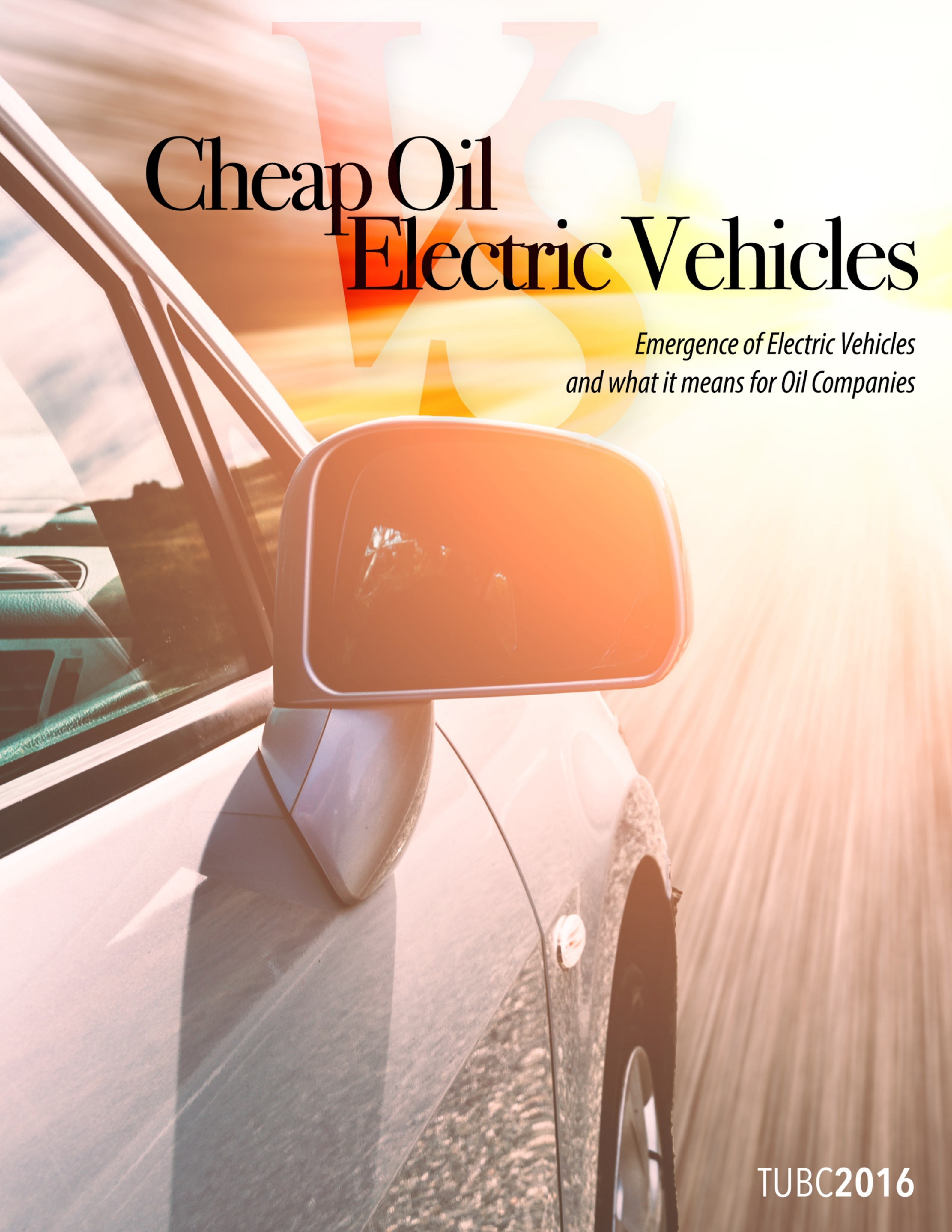
THAMMASAT UNDERGRADUATE
BUSINESS CHALLENGE

ptt GLOBAL CHEMICAL

Cheap Oil VS Electric Vehicles

Emergence of Electric Vehicles and what it means for Oil Companies



TUBC**2016**

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Supawat Likittanawong prepared this case under the supervision of the case company. The case was prepared solely as a basis for discussion. Cases are written in the past tense; this is not meant to imply that all practices, organizations, people, places or facts mentioned in the case no longer occur, exist or apply. Cases are not intended to serve as endorsements, sources of primary data, or illustration of effective or ineffective handling of a business situation.

INTRODUCTION

Senior executives at PTT Global Chemical Public Company Limited (PTTGC) have just returned from an energy conference in Houston, Texas. At the conference, one of the topics discussed was the potential impact of Electric Vehicles (EVs) on the future of the energy business. Oil executives at the conference had differing views on the topic. Some believe that EV has yet a long way to go before becoming mainstream while others believe that EV will replace a significant portion of automotive in less than two decades. With approximately 21% of PTTGC's current revenue derived directly from refinery of crude to gasoline (diesel included) and a lot more coming from conversions of crude to other by-products, executives at PTTGC wonder if they should be worried about the emergence of EVs particularly in the core markets that they operate in, and what actions they should take (if any) to prepare the organization for this potential disruptive force in the energy business.

*We Contribute to a **Better Living** Together with Creating Economic, Social and Environmental Values for Sustainable Growth*

– PTTGC

PTTGC, the chemical flagship powerhouse for the PTT Group

PTT Global Chemical Public Company Limited (PTTGC) was founded on 19th October 2011 through the amalgamation of PTT Chemical Public Company Limited, PTT Aromatics, and Refining Public Company Limited. The amalgamation created a chemical flagship powerhouse for the PTT Group. Since the merger, PTTGC benefited from reduced manufacturing cost due to the large volumes and reduced overhead cost by delivering value-added products within the downstream specialties sector under the same management umbrella.

As PTT Group's chemical flagship, PTTGC commands a combined capacity of 9.26 million tons per year together with 280,000 barrels per day of crude oil and condensate refining capacity, making it Thailand's largest and Asia's leading integrated petrochemical and refining company. PTTGC was listed in the Top 10 of the Dow Jones Sustainability Indices (DJSI) for two consecutive years and was ranked twenty-second among world-leading petrochemical companies on the ICIS Top 100 Chemical Companies listing.

PTT Public Company Limited or simply PTT is a Thai state-owned SET-listed oil and gas company. Formerly known as the Petroleum Authority of Thailand, it owns extensive submarine gas pipelines in the Gulf of Thailand, a network of LPG terminals throughout the kingdom, and is involved in electricity generation, petrochemical products, oil and gas exploration and production, and gasoline retailing businesses. Affiliated companies include PTT Exploration and Production, PTT Global Chemical, PTT Asia Pacific Mining, and PTT Green Energy. PTT is one of the largest corporations in the country and also the only company from Thailand listed in Fortune Global 500 companies. The company ranks 81st among top 500 on the Fortune 500, and 180th on the Forbes 2000.

Being a subsidiary of PTT, the largest producer and supplier of natural gas, petroleum and related products in Thailand (by market share and revenue), PTTGC benefits greatly from this relationship. PTTGC has also entered into long-term arrangements with PTT, and to a lesser extent, other parties for both supply of their feedstock and off take of their products. This secure contractual position provides important stability to PTTGC.

PTTGC Plant in Map Ta Phut

PTTGC's production covers and links the major components within the carbon value chain, including the production of refinery, aromatics and olefin products. In addition, their downstream derivative products (See appendix for an overview of PTTGC's plants) have the ability to process a variety of crude and natural gas feedstock, reducing their dependence on any given type of crude or natural gas feedstock. They also benefit from the ability to produce higher value-added petrochemical products instead of selling those products in their intermediate stage at marginal prices to the market.

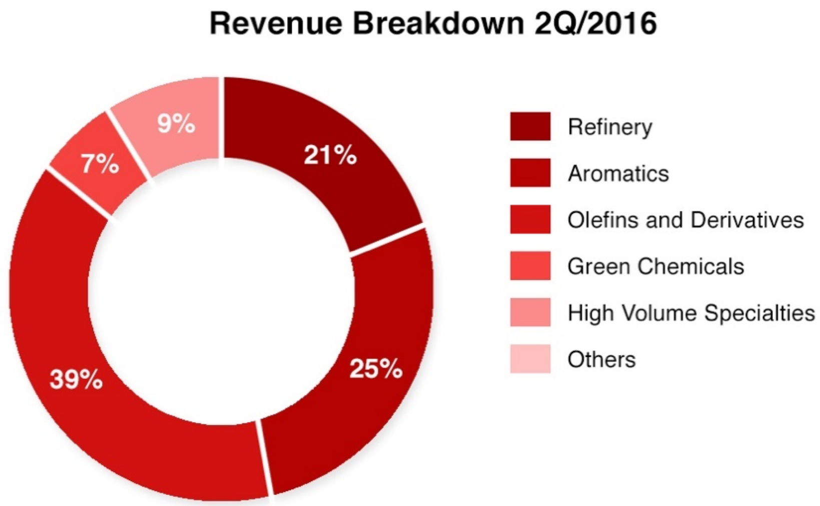
PTTGC's refineries and plants are located in the Map Ta Phut Industrial Estate, Thailand's major petrochemical production area. This strategic location provides key competitive advantages as it puts them in close proximity with a number of their key suppliers and customers. This allows PTTGC to minimize feedstock and product transportation costs, enabling them to receive feedstock, convert them into end products, and deliver products to their customers in a timely and cost-effective manner.

