McKinsey&Company

Beyond fossil fuels

Prepared for Petrotech-2016
12th International Oil & Gas Conference and Exhibition

December 2016

PETROTECH-2016
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Theme: Hydrocarbons to fuel the future:Choices & Challenges

Authored by:
Navtez Bal
Patrick Hertzke
Amit Khera
Nitesh Jain
Niklas Niemann
Suvojoy Sengupta
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Navtez Bal
Partner

Amit Khera
Partner

Suvojoy Sengupta
Partner

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Executive summary

Historically, fossil fuels have been major contributors to the world's energy supply. In the last 40 years, the share of fossil fuels in the global energy sector has remained over 80 percent, declining from 86 percent in 1973 to 82 percent in 2014.[1] With recent technological advances and rapidly declining cost of renewable energy sources, there is a distinct possibility that these sources could fulfil new energy capacity in the near future. The rapid evolution of electric and hybrid vehicles and their emerging commercial adoption could have potential to change the landscape of the energy supply space, reducing dependence on fossil fuels.

The global solar photovoltaic (PV) power generation capacity has grown swiftly in the last decade, from 7 GW in 2006 to 277 GW in 2016. The rapid increase in installed capacity has been driven by the decreasing cost of solar PV equipment. Recent tenders for solar energy in countries like the UAE and Chile have seen winning bids offering prices as low as 2.9 cents per kWh for plants expected to be commissioned in 2018. Solar penetration is expected to be further aided by a decrease in storage cost, which has fallen by 65 percent in just five years, from 2010 to 2015. Solar PV penetration could continue with its rapid growth as large-capacity storage becomes more affordable, with some original equipment manufacturers (OEMs) expected to touch the USD 100/kWh mark by about 2020–22.

The Paris Agreement of 2015 has given fresh impetus to emission-free technologies such as electric vehicles (EVs), which have a bright future.[2] There is possibility that up to 50 percent of all new car registrations in the US, the EU and China could be EVs by 2030. Many countries have adopted favourable policy frameworks for promoting EVs. For instance, in 2015, the FAME framework—Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India—was launched in the country to promote the adoption of EVs.

Key enablers like regulatory measures, battery technology and charging infrastructure could determine the future of the EV landscape globally. CO_2 regulation continues to be tightened in key markets, with the EU setting the target of 95 g/km of CO_2 by 2021.[3] India has decided to adopt the Bharat Stage emission standards (BS VI norms), which stipulate less than roughly 1 g/km of CO emissions for light-duty petrol vehicles.[4]

Battery manufacturers are making massive investments to reduce battery costs and improve financial attractiveness of owning EVs. Economies of scale, value-chain integration

1 *World Energy Statistics 2016*, International Energy Agency

2 United Nations Framework Convention on Climate Change website

3 International Council on Clean Transportation, May 2013

4 Ministry of Road Transport and Highways, Government of India, February 2016

along with improvements in design and the battery management system (BMS) are major drivers for the decline in battery cost.

The rapid technological evolution of solar PV and EVs has forced incumbent oil and gas (O&G) players to look for new opportunities. These companies are keenly observing the renewable energy sector, establishing cleantech venture-capital departments, incubating technologies and acquiring proven business propositions through mergers and acquisitions (M&As). Total's acquisition of Saft (a battery manufacturer) and Tesla's acquisition of SolarCity (a provider of solar energy services) are some of the biggest examples of M&A developments.[5]

Downstream O&G players, in the face of anticipated declines in fuel demand, could leverage their traditional strength in sales, distribution and maintenance to provide new offerings to cater to the diversified energy needs of customers. This includes potential opportunities for them to become one-stop energy providers for large accounts, enter the battery play and establish a charging infrastructure.

India's energy demand is expected to expand at a rapid pace, with population growth, rising urbanization and increased industrial activity acting as the key growth drivers. Compared to other growing economies, India's per capita energy consumption is still very low at around 1,000 kWh compared to China's at around 3,800 kWh.[6]

Major energy sources for India have historically been coal and crude, with 75 percent being imported. With rapid technological advancement in alternative sources of energy, India could have an opportunity to undertake a transformative shift in its long-term energy mix, thereby reducing dependence on coal and imported crude.

Fossil fuel demand also faces competition from other initiatives like electrification of transport (including railway electrification), 24x7 power for all, growth in ride-sharing travel apps and increased use of public transport. It is estimated that India has the potential to reduce dependence on fossil fuels by roughly 40 to 60 MMTPA in 2030 by embracing environment-friendly technological breakthroughs.

Electrification of transport is expected to be the focus of urban transport in the 21st century. India could become a laboratory for experiments within the EV ecosystem for developing countries—exploring new business ideas, adopting the most suitable ones and exporting those to other developing countries.

5 Total corporate website; Tesla corporate website

6 Central Electricity Authority; China Electricity Council

Beyond fossil fuels

The advent of fossil fuels has had a significant impact on the world by providing more reliable sources of energy, new materials and faster transport. However, there have been concerns about the effects of greenhouse gas (GHG) emissions from fossil fuels on the environment (leading to climate change). Therefore, nations are looking to alternative sources of energy to power their economic growth and also to reduce their carbon footprint.

Various developments on the alternative energy front have the potential to reduce dependence on fossil fuels. Solar PV and EVs, two key technological developments, seem to be the most promising in achieving a cleaner future.

This report discusses the implications of the rise of solar PV and EV for O&G players and explores possible actions to enable these players to survive and grow. It also discusses the impact of these on the Indian economy and highlights opportunities for the country at a time when the global energy map is preparing itself for a massive shift.

Fossil fuels as the main source of energy

Fossil fuels have been the main source of energy. According to the International Energy Agency (IEA), the contribution of fossil fuels to primary energy has remained above 80 percent from 1974 to 2014, while that of renewable energy like solar and wind has remained low.[1] In 2013, solar and wind energy contributed only around 0.7 percent to the primary energy demand globally (Exhibit 1).

