

EQUITY RESEARCH

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SRINVEST

ELECTRIC VEHICLES – NICHE FUTURE OR MAINSTREAM POTENTIAL?



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ELECTRIC VEHICLES – NICHE FUTURE OR MAINSTREAM POTENTIAL?

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Barclays Capital is pleased to launch our first SRIInvest product today. We plan a series of reports over the coming quarters around environmental and corporate governance themes. Our approach is to make commercial and entrepreneurial recommendations to our clients to help drive investment decisions, and we welcome any feedback you may have.

We expect see demand reach 4.8 million units (3.6mn hybrid and 1.2mn full EV) globally by 2020, though in the short term we expect to see hybrid vehicles gain momentum as the barriers towards switching to hybrids will be seen as lower. From 2014-15, we expect to see a greater uptake in pure electric vehicles, as technology improves, battery costs fall and range anxiety diminishes. We expect to see 34% of 2020 geographic demand from Europe, 37% from the US, 20% from Japan and 9% from China. We believe upside exists to our forecasts depending on cost developments and the outlook for regulation.

Cost reduction will be a key driver – we expect battery costs to fall by 50%: Currently, for pure electric vehicles batteries represent approximately 50% of the cost, and we expect to see battery costs fall by half over the next three years. Despite this cost reduction, we still expect to see improvements in energy density and efficiency, further improving the relative appeal of pure electric vehicle products. We see potential for power generating companies to support the roll out of pure electric vehicle products which will allow users to charge vehicles at discounted rates when grid utilization is low overnight.

Which stocks could benefit from a take up in electric vehicles in the medium term? We favour exposure to Umicore (1-OW, EUR40.0 PT, 19% upside from closing price on 31 August 2011) for its recycling segment for batteries. The details around our investment thesis are included in our Clean Technology & Sustainability report published today entitled, 'Initiating coverage on Umicore & Alerion, Best Ideas Update'. We believe that exposure to the value chain directly through the battery segment of the EV value chain to carry significant levels of risk.

Do recent changes in China present risk of a delay? We believe that for many emerging economies the move towards electric vehicles remains sensible, though we note that China has revised its focus from the manufacture of purely electric vehicles to now allow focus on ICE/hybrid models too, with a future move towards electric vehicles from 2014-15.

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Executive summary

Electric vehicles has been a growing theme for capital markets as policy makers seek to quicken the rate of technology development in the space to positively reduce carbon emissions and contribute to lowering costs for consumers. Our report published today – part of Barclays Capital's **SRIInvest** product – outlines our expectations for demand, technology developments and stocks set to benefit from these trends.

Where can demand reach in 2020?

We anticipate significant growth in the EV market, initially hybrids

We expect demand to reach 4.8 million units in 2020, but unlike other expectations, we do not believe the adoption curve will necessarily be a steady rate of growth. This is primarily because of the impact of product launches; the impact of regulation and policy support; and the outlook for gas or petrol prices in varying countries.

Hybrid, Plug-in hybrid and full EV sales projection by country and year

	2011	2012	2013	2014	2015	2016	2017	2020
Europe Top 4	122,471	188,168	277,238	378,606	476,158	617,675	791,936	1,031,896
Rest of Europe	81,648	125,445	178,293	241,088	298,298	385,913	491,000	620,504
US	496,467	843,418	1,121,594	1,373,033	1,554,484	1,673,953	1,683,451	1,780,737
Japan	487,724	593,367	641,637	661,136	695,523	774,221	800,899	942,041
China	33,635	66,356	101,669	142,551	194,265	267,442	299,288	430,009
Total	1,221,945	1,816,754	2,320,431	2,796,414	3,218,728	3,719,204	4,066,574	4,805,187

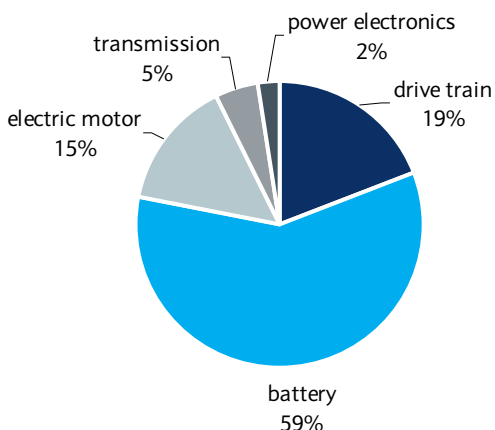
Source: Barclays Capital, JD Power, car manufacturers' press releases

What cost reduction from electric cars is possible over the coming years?

In our view, battery costs will decline by up to 50% over the coming years, in combination with increased energy density and efficiency

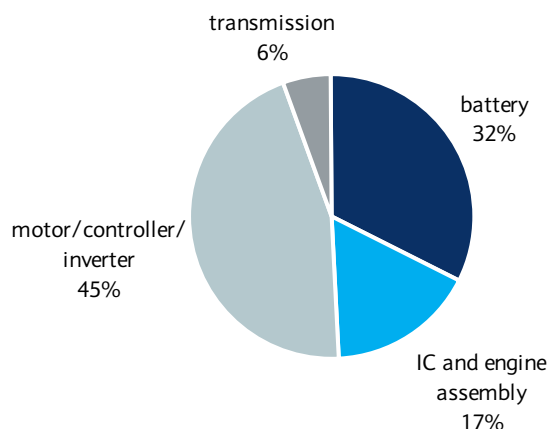
We outline below the current cost breakdown of an all electric and a hybrid vehicle and note that currently the battery is a major expense in both designs. We expect to see technology costs in the area of batteries to decline by around 50% over the coming years, which will substantially reduce the cost of all electric vehicles relative to hybrid, all other things being equal. In addition, during this cost reduction, we expect to see an improvement in energy density and efficiency, further improving the relative attractiveness of non-ICE products in the market.

Cost breakdown of electric vehicle



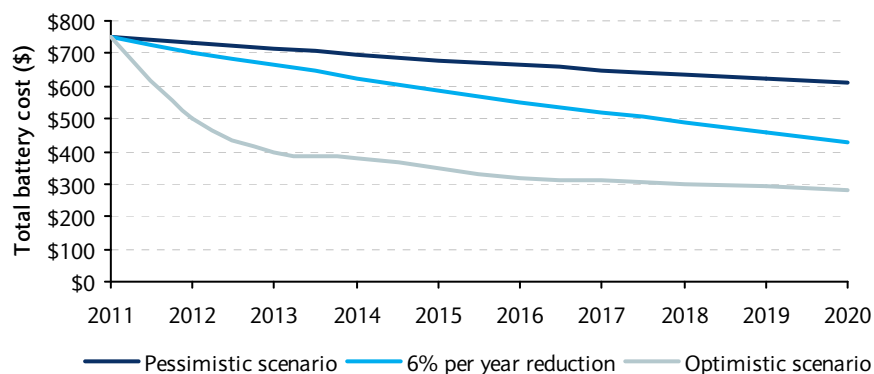
Source: Barclays Capital

Cost breakdown of Powertrain of a hybrid vehicle



Source: University California Berkeley, UC Davis

Battery cost projection



Source: Barclays Capital, industry sources

Where do the major opportunities for EVs lie?

In our view, companies with battery recycling capabilities stand to benefit from the adoption of EVs.

We believe a major area of focus, relative to battery cost development alone, will be the area of recycling of batteries, and in this regard we believe companies with a global footprint in key EV markets will be able to benefit from this. Our initiation report in the Global Clean Technology & Sustainability sector published today, entitled 'Initiating coverage on Umicore & Alerion, Best Ideas Update', highlights one company we expect to benefit from this.

What about “range anxiety” as a major area of concern for EVs take up?

We believe range anxiety will decline as charging times reduce and new EVs are launched and marketed specifically as second vehicles

The major area of concern for electric vehicles in particular, relates to “range anxiety”, which is concern about their ability to cover longer distances. We believe this will diminish for a number of reasons. First, the initial new product launches will be aimed at second car families, rather than for use as a primary vehicle, with cost savings a highlighted benefit. Second, we expect to see positive developments from information technology displays, which will significantly reduce anxiety regarding performance. Third, we expect to see significantly shortened “fast charge” capabilities, which will allow 80% battery charges in under an hour.

Barclays Capital Clean Technology & Sustainability Coverage Universe: Valuation Summary

	EV/Sales				EV/EBITDA				EV/EBIT				PE			
	Barclays Capital 2011e	2012e	Consensus 2011e	2012e	Barclays Capital 2011e	2012e	Consensus 2011e	2012e	Barclays Capital 2011e	2012e	Consensus 2011e	2012e	Barclays Capital 2011e	2012e	Consensus 2011e	2012e
Acciona	2.0x	2.0x	1.9x	1.9x	10.6x	9.9x	9.4x	8.6x	21.0x	18.4x	19.6x	17.0x	22.0x	18.1x	19.9x	17.5x
Alerion	7.5x	7.3x	8.4x	6.6x	12.1x	10.9x	12.8x	8.8x	28.6x	23.1x	39.4x	17.6x	na	na	na	16.6x
EDP Renovaveis	7.2x	6.4x	7.6x	8.0x	9.1x	8.0x	9.8x	8.8x	21.2x	17.0x	23.2x	19.4x	na	21.1x	26.9x	21.3x
Enel Green Power	4.4x	4.2x	5.3x	5.4x	7.8x	7.1x	8.8x	8.1x	12.9x	11.4x	14.3x	13.0x	16.6x	14.7x	17.6x	14.5x
Iberdrola Renovables	7.4x	6.9x	6.8x	7.0x	11.4x	10.5x	10.2x	9.3x	23.5x	19.8x	20.0x	17.7x	27.6x	21.4x	23.9x	20.6x
Terna Energy	5.6x	4.7x	6.5x	7.7x	13.2x	10.6x	13.3x	9.9x	15.9x	12.6x	19.2x	13.1x	19.7x	14.0x	23.0x	14.0x
Wind operators	5.5x	5.1x	5.6x	5.8x	9.9x	9.2x	9.8x	8.9x	19.3x	16.6x	18.7x	16.4x	22.4x	18.5x	21.3x	17.9x
Gamesa	0.4x	0.4x	0.7x	0.7x	2.7x	2.3x	6.1x	4.9x	7.5x	6.2x	14.8x	10.9x	12.7x	9.9x	18.3x	14.6x
Gurit	0.6x	0.5x	0.7x	0.6x	4.8x	3.7x	5.4x	4.4x	7.2x	5.2x	7.9x	6.3x	11.5x	9.4x	12.1x	10.0x
Hansen	0.9x	0.7x	0.9x	0.8x	8.1x	5.7x	9.3x	6.4x	na	11.9x	na	na	na	15.3x	na	16.5x
Nordex	0.6x	0.5x	0.3x	0.3x	13.8x	8.7x	5.1x	4.3x	na	13.1x	8.0x	6.5x	na	17.5x	23.1x	18.4x
Repower	0.8x	0.7x	0.7x	0.7x	9.6x	7.9x	8.8x	7.8x	12.5x	10.0x	12.5x	10.4x	21.6x	17.0x	19.3x	16.6x
Suzlon	0.9x	0.8x	0.9x	0.9x	10.2x	8.7x	17.4x	7.7x	15.4x	12.3x	na	10.4x	21.4x	11.4x	18.8x	12.1x
Vestas	0.6x	0.5x	0.8x	0.8x	5.0x	3.9x	6.4x	5.2x	8.9x	6.5x	10.6x	8.6x	10.7x	8.0x	12.4x	10.0x
Wind equipment manufacturers	0.6x	0.5x	0.8x	0.7x	6.4x	5.0x	8.0x	5.7x	9.9x	8.0x	11.5x	9.3x	13.9x	10.5x	15.5x	12.3x
Centrotherm	1.1x	1.0x	0.6x	0.7x	6.6x	5.5x	4.2x	4.1x	8.7x	7.1x	5.6x	5.7x	12.2x	10.5x	13.2x	12.3x
Manz Automation	1.2x	1.0x	0.8x	0.9x	10.9x	8.5x	6.8x	5.4x	24.1x	14.8x	12.4x	9.2x	25.6x	15.0x	12.7x	11.2x
Meyer Burger	1.4x	1.3x	1.4x	1.3x	8.7x	7.8x	7.8x	6.8x	14.1x	12.1x	11.7x	10.2x	21.3x	19.2x	16.5x	16.8x
Roth & Rau	0.6x	0.5x	0.5x	0.6x	5.4x	4.7x	4.5x	4.6x	8.8x	7.0x	8.1x	7.9x	14.4x	11.8x	15.1x	14.1x
Solar equipment manufacturers	1.2x	1.1x	1.0x	1.0x	7.9x	6.8x	6.2x	5.6x	12.7x	10.2x	9.4x	8.4x	18.0x	15.2x	14.9x	14.5x
Phoenix Solar	0.3x	0.3x	0.2x	0.2x	na	5.5x	3.6x	3.2x	na	6.0x	3.6x	3.3x	na	10.0x	7.5x	7.3x
PV Crystalox	0.5x	0.5x	0.6x	0.5x	2.8x	2.6x	3.1x	2.3x	3.7x	3.4x	4.1x	3.0x	7.9x	7.2x	10.8x	9.6x
Q-Cells	0.6x	0.5x	0.6x	0.6x	5.6x	4.3x	4.8x	4.4x	16.8x	9.3x	10.8x	9.3x	na	14.4x	13.6x	10.2x
Renewable Energy Corp.	1.6x	1.5x	1.5x	1.4x	4.8x	5.2x	5.2x	4.8x	na	10.9x	11.5x	10.0x	na	11.3x	14.2x	11.4x
SMA Solar	1.4x	1.3x	1.4x	1.3x	5.2x	4.9x	5.3x	5.3x	6.3x	6.2x	5.9x	6.3x	10.3x	10.8x	10.0x	10.9x
Solar Millennium	1.4x	1.3x	1.1x	1.3x	11.2x	9.1x	8.3x	7.8x	15.8x	13.4x	7.2x	9.5x	16.1x	11.9x	8.0x	na
SolarWorld	1.3x	1.2x	0.9x	1.0x	6.6x	6.5x	5.4x	5.4x	10.2x	9.9x	8.8x	8.2x	13.6x	11.3x	14.2x	13.0x
Wacker	1.4x	1.2x	1.4x	1.4x	5.8x	4.8x	5.4x	4.7x	9.5x	7.5x	8.1x	7.0x	13.0x	10.7x	12.3x	11.0x
Solar supply chain	1.4x	1.2x	1.3x	1.3x	5.6x	5.0x	5.3x	4.9x	9.1x	8.0x	8.2x	7.4x	12.4x	10.9x	12.2x	11.1x
Abengoa	1.4x	1.2x	1.3x	1.4x	8.5x	6.7x	8.1x	7.6x	13.9x	11.0x	12.5x	11.5x	10.4x	6.1x	7.4x	4.7x
Mersen	1.1x	1.0x	1.1x	1.1x	7.2x	6.3x	7.1x	6.3x	10.6x	9.0x	10.1x	8.7x	14.5x	12.4x	13.1x	11.4x
Outotec	1.3x	1.0x	1.2x	1.1x	11.6x	9.1x	11.2x	8.2x	13.5x	10.5x	13.0x	9.2x	22.0x	18.0x	15.3x	13.0x
Prysmian	0.8x	0.7x	0.6x	0.6x	7.6x	6.9x	6.6x	5.4x	9.2x	8.2x	8.4x	6.8x	12.1x	10.8x	9.6x	8.0x
Umicore	0.3x	0.3x	0.4x	0.3x	7.7x	6.8x	8.0x	7.5x	10.9x	9.6x	10.6x	9.9x	12.5x	11.2x	13.2x	12.4x
Saft	1.3x	1.2x	1.3x	1.3x	7.7x	6.2x	7.3x	6.7x	11.4x	8.8x	10.5x	9.7x	22.6x	12.6x	14.3x	11.9x
Energy efficiency	1.1x	1.0x	1.0x	1.0x	8.7x	7.2x	8.1x	6.7x	11.5x	9.5x	10.7x	8.8x	15.0x	11.6x	11.1x	9.0x
Renewables & Clean Technology	3.2x	3.0x	3.2x	3.3x	8.2x	7.3x	8.3x	7.2x	14.8x	12.4x	14.2x	12.2x	17.9x	14.7x	17.1x	14.4x

Source: Barclays Capital, DataStream Consensus (Priced at the close of 31 August 2011)

Electric vehicles and improved Internal Combustion Engines (ICEs) will be the main drivers for emissions reduction

Electric Vehicles

With the current push for sustainability, car manufacturers have two main options: electric vehicles and improving the energy efficiency of internal combustion engines (ICEs). ICEs have the potential to reduce emissions by up to 50% in the long term. At the same time, electric vehicles have been boosted by government support and recent advances in energy storage, expanding opportunities in major world car markets. In this report we review the main types of electric vehicles and their challenges, the government incentives and support in different regions. At a high level, we also identify the opportunities to benefit from these trends.

