

Charging forward: Electric vehicle survey

April 2011

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion (United Nations 1999).

There are a number of reasons why the number of children in the world is increasing. One of the main reasons is that the number of children who are surviving to adulthood is increasing. This is due to a number of factors, including improved medical care, better nutrition, and a decrease in child mortality rates.

Another reason why the number of children in the world is increasing is that the number of children who are being born is increasing. This is due to a number of factors, including a decrease in the age at which women are having children, and an increase in the number of children who are being born to women who are already having children.

There are a number of challenges that are associated with the increasing number of children in the world. One of the main challenges is that there are not enough resources to care for all of the children. This is particularly true in developing countries, where there is a lack of access to education, healthcare, and other basic services.

Another challenge is that there are not enough jobs for all of the children. This is particularly true in developing countries, where there is a high unemployment rate. This means that many children are forced to work to support their families, which can have a negative impact on their health and education.

There are a number of ways that we can address these challenges. One way is to improve access to education, healthcare, and other basic services. Another way is to create more jobs for children. This can be done by supporting small businesses and providing training and education for children.

It is important that we take action to address these challenges. If we do not, the number of children in the world will continue to increase, and the lives of many children will be negatively impacted. We need to work together to find solutions that will improve the lives of all children.

There are a number of organizations that are working to address these challenges. One of the most well-known is UNICEF. UNICEF is a United Nations agency that is dedicated to the well-being of children. It provides a wide range of services, including education, healthcare, and protection.

Another organization that is working to address these challenges is the World Bank. The World Bank is an international financial institution that provides loans and technical assistance to developing countries. It has a number of programs that are specifically designed to improve the lives of children.

There are also a number of private organizations that are working to address these challenges. One of the most well-known is the Bill & Melinda Gates Foundation. The foundation has a number of programs that are focused on improving the lives of children, particularly in the areas of education and healthcare.

It is important that we continue to support these organizations and work together to find solutions that will improve the lives of all children. We need to make sure that every child has the opportunity to reach their full potential.

There are a number of things that we can do to help improve the lives of children. We can donate to organizations that are working to address these challenges. We can also volunteer our time and skills. We can also advocate for policies that will improve the lives of children.

It is our responsibility to make sure that every child has the opportunity to reach their full potential. We need to work together to find solutions that will improve the lives of all children. We need to make sure that every child has the opportunity to reach their full potential.

PwC's Charging Forward EV Survey

Throughout its 100+ years of existence, the automotive industry has been a constant pioneer in the innovation, development and integration of advanced technologies. That drive continues to exist today as the industry collaborates across multiple sectors to address broader sustainability challenges in a quickly evolving global environment.

One of the more newsworthy initiatives to achieve these common goals is the production of electric vehicles (EVs). While many of the determining factors for the success of EVs have been identified, such as development of a suitable infrastructure and continued cost reduction of batteries and their supporting systems, other variables continue to be a matter of debate.

While automotive companies search for innovative ideas to spur advanced-technologies, create new product designs and develop viable infrastructure solutions, a noticeable sense of urgency has emerged to bring alternative fuel applications to market. In large part, this is due to various emissions and fuel economy regulations around the world (i.e., the 35.5 mpg CAFE standard in the U.S. for 2016, and further legislation proposing ~60 mpg CAFE by 2025). Collaboration between relevant cross-sector participants (automotive, energy, utilities, cleantech, etc.), as well as private and public interests, will be essential in meeting these requirements and achieving significant reduction in global greenhouse gas (GHG) emissions.

Certainly, there has been plenty of cooperation and investment to date. Government incentives, including low interest loans and grants, along with private investment, have allowed for key initial investments to be made in developing a sustainable future for EVs. However, the question remains...what does the future hold for EVs?

Addressing the key issues mentioned herein certainly will play a major role in determining the fate of EVs, but ultimately, it will be the consumer that decides the size of the opportunity.