The Paris Agreement, which was ratified by 113 countries, has given a new impetus to low-carbon technology.[2] Regulatory support along with rapidly falling installation prices for solar and wind energy hold the promise for a much larger contribution from these sources to India's future energy portfolio. By 2050, the contribution of renewable energy sources is expected to increase 10 times to 7 percent. Given this scenario, India plans to install 175 GW of renewable energy capacity by 2022, out of which 100 GW will come from solar PV.[3] Similarly, by 2025, the US plans to source 30 percent of its energy requirements from renewable energy sources.[4]

1 *World Energy Statistics 2016*, International Energy Agency

2 United Nations Framework Convention on Climate Change website

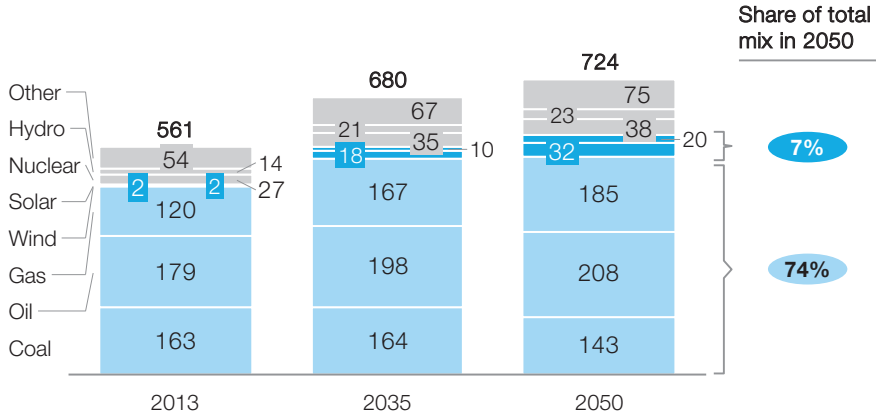
3 Ministry of New and Renewable Energy, Government of India website

4 Office of Energy Efficiency and Renewable Energy website

Exhibit 1

The fuel mix remains reliant on fossil fuels but growth is stagnant

Million terajoules



1 Other includes Biomass, Geothermal and Marine

SOURCE: Energy Insights; Global Energy Perspective

Alternative technologies are leading to reduction in fossil fuel usage

Energy-efficient technologies and materials, together with information technology (IT), smart systems and analytics, have the potential to reduce dependence on fossil fuels. These new technological developments are already making an impact on some of the largest energy-consuming sectors like power, transport, building, manufacturing, water and waste management, and CO_2 management.

Solar PV and EV are the two most promising technologies that are expected to have maximum impact on the fossil fuel industry. Other technologies like fuel cells/hydrogen and biofuels (Exhibit 2) have also been of interest for long. However, the commercial exploitation of fuel cells has been hampered by safety concerns regarding the storage of hydrogen. Biofuels also seem to be economically unfeasible at present because of their steep production costs and low crude oil prices.

Energy storage solutions, smart grids, autonomous vehicles and car sharing are examples of the key role of technology in enabling a low-carbon future. Advanced analytics, already used in wind-speed forecasting and in optimizing wind-energy output, could be further leveraged for more insights into an energy-efficient future.

Exhibit 2

Types of alternative technologies across some important sectors

Power		Transport	
Generation technologies	Supporting infrastructure and IT	Vehicle technologies and fuels	Supporting infrastructure and IT
Solar	Storage	EVs	Car sharing
Onshore wind	Smart grid (e.g., grid control technology)	Fuel cells/hydrogen	Charging infrastructure
Offshore wind	Smart metering	Biofuels	Multi-fuel infrastructure
Geo-thermal	Advanced analytics (e.g., wind forecasting)	CNG/LNG	Autonomous vehicles
Hydro-power	Demand response		Intermodal urban transport systems
Nuclear			
Biomass			

Buildings		Industry		Water & Waste	CO_2 management
Building technologies	Supporting infrastructure and IT	Industrial technologies	Supporting infrastructure and IT	Water & waste technologies	Carbon technologies
Modular construction	Building energy management systems	Efficient industrial equipment (e.g., boilers, pumps)	Energy management systems	Water-saving technologies (e.g., drip irrigation)	Carbon capture
Low-carbon cement		Bio-based chemicals		Desalination	Carbon usage
Compres-sorless HVAC				Waste-to-biogas	
Dynamic windows				Waste recycling	
LED lighting					
Insulation					
Efficient appliances					

Solar PV as a source of energy

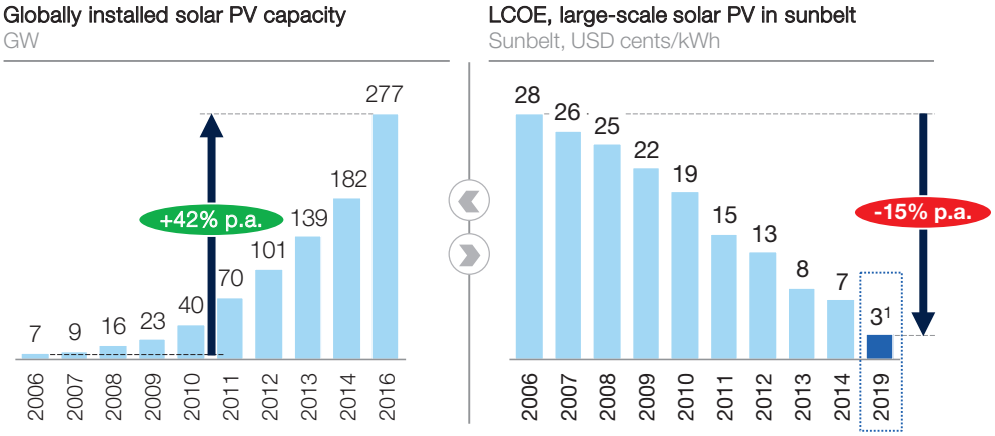
Since its first application in space missions in 1958[1], growth in solar PV and its installation has exceeded expectations.[2] Cost reduction has taken place throughout the solar energy system, from sourcing raw materials to manufacturing to installation and service, thus enabling smoother and faster adoption.