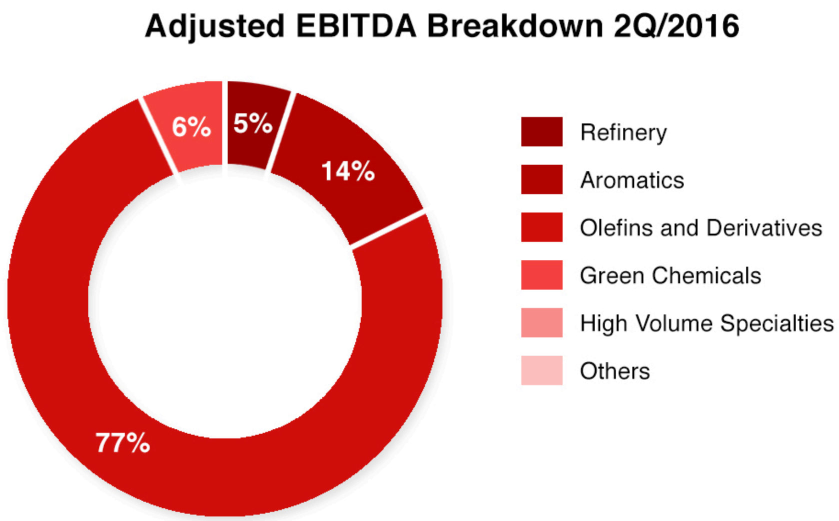
Being a substantial part of a PTT, PTTGC is able to tap into the resources of its strong parent company. Although PTTGC is a producer of gasoline and diesel, they do not operate the distribution channels. The gas stations are operated under PTT Retail Management Company Limited (PTTRM), a sister company and a subsidiary company of the same parent company, PTT. Other than the distribution channel, PTTGC also benefits from PTT's pool of highly experienced executives and their senior management team is highly experienced, all of whom have a proven track record in the refinery and petrochemical related industries.

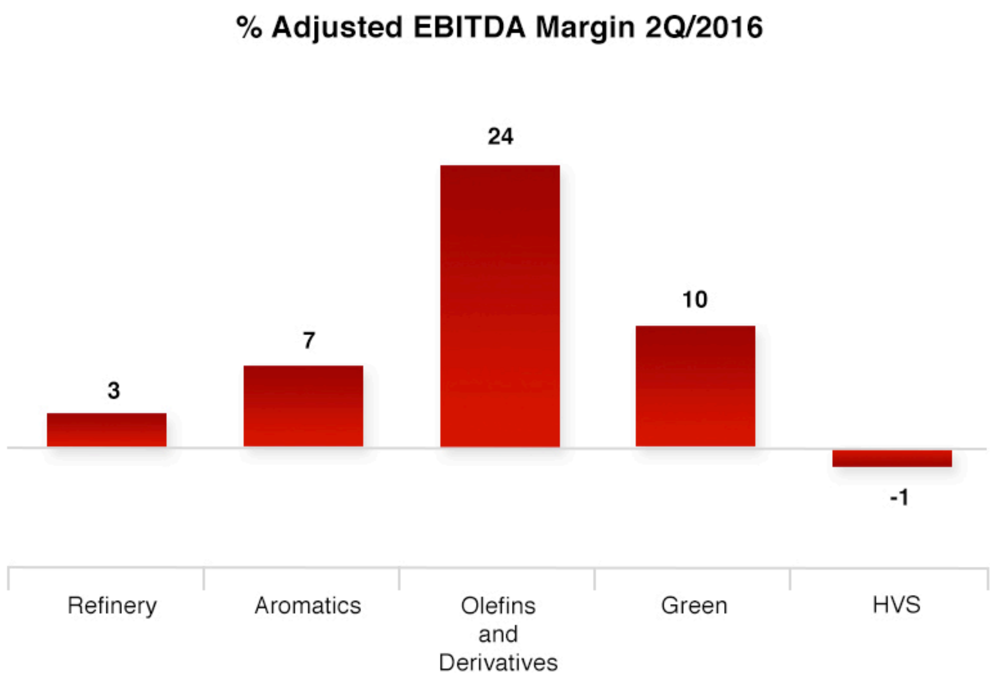
PTTGC Refinery and Shared Services business unit

PTT Global Chemical Public Company Limited has operations that cover both the upstream and downstream oil and gas businesses. The company has eight key business units with Refinery and Shared Services being a core business unit. It operates as a leading petroleum refiner and supplier of refined petroleum products in Thailand that owns and operates an advanced, complex and energy-efficient refinery in Asia Pacific. The refinery unit has a capacity of 280,000 barrels per day of crude oil and condensate intake, with specific crude oil capacity of 145,000 barrels per day.

Figure 1. PTTGC Financial Highlights for Q2, 2016







Source: PTTGC

Key output of the refinery unit includes fuel oil, diesel, jet fuel, and LPG among others. Although PTTGC is a producer of fuel, they do not operate the distribution channels or the gas stations. These products are sold almost entirely locally with the retail part of the value chain operated by a sister company, PTTRM, who manages the retail channels.

At the end of 2Q, 2016, the refinery unit directly accounts for approximately 21% of total revenue for PTTGC and a 5% of total EBITDA with adjusted EBITDA margin of approximately 3%. Figure 1. provides key financial highlights for PTTGC as of 2Q, 2016.

Emergence of Electronic Vehicles (EV)

Ever since the Ford Motor Company began mass production of the Model T on Henry Ford's first assembly line, the way people commute was changed forever. The automobile quickly spread through the world as an efficient means to travel to work, shopping trips, and to other cities. It has become an indispensable part of modern life.

The inventors of the internal combustion engine knew that petroleum was a practical energy source where over 80% of the volume of crude oil could be burned and converted to energy. There are probably very few other alternatives that are as efficient. This is why gasoline fueled cars have been the norm for over 100 years.

Over time, engineers have continuously improved the efficiency of fuel and searched for other alternative methods to power our cars. Modern methods include hydrogen-powered vehicles running on hydrogen fuel cells, but creating hydrogen fuel cells takes as much energy as it expands, so outside of areas like Iceland, hydrogen fuel is not necessarily practical or cost effective.

Some countries have experimented with plant-based fuels, such as corn-based Ethanol, which is a major component in E85 fuel, and oil and fat based Biodiesel, which is used in some public transportation systems. This has worked well in Brazil, where enough sugar cane is grown to fuel much of the country's transportation needs.

Natural gas and propane have also been considered, but similar to the gasoline they hope to replace, are considered carbon polluting fossil fuels, a limited resource in an increasingly resource hungry world.

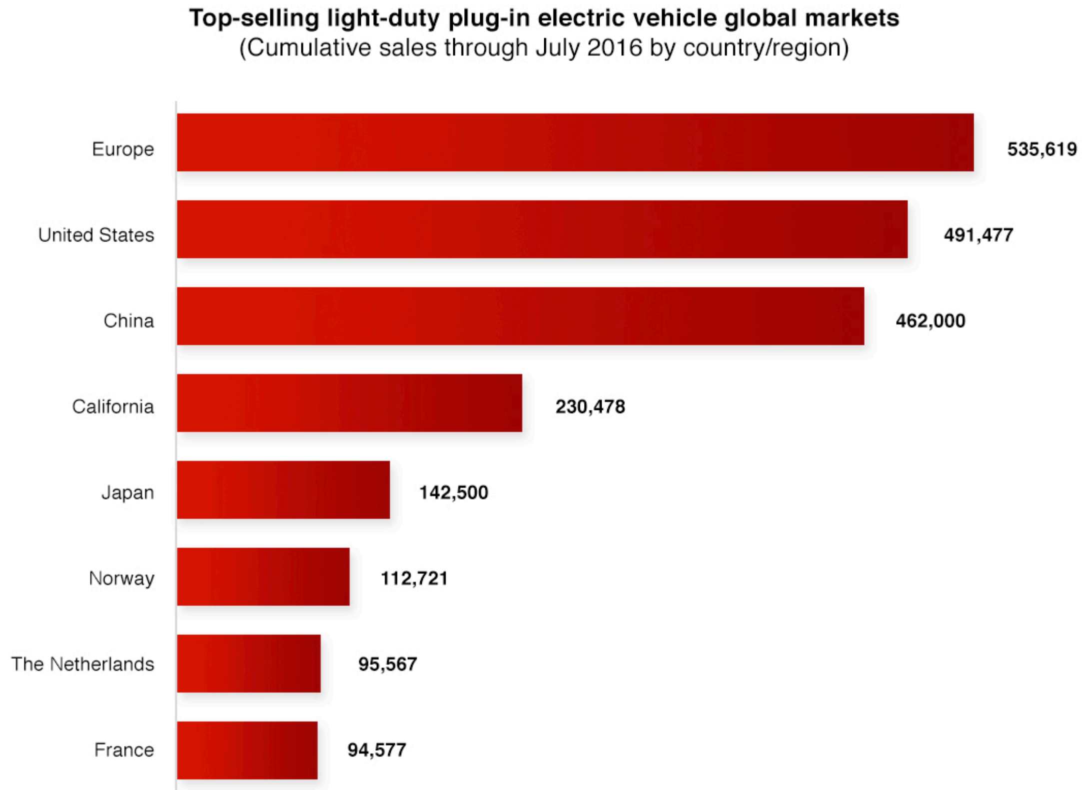
Can EVs really substantially replace the fuel-operated vehicles?