For electric vehicles, we refer to all the technologies that employ some sort of electrification. These can be separated into two categories:

- a) Hybrid vehicles that use an electric motor and an ICE. The electric motor is powered from a battery pack that is charged through regenerative braking and/or the ICE. Hybrids can offer power acceleration (mild hybrids) or can have an electric launch operation. Hybrid vehicles do not recharge through the electric grid. Typical energy capacity is around 1-2kWh
- b) Plug-in hybrid and full electric vehicles. The plug-in hybrids have similar layout as hybrids (combinations of electric motor and ICE), but the battery can be charged by electricity from the electric grid. Their battery capacity is 5-15kWh. Full electric vehicles are powered solely by the rechargeable battery pack. The battery size is the largest among all other EV types with current capacity around 25-30kWh

The emissions reduction for hybrid vehicles stems from the reduced gas consumption. Various studies have shown that emissions reduction caused by plugged-in EVs vary by location, as each region has a different fuel mix for electricity production.

Market penetration will be achieved through a variety of factors

The market penetration of the electric and plug-in hybrid vehicles depends on: a) the cost of the energy storage, b) their maximum range, c) the financial incentives provided by the local governments, d) the consumer's preference, e) the recharging time of the vehicle (if any), f) the availability of charging stations, g) the cost of electricity, and finally, h) the cost of gas/petrol.

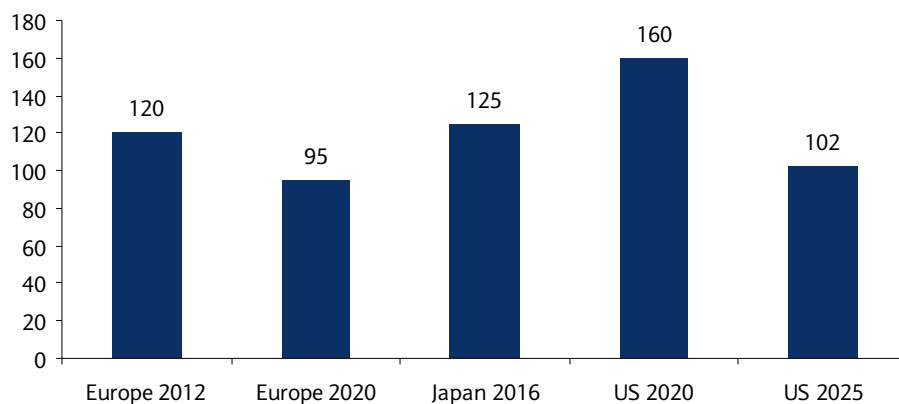
ICE can meet the emission requirements for now. But as requirements get stricter, EVs will gain momentum

Emissions regulation becomes more stringent

Over the past few years, major car markets are being regulated in an increasingly strict fashion. This is pushing car manufacturers to innovate in order to meet the updated emissions criteria. While electrification of the automotive fleet seems the most apparent solution, ICE vehicles have enough potential to meet those regulations. Already, most of the major automakers are close to meeting their 2012 standards through ICE related techniques (engine downsizing, transmission optimization, aerodynamic optimization etc.). However, the extra 20% reduction in emissions until 2020 is proving harder to achieve. This creates an opportunity for the EV market with a range of products that can assist in reducing emissions, either by offering some sort of electrification in the drive-train or by fully replacing the ICE.

*ICE can achieve the 2016
emission requirements, but will
face difficulties achieving the EU
2020 emissions*

Regulation and current auto manufacturers emissions



Source: Barclays Capital, Industry data

Hybrids are favoured in Japan and US, plug-in hybrids in Japan, US and China while full EVs are attractive in US and Japan

Are EVs cost competitive?

We employ a Total Cost of Ownership (TCO) model to evaluate the cost competitiveness of EVs with and without incentives in China, US and Japan. For an accurate estimate, we use the local car usage patterns and prices. We summarise our findings:

- The Japanese market is well suited for hybrid and plug-in hybrid vehicles. The lack of incentives and the high purchase price of complete EVs, however, do not allow mainstream market penetration. Hybrids and Plug-in hybrid EVs have a clear advantage compared to ICE cars, due to the high gas price.
- The Chinese market is an attractive one for EVs. However, due to the low purchase price of conventional ICE cars, Chinese consumers may not be willing to pay the high upfront cost required for an EV. While 5 years is enough to break even with an ICE car, the benefit is not yet substantial. The Chinese market is not suitable for hybrid vehicles yet. High upfront cost and current gas price favour less costly ICE vehicles.
- In the US market, the combination of incentives, increasing gas prices and high average mileage per year result in an ideal environment for the development of all types of EVs.

We summarize in the table below the TCO results for US, Japan and China:

TCO summary for EVs in US, Japan and China

	US	Japan	China
Hybrid	+	+	-
Plug-in hybrid	+	+	+
Full EV	+	-	+

Source: Barclays Capital

Many EVs will enter the market during 2012-2013

2012 and 2013 are expected to be pivotal years for the EV market. Several major car makers are launching a variety of new EVs (approximately 20 new models will enter the market in the following 3 years). We base our predictions about the EV market on the announced production plans, the total cost of ownership, industry forecasts and national targets for three different markets.

Total cost of ownership

Total cost of ownership is a useful tool to compare the price of an EV with conventional ICE vehicles

TCO is a useful metric to evaluate the market acceptance of EVs and examine the effect of the different variables that affect cost. TCO can also serve as a platform to compute the years required for an EV to break even compared to an ICE vehicle. The total cost of ownership is computed as follows:

Total Cost of Ownership = Purchase Cost – Incentives + Cost of fuel – Residual Value

Maintenance costs (despite being lower for the complete EV due to fewer moving parts) are not included since they are case specific and the data available for EVs are not adequate.

Assumptions

The analysis is based on a series of assumptions that relate to: a) average mileage per year, b) total years of ownership, c) cost of gas, d) cost of electricity, e) residual value of the vehicle at the end of the ownership, f) fuel consumption of the vehicles and the electricity

consumption per distance travelled by plugged-in EVs, g) financial incentives given by each government, and finally, h) the cost of the baseline ICE vehicle. The assumptions are summarized below for the US, Japanese and Chinese markets.

Assumptions per country for Total Cost of Ownership model

(% of initial price)

	USA	Japan	China
Baseline car price (\$)	EV \$14380	EV \$18000	EV \$11000
	Plug In \$18000	Plug In \$26000	Plug In \$11000
	Hybrid \$19000	Hybrid \$21800	Hybrid \$11000
Mileage per year	15000	5000	11500
Total years of ownership	5	7.5	5
Cost of electricity (\$/kWh)	0.112	0.29	0.063
Cost of gas (\$/gal)	3.5	8.0	3.8
Residual value of ICE vehicle*	40%	25%	40%
Residual value of hybrid/EV *	30%	10%	30%
MPG plug-in hybrid	60	60	60
MPG hybrid	50	50	50
MPG ICE	28	28	28
kWh/mile EV	0.34	0.34	0.34
kWh/mile Plug-In	0.36	0.36	0.36
TCO Hybrid (\$)	\$21,000	\$30,825	\$32,202
TCO Plug-in Hybrid (\$)	\$24,367	\$32,943	\$23,734
TCO Full EV (\$)	\$18,302	\$31,920	\$15,360

Source: US Environmental Protection Agency (EPA), International Energy Agency (IEA), current market data, car manufacturers' websites

The baseline car assumptions depend on the market. For the US market, given the high incentives for complete EVs and plug-ins, we compare them with low cost competitors such as Nissan Leaf vs. Nissan Versa and GM Volt vs. Chevrolet Cruze. The hybrid market is compared with equivalent upscale class vehicles such as Toyota Prius vs. VW Golf/Toyota Corolla.

Due to the importance of the Chinese market, we select the same vehicle price for all EV segments (\$11,000) due to the fact that more than 40% of the cars sold there do not exceed that price tag (source: BCG). As such, the hybrid vehicle segment which lacks incentives is possibly underestimated due to its price premium; however we conclude the other two market segments prove highly attractive. Due to the lack of official data concerning car prices outside the US, we show results of our model for the US market and for the Chinese market when applicable. However, using indicative car prices for the rest of the markets and EVs, we derive important conclusions concerning the market penetration of EVs.

EVs are not financially attractive everywhere. However, they are already cost competitive in the US and China

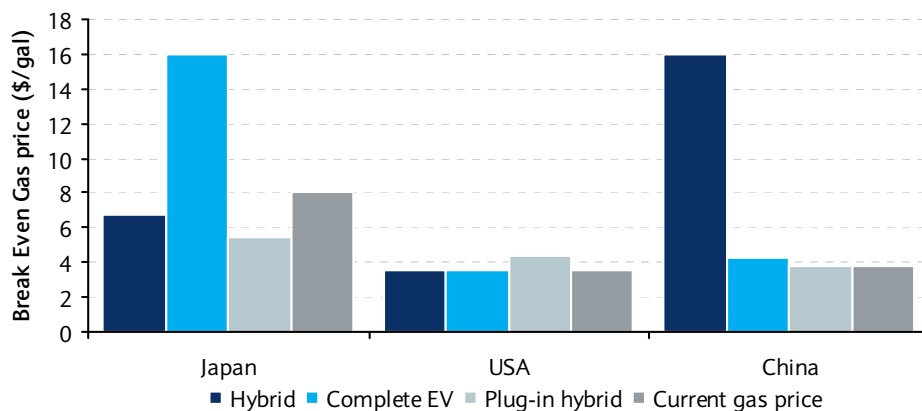
TCO Conclusions: Different EVs cost competitive in different countries

We summarize our findings in the chart on page 37 where the break-even gas price between an ICE vehicle and EVs is shown. The different usage of the car in each country and the different gas price affect the competitiveness of the different EVs.

In Japan, Hybrids and Plug-in hybrids have a lower TCO than ICE cars, but Full EVs are twice as expensive as an ICE car. In China, Plug-In hybrids and Full EVs have almost the same TCO as ICE cars, but hybrids appear too expensive. Finally, in the US all EV segments have a TCO which is almost the same as ICE vehicles.

Taking into account the extra incentives that are offered in some states of the US and some provinces of China, Full EVs and Plug-in hybrids become even more attractive. The extended calculations and analysis for the different EV segments and different markets can be found in Appendix A.

Break-even gas price for Japan, US and China



Source: Barclays Capital

Our demand forecast is based on industry forecast, national targets set by countries, car manufacturer's press releases and interviews

Demand forecast: Industry expects CAGR 45% for 2012-2020

We summarize key findings from our demand forecast:

- The national targets are unlikely to be achieved under the current production plans, total cost of ownership and financial incentives. In the Chinese market, especially, despite its ambitious plans, sales are expected to reach around 500,000 EVs per year by 2020.
- Europe we forecast to become a popular EV market by 2020, reaching 1.7 million EVs per year. However, the electrification process will be delayed until 2014-2015, because: i) most of the European automakers are expanding their product portfolio with advanced ICE low emission vehicles, and ii) because of the unsettled financial situation and government policy in many of the European markets.
- The Japanese market will continue growth in hybrids and plug-in hybrids (close to 800,000 plug-ins per year by 2020), but will not be an attractive market for full EVs, with around 70,000 Full EVs per year.
- While in the long term a supply shortage is predicted, in the short term there might be an over supply of EVs during 2012-2014, higher than what the sales forecast of industry experts expect. Therefore, we see a risk towards a production push back by OEMs during that period.

We outline below a summary of the sales projection by year and market. A detailed list of sales by EV segment in each country can be found in Appendix D (see page 43). We note here that Europe Top 4 represents Germany, France, Spain and UK.

Hybrid, Plug-in hybrid and full EV sales projection by country and year

	2011	2012	2013	2014	2015	2016	2017	2020
Europe Top 4	122,471	188,168	277,238	378,606	476,158	617,675	791,936	1,031,896
Rest of Europe	81,648	125,445	184,825	252,404	317,439	411,783	527,957	687,930
US	496,467	843,418	1,121,594	1,373,033	1,554,484	1,673,953	1,683,451	1,780,737
Japan	487,724	593,367	641,637	661,136	695,523	774,221	800,899	942,041
China	33,635	66,356	101,669	142,551	194,265	267,442	299,288	430,009
Total	1,221,945	1,816,754	2,326,963	2,807,730	3,237,869	3,745,074	4,103,531	4,872,613

Source: Barclays Capital, JD Power, car manufacturers' press releases

2011 is the first year where plug-in vehicles started to roll out. Our research forecasts the EV penetration based on:

1. Goals set by the major countries – markets.
2. Conclusions from the TCO analysis which predicts: a) strong acceptance of plug-ins and hybrids in the US and Chinese market, b) sustained growth of hybrids in the Japanese market, and c) an increased market acceptance of full EVs in China and the US.
3. Press releases from auto-manufacturers with volume production planning of EVs.

Global market demand

The EV market will grow, but is unlikely to achieve the national targets by 2020

There is a discrepancy between the forecast production and the EV growth as outlined by governments detailed in Appendix C. According to volume production plans and forecast data (JD Power's analysis) as well as press releases by auto manufacturers over the past 12 months, we outline the global production of EVs until 2020. Many of the major car manufacturers are not included in the table as they have not all made public announcements for their volume plans for the future. In addition, the Chinese market and its production capacity are not included in the reported figures.

In the table on the previous page, we present the growth of plug-in EVs as announced by different governments (US, Japan, China and Europe top 4 markets – Spain, France, Germany and UK, and rest of Europe). In the bottom chart on the next page the sales forecast of JD Power is shown where the numbers outline a significant deviation from national targets. Taking into account the production figures as reported in the press, the differences with the national and the industry forecasts are shown in the table on the previous page. Up to 2014 the auto industry is forecast to supply broadly what the targets estimate, from 2015, there is a large gap between the production and the target. We believe however, once the manufacturing capabilities are in place, and consumer preferences for brand, reliability and performance are more clear, then it is feasible to ramp up the production as shown by the examples of Nissan and Chevrolet.

Hybrid electric vehicles are already experiencing strong growth and this is expected to continue by replacing existing ICE vehicles. Hybrids are expected to sell more than two million vehicles per year as: a) more hybrid cars enter the market and, b) the cost of hybrids becomes more competitive compared to ICE vehicles. We outline the sales forecast for 2012-2020 for hybrid vehicles in the chart on page 13.

