EV SECTOR

Sector Outlook: Bullish

Inv. Timeframe: Decade

Research Analyst:

Endeavor Analytics

Alternative Transportation

Relevant Equities & ETFs:

- LIT
- BYDDY
- CBAK
- TSLA
- ZAAP
- UQM
- KNDI
- NSANY
- F
- GM
- AVAV

Bullish Sector Outlook: Decade Inv. Theme

An Immature & Unstoppable Sector

- The EV "revolution" is investable in 3 ways; through EV manufacturers, EV charging station operators or through firms involved in lithium mining or cell creation.

- EV adoption is still extremely low, with market penetration remaining around 1% or less in most developed markets worldwide.

- Aggressive government subsidies have sped up adoption of EVs, while some European governments such as Germany are considering banning the registration of new gas cars after 2030. Policies like this likely continue to artificially drive the double digit growth the EV sector has experienced in recent years.

- EVs are becoming increasingly economical without subsidies as well due to their extremely low operating costs, particularly among high gas prices.

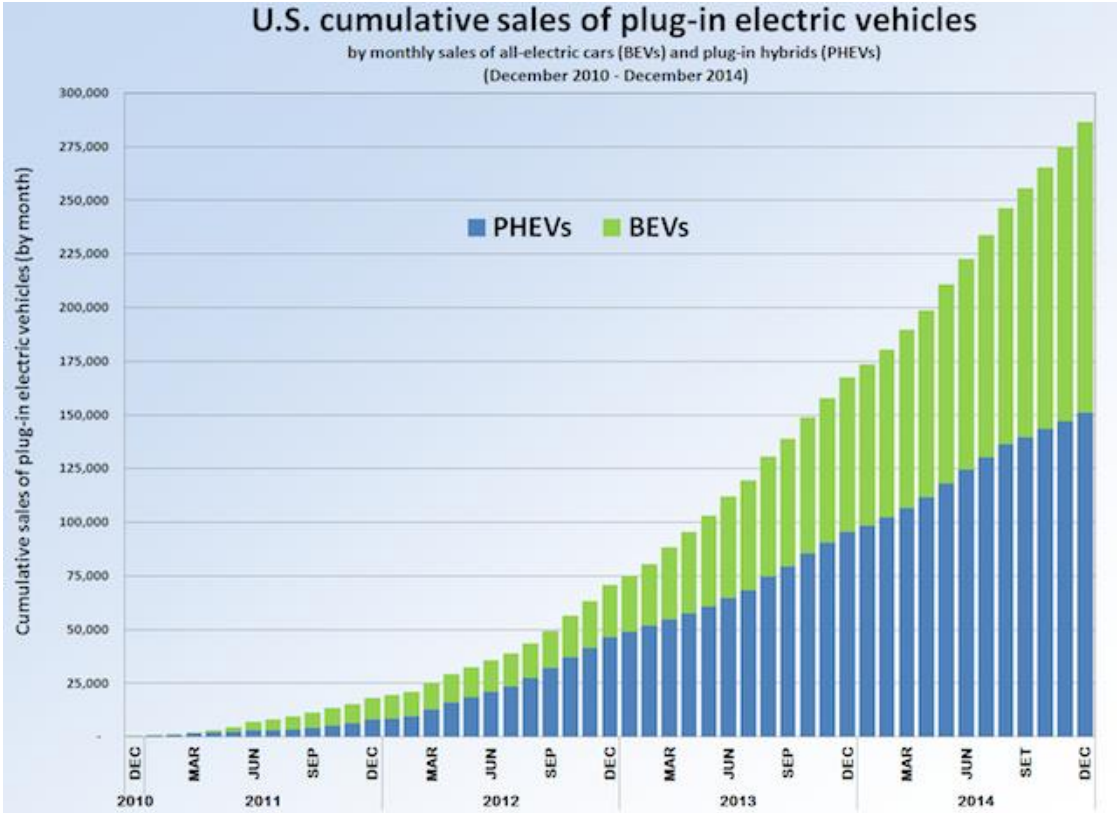
- Improving battery technologies and the rapidly expanding DC fast charger network are making BEVs increasingly attractive for consumers.
- The implementation of the Chevy Bolt and the Tesla Model 3 will likely launch the first mass adoption of EVs

Key Highlights – An Overview

The electric vehicle industry is a relatively new one, which arguably became notable after GM introduced the Chevrolet Volt in 2010. To give a quick overview, the EV market could be divided into a few main parts. Most notably, EV manufacturing, lithium battery manufacturing and EV charging infrastructure installers. There are few "pure plays" in the EV industry, as most of the major players are conglomerates or large companies which also produce gasoline powered vehicles.