Installed solar PV capacity has increased 40 times, from 7 GW in 2006 to nearly 280 GW in 2016, showing an impressive growth of 42 percent per annum (p.a.), while costs have decreased rapidly at 15 p.a. during the same period (Exhibit 3). India has already installed more than 5 GW of solar PV capacity by the end of November 2016, which is more than the total installed solar PV capacity until 2015 (Exhibit 4).

Between January 2015 and October 2016, there has been a sharp decrease in the quoted prices (power purchase agreement or PPA) of winning tenders. For example, Granja Solar signed a PPA of 2.91 cents per unit with the Government of Chile for a plant scheduled to be operational in 2019 (Exhibit 5). This is a 50 percent reduction in the price of the winning tender in January 2015 by ACWA Power, within a short span of one-and-a-half years.

Exhibit 3

Global solar PV power generation capacity has grown exponentially as costs declined



1 Based on successful tender bid of Granja Solar in Chile in 2016 at USD2.91/MWh, expected to be operational in 2019

SOURCE: European Photovoltaic Industry Association; SolarPower Europe 2010-2016; PV-Magazine website, May 2016

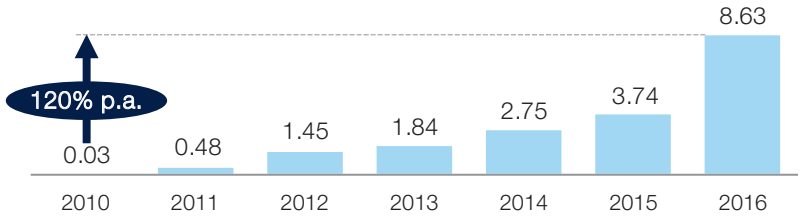
1 First commercial application of solar energy in Vanguard 1 space satellite, US Department of Energy website

2 *Peering into energy's crystal ball*, McKinsey Quarterly, July 2015

Exhibit 4

Total Solar Capacity Installed in India

Total solar PV capacity , GW



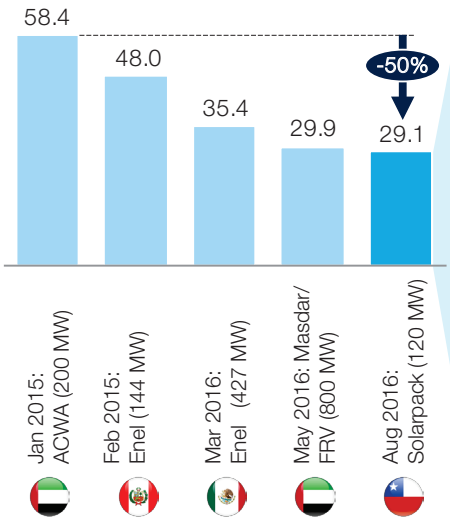
1 Till November 2016

Source: Ministry of New and Renewable Energy annual reports; Central Electricity Authority, 2010-2016

Exhibit 5

Solarpack set a new record-low solar bid at USD29.1/MWh in Chile, which beats the USD29.9/MWh bid by Masdar Consortium in UAE earlier this year

Lowest winning solar PV bids since 2015
USD/MWh



Tender details[1]

- **120 MW** plant "Granja Solar"
- **280 GWh/year PPA** with Chilean government for **20 years**, between the hours of 08:00 and 18:00
- Operational from **2019**, supply under contract starting **2021**
- To be built by Solarpack's local subsidiary **Maria Elena Solar S.A.**
- Bid part of latest auction to supply a total of **12.34 TWh per year,** with an average price of **USD47.6/MWh**

Solarpack[2]

- Spanish **solar PV developer** founded 2005
- **Developed projects:** Spain (35 MWp), Chile (37 MWp), Peru (62 MWp), Urugay (26.4 MWp)
- Further activities in **South Africa** through JV "Kabi solar"[3]
- Current **pipeline of ~1 GW**

1 Solarpack website, August 2016
2 Corporate name: Solarpack Corporación Tecnológica, SL
3 In partnership with Navitas Holdings Ltd

SOURCE: Solarpack corporate website

Shift towards solar PV as a source of power could continue to increase

Going by recent trends, solar PV could emerge as one of the most economically competitive energy sources over traditional sources like oil, gas and coal:

- **Solar vs. oil:** Oil-rich countries with high solar radiation, such as Saudi Arabia, Mexico, Turkey and Angola, could consider migrating to solar PV from their oil-based power generation. Even at the currently low global oil prices, the fuel costs of oil-based power plants are above the full costs of utility-scale PV power generation.

- **Solar vs. gas:** The winning bid of Granja Solar in 2016 had a PPA of 2.91 cents per unit. For gas-based power generation to be competitive under this bid, it would have to be priced as low as USD 1.6 per MMBTU, which is higher than the last five-year average price of natural gas[3] (Exhibit 6). In regions with high gas prices, such as the Asia-Pacific, utility-scale PV outcompetes gas easily on variable costs (that is, fuel + operations and maintenance [O&M]).

- **Solar vs. coal:** At the current level of the capex required for installing solar PV plants, the levelized cost of energy (LCOE) from solar is higher by 40 to 50 percent[4], as compared to the baseload coal in India. In India, the LCOE of solar could be lower than the LCOE of coal-based power plants by 2019, if solar PV installation costs continue to decrease at the rate of roughly 15 percent p.a and if the carbon tax on coal increases to roughly INR 600/tonne. Even if solar PV prices were to decrease at the rate of roughly 10 percent p.a., without taking into consideration carbon tax on coal, the LCOE of solar would still be lower than the LCOE of coal-based power plants by 2022. This implies that India might prefer to invest in solar energy over coal-based power plants for adding any new installed power capacity beyond 2022.

