OECD refineries could result in capacity closures that offset some demand weakness. For refiners, as well as producers, the rate at which these different dynamics evolve will be critical.

Regulated utilities

For US utilities, the electrification of transportation presents growth opportunities when pursued in a credit-friendly manner with adequate regulatory support. It could be a solution for utilities to counter slumping electricity demand by generating additional revenue streams. We expect growth to be two pronged, resulting from an increase in electricity demand as well as from higher capital investment in electric vehicle supply equipment (EVSE) or EV charging infrastructure.

We believe greater electricity demand from drivers will result in moderate growth, with any meaningful increase in consumption accruing over about five to seven years or longer. We project EV-induced load, in aggregate, to remain less than 5% of total projected load growth from 2018 through 2035. This estimate includes projected demand from battery plug-in electric light-weight vehicles, but excludes recently announced electric heavy-duty trucks. Large-scale production of electric heavy-duty trucks has the potential to increase demand over and above our current projections. With load from EVs contributing about 1%-4% to total projected load over the next 15 years, EV-related consumption is not likely to be a major growth contributor to overall electricity sales in the sector.

Electric utilities appear positioned to participate in EV infrastructure development. Utility companies in Georgia, Massachusetts, Kentucky and Washington, in collaboration with state regulators, are in the process of launching pilot EV-charging infrastructure programs to comprehend and address the technical and regulatory issues. However, over the next few years, large-scale deployment is expected to be limited to California, where the state’s three largest investor-owned utilities are ready to spend close to a combined $1 billion over five years on EV infrastructure programs, subject to regulatory approval. The potential for rate basing of EVSE costs could result in utilities being more aggressive in installing the charging stations.

Metals and mining

The auto industry is one of the main customers of bulk commodities. About 25% of the total production of steel is transformed into car bodies. The long arching trend of improving the efficiency of cars led to a transition from commodity grade steel into a highly advanced composition, mixing the iron ore with other metals—and more recently, using aluminum, plastic and carbon fiber. Electric cars are not going to accelerate the shift to complex materials.

Currently, the auto industry is responsible for 5% to 35% of the main commodities. The introduction of electric cars will result in higher demand for commodities, but the impact of the swing will not spread evenly. We see three categories of demand: More abundant and cheaper commodities such as copper, aluminum and nickel; critical commodities for batteries such as lithium and cobalt; and energy and grid commodities such as coal and nuclear.

One of the main concerns in the market is that a healthy demand for EVs will be slowed down by the short supply of lithium and cobalt (each car requires about 60-65 kg of lithium and 3.8-4.2 kg of cobalt).

In 2016 the total mined cobalt was about 100,000 tons and could reach 200,000 tons or more by 2025, depending on different electric car penetration scenarios. Recently Glencore announced that it will double its cobalt production, aiming to produce 63,000 tons of cobalt by 2020. This increase is equivalent to about 7.5 million new cars.

With lithium prices soaring by more than 300% over the last two years, there are more than 20 lithium projects in the market in different stages, mostly executed by junior miners. While there could be a timing mismatch between the demand and supply, a scenario that will translate into oversupply of lithium in the next decade cannot be ruled out. It is important to mention that even a very sizeable hike in lithium prices will have only a modest impact on the price of a battery and on the overall demand for electric cars.
Disruptive forces
Looking further into the future, the change in the technology of batteries may lead to some changes in the battery composition and to slightly less demand for specific commodities, with cobalt being the main candidate to be replaced with nickel.

Most of the major miners have a sizeable exposure to copper and iron ore. We believe that the demand for EVs will result in higher demand for copper, resulting in high prices and profitability. As of today we expect a shortfall of copper taking place in 2019 without any large-scale projects coming online. On the flip side, the exposure of the major miners to rare commodities is rather small (for example, the contribution of lithium to Rio Tinto’s EBITDA is less than 1%).

On the other hand, companies such as Eurasian Resources Group will be the immediate winners. The company is about to launch a tailing reclamation project in the Democratic Republic of the Congo, and with current prices it is estimated to have abnormal returns. Other junior miners with sizeable projects include Montero Mining in Namibia, Kodal Minerals with a project in Mali and Premier African Minerals with a project in Zimbabwe.

Automotive

In China, electrified new vehicles could expand to represent 35% of new car sales in 2026 under the stimulus provided by the new carbon scheme to be introduced in 2019. We estimate that, in Europe, battery EVs and plug-in hybrids will account for about 25% of light vehicle sales by 2025, with the number closer to 10% in the US, as technological advances will lead to a more cost-competitive proposition. Given our expectations for ongoing technological improvement, the two most important factors that could fuel higher consumer demand for EVs, relative to our expectations, will be the extent of government subsidies and reductions in battery costs. Nevertheless, the key challenge for original equipment manufacturers (OEMs) is how deftly they can share the responsibility of developing new technologies with their suppliers without relinquishing the core value of the vehicle in consumers’ eyes. While some OEMs may still opt to manufacture electrification equipment themselves, we expect suppliers to start playing a much bigger role too.