Chinese demand strong for plug-ins and complete EVs

Despite the low EV sales in China, it is expected to become a key market

Last year, EV sales were in line with our TCO analysis, at 4,000 Toyota Prius sales (considered a benchmark for the market). Local Chinese EV auto manufacturers performed weakly. In 2010, Chinese BYD sold 290 hybrids and 54 complete EVs. However, it is worth noting that the cars were only available in limited numbers and few cities. However, most of the auto manufacturers are entering the Chinese EV market through joint ventures with local Chinese manufacturers. The local manufacturers (significantly supported by the Chinese government) are aggressively pursuing ambitious research programs to produce their own EVs. According to a recent BCG report ('Powering Autos to 2020: The Era of the Electric Car?', July 2011), the majority of car purchasers in China are interested in purchasing an EV. Moreover Chinese car buyers are most willing to pay upfront a premium for future lowered operating costs, compared to American, Japanese and European peers. We believe that China has all the ingredients to become a global player in the EV space, though as outlined, the aggress move to all electric may take longer than currently anticipated.

US has the potential in all EV segments

In line with our TCO analysis, plug-in hybrids and full EVs are expected to experience strong growth until the incentives of the US government expire (200,000 vehicles). According to the manufacturing plans of the leading automotive companies, this is expected to happen sometime towards the end of 2013 reaching 1.5 million EVs per year in 2015 and 1.8 million in 2020. The continuing growth of plug-in EVs remains linked to the state financial incentives policy.

European demand will be slow in the beginning but will catch up later. Japan will show strong growth in hybrid cars

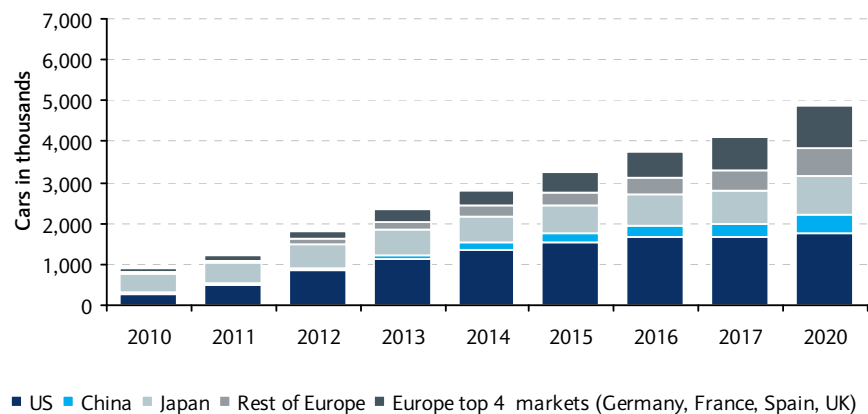
European demand will be weak initially but catch up by 2020

European automakers are focused on ICE improving technologies, such as the popular Diesel technology that meets current emissions requirements. As such, EVs are not as popular as other markets. However, given the incentives policy followed by most of the European countries and the increasingly strict emissions thresholds, EVs are expected to grow significantly during the next decade reaching 800,000 EVs in 2015 and 1.7 million in 2020.

Japanese demand not high for complete EVs

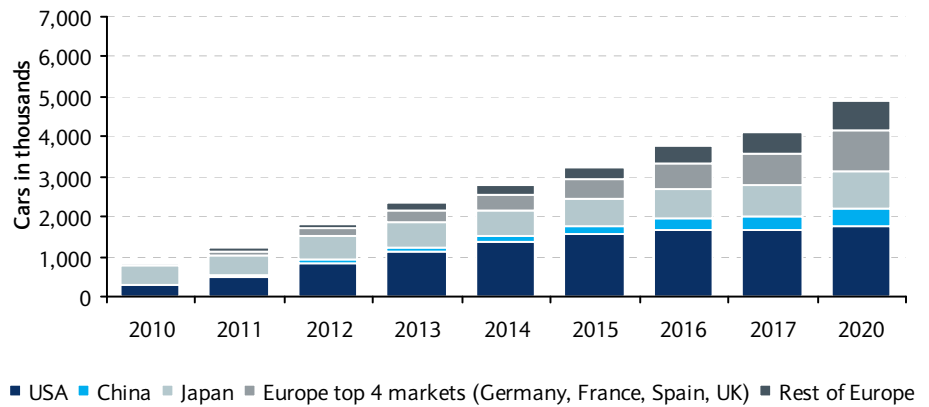
The 10% market share of hybrid vehicles in Japan is the world's highest, and demonstrates their popularity. Industry experts expect the same trend to continue with 700,000 HEVs in 2015 and 940,000 HEVs in 2020. Complete EVs are not expected to enjoy similar, strong growth, which is in line with our TCO analysis, outlined in the chart on page 2.

Plug ins and complete EVs national growth target



Source: JD Power, International Energy Agency (IEA), Barclays Capital

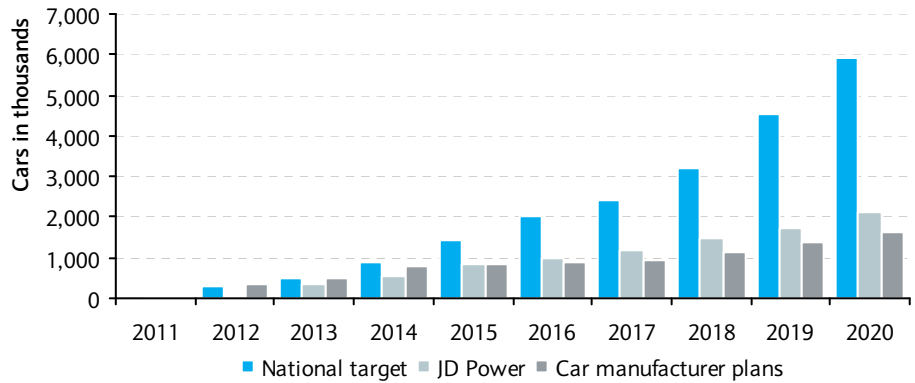
Hybrids – Plug Ins and complete EVs sales forecast



Source: JD Power

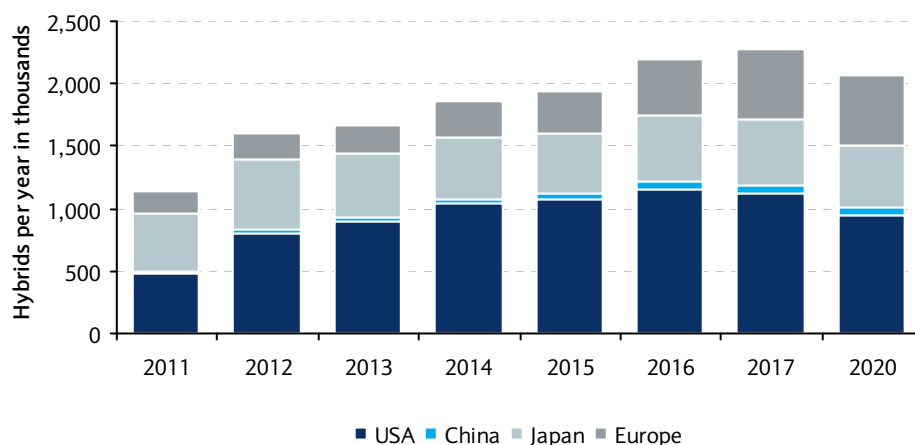
The industry forecasts, the press announcements and the national EV market penetration targets show large deviations

Difference of production plans with sales forecast and national targets for plug-in EVs



Source: JD Power, IEA, Barclays Capital

Global sales growth of hybrid vehicles



Source: JD Power, Auto-manufacturers press releases, Barclays Capital

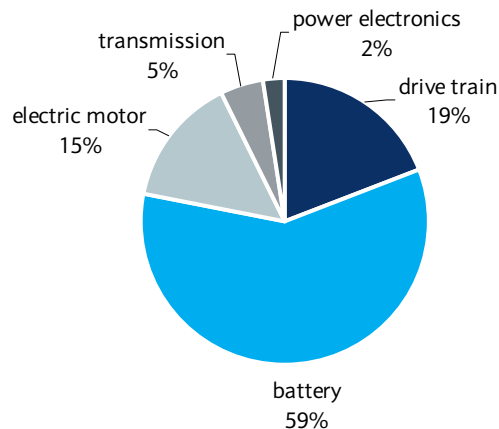
EVs cost breakdown: Battery and raw materials are key factors

The common factor for all modifications of EVs is the storage of energy and the energy conversion from electrical (battery) to mechanical (wheels). The electric motor has already reached high conversion efficiency. Thus the burden is transferred to developing energy storage systems, which are able to reliably and safely deliver the required power at minimal time and cost.

Examining the cost breakdown of a full electric car such as the Nissan Leaf (shown in left-hand pie-chart below), more than half of the vehicle's cost is for its battery. Energy storage has been a research issue for the past decades with major advances both in energy density and cost of storage. While the cost of storage for electric vehicles is still high enough to impose a significant premium compared to ICE vehicles, we believe that over the next few years, the energy density (kWh/kg, range of EV) and the subsequent storage cost (\$/kWh) will be reduced by approximately half.

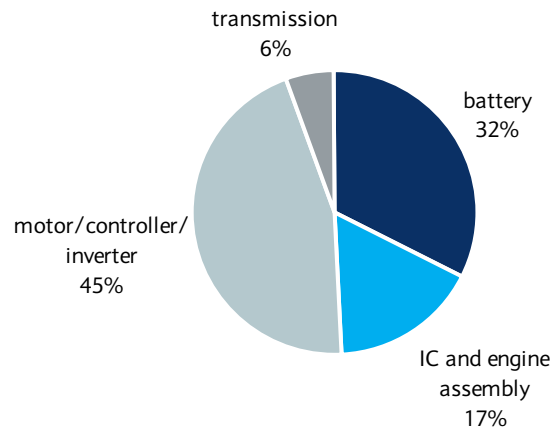
The cost of a hybrid electric vehicle is differentiated from an electric vehicle in the size of the battery that is substantially smaller (Toyota Prius capacity is ~2kWh). In addition, there is the additional cost of the ICE. As the right-hand pie chart below shows, the motor/controller/inverter assembly of a hybrid vehicle is the most cost intensive component.

Cost breakdown of electric vehicle



Source: Barclays Capital

Cost breakdown of Powertrain of a hybrid vehicle



Source: University California Berkeley, UC Davis

Are materials cost a concern for electric motors?

Electric motors are an integral part of every EV. We identify two types:

- Motors that require permanent magnets exhibit high efficiency, but they are susceptible to the volatile behaviour of rare earth materials price that are required for the magnets
- Motors that do not require rare earths, but have lower efficiency
- Rare earths are experiencing a shortage in supply for the next 12-24 months

There are two major types of electric motors, permanent magnet DC brushless motors and induction motors (no permanent magnets)

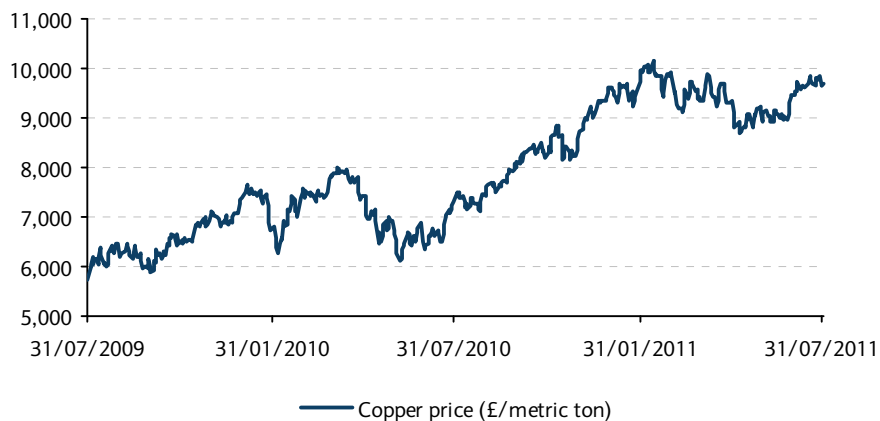
Two types of electric motors are applicable to EVs, DC brushless drives (essentially AC synchronous motors) and induction motors. DC brushless motors use permanent magnets and require an inverter to keep the torque constant and the conversion of electrical to mechanical optimal efficiency. Induction motors on the other hand, do not have permanent magnets, but have lower conversion efficiencies. DC brushless motors have broadly higher efficiency, and they are controlled more easily than the induction motors. The industry view is that DC brushless drives will likely dominate the hybrid and plug-in hybrid markets, while induction motors will be used for fully electric vehicles.

Permanent magnets require rare earth materials. Rare earth material prices have soared over the past year, due to Chinese export quotas

DC permanent magnet drives contain a considerable amount of rare earth materials such as Neodymium and Dysprosium. For example, the Toyota Prius hybrid vehicle uses approximately 1kg of Neodymium for each electric motor. The price of Neodymium has risen significantly (see graph on next page) by 25.6 times since 2009. The reason for this increase is China's reduction of rare-earth export quotas by 72%. China is the largest producer of rare-earth materials with approximately 90% of the global production. This poses an obstacle to car manufacturers outside China and some of them are already trying to substitute this technology with induction motors that do not use permanent magnets (Toyota is collaborating with California based Tesla motors who already use this technology for their products). However, this is expected to be a near-term issue for the industry, lasting 12 – 24 months, until new mines become operable outside of China. Furthermore, new areas abundant in rare earths are being discovered. For example, Japan recently announced that researchers located a massive amount of rare earth materials in the seabed of the Pacific Ocean at extractable depth. Therefore, while a bottle neck in the supply of those materials is possible in the short term, in the long run it likely will be more balanced.

High efficiency motors require electrical steel and copper. Electrical steel helps to reduce core losses and is an alloy that may have up to 6.5% silicon. Copper is used to form the windings of the motor. Its price appears to be volatile with current price ~£10,000/ton showing a 66% increase over the last 2 years as shown in the chart below. While the Earth is abundant in copper, only a small fragment is economically extractable. The annual increase in extraction over the past 50 years is ~ 4%. A continued growth of EVs may cause problems on copper supply.

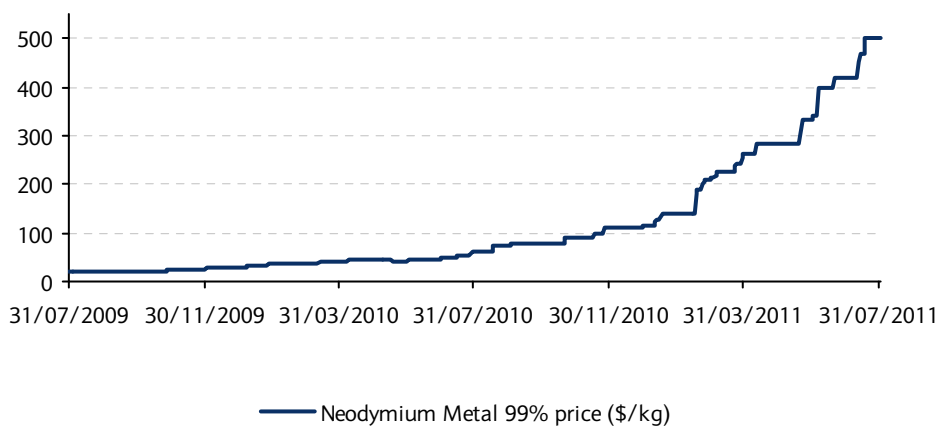
Price of copper (£/ton) since 2009



Source: Datastream

Price of Neodymium (\$/kg) since 2009

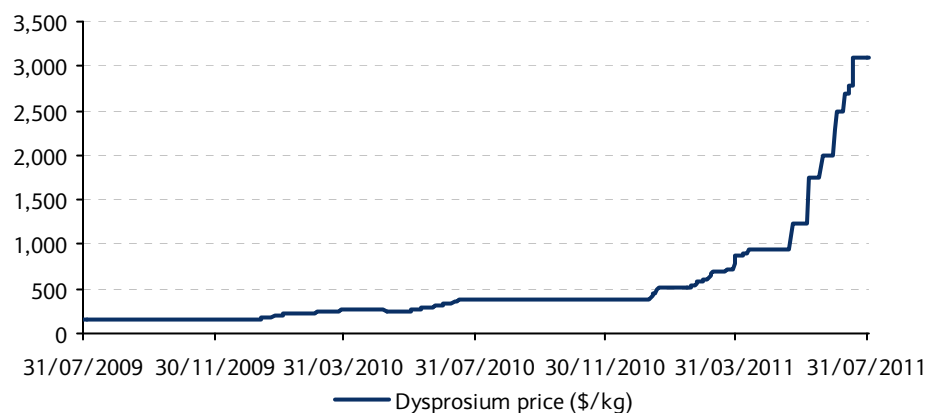
Rare earth prices are spiking since early 2011 due to China's export policy. This is causing problems to auto manufacturers that require those materials for electric motors



Source: Datastream

Apart from Neodymium, electric motors use other rare earths such as Dysprosium. As shown in the chart below, the price of dysprosium is spiking since China's change of export quotas. However, with the opening of rare earth mines outside of China over the next few years, the rare earth supply problem likely will be solved.