3 International Energy Agency website

4 In India, the current price for solar is about INR 6 and the price for coal-based load power is between INR 3 and 5.5

Exhibit 6

Recent investments in Chile and Dubai highlight the rapidly increasing competitiveness of renewables compared to gas fired generation

Solar PV

Year	Market	Bidder	Bid size MW	LCOE offered, USD c/kWh	Equivalent gas price[1], USD/mmbtu
2016		JinkoSolar/Marubeni	350	2.42	0.9
2016		Solarpack	120	2.91	1.6
2016		Masdar/FRV/Gransolar	800	2.99	1.8
2016		Enel	427	3.54	2.6
2016		JinkoSolar	-	3.65	2.7
2016		Acwa, First Solar	260	3.95	3.2
2016		Various bidders	1500	4.50	4.0
2016		Enersur	185	4.85	4.5
2015		Taqnia Energy	50	4.90	4.6
2015		Various bidders	200	5.71	5.8
2014		ACWA Power	70	5.84	5.9
2016		Fortum	500	6.70	7.2
2015		SunEdison	–	7.12	7.8

1 Assuming 57% efficiency, USD 700k/MW construction cost, 40 year operational life, 9% WACC, USD 25k/MW O&M and 5000 run-hours per years

SOURCE: Energy Insights, press search

Storage could become an important enabler of solar PV growth

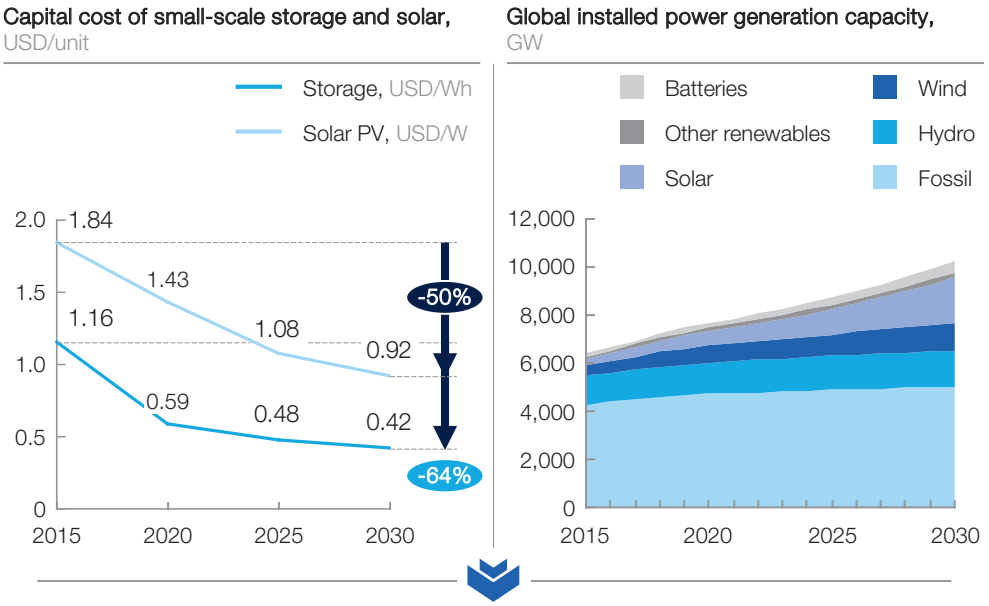
As solar is an inherently intermittent source of energy, peak times of solar power production may not match the peaks in demand. This reduces the overall plant load factor (PLF) for solar energy. In India, PLFs vary between 12 and 20 percent.[5]

The development of large-scale storage capacity at affordable prices could further push the adoption of solar PV by increasing PLF. A study by McKinsey and Bloomberg New Energy Finance in 2016 shows that the capital cost of small-scale storage and residential solar PV is projected to decrease by 50 percent and 64 percent respectively by 2030 (Exhibit 7).

5 Annual Report 2013–16, Ministry of New and Renewable Energy

Exhibit 7

Renewable penetration increases as the cost of distributed generation and storage fall



- **Cost** of **renewable power generation** has **decreased** significantly
- Continuous **increase of installed power generation capacity** from **renewables** expected until 2030

NOTE: Residential system costs

SOURCE: Bloomberg New Energy Finance; An integrated perspective on the future of mobility, McKinsey Quarterly, October 2016

Further, as the capital cost of small-scale storage and distributed generation decreases, the penetration of renewable energy is expected to increase.

New cost-competitive supply sources could lead to changes in existing business models

As new cost-competitive supply sources emerge, several players across varied sectors like O&G, solar, technology and auto are exploring opportunities to enter the new energy and transport value chains.

In 2016, Shell established a renewable energy division, New Energies, to invest in renewable and low-carbon power.[6] Statoil, Total and Shell have also set up cleantech venture-capital departments to identify potential investment-friendly companies. Total has also established an internal incubator to nurture new technologies with the aim of scaling up, if successful. DONG Energy intends to build a world-class clean energy company with a portfolio based on leading capabilities in offshore wind energy, bioenergy, green distribution and customer solutions.

O&G players are entering new energy value chains through M&As (Exhibit 8). Total acquired Saft, a battery manufacturer, at a premium of 38 percent in a USD 1.1 billion deal. Previously, Total had acquired SunPower, a solar-energy solutions provider, for USD 1.2 billion. Earlier this year, Tesla acquired SolarCity to vertically integrate its value chain and further improve its offerings to its customers.[7] Recently, Tesla introduced solar tiles in rooftops to capture solar power in residential areas, which could also be used to charge EVs.