Electric Vehicles Overview – EV Manufacturing

There are also two types of EVs I will reference throughout the paper. Plug-in Hybrid Electric Vehicles (PHEVs) like the Chevy Volt have a intentionally shorter electric range (enough to cover day to day use), though they have a gas generator which powers the electric motor for extended trips. There are also pure battery electric vehicles (BEVs), which typically have a longer range than PHEVs and can take advantage of DC fast chargers, which can provide up to a few hundred miles range in roughly half an hour. The below chart only shows the US cumulative sales of EVs, though it gives the reader an idea as to the sales mix of PHEVs and BEVs in the United States. Historically, they seem to be about even with a slight bias towards PHEVs.

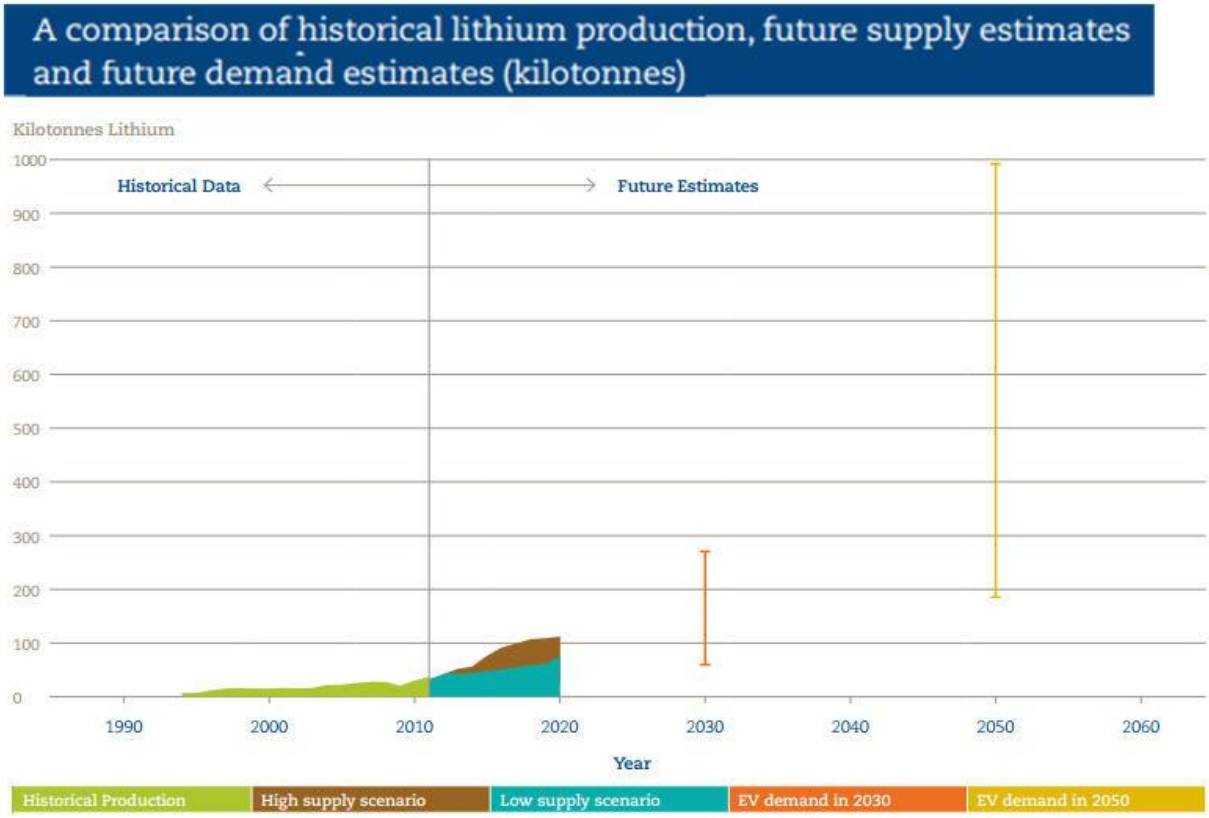


Tesla Motors (TSLA) aside, today most PHEVs are manufactured by Chevrolet or Ford and most BEVs are produced by Nissan. EVs often take massive capital expenditures to retool plants for a new vehicle that uses significantly different parts from other vehicles these companies produce or for the research and development expenses associated with developing these vehicles. As an example, GM spent $1.2B on the Chevy Volt program to develop what was essentially the first PHEV. They will apply this technology across all new EVs they develop in the future, which greatly reduces the average R&D cost per vehicle, though it still required a massive R&D spend and the construction or retooling of plants to manufacture Volts. Tesla has also been a prime example as to the amount of capital it takes to ramp up production of a new EV, as the company has had to raise money (often through issuing equity) on a fairly regular basis as it prepares to launch the Model 3. These manufacturers are also susceptible to the pricing of various commodities as well, as some rare earth metals are used in the production of EVs.