Price of Dysprosium (\$/kg) since 2009



Source: Datastream

Batteries for EVs

Batteries are the most cost intensive part of an EV. Their cost and ability to store energy will determine the viability of EVs. We believe:

- Lithium-Ion batteries are the next generation batteries that will equip the majority of EVs
- The current cost of batteries is around \$650-750/kWh, but through an increase of volume production, the industry expects a 30-40% cost decrease by 2014
- Polymer electrolytes are the next commercial advancement that will allow thinner batteries to further reduce costs

Established battery technologies

Battery Type	Year of commercialization	Features	Environmental Impact
Lead- acid	1910	Poor energy density, moderate power density, low cost	Lead toxic, but recyclable up to 95%
Zinc – air	1932	Low - Medium energy density, high power density	Zinc smelting not eco-friendly
Ni-MH	1989	Moderate energy density, high power density	Nickel not eco-friendly, toxic and rare. Recyclable
Lithium ion	1991	High energy density, high power density, high cycle life, high cost	Different combination, different impact. Cobalt very popular, but rare. Iron and Manganese possible alternatives and eco-friendly. Lithium relatively green. Recyclable

Source: Nature publication, Building better batteries. Armand et al.

EVs have specific requirements imposed on their batteries. These characteristics are vital to their performance and reputation:

- Power density (W/kg) that affects the acceleration of the vehicle
- Energy density (Wh/kg) that affects the range of the vehicle
- Recharging time required to charge the battery
- Reliability of the battery for at least 10 years
- Safety
- Robustness of the battery that is required to operate at a large range of different climates and temperatures
- Environmental impact
- Recycling

Lithium ion batteries can provide enough power, but their capacity and cost are still an issue

There is an inherent trade off between power density and energy density for all batteries. Power density is in general considered a solved problem for all type of EVs. However, battery manufacturers still work on the rest of the issues which have equal importance for the competitiveness of EVs. Several battery technologies exist to date, each one at different level of development. The table above shows a short summary of the established, mature technologies commercially available today accompanied with the environmental impact of each technology. So far, Nickel Metal Hydride (Ni-MH) batteries have been popular for hybrid vehicles, however,

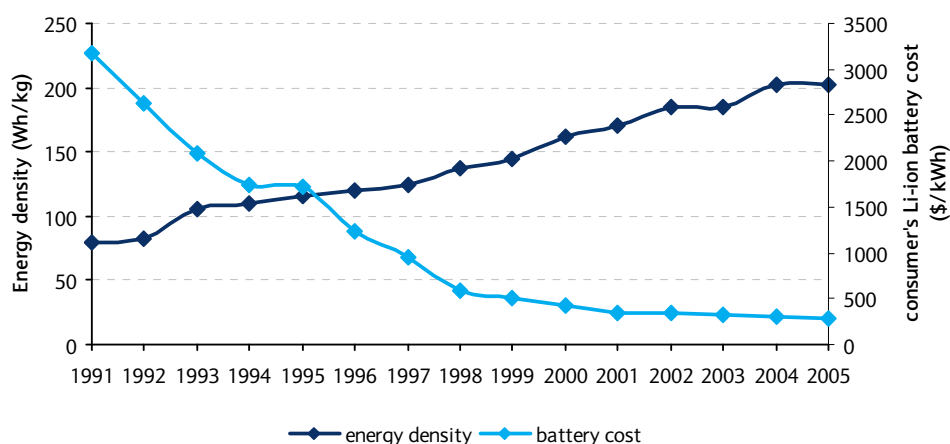
lithium ion is nowadays the major technology researched due to its high energy and high power density that appears to have the potential for establishing EVs.

Lithium-ion batteries for EVs are the next advancement

Consumer electronics lithium-ion batteries cost dropped 80% from 1991 to 2005

Sales of lithium-ion batteries for EVs only began in 2009, but we can draw some conclusion by observing the evolution of lithium ion cost and energy density of consumer electronics batteries. The prices per unit energy stored between 1991 and 2005 have dropped by ~80% (see chart below). The steep cost reduction since its commercial introduction is due to production volume increase in Asia, technology reduction, as well as better space utilization within the battery. At the same time, the energy density has increased 2.5 times, which translates into smaller batteries. While the safety regulations compared to EV batteries are less stringent and the power management electronics required are less sophisticated, their fundamental operation remains the same. One of the key differences between batteries for consumer electronics and vehicles is the power management software and the cooling that is required for reliable and safe operation. It is estimated that the electronics of the battery account for approximately 20% of the total battery cost. Almost 30% of the total cost is the cost of the materials in the battery cell. The cost breakdown of batteries is shown in the chart on page 23.

Lithium batteries for consumer electronics historical prices and energy density

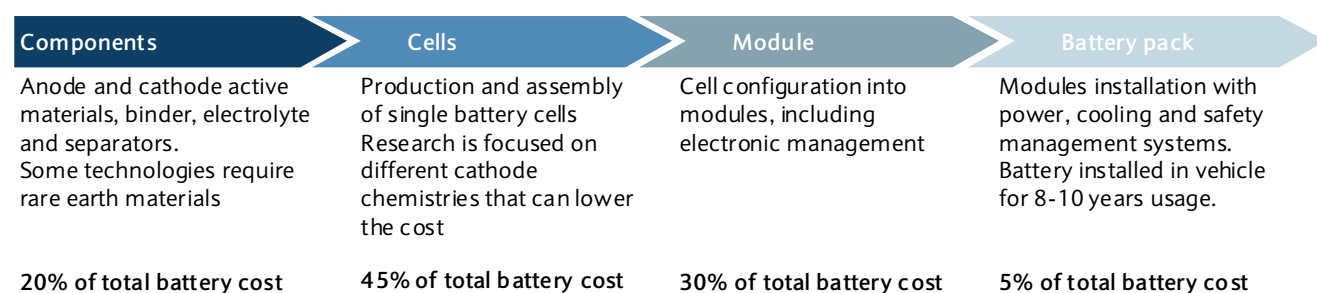


Source: historical data, Duke University

Lithium ion batteries value chain

The basic component of a lithium battery is its cell. After the cells are produced they are combined in optimal arrangements to form a module. Finally, the modules together with electronics and cooling systems form the battery. A summary of the supply chain of Lithium ion batteries is outlined in the table on the following page.

EV battery value chain



Source: Barclays Capital

Highest energy cathode technologies include cobalt, which poses a safety hazard and is a rare earth material

The cell is composed of four basic structures: cathode, anode, electrolyte and separator. While anodes have high specific capacities, cathodes exhibit much lower capacities: to remedy this, the industry is attempting to develop the appropriate chemistry to boost their performance. The dominant chemistries for consumer electronics contain cobalt, however due to the scarcity of the material and its safety issues, manufacturers are shifting to different technologies. The major technologies today are:

- LMO (lithium manganese oxide) is the most popular solution for EVs with medium energy density (~150 Wh/kg), low cost, high power density, but lower expected lifetime
- LCO (lithium cobalt oxide) used to be the solution for consumer electronics, due to the highest energy density (theoretical energy density for LMO is 570 Wh/kg). However, the safety issues related to cobalt, the scarcity and the consequent price increase of cobalt have shifted many of the battery makers into other technologies
- LFP (lithium iron phosphate) with lower energy density, but lower materials cost, higher lifetime and increased safety. Furthermore, it is viewed as a substitute to the leading cobalt technologies
- NCA (nickel cobalt aluminium) (~160 Wh/Kg) exhibits high energy density, but is thermally unstable
- NMC (nickel manganese cobalt) is extensively researched due to its high energy density (high conductivity), but it suffers from the same issues as cobalt
- Lithium ion nanophosphate where the cathode consists of nanophosphate materials. As a result, the surface area of the cathode is increased with increased conductivity and faster charging times

Anodes are less difficult, because of the high energy density that has been achieved. Anodes are usually made from graphite. Recent advances have developed novel anode technologies that replace the graphite with lithium titanate oxide. As a result, the recharging time is reduced materially.

Electrolytes of lithium ion batteries are a focus of development and the two types that are being developed are:

- A mixture of lithium salt and organic solvent, which is the current dominant technology
- Polymer electrolyte, that allows thinner batteries, flexibility in the shape of the battery and potential reduction of the cost due to the inexpensive polymers

Next generation batteries are lithium-ion with polymer electrolytes that can offer freedom in battery shapes and reduce the volume of the battery

The lithium-polymer technology was first introduced in 1999 and is a popular and growing technology for consumer electronics (Apple recently introduced lithium polymer batteries for its laptops, allowing the fabrication of ultra thin portable devices). Following the general trend in battery technology, we expect this to be introduced into EVs in the coming years. NiMH batteries entered the consumer electronics market in 1989 and the car industry 1996 (GM EV1) followed by Prius in 1997. Following a similar trend, lithium polymer batteries were commercially introduced a few years ago (around 2007) and we expect the next generation of lithium-ion batteries for EVs to utilize this technology.

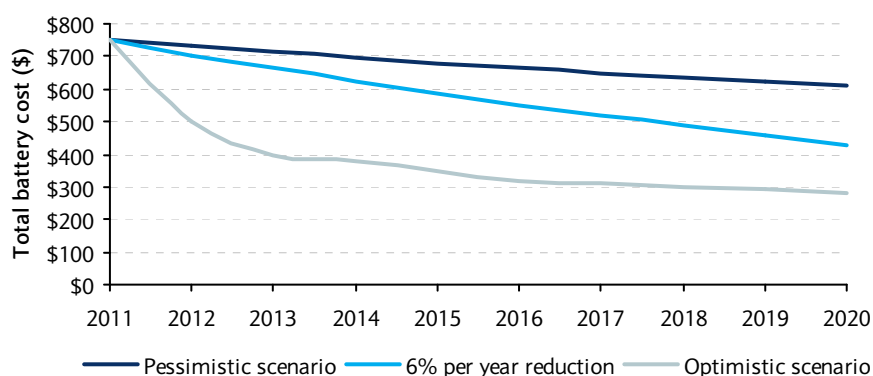
The final component of the cell is the separator that does not allow any contact between the anode and the cathode. Furthermore, it acts as a safety mechanism in case of overheating.

Cost of batteries remains high, but will decrease materially

Current battery cost is \$650-750/ kWh and is expected to be reduced to \$400-500/kWh over the next two-three years

The current cost of energy storage for Li-ion suitable for electric vehicles is in the order of \$650-750 / kWh and the capacity needed depending on the application spans from 1kWh for a mild hybrid application to around 30kWh for a full electric vehicle. The battery industry expects this figure to drop over the next few years to \$400-500/kWh at the battery cell level due to volume increase (see chart below). It will be higher at the battery level due to the cooling and the electronics that are required. Even at this cost, however, ICE vehicles still carry an advantage.

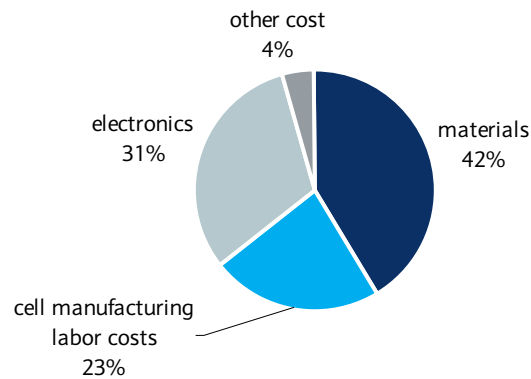
Battery cost projection



Source: Barclays Capital, industry sources

There are two ways the battery cost can be decreased: a) through increase of the energy density of the battery which results into a decrease into the total mass of materials required, and b) through manufacturing improvements and volume production increase which results into a cost reduction.

Cost breakdown of Lithium Ion batteries



Source: Industry sources

Given the battery cost breakdown, shown above, we have generated three scenarios about the cost of Lithium batteries over the next few years. Starting with the industry notion that batteries exhibit a 6% yearly decrease in their cost, we calculate two possible scenarios. In an optimistic scenario, given the increased research funds allocated by governments over the last years and the targeted efforts by battery manufacturers to reduce their cost, we expect the unit battery cost to decrease as manufacturing capacity increases. In an extreme scenario, we assume a sudden drop in the labour cost and a 10% per year decrease to materials cost and power electronics cost, due to manufacturing increases and research developments. In a pessimistic scenario we assume steady labour costs and 5% yearly decrease in materials and electronics cost. The graph on the previous page shows the outcome of each scenario.

Key Considerations

Our forecasts rely on implied assumptions concerning the government's support of EVs, our anxiety over range, recycling of the batteries and the charging infrastructure. We analyze each of these aspects.

Governments in US, China and Europe are adopting ambitious incentive programs to bolster the growth of EVs

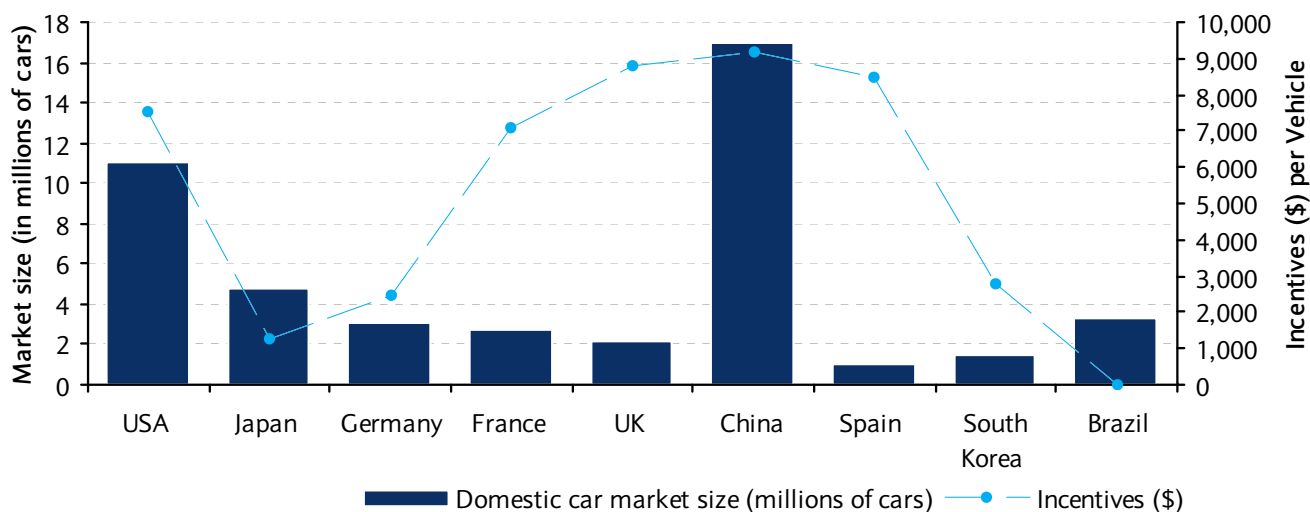
Governments broadly support the development of EVs

Financial incentives are strong in certain major markets such as China and the US. This is expected to bolster the growth and increase the initial public acceptance of EVs. We outline a summary of our findings:

- China exhibits a strong support towards its transportation electrification. This is demonstrated by the injection of US\$15.5 billion in financial incentives, public infrastructure, and development of the domestic automotive industry
- US is following a similar approach with the allocation of US\$2.85 billion as part of the Recovery and Reinvestment Act and with the award of incentives of up to \$12,000 for EV buyers
- Japan is reducing the amount of incentives offered for EVs, likely relying in the increase public acceptance of hybrids that already have a 10% market share
- Despite the fiscal austerity measures, European governments are adopting rebates and tax credit schemes, with UK, Spain and France offering incentives for EV purchasers

Transportation and Energy policy dictated by local governments is playing a key role in the adoption of hybrid and electric vehicles. Many countries have set ambitious goals for the electrification of their respective vehicle market (Appendix B, page 41). Despite the overall shift towards electrification of the transportation sector, each country offers a different set of regulations and incentives to promote the usage of electric vehicles. The state policy towards this end is expressed through allocation of funds to research and development and financial incentives to retail customers.