Software players have also been active in the solar-energy sector. They are building products and platforms for energy demand forecast, demand dispatch, revenue and cost optimizations. For example, Oracle acquired Opower, a niche utility player, at a premium of 30 percent in 2016 (Exhibit 8).

Exhibit 8

Mergers & acquisition activity is back

Total	+	Saft	▪ **USD 1.1 billion deal**[1] for French battery specialist Saft representing a **38% price premium**
Tesla	+	SolarCity	▪ **Tesla** purchased **SolarCity** for **USD2.6 billion**[2] in all-stock deal
Oracle	+	Opower	▪ **Oracle** agreed to pay a **30% premium** to buy Opower at **USD532 million**[3]

1 Total website, August 2016
2 Tesla wesbite, August 2016
3 Oracle website, May 2016

6 All references in this section are from the corporate websites of Shell, Statoil, Total and DONG.

7 Tesla corporate website

The growth of electric vehicles

An electric car is powered by an electric motor rather than a gasoline engine. Various types of EV hybrids like hybrid electric vehicles (HEVs), plug-in hybrid vehicles (PHEVs), fuel cell electric vehicles (FCEVs) and battery electric vehicles (BEVs) have been introduced across Europe and the US since the late 1990s. Toyota launched its FCEV Toyota Prius in 1997.[1] Tesla, a pioneer in BEVs, rolled out its first complete BEV in 2008 and launched new models with variations a few years later.[2]

Strong growth in demand for EVs in many countries

In 2015, electric cars exceeded the global threshold of 1 million electric cars on the road.[3] Market shares of electric cars rose above 1 percent in many countries worldwide, reaching 23 percent in Norway and nearly 10 percent in the Netherlands in 2015.[4] Exhibit 9 illustrates the growth of cars in different geographies from 2011 to 2015.

The increase in the sales of EVs is also associated with the decrease in battery costs. The average price of lithium-ion battery packs used in EVs dropped by nearly 65 percent between 2010 and 2015. This decline in battery prices is mainly driven by economies of scale, improvements in battery chemistry and better battery management systems.

1 Toyota corporate website

2 Tesla corporate website

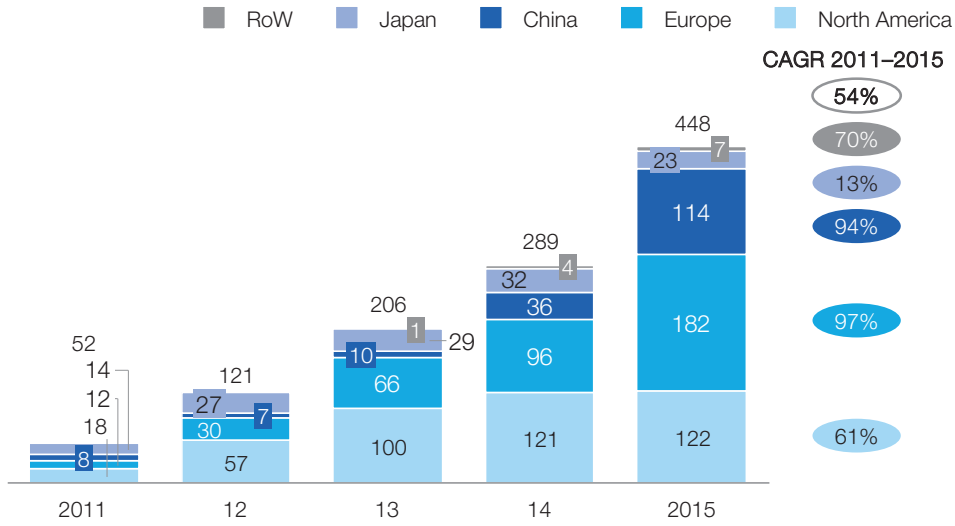
3 *Global EV Outlook 2016*, International Energy Agency

4 *Global EV Outlook 2016,* International Energy Agency

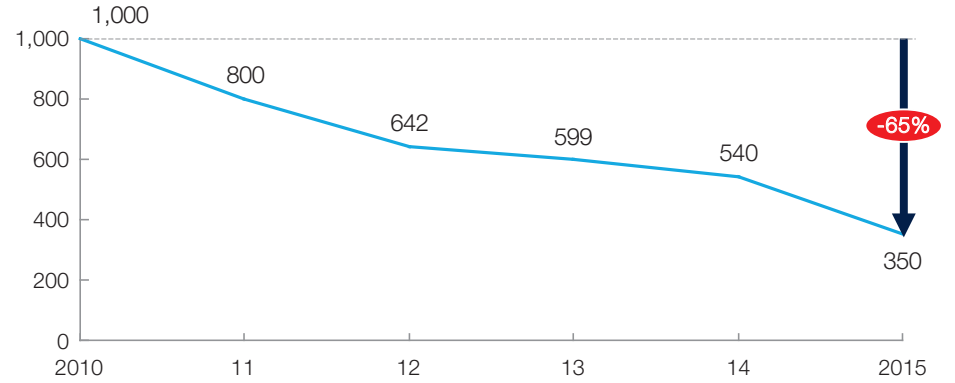
Exhibit 9

Electric vehicle sales have risen and battery costs have fallen rapidly

Electric vehicle sales
Sales, thousands



Average battery pack price
USD per kWh



NOTE: Plug-in hybrid electric vehicles and battery electric vehicles. Excluding low-speed vehicles and hybrid electric vehicles without a plug

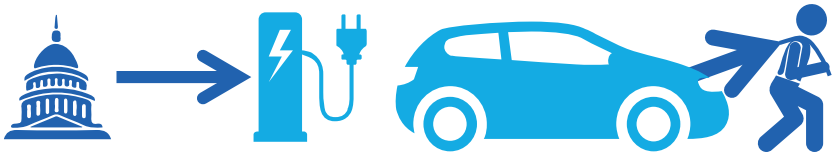
SOURCE: Bloomberg New Energy Finance; An integrated perspective on the future of mobility, McKinsey Quarterly, October 2016

The future outlook of EVs

The dynamics of regulatory push and consumer pull would ultimately determine the uptake of EVs. Regulatory push includes tightening emission targets and subsidies, while oil, battery prices and eco-friendliness of EVs are the key drivers for consumer pull (Exhibit 10).

