PikeResearch
Cleantech Market Intelligence

Research Brief

Electric Vehicles: 10 Predictions for 2010

Published 4Q 2009

Published in partnership with:

hybridCARS.com

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Introduction

A new era of electrified vehicles will soon be upon us. During the next decade, millions of vehicles that primarily run on electric power and are plugged in to be recharged will enter roadways as the automotive industry slowly begins to wean itself from fossil fuels. While the transition will be slower than many individuals with concerns about climate change would like, the impact on auto manufacturers, battery makers, utilities, and smart grid companies will be profound.

Despite rapid growth in the sales of plug-in hybrid electric vehicles (PHEVs) and pure battery electric vehicles (EVs), the hybrid electric vehicle (HEV) market will continue to be the largest market for the foreseeable future. This combined market for electrified vehicles will represent just a small (2.5%) portion of the total vehicle market. Yet, it will require billions of dollars in investment in charging equipment and upgrades to the power grid to manage the additional load. In 2015, Pike Research forecasts that charging stations where drivers can plug in and recharge their vehicles will be available at more than 5.3 million locations around the globe.

Lithium ion (Li-ion) battery manufacturers are gearing up for the EV age by building new manufacturing plants and expanding capacity to provide the necessary millions of cells and packs. Pike Research anticipates that this expansion will create an $8 billion industry for batteries by 2015.

The EV revolution will have obvious impacts on the automotive industry and consumers. Deeper analysis reveals some trends that will influence the way vehicles are built and used. As such, Pike Research has identified 10 key trends to watch out for as the EV market takes shape.

1. The cost of owning and driving an electric vehicle is not likely to be cheaper than using gasoline.

Proponents of EVs suggest that driving on electric power will cost a fraction of using gasoline as fuel. The commonly quoted estimate is approximately 75 cents per gallon equivalent for electricity, or 3 cents a mile. Gasoline at $3.00 per gallon equals approximately 12 cents per mile.

Figure 1 Cost per Mile Driven: Gasoline vs. Battery Power

Usage Model	Cost per Mile	Monthly Cost	Assumptions
Low Gas	$0.12-$0.14	$120-$140	Gas $3 gallon/22-25 MPG sedan
High Gas	$0.18-$0.22	$180-$200	Gas $4 gallon/22-25 MPG sedan
7 years (84,000 miles)	$0.133	$133	$540 kWh battery net cost, 3 cents per mile for electricity
10 years (120,000 miles)	$0.105	$105	$565 kWh battery net cost, 3 cents per mile for electricity

(Source: Pike Research)

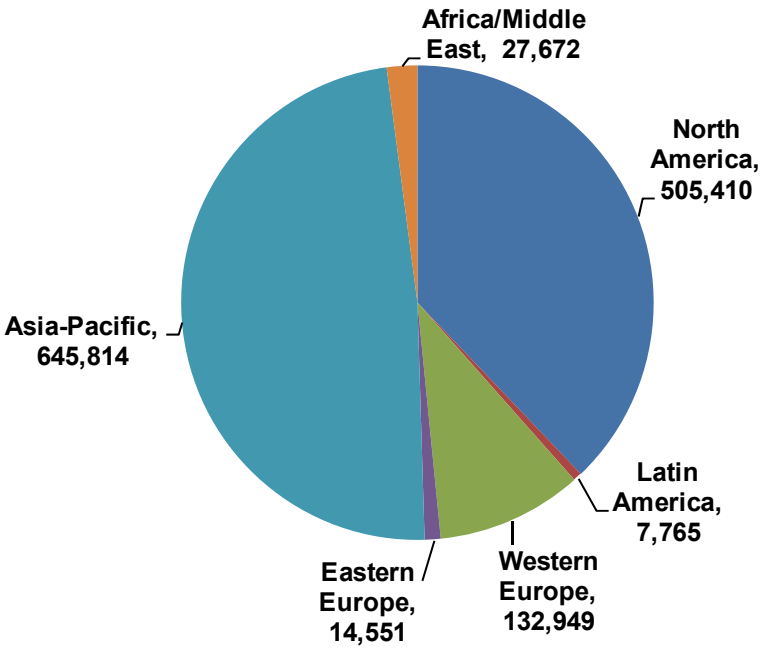
However, these estimates do not include the premium paid for a PHEV/EV (and its batteries). The overwhelming majority (about 75% depending on miles driven) of the cost of driving on electric power is paid upfront in the form of the cost of the batteries and the electric drive train. These components can add up to 50% to the cost of the vehicle. Driving on electric power can become cost-competitive or possibly offer some savings over gasoline driving only if consumers keep their PHEV/EVs for 7 years and nearly fully deplete and recharge their batteries daily.