Electric Vehicles Overview – Lithium and Cell/Battery Supply

Globally, the lithium cell/battery industry is scaling quickly to help meet the massively increased demand for lithium-ion batteries driven by EV adoption. Some manufacturers such as Tesla Motors who use large amounts of lithium cells, have decided to build their own lithium cell production facilities. Tesla Motors is producing the Gigafactory 1, which upon completion is expected to double the world's lithium cell production capacity. China tripled its capacity in 2015 as well to meet the recent uptick in demand for lithium cells.

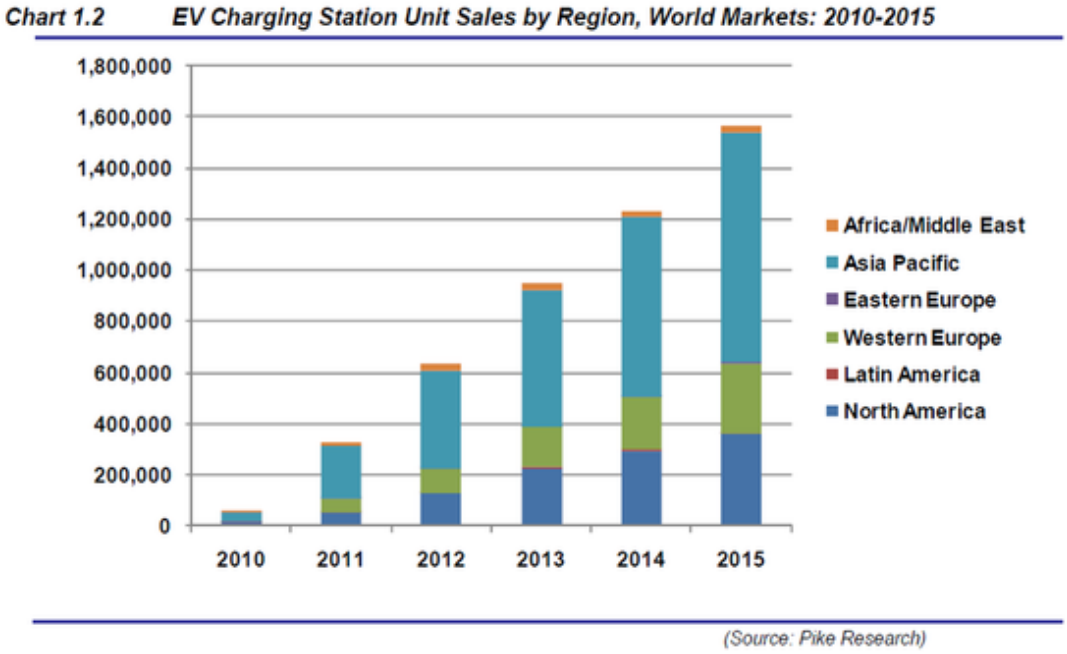
Industry-wide, the demand for lithium will undoubtedly increase. Goldman Sachs sees EVs achieving 22% market penetration in the United States by 2022, which will place intense pressure on suppliers. Lithium prices have already soared on the back of increased demand due to the rapid pace of EV adoption. As you can see on the chart on the next page, supply shortages may be prevalent in the future. EVs use only a few hundred dollars of lithium carbonate per vehicle, so it will likely have little impact on retail EV prices, though it may create difficult situations for manufacturers trying to scale operations. Some firms such as Tesla have already gone as far as to secure lithium supplies for their exclusive use. There is ample lithium supply in the oceans, though the cost of extracting it is $14-20K ton, so the currently high lithium carbonate prices may be here to stay, though with those prices come the assurance of a stable supply.



