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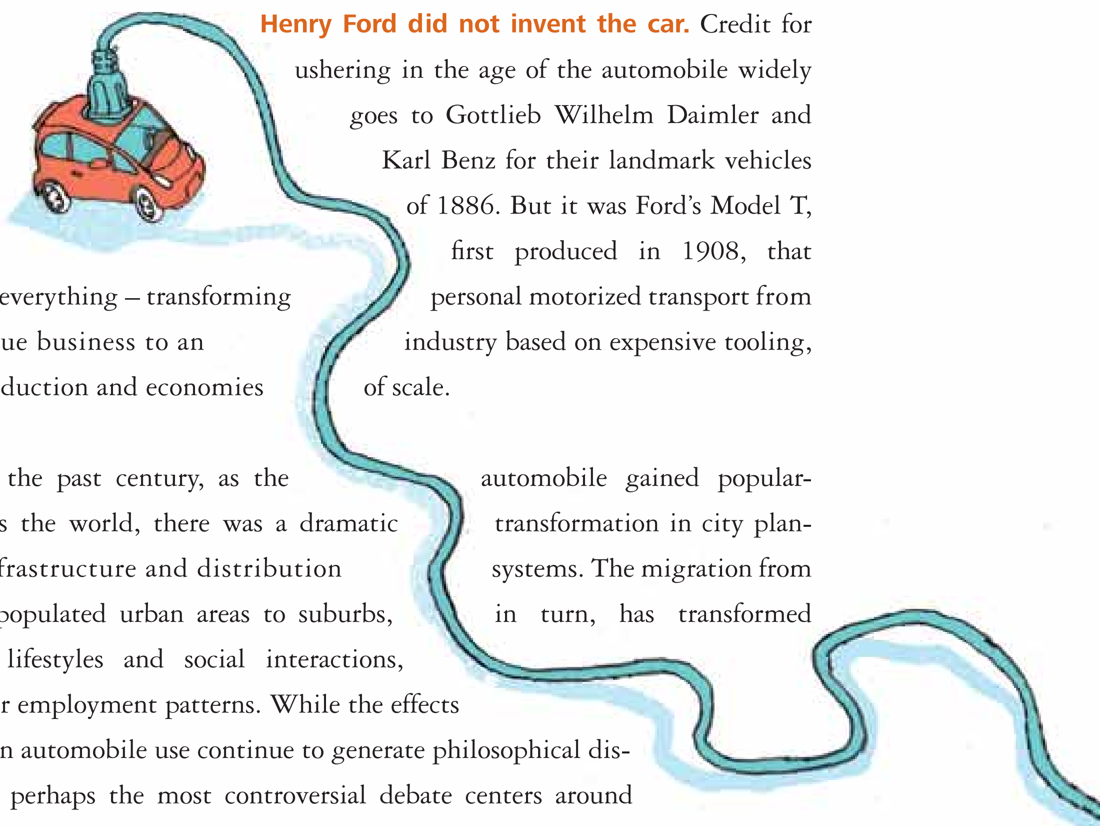
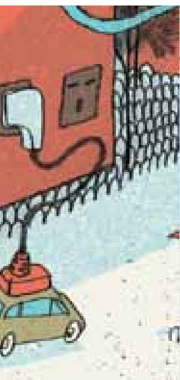


Henry Ford did not invent the car. Credit for ushering in the age of the automobile widely goes to Gottlieb Wilhelm Daimler and Karl Benz for their landmark vehicles of 1886. But it was Ford's Model T, first produced in 1908, that changed everything – transforming personal motorized transport from a boutique business to an industry based on expensive tooling, mass production and economies of scale.

Over the past century, as the automobile gained popularity across the world, there was a dramatic transformation in city planning, infrastructure and distribution systems. The migration from densely populated urban areas to suburbs, in turn, has transformed people's lifestyles and social interactions, even their employment patterns. While the effects of modern automobile use continue to generate philosophical discussions, perhaps the most controversial debate centers around the impact that nearly one billion cars worldwide are having on the environment. Environmental sensitivities have begun to drive demand for an alternative to the conventional internal combustion engine (ICE) vehicles.[1] Among the front-runner technologies: the Battery Electric Vehicle (BEV), a zero-emission vehicle.