A sharp increase in the price of oil or levying of a significant gasoline tax could heavily weight the equation toward PHEVs/EVs. While the price of electricity is likely to grow only slightly during the next 5 to 6 years, the price of crude and gasoline in the coming years could rise sharply. Should gas stay above $5.00 per gallon for an extended period of time and the cost of vehicles drop, then electric driving power might become cheaper.

2. 2012 will be a critical year for the commercialization of EVs and plug-ins.

The Obama administration and governments in Europe and Asia have provided significant financial support for the launch of mass market PHEVs and EVs. Billions of dollars in grants to automakers and battery companies to build or retrofit manufacturing plants have reduced the cost of the vehicles and have provided OEMs with greater flexibility in pricing. Federal and state mandates to purchase electrified vehicles and consumer incentives of up to $7,500 will make purchases more palatable for early adopters. Historically, however, hybrid tax credits have had only a minor effect on increased market adoption.

Figure 2 HEV, PHEV, and EV Sales, World Markets: 2012



(Source: Pike Research)

The U.S. federal government's commitment to avoiding the demise of the auto industry and developing green jobs in the United States is providing a temporary crutch. A reduction in this financial commitment could remove a vital safety net. By 2012, many of the consumers most interested in and able to purchase PHEV/EVs will have purchased

vehicles. The remaining group of consumers interested in driving on electric power is likely to require vehicles that are much more cost-competitive with conventional vehicles. At the same time, the impact of government subsidies and incentives on supply and demand is likely to begin declining. New or extended government support could depend on the recovery of the global economy and the political efficacy of additional government spending in an election year.

For these reasons, 2012 and into the following year could be a "make or break" period for the EV industry. Automakers are looking to EVs to jumpstart sales across their lineups by bringing customers into showrooms. They need to identify and convert consumers and fleet owners interested in electrified transportation. Thus, their focus should be on successfully marketing the EV driving experience – not on the cost of driving, which at that time is likely to favor gasoline. Battery suppliers that expand manufacturing capacity during 2010-2011 in anticipation of a rapidly growing market will have to generate sufficient revenue to cover operating expenses. Overcapacity of battery production could drive down prices. This price decline would result in less expensive vehicles and spur sales, but could also impact the viability of U.S. battery manufacturers. If the EV market falters, battery manufacturers will likely expand sales to the grid storage sector, which has shown an interest in acquiring batteries with similar technology.

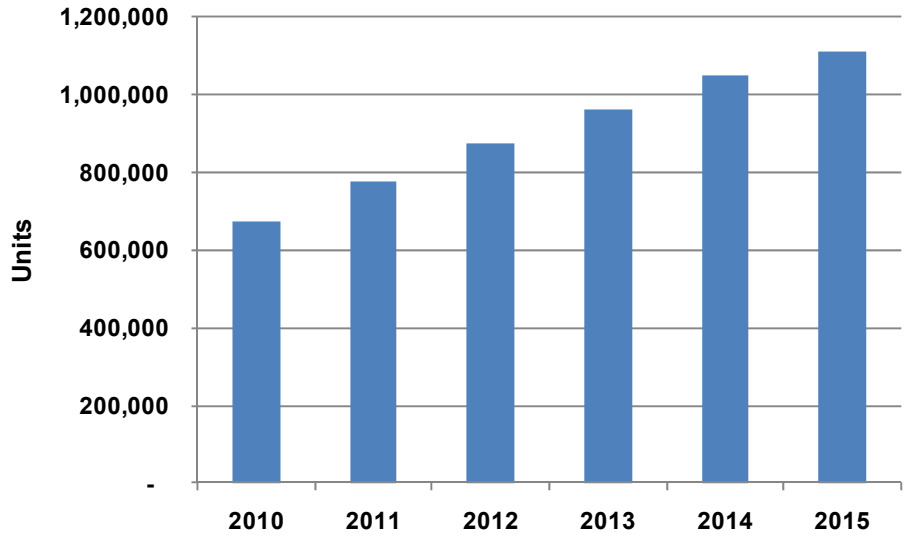
3. Despite the arrival of PHEVs, the hybrid market will continue to grow by adding a greater variety of subcategories, from micro hybrids to hybrids+.