Exhibit 10

Future EV adoption will be shaped by consumer pull and regulatory push



Regulatory push

Increases in emissions targets regulation through 2025 and potentially 2030

Recent emissions scandals make OEM lobbying for delays/reductions hard

EV subsidies continue (for now)

Consumer pull

Battery pack prices have declined by 20%+ p.a. over the past 5 years improving economics, but oil prices have held back mass-market adoption

Existing EV owners are likely to repurchase and High-performance EVs demonstrate growth potential in premium segment

To meet targets OEMs may need to sell vehicles at unprofitable prices in near-term

Further, the uptake of different EV hybrids could depend on the amount and type of the incentives offered for their development. For example, most electric cars entering the Norwegian market are BEVs, which are largely exempt from registration taxes and VAT, rather than PHEVs, which are subject to significantly lower levels of tax exemptions.[5]

Market distribution is significantly different in the Netherlands—which had the second largest car market share in 2015, as most of the newly registered cars were PHEV.[6]

5 *Global EV Outlook 2016*, International Energy Agency

6 *Global EV Outlook 2016*, International Energy Agency

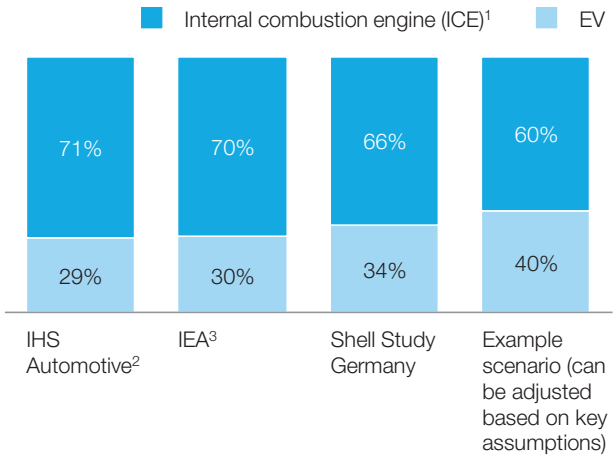
This was attributed to rebates and exemptions linked to CO_2 emissions rather than to the specific type of hybrid.[7] These resulted in the stronger market uptake of PHEVs, which offered more flexibility and had lower acquisition costs.

The future outlook for EVs, inlcuding hybrids, continues to be ambiguous with large variations in projected scenarios for 2030. This is largely due to the uncertainty regarding CO_2 regulations (Exhibit 11). In the most progressive scenario, about 50 percent of all new car registrations in the EU, the US and China in 2030 could be for EVs (including hybrids).

Exhibit 11

The outlook for EVs in 2030 is very uncertain, but a range of scenarios show the potential for 30–40% new car sales in US, EU, and China

Share of global new car sales (EU, US, China only), 2030



Example scenario could be possible if you believe…

Assumptions:

- Majority of OEMs meet currently proposed fleet regulations for 2025 and regulations tighten 2% p.a. from 2025–2030 in US, EU, and China
- Oil prices grow 2X+ vs. today
- Battery pack prices fall below USD 100/kWh in 2030
- Shared mobility fleet sales grow to 5%+ in US, EU, and China

1 Including 48V and mild hybrids
2 Forecasts only until 2023 available, data extrapolated
3 ICE includes HEV, xEV includes PHEV, BEV; Approx emission deviation based on average of PHEV and BEV emissions

SOURCE: Global Strategy analytics; HIS; IEA

7 Extensive reductions in registration tax and circulation tax below 82g CO2/km. Derived from the *Global EV Outlook 2016*, International Energy Agency

Potential enablers for the EV landscape

Going forward, the following enablers are likely to shape the EV landscape (Exhibit 12):

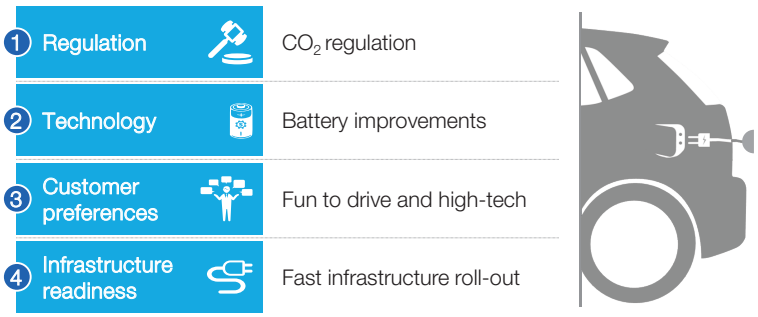
- **Regulations:** CO_2 regulations continue to be tightened in key markets like the EU and the US. In 2012, the US finalized standards of fuel efficiency of 54.5 mpg for cars by 2025.[8] In 2013, the European Parliament recommended an "indicative range" for a 2025 new-car CO_2 emission target of 68 to 78 g/km and called for the consideration of a lower target as well.[9] Rapid amendments in subsidies from national, regional and city governments along with revisions in non-financial incentives or penalties could significantly affect EV sales.

- **Battery technology:** An important driver for the total cost of ownership (TCO) of the battery is the cost of the battery pack. Battery improvements could see significant declines in price in the next five to 10 years. Various estimates indicate that battery prices could be in the range of about USD 170 to 100/kWh by 2020, which could further drop to nearly USD 70/kWh by 2025 (Exhibit 12). Decline in battery prices is key to making the TCO of EVs more attractive.