The PwC *EV Survey: Charging Forward*, was developed to provide a check-up on some of the major determining factors for the success of EVs in the near, mid and long-term. More than 200 participants from the automotive, utilities, energy, technology, government, finance, education and other sectors provided their feedback. Key results have been included, along with additional thoughts from PwC on the present and future outlook of EVs.

The survey findings cover a range of issues. We welcome you to explore the results and accompanying point of view to gain a better understanding of what is driving the success of EVs. Please visit www.pwc.com to view additional PwC publications.

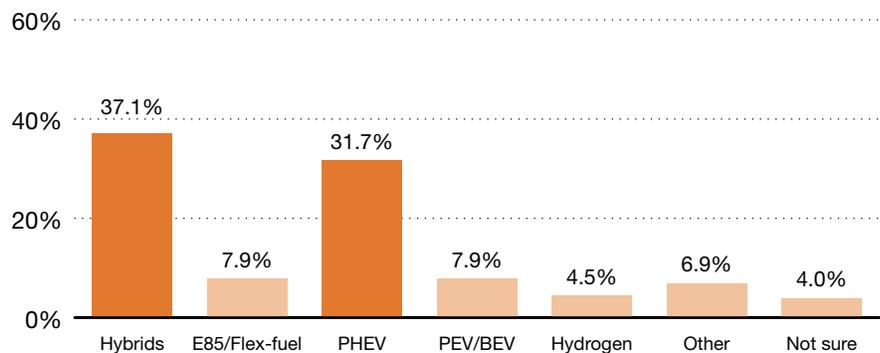
Building what consumers want

Automakers, particularly in the U.S., have struggled at times to achieve the flexibility (and in some cases the willingness) to develop and produce vehicles that consumers want to buy. Thanks to fluctuating fuel prices, economic turmoil, and changing government policies, consumer preferences can change at a rapid pace. However, automakers are making strides to adapt more quickly to these changes. The majority of respondents (68.8%) believe Hybrids and Plug-in Hybrid Electric Vehicles (PHEVs) are the most appealing to consumers overall.

Thirty-seven percent of respondents felt hybrids offer the best practical business case of currently available alternative fuel technologies, followed closely by PHEVs, which received 31.7 percent. While no alternative fuel occupies significant share in the marketplace, traditional hybrid vehicles (such as the Toyota Prius and Ford Escape Hybrid) hold roughly 2.5 percent of U.S. market share. And some technologies such as E85 (flex-fuel which contains 85% ethanol and 15% gasoline) have been in the market longer than hybrids, they have failed to gain significant share. It should be noted that share for E85 is difficult to accurately determine. Millions of E85 capable vehicles are on the road today but few consumers actually utilize the flex-fuel function due to the added cost, decrease in fuel economy, and limited availability of the fuel. Other technologies such as Pure Electric Vehicles (PEVs) and PHEVs are just beginning to be rolled out, and face their own unique roadblocks to market penetration.

Figure 1: Respondents believe consumers will choose Hybrids and PHEVs

Q. Which alternative fuel technology do you feel currently offers the best mix of cost effectiveness and practicality (i.e., ease of use, accessibility, etc.) to consumers?



Source: PwC Charging Forward Survey

Autofacts®, PwC's internal forecasting group, predicts that hybrid vehicles will continue to lead the way in alternative fuel market share. This is primarily due to reduced cost for the technology as a result of third and fourth generation development and a rollout of numerous vehicles with available hybrid powertrains. By 2020, hybrid vehicles (mid and full) are forecasted to comprise about 5 percent of global annual production, while EVs (PHEVs and PEVs) will account for roughly 2.5 percent.¹

¹ Autofacts analysis

With price premiums for EVs currently starting around \$15,000, it seems they still have a long way to go to compete head to head with existing technologies in the market, even when taking into account government incentives.