The hybrid vehicle market will grow out in both directions by offering new levels of fuel efficiency. According to the Pike Research report, *Hybrid Electric Vehicles for Fleet Markets*, the hybrid market will surpass 1 million units in annual sales in 2014. Saving fuel by turning off the engine when the vehicle is stopped (known as "stop-start") will be incorporated into dozens of new models, some of which will be classified as mild or micro hybrids and some as conventional vehicles. Among the technologies used for stop-start will be larger lead acid batteries and generators that are significantly less expensive than Li-ion batteries.

Ultracapacitors, which have a much greater power density and longer lifecycle than Li-ion batteries, will be introduced into hybrid vehicles. They will be used alongside Li-ion batteries due to their greater ability to store energy without building up heat and their more efficient storage of regenerative braking energy. The low energy density of ultracapacitors excludes them from consideration as a primary energy storage solution for extending vehicle driving range. This can extend the life of the batteries by reducing the number of times the batteries must be accessed for short bursts of acceleration. Ultracapacitors will also be used in place of batteries in mild hybrid applications, which do not require extensive energy storage.

As the price and size of Li-ion batteries decrease, hybrid manufacturers are likely to add battery capacity to allow consumers to drive longer distances on battery power without plugging in. This development will eventually encroach on the market for PHEVs, but not for several years. Advances in Li-ion batteries in terms of power and reductions in cost will also benefit HEVs, which will begin to shift from Nickel Metal Hydride (NiMH) technology.

Figure 3 Hybrid Electric Vehicle Sales, World Markets: 2010-2015



(Source: Pike Research)

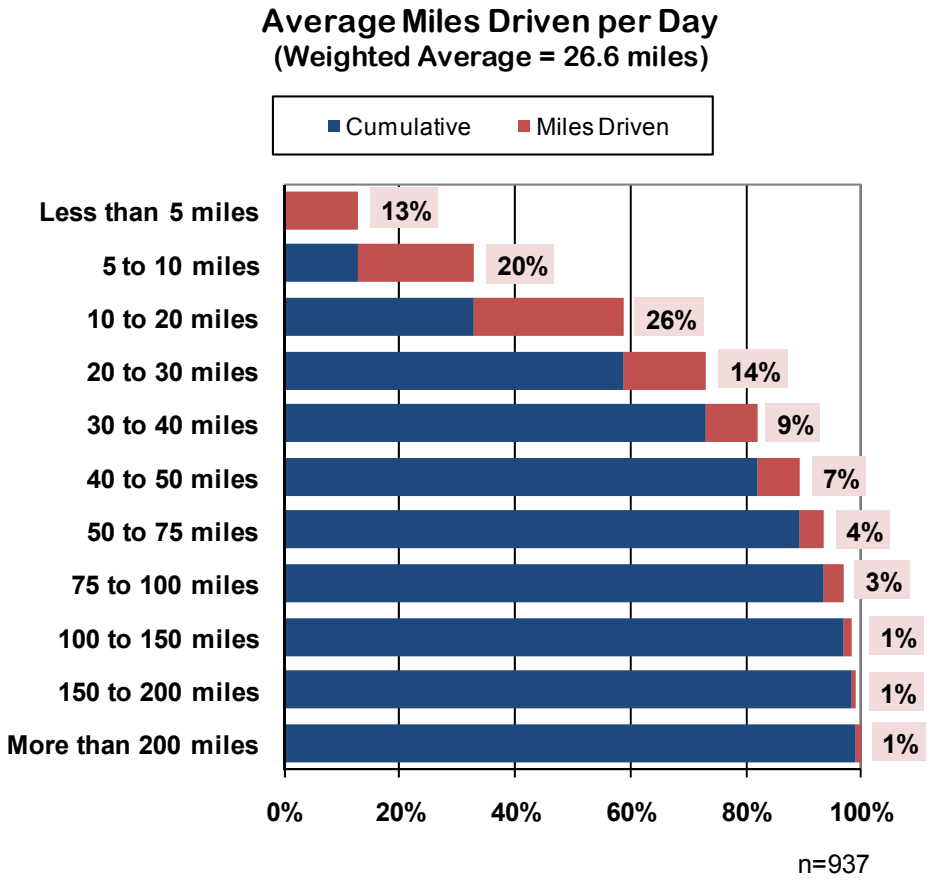
4. The plug-in hybrids of 2020 may not resemble the plug-ins of 2010.