Because BEVs consume electricity, replacing ICE cars with BEVs has the obvious benefit of reducing significantly the amount of vehicle-emitted environmental pollution. But the implications are broader and potentially disruptive, both with regard to infrastructure and more immediately the automotive value chain. Because BEVs contain a large capacity battery, they could act as distributed power storage devices in cities, thus potentially reducing the risk of blackouts as well as generating intermittent renewable energy. The nature and characteristics of BEVs may well change the structure and business models of the auto industry – who the players are and where the money is made. In that sense, the spread of BEVs may be even more transformative than the Ford Model T and its legendary assembly line.



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BEVs have a bit of a "been there, tried that" aura to them. Automakers and parts suppliers have made several attempts to introduce the BEV to the market, with each effort foundering on inadequate battery technology and ultimately cruising range. But the playing field has changed. Advances such as tires with lower rolling resistance, lighter body materials and regenerative braking have made the concept more feasible and practical. Governments, too, are lending support through policies to reduce environmental impacts and offering economic stimulus measures to boost the sales of environment-friendly vehicles. To that end, in Japan—one of the leading automotive manufacturing countries in the world—2010 has been touted as "the Year of the BEV."[2] Many major automakers in the world are entering the market with their versions of the BEV.

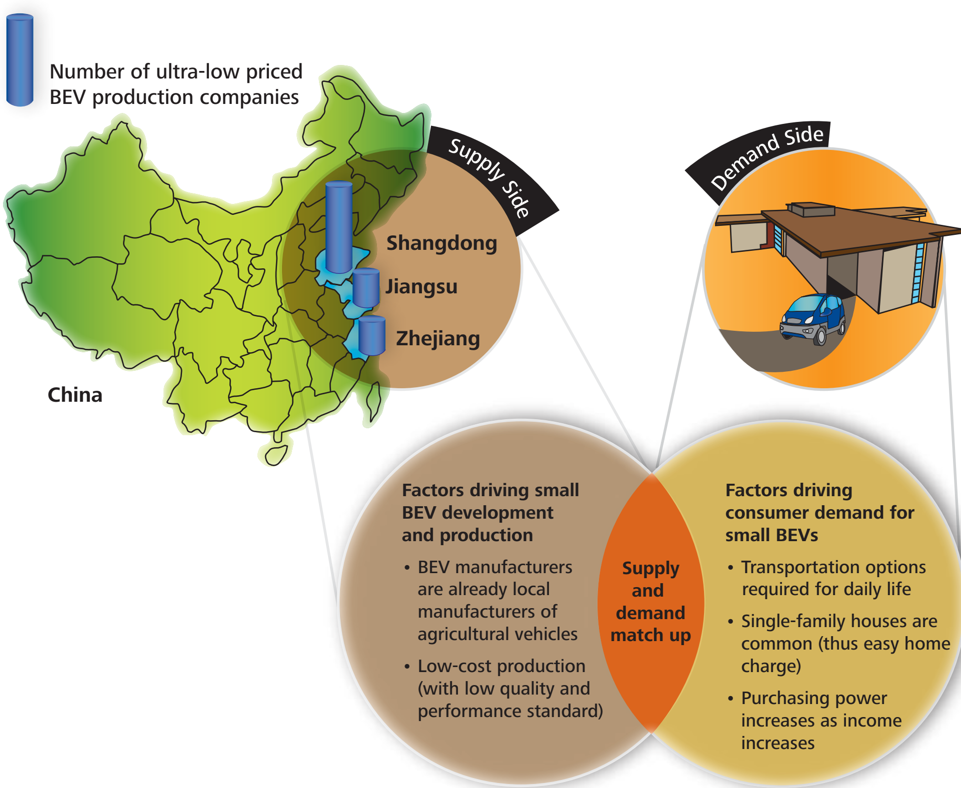
IS THE MARKET READY?

Although many automakers are expected to introduce BEV models, there is continued debate on whether BEVs will be embraced by the mass market. According to one market forecast, the BEV market will comprise approximately 13 million vehicles in 2020,[3] while another research company's forecast for the same year is just two million vehicles.[4] Given that total vehicle sales are predicted to be around 100 million in 2020,[5] the share of BEVs in the vehicle market is therefore likely to be small, while ICE vehicles continue to dominate the market for at least another decade. But based on our interviews with more than 30 industry experts around the world—automakers/suppliers, industry executives, professors/researchers and government policymakers—BEV expansion could be much faster than expected, similar to the rapid growth of electric bicycles in China.