- **Infrastructure readiness:** Key markets like the US, the EU and China are currently witnessing the rapid roll-out of charging infrastructure, which is crucial for EV uptake. In the current scenario, buying a BEV might require a change in driving lifestyle.

Exhibit 12

EV growth drivers



8 White House press release, August 2012

9 International Council on Clean Transportation, November 2016

In addition to these three key aspects, EV manufacturers could also shape consumer perceptions more favouravly—by portraying to customers that while such vehicles are eco-friendly and efficient, they are also fun to drive, e.g., Tesla Model 3[10].

Regulations for EV

Regulations and incentives are expected to be the biggest driver for the adoption of EVs to curtail pollution levels and to make cities healthier and more liveable (Exhibit 13). These incentives could involve a combination of exemptions in registration tax, VAT, circulation tax, free access on toll roads and ferries and the use of high-occupancy lanes.

In April 2015, to promote the adoption of eco-friendly vehicles, the Government of India adopted the FAME framework—Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India—offering incentives of up to roughly INR 29,000 for motorcycles and INR 1.38 lakh for cars.[11] Although the FAME framework is ambitious, there are significant challenges in its implementation which may not allow policy to realize its full objective.

Exhibit 13

Example of regulatory measures taken to promote EV sales

Delhi	▪ Reduced VAT on e-mobility from 12.5% to 5.0%
Netherlands	▪ Zero-emission cars are exempt from paying road taxes
China	▪ EVs are exempted from circulation/ownership taxes
France	▪ BEVs and some PHEVs are exempted from annual taxation for company cars
Japan	▪ EV exemptions from annual tonnage tax and reductions for automobile tax
USA	▪ Exemptions and offers vary from state to state. California residents can get up to USD7,000 for the purchase of new eligible zero-emission or plug-in hybrid light-duty vehicles

SOURCE: International Energy Agency, Global EV Outlook Report, 2016

10 Tesla corporate website

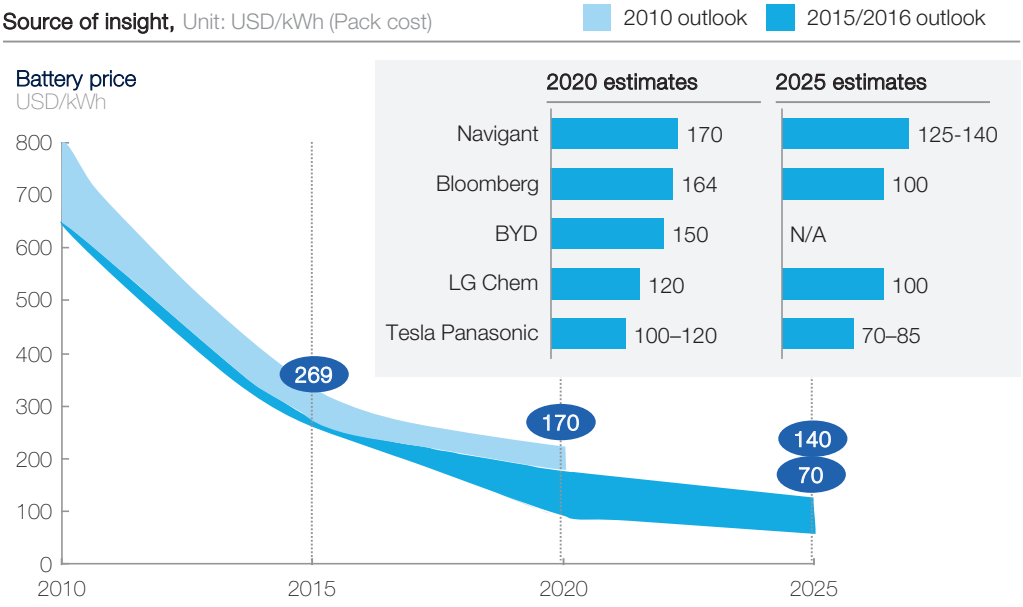
11 FAME India website

Battery technology

Battery prices have declined significantly in the last five years. Some estimates also indicate the possibility of battery prices touching USD 100/kWh for some OEMs as early as 2020 (Exhibit 14). Improved battery management systems, economies of scale and value-chain integration are key drivers for reducing battery prices.

Exhibit 14

Further declines in EV battery costs is expected with several sources suggesting steep declines in the next 5–10 years



SOURCE: SNE research; Navigant; Avicenne Energy; Berstein; expert interviews

Infrastructure readiness

Infrastructure readiness for charging points, especially at residences, parking lots and along the highways, is essential for the adoption of EVs. The private development of fast-charging networks along highways would especially enable long-distance travel.

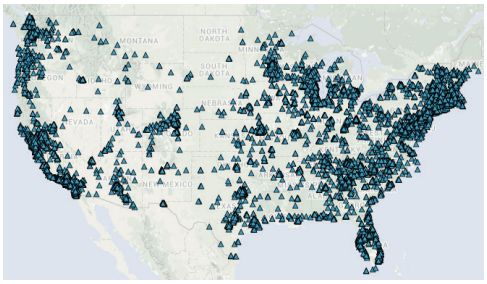
Currently, there are more than 12,000 publicly accessible charging-station locations in the US, with multiple organizations providing charging facilities (Exhibit 15). ChargePoint,

Blink and EVgo are some of the leading charging networks, with charging facilities spread across the US. Superchargers could help cars travel for about 170 miles in as little as 30 minutes of charging. Tesla is way ahead of its peers in a bid to establish a solid supercharger infrastructure across Europe (Exhibit 15).