When electric vehicles were first introduced, it was not a popular or feasible option for most people. This is largely due to high costs, a lack of familiarity, and resistance from major automakers to produce them. However, in recent years, quite a lot has changed. Electric cars are becoming more common on roads around the United States, Europe and parts of Asia like Hong Kong and Singapore, where their popularity is growing. That being said, there still remains a few major obstacles that could prevent EVs from becoming mainstream.

The first major obstacle to replacing gas-powered cars with electric vehicles is the cost. Upfront costs of electric vehicles have historically run higher than gas cars. New technologies are bringing the costs down to be more competitive, but the purchase price is still something to consider.

Once you buy the car, however, your cost of ownership does decrease. While you still have to rotate and change your tires, but the oil changes and visits to the gas station will be a thing of the past. In general, maintenance costs and general running costs are lower with an EV than with a gas car. In addition, some governments have offered some tax deductions and credits for people who purchase electric vehicles, which can further lower the cost.

Chart 2. Number of EVs by Countries



Source: Wikipedia

The high end Tesla Model S, with a 240 – 270 mile range, costs USD 75,000 for the starter model after incentives, and includes gasoline savings, when compared to your current car. The highest end model runs USD 105,000. Even after the USD 7,500 federal tax credit and incentives offered by some states, it is still considered an expensive car.

Other electric cars are much more affordable. The 2015 Nissan Leaf has a base cost of USD 21,510, while the 2015 Chevy Volt runs USD 34,345. If the average consumer saves USD 10,000 on gasoline over five years, which is a high estimate, the cost is more reasonable compared to gas-powered cars, and you might even save money in the end. That is, however, if you have enough power to get to everywhere you want to go with an electric vehicle.

The next biggest hindrance to electric vehicle ownership for many people is the battery. While Tesla Motor is busy trying to improve battery technology, most EVs still have a limited range.

Figure 2. The Tesla Model S

Source: Tesla

Figure 3. The Nissan Leaf

Source: Nissan

For example, the Nissan Leaf can only go 84 miles on full charge, even less with the air conditioning or heater turned on. These cars are practical for commuting, but can't be used for long drives or road trips. Even if you can find a charger at your halfway point, you need to take time to plug in if you want to make it back.

Chargers are showing up in more places, but the battery is still holding back electric cars from their full potential. Charging a Nissan Leaf from 0% to 100% can take all night on a standard outlet. With a home charging station, which can cost thousands to buy and install, you can charge in seven hours. New charger technology allows you to reach 80% in 30 minutes, but those chargers are expensive and difficult to come by.

Low Oil Prices Can Hurt Electric Vehicles

One of the biggest drivers for long-term electric vehicle sales won't be sustainability or societal pressures, but the overall cost of ownership. As with solar power, EV sales won't hit mass adoption rates until consumers are choosing the technology on the basis of economics rather than environmentalism.
Consumers tend to be capable of directly comparing sticker prices of vehicles, but struggle to assess the overall lifetime cost of ownership. In a survey by researchers from Indiana University and the University of Kansas, a majority of respondents failed to correctly answer basic factual questions about plug-in electric vehicles. Most of the incorrect answers dealt with financial benefits, with respondents typically underestimating the cost advantages of going electric. Thus, although EV's typically cost less over the long run (despite the higher initial purchase price), car buyers have proven to be unwilling to pile into EV's until the initial price is lower than the gas-guzzling competition.

Until mass-market EV's like Tesla's Model 3, Nissan's Leaf and GM's Bolt hit the market, the price of gasoline will remain another major factor influencing consumers' choice of buying a gas-powered vehicle or an EV. "We know that consumers are extremely price sensitive and shop for gasoline based on price, and that the price per gallon affects their overall feelings about the economy," said John Eichberger, executive director of the Fuels Institute.

With oil prices averaging roughly USD 50 in 2015 (down 50% from 2014 highs), we can get a fairly straightforward case study of how falling energy prices impact car-buying habits. While U.S. EV sales continue to hit records, year-over-year growth has slowed to its lowest levels in years. Considering how total U.S. car sales hit a 15-year record last year, EV's as a percentage of cars sold actually fell. In 2013, electric-drive vehicles were 3.84% of U.S. vehicles sold. By 2014 (which saw lower oil prices in the second half of the year), electric-drive vehicle's share fell to 3.47%. In 2015 (which saw a full year of depressed oil prices), the decline accelerated to just 2.87% of cars sold. With the data so far, 2016 anticipates a further drop to roughly 2.5%.

Clearly, low oil prices played a hand in slowing electric vehicle adoption. Another factor working against EVs will be the rising fuel economy standards for traditional vehicles. By 2018, car manufacturers need to produce vehicles with an average economy of 40 miles per gallon (MPG). In 2022, this figure should rise by another 25% to 50 MPG. If the cost to fill up your car impacts EV buying habits, it would make sense that improving fuel standards should pose yet another threat to mass adoption. While mass-market cars like the Tesla Model 3 and GM Bolt will alleviate most consumer concerns (i.e. range anxiety and high initial cost), prolonged lower oil prices and improved fuel economies may slow down EV adoption for years to come.

The Future

Looking into the future, whether EVs will replace gas-powered cars still remains to be seen. As of current, we can see that electric vehicles have already replaced gas-guzzlers for a growing number of people, and as technology improves, they will become more popular. The average commute in the United States is 25 minutes per travel, which likely falls within the range of most EVs today. However, adding errands may make the EVs impractical.

The recent drop in oil prices that translates to a significant drop in prices of petrol, coupled with the gloomy outlook, suggests that the trend of low oil prices will continue. In addition, engineers have constantly improved the efficiency of fuel consumption for vehicles. Both of these trends add more obstacles for the growth of EVs. Hence, until battery technology improves, most of us are stuck with our trips to the pump. And depending on the development of technologies and the emergence of alternative energy that could address the environmental impact related to EVs, it is still not clear if and when a substantial number of automotive on our roads will be EVs. *(More information on developments of EV related technologies and alternative fuels is available in Article 3: Excerpts from World Energy Outlook Report 2015 – "Energy and Climate Change" by International Energy Agency (IEA))*

Thailand's reliance on petroleum as energy power source for vehicles

A recent report from the International Energy Agency (IEA) on the energy outlook for South-east Asia, found that Thailand's oil import bill could climb to USD 70bn by 2035, three times its present level.

According to the report, Thailand is the second-largest energy consumer in the region, ranking behind just Indonesia. The IEA estimates that Thailand's energy consumption will hit 206m tons of oil equivalent (TOE) in 2035, amounting to a 75% increase over the two-decade-plus period. While the agency says the country's population will remain relatively stable, the economy will treble in size over the coming 22 years, driving the higher demand for energy, with oil continuing to be the fuel of choice.

"Fossil fuels are by far the most important source of energy in Thailand and are projected to remain so through to 2035, with their share of the primary energy mix remaining above 80% throughout the period," the report said. "Oil keeps its position as the dominant fuel, with demand rising from 1m barrels per day in 2012 to 1.6m barrels per day in 2035."

Not withstanding the importance of petroleum, coal continues to play an increasing role in power generation. Coal is seen as the potential replacement for at least some of Thailand's oil and gas consumption, with usage expected to rise by 4% per year to reach 47m TOE by 2035, equivalent to 23% of the projected total. Most of this will be consumed by power stations, as demand for electricity continues to increase. According to the IEA, coal-fired plants will provide just over one-third of the nation's needs in 2035, while the share of natural gas will fall from 68% to 52%.