The market size of electric bicycles in China has expanded more than 200 times within the past 10 years, from 0.1 million units to 22.5 million units.[6] This explosive growth reflects a strong demand for motorized vehicles in the market. Consumers are satisfied with the attractive cost-performance ratio of electric bicycles: They can enjoy motorized transportation as a replacement for traditional bicycles at a price far less than that of an automobile. Given the persistent demand for motorized transportation, particularly in rural areas, BEV market potential may be underestimated by those whose frame of reference is more traditional automotive markets.

Consider China and the recent spike in ultra-low priced BEVs launched in the market. These ultra-low priced BEVs—prices start at 30,000 RMB (about US$4,500)—can reach a top speed of 60km/h and travel up to 100km. Mostly made of fiber-reinforced plastic, these BEVs lack features such as air conditioning or an audio system. Their makers are often manufacturers of agricultural vehicles, and can produce their BEVs at low cost by using inexpensive labor in rural areas

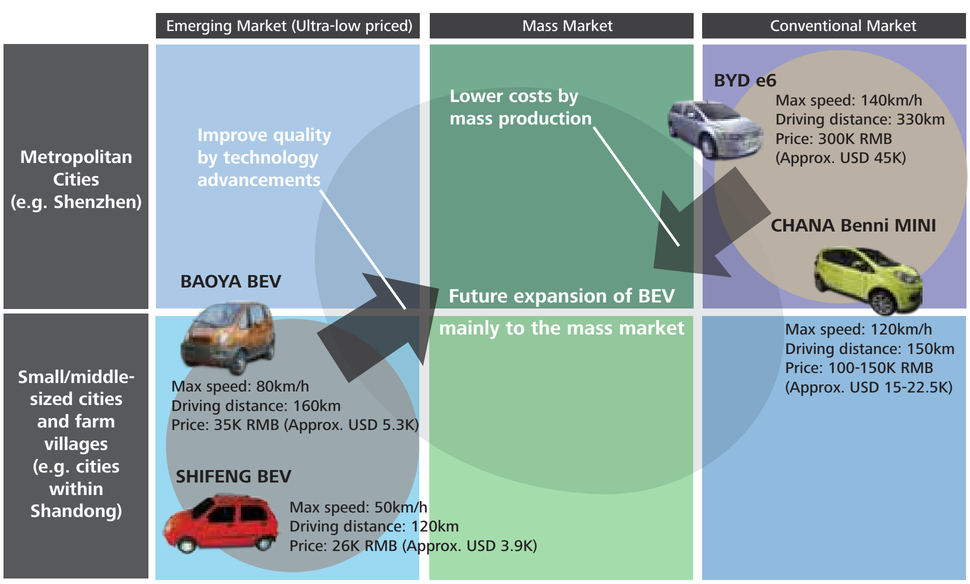
Figure 1. Manufacturers and markets for ultra-low priced BEVs



like Zhejiang and Jiangsu. On the other hand, the demand for such BEVs is strong in these areas as households want transport options for daily use, and since most reside in single-family houses, they can charge BEVs at home. It also helps that their income levels have increased such that they can afford ultra-low priced BEVs. All of these factors point to an increase in BEV sales volumes in these regions (figure 1).

Because these models are extremely basic, they are unlikely to pique consumer interest in developed nations. However, small BEV manufacturers are tweaking ultra-low priced BEVs to fit evolving tastes. BAOYA, one such small-sized BEV manufacturer, has complied with some U.S. and EU regulations and successfully exported BEVs to these regions. Likewise, other BEV manufacturers are trying to meet foreign regulations. This type of cross-border compatibility is expected to gain momentum, with many more BEVs likely to emerge from China and a few of them even outgrowing today's conventional automakers. The result: improved quality due to new technological advancements and gradually declining prices due to mass production may accelerate BEV expansion, pushing it from emerging and conventional markets toward the mass market (figure 2).

Figure 2. BEV expansion from the emerging market and the conventional market



A BATTERY-POWERED FUTURE?