Exhibit 15

Charging stations network across US

Publicly accessible charging stations in the US[1]



Total public stations = ~12,300
Total charging outlets = ~40,000
(not including private chargers)

Tesla super charger infrastructure[2] currently being rolled out in Europe

527 Supercharger stations with
2.983 Supercharger slots

1 Alternative Fueling Data Center, 2016
2 Telsa corporate website

Implications and possible actions

Improved economic feasibility of alternative sources of energy along with concerns around climate change could alter the energy map of the world. These changes would also impact Indian O&G players and the Indian economy.

Implications and possible actions for the Indian O&G sector

The decrease in prices of solar PV and the advent of EVs could have significant implications for O&G players in India:

- **Reduced demand for diesel:** The total installed power capacity of diesel generators in India is estimated at 72 GW.[1] The diesel consumption for backup power generation is expected to decrease with increased access to 24x7 power, lower aggregate, technical and commercial (AT&C) losses through the UDAY scheme[2] and the availability of alternative sources of power. Diesel demand for power generation could also decrease by 60 to 65 percent in the next six years, amounting to 5 MMTPA by 2022, which is roughly 7 percent of the total diesel consumption in FY 2016.

- **Demand contraction for retail liquid fuels due to EV uptake:** EVs could reduce the need for retail fuel in cities. The extent of the decline in demand will depend on the share of electric cars in cities. For example, if 10 percent of all new cars sold by 2030 are EVs (including hybrids), there could be a demand destruction of 20 MMTPA of liquid fuel. The growth of travel-sharing services, efficient public transport systems and improved vehicle mileage in internal combustion engine (ICE) vehicles could also affect the demand for liquid fuel.

Indian O&G players could consider the following actions to thrive in the new energy landscape:

- **Energy management services and analytics for large accounts:** O&G companies could play the role of an energy-optimizer for large accounts, comprising both ICE and EV vehicles in the transport industry. For example, logistics players might use EVs for intra-city movements and ICE-based engines for inter-city travel. O&G players could leverage their existing strengths to meet the energy needs of all these clients, including oil, battery replacement and maintenance, charging infrastructure, wholesale power procurement and hedging fuel price. They could also provide solutions using analytics for demand forecasting, demand scheduling and energy efficiency.

1 *All India Study on Sectoral Demand of Diesel and Petrol*, Petroleum Planning and Analysis Cell, 2013

2 Ujwal DISCOM Assurance Yojana, Ministry of Power, Government of India

- **Measured approach towards expansion of retail fuel outlets in cities:** The expansion of the retail outlet network at a rate faster than the growth in liquid fuel demand has already resulted in the steep decline in volume throughput per outlet (TPO). The expected rise of EVs could limit the demand for liquid fuel in cities for reducing TPO. Companies would have to carefully plan growth in a number of fuel outlets in metro areas accordingly.

- **Battery play:** O&G companies could leverage their existing strength in sales and distribution to provide services like battery charging, battery maintenance and battery swapping.

- **Research and development (R&D):** O&G players could compete more strongly with EVs by decreasing the cost of ownership, reducing emissions and improving consumer perceptions of ICE-based vehicles. They could consider collaborating with auto players to improve auto design and the quality of fuel and lubricants for better mileage.

Implications and the way forward for India

Rise in renewable energy capacity and growth in EVs could have several significant implications for the India economy:

- **Reduced import dependence:** India is a net importer of fossil fuels and energy. Renewable energy sources such as solar and wind, along with EVs and other energy-efficient technologies, could provide India with significant opportunities to reduce import dependence. By adopting alternative sources of energy, India could hope to reduce its crude import by roughly 40 to 60 MMTPA in 2030.

- **Cut in carbon emissions:** Renewable energy and EVs have the potential of reducing carbon emissions by up to 25 percent in 2030 and could help India move closer to achieving its emission targets in line with the goals of the Paris Agreement.

- **Installation of robust transmission networks:** Ancillary services like frequency control, spinning reserves and operating reserves would be needed to support intermittent energy supply through renewable sources of energy, like solar PV and wind, to maintain grid security and stability.

Going forward, India could benefit from these emerging trends by focusing on the following dimensions:

- **Resilient and flexible power supply:** India could develop a transmission network that would be able to absorb large renewable energy outputs. Smart meters and a peak-tariff

policy are crucial to incentivize conventional fuel power plant players to dispatch power to meet peak power demand. There is a huge need for a transmission network that could bring about voltage/frequency stability in the grid. Better demand forecasting and demand-side management can improve the availability of delivered power, a goal aligned with the vision of 24x7 access to power for all.

- **Laboratory for development of EV ecosystem:** The EV ecosystem in developing countries like India would probably undergo a different form of evolution and might play out differently than the one in advanced economies such as the US, Europe, etc. An innovative mindset among industry players and support from the government could lead to the emergence of business opportunities suitable for developing countries. India could become an exporter of EVs to other developing countries, leveraging its strength as an automotive hub. Further, with a large domestic car market, there are tremendous opportunities for entrepreneurs to explore business models in the EV space, some of which might be a good fit for markets in other developing countries.

- **Smart cities:** India needs to prepare itself for a paradigm shift in urban infrastructure for upcoming new cities (e.g., Amaravati) and the transformation of existing cities into smart cities. Along with EVs, an overall ecosystem of mobility, including multimodal transport, electric charging infrastructure, ridesharing and walkways, needs to be developed to build an urban infrastructure with reduced emissions, less congestion and enhanced user convenience.

The future of energy will be shaped by emerging energy sources that would become mainstream and could significantly displace fossil fuel. Technology-led disruption could reshape the entire transportation sector, reducing overall costs and enhancing sustainability. Countries might have to prepare themselves for a future where solar energy powers the world, EVs are the prevalent mode of transport and vehicular air pollution is a thing of the past. This exciting future would eventually influence incumbents like O&G and auto players to rethink their role in the energy and transport value chains. Governments across the world could also provide a conducive regulatory framework and play a proactive role in creating an ecosystem for supporting the development of alternative energy models and their adoption by end-users.

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