There is also the possibility that other disruptors, such as autonomous vehicles, could have similar and even greater impacts over time. Beyond EVs, autonomous vehicles will drive the next phase of disruption in the infrastructure space. Full-scale testing of self-driving vehicles without human control is being done by a number of companies now. Clearly how people travel has been changing, as a result of ride-sharing, new offerings from transport network companies, such as Uber or Lyft, and is about to get even more interesting. Similarly, large US shippers, distributors and retailers, such as UPS and Walmart, are placing orders for new transport technology, such as Tesla’s heavy-duty electric tractor trailer truck, that will upend how goods and services are delivered to customers.

Importantly, though EVs are likely to have a dramatic impact on the landscapes of several industries, any ratings actions are likely to be longer term in nature, and, at this point, remain subject to the actions of management teams; additionally, the effects are likely to vary greatly by region, depending on a variety of factors. Still, a focal point of ratings surveillance is ensuring that the full impacts of disruption are captured. The coming years will determine which companies have best positioned themselves to compete in this changing framework.
Interconnected

How will power grids manage rising demand from electric vehicles? There is a solution but it requires careful planning, a mix of technologies and, crucially, buy-in from drivers.

- Fast charging an EV can double a household’s instantaneous power demand
- Indiscriminate recharging will test local network stability
- Smart charging smooths peaks, can deliver system benefits
- Drivers need incentives to hand over charging control, losing refueling flexibility
- Fast-charge stations essential complement to home trickle charge

Fast-charging an electric vehicle at least doubles the average household’s instantaneous load, whether in Europe or North America, placing significant new demand on local distribution circuits.

In a world where almost all cars are electric, the prospect of millions of residential charge points pulling on the grid simultaneously is exercising system operators and prompting suppliers to warn of higher electricity tariffs if charging is unmanaged.

Even at relatively low numbers, indiscriminate EV charging during peak periods is going to congest local transformers and disrupt voltage levels. As such the network management of EV demand is a critical factor in the transition to alternative transport.

While seen as a challenge that could well require expensive infrastructure fixes, the EV transition may also present an opportunity for network operators charged with adopting smarter technologies to manage future volatility in distributed supply and demand.

Adoption of smart charging is the key. Smart charger technology allows a normal charging cycle to be altered by electricity price and control signals, integrating flexible EV demand into the power system.

Using bi-directional communication, smart charged EVs respond to time-of-use hourly pricing signals according to grid and market situations. The control mechanism can be enabled by the grid, by the charging point or by the vehicle itself.

Smart charging will shift EV demand toward off-peak periods, trimming peak demand, boosting baseload plant run times and diurnal storage of renewables, and minimizing network investment. Over time and as technology evolves, mass EV batteries could offer further flexibility by releasing stored power back to the grid or the home.

This level of intelligent load management is a vision, not a reality. Crucially, smart charging will only be possible if customers receive
clear financial benefits that encourage them to hand over some control of when and how they charge – in effect trading refueling flexibility with savings.

**Need for speed**

The nature of charging is another critical swing factor for networks. At the residential level, anything faster than trickle charging over several hours is going to require uprated domestic electricity infrastructure – current connections simply cannot support fast charging.

A typical EV such as the Nissan Leaf with a 30 kWh battery takes four hours to charge from empty using a 7 kW home charging point connected to a standard single phase supply (230 V, 100 A), according to UK charge point manufacturer Pod Point.

A 7 kW charger provides the average EV with 30 miles of range per hour of charging. Boosting this to 50 miles of range per hour requires a 22 kW charger – and in the UK, this would need a (potentially expensive) upgrade to a three phase power connection (400 V, 3 x 100 A).

If fast-charging forecourts become as numerous and accessible as current gasoline forecourts, however, then the need to improve domestic charging speeds via costly connection uprates diminishes. This appears to be a more achievable outcome, even if it still requires significant network planning and investment ahead of mass EV adoption.
Interconnected

Managing peak demand

In volumetric terms, the EV revolution appears to pose achievable goals for generation supply, but also potential challenges during peak demand periods. Under the upper forecast in the International Energy Agency’s World Energy Outlook 2017, the global number of light duty EVs rises to 240 million by 2040, consuming 532 TWh/year or 1.55% of 2040 electricity demand.

If the number of heavy duty EVs grows at a similar rate, to reach 39 million in 2040, they would consume about 2,700 TWh/year, 7.85% of 2040 electricity demand.

This is a material increase, but one the power industry should take in its stride. Global electricity generation grew by 2.2% in 2016 alone, and this was below the 2.8%/year 10-year average reported in BP’s Statistical Review of World Energy 2017.

Analysis done for the whole of Europe shows that, even if all cars on the road were electric today, the electricity system could cope with the resulting 24% (802 TWh) increase in demand, but only if charging was carefully managed.

If not, then the management of peak demand on networks already facing growing intermittency quickly gets out of hand.

Peak demand is the maximum amount of electricity required at any one point in the year. For northern European economies this occurs on a winter weekday evening in December or January when homes need light and heat and before factories and offices close.