Current incentives for fully EVs in major car markets



Source: Barclays Capital, industry sources

The US is offering high incentives for full EVs and plug-in hybrids. In certain states the incentives are up to \$12,500

Since 2009, the US has focused attention on electrification by funding R&D and providing buyer incentives. Through the Recovery Act and Advanced Research Projects Agency – Energy (ARPA-E) program the US government is allocating \$14 million to the development of novel storage concepts that can drive the cost of storage significantly lower than today's levels. Moreover, through the Recovery and Reinvestment Act, in total \$2.85 billion is being invested in the electrification of transportation. Part of this funding policy – indeed, the key driver for the next two years – is directed at incentives to retail customers.

The financial incentives vary by region and time. As the technology matures it is likely that the incentives will start to fade, but the strong intent of certain key countries (USA, UK, China) to promote energy security and energy efficiency may sustain attractive incentive schemes. For example, the US offers a maximum incentive of \$7,500 for the purchase of plug-in vehicles if the storage capacity exceeds 5kWh and some of the state governments offer extra incentives. California offers up to \$5,000 for EVs and \$3,000 for plug in hybrids. These discounts lead to a price for the GM Volt plug-in hybrid of \$29,780 (starting price \$40,280). On the other hand Brazil (3.3M sales in 2010) was about to implement incentives for electric vehicles, but cancelled its plans due to concerns expressed by its ethanol industry.

The fiscal austerity policies adopted by most of the EU countries are likely to affect the state funded EV programs. Despite the macro headwinds, we anticipate countries will seek to align incentives that represent good value for taxpayers, while still ensuring public policy objectives are achieved towards the build out.

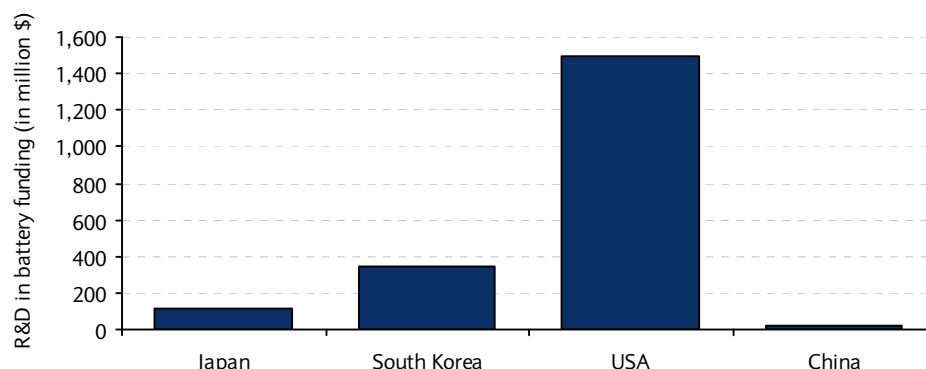
China will spend 100 billion CNY for the adoption of EVs and is expected to become a significant market for most manufacturers

The Chinese market requires particular attention as it will play an important role in the growth of EVs over the next three years. The government has targeted 500,000 EVs by 2015 and 5 million by 2020. To that end, it has: a) adopted financial incentives for customers up to \$9300 for full EVs, b) set up an alliance of companies backed with 100 billion CNY, and c) ordered the State Grid to prepare 2,300 charging stations and 220,000 charging poles between 2011 and 2015. Furthermore, local governments offer further incentives. For example, in Shenzhen additional subsidies of RMB 60,000 (\$9300) for complete EVs and RMB 20,000 (\$3105) for plug-in hybrids are being offered, resulting in total consumer subsidies of RMB 120,000 (\$18631) for complete EVs and RMB 70,000 (\$10867) for plug-in hybrids.

There are several Chinese car manufacturers that are investigating producing competitive EVs. However, despite the ambitious goals, only 10,000 EVs were sold in 2010 (to state controlled agencies) and the research funds allocated from the Chinese government are low compared to its international competitors (see chart on the next page). For example, South Korea is investing US\$342m until 2014, while Japan, which has the largest market share and a long research tradition in the field of energy storage, US\$116m throughout 2012. There are strong indications that EVs will ultimately be successful, namely; a) the introduction of major OEMs into the Chinese market, b) the establishment of several Chinese EV companies, c) the ability of the government to successfully implement its targeted energy policy, and d) China's exclusivity in rare earth materials as it possesses 30% of the world's reserves and supplies 95%.

The US has increased the R&D spending in EV batteries over the past few years. Japan and South Korea have decreased their spending at the same time due to their leading position in the field

R&D spending of major battery manufacturers



Source: United Nations

The graph on page 24 shows the maximum incentives offered for 2011-2012 (including rebates and tax credits for five years) in 9 major car markets. While the table below shows the incentives for plug-in hybrids, an estimate of the future of this incentive for 2013 and electricity prices. These financial incentives are given as cash rebates plus tax credits (we assume the tax credit assuming average CO₂ emissions 120-150g/km for a duration of 5 years).

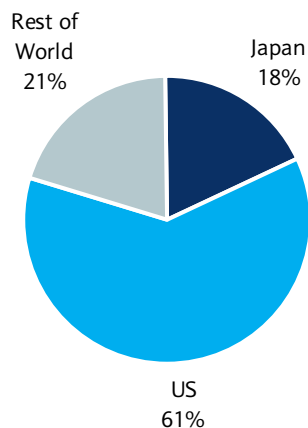
Incentives, outlook and cost of electricity

Country (million cars sold in 2010)	Outlook for 2012-2013	incentive in USD for plug in hybrid vehicle	Cost of electricity (\$/kWh)
USA (11)	Neutral	7500	0.112
Japan (4.8)	Neutral	1239	0.29
Germany(3.1)	Neutral	2460	0.349
France (2.6)	Neutral	7094	0.193
UK (2.2)	Neutral	8773	0.161
China (17)	Positive	8800	0.063
Spain (1)	Neutral	8460	0.263
South Korea (1.5)	Neutral	2759	0.086
Brazil (3.3)	Negative	0	N/A

Source: Barclays Capital

The side effects of government incentives are shown in the Japanese market, where the electricity price is almost three times higher than in the US. Government incentives, which included tax breaks and a scrappage program (\$2,500), boosted the sales of hybrid vehicles and made Japan the leading market in the world during 2009, as shown in the pie chart on the next page.

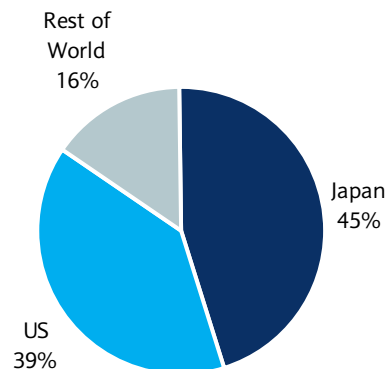
Hybrids sales breakdown for 2008



Source: Industry data

EVs success in the US depends on the gasoline price as well as the financial incentives

Hybrids sales breakdown for 2009

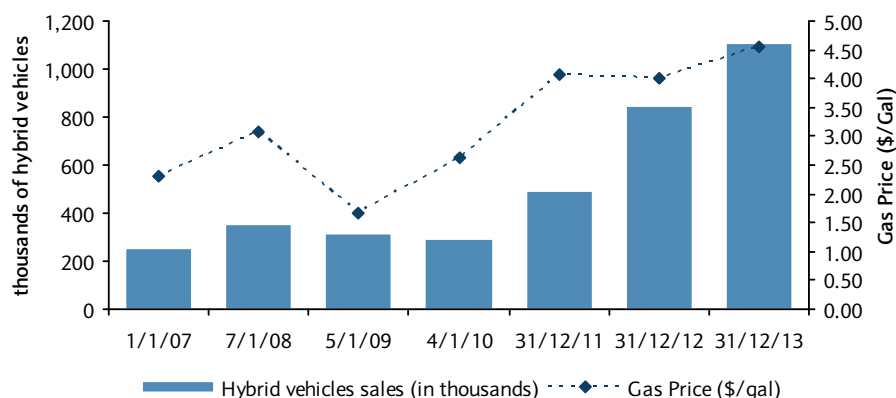


Source: Industry data.

In the US market the gasoline price seems to have a higher impact than incentives. The graph below shows the historical price of gasoline and the annual sales of hybrid electric vehicles in the US. Since 2006, US government started providing substantial incentives for hybrid vehicles. Combined with the increasing gasoline price, the sales of hybrid vehicles and its respective market share exhibited a strong growth. During 2008-2009 the gasoline price fell from ~\$4/gal to \$1.5/gal and the sales of hybrid cars started to decrease. The same trend continued in 2010 where the gas price, while it increased, stayed well below \$3/gal and the incentives for hybrids started to fade. However, during the first quarter of 2011 as the price of gas started increasing above \$3/gal and without any incentives for hybrids (since they are now offered only to plug-in EVs), the sales of hybrids in the US market grew by more than 30% (higher than the general car market increase of 20%).

Due to the Japan earthquake, sales of the major hybrid market players (Toyota and Honda) are expected to decline, but the trend is clear. In the US market, gasoline prices, even with mild incentives, show a correlation to the sales of hybrids. The market share of HEVs has reached ~3% of the total US market. The outlook for the oil price to 2020 seems to have an upward trend which means that a volatile, high gasoline price will probably be the norm over the next years.

Effect of gasoline price to the sales of HEVs in the US market



Source: Barclays Capital, Energy Information Administration (EIA)

Range anxiety a concern?

A common concern that hinders the market penetration of EVs is the range anxiety that stems from the limited maximum range of a full EV compared to an ICE vehicle. ICE vehicles range is around 300-400 miles, while the maximum reported range of a full EV is 100-200 miles. Range anxiety refers to the driver's concern with respect to the autonomy an electric vehicle has without a network of charging stations. It is considered an important factor affecting the overall market acceptance of EVs. However, research has demonstrated, range anxiety is significantly diminished for EV owners once accustomed with EVs and the information systems used by OEMs. In addition, with current and forecast technology, EVs are primarily designed for short distances. Their target base is the consumers that commute daily in cities. As the infrastructure for charging EVs is deployed in the major cities, range anxiety will likely further diminish. At the same time, the combination of a) non-financial incentives such as use of bus lanes, parking spaces in downtown areas of metropolitan cities and b) discounted electricity prices from utilities that can benefit from increased capacity factors during off-peak hours result in a convenient and affordable means of transportation. We note here that range anxiety is an issue only for full EVs and not for hybrids or plug-in hybrids where in the absence of charging poles, ICE charges the battery.

Recharging infrastructure creates an opportunity for power utilities

The current range of plug-in EVs is roughly 150km (for complete EVs) to 300km for plug-in EVs. To provide the required infrastructure, governments, auto manufacturers and start-ups are collaborating to provide enough charging stations and/or battery leasing schemes in order to eliminate the range anxiety until batteries increase their energy storage capacity. In addition, the timing that is required to charge the vehicles depends on the capabilities of the recharging equipment.

Ideally, each plug in requires at least a charging facility at the owner's 'home' parking. At the same time, recharging infrastructure at the workplace is equally important as EV owners will recharge their vehicles while at work. Public infrastructure is required to ensure the reliable and safe recharging of EVs.

EVs are unlikely to cause a power load issue

Finally, the increasing number of plug-in EVs will increase the electrical load. Utilities have a strong interest in the recharging of EVs from the grid. Research has shown that the current projections of EV adoption will not create instability on the grid's operations particularly if the recharging of EVs is done during off peak hours. Off-peak hour recharging would offer more favourable costs for the EV owner and would increase load factors for power utility companies.

As EVs grow, recycling will be needed

There is plenty of lithium, but a bottleneck is possible

As the number of EVs rises, there are several questions about the recycling of batteries and other EV components after their performance is deteriorated.

Over the last two years, the global recession created a lithium surplus. By 2013 the supply and demand is expected to be in balance again and a production crunch could occur around 2017 and beyond. However, car makers believe that lithium's volume production is not at its peak and therefore the cost of lithium may be further decreased by rising production volumes.

In addition, there is some concern about cobalt, which is an active, rare earth material in cathodes of certain Li-ion batteries as described earlier. However, cobalt is likely to be phased out of vehicle batteries manufacturers in the long term.

Rare earth materials are the biggest concern

Finally, the rare earth materials (such as neodymium and dysprosium) that are contained in the electric motors and the batteries pose the greatest concern in the industry. As mentioned earlier, several motor manufacturers are trying to replace the current electric motor technology with alternatives that do not require those materials. However, most manufacturers install motors with permanent magnets that offer higher efficiency (up to 30% compared to induction motors). Rare earth materials included in electric motors and batteries are recyclable, by up to 95%, and therefore companies that have this ability are expected to benefit in the event of possible supply shortage.