Electric Vehicles Overview – Charging Infrastructure

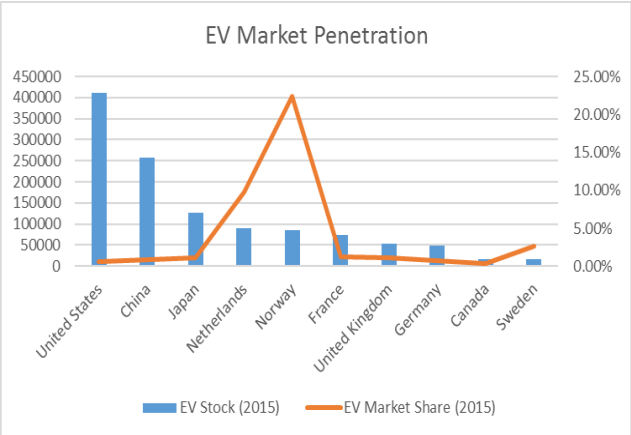
EV charging stations have grown exponentially over the years, from under 50K installed globally in 2010 to over 1.6M today. Within the US, EV charging stations are still growing at a high rate, due in part to a Department of Energy program which provides $4.5B in guaranteed loans to companies installing EV charging stations.

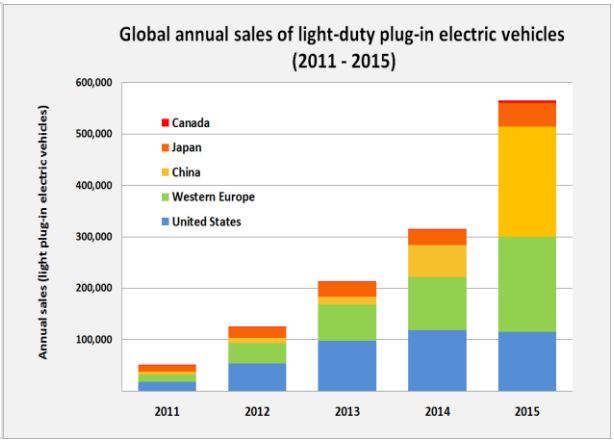
The high capital costs of installing EV chargers and the still low market penetration of EVs have prevented pure play companies in this space, such as Chargepoint, from attaining profitability. From the end of 2015 through September of 2016, the number of EV charging stations grew from 27,850 to 34,454, a 24% increase. More importantly, the number of DC fast chargers, capable of providing hundreds of miles of range per hour, grew by 33%. These types of chargers are most likely to encourage widespread EV adoption, as having chargers to use during road trips are most likely to relieve consumer "range anxiety". The slower but much more prevalent Level 2 EV charging stations, which grew by 20% over the aforementioned time period, only provide 22 miles of range per hour and therefore are more suitable for destination charging. Encouragingly, the installation of EV charging stations is correlated with EV sales in the area.