Add EVs and the impact could be dramatic. Studies show indiscriminate charging could boost peak demand by a third to a half by 2050. Conversely, smart charging that pushes demand to off-peak periods could limit the increase in peak demand to 10% or less to 2050.

Quantifying costs/benefits

A German study illustrates the range of outcomes facing one developed economy likely to embrace EV adoption.

In line with EV targets announced by German carmakers and the UN’s...
Paris Climate Agreement, the study assumes 5.7 million EVs will be on German roads by 2030, and 25.4 million (about half the German car fleet) in 2050.

Unmanaged charging of the EV fleet increases peak demand by 5.5 GW in 2030 and by 21 GW in 2050, compared to a system peak of 65 GW without EVs.

With smart charging the increase in peak demand is completely avoided in 2030 and minimized in 2050 to 3 GW, the study says.

In terms of cost, the difference between unmanaged and smart charging translates into a Eur350 million/year (about $424 million at current rates) net cost versus a Eur140 million/year net benefit for the German power system in 2030.

By 2050, the costs have quadrupled to Eur1.35 billion in an unmanaged scenario versus Eur110 million in network benefits in a smart-charging scenario. Smart charging savings flow from avoided network and generation investment, not to mention avoided peak prices for consumers.

With managed charging, disruptive system loop flows are reduced and surplus wind and solar power is absorbed rather than curtailed at cost.

In short, the power sector is enthused rather than cowed by the prospect of an EV boom because EV batteries are large and dispatchable. An EV may need to charge for two hours every night, but those two hours can be moved around within a 12-hour window.

Fast and slow

UK research suggests there are significant provisos to this analysis. Today’s top-of-the-range EV has a 90 kWh battery and can travel 300 miles on a single charge. This may be the standard size of battery in the future as prices drop and range expectations are met, according to UK transmission system operator National Grid.

Domestic recharging of such a large unit takes several hours and, as noted, may require expensive retrofits to the local network. Ideally, then, off-street domestic recharging would be limited to topping up every night via a 3.7 kW charger – akin to boiling a kettle.

Even at this modest level of recharge, once 40% to 70% of households have EVs a third of the UK’s low voltage local distribution networks (312,000 circuits) will need reinforcement, National Grid says. Push the size of rechargers to 7 kW, a size already available and soon to be prevalent, and the problem gets worse – even with smart charging.

National Grid’s solution? Back to the future – a national network of “a few thousand” large, fast-charging forecourts with drivers taking minutes to “fill up.” These EV charging stations will need 3 MW to 7 MW of capacity with a direct connection to the distribution network.

Achieving this, National Grid warns, will require someone (car makers, supermarkets, existing gasoline station owners, or perhaps networks and power suppliers working in tandem) to take the lead.

The bottom line: large battery EVs will not become commonplace unless there are sufficient fast-charging stations to service them, no matter how many residential charge points there are.
What is Groupe PSA’s baseline expectation for the penetration of electric vehicles (EVs) during the coming decades?

By 2020, intense pressure to reduce carbon dioxide (CO₂) emissions will require the development of a range of electrified powertrains. Groupe PSA plans to roll out an electrified version, plug-in hybrid electric vehicle or battery electric vehicle, of each new vehicle starting 2019. As a matter of fact, our multi-energy platforms strategy enables us to offer an electrified version of 50% of PSA personal cars by 2020 and more than 80% by 2023. Thus, we will significantly and sustainably increase our sales of EVs with a forecast of 15% of our global personal car market share sales by 2025, and 25% by 2030. This penetration of EVs will of course be linked to an active participation of the public authorities.

What barriers do you see facing the large-scale roll-out of EV technology?

Groupe PSA will be ready with a large offer of EVs by 2020. However, the deployment cannot be done without the active participation of the public authorities. The large-scale roll-out implies a guarantee of a wide deployment of the charging stations network.

PSA will focus on mastering the value chain, from design to production of electrified vehicles, delivering the most efficient technologies to maintain the technological leadership already acknowledged in internal combustion engines, and extend it to the field of EVs, and managing the energy transition of its industrial facilities as intelligently as possible.

The deployment of the electrified market will only be possible if the public authorities take an active part, notably in terms of infrastructure and energy supply.

Do you have any concerns about the future supply and availability of commodities involved in EV production?

Strategically, of course, we are careful on the supply and availability of all the components involved in our vehicle production. It becomes even more important when we talk about some strategic components, such as batteries, for example. From this perspective, we work of course with the Asian suppliers. We are also part of the EU Battery Alliance initiative, which is being defined in order to develop a sustainable and competitive battery supply chain in Europe.

What other behaviors and technologies does Groupe PSA expect to have a tangible impact during the coming decades? For example, do you foresee autonomous vehicles or ride sharing to changing the industry in a similar way?

We are facing a progressive transition from automated to autonomous cars.
The cost of autonomous cars will limit their market share in the next decade, starting with premium models. We don’t foresee a major breakthrough in the market. The technological challenge for this feature remains huge.