EV value chain

We conclude our analysis with the overview of the value chain of EVs as has been discussed in the previous sections. We outline a summary of the EV value chain below:

- We separate the value chain into two parts. The first one refers to the supply chain of the battery and the second to the supply chain of the power train and its integration to EVs
- Raw materials for batteries and electric motors are key elements of the supply chain. Especially, the rare earth materials required for electric motors and materials required for battery cells. A favourable future for EVs would likely cause a shortage of rare earth materials in the short term and a shortage of Lithium in the medium term
- Specific parts of the battery components such as separators and electrolytes offer high EBITDA margins with 4-5 companies active in the field

Powertrain - EV Value Chain

Power train raw materials	Powertrain	Recycling	OEMs	Recharging
Cost 60% of motor cost Magnets 45% of motor cost 8.5\$/KW of motor power	Cost 19\$/kW (KW of motor power)	Cost 2011 \$5/kg 2020 2.5\$/kg	Cost 1450 \$/kWh, (Nissan Versa EV) 2438 \$/kWh (GM Volt plug in hybrid)	Cost \$300 - \$1000 (one time purchase cost)
EBITDA Margin Range: -90% - 47%	EBITDA margin (average) -36%	EBITDA margin 12%	EBITDA margin (average): -5% (without Tesla 11%)	EBITDA margin N/A
Players 10-15 Many in their first year of operation	Players: 10 – 20	Players 1-5	Players 7 – 12	Players Power utilities and few start ups
Techonology Developing mines outside of China, collaborations with chinese mines, operational 2013	Techology Permanent magnets motors (rare earths) Induction motors (no rare earths)	Technology Pyro metallurgical extraction Hydro metallurgical Extraction	Techonology: Hybrid, plug in hybrid, complete EVs	Techonology Fast and regular charging, battery swaps
Cost reduction Induction motors development, mines outside China, China's increase of export quota	Cost reduction Induction motors development (no rare earth materials)	Cost reduction Volume increase	Cost reduction Volume increase	Cost reduction Battery leasing schemes, volume increase
Comments Year end capacity: 100,000 tons, >90% in China 2014: 170,000 tons 60% in China Due to Chinese export quotas supply shortage is expected	Comments Some OEMs develop their own powertrains	Comments Bottleneck possible around 2017 for Lithium Recycling Cobalt will become crucial	Comments Few OEMs dedicated to EVs. Only one of them is developing its own batteries (BYD)	Comments Power utilities can benefit from off-peak hours discounted prices

Battery Value Chain

Battery Raw materials	Cell components	Battery	Recycling
Cost 30% of battery cost 2011 cost ::225 \$/kWh	Cost 50% of battery cost 2011 cost:: 375 \$/kWh 2015 cost: 187.5 \$/kWh	Cost 20% of battery cost 2011: 150 \$/kWh 2015: 75 \$/kWh	Cost 2011 \$5/kg 2020 2.5\$/kg
EBITDA Margin (average) Cathodes lithium: 32% Cathodes cobalt: 29.2% Anodes: 18% Electrolytes: 17%	EBITDA Margin (average) Cathodes : -7.5% (without A123 14%) Anodes: -30% (without altair nano 16%) Electrolytes: 11% Separators: 2.6% (21.4% without Entek)	EBITDA Margin (average) 5.6%	EBITDA margin 5%
Players Cathodes (6 – 10 Lithium, cobalt) Anodes (1 graphite) Electrolytes (2-5)	Players Cathodes: 8-10 Anodes 6-10 Electrolytes: 2-5 Separators: 5 – 7	Players 20 – 30 Some battery players fall into cell components category	Players 1-5
Materials Steel, Cobalt (rare earth element), Lithium	Technology Cathodes with cobalt and without cobalt Anodes : graphite Separators : polymer	Technology Some players are in cell components, rest do packaging and electronics/ cooling	Technology Pyro metallurgical extraction Hydro metallurgical Extraction
Cost reduction: Development of technologies without rare earth material (cobalt) Operation of new mines outside china	Cost reduction: Increase of volume production New cathode technologies Polymer separator for smaller batteries	Cost reduction: Increase in volume production Optimize arrangements inside battery pack	Cost reduction Volume increase
Comments 2011: – 5% of world lithium production 2020: 10 – 30% of world production) Cobalt: 27% of world's production for batteries	Comments 2011 – Cobalt based technologies 2015 – Li-ion polymer, some players with non – cobalt technologies	Comments 41 times increase in production capacity in 2011-2015	Comments Possible Lithium bottleneck during 2017

Selected stocks across the value chain

We outline below a list of companies that would benefit from EV growth in specific value chain components. Only Umicore listed below is under Research Coverage at Barclays Capital, all other stocks are not rated.

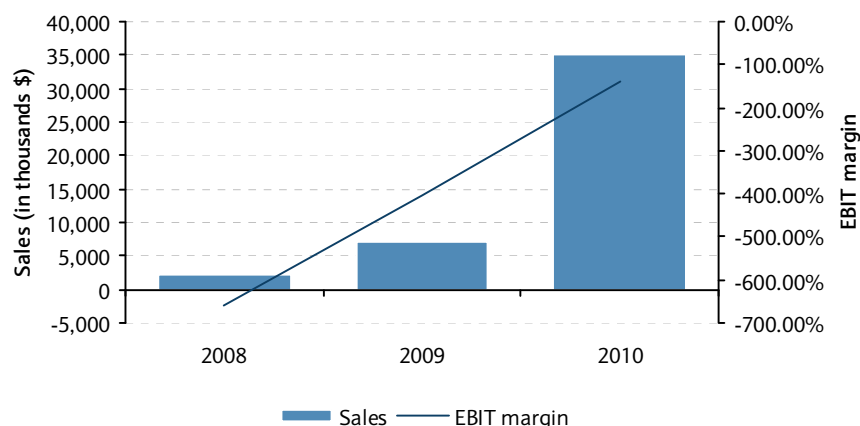
Powertrain Raw materials

Molycorp MCP:US Not Rated (USD 5.4bn Market Cap, \$65.41 Current stock price)

Molycorp is one of the few companies with rare earth mines outside China. The mines will be operable end of 2012

Molycorp is an American company based in Colorado operating and expanding its rare earth mine, crushing and processing site in Mountain Pass, with the ability to produce and transport lanthanum, neodymium, praseodymium, dysprosium, terbium and samarium oxide. Currently, Molycorp is the only rare earth oxide (REO) producer in the Western hemisphere and owns one of the world's largest, rare earth projects outside of China. Its business plan predicts an expansion in two phases. The first it expects will be completed by the end of 2012. Molycorp is partnering with Hitachi to create a joint venture that will convert the rare earth materials into high performance permanent magnets. We note that Hitachi is the supplier of electric motors to Toyota.

Molycorp Sales and EBIT margin



Source: Molycorp

Neo material Technologies NEM:CN Not Rated (USD 1bn Market Cap, CAD 9.11 Current stock price)

Neo materials is a producer, processor and developer of neodymium-iron-boron magnetic powders, rare earths and other rare metals that include gallium, indium and rhenium. The company has two divisions, the Neo performance materials that produce rare earths and the Magnequench that produces Magnetic Neo powders. Revenue streams are 51% from China, 17% from Japan, 9% from N. America, 8% from Europe, and customers include Daido, Panasonic, and Hitachi. It owns and has long worked with rare earth sites in China and has production centres in China, Canada, US and Europe. It recently acquired 50% of Buss & Buss Spezialmetalle GmbH, a company that specializes in recycling and recovery of rare metals.

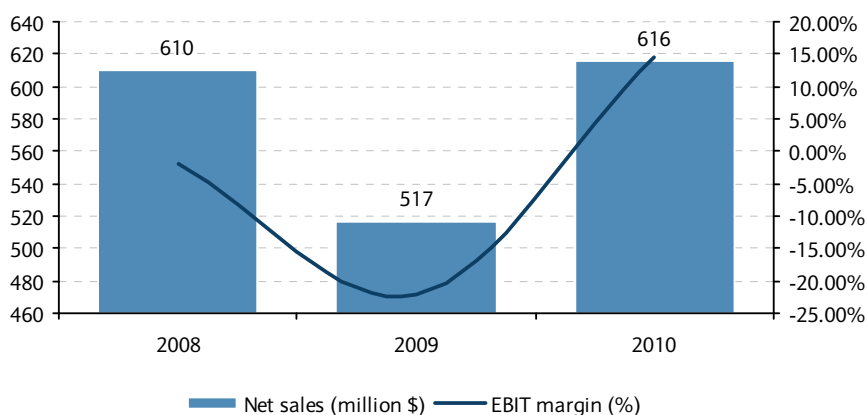
Jinling 000655:CH Not Rated (USD1.8bn Market Cap, CNY 19.47 Current stock price)

Shandong Jinling Mining Co., Ltd. is principally engaged in the manufacture and sale of refined ferrous powder, copper powder and cobalt powder, as well as in machine processing and electricity generation. During the year ended December 31, 2010, the company produced 1.29 million tons and sold 1.29 million tons of ferrous powder; produced 1,546 tons, and sold 1,611 tons of copper powder, and produced 56 tons of cobalt powder, of which it sold 55 tons.

Battery Cell Components: Separators**Polypore International PPO:US Not Rated (USD2.96bn Market Cap, \$66.98 Current stock price)**

Polypore is engaged in the fabrication of Lithium ion battery separators.

Polypore is US based company that develops and manufactures microporous membranes used in separation and filtration processes. It operates in two segments: a) energy storage and b) separations media. In batteries it supplies polymer separators for lithium-ion and lead-acid batteries for consumer electronics and for the automotive industry. The company is increasing the capacity of US Lithium battery separator production (\$102 million, \$49 million funding from Department of Energy) that it expects will more than double the total existing capacity. Furthermore, the company is increasing its production capacity in Korea with a \$30 million expansion. The lithium battery business represents around 25% of total sales and experienced a growth of 39% over 2010.

Polypore net sales and EBIT margin

Source: Polypore

Battery Cell Components: Anodes**ShanShan 600884:CH Not Rated (USD1.12bn Market Cap, CNY 17.54 Current stock price)**

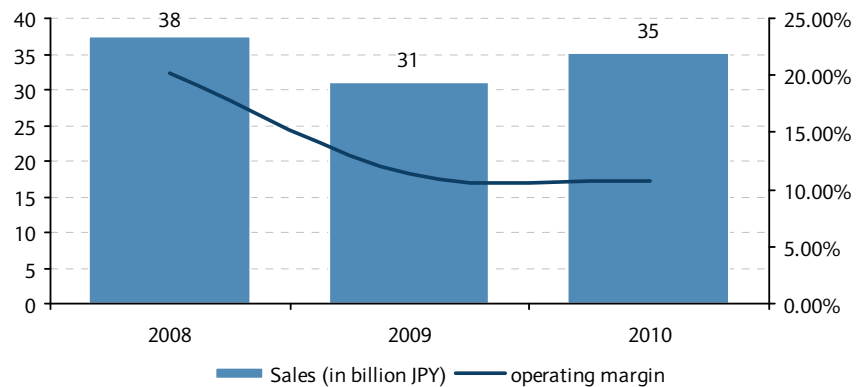
Chinese company involved in production of lithium batteries. Our research shows that it is one of the few companies manufacturing electrolytes for lithium-ion batteries. The company is the supplier of BYD.

Nippon Carbon is one of the few listed companies that develops anodes

Nippon Carbon 5302:JP Not Rated (USD 0.37bn Market Cap, JPY253.0 Current stock price)

Nippon Carbon Co., Ltd. is a Japan-based company mainly engaged in the manufacture and sale of carbon products. The company operates in three business segments. The Carbon segment is engaged in the manufacture, processing and sale of carbon products, including artificial graphite electrode, impervious graphite, isotropic high purity graphite, graphite products for equipment, general carbon fiber and graphitic fiber, lithium-ion battery negative-electrode materials and others. The Real Estate Leasing segment is engaged in the leasing of real estate properties and the operation of parking lots. The other segment is engaged in the manufacture and repair of industrial machinery. In March 2010, its consolidated subsidiary sold the sports facility business. On October 4, 2010, the Company's Tokyo-based non-consolidated subsidiary completed its liquidation.

Nippon Carbon sales and operating margin



Source: Nippon Carbon

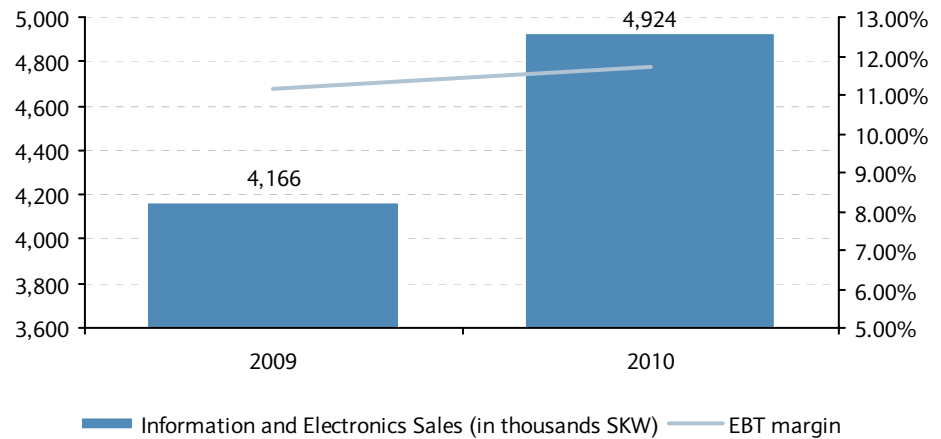
Battery

LG Chem 051910:KS Not Rated (USD2.9 bn Market Cap, KRW416,000,000 Current stock price)

LG Chem already supplies GM and Hyundai with Lithium Ion battery packs and has developed Lithium ion polymer batteries for EVs.

LG Chem Ltd. is a Korea-based manufacturer engaged in the provision of petrochemical goods and electronic materials. The Company operates two divisions: the petrochemical division, which provides basic chemicals, polyvinyl chloride products, plasticizers, polyethylene compounds, acrylic acids, performance polymers, engineering plastics, acrylonitrile butadiene styrene, conductive resins and other chemicals. The second division is information and electronic materials, which produces rechargeable batteries, printed circuit materials, toner products and other recording materials. LG Chem is the supplier of some of the auto-industry major manufacturers that prepare to enter the EV market. It supplies the GM-Volt and it expects it will supply Ford and Hyundai. Currently, the Information and Electronics Materials (in which the lithium-ion and lithium-ion polymer business belongs) represents approximately 25% of the total revenues.

LG Chem Information and Electronics sales and EBT margin



Source: LG Chem

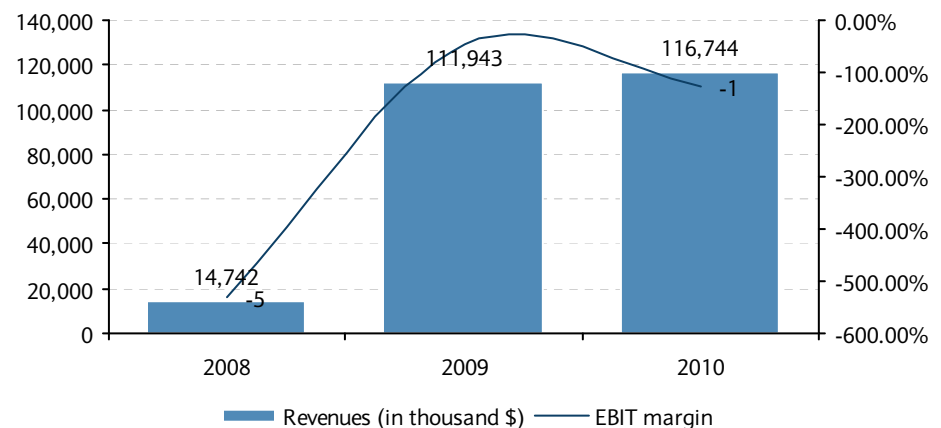
OEMs

Tesla Motors TSLA:US Not Rated (USD2.8bn Market Cap, USD27.2 Current stock price)

Tesla is well positioned in a possible bottleneck of rare earths due to the induction motor technology that it has developed

Tesla designs, develops and manufactures full EVs and electric powertrain components. It currently produces the Tesla Roadster and expects to introduce the EV sedan Tesla S in mid 2012, with more than 3,000 reservations so far. The Tesla S is expected to have a 42% cheaper battery compared to the first edition of the Roadster. Tesla roadster has a range of 236 miles on a single charge. It has sold over 1,400 Roadsters so far. It recently announced a collaboration with Toyota to produce the RAV4 EV.

Tesla Motors sales and EBT margin



Source: Tesla Motors

We outline below a summary with a list of equities from the value chain.