Overcoming the odds

Bringing the cost of EVs in line with Internal Combustion Engines (ICE) vehicles remains a key challenge to achieve widespread adoption among consumers. Survey respondents indicated multiple issues that EVs must overcome to increase overall market share. More than half of the respondents (51.4%) said cost and lack of acceptable driving range were the primary disadvantage of EVs. This is more of an issue for PEVs than PHEVs, although the ability to travel on pure electricity is limited for both types of vehicles.

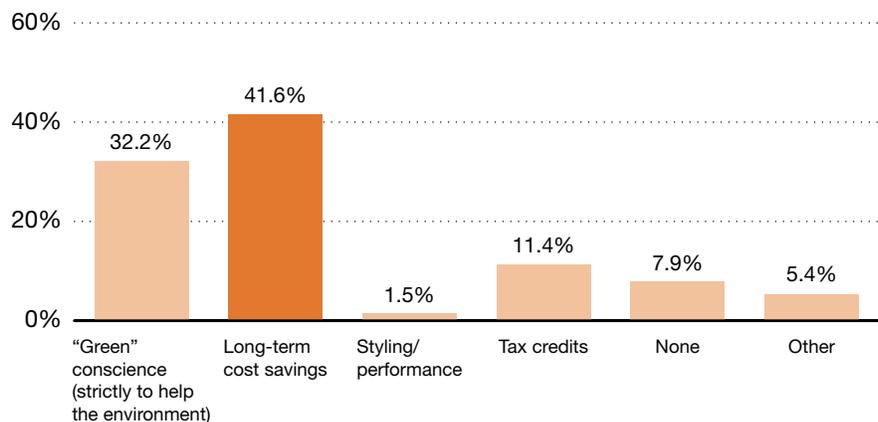
Nearly a third of those surveyed (30.8%) said that EVs must have a minimum driving range of 101-150 miles in order to compete with traditional ICE vehicles. Vehicle cost rapidly increases with each added mile of battery capacity. This is the primary barrier attributed to limited range. Furthermore, the lack of infrastructure (21.8%), lack of availability (8.4%), and development of new and unproven technologies (7.4%) will also be major contributing factors that will result in a slow rollout of EVs.

The price is right

Companies continue to work on achieving a balance between investing in development of new technologies and passing these costs to the consumer. So why would potential customers be willing to pay such a premium for an EV? The majority of respondents indicated long-term cost savings (41.6%) is the primary reason. This suggests most think buyers must be offered an economically sound business case to purchase an EV. It seems there will always be a select group who are willing to pay a high premium as first adopters, who aren't primarily concerned by the cost equation. This is evidenced by the respondents (32.2%) who felt consumers would be willing to pay a premium because of their "green" conscience. However; based on the previously mentioned market share of current hybrid offerings ($\approx 2.5\%$), this does not appear to be representatives of mainstream consumers.

Figure 2: Respondents believe price will determine purchasing decision

Q. What, if any, is the primary reason that consumers would be willing to pay a premium for an EV?



Source: PwC Charging Forward Survey

In order to achieve long-term cost savings, two things must happen. First, fuel prices must continue to rise, and second, costs for EVs must come down... a fairly simple cost equation. How much fuel prices must rise and how much EV costs must come down is debatable. The payback period for an EV can escalate quickly depending on the premium, but even in a best case scenario it is still well beyond the average length of vehicle ownership in the U.S., which is currently around 5.5 years.

EVs must also fight with an increasingly savvy consumer, who has become more aware of important variables such as interest rates, fuel economy, incentives, quality ratings and residual values when they are looking to purchase a new vehicle. When asked what price premium they thought consumers were willing to pay for a PEV and PHEV, the top responses by far were 0-\$5,000 (48.2% for PEV, 49.5% for PHEV), which would essentially put them on par with traditional hybrid and diesel applications. With price premiums for EVs currently starting around \$15,000, it seems they still have a long way to go to compete head to head with existing technologies in the market, even when taking into account government incentives.