A review of key trends suggests the stars may be aligning for BEVs. Economic trends such as strong and potentially rising oil prices, as well as a pervasive awareness of environmental impacts—and an ongoing, contentious debate surrounding climate change—will likely keep BEVs in the spotlight. Policy changes, evolving technology and changes in the market—from consumer tastes to personal economics—likewise suggest that while the ICE will continue to play an important role it may no longer have the stage to itself.

Policy and Environmental Changes

One of the driving forces of BEV expansion is government policies favoring mobility with less impact on the environment. Many governments have set clear goals for BEV expansion: Germany is aiming for one million BEVs held by 2020; the United States for one million Plug-in Hybrid Vehicles held by 2015; and China for four million BEVs held by 2020.[7] These countries are also proactively developing policies to create an initial demand that will directly impact the market. These include developing the necessary charging infrastructure for BEVs, providing a subsidy to consumers for choosing BEVs, and opting for BEVs for official use.

While we have known for decades that ICEs were dirty—and have spent much of that time modifying them to run more cleanly and efficiently—the fact remained that in most situations a petrol engine was the best and most affordable solution.

Another trend that will likely affect the spread of BEVs relates to regulations to promote the use of public transport systems. For example, in Stockholm and London, a congestion tax encourages people to leave their cars at designated parking areas and instead use public transport to enter the city center.

Evolving Technology

While we have known for decades that ICEs were dirty—and have spent much of that time modifying them to run more cleanly and efficiently—the fact remained that in most situations a petrol engine was the best and most affordable solution. And the biggest challenges faced by BEVs—high battery costs, a range of less than 100 miles, and insufficient infrastructure—reinforced the practicality of ICE cars. In fact, a BEV's battery cost equals two-thirds the price of the vehicle.[8] If battery costs remain high, BEV sales will not be lucrative, assuming that consumers are unwilling to pay a significant premium for them.

But both a greatly increased interest in the potential of battery power and recent innovations have begun to change that equation. Some automakers and suppliers in Japan, the United States and China have committed to halving the cost of a battery this year. In coming years, production costs should further decline with the effects of mass production as the number of BEVs increase.

There are also proposed advancements in battery performance. For example, New Energy and Industrial Technology Development Organization (NEDO), a Japanese public management organization promoting research and development, is working to develop a new generation of batteries by 2030 that will perform 10 times better than batteries used today.[9] This would improve the BEV's cruising range to approximately 1,000 miles.

Changes in the Market

While consumers are unlikely to throw away their car keys *en masse*, and in many cases enjoy their cars, there is a growing awareness of the automobile's ecological impact. This coincides with a more general interest in environmentally friendly products. For example, "Car Free Day"—first introduced in La Rochelle in France in 1997—was instituted to raise awareness about air pollution, encourage people to walk or use bicycles, and promote the use and development of public transport systems. By 2008, 2,102 cities around the world were actively participating in this program.[10] With the public mood trending toward minimizing the environmental impact of what they drive, BEVs may find a welcome market.

Because BEVs are manufactured with one-third the number of ICE cars' components, less collaboration will be required between automakers and parts suppliers in the research and development process. In fact, vehicle-to-component calibration will be decreased ...

Structural Changes in the Automotive Industry

The existing automotive industry has grown over the past century in large measure shaped by the complexity of the ICE and the amount of engineering put into both the engine and the numerous ancillary systems. As automakers have extensive knowledge in engineering core technologies such as the engine and the chassis, they constitute the key industry players, followed by parts suppliers and car dealers. Indeed, the structure of many Japanese automakers such as Toyota, Honda and Nissan are governed by *Keiretsu*, integration across the value chain constituted by their group companies. Put simply, these companies manage their products from engineering to raw material procurement to assembly and distribution and after-sales support.