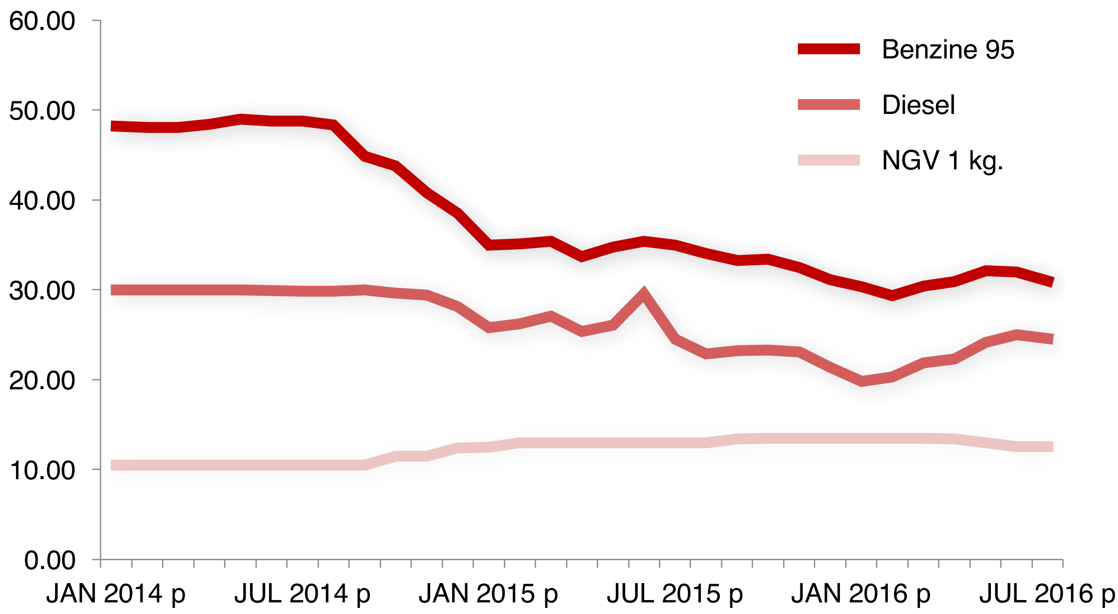
The biggest single call on energy, and in particular oil, will be the transport sector, which will use 41m TOE per year by 2035. For the most part, the rise will result from a growing number of private vehicles on the road, which is set to jump from 3m to 10m. Thailand will also see many more buses and commercial vehicles take to the nation's roads, pushing up diesel consumption as well. The IEA puts Thailand's fuel mix for 2035 at 84% oil-based, 10% gas and 6% biofuels, with oil's contribution only marginally down from its present figure.

With the substantial fall in fuel prices, fuel consumption in Thailand rose in the first half of 2015. According to the Energy Business Department, the consumption of all petrol products rose by 14.04% while that of diesel went up by 2.69% from the same period last year.

As of January 4, 2014, 91-octane petrol was retailed at THB 38.48 per litre. On January 3, 2015, the price dropped by 23.34% to THB 29.50 per litre. Due to subsidies, diesel on January 4, 2014 was at THB 29.99. On January 3, 2015, it went down to THB 29.39 in line with a drop in global prices. In the period, a daily average of 25.77 million litres of petrol products were consumed, against 61.37 million litres of diesel. Of all petrol products, 91-octane accounted for the largest portion, at 10.94 million litres.

In the period, the number of petrol-driven vehicles increased by 2.2% on year, while diesel vehicles rose by 8.74%. Meanwhile, the phasing end of gas subsidies resulted in an 8.74% drop in LPG consumption and a 0.84% cut in NGV consumption. There has been a negligible adoption of electric vehicles in Thailand and the general public sentiment towards EVs is more a novelty than a real transportation option.
During January and June 2015, LPG consumption averaged at 18.53 million kg per day and 558.86 million kg per month. Of total, 108 million kg of LPG was imported on a monthly basis, showing a 37.61% drop from the same period last year. NGV consumption averaged at 8.71 million kg per day during the same period. The historical fuel prices are presented in chart 1.

Chart 1. Historical fuel prices in Thailand



Source: Bank of Thailand

Thai government looks to promote energy efficiency and the development of EV

The Thai ministry of energy has set a target to reduce energy consumption in the transportation sector by 46% by 2036. A majority of this reduction is to come from an improvement in vehicle energy efficiency. The ministry intends to achieve this through the promotion of more energy efficient vehicles utilizing a number of measures. One of which is through imposing CO_2 tax with the expectation that consumers will be encouraged to move towards more energy efficient options such as EV.

The ministry is also working on a plan to improve infrastructure that supports more energy efficient transportation option. One such plan is the promotion of EVs in Thailand. With an internal target of EV adoption in Thailand of approximately 1.2 Million by 2036, the ministry has conducted a detailed study on what needs to be put in place to help support this target. This includes the potential development of charging stations for EVs and related regulations that would govern and provide a standard for the roll out of these charging stations nationwide. Based on the study, 400,000 EVs will require 230 charging stations. As such, a target of 1.2 Million EV would require at least two or three times that number of charging stations nationwide.

Another parallel development to the ministry of energy plans is a proposition by the National Science and Technology Development Agency (NSTDA). Since Thailand is a major hub for automotive manufacturing and has been called the “Detroit of Asia”, the NSTDA has developed a proposal to support the development of Thailand’s automotive industry to be a leader in EV production.

Through a detailed study, the NSTDA has concluded that if Thailand is to continue to be a manufacturing hub for automotive, it has to start developing the competencies required to compete in the EV market. The organisation has put forward a proposal to prepare Thailand for EV manufacturing. The plan details the need to develop local talent and promote local production of EV parts.

Based on the research and the proposals of the two agencies, both have indicated the intention to push Thailand towards the direction of faster adoption of EVs in both production and consumption.

Conclusion

Although the current adoption of EVs in Thailand is negligible, there seems to be a clear drive by the Thai government related agencies to drive its growth over the next twenty years. The executives at PTTGC wonder if and when the trend will arrive in Thailand and nearby markets. With the government's plan to promote more energy efficient vehicles with a focus on EVs, this could come faster than what many have predicted. However, the lower fuel costs and the constantly improving fuel efficiency of cars might delay this growth. To ensure that PTTGC is well prepared, the executives at the company are keeping a close watch on the developments and emerging technologies, to see whether this new Electric Vehicle trend is just a fad or a real threat to their business. PTTGC would still want to be well prepared for what's to come. The executives are exploring on what actions (if any) that PTTGC should take to prepare for the potential change in market landscape?

PTTGC Statement of Financial Position

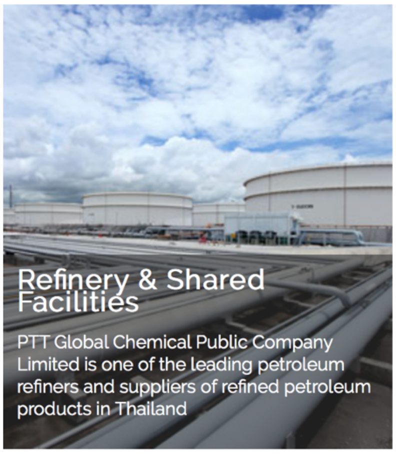
(MILLION THB)	2013	2014	2015	1Q/2016	2Q/2016
Non-Current Assets	275,170	256,799	259,644	261,187	261,666
Current Assets	160,891	123,131	117,901	124,500	108,785
Equity	238,044	226,936	234,265	238,243	237,203
Non-Current Liabilities	128,372	96,875	102,059	103,652	95,525
Current Liabilities	69,645	56,119	41,221	43,792	37,722