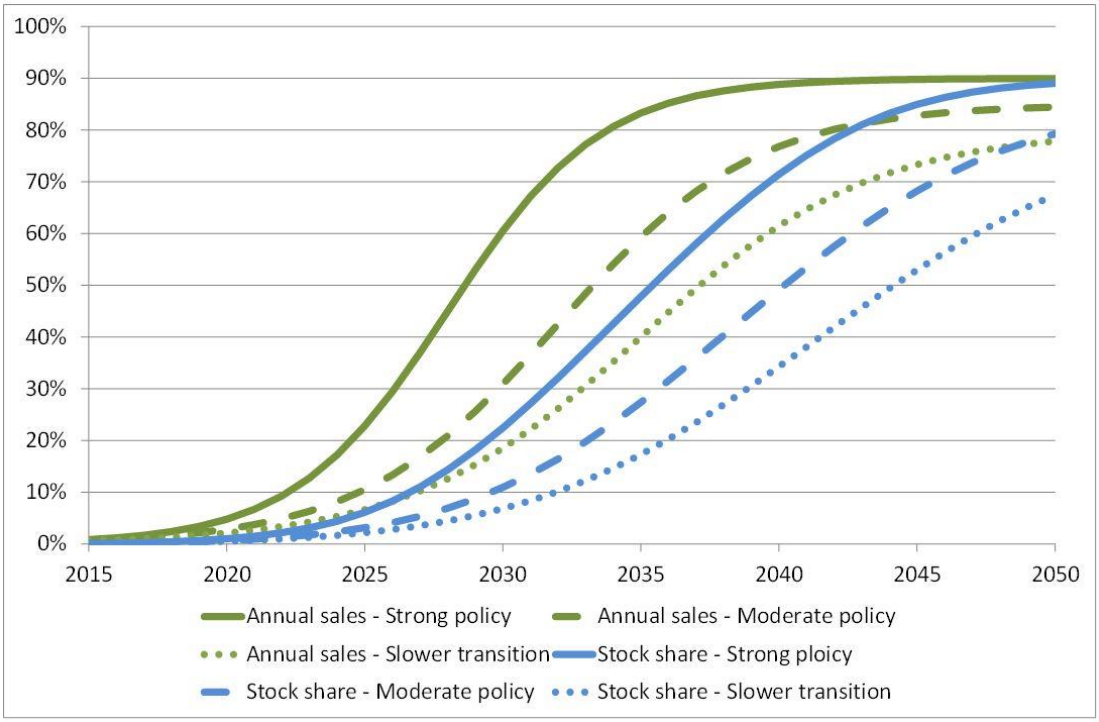
Status of the Industry – Current Market Penetration

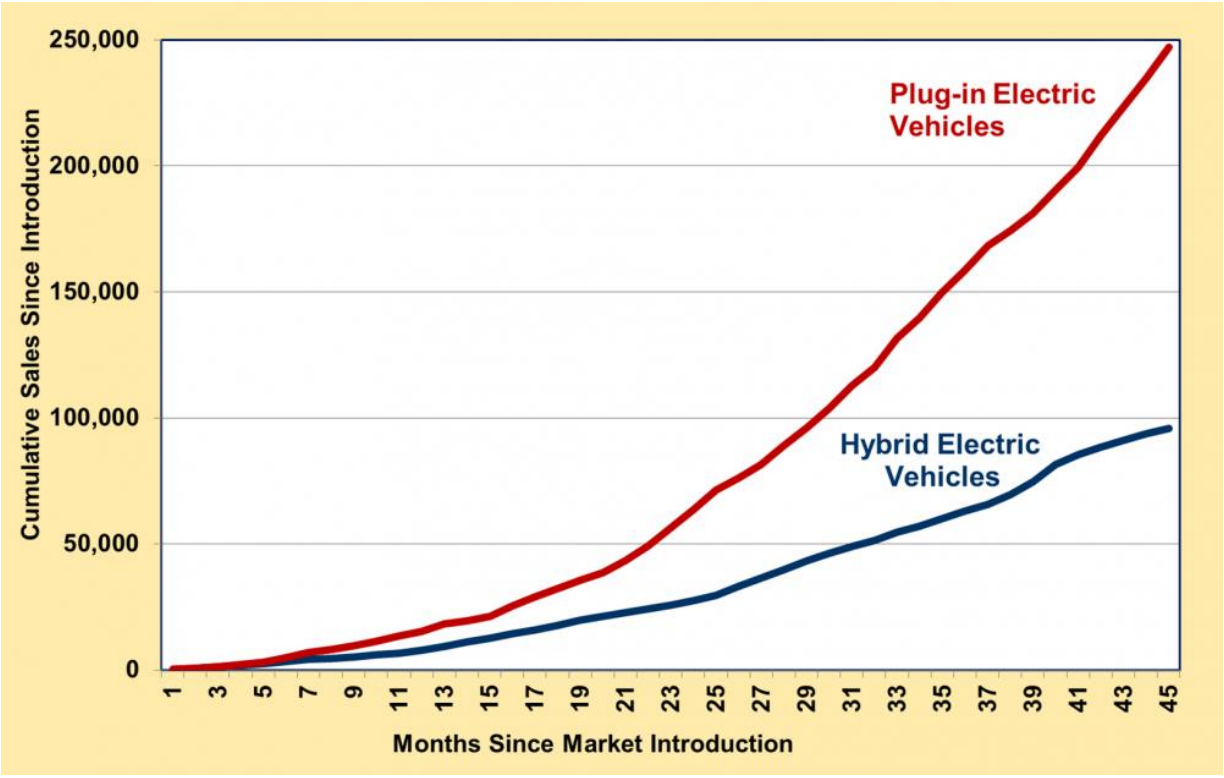
To date, EVs have achieved very low market penetration worldwide. The industry is still in its infancy. Outside of Nordic countries, the market share of EVs has barely cracked 1% at best in most developed countries. EVs have historically been dependent on policy and early adopters for most of their sales, only recently have they become cost competitive in many markets (though this fluctuates with gas prices). For example, 2015 EV sales were lower than 2014 EV in the US due to the oil price downturn. In 2016 YTD, worldwide sales are up 48% over 2015. As is evident in the chart on the next page, the EV adoption curve has been significantly steeper than it was for traditional hybrid cars since their launch.





