

# Adopting electric vehicles: The role of technology and investment



## At a glance

The electrification of the automobile represents a potentially revolutionary step in increasing vehicle efficiencies

Battery systems can add \$10K to upwards of \$20K to a vehicle price tag and supporting infrastructure will require a large scale investment.

Electric vehicles are expected to have a minimal volume impact in the short- to mid-term

Electric vehicles (EVs) have garnered increased attention recently as the automotive industry begins to show signs of stabilization and recovery. While there remains little doubt that this technology will have a significant impact on the industry moving forward, several factors will determine just how quickly and deeply EVs will penetrate the market and whether or not it will become a sustainable market segment.

### The drive for change

Climate change and the negative impact that various human activities can have on our ecosystem are among the inescapable challenges world leaders are facing. While the issue of global warming remains highly debated, there is increasing evidence to support the environmental impact of carbon emissions. It is estimated that the automotive industry is responsible for roughly 15% of global carbon emissions, equating to roughly eight billion metric tons per year. Although environmental protection has been cited as the primary driver for change, other factors such as the price volatility of fossil fuels and energy independence also have helped perpetuate a shift towards alternative and renewable energy sources.

Accordingly, many governments have implemented a wide array of policies aimed at reducing carbon emissions, some of which specifically target the automotive industry. In the U.S., the recently proposed changes to the Corporate Average Fuel Economy (CAFE) standard, announced by President Obama, mandate a 30% reduction in carbon emissions by 2016. Some

critics have protested that the new standard is too lenient. However, imposing such regulations in the midst of a massive market downturn, while R&D funding is under duress, is a sign to automakers that fundamental changes must begin to take place.

The European Union, widely seen as a leader in reducing automotive carbon emissions, has taken additional steps in setting a limit of 130g/km of carbon emissions by 2015, with 65% of new vehicles required to meet the standard by 2012. While other developed markets such as Japan are also enforcing tough emission standards, developing markets that have long lagged other regions in terms of enforcement are beginning to catch up and are adopting increasingly stringent emission regulations.

EVs are seen as one possible solution automakers can focus on to meet increasingly stringent emission regulations around the world, since they release no carbon emissions while running on electric power. However, some question whether EVs are truly “clean vehicles” because in some cases, the electricity used to power the vehicles is produced by

high polluting coal power plants. This has drawn attention to the need to invest in a clean energy infrastructure. EVs are grouped into two main categories; plug-in hybrid electric vehicles (PHEV) and pure electric vehicles (PEV). A PHEV is powered by an electric motor and an internal combustion engine (ICE) that functions as a generator to recharge the batteries. PEVs do not have an engine or a generator and are therefore subject to more limited driving ranges. Both PHEVs and PEVs benefit the environment in terms of lowered carbon emissions, but also provide dramatic fuel economy savings for consumers already dealing with continually high pump prices. While EVs are undoubtedly more efficient than their gasoline fueled counterparts, the EPA is still working on a standard in which to accurately measure these gains. Developing a fair and comparable methodology is seen as vital in the promotion of EVs. Perhaps most important, EVs are seen as a way of decreasing, if not eliminating, U.S. dependence on foreign oil. The Obama Administration has included EVs as part of its energy plan, setting a goal of one million PHEVs on the road by 2015.

## Electrifying the industry

As vehicle electrification continues to emerge, significant changes within the industry are likely to happen concurrently with this rollout. In addition to the need for a network of recharging stations, fundamental changes to the traditional business model of automobile ownership should be considered as well. For example, some have proposed a battery swap program in lieu of waiting for a battery to charge. This brings into question the issue of battery ownership, which may open

Resources previously allocated to gaining incremental or evolutionary efficiencies could be repositioned to accelerate the development of this technology, which is seen as revolutionary. Within this context, some EV manufacturers are beginning to capitalise on this opportunity, and new entrants that offer EVs have also begun to emerge.

Now that the automotive manufacturer playing field has expanded, no traditional automaker has a significant advantage over another in regards to EV technology,

“We recognize that pursuing electrification as one of our technology paths presents unique challenges for commercialization of the vehicles... It requires us to collaborate with new partners, define new business models, connect to a new infrastructure for the vehicles and meet new customer expectations around the globe.”