A plug-in hybrid can be designed to provide sufficient battery storage to enable the majority of consumers to complete their daily driving on battery power alone on most days. Due to estimates that vehicle owners drive 13,000 miles per year, automakers designed many of the first wave of PHEVs with the ability to travel 30 miles or more on electric power only. The Chevrolet Volt is a well-known example of a PHEV that seeks to satisfy the approximate 80% of drivers estimated to commute 33 miles per day or less.

However, Pike Research believes that the assumption that PHEVs should be built to satisfy a very broad audience is likely flawed because the target audience represents a small percentage of vehicle buyers. The first wave of PHEVs requires a premium of $10,000 or more due to the expensive Li-ion batteries. According to a recent consumer survey conducted by Pike Research, just 17% of consumers would be willing to pay a premium of 20% or more for a PHEV.

If a significant consumer audience fails to embrace the initial class of PHEVs because of the cost, it is likely that automotive OEMs may shift to designing vehicles with a shorter all-electric range and smaller, less costly battery packs. These vehicles would be priced more competitively against today's hybrids and they would enable drivers to significantly reduce the number of refueling trips. For example, a PHEV with a 10 or 20 mile range would enable nearly 60% of all drivers to complete their daily journeys without accessing the gas tank, according to our research. "Right-sizing" the battery packs would also require less space, giving engineers more flexibility in designing the vehicles. EVs provide even more flexibility in the design phase because there's no engine. When the consumer tax credits for the purchase of PHEVs (based on the size of the pack) passed in 2008 are exhausted, OEMs will have less incentive to create PHEVs with larger battery packs.

Figure 4 Average Consumer Miles Driven per Day



(Source: Pike Research)

5. The Li-ion batteries sold with the first EVs may have little to no resale value.

Automakers agree that for PHEV/EVs to become mass market transportation, the cost of batteries must rapidly fall to $300 per kWh or less. But a quick decline in the cost of energy storage will hamper the ability to resell batteries sold in 2010-2011 at the end of their useful life. Pike Research estimates that the cost of Li-ion batteries will fall by more than half to $470 per kWh by 2015. By then, auto OEMs will be able to price plug-in vehicles more competitively with conventional models.

Figure 5 Li-ion Battery Cost per kWh, World Markets: 2008-2015

	2008	2009	2010	2011	2012	2013	2014	2015
Li-ion Battery Cost	$1,200	$1,070	$940	$810	$680	$550	$510	$470

(Source: Pike Research)

This steep decline in the cost of new batteries in future years will equally depreciate the residual value of EV batteries, which some companies have proposed could be sold to the stationary energy storage market. In addition, the ability of Li-ion batteries to store energy will degrade over time. The range of today's PHEVs when new may be noticeably

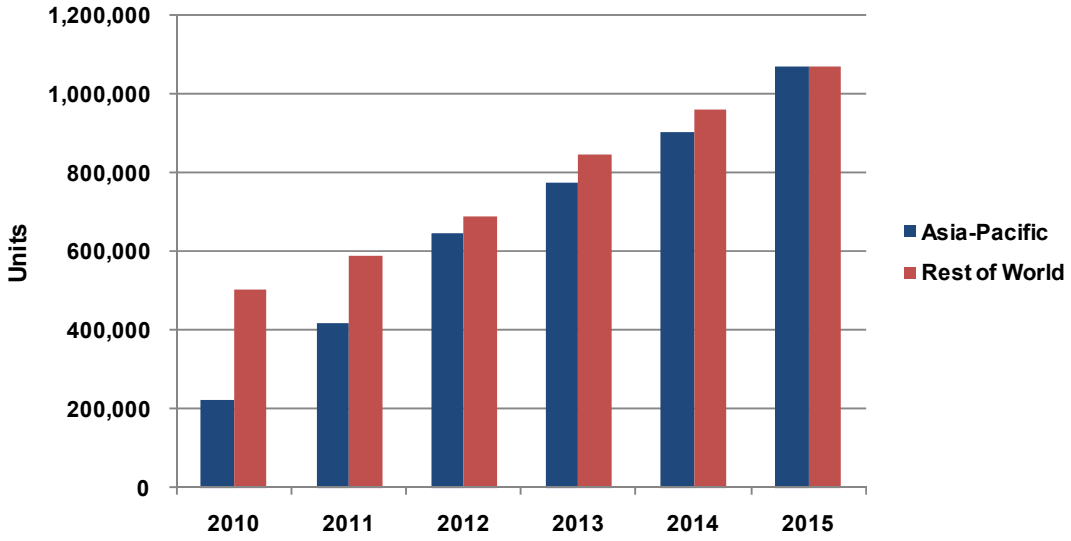
shortened within 5 years. Engineers estimate a maximum useful life of 7 to 10 years depending on how the batteries are cared for and how the vehicle is driven.