After designing and manufacturing cars for more than a century, we must now develop and offer personalized services. To take up this challenge, we can rely on our agility, which is a core value of our group. We made it stronger by developing new tools in order to become a key player in the new ecosystem. For instance, we created our Business Lab to detect, test and transform opportunities into new businesses for the group, especially for mobility and digital challenges. It is paramount to combine the spontaneous innovation of startups, and the strength of big partners like Huawei, for its “internet of things” platform, or Nidec Corporation, for automotive electric traction motors.

We are also reinforcing our position at the forefront of data management, which is crucial lever of future mobility. Today, humanity produces more data in two days than were produced in total between 1989 and 2003. The forthcoming 5G technology will accelerate this trend, which should allow vehicles to communicate permanently with their environment, car-to-car and car-to-infrastructure, with a clear contribution to strengthen both the fluidity and the safety. If we want the car to provide freedom to move, data collection and security will be the major challenges. Data protection is key for us and we have nominated a dedicated PSA compliance person on this matter, who will represent the customer inside our company.

Regarding mobility services, we envision that urbanization, lifestyle digitalization and regulation will bring more and more customers to use car sharing services. We can witness this trend firsthand, through our brand dedicated to mobility services, called Free2Move, and successes such as the emov [car sharing joint venture] in Madrid. What strategies are you adopting to ensure you remain equipped for future changes in mobility over the coming decades?

Freedom of movement is what guides us every day. We made it the central pillar of our Push to Pass strategic plan, which is geared towards meeting the new needs of our customers. To make sure the young generation can access mobility, we switched to a new perspective: we do not think about cars anymore, we think about mobility. Our strategy is clear and customer oriented. We want to be both a great car maker and a preferred mobility provider.

Concretely, we propose a portfolio of solutions adapted to each customer needs. Our Free2Move [car sharing] platform ensures our customers smooth and efficient mobility, every day and everywhere. We must bring solutions to support our customers throughout their lives, be it for new cars, used car maintenance, car sharing or fleet management. We are convinced human beings will continue to look for comfort, convenience and safety. Groupe PSA will be able to offer its customers a diverse line-up of technologies that meet all of their sustainable and responsible mobility requirements.

Our customers’ requirements evolve also from ownership to usage. That’s why we are developing new mobility solutions and services. The autonomous and connected car goes beyond the imagination, inspiring dreams, hopes, questions and fears all at once. But it is also a major development in road safety. It will eliminate human error, which is currently the cause of more than 90% of accidents, while making roads safer.

What are the most exciting new technologies you are working on?

All the developments of new technologies accompanying our customers’ expectation changes are exciting: energy transition towards a cleaner mobility, but also connected and autonomous cars to address new usages.

Two major changes are reshaping the way our society understands and experiences mobility.

First, customers move from the property to the experience: fewer cars are owned, but they are more shared than ever. The rise of new collaborative practices like car sharing shows us that customers want a mobility that combines individual movement and social bonding. Cars are no longer a mere extension of oneself, but a rallying point to our peers.

Second, mobility has become a CO₂ challenge. Overall, transport emits 22% of CO₂ in Europe. With 13%, the car is at the level of CO₂ emissions from agriculture. It is our duty to constantly progress by making the most efficient use of the capacity of the automotive industry, which is made up of more than 250,000 engineers worldwide.

Tomorrow’s mobility will be more interactive, more entertaining, and more sustainable. Besides, developing mobility services lets us widen our customer base beyond car sales, to ensure we can address the widest public as a mobility provider.
Big Oil 2.0

Oil majors are standing by their core business of providing fuel for the transportation sector, but also aim to play a part in what they see as a long-term transition to alternative vehicle types.

- Doubling of vehicle fleet underpins strategies
- EVs seen making small dent in oil demand
- Engine improvement viewed as more significant
- Companies back wide variety of technologies
- Warnings on under-investment in oil

The world’s biggest oil companies are talking about electric vehicles (EVs) as never before. But they remain committed to the internal combustion engine.

Striking a balance between their past, and possibly radical future changes in transportation, will be key to future success.

The companies acknowledge uncertainty about the precise impact of electric and hybrid vehicles, but their forecasts, informed by business operations around the world, broadly align with bodies such as the International Energy Agency in viewing EVs as only slightly denting oil demand.

This leads some in the industry, such as Total chief executive Patrick Pouyanne, to warn that not enough is being invested in oil and gas – the IEA said last year it would be necessary to double rates of investment in conventional oil and gas to avoid a supply crunch around 2025.

“Many wish for a quick revolutionary role reversal between the oil and gas industry and the renewables and new electric industry, but an overly ideological approach could bring great economic and social damage to 6 billion customers today and 9 billion tomorrow,” Pouyanne told the Oil and Money conference in October 2017.

ExxonMobil — the largest of the publicly listed international companies — still remains particularly attached to oil despite investing in big gas projects in Qatar, Mozambique and Papua New Guinea. Oil accounted for 57% of the company’s production in 2017, compared with 50% for Shell, although gas has gained weight in Exxon’s portfolio in the last decade.