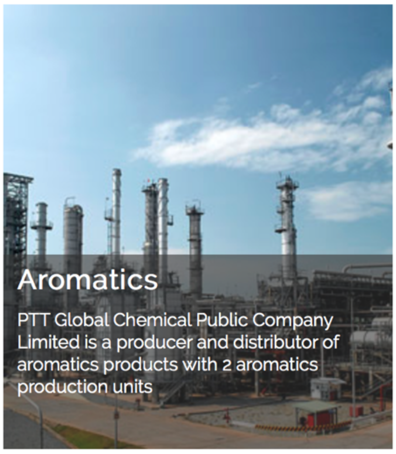
Financial Ratio

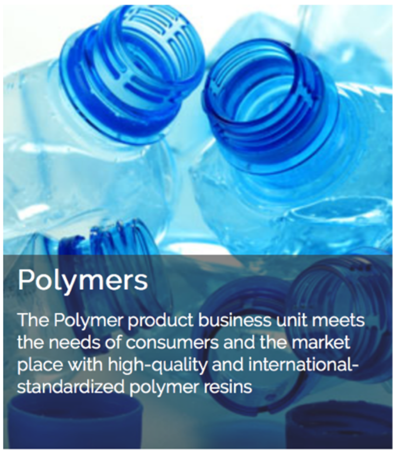
	2013	2014	2015	1Q/2016	2Q/2016
Current Ratio	1.93	2.13	2.86	2.84	2.88
EBITDA to Sales revenue	10.63%	6.09%	11.18%	11.47%	11.26%
Net Profits to Sales revenue	6.06%	2.64%	5.12%	5.13%	4.62%
Return on Assets	9.42%	4.68%	7.36%	6.95%	5.65%
Return on Equity	14.44%	6.29%	8.99%	8.42%	6.62%
Interest Bearing Debt to Equity	0.49	0.49	0.45	0.45	0.41
Net Interest Bearing Debt to Equity	0.31	0.29	0.25	0.21	0.2
Net Interest Bearing Debt to EBITDA	1.3	2.04	1.3	1.12	1.27

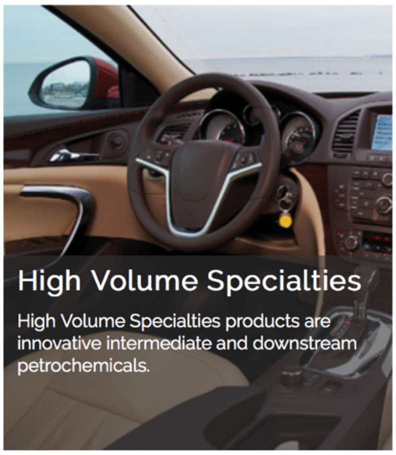
Source: http://www.pttgcgroup.com/en/governance/shareholders-annual-report

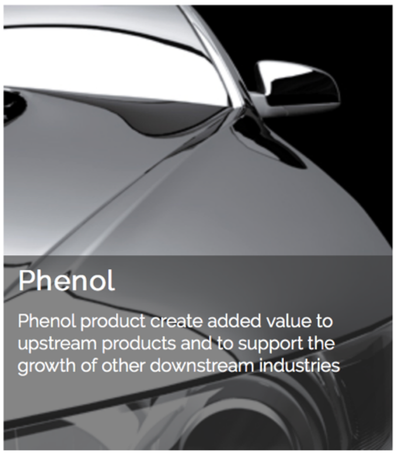
Appendix 1. PTTGC's Business Unit, Capacity and Product Overview











Source: PTTGC website - for more details on the business units, please visit www.pttgcgroup.com

Business Unit and Capacity

Refinery & Shared Facilities — **280,000 barrels/day**

LPG	Jet A1	Crude Oil Distillation	145,000 barrels/day
Light Naphtha	Diesel	Condensate Distillation	135,000 barrels/day
Reformate	Fuel Oil		

Aromatics — **2,259 KTA**

Paraxylene	1,195 KTA	Mixed Xylenes	76 KTA
Benzene	662 KTA	Orthoxylene	66 KTA
Cyclohexane	200 KTA	Toluene	60 KTA

Olefins — **Ethylene and Propylene 2,888 KTA**
Butadiene/Butene-1 100 KTA

Ethylene	2,376 KTA	Butadiene	76 KTA
Propylene	512 KTA	Butene-1	66 KTA
			60 KTA

Polymers — **Polyethylene 1,500 KTA**
Polystyrene 90 KTA

HDPE	800 KTA	LDPE	300 KTA
LLDPE	400 KTA	Polystyrene	90 KTA

EO-Based Performance — **470 KTA**

MEG	395 KTA	Ethoxylate *	25 KTA
EA	50 KTA		

Note: * Including the capacity of Thai Ethoxylate Co.,Ltd. (TEX) proportionate by 50%

Green Cheminals — **828.6 KTA**

Fatty Acid	265 KTA	Ester Plastic	25 KTA
Methyl Ester *	242.7 KTA	Home & Personal Wellness Surfactants	
Fatty Alcohol *	131 KTA		10 KTA
Polylactic Acid **	75 KTA	Ozone Acid	9 KTA
Glycerin/Triacetin *	69.4 KTA		

Note: * PTTGC wholly owns Thai Oleochemicals (TOL) and Thai Fatty Alcohols (TFA). Capacities reflect this fact, as well as PTTGC's 50% shareholding in Emery Oleochemicals (M) Sdn. Bhd
** PLA capacity reflects PTTGC's 50% shareholding in Natureworks LLC

High Volume Specialties — **610 KTA**

Phenol	200 KTA	Toluene Diisocyanate *	25 KTA
Bis Phenol A	150 KTA	Hexamethylene Diisocyanate & Derivatives *	
Acetone	124 KTA		29.75 KTA

Note: * Represent TDI and HDI & derivative capacities of Vencorex Holding, where PTTGC holds 85% shares

Article 1.

FEB 25, 2016

ELECTRIC VEHICLES TO BE 35% OF GLOBAL NEW CAR SALES BY 2040

Continuing reductions in battery prices will bring the total cost of ownership of EVs below that for conventional-fuel vehicles by 2025, even with low oil prices.

London and New York, *25 February 2016* – The electric vehicle revolution could turn out to be more dramatic than governments and oil companies have yet realized. New research by Bloomberg New Energy Finance suggests that further, big reductions in battery prices lie ahead, and that during the 2020s EVs will become a more economic option than gasoline or diesel cars in most countries.

The study, published today, forecasts that sales of electric vehicles will hit 41 million by 2040, representing 35% of new light duty vehicle sales. This would be almost 90 times the equivalent figure for 2015, when EV sales are estimated to have been 462,000, some 60% up on 2014.

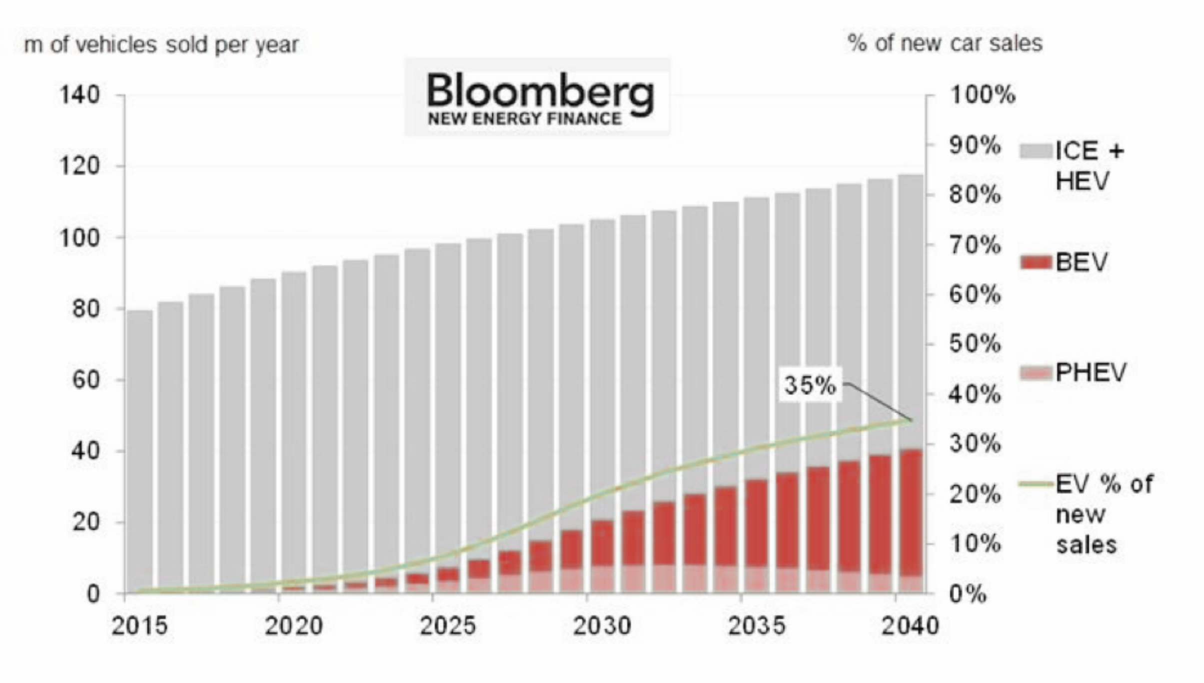
This projected change between now and 2040 will have implications beyond the car market. The research estimates that the growth of EVs will mean they represent a quarter of the cars on the road by that date, displacing 13 million barrels per day of crude oil but using 2,700TWh of electricity. This would be equivalent to 11% of global electricity demand in 2015.[1]

Colin McKerracher, lead advanced transportation analyst at Bloomberg New Energy Finance, said: "At the core of this forecast is the work we have done on EV battery prices. Lithium-ion battery costs have already dropped by 65% since 2010, reaching USD 350 per kWh last year. We expect EV battery costs to be well below USD 120 per kWh by 2030, and to fall further after that as new chemistries come in."