Stocks in the battery Value Chain

	Company name	Comment	Market cap (in millionUSD)	100 day avg. volume	Free float
Battery Raw materials	Nippon Carbon	Developing anode graphite	392	1,362,820	96%
	Kanto Denka Kogyo	Develops Electrolytes raw materials, no opponent	393	286,330	88%
Cell Components	LG Chem	Proven technology, supplier of many major OEMs	29,000	293,429	66%
	Nippon carbon	Manufactures anodes	392	1,362,820	96%
	Polypore	Manufactures separators	2,828	890,715	99.5%
	TechnoSemichem	Manufactures electrolytes, has 45% of Korean market and expanding to US (20% of total revenue) 79% CAGR from 2008 – 2011	659.77	825,591	47.7%
Battery	BYD	Technology that doesn't depend on Cobalt, also a Chinese OEM	7,433.68	18,244,206	97%
	LG Chem	Proven technology, already operating and batteries significant revenue generator	29,000	293,429	66%
Recycling	Umicore	One of few companies that has developed recycling for lithium batteries	5,820	388,062	100%

Stocks in the EV Powertrain Value Chain

	Company name	Comment	Market cap (in millionUSD)	100 day avg. volume	Free float
Powertrain raw materials	Molycorp	Has largest mine outside China	4,927	6,587,540	89.5%
	Neo Material Technologies	Strong ties with Chinese rare earth mines	1,124	824,161	80%
Powertrain	Tesla	No rare earths, proven technology	2,811	1,470,266	56.5%
Recycling	Umicore	Recycles rare earths and lithium	5,820	388,062	100%
	Hitachi Metals	Recycles and manufactures permanent magnets	5,104	1,192,990	46%
OEMs	BYD	Chinese domestic market potential	7,433.68	18,244,206	97%
	Tesla	partnership with Toyota and Daimler, first mover in a niche market	2,811	1,470,266	56.5%

Appendix A: Total Cost of Ownership

TCO is a useful metric to evaluate the market acceptance of EVs and examine the effect of the different variables that affect the cost. TCO can also serve as a platform to compute the years required for an EV to break even compared to an ICE vehicle. The total cost of ownership is computed as follows:

$$\text{Total Cost of Ownership} = \text{Purchase Cost} - \text{Incentives} + \text{Cost of fuel} - \text{Terminal Value}$$

Maintenance costs (despite being lower for the complete EV due to less moving parts) are not included, since they are case specific and the data available for EVs are not adequate.

We estimate the total cost of ownership for three different types of EVs, hybrids, plug-in hybrids and full EVs, and for three different markets, US, Japan and China.

Assumptions

The analysis is based on a series of assumptions that relate to a) average mileage per year, b) total years of ownership, c) cost of gas, d) cost of electricity, e) terminal value of the vehicle at the end of the ownership, f) fuel consumption of the vehicles and the electricity consumption per distance travelled by plugged-in EVs, g) financial incentives given by each government, and finally, h) cost of the baseline ICE vehicle. The assumptions are summarized in the table below for the US, Japan and China markets.

Assumptions per country for Total Cost of Ownership model

	USA	Japan	China
Baseline car price (\$)	EV \$14380	EV \$18000	EV \$11000
	Plug In \$18000	Plug In \$26000	Plug In \$11000
	Hybrid \$19000	Hybrid \$21800	Hybrid \$11000
Mileage per year	15000	5000	11500
Total years of ownership	5	7.5	5
Cost of electricity (\$/kWh)	0.112	0.29	0.063
Cost of gas (\$/gal)	3.5	8.0	3.8
Residual value of ICE vehicle*	40%	25%	40%
Residual value of hybrid/EV *	30%	10%	30%
MPG plug-in hybrid	60	60	60
MPG hybrid	50	50	50
MPG ICE	28	28	28
kWh/mile EV	0.34	0.34	0.34
kWh/mile Plug-In	0.36	0.36	0.36
TCO Hybrid (\$)	\$21,000	\$30,825	\$32,202
TCO Plug-in Hybrid (\$)	\$24,367	\$32,943	\$23,734
TCO Full EV (\$)	\$18,302	\$31,920	\$15,360

Source: US EPA, IEA, Current market data, car manufacturers' websites.

The baseline car assumptions depend on the market. For the US market, given the high incentives for complete EVs and plug-ins, we compare them with low cost competitors (Nissan Leaf vs. Nissan Versa and GM Volt vs. Chevrolet Cruze), while the hybrid market is compared with equivalent upscale class vehicles (Toyota Prius vs. VW Golf/Toyota Corolla).

Due to the importance of the Chinese market, we select the same vehicle price for all EV segments (\$11000) due to the fact that most of the cars sold there (more than 40%), do not exceed that price tag. This leads to a possible underestimation of the hybrid vehicle segment that has no available incentives with a considerable price premium. However we conclude the other two market segments prove highly attractive. Due to the lack of official data concerning car prices outside the US, we show results of our model mostly for the US market and, when applicable, for the Chinese market. However, using indicative car prices for the rest of the markets and EVs, we derive an overview of the market penetration of EVs.

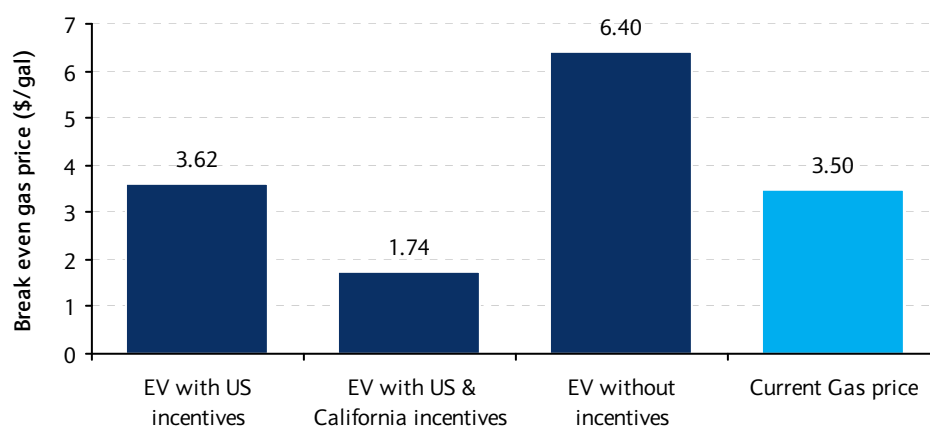
Electric vehicle

The high incentives in US and China make the full Electric Vehicle much cheaper than ICE.

Comparing the Nissan Leaf with a Nissan Versa for three different markets we conclude that the incentives given by the US and the Chinese governments are important for the early adoption of the complete EV and prove quite attractive. This is shown in the bottom table on page 35. Without the current incentives in the US, EVs do not show potential for mass adoption, as they require gasoline prices to rise up to \$6.5/gal to become cost-competitive. However, the introduction of the incentives makes the full EV an attractive option compared with conventional ICE cars. Furthermore, the additional incentives given in some of the states, the complete EV becomes a viable option even with gas prices as low as \$1.5/gal. Since the incentives of the US government hold for 200,000 cars, we expect this deployment to be accomplished during the next few years, provided that enough electric cars and plug-in hybrids enter the market.

A similar situation is found in the Chinese market, despite the lower cost of the baseline car, due to the low electricity price. Hence, if the current incentive pattern, infrastructure investments and the OEM's EV supply are sustained, EVs should be successful in the domestic market. The Japanese market, on the other hand, seems unattractive due to the high electricity price, which may rise further. As a result, complete EVs remain a niche market and low penetration is expected over the following years.

TCO in US for complete EVs with and without incentives



Source: Barclays Capital

Plug-in hybrid

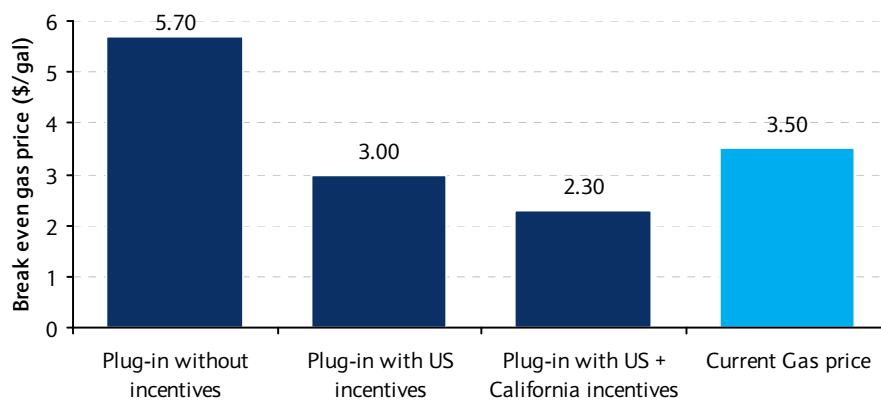
There is an inherent difficulty in estimating the TCO of a plug-in hybrid due to the limited range of all electric operation of the car. The US Environmental Protection Agency (EPA) has estimated an equivalent gas consumption rate for the Chevrolet Volt (the only plug-in currently available in US) for a combined operation of the car (60 mpg), which is the rate we use for our analysis. Using this data, the current plug-in price is not attractive in any market. However, implementing our battery cost model and forecasting a 2013 price for plug-in hybrids, the breakeven point between ICE and plug-in hybrid for the US market comes down to \$3 /gal (see chart below). If one takes into account the extra incentives given by some US states (California offers \$5000 on top of the federal government's incentives), the break-even point is further lowered to \$2.3/gal. Hence, we estimate that the plug-in segment will show strength growth in areas with strong incentives, such as California.

Plug-in hybrids have a lower TCO in US and China, but not in Japan

Given the high initial price of Plug-In hybrids, it is unlikely that they can gain a significant market share without government incentives. However, the combination of the incentives and the lower car prices of the domestic Chinese manufacturers (BYD has launched a low cost plug-in hybrid \$26,600 compared to \$40,000 to GM-Volt), plug-ins prove cost competitive to the low cost popular vehicles. This is shown in the top chart on the next page.

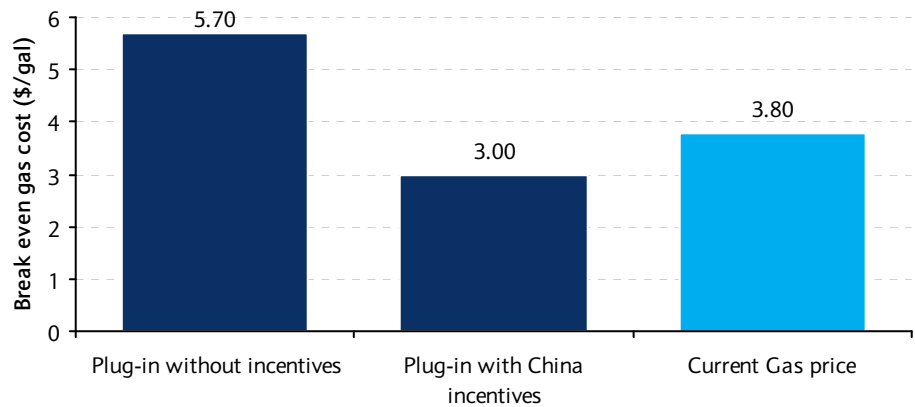
The lack of incentives and the high gasoline price in the Japanese market does not allow a break-even point until \$8/gal (which is close to the current price of 7.5\$/gal). However, given the expectations of the market for cheaper plug-ins starting from 2012 (Prius), our model suggests that the break-even point will substantially drop to \$2-3/gal.

Plug-In hybrid TCO in US market



Source: Barclays Capital, Car manufacturers' websites

Plug-In hybrid TCO in China market



Source: Barclays Capital, Car manufacturers' websites

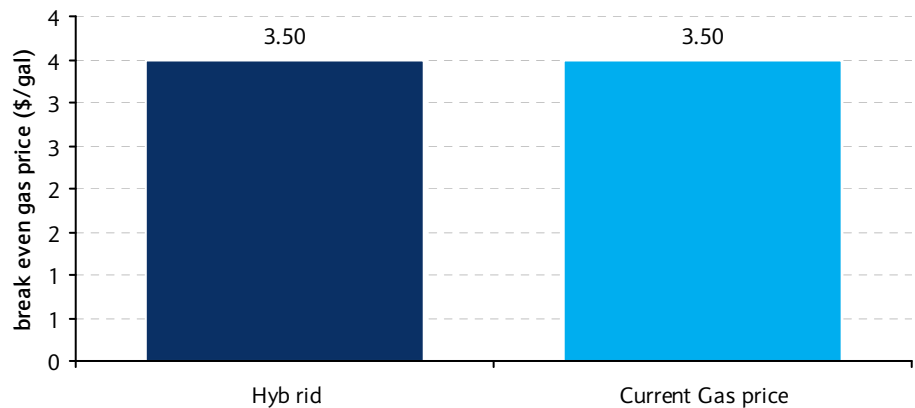
Hybrid vehicles

The TCO of hybrid vehicles in the US is equal to the ICE car. In Japan the high gasoline price makes hybrids attractive with a lower TCO. In China hybrids are more expensive

Until recently hybrid vehicles were supported by the US and Japanese governments, however the mature state of the vehicle (recently reached 10% market penetration in the Japanese market and 3% in the US market as shown in the chart on the next page) has removed those incentives. Based on our model, the breakeven gasoline price in the US is around \$3.5/gal which makes it less attractive than other EV segments (see graph below). However, given a) the sales growth of the hybrid vehicles, b) the consumer's acceptance of hybrid vehicles, c) the adoption of the hybrid technology from most of the major automotive manufacturers and d) the shrinking of the gap between the TCO of ICE and hybrid cars, we expect the growth trend to be sustained.

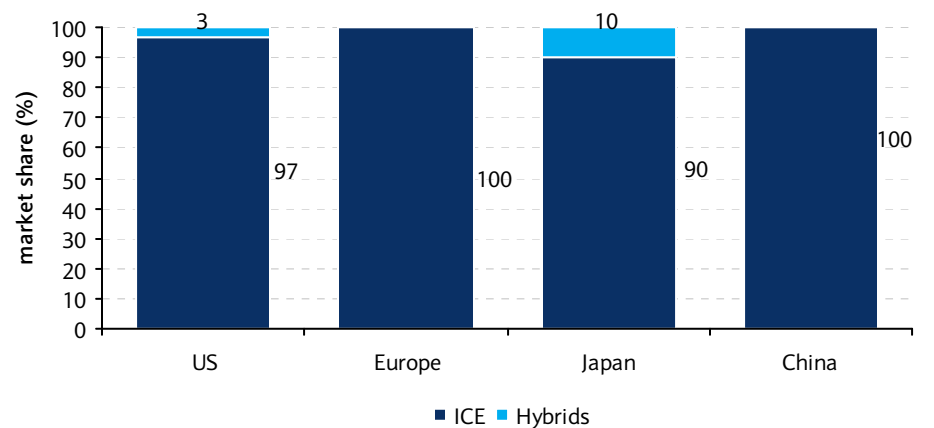
Furthermore, the hybrid vehicles market is sustainable in the Japanese market, and we expect the current growth to remain during the next years. The high gasoline price in Japan in combination with the high purchase cost of cars, sets a break-even point of around \$7-8\$/gal, which is in line with the current gasoline price in Japan.

Hybrid vehicles TCO in US



Source: Barclays Capital, car manufacturers websites

Market share of EVs in major auto markets in 2010



Source: Barclays Capital, BCG analysis, European Automobile Manufacturer's Association, Autonews, They Daily Yomuiro, car manufacturers websites

The Total Cost of Ownership (TCO) analysis offers the following conclusions which are used in our demand forecast:

- The Japanese market is suitable for hybrid and plug-in hybrid vehicles. The lack of incentives and the high purchase price of complete EVs do not allow mainstream market penetration. Hybrids and Plug-in hybrid EVs have a clear advantage compared to ICE cars, due to the high gas price.
- The Chinese market is an attractive one for EVs. However, due to the low purchase price of conventional ICE cars, Chinese consumers may not be willing to pay the high upfront cost required for an EV. While 5 years are enough to break even with an ICE car, the benefit is not yet substantial.
- The Chinese market is not suitable for hybrid vehicles yet. High upfront costs and current gas prices favour less costly ICE vehicles.
- In the US market, the combination of high incentives, increasing gas prices and high average mileage per year result in an ideal environment for the development of all types of EVs.