In its latest Outlook for Energy, which charts long-term trends, ExxonMobil raises its estimates of oil use in transportation compared with five years ago, to 60 million b/d in 2040. With the global “middle class” set to nearly double by 2030, ExxonMobil forecasts that the total miles traveled by cars and light trucks annually will rise by 60% by 2040, to 14 trillion miles. It sees oil use in light vehicles remaining relatively flat, largely based
on improved engine efficiency, but overall oil use in transport still rising inexorably, due to continued increases in the aviation, marine, rail, and above all truck sectors.

Irving, Texas-based ExxonMobil predicts there will be around 160 million plug-in and hybrid vehicles on the world’s roads in 2040 – probably less than 10% of the total – but acknowledges uncertainty given recent government policies supporting electric vehicles. However it still expects the vast majority of energy used in transport to come from oil in 2040 and argues that it is mainly gains in the fuel efficiency of conventional vehicles that will limit energy consumption, rather than electric vehicles.

By contrast S&P Global Platts Analytics’ reference case assumption is for 280 million electric cars in 2040. ExxonMobil estimates that oil demand will be reduced by 1.2 million b/d for every 100 million extra electric vehicles on the roads in 2040.

Electric strategy

ExxonMobil’s view of oil’s longevity is broadly shared across the industry. But big oil companies are preparing to meet growing demand for power in transportation. Shell, along with being a leading LNG provider and targeting power demand in Asia, has made several direct investments in EV recharging, buying vehicle charging company NewMotion, which has charging points in Western Europe, last year.

The Anglo-Dutch major has also signed a collaboration deal with fast-recharging operator IONITY, a joint venture among several European car makers. Even in developed countries fast-recharging could be vital for EVs as they come up against limitations in power infrastructure.

The move comes as Shell’s home country, the Netherlands, plans for all new cars to be emissions-free by 2030. Meanwhile, Shell continues to champion alternatives to EVs, particularly hydrogen vehicles, which it argues have advantages over electric vehicles, particularly speed of refueling and range.

The largest publicly traded producer of liquefied natural gas (LNG) is also matching its upstream commitments by providing LNG fueling facilities for trucking and shipping. Shell argues that governments should penalize emissions, rather than backing or banning, particular technologies.

But ultimately Shell also remains convinced of the need for oil. In comments last July, its chief executive Ben Van Beurden — who plays up his EV-driving credentials — played down the idea of oil demand peaking in the late-2020s. Van Beurden argued that investment in oil would still be needed even in the unlikely event of a complete switch to EVs in developed countries.

“We still have less advanced economies that cannot simply make that switch, that do not have the electrical infrastructure to do so, do not have the wealth to do so, and therefore they will go slower,” he said.

Banning conventional vehicles in advanced economies could also end up stifling innovation in engine design, to the detriment of standards in less advanced car-producing countries, Shell’s chief energy adviser and head of its energy ‘Scenarios,’ Wim Thomas, has warned. “You could make a scenario whereby if you have a very high uptake of electric vehicles, you have less efficiency improvement to the internal combustion engine,” Thomas told journalists in September.

Motoring expansion

BP is especially cautious on electric vehicles, although it made a $5 million investment in a manufacturer of mobile fast recharging systems, FreeWire, in January. BP’s 2017 Energy Outlook predicts there will be 1.8 billion cars on the world’s roads by 2035, thanks both to rising prosperity and better infrastructure. On the take-up of electric vehicles it acknowledges that
uncertainties include the role of governments in tightening vehicle standards and banning conventional vehicles, falls in battery costs and the prospects for autonomous vehicles.

The British oil major’s conclusion is that switching to EVs is likely to impact liquids demand by just 1.2 million b/d in 2035, compared with a 17 million b/d reduction achieved through improvements in engines. Overall, the company expects oil demand for cars to rise by 4 million b/d in 2015-35, to 23 million b/d.

Away from their long-term economic forecasts, oil companies are in some cases funding of well-publicized alternative energy projects. But their commitment to these schemes is mixed. European refiner OMV also highlights the gap between ideals and the real world.

At last November’s ADIPEC conference in Abu Dhabi, OMV chief executive Rainer Seele noted that European diesel consumption had been buoyant despite the backlash against diesel cars after the VW emissions scandal. His comments partly reflected OMV’s customer base in some poorer parts of Europe, where aging cars predominate and regulation is less stringent.

Seele argued that oil prices fluctuations had also played their part, noting that diesel consumption had increased as more goods were sent by truck, and rail freight struggled to compete.

Seele predicted European consumers, worried by the limitations of pure electric cars, would continue to hedge their bets and favor hybrid vehicles. EVs may be popular “in the political class, but nobody is really raising the big challenges waiting for the industry,” he said.

Climate change

EVs and climate concerns are inextricably linked in the public’s perception. The connection is also changing the behavior of Big Oil.

All the major oil companies are putting some money into renewable energy. Shell — with one of the highest research and development budgets in the industry — recently backed a project that involves using waste coffee granules as a biofuel in London buses. Total invested over $1 billion buying industrial and vehicle battery manufacturer Saft in 2016. Likewise, BP boasts its involvement in wind and biofuels projects. The company recently backed a scheme to make low-carbon jet fuel from municipal waste.