For automakers that lease EVs and PHEVs and the consumers who purchase them, the best time to resell the batteries might be never. Vehicle owners that would spend thousands of dollars for new batteries with a small increase in driving range would be making a poor investment. Attempting to sell the batteries at the end of their useful life is likely to yield only a small fraction of the original investment. Keeping the batteries until their performance is unacceptable or new batteries become relatively inexpensive may be the best option. Leasing vehicles (thereby avoiding the question of selling batteries) is a less risky alternative.

6. Asia will be the dominant supplier and consumer of EVs and batteries.

Asia is projected be the global leader in EV and battery production and consumption in the transportation industry during the next half decade and beyond. The governments of China and Japan have pledged to rapidly move their automotive industries toward electrified vehicles through aggressive goals for production, the creation of charging infrastructure, and incentives for consumer purchases.

Figure 6 Electric Vehicle Sales, Asia Pacific and Rest of World: 2010-2015



(Source: Pike Research)

More than 1 million electrified vehicles (including hybrids) will be sold in Asia during 2015. The Asian Li-ion battery market, powered by Japan, Korea, and China, is projected to surpass $4 billion in 2015, which will represent a 53% market share. China will be the largest player internationally, as the government has pledged to produce 500,000 electrified vehicles per year. The country's expertise in cost-effective manufacturing will provide an advantage in ramping up domestic sales, as well as in selling internationally.

Since only a small percentage of EV owners in China will have access to vehicle charging at home, the ratio of charging stations to EVs will be higher than in other regions. The government's commitment to success is evident in its invitation to foreign companies to help build China's charging network.

Asia will continue its leadership in Li-ion innovation and manufacturing. The companies that succeed with the second generation of battery technology are likely to secure a dominant position for the future.

7. Battery swapping is not likely to be a significant industry.

Fully recharging depleted PHEV/EV batteries can take 2 to 8 hours depending on the type of charging equipment used and the size of the battery pack. Drivers looking to travel hundreds of miles may not want to wait that long before recharging. Better Place of Palo Alto, California is one of the few companies that envisions building battery swapping stations that avoid lengthy recharge times by exchanging batteries in about the same time it takes to fill a gas tank.

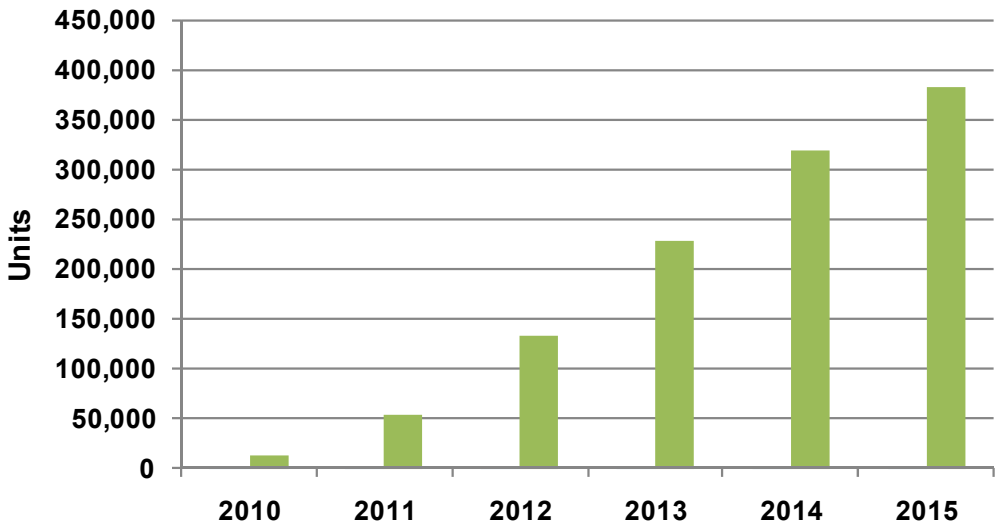
These stations could cost as much as $500,000 each for the machinery to automate the process. To facilitate a fast exchange of batteries, automotive OEMs would have to standardize the location and size of the battery packs so that they can be easily removed and installed. Such standardization is unlikely to happen because automakers want to customize their battery systems.