Salim Morsy, senior analyst and author of the study, commented: "Our central forecast is based on the crude oil price recovering to USD 50, and then trending back up to USD 70-a-barrel or higher by 2040.[2] Interestingly, if the oil price were to fall to USD 20 and stick there, this would only delay mass adoption of EVs to the early 2030s."

The electric vehicle market at present is heavily dependent on "early adopters" keen to try out new technology or reduce their emissions, and on government incentives offered in markets such as China, Netherlands and Norway. Although some 1.3 million EVs have now been sold worldwide and 2015 saw strong growth, they still represented less than 1% of light duty vehicle sales last year.

EVs come in two categories – battery electric vehicles, or BEVs, that rely entirely on their batteries to provide power; and plug-in hybrid electric vehicles, or PHEVs, that have batteries that can be recharged but have conventional engines as back-up. The best-selling BEV over the last six years has been the Nissan Leaf, and the best-selling PHEV the Chevrolet Volt.



The study's calculations on total cost of ownership show BEVs becoming cheaper on an unsubsidised basis than internal combustion engine cars by the mid-2020s, even if the latter continue to improve their average mileage per gallon by 3.5% per year. It assumes that a BEV with a 60kWh battery will travel 200 miles between charges. The first generation of these long-range, mid-priced BEVs is set to hit the market in the next 18 months with the launch of the Chevy Bolt and Tesla Model 3.

Morsy said: "In the next few years, the total-cost-of-ownership advantage will continue to lie with conventional cars, and we therefore do not expect EVs to exceed 5% of light duty vehicle sales in most markets – except where subsidies make up the difference. However, that cost comparison is set to change radically in the 2020s."

[1] The TWh and percentage figures in this paragraph were corrected on 7 March.
[2] This is in line with the price trajectory mentioned by the US Energy Information Administration in its Annual Energy Outlook 2015.

Article 2.

FEB 29, 2016

HOW LOW OIL PRICES ARE SLAMMING HYBRIDS AND ELECTRIC CARS

By **Rob Nikolewski** ***Contact Reporter***

Toyota Motor Corp. Executive Vice President Mitsuhisa Kato poses with a Toyota new Prius at the automaker's showroom in Tokyo, Wednesday, Dec. 9, 2015. Sales for the Prius dropped 10.9% in 2015, marking the first time annual sales were down since the hybrid was introduced in 1997. (AP Photo/Shizuo Kambayashi) (The Associated Press)

The cratering price of oil has not only put a stranglehold on oil companies. It's also hammering the sales of electric and hybrid cars.

"Fuel efficiency isn't as important to consumers right now as it was when gas was a lot higher," said Akshay Anand, commercial insights manager for Kelley Blue Book, the Irvine-based company that researches and assigns values to cars.

Low oil prices translate into low gasoline prices, which has blunted the incentive for many U.S. consumers to buy vehicles that go farther on a gallon of gas — or in the case of all-electric vehicles, that don't use any gas at all.

Gasoline prices in California are half what they were on Oct. 9, 2012. Nationally, prices are down 70% since June 2014.

Registrations in California for Land Rover were up 39.4% in 2015 compared to 2014 and Jeep saw a 29.8% surge, according to IHS Automotive.
The state's market share of hybrid vehicle registrations dropped from 6.3% to 5.8%.

The Toyota Prius was still the third-best selling car in California in 2015 but has fallen from its No. 1 spot in 2012 and 2013.

Nationally, the numbers are more pronounced.

Sales for hybrids and alternative energy cars in the U.S. were down 13.2% in recently released figures by Kelley Blue Book that looked at sales in 2015 compared to 2014. At the same time, luxury compact sports utility vehicles surged 36.8% and mid-sized pickup trucks were up 40.8%.

As a result, in perhaps the biggest irony of the collapse in oil prices, the hybrid car and electric vehicle sector that has used its relative independence from fossil fuels as a major selling point is suffering nearly as much as the oil industry.

"It's not hugely talked about," said Jeremy Acevedo, an auto industry analyst for Edmunds.com, the online car-shopping website headquartered in Santa Monica. "The sales of hybrids and plug-ins have been waning."

Oil's slump isn't just hurting energy companies, said Saeed Irani, president of Sacramento-based Irani Engineering, a company that has drilled more than 1,500 wells in California. "The low price of oil is affecting car manufacturers and all kinds of sectors of the economy," Irani said.

National sales for the Prius dropped 10.9% in 2015, marking the first time annual sales were down since the hybrid was introduced in 1997. Chevrolet sold 18.1% fewer Volts in 2015 than the previous year.

The all-electric Nissan Leaf was down a whopping 42.8% from 2014 to 2015.
Despite warnings about a warming planet and a Paris Climate Summit attended by President Obama and other world leaders, it seems environmental concerns only go so far when it comes to buying a car.

"We consistently find that the top two factors, regardless of segment, whether you're looking at a small car or a huge luxury SUV or a pickup truck, are reliability and safety," Anand said in a telephone interview. "Fuel efficiency for a lot of people isn't a top-five important thing anymore."

Why not? Because SUVs are not the gas guzzlers they used to be.

"The spread between a hybrid and an SUV has diminished," Anand said. "It used to be that an SUV got you 20 mpg and a hybrid got you 50. And yes, that 30 mpg difference is a big deal, especially when gas prices are higher.

"But now you can get SUVs with 30 mpg highway now, no problem. Now that the gap has been narrowed and gas prices are lower, I think that's one of the critical reasons hybrids are suffering."

Acevedo said customers — especially in California — still care about the environment but "when you look at the SUV landscape right now, it not the same. It's not a yellow Hummer that's tearing up the road.

"The best-selling SUVs, like the Honda CRV, are something comparable to a mid-sized car in almost every way as far as emissions go."

And while driving Tesla may be the ultimate cultural status symbol for some, the alternative car icon does not appear immune to the downturn either.

While the Silicon Valley-based car maker doesn't like to talk about sales — it prefers to call them "deliveries" — Tesla delivered 50,580 vehicles last year, at the low end of its predictions.

Tesla's media relations department did not respond to a request from the San Diego Union-Tribune for an interview but during an investors call last month CEO Elon Musk didn't mention lower gas prices as a reason for the down-tick.

Instead, he pointed to tweaks Tesla made on its Model X at the end of last year.
"We limited Model X production for a period of time to maintain our quality production standards," Musk said.

Only 507 Model Xs were produced in the fourth quarter of last year. For all the attention Tesla gets, the company makes up just a tiny fraction of the auto landscape and industry analysts look at the company as something akin to an outlier. "Tesla is almost like a lifestyle, something people aspire to rather than just a car brand," Anand said.

Even beyond the issue of low gasoline prices, another thing slowing down the electric car market is something the industry calls "range anxiety" — motorists' concerns that an electric car could leave them stranded should it exhaust its charge.

Cost is another hurdle. Even with federal subsidies up to USD 7,500 per vehicle and as much as USD 4,000 in California rebates, most electric vehicles are more expensive than gasoline-powered cars of similar size. Throw in lower gas prices and the incentive to buy EVs diminish.

What's more, prices at the pump may stay low for a long time.

While predicting oil prices has always been a tricky game, most energy analysts don't see oil supplies tightening soon.

Even if oil demand bounces back, shale producers have proven remarkably resilient and quick to get oil back on the market.

In addition, the recently completed nuclear deal with Iran is expected to bring about 1 million more barrels of oil per day onto the global market as sanctions get lifted on Tehran. Acevedo thinks low gas prices for an extended time present a real threat to the hybrid/electric car industry.

The price of a gallon of gas is "going to have to get to USD 5 for people to freak out and go buy themselves a hybrid or an EV," Acevedo told the Union-Tribune in a telephone interview. "That’s the kind of stimulus that segment needs. Right now it looks like gas prices are poised to continue dropping. Long term it’s definitely going to hurt."

Supporters of alternative vehicles point to some hopeful signs, though.

Tesla plans to roll out the more affordable Model 3 — proposed to be listed at about USD 35,000 — March 31.

A re-designed Prius with a snazzier look has just hit dealerships with Toyota promising drivers better handling.

Later this year Chevrolet unveils its all-electric Bolt that promises to more than double the range of typical plug-ins to 200 miles while promising to sell for as low as USD 30,000. "You’re looking at vehicle that could really shake things up if it gets the traction I’m sure Chevy is hoping for and a lot of people are expecting," Acevedo said.