Despite these moves, the companies are making only limited changes to their overall strategies in response to climate change — including government bans on conventional vehicles. And their energy forecasts for the most part are skeptical about electric vehicles, stressing that improvements in the efficiency of the internal combustion engine will be more significant in reducing oil consumption.

And while many companies are devoting a bigger share of investment to gas and LNG — BP has a swathe of gas projects underway for example — this is probably not a reflection of fundamental doubts about oil. Instead it reflects expectations that gas demand will grow at roughly twice the rate of oil demand in the coming decades, and the less mature LNG market has particular potential.

Pointing to an array of measures aimed at curbing emissions, BP chief executive Bob Dudley told the Oil and Money conference in October: “We’re making smarter, and in many cases, smaller bets, and making more of them across a wider range of technologies and business models. We think that’s the way to go given how tough it is to pick winners in this rapidly evolving space.”

Total’s Pouyanne was blunter: “Today we are considered an industry of the past by some people, but it’s not an industry of the past at all. We today provide 60% of the world’s energy requirement and I’m convinced we need to be more vocal about it.”
London black cabs plug in

Iconic taxi fleet to go electric over the next 15 years, reducing fuel costs and emissions in Europe's largest city.

- London begins electric conversion of over 20,000 diesel black cabs
- Key policy, funding initiative made conversion possible
- Geely Group 'green' bond, government grant funds LEVC's Horizon project
- Power source for EV charging has direct impact on environmental benefits
- A 30% cut in emissions from black cabs is expected by 2020

The alignment of government policy and green bond financing is expected to transform London's diesel black cabs into a plug-in electric service starting this year with completion by 2032. It's an important step toward reducing London pollution that is almost double the maximum level under the World Health Organization's air quality guidelines.

Trucost, part of S&P Dow Jones Indices, analyzed the potential environmental benefits of this transition over the next 15 years, focusing on carbon savings and pollution reduction from introducing a more sustainable type of taxi.

London black cabs are an iconic symbol of the UK's capital, with over 20,000 vehicles on the road every year. Until recently, all London black cabs have been running exclusively on diesel, emitting large amounts of carbon dioxide (CO₂) and air pollutants. This is potentially set to change though, with the new TX model, developed and manufactured by the London EV Company (or LEVC, formerly called the London Taxi Company). Backed by a $400 million bond issued by its

![Image of Anna Shkuratova]

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Use your smartphone to scan code or visit platts.com/transport-black-taxi to watch Anna Shkuratova and Diana Kinch going for a ride in a brand new London electric taxi.

![Graph showing carbon emissions from London black cabs 2007-2017]
parent company, a Chinese automaker Zhejiang Geely Holding Group, the company launched the first fleet of zero-emissions capable (ZEC) black cabs on 5 December 2017.

This is the first offshore green bond issued by the Geely Group, the net proceeds of which supported LEVC’s Horizon project to design, develop and manufacture the next generation of the London taxis. The project was also supported by a grant from the UK government. LEVC has launched 150 vehicles on the market at the end of 2017, with the aim of completely replacing the diesel version of the cab by 2032.

This falls in line with the Mayor of London’s Taxi and Private Hire Action Plan, designed to make London’s taxi fleet the cleanest in the world. From January 1, 2018, first-time taxi licenses can no longer be granted to diesel vehicles. To get a new license, the taxi needs to be either a ZEC vehicle, with CO2 emissions of no more than 50 gCO2/km and a minimum 30-mile zero emission range, or a petrol vehicle that meets the Euro 6 emissions standard. The regulatory change is to be followed by the creation of an Ultra-Low Emissions Zone, planned to come in action from 8 April 2019, which will require vehicles travelling in central London to meet exhaust emission standards or pay a daily entry charge.

Given that the current maximum age for older diesel taxis has been kept at 15 years, the planned transition to low carbon emission black cabs is expected to be finalized by the early 2030s.

So how does the Geely bond issuance potentially contribute to the low carbon transition of London black cabs? The key areas that Trucost focused on are the carbon emissions and the air pollution reduction resulting from replacing diesel cabs by plug-in electric vehicles (EVs).

Carbon emissions originating from the London black cab fleet are contributing to global warming, and diesel vehicles are the highest contributors in terms of carbon intensity, when compared to the similar capacity hybrid or electric engine. Burning fuel also leads to air pollution by releasing carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC) and particulate matter (PM) – which have an immediate negative impact on human health. Trucost took historic and current levels of carbon emissions and pollution as a baseline, and projected the potential environmental benefit from replacing diesel black cabs by a new TX model.

Carbon emissions

Over the past 10 years, there has been a 10% reduction in absolute carbon emissions from London black cabs. This reduction is due to both the evolution of taxi design and more stringent regulated emissions standards. For example, a new TXII model in 2007 that was compliant with the Euro-4 standard was emitting 244 gCO2/km, while the latest TX4 Euro-6 model was emitting 222 gCO2/km in 2017.

The most significant drops in carbon emissions occurred in 2013, as a result of switching to the Euro-5 standard, and over the period 2015-2017 after introduction of the Euro-6 standard. Despite the trend in decarbonisation of black cabs, the vehicles still emit a significant amount of carbon due to burning diesel. In 2017, all registered black cabs emitted 152,199 metric tons of carbon dioxide, which is represents 2% of annual emissions from all London transport.