While several governments in Asia and the Middle East have expressed interest in the battery swap station concept, the high cost of the equipment prevents it from becoming widely adopted. The constraints it would impose on vehicle design and are too great to be adopted by many manufacturers, and the amount of return on the investment in hardware is too little. Auto industry executives have expressed strong reservations about battery swapping in the United States.

8. Operating commercial EV charging stations will not be a very significant or profitable industry.

The arrival of electric vehicles requires the construction of a network of geographically dispersed charging stations that will provide ready access to electricity and alleviate consumers' "range anxiety" fears. EV owners are expected to recharge their vehicles primarily at their residence or workplace and rely on public and private charging stations as secondary resources when traveling on longer trips. The majority will purchase home charging stations due to the convenience of being able to plug in overnight. Public charging stations operated by municipalities and parking garages will provide charging for free (to encourage environmentally sensitive "emissions-free" driving) or at minimal cost because the electricity consumed when recharging a vehicle is relatively cheap.

Figure 7 Charging Station Unit Sales, North America: 2010-2015



(Source: Pike Research)

Recharging a PHEV would cost less than $1 in most states, while an EV would require approximately twice that amount. The expected availability of inexpensive and free charging will make it difficult to operate commercial charging stations profitably. Since standalone charging stations can cost from $2,000 to $40,000 to build, even very active charging stations that require a significant premium for charging would require many years to gain a return on the investment.

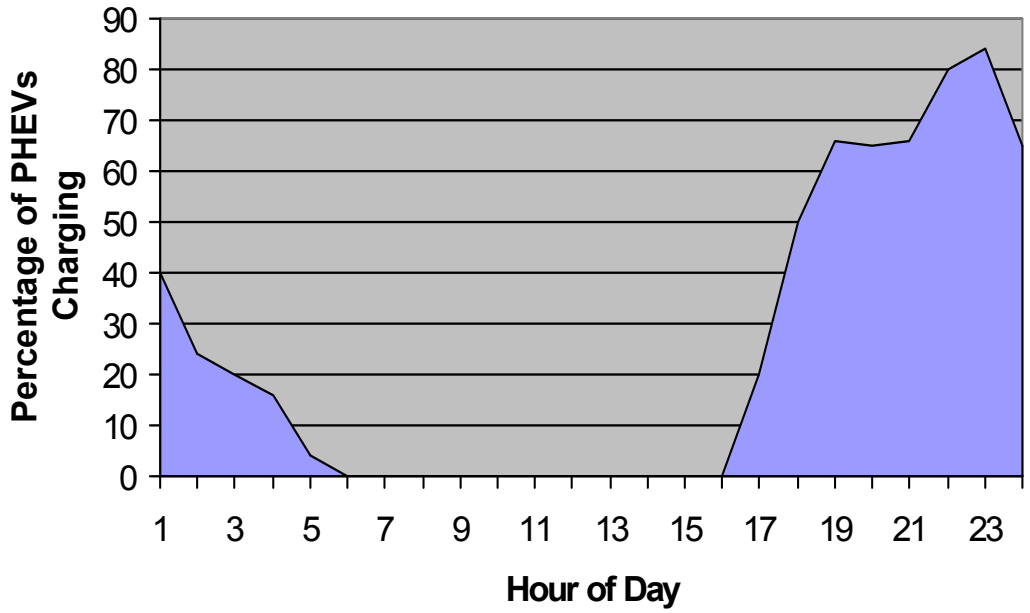
The majority of standalone charging stations will be publicly funded for environmental and economic development reasons, or built by retailers that give away the electricity to attract the more affluent EV owners. Most of the revenue for commercial stations will come from value-added services, such as point-of-contact marketing services. Indirect revenue will result from transactions completed inside. Examples of locations expected to provide charging stations include restaurants, big box retailers, and movie theaters.