Anand thinks alternative vehicles need a different marketing strategy. "We're keen to see if automakers start touting the fact these cars are good cars that happen to get great mileage or great range or whatever rather than marketing them as hybrids first," Anand said. "Because what you're seeing with hybrids right now is that sales aren't doing well."

Article 3.

Excerpts from World Energy Outlook Report 2015 - “Energy and Climate Change” by International Energy Agency (IEA)

TECHNOLOGIES FOR TRANSFORMATION

Alternative fuel vehicles

Opportunity

The transport sector is the second-largest emitter of CO2 emissions after power generation. It accounts for more than one-fifth (7.3 Gt) of global energy-related CO2 emissions today, a rise from 3.3 Gt/year in the 1970s. Road transport (passenger and freight) is the primary cause of the increase, accounting for over 80% of the growth, due to its heavy reliance on oil. Despite many attempts, dependence on oil as a transport fuel has not been overcome. Biofuels, in particular, have made some inroads, but still meet only 2% of road transport fuel demand today (mostly in Brazil, United States and European Union). Natural gas, as a road transport fuel, is important in some markets, such as Brazil, Pakistan and Iran, and has seen impressive growth in China and the United States over the last few years; but it remains a carbon-based fuel, which cannot deliver the long-term decarbonisation that is required in the transport sector. To date, sales of electric vehicle[1] represent well below 1% of global car sales, far below the volumes required in the 450 Scenario.

Growing demand for mobility, particularly from emerging markets, threatens to continue to push up transport oil demand, increasing the need for the development and deployment of alternative fuel vehicles in order to decouple mobility growth from emissions growth and put the world on track to meeting the 2 °C climate goal. In the 450 Scenario, electricity (through electric vehicles) and advanced biofuels[2] are the main alternative fuel options

that deliver the deeper emissions reductions required from the transport sector. Together, they reduce oil consumption by 13.8 million barrels of oil equivalent per day in 2040 and energy-related CO2 emissions by 11.5 Gt over the period 2015 to 2040, compared with the average fuel economy of the remaining vehicle fleet. Hydrogen (through hydrogenpowered fuel-cell vehicles) also plays a role, but to a much lesser extent.

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[1] EVs here include plug-in hybrids and battery-electric vehicles.

[2] Advanced biofuels here refer to those produced from conversion technologies that are currently in the research and development, pilot or demonstration phase. This differs from the definition applied in the US Renewable Fuel Standard, which is based on a minimum 50% life-cycle greenhouse-gas reduction and therefore includes sugarcane ethanol.

The use of biofuels (primarily in road and aviation sectors) more than doubles in the 450 Scenario, relative to the Bridge Scenario. Their use, reaching 8.7 million barrels per day in 2040 in the 450 Scenario, displaces the need for refined petroleum products, namely gasoline, diesel and kerosene. Around 30% of the increase in biofuels use comes from the aviation sector, which has few viable alternatives to oil (on-board storage is a major limitation for hydrogen and electricity). As a result, the fuel mix in the 450 Scenario is much more diversified by 2040, and biofuels earn a share of around 17% for world transport demand as a whole. A large part of the increase in biofuels use is due to the development and deployment of advanced biofuels that can be sustainably manufactured from non-food, cellulosic feedstocks and algae, and can be used in vehicles and other transport modes, e.g. as aviation jet fuel. Advanced biofuels are assumed to be commercially available at scale from 2020 onwards in the 450 Scenario. As biofuels can readily be supplied through the existing refueling infrastructure, the use of advanced biofuels can expand rapidly, reaching more than 10% of road transport fuel demand by 2040, and 33% in the aviation sector.

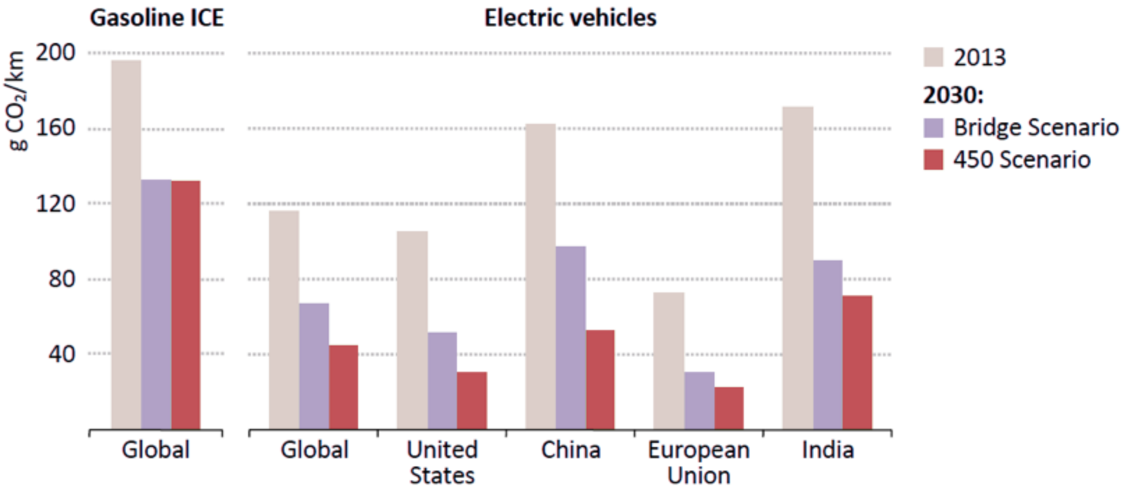
Sales of EVs also grow rapidly in the 450 Scenario. From around 2020, they make a notable impact on global vehicle sales, reaching nearly 25% by 2030 and more than 40% by 2040 (Figure 4.7). Total annual EV sales reach nearly 80 million vehicles by 2040, equivalent to the global vehicle sales of all types in 2010. Primarily, the increase in sales in the 450 Scenario is driven by the large vehicle markets: China, India, United States and European Union. Road transport provided by EVs reduces global oil demand by around 1.5 million barrels per day in 2030 and nearly 6 million barrels per day in 2040. One primary benefit of using EVs, which use a highly efficient electric motor for propulsion, is that they can shift transport emissions from millions of mobile sources to a much smaller number of stationary sources in the power sector. If centralized power generation relies on low-carbon sources, as in the 450 Scenario, EVs effectively reduce overall GHG emissions. Climate change is not the only reason to promote electric vehicles; as EVs do not emit air pollutants and make little noise, they are well suited to urban use. In China, for example, air quality concerns have already supported the introduction of 230 million electric scooters in place of diesel scooters (IEA, 2015b). Innovative programs, such as the Autolib system in France, can also serve to increase the uptake of EVs in urban areas, displacing the need for personal vehicles.3

A shift to EVs always reduces CO2 emissions directly from the transport sector, as there are no emissions at the point of use. However, power sector emissions may increase due to the additional electricity demand from EVs (which also have the advantage of higher motor conversion efficiencies compared with conventional cars).

[3] Autolib is a subscription-based electric vehicle sharing programme in Paris, France. Autolib estimates that 3,000 vehicles will displace ownership of 22 500 private vehicles, www.autolib.eu/en/.

Therefore, the extent to which EVs can contribute to energy-related CO2 emissions reductions depends critically on the carbon-intensity of the power mix. Today, EVs generally offer overall CO2 mitigation benefits compared with new gasoline internal combustion engines (ICE) cars, unless the power system is heavily dominated by coal and the overall emissions intensity of electricity is 800 g CO2/kWh or above. Due to their relatively carbon-intensive power mix, the benefit of EVs is lowest today in some countries in Asia, including China, India and Indonesia, but with increasing power sector decarbonisation, such as in the 450 Scenario, the emissions reductions become more pronounced over time (Figure 4.8).

Figure 4.8 ▷ On-road emissions intensity of gasoline-fuelled and electric vehicles by selected region in the Bridge and 450 Scenarios



Notes: Emissions intensity of electric vehicles is based on the emissions intensity of grid-supplied electricity by region. The global figure is based on the world average emissions intensity of electricity.

Hydrogen fuel-cell vehicles can also contribute to decarbonisation of the road transport sector. The idea of hydrogen as a transport fuel for vehicles has attracted the interest of industries, government and the public since the 1960s. There are signs of renewed attention today. Toyota has just launched the Mirai ("Future") in Japan, the first commercially available hydrogen fuel-cell car; Hyundai is targeting to sell several thousand vehicles soon (the Hyundai Tucson Fuel-Cell Electric Vehicle has been available for lease since mid-2014); and Honda has announced its intention to launch a hydrogen-powered car in 2016. During the past decade, several global public-private partnerships have been created to secure funding for coordinated action to promote the application of fuel-cell technology beyond the car industry (e.g. in California, Europe, Japan, Korea and recently in Dubai). But no such alternative applications on a commercial basis have yet been announced and widespread adoption of hydrogen has so far failed to materialize.