The new model – TX – runs on a 31 kWh lithium-ion battery and a petrol-powered range extender, which provides an 80 mile (129km) EV range. TX would allow drivers
to recharge 60% of the battery, corresponding to an additional 50 miles, within 45 minutes using a 22kW fast public charging point. LEVC suggests three driving modes: “pure” – corresponding to driving using only electric power; “smart” – which changes automatically between the battery and petrol extender, and “save” mode that uses the range extender to save the battery.

Trucost evaluated the environmental impacts from three scenarios in line with the manufacturer's outlined modes, assuming an average annual mileage of 20,000 miles:

- Scenario 1: the taxi driver drives until the battery runs low, recharges and continues driving using the battery;
- Scenario 2: the taxi driver drives until the battery runs low, and continues using the petrol range extender for the rest of the day;
- Scenario 3: the taxi driver only uses the petrol range extender without switching to the battery.

The scope of carbon emissions accounted for in this analysis includes the direct emissions from the operation of the black cab, as well as the indirect emissions associated with generating the electricity to recharge the cars. As expected, Scenario 1 would result in lower annual carbon emissions – 4% less carbon than under Scenario 2 and 12% less when compared to Scenario 3.

It is important to note, however, that the source of the electricity used to power a battery has a direct impact on the environmental benefits from driving a plug-in EV. Unless the charging points are specifically powered by clean or lower carbon energy, the indirect emissions of a car will depend on how clean the location’s power grid is. If the electricity grid of a country is heavily fossil fuel based, Scenario 1 will not necessarily be the most carbon-optimal for the economy.

To illustrate, Trucost calculated the carbon emissions associated with driving the same TX model in several European countries. Exhibit 3 shows emissions from petrol fleets and electricity generation for several European countries when driving each of the three scenarios. Similar to the UK, the total direct and indirect emissions from driving a TX in France and Sweden using purely electric power are lower than switching technologies or driving using only a petrol range extender. Both France and Sweden have lower carbon energy grids, with the majority of their power generated from nuclear or renewable sources. However, in countries like Poland, Germany and Netherlands, where the grid is dominated by fossil fuels such as coal, emissions from generating power required to charge the battery will exceed fleet emissions for the petrol use under scenarios 2 and 3. However, the TX model still would emit less carbon than its diesel predecessor, the TX4.

**Air pollution**

Recent research published by Transport of London on the UK’s capital pollution levels shows that every part of the city is exceeding limits in the World Health Organization’s air quality guidelines, in particular PM2.5. The annual average for the city is almost double the maximum allowed level. The majority of London’s pollution comes from diesel vehicles, and London black cabs are among those contributors.

The typical pollutants in diesel exhaust gases are CO, HC, NOx and PM. While carbon emissions contribute to longer term impacts of climate change, air...
pollutants have an immediate impact on human health, resulting in respiratory and cardiovascular diseases, especially in the young and elderly.

In 2007, the amount of air pollutants from London black cabs (TXII model) was over 570 metric tons. The direct environmental and human health impacts of the pollution equated to $3.32m. The monetary impact reflects the loss of productivity, time spent in hospitals, and the cost of environmental externalities. The introduction of the TX4 model in 2009 resulted in air pollution dropping by almost half, mostly due to the reduction of NOx emissions, while the implementation of the Euro-6 standard in 2016-2017 regulated the maximum allowed pollution levels, including PM, for both diesel and petrol cars. Overall, for the period 2007-2017, there has been a reduction in absolute amounts of air pollution by almost six times. The monetary value of the environmental externalities has reduced by almost 96%. Based on government statistics, banning older (pre-2009) TXII model taxis could make a more meaningful difference than a like-for-like replacement of the existing fleet with plug-in electric cabs.

It is important to note, that while EVs do not have exhausts and are often advertised to emitting no PM, the majority of PM comes from brakes and tires. This means that using electric cabs would not eliminate as much air pollution as assumed. As with carbon emissions, the source of the electricity used to charge EV battery matters: any fossil-fuel based power used to charge the battery would contribute to the air pollution at the location where this power is being generated.

Trucost estimated the annual pollutant load of the new TX model, based on regulatory requirements and vehicles with similar engines and technologies. The results show that if all diesel black cabs were to be replaced by TX black cabs, the pollution would have reduced by 50% when compared to driving the TX4 (Euro-6) model in 2017, and by 80% from 2015 levels. The reduction would apply to all air pollutants, but toxic HC and NOx would be reduced the most.

**Overall impact**

By the end of 2017, 150 electric black cabs joined London’s roads, and a transition to move away from diesel taxis started. LEVC’s production plan is to launch 9,000 electric black cabs by 2020, and replace all diesel black cabs by 2032. The findings show that every time the new TX model replaces one diesel black cab, it could result in an 80% annual carbon emissions reduction and approximately 50% air pollution reduction. Based on the LEVC’s production plan and the Mayor of London’s Taxi and Private Hire Action Plan, a 30% reduction in carbon emissions from black cabs is expected by 2020, with a further 8% reduction by early 2030.