Level 3, also known as rapid charging, will be relegated to a niche industry because the equipment can cost up to $50,000 per station. Moreover, rapid charging can negatively impact battery life.

9. The grid as a whole will accommodate and even benefit from EV charging, but some neighborhoods with multiple EVs could overwhelm transformers.

The additional demand for electricity from EVs is not likely to have an impact on the performance and reliability of the power grid as a whole. Even with 1 million vehicles plugging in every day, the amount of additional electricity consumed will be less than one-half of 1%. However, if actions are not taken to encourage off-peak charging, utilities may have to add resources during early evening hours to meet increased demand in some regions with high concentrations of EVs.

Figure 8 Example of Evening Charging



(Source: Pike Research)

Most people will likely plug in their vehicles at the conclusion of their workday, usually between the hours of 4:00 and 8:00 p.m. Charging will take between 2 and 7 hours depending on the charging equipment and percentage of the battery that is depleted. This trend has the potential to add to the load during peak hours and extend peak demand later into the evening, possibly until midnight. Utilities are expected to develop incentives that would prompt most consumers to delay charging until 10:00 p.m., thus minimizing the impact of vehicle charging during peak times.

The weakest links in providing power to EVs today are the small transformers that provide power to three to five homes. Charging several vehicles simultaneously through a transformer can overwhelm it, causing it to fail. Most of the transformers in place do not automatically notify utilities of failure. Customers will have to report this type of power loss, which requires a service technician to replace the transformer.

10. Vehicle to Grid services will be minimal in 2015 and beyond.

The concept of Vehicle to Grid (V2G) power interaction is one in which EVs complement the grid by becoming distributed energy resources. Vehicle batteries act as temporary storage devices that can provide power to the grid during times of peak demand. They can also store surplus energy from wind and solar power. While several pilot projects are now underway, V2G installations will remain niche applications. Such installations will be limited primarily to centrally charged vehicle fleets for the foreseeable future.

Utilities are not prepared to manage the thousands of batteries that would be required to meaningfully impact peak demand. Tracking mobile power resources distributed throughout a service territory will require creating new applications and the installation of communications services. Most utilities are currently unwilling to invest the money and resources needed to manage V2G services.

In addition, automotive OEMs are reluctant to allow batteries to be used for anything besides powering vehicles. The impact of the additional charge cycles on Li-ion batteries is not fully understood today. Since automotive OEMs would not receive any financial benefit from secondary uses, they are unlikely to cover any V2G application under the warranty.

ADDITIONAL READING

Electric Vehicle Batteries
Lithium Ion Batteries for Plug-in Hybrid and Battery Electric Vehicles: Market Analysis and Forecasts

http://www.pikeresearch.com/research/electric-vehicle-batteries

Electric Vehicles on the Grid
Residential, Public, Private, and Workplace Charging Stations, EV Charging Business Models, and Vehicle to Grid Technology

http://www.pikeresearch.com/research/smart-energy/electric-vehicles-on-the-grid

Energy Storage Technology Markets
Advanced Battery Technologies, Pumped Hydro, Compressed Air, Flow Batteries, and Frequency Regulation for Utility-Scale Storage Applications

http://www.pikeresearch.com/research/energy-storage-technology-markets

Hybrid Electric Vehicles for Fleet Markets
Commercial Hybrid and Plug-in Hybrid Electric Vehicles: Cars, Light Trucks, and Medium/Heavy Duty Trucks

http://www.pikeresearch.com/research/hybrid-electric-vehicles-for-fleet-markets

Plug-in Hybrid Electric Vehicles
The Global Outlook for PHEVs: Business Issues, Technology Issues, Key Players, and Market Forecasts

http://www.pikeresearch.com/research/plug-in-hybrid-electric-vehicles

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Additional analysis includes secondary research conducted by Pike Research's analysts and the firm's staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Pike Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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HybridCars.com is the Internet's premier website dedicated to hybrid gas-electric vehicles and the full range of consumer information and tools about cars, energy, and the environment. Car reviews, interactive tools, news, and user forums are designed to help car shoppers make informed purchase decisions. Content from HybridCars.com is syndicated to Yahoo! Autos, Reuters, BusinessWeek Online, and numerous newspaper, television, and radio station websites. HybridCars.com was founded by Bradley Berman, who writes about hybrid and plug-in cars for *The New York Times*, *Detroit Free Press*, and other publications.

Published 4Q 2009

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