One big potential advantage of hydrogen-fuelled vehicles is that their range is not limited like that of an EV, a subject of considerable consumer anxiety. The refueling time is also generally much lower than the charging time of a battery. If hydrogen is produced from low-carbon sources, the CO2 benefits offered are comparable to those of EVs. There are, however, serious challenges constraining the outlook for deployment of hydrogen vehicles (discussed below) and their use in the 450 Scenario remains limited.

Challenges

For EVs, the key barriers that currently hold back their deployment include their relatively high cost, the low energy density (and correspondingly heavy weight) of batteries and the lack of recharging infrastructure. Despite recent cost reductions, batteries remain the most costly component of EVs. From an industry perspective, the prize for developing a battery that makes EVs competitive with conventional cars is potentially huge, as is already reflected in the significant level of research and investment (IEA, 2015c). Industry-wide estimates of the cost of batteries declined by approximately 14% annually between 2007 and 2014 (from above USD 1,000/kWh to around USE 400/kWh) and the cost of the battery packs of market-leading manufacturers are even lower (USD 300/kWh), revealing cost reductions of 6% to 9% for each doubling of cumulative production (Nykvist and Nilsson, 2015). In some cases, EVs have had significant success in the marketplace in recent years: for example, in Norway, EVs were reported to make up 10% to 15% of monthly passenger vehicle sales in 2014 supported by tax breaks and other incentives. Electric vehicle fleets – such as taxis, buses, delivery vehicles – and EV sharing schemes are increasingly common in many parts of the world, particularly in cities where concerns about the vehicle's range are less pronounced. The number of EV models has continued to increase, many from the world's largest car manufacturers. Despite these positive signals, however, total sales of EVs worldwide have been far slower than expected. Policy targets set for achievement by 2015 are likely to be missed in all regions, in particular the United States and China. In the absence of new support measures, 2020 targets might need to be adjusted as well.

The widespread adoption of EVs requires an expansion of the recharging infrastructure. The convenience of charging can be a major factor for people considering investment in an EV, including a safety net for emergency charging. By the end of 2014, the number of slow chargers installed globally is estimated to have reached more than 94,000, while the number of fast-chargers was around 15,000 (IEA, 2015c). For comparison, the United States alone has around 120,000 gasoline filling stations. The European Union agreed upon a directive in 2014 specifically to support the deployment of infrastructure for alternative transport fuels across its member countries and similar action will be essential elsewhere to support EV deployment on the scale projected in the 450 Scenario. Global charger costs in the 450 Scenario are of the order of USD 20 billion per year on average to 2040. Although this is just a fraction of expected investment in land transport over the same period, it will be a demanding challenge to mobilize the required investment and to put the required infrastructure in place in a system that is currently almost entirely reliant on oil-based transport fuels.

Progress related to the production of advanced biofuels has also been slow and currently they are not commercially available at scale. However, some notable progress was registered in 2014. Five commercial-scale advanced biofuels production plants opened, three in the United States and two in Brazil (IEA, 2015b). The combined capacity of these plants, at 9,000 barrels per day (in volumetric terms), makes up about one-fifth of current global advanced biofuels production capacity but less than 1% of total biofuels production capacity today. The United States is the only country which has volume requirements for advanced biofuels in 2015 (Renewable Fuels Standard), though it has had difficulty meeting targets to date. In late 2014, Italy set national targets for advanced biofuels as a share of transport fuel demand, rising from 1.2% in 2018 rising to at least 2.0% in 2022. In April 2015, the European Union also set an indicative target of 0.5% for advanced biofuels by 2020. During 2014, several companies announced new advanced biofuels projects, but several others have been cancelled in recent years.

The two major challenges associated with advanced biofuels are reducing production costs and ensuring sustainability. Most of the technologies today have total production costs significantly greater than USD 3 per gallon (IRENA, 2013), which is well beyond the untaxed price of petroleum products. The price level of conventional oil will be of critical importance to the long-term prospects for biofuels as a competitive fuel. The second issue, the sustainability of conventional biofuels, has been in question for many years. As a result, the European Union, to take one example, has restricted the extent to which conventional biofuels can contribute to biofuels targets. It is therefore imperative to ensure that advanced biofuels do not raise the same concerns.

As to the use of hydrogen in road transport, the challenges are numerous, ranging from the high costs of the hydrogen fuel-cell vehicle to the absence of refueling infrastructure and consumer skepticism. Despite the recent notable step forward of the launch of the first commercial models, hydrogen fuel-cell vehicles still have many hurdles to overcome before they can achieve mass commercialization. The most fundamental challenge is the need to build-up an entirely new hydrogen generation, transmission and distribution and retail network (IEA, 2015d). Although decentralized hydrogen production is feasible, large-scale deployment of hydrogen fuel-cell vehicles is likely to hinge on the development of such a dedicated integrated infrastructure.

Solutions

Given the variety of new technologies under development in the transport sector and the early stage of their deployment, it is important for government actions to enable innovation across a broad set of technologies in road transport. Market-driven, technology- and fuelneutral policies (e.g. such as greenhouse-gas emissions standards per vehicle-kilometre travelled), based on sound science and offering cost-effective pathways to achieve societal goals of energy security and GHG emission reduction, are to be preferred. Technology neutral policy measures can be complemented by targeted and temporal incentives to help overcome obstacles during early advancement and market introduction. The 450 Scenario assumes the (supported) emergence of a variety of solutions, without imposing a shift to other modes of transport, i.e. to non-private, non-motorized transport modes, or measures to suppress demand for mobility. It will nevertheless be important to keep open the opportunity for more radical possibilities, especially in urban areas where good planning might induce behavioural changes which contribute significantly towards decarbonizing transport or, more broadly, the demand for mobility (Box 4.2).

To put EVs on track for their role in the 450 Scenario, RD&D must continue with government support to overcome obstacles to commercial success, particularly related to batteries, in order to lower costs and increase vehicle range. Second, support to cities and regions needs to be offered for sustainable business models in the creation of battery charging infrastructure. Third, encouragement is required for the development of smart grids which can support a larger role for the EV fleet as an electricity storage option.

In addition, governments may need to consider countermeasures, such as increased fuel or emissions taxes and systems of fees or rebates for vehicles depending on their environmental credentials, if the current period of low oil prices persists, reducing the relative attractiveness of alternative transport fuel.

To address the challenges associated with advanced biofuels, government support is required for the development of cellulosic biofuel refineries to drive down costs through learning. In addition, government- and industry-funded RD&D efforts are necessary to develop innovative processes to produce advanced biofuels, particularly from agricultural and forestry waste products. Governments have a particular role in supporting the development of indicators, such as those described by Franke et al. (2012), to set standards of sustainability in the production and use of biofuels which must be met, particularly in relation to competition with food production and any direct or indirect land-use change.

Box 4.2 ▻ Policies to avoid or shift transport activity

Technological change is not the only route to reducing carbon emissions from transport. Policies to reduce travel needs include land-use planning instruments that favour compact urban design and mixed-use development (e.g. commercial and residential), pricing and other measures encouraging travel demand management, such as the promotion of virtual mobility (e.g. tele-working), freight delivery co-ordination and logistical optimisation to decrease travel volume by finding shorter, more efficient routes. Such measures can be complemented by policies to encourage movement from private motorised travel to more energy-efficient modes, such as public transit systems, cycling, and rail. In densely populated urban environments, the availability of affordable, frequent and seamless public transport connections can be provided cost effectively, especially when taking into account the advantages of lower road space utilisation, lower exposure to pollutant emissions and reduced congestion.

The impact of such policies can be large. Cuenot et al. (2012), using the IEA Mobility Model, have shown that a 25% reduction in car and air travel in 2050 can reduce global energy use and CO_2 from transport by 20%. The IEA's *Energy Technology Perspectives* has shown that policies such as those considered here can reduce global transport energy consumption and emissions by 15% or more by the middle of this century in a stringent mitigation case, primarily through better management of travel demand and moving passenger and freight travel to more efficient modes (IEA, 2015a).

The measures necessary to achieve these effects include integrating urban and transport planning, facilitating investment in public transport infrastructure, supporting well-integrated public transport networks and options that lead to quicker vehicle utilisation turnover (e.g. car-sharing schemes). Some developments might take place naturally: the younger generation, particularly in urban areas, tends increasingly to prefer alternative transport options to the use of personal cars (e.g. public transport, cycling, walking), recognising that what counts is the transport service, rather than the means (personal cars). Transport demand reduction may also stem from the use of modern information and communication technologies.

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