– Sue Cischke, Ford’s group vice president of Sustainability, Environment and Safety Engineering<sup>1</sup>

the door to business models based on fixed-price leases for batteries and/or entire vehicles. As the initial rollout of large scale EVs seems likely to be initiated through public and private fleets, corresponding large-scale leasing models could be tested via this scenario. Another issue is the lifecycle of EV batteries. What happens to the battery when it is no longer able to provide the charge necessary for adequate driving ranges? Some utility companies foresee extending the life of the batteries by serving to expand the capacity of the power grid during peak usage. However, once the batteries have reached the end of their lifecycle, safe and environmentally-friendly scrappage protocols still need to be established.

Product development also could be affected by the introduction of EVs.

which enables new entrants to compete. Additionally, suppliers of lithium-ion batteries and systems are expected to be in high demand as a large portion of current production capacity is allocated to supplying non-automotive sectors such as the computing and telecom industries. As a result of these developments, non-traditional suppliers that offer proven EV components are expected to emerge within the automotive industry.

The changing geography of the automotive industry also represents an opportunity for traditional players in emerging markets. Chinese automakers, for example, understand it will behoove them to focus on developing electric vehicles rather than committing major resources to catching up on internal combustion engine standards.

<sup>1</sup> CNBC, October 9, 2009.

“If we want to reduce our dependence on oil, put Americans back to work and reassert our manufacturing sector as one of the greatest in the world, we must produce the advanced, efficient vehicles of the future.”

– President Barack Obama<sup>2</sup>

### Roadblocks ahead

Despite the aforementioned benefits electric vehicles provide, several important challenges remain that may slow and/or impede the penetration that these vehicles can achieve in the marketplace.

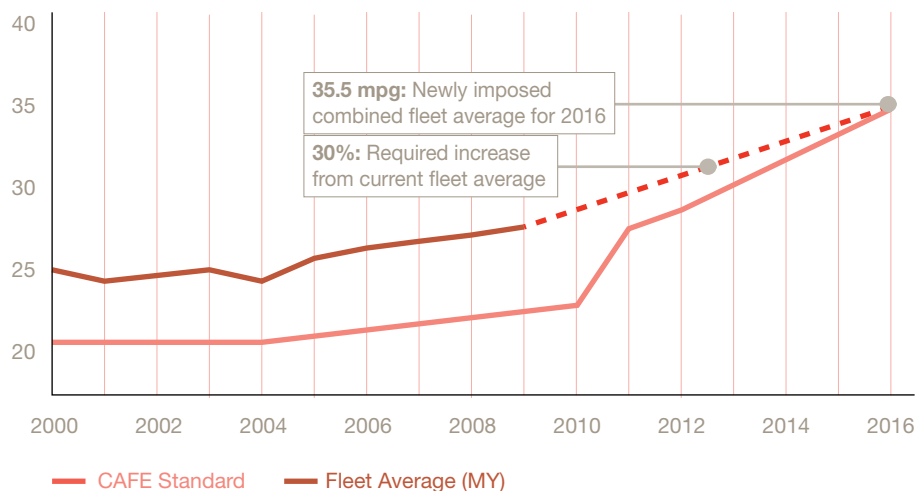
### Lagging Battery Technology

The first issue is related to the technology surrounding EVs. The main components of an EV are the electric motor and the battery pack that supplies power to the motor. For PEVs, the main drawback in this setup is limited driving range due to relatively short battery life. In response to this limitation, more powerful and efficient batteries are now being developed. Lithium-ion has emerged as a leading battery material for power, driving range, and price point considerations.

### Community Infrastructure Readiness

Inadequate infrastructure also will delay any significant shift to EVs. The lack of an available network of charging stations restricts drivers to short commutes, while it can take up to several hours to fully recharge

**Current CAFE Guidelines vs. Industry Average\***  
2000–2016 (miles per gallon)\*\*



\* CAFE: Corporate Average Fuel Economy MY: Model Year  
 \*\* 35.5 mpg target for 2016 includes expected emission reductions from HVAC improvements, actual on-road fuel economy target is 34.1 mpg  
 Source: NHTSA/PwC AUTOFACTS Analysis.

an EV. The space required to place charging stations, coupled with a suitable means for consumers to pay for the electricity they use while charging their vehicles, are open issues. Programs such as Project Better Place have provided EV infrastructures in countries like Israel and Denmark that allow EV drivers to quickly recharge or swap out batteries. Despite the program’s

success, significant start-up costs remain a central concern. Like any new technology, there are several different production options being introduced in terms of battery layouts and plug design. The plug design is of particular concern, as a universally accepted standard will likely need to be in place before significant infrastructure investment can occur.