Below: Anticipated EV Market Penetration

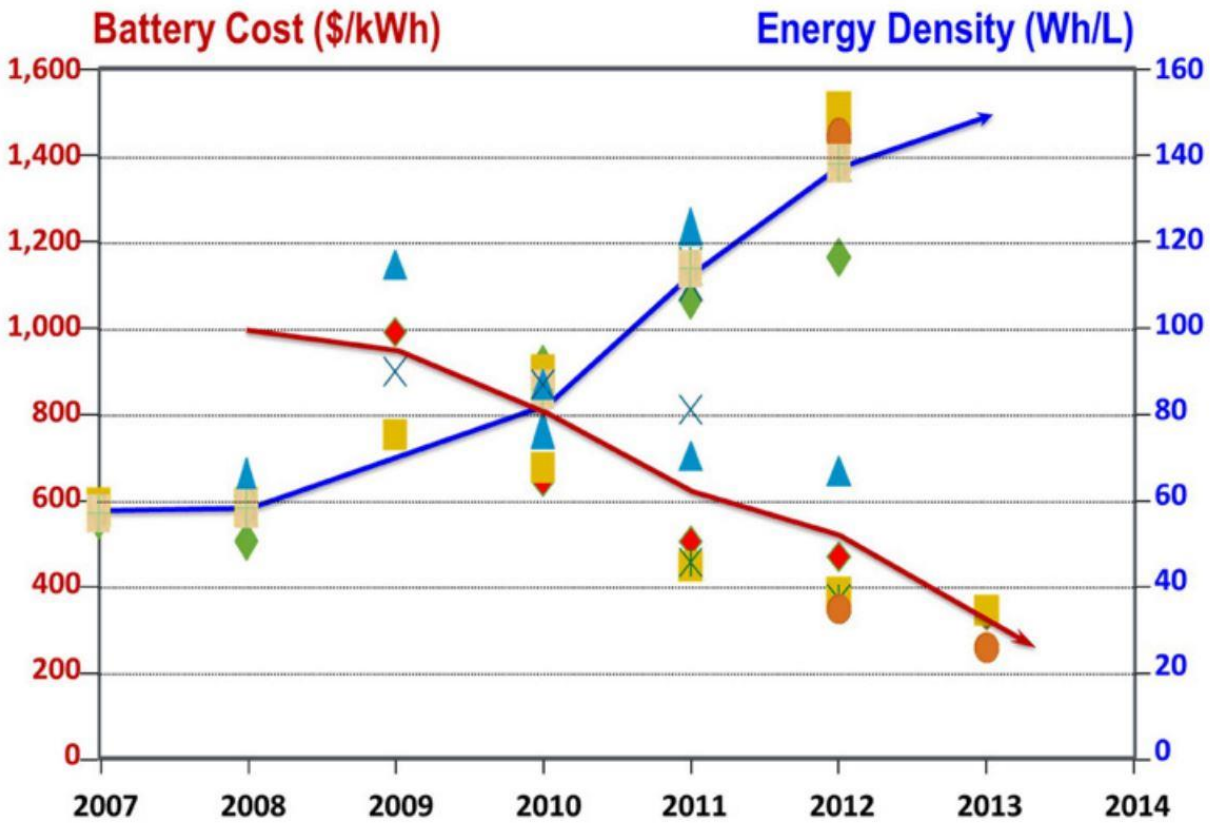

100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2015
2020
2025
2030
2035
2040
2045
2050
Annual sales - Strong policy
Annual sales - Moderate policy
Annual sales - Slower transition
Stock share - Strong ploicy
Stock share - Moderate policy
Stock share - Slower transition