Appendix B: National market penetration targets

We outline below a list of press releases with information about various national targets regarding the market penetration of EVs by year 2020.

National EV penetration targets

Country	Target (expressed in units or in market share)	Announcement Date	Source
Australia	2018: mass adoption 2050: 65% stock	6/2009	Project Better Place Energy White Paper
Australia	2020: 20% production	6/2009	Mitsubishi Australia
Canada	2018: 500,000	6/2008	Government of Canada
	2020: 18,000 (sales in Ontario)	6/2009	Canadian EV Technology Roadmap
China	5,000,000 EVs	3/2011	EVI (Electric Vehicle Initiative)
China	540,000 by 2015	7/2009	Pike Research
China	2008: 21,000,000 electric bike sales	4/2009	The Economist
China	2020: 7-9% EVs, 4-6% hybrid EVs (5,000,000 EVs)	7/2011	Boston Consulting Group
China	2030: 20 – 30% market share	10/2008	McKinsey & Co.
Denmark	2020: 200,000		ENS Denmark
	2020: 50,000		EVI
France	2020: 2,000,000	3/2011	EVI
Germany	2020: 1,000,000	3/2011	EVI
Ireland	2020: 230,000	10/2009	Electricity Supply Board (ESB)
	2030: 40% market share		
Israel	2011: 40,000 EVs	9/2008	Project Better Place
	2012: 40,000 to 100,000 EVs annually		
Japan	2020: 20% market share (around 800,000 based on IEA)	3/2011	EVI
Netherlands	2015: 5% market share	9/2007	Dutch Energy Agency
	2040: 60% market share		
New Zealand	2020: 5% market share	10/2007	Prime minister Helen Clark
	2040: 60% market share		
Spain	2020: 2,500,000	3/2011	EVI
Sweden	2020: 600,000	3/2011	EVI
Switzerland	2020: 145,000	7/2009	Alpiq Consulting
UK	2020: 1,200,000 EVs, 350,000 PHEVs	10/2008	Department for Transport
	2030: 3,300,000 EVs, 7,900,000 PHEVs		
USA	2015: 1,000,000 PHEV	1/2009	President Barack Obama
Worldwide	2030: 5 – 10% market share	6/2008	McKinsey & Co.
Worldwide	2020: 10% market share	6/2009	Carlos Ghosn, President of Renault
Europe	2015: 480,000 EVs	5/2009	Frost & Sullivan
Nordic countries	2020: 1,300,000	5/2009	Nordic Energy Perspectives

Source: IEA, Barclays Capital and listed sources

Appendix C: Production plans

We outline below a list of production plans by OEMs as they have been appeared in the press.

Announced production plans (plug-ins and complete EVs) for 2012 – 2014

Manufacturer	Model	Production and date	Battery manufacturer
Daimler	Smart ForTwo electric	10,000 in 2013	Johnson Controls – Saft (JCS, joint venture about to dissolve), Sanyo, SK Innovation, Li-Tec Battery
Fisker	Karma	50,000 in 2013 85,000 in 2014	A123 Systems
Ford	Focus electric C-MAX Energi	18,000 in 2012 21,000 in 2013	LG Chem, JCS, MAGNA E-Car Systems, Toshiba, Sanyo
General Motors	Volt	60,000 in 2012 67,000 in 2013 120,000 in 2014	LG Chem, JCS
Mitsubishi	MiEV	40,000 in 2012 5% in 2015 20% in 2020	GS Yuasa Corporation, Lithium Energy Japan, Toshiba
Nissan	Leaf	24,000 in 2011 in Japan 35,000 in 2012 54,000 in 2013 200,000 in 2014	AESC
PSA		40,000 in 2014	Lithium Energy Japan, GS Yuasa, JCS
Renault	Zoe Fluence Kangoo van	250,000 in 2013	AESC, LG Chem, SB Limotive (SBL)
Tesla	Model S	10,000 in 2013 20,000 in 2014	Panasonic Energy Company
Toyota	Prius Plug-in RAV4 EV	16,000 in 2012	Prime Earth EV Energy (80.5% Toyota, 19.5% Panasonic)
Think	City	10,000 in 2013 20,000 in 2014	A123 Systems, Enerdel, FZ Sonick
Volkswagen		3% in 2018	Sanyo, Toshiba, SBL, Varta Microbattery

Source: Company press releases, IEA

Appendix D: EV market penetration forecast

We outline below a summary of the sales projection by EV segment, market and year.

Hybrid cars sales projection by country and year

Hybrids	2011	2012	2013	2014	2015	2016	2017	2020
US	482,675	801,852	893,049	1,034,962	1,081,199	1,160,429	1,122,512	951,821
China	16,603	31,286	35,075	41,876	47,695	57,456	57,998	55,328
Japan	470,021	56,2870	512,505	496,425	477,946	530,628	529,797	497,883
Europe top 4	99,454	128,273	138,364	174,198	201,644	266,309	335,336	333,834
Rest of Europe	66,302	85,515	92,242	116,132	134,429	177,539	223,557	222,556

Source: Barclays Capital, JD Power, company press releases, IEA.

Plug-in hybrid cars sales projection by country and year

Plug-in hybrid	2011	2012	2013	2014	2015	2016	2017	2020
US	0	0	158,104	252,124	384,870	422,731	463,922	720,917
China	0	0	6,209	10,201	16,978	20,930	23,969	41,905
Japan	0	0	90,733	120,933	170,132	193,302	218,959	377,100
Europe top 4	0	0	24,495	42,435	71,778	97,013	138,591	252,849
Rest of Europe	0	0	9,798	16,974	28,711	38,805	55,436	101,139

Source: Barclays Capital, JD Power, company press releases, IEA.

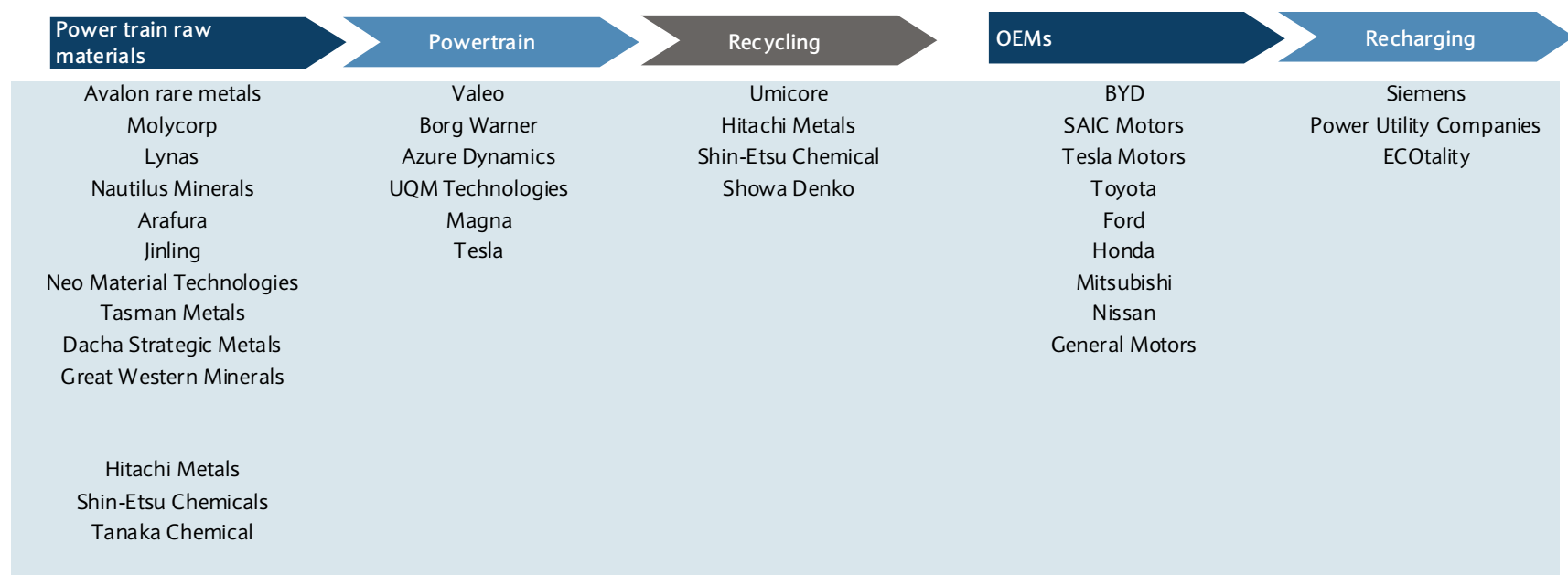
Full EV cars sales projection by country and year

Full EV	2011	2012	2013	2014	2015	2016	2017	2020
US	13,792	41,566	70,440	85,946	88,414	90,792	97,016	107,998
China	17,032	35,070	60,384	90,473	129,591	189,055	217,320	332,775
Japan	17,703	30,497	38,398	43,777	47,444	50,290	52,142	67,057
Europe top 4	23,017	59,894	114,377	161,971	202,735	254,352	318,007	445,212
Rest of Europe	15,344	39,929	76,251	107,981	135,156	169,568	212,005	296,808

Source: Barclays Capital, JD Power, company press releases, IEA.

Appendix E: Players across the value chain





Appendix F: Valuation summary

We outline below a summary valuation of selected stocks.

Valuation Summary

Company Name	EV/Sales					EV/EBITDA					EV/EBIT					PE			
	FY09	FY10	FY11e	FY12e	FY13e	FY09	FY10	FY11e	FY12e	FY13e	FY09	FY10	FY11e	FY12e	FY13e	FY09	FY10	FY11e	FY12e
Nippon Carbon	1.5x	1.2x	1.0x	0.9x	0.9x	6.5x	5.7x	4.3x	3.8x	4.2x	13.5x	11.1x	NA	4.9x	NA	15.5x	17.1x	11.9x	8.8x
Kanto Denka Kogyo	1.3x	1.3x	1.0x	0.9x	0.9x	6.8x	6.5x	6.1x	5.7x	8.7x	27.7x	27.7x	NA	NA	NA	-	36.8x	14.4x	10.3x
LG Chem	1.9x	1.5x	1.3x	1.2x	1.1x	10.7x	8.2x	6.8x	6.1x	5.4x	13.5x	10.1x	7.9x	7.0x	6.2x	22.4x	14.3x	10.8x	9.6x
Polypore	6.3x	5.3x	4.2x	3.5x	3.0x	25.0x	19.8x	12.9x	10.6x	9.1x	34.2x	24.6x	16.6x	13.7x	11.3x	NM	40.8x	24.4x	19.5x
A123 systems	3.4x	3.2x	1.6x	0.7x	0.4x	NM	NM	NM	NM	14.0x	NM	NM	NM	NM	NM	NM	NM	NM	NM
ENER1	6.1x	2.8x	1.7x	1.0x	0.7x	NM	NM	NM	NM	19.4x	NM	NM	NM	NM	NM	NM	NM	NM	NM
Altairnano	19.9x	9.9x	5.6x	-	-	NM	NM	NA	NA	NA	NM	NM	NA	NA	NA	NM	NM	NM	-
Techno Semichem	2.4x	1.9x	1.4x	1.2x	1.0x	14.4x	10.5x	8.1x	6.4x	5.6x	19.7x	13.4x	10.2x	8.0x	6.7x	26.2x	19.0x	12.2x	9.8x
Batteries	5.4	3.4	2.2	1.3	1.1	12.7	10.2	7.7	6.5	9.5	21.7	17.4	11.6	8.4	8.0	21.4	25.6	14.8	11.6
Shanshan	4.1x	3.0x	2.0x	1.5x	-	45.3x	30.2x	-	-	-	90.5x	45.3x	-	-	-	-	-	35.0x	18.8x
Molycorp	541.2x	108.2x	9.1x	5.1x	2.6x	NM	NM	16.9x	6.2x	3.1x	NM	NM	20.8x	8.1x	3.6x	NM	NM	28.3x	11.6x
Neo Material Technologies	4.3x	2.4x	1.5x	1.5x	1.4x	25.2x	10.1x	4.7x	4.4x	4.3x	31.9x	11.2x	6.5x	6.9x	7.0x	41.5x	15.8x	7.0x	6.9x
Hitachi Metals	1.0x	1.2x	0.9x	0.8x	0.8x	13.0x	11.5x	6.5x	5.5x	5.0x	40.4x	39.4x	11.2x	8.1x	7.5x	-	192.7x	14.9x	11.3x
Chemetal	1.9x	1.7x	1.5x	1.4x	1.3x	12.6x	10.1x	6.4x	5.9x	5.5x	23.1x	14.9x	9.3x	8.3x	7.4x	172.7x	15.8x	12.2x	10.6x
Jinling	11.6x	6.6x	5.1x	4.2x	3.2x	32.8x	14.8x	11.4x	-	-	37.7x	15.9x	-	-	-	-	-	17.3x	15.3x
Rare Earth	94.0	20.6	3.3	2.4	1.8	25.8	15.3	9.2	5.5	4.5	44.7	25.3	11.9	7.8	6.4	107.1	74.7	19.1	12.4
BYD	0.8x	0.6x	0.6x	0.5x	0.4x	5.2x	6.3x	5.2x	4.4x	3.7x	7.2x	10.9x	8.8x	6.7x	5.7x	10.9x	17.2x	18.8x	15.7x
Tesla	22.7x	21.7x	13.0x	4.3x	1.4x	NM	NM	NM	NM	12.5x	NM	NM	NM	NM	18.7x	NM	NM	NM	NM
OEMs	11.7x	11.2x	6.8x	2.4x	0.9x	5.2x	6.3x	5.2x	4.4x	8.1x	7.2x	10.9x	8.8x	6.7x	12.2x	10.9x	17.2x	18.8x	15.7x
Umicore	0.6x	0.5x	0.3x	0.3x	0.3x	17.9x	11.4x	7.6x	6.9x	6.4x	36.4x	17.0x	10.0x	9.1x	8.3x	47.2x	15.0x	11.3x	10.3x
GS Yuasa	1.1x	1.1x	0.8x	0.8x	0.7x	13.2x	13.3x	7.4x	5.8x	5.2x	21.9x	24.0x	-	-	-	-	33.8x	15.7x	12.9x
Recycling	0.8x	0.8x	0.6x	0.5x	0.5x	15.6x	12.4x	7.5x	6.4x	5.8x	29.1x	20.5x	10.0x	9.1x	8.3x	47.2x	24.4x	13.5x	11.6x
Ecotality	5.0x	3.2x	1.2x	0.5x	0.4x	NM	NM	NM	9.1x	5.4x	NM	NM	NM	NM	8.0x	NM	NM	NM	NM
Recharging	5.0x	3.2x	1.2x	0.5x	0.4x	NM	NM	NM	9.1x	5.4x	NM	NM	NM	NM	8.0x	NM	NM	NM	NM
Mean	33.5x	9.3x	2.8x	1.7x	1.2x	17.6x	12.2x	8.0x	6.2x	7.3x	30.6x	20.4x	11.2x	8.1x	8.2x	48.1x	38.0x	16.7x	12.2x
Median	3.4x	2.4x	1.5x	1.1x	0.9x	13.2x	10.5x	6.8x	5.9x	5.5x	27.7x	15.9x	10.0x	8.1x	7.4x	26.2x	17.2x	14.6x	10.9x
High	541.2x	108.2x	13.0x	5.1x	3.2x	45.3x	30.2x	16.9x	10.6x	19.4x	90.5x	45.3x	20.8x	13.7x	18.7x	172.7x	192.7x	35.0x	19.5x
Low	0.6x	0.5x	0.3x	0.3x	0.3x	5.2x	5.7x	4.3x	3.8x	3.1x	7.2x	10.1x	6.5x	4.9x	3.6x	10.9x	14.3x	7.0x	6.9x

Source: Datastream

- Not Available

NM Not Meaningful

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