<sup>1</sup> U.S. Department of Energy, <http://www.energy.gov/7749.htm>

### The burden on Power Grids

Additional concerns about the effect EVs will have on the nation's power grid also remain. Experts disagree on what the actual drain on the nation's power grid will be. Some have argued that no additional capacity will be needed if vehicles are charged during off peak hours, while others have claimed that a significant investment will be required to sustain any large number of EVs.

### Shortage of Investment Capital

Because the concept of mass vehicle electrification is fairly new to the automotive sector, continued R&D funding is necessary to increase efficiencies and decrease consumer cost. Major automakers and suppliers typically allocate between 1.5-6% of revenue to R&D expenditures. Financial constraints brought about by the current recessionary trends will make it likely that automakers could make budgetary decisions that negatively impact EV development, and favor traditional and less costly vehicle programs that require less R&D spend and bring quicker payoffs in the short term.

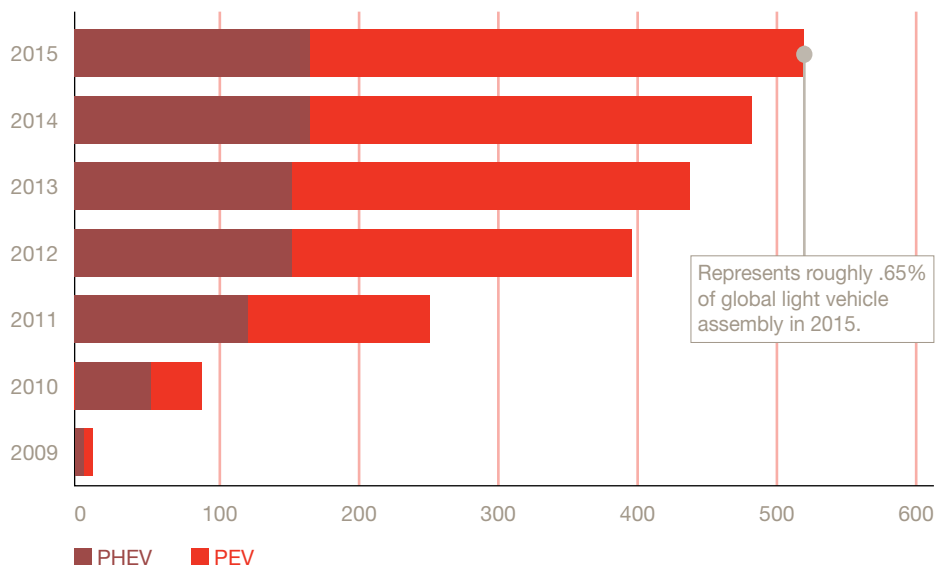
### Higher Initial Vehicle Cost

With relatively new technology and low sales volumes, significantly higher costs will be incurred

# 1M

Number of plug-in hybrids (PHEVs) the Obama Administration hopes to have on the road in the U.S. by 2015

**Global EV Forecast: Pure Electric Vehicle (PEV) vs. Plug-in Hybrid Electric Vehicle (PHEV)**  
2009-2015 (Thousands)



Source: PwC AUTOFACTS Analysis.

by consumers purchasing EVs compared with vehicles powered by a traditional internal combustion engine. The cost differential can range from \$10,000 to \$20,000 and up depending on the type of vehicle under consideration. Most of this premium is directly attributable to the raw materials that comprise the vehicle's battery. The extraction of the active battery components such as lithium and graphite, as well as the manufacturing and recycling process, contribute to a large portion of the cost. An appeal to consumers is that the cost savings realized from using electricity rather than gasoline will allow a partial payoff of the higher transaction price.

### Proceed with caution, or full speed ahead?

The outlook for electric vehicle technology will, inevitably, mean

different things for different industry participants. For suppliers who are at the forefront of lithium-ion battery production, demand is expected to remain strong. Even if automotive demand begins to level off, lithium-ion systems remain marketable across multiple industries (commercial, construction, telecommunications, etc.), so a diversification of a supplier's customer base is likely to support a positive outlook.