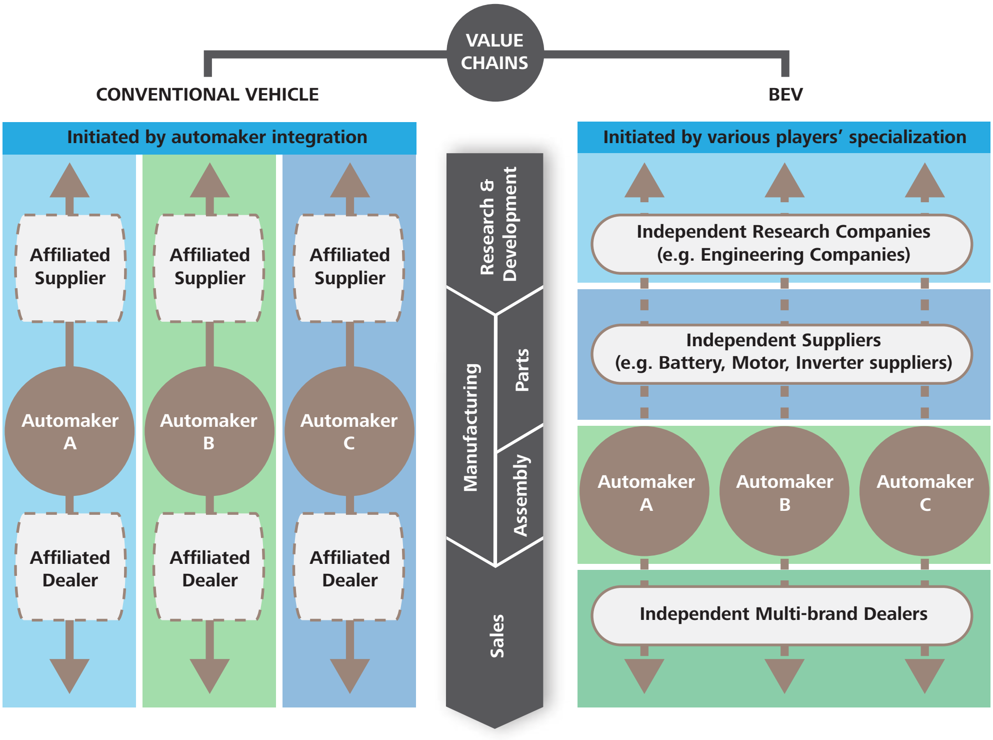
But the emergence of BEVs as a dominant market segment could change this picture considerably. The BEV's distinctive characteristics, such as simplicity of its vehicle structure and driving capability, could bring about major changes to an industry that has progressed without significant changes for a century.

THE VALUE CHAIN

The spread of the BEV may bring about a substantial structural change, from a vertical to a horizontal structure, throughout the value chain of the industry (figure 3). First, because BEVs are manufactured with one-third the number of ICE cars' components, less collaboration will be required between automakers and parts suppliers in the research and development process.[11] In fact, vehicle-to-component calibration will be decreased, with fewer adjustments between components and vehicle required. This means that parts suppliers can develop their products with more autonomy.

The manufacturing process of BEVs is also somewhat different from that of ICE cars. While expertise is still required to maintain BEV quality, including its safety, the assembly process of BEVs will be simpler because of manufacturing line simplification, suggesting that the entry barrier to the automotive industry will become lower. Under these circumstances, new BEV manufacturers are likely to break into the automotive industry, much like BYD and Tesla Motors have done.

Figure 3. Structural change in value chain caused by BEV'S spread



It is also possible that we will see new dealers, like retail stores, that specialize in selling BEVs for emerging automakers. Thus, in the BEV business value chain, industry players may work horizontally across each process.

As the horizontal division of structure becomes widely used in the BEV industry, global standards will hold more significance for the BEV battery and charger. With standards for the interfaces between the components defined, some companies may develop a plug-and-play type of platform to be used by tier two suppliers. As a result, some others may decrease their competitive advantage in vertical integration. Participants in the emerging BEV industry will clearly find it quite important to be familiar with, and perhaps contribute to, the discussion surrounding the standardization process.

The impact of BEVs may extend well beyond manufacture, with the potential for a new business model developed through closer cooperation with external players, particularly those related to urban transportation and the energy industry.