250,000
200,000
150,000
100,000
50,000
0
Cumulative Sales Since Introduction
Plug-in Electric Vehicles
Hybrid Electric Vehicles
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
45
Months Since Market Introduction

Electric Vehicle Overview – Other Factors Affecting the Economics of EVs

There are a number of factors that affect consumer decision making regarding EVs. I have posted commentary on each relevant growth driver/pain point regarding EVs below.

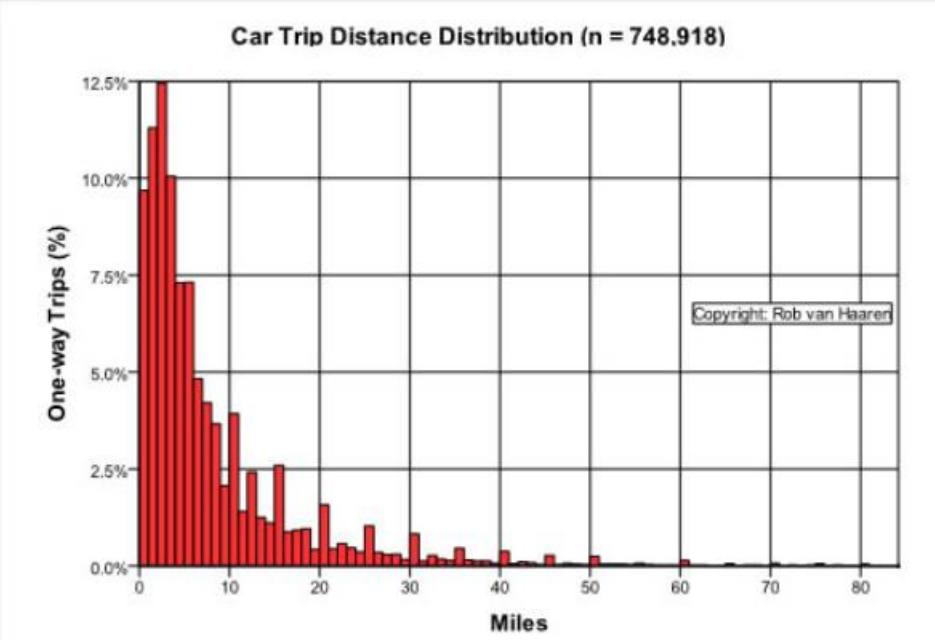
Vehicle & Maintenance Costs: EVs generally have a higher upfront vehicle cost that is generally offset over time by the much lower operating costs (electric prices are comparable to sub $1/gallon gas) and the near absence of ongoing maintenance costs due to the fact that BEVs essentially have just one moving part (the electric motor). A $7,500 federal tax credit plus state tax credits in some markets further lower upfront costs. Battery packs do slowly degrade though and are usually replaced after about a decade, but this naturally varies based on how the technology develops. The economics of batteries are swiftly improving as the prices drop and energy density improves.



Range & Charging Time: A common complaint regarding some BEVs is their limited range and perceived slow charging time. While some higher priced BEVs can drive 300+ miles on a charge, lower end BEVs such as the Nissan Leaf have a range of just under 100 miles. A portion of US consumers perceive "range anxiety", or the fear of getting stranded when the vehicle's range is exhausted and no chargers are nearby. As you can see in the chart below, range anxiety is a somewhat unrealistic fear when analyzing realistic driving habits (and considering the fact that roughly 2/3 of households have 2 or more cars). It does not appear to be a common problem as BEV drivers are conscious of range limitations according to some anecdotal research on the topic. Over the next few decades, the average range of EVs is likely to vastly increase alongside battery technology improvements. For example, Chevy's new Bolt and Tesla's Model 3 are 2 electric BEVs with 200+ mile ranges which will be priced just under $30K after tax incentives.