For automakers, who must continually balance R&D spending on a variety of new technologies, increased sharing and collaboration with competitors will likely continue to occur. Consumers should expect to see a number of technology options in addition to electric vehicles, including hybrid, clean diesel, and direct injection and turbocharged engines that will increase automobile efficiencies .



Overall, the focus on climate change and environmental sustainability, as well as the need for reduced dependence on foreign oil, will continue to drive automakers, battery developers, scientists and urban planners toward pioneering efforts in alternative-fuel vehicle development and integration of these new technologies into the automotive landscape. On the other hand, EVs are expected to play an important role in driving technological advances and increased vehicle efficiencies in the near term, not necessarily from a volume perspective, but rather in terms of pushing development of industry innovation.

### Factors that will drive success

The extent to which EVs will be able to penetrate the market in the near term remains somewhat unclear, as automakers have been toying with this industry segment with limited degrees of success for the past 15 years. While there is an increased focus on the environmental advantages of electric vehicles, several key drivers are expected to shape the future outlook for this technology in the automotive industry:

#### Government Support

Continued support from both the public and private sectors will be needed to assist in the development of EV technology and increase consumer appeal. This can be achieved through grants, low interest loans and tax credits. Investment in network infrastructure will also be needed in order to provide convenient and easy to use charging stations.

#### Network Infrastructure

While consumers will be able to plug-in their vehicles at home, a

larger concern exists around building a broader, public charging infrastructure for EVs, much like the role gas stations play in today's market. Due to the finite range of EVs, public and private investment in a network of charging stations will play a key role in giving consumers the driving freedom they currently enjoy with ICE (Internal Combustion Engine) vehicles.

#### Battery Technology

As development of lithium-ion technology progresses, costs will continue to decrease as quality and safety metrics increase. Since the battery is the most expensive component in an EV, continued R&D investment is needed in order for automakers to create a solid, long-term business case.

#### Consumer Acceptance

Ultimately, consumers will determine the success level of electric vehicles. There has been an initial "sticker shock" by mainstream consumers toward current and upcoming EV models. In order to reach the masses, EVs must be priced at an attainable level. Economic and environmental factors are seen as the top reasons for considering electric-powered alternatives to vehicles that run on conventional fuels such as gasoline, propane and diesel. Major benefits that consumers are likely to consider before purchasing an electric vehicle include:

- **"Green" Conscience**

EVs emit no pollutants from the tailpipe, so they are cleaner for the environment. The overall emissions associated with using EVs, even including the power plant emissions, are typically far less than the emissions produced from their combustion-powered counterparts.

- **Overnight Charging**

Most EVs charge up at night when system wide demand for electricity is low. They tap existing generating capacity that is not fully used rather than increasing demand for new capacity. However, concerns still remain on the effect EVs will have on the power grid as demand increases.

- **Reduced Oil Consumption**

Choosing EVs over combustion powered vehicles contributes to reduced dumping of engine oils into the environment and reduced U.S. reliance on foreign oil, which in turn has put a focus on providing clean and sustainable energy.

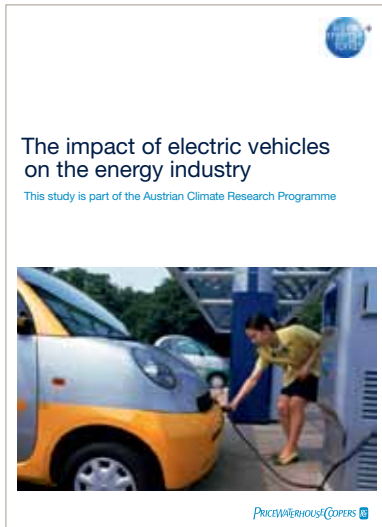
PricewaterhouseCoopers AUTOFACTS estimates that by 2015 EVs will comprise less than one percent of global light vehicle output, or roughly 600,000 units annually. On the surface, this estimate might appear to have a minimal impact on worldwide sales volumes, yet these numbers should be understood in context to be fully appreciated. While this is relatively small volume in the short- to mid-term, the progress expected in infrastructure development and supporting technology represents a roadmap to future market growth.

# 11

Number of announced EV introductions that will begin sales in the U.S. in 2010 and 2011

## Recommended reading

The Impact of Electric Vehicles on the Energy Industry



Global Automotive Perspectives: Capitalizing on Change



Electric Vehicles: Plugging into Tomorrow's Vehicles



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