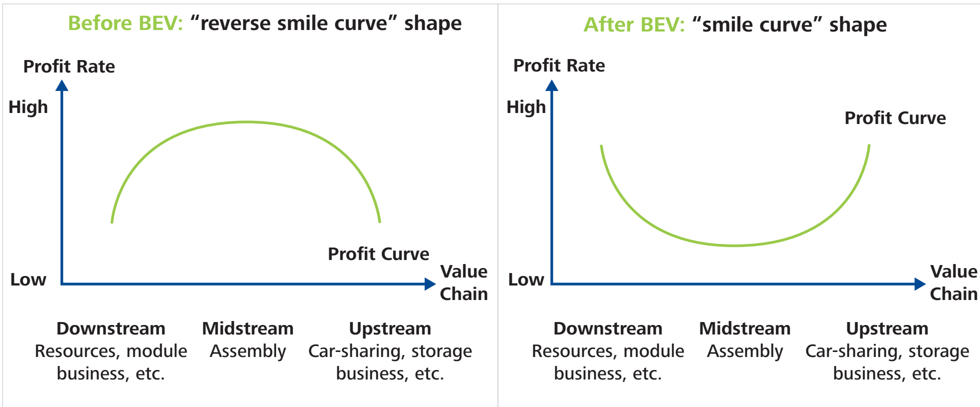
On the downside, there is a risk to creating standards that are too restrictive—for example, restriction of battery shape and size—as they may freeze innovation in BEV technology. While some in the industry maintain that battery communication protocol, charger data link and function should be standardized, our conversations with BEV technologists and automakers suggest that the industry can benefit from standardization in the long run, but that it may be too soon to lock in standards. They advocate some allowance and flexibility for future technological breakthroughs with regard to what materials are used for batteries, how the batteries are loaded, and other specifications.

A SHIFT IN PROFIT STRUCTURE

For decades, the profit structure in the automotive industry has followed a "reverse smile curve" in which the profitability of the processes in the middle of the value chain (e.g., assembly) has increased, whereas the processes at the ends of the value chain have seen decreased margins. This has helped make automotive assemblers the most profitable links.

However, this revenue structure is likely to change if the automotive industry structure changes from being largely vertical to being predominantly horizontal, and if automakers purchase all necessary parts from suppliers and engage only in assembly. In this case, the profit structure would change drastically and evolve to a "smile curve" structure, with a profit shift from the middle of the value chain to the upstream and downstream (figure 4). The emergence of new upstream/downstream businesses may also catalyze this change.

Figure 4. A change in profit structure by BEV expansion



Profit structure change: upstream

To understand profit structure change in upstream industry, let us first look at the module businesses of one of the core parts: batteries. Currently, each automaker is trying to reduce battery cost. When the battery supplier can sell the battery to many automakers, costs will be reduced due to economies of scale attained through mass production. Especially after interface standards between BEVs and batteries are defined, enabling connectivity without calibration ("plug-and-play"), mega battery manufacturers may supply their products to two or more automakers. This suggests that a small number of mega-suppliers can achieve economies of scale in the battery module production — similar to what we have seen in the semiconductor industry. Consequently, the mega-suppliers of battery modules would become profitable, while automakers producing relatively small volumes of BEVs would be less so.

Raw materials may also reconfigure the value chain. In planning ahead for mass production of BEVs, automakers and suppliers need to enter into a contract with new raw material suppliers. BEVs' core components are different from those in ICE cars in that they require materials like lithium and other rare metals. These resources are concentrated in South America and China, and their exports are already restricted in some countries. A key issue, therefore, will be building relationships with these countries' governments and resource companies. This is important not only for parts suppliers but also for automakers that need to control costs driven by the scarcity of these resources.

Profit structure change: downstream

The impact of BEVs may extend well beyond manufacture, with the potential for a new business model developed through closer cooperation with external players, particularly those related to urban transportation and the energy industry.

Urban transportation: First, the BEV's connection to the urban transportation system suggests a new business model. The driving range of current BEVs is far below the general consumer's expectation. Given today's technologies, and even allowing for a reasonable degree of improvement, it is difficult to achieve the cruising range of typical ICE cars. On the other hand, BEVs may be a better fit due to their strengths as short-range, economical personal vehicles.

It is conceivable that the transportation system will evolve to one where BEVs are used for short commutes, for instance from home to the closest station, and light rail trains are used for longer commutes, such as from the closest station to the final destination. There will likely be a variety of BEV business models that act as integrated systems interconnecting various urban transportation systems.

Such transformational change can be seen in BEV car-sharing services such as the Petit Renta in Japan, the Car Clubs in the United Kingdom and the Autolib' and Liselec in France. With the support of their governments, these car-sharing services have seen dramatic growth. Membership in Car Clubs reached 100,000 in 2009.[12] In these models, since BEVs are shared and often used for short trips within the city, their limited driving range is not much of a drawback. If more people look to rent BEVs rather than to own them, BEV manufacturers may shift sales resources from B2C to B2B sales, such as car-sharing companies.