While the launch of the TX model significantly reduces carbon emissions and air pollution during the vehicle’s lifetime, the positive impact can be further improved by providing cleaner power to charge the battery. It is also important to make sure that sustainable technology is used to manufacture the vehicles and batteries, as well as for managing waste from end-of-life vehicles.
The road ahead

Whatever new directions transportation may take, fossil fuels are likely to dominate the landscape for years to come, argues Chris Midgley, Global Director of Analytics at S&P Global Platts.

Mark Twain is famously quoted as saying, “The reports of my death have been greatly exaggerated,” and so might one suggest has the demise of fossil fuels or the internal combustion engine!

Last year we saw another year of record new car sales, and, after three years of low oil prices, a continued trend towards larger passenger vehicles (SUVs and light trucks) and increased vehicle miles travelled per capita. In addition, with the ever growing population of middle income earners, air travel continued to grow (4.9%) and demand for goods and services has seen year-on-year increases in shipping (3.6%) and commercial road transport (2.2%) in 2017.

With growing urbanization and a buoyant global economy, this trend is likely to continue, providing strong “demand stickiness” for fossil fuels in the near term, which many commentators have failed to factor in when considering the future trajectory for oil demand.

Despite the sale of electric vehicles (EVs), including battery EVs (BEVs) and plug-in hybrid EVs, growing 55% in 2017 and the number of models increasing, their overall sales were less than 2% of total market share. Today, the 3 million EVs in the car pool displace less than 0.06% of total global oil demand. To date, fuel efficiency standards in conventional internal combustion engines have resulted in far greater demand destruction.

Without subsidies and high fuels duties or taxes, BEVs are likely to continue to struggle to compete on a total cost of ownership basis. Battery costs have declined significantly but have some way to go to get to below $100/kWh, where BEVs can compete in the mass market.

With the cost of critical materials such as lithium, nickel, copper and cobalt rising fast this is becoming increasingly challenging. In addition, many consumers have yet to get over the concerns of range anxiety, while charging infrastructure needs to improve to accommodate large-scale adoption of BEVs.

Governments continue to grapple with the trilemma of energy security, cost and lower greenhouse gases. Switching the entire transport system to electric mobility creates substantial vulnerabilities to energy security, unless large-scale storage solutions are included and cyberattacks on infrastructure and assets can be eradicated. Initial subsidies of BEVs are needed to gain early momentum and encourage investment into charging infrastructure, but this costs governments twice: firstly in the cost of the subsidies; and secondly in the loss of fuel duties/taxes, which in the UK alone generate $30 billion of revenue.
per year. These will need to be recovered by other means, either through higher taxation on electricity or perhaps a road miles tax.

Today’s legislation in Europe has predominantly focused on reducing new diesel car sales with a focus on air quality versus carbon dioxide (CO2), with bans on internal combustion engines being “pencilled in” for 2030. Alternative policy approaches, such as vehicle scrappage plans, would prove to be much more effective in improving air quality and reducing CO2 emissions today. The environmental performance of the latest highly efficient diesel engines has seen marked improvement down to levels comparable to EVs.

Switching to electric mobility before decarbonizing the grid weakens clean green claims by EVs, especially in parts of the world with high share of coal-fired power. With this context, talk of a transport revolution may seem exaggerated. Certainly for passenger vehicles, it is more likely to be an evolution given long fleet turnover times.

However, in places like China where a larger proportion of car sales are first-time buyers, the change may be far more dramatic, especially as China Inc. sees the opportunity to leapfrog technology and take the lead in the development of batteries, EVs and furthermore autonomous vehicles (AVs). The impact of the uptake of AVs is complex: vehicle miles travelled are likely to increase, but quicker fleet turnover could hasten ultimate efficiency gains.

Heavy duty trucks turn over more often and this is where the major revolution may occur. Today, dozens of countries have fuel efficiency standards for passenger vehicles, while just a handful have them for heavy duty trucks. Improvements in truck engine efficiency, better scheduling and reducing vehicle drag through design or platooning could all improve fuel efficiency dramatically.

Further reductions in CO2 emissions could be achieved though substitution to LNG or in duel fuel high pressure direct injection engines, which could use renewable ethanol or natural gas to get closer to net zero emissions. Electric mobility could be the solution, triggering a significant transition to hydrogen for long distance trucks and coaches, and subsequently also in passenger vehicles, as costs come down.

Changes in aviation and shipping are likely to be much more challenging than road transport, although we do see a growing trend towards LNG in shipping. Changes in aviation could lead to faster adoption of drop-in biofuels and potentially in the future converting power to liquids, through CO2 capture and hydrogenation.

While the future roadmap for transportation may not yet be clear, it is certain that across all sectors the industry is changing lanes. With advancements in technology, intervention of policy or regulation, and growing societal acceptance of alternative mobility solutions, change is inevitable. A strong focus on understanding the flows of information and data in this space and on utilizing the best analytical tools to regularly hone outlooks and expected paths will ensure key stakeholders are prepared.
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