If you view the appendix, you can see a helpful graphic which shows the various types of EV chargers and how many miles of range per hour one can expect. Most EVs can utilize almost any EV charger with the exception of Tesla's proprietary supercharger system. The prevalence of EV charging stations varies heavily based on the area, California has about a fifth of the nation's EV charging stations for example. Since most people charge at home, charging time isn't a huge barrier, since DC fast charging can give multi hundred-mile range in 30 minutes (varies by model etc.). Prevalence and continued improvement in DC fast chargers is crucial.

Naturally PHEV drivers do not experience range anxiety due to the fact drivers can use gasoline as a backup, which also makes charging time less prevalent.



Policy & Tax Incentives: Government incentives of various sorts have had a tremendous impact on the EV industry, particularly in its early stages. Globally, policymakers generally will either incentivize EV purchases or make the purchase of gas cars punitive in one way or another.

One example in the United States which drove early adopters was the $7,500 tax credit one receives when purchasing an electric vehicle (plus some state incentives). This made the Nissan Leaf and the Chevy Volt a more realistic option for many upon their release, before the companies later cut the sticker price and boosted the range on these vehicles as costs went down.

Another example is Norway, where EVs receive about 17,000 Euros in upfront subsidies plus they save on ongoing vehicle registration costs. The steep tax on fuel in Norway results in fuel prices about twice as high as in the United States, which further incentivizes drivers to switch to EVs. As a result, about 1/5 of all new cars sold in Norway are EVs.

Some countries such as Germany and Norway are seeking to ban sales of new gasoline cars by 2030 and 2025 respectively. Approaches like are expected to be implemented across Europe over the next few decades and will naturally draw a huge increase in sales.

"Big Auto" is Shifting: Major auto companies, which have traditionally been reluctant to develop EVs, recently began to shift towards electrifying their fleets. Audi is looking to launch a new PEV annually starting in 2018 while Ford is spending $4.5B to add 13 new PHEVs (mostly PHEV versions of its current vehicles) to its fleet.

A problem with selling EVs which was very prevalent with the launch of the Chevy Volt (and may be prevalent for "big auto" companies shifting into EVs) is the dealership network. Salespeople at car dealerships are generally not knowledgeable regarding their EV offerings and Chevy dealerships would often not stock Volts on their lots early on. EVs require little to no maintenance, so when one considers that dealerships make a good portion of their money off of ongoing maintenance on cars they sell, there is a clear conflict of interest.

Conclusion

The EV market is still young and the technology is rapidly improving, though through aggressive government subsidies and what has been (at times) high oil prices, EVs have become an economical choice for many. This long term trend will likely hold as battery technology continually improves and as oil prices (eventually) inevitably rise again. So while "pure play" EV investments are extremely difficult to find in the public markets, the EV related divisions of large companies will likely make up an increasingly larger portion of the greater company and I expect the sector to continue its high double digit growth over the next few decades.

Appendix

A. Detailed chart on EV charging options.

		EDITOR'S CHOICE						
	120 V Outlet	NEMA 14-50R Outlet	Level 2 Station	Networked L2 Station	Tesla Wall Connector	DC Quick Charger	Networked DCQC	Tesla Supercharger
Avg. Installation Cost	$100	$300	$2,000	$4,000	$2,000	$20,000	$50,000	?
Avg. Electricity Cost Per Car	$0.50	$3	$2	$2	$4	$4	$4	$10+
Likelihood of Attracting EV Drivers	🧍	🧍🧍	🧍🧍🧍	🧍🧍	🧍🧍	🧍🧍🧍	🧍🧍🧍	🧍🧍🧍
Max Miles Per Hour of Charging	4	30	22+	22+	66	150	150	400+
Max Power (kW)	1.4	10	6.6+	6.6+	20	50	50	120
Expected Dwell Time	12+ hr	2-4 hr	2-4 hr	2-4 hr	1-2 hr	20 min	20 min	20 min
Driver Convenience	😐	😊😊	😊😊😊	😊😊	😊😊😊	😊😊😊	😊😊	😊😊😊
Network Subscription Fees	—	—	—	$$	—	—	$$	—
Compatible Vehicles	All	Tesla & Enthusiast	All	All	Tesla	LEAF	LEAF	Tesla
Offer for Free or Charge Flat Rate	Free	✓	✓		✓	✓		✓
Complex Payments (Time, kWh, Variable)				✓			✓	