Another effective method of connecting BEVs with other transportation infrastructure is through Intelligent Transportation System (ITS) technology/Telematics. Currently, ITS/Telematics is used for smoothing interactions between road traffic systems and traffic control signals. In the future, interactions are likely possible over a wider operational area including other public transportation infrastructures. For instance, ITS/Telematics could help customers search for charging facilities nearby and give them access to reviews and other information related to the reputation of these facilities. Even from remote places, owners of BEVs could control the charging speed and view real-time state of charge through ITS/Telematics technology.

What are smart grids?

Smart grids are electric power networks that enable efficient, stable and bidirectional electricity delivery through information technology use. Smart grid technology allows society to optimize renewable energy such as photovoltaic and wind turbines. It is under development in many places such as Colorado, United States and Amsterdam, Netherlands to achieve the governments' target of renewable energy usage.

Governments' renewable energy targets

U.S.	25% by 2025
EU	20% by 2020
Japan	20% by 2020
China	15% by 2020*

* Non-fossil fuels in primary energy consumption

Data Source:
The office of the president-elect, US http://change.gov/agenda/energy_and_environment_agenda/;
European Commission "The EU climate and energy package," http://ec.europa.eu/environment/climat/climate_action.htm;
Agency for natural resources and energy, Japan "Current use of renewable energy and promotion policy," http://www.meti.go.jp/committee/materials2/downloadfiles/g91106a03j.pdf;
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Energy industry: With increased use of renewable energy sources such as solar and wind gaining momentum in many countries, there is a strong case for strengthening the business model connecting BEV infrastructure and energy. This includes BEVs as a component of smart grids, where they could act as storage devices.

Research institutes such as the University of Delaware are currently developing Vehicle-to-Grid (V2G) technology that enables BEVs to communicate with the power grid. Using this technology, BEV owners can charge their BEVs at a lower rate during off-peak time, and discharge electricity from their cars during peak time.[13] So for as many days as a BEV stands in the garage or in the parking lot, consumers can save energy and electricity costs. Electric power companies can also enjoy benefits from electric-load leveling. Moreover, usage of intermittent renewable energy can be increased by BEVs acting as battery storage devices. Thus, by connecting to the electric power network, it becomes possible for the BEV to take on new value creating roles apart from mere transportation.

However, there are many challenges to realizing V2G technology. For example, a power grid system is required that safely absorbs reverse power flow from BEVs. Many existing residences would require upgraded electrical systems to handle the voltage for reverse power flow. Moreover, an accurate forecasting system of electricity demand for BEVs would be required to avoid sudden power shortages. In order to overcome these challenges, automotive industry players would need to collaborate with companies outside the automotive industry

– for example Google, GE and Cisco, which are all currently working on smart grid technology.[14] Companies that can develop BEV services that coexist with the energy infrastructure will be much better positioned to be big gainers over the next several decades.

THE AUTOMOBILE IN SOCIETY

The automobile industry has historically followed a hierarchical structure with automakers at the top and suppliers meeting their requirements. This posed no problem as long as the structure met society's view of the car as a standalone product. However, as the BEV may become part of the social system in a technological sense, it must complement various products and services that are also connected to the social infrastructure. Moreover, BEV manufacturers will need to coordinate with agents of urban development and, of course, electric power utilities. In other words, the scope of competition in which automakers take part will expand, and the resultant business model may well shape competition.

Indeed many companies, not just existing automakers, are eager to develop new business models with BEVs. The relative simplicity of BEV production and their many potential uses in an advanced infrastructure are very attractive.

Yet for all of their abstract technological promise, existing automakers and new entrants who develop and produce BEVs need to remember that the main use of BEV is as a mode of transport. Despite their relative ease of production, BEVs will have to abide by the same regulations that have guided the development of the modern ICE automobile. Will it perform as well as its petrol-powered counterpart? Does it protect its occupants in a crash? What happens to those batteries when their service life is done, or when there is a fire or an impact? For all of its environmental drawbacks, the modern car does a lot of things well, something BEV manufacturers cannot afford to overlook.

If BEVs can conquer those problems, they seem poised to change society on a scale that may indeed rival old Henry Ford's assembly line in Dearborn, Michigan.

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