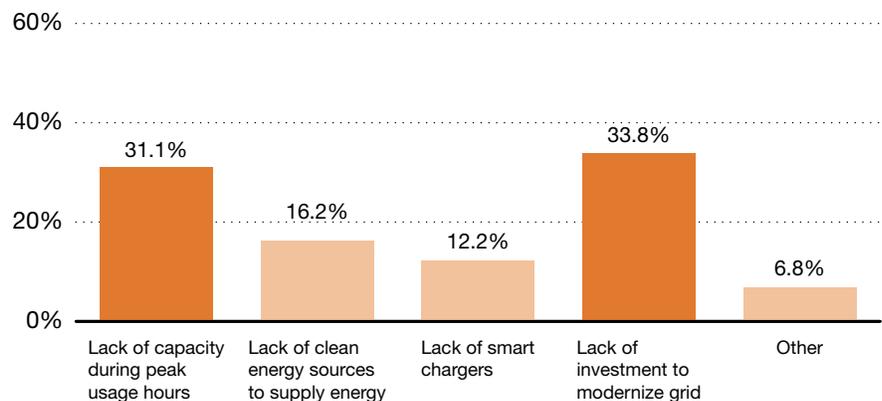
Roadblocks ahead

Beyond the continued development of EVs, a potentially larger and more pressing issue is the infrastructure investment needed to support these vehicles. Approximately one-third (33.8%) of respondents felt the lack of investment to modernize the grid is the primary roadblock to supporting EVs as a mainstream offering. While nearly another third (31.1%) felt the lack of capacity during peak usage hours is the biggest concern.

Let's begin with the issue of capacity. The obvious, and more costly option, is to increase capacity by adding new energy facilities (nuclear, coal, natural gas, etc.) to power the expected spike in demand. However, this may be an unnecessary reaction. While some areas (most notably California and areas in the western U.S.) continue to suffer brownouts during peak usage, many other areas vastly underutilize their capacity, particularly during off-peak usage. So at least one near-term challenge is how to better utilize the current capacity of the grid.

Figure 3: Respondents express lack of investment and capacity as biggest concerns

Q. What is the primary roadblock preventing the nation's power grid from supporting a large number of EVs?



Source: PwC Charging Forward Survey

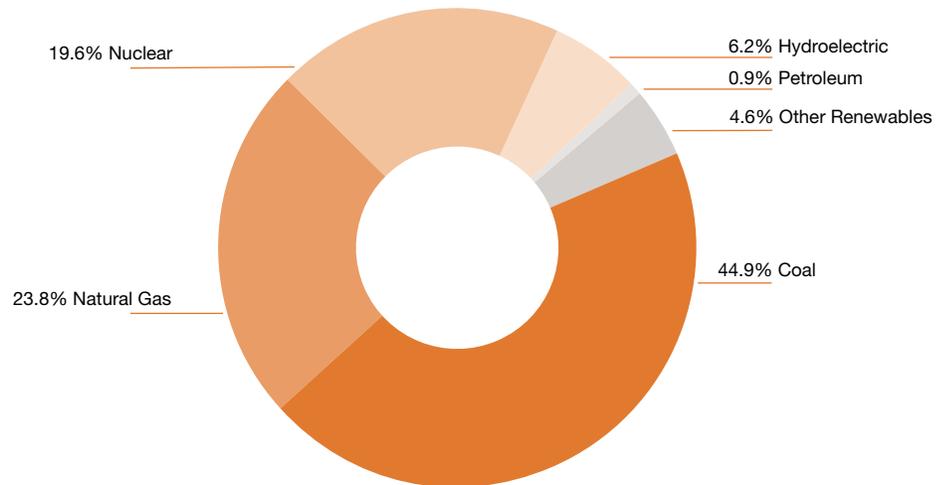
Several options are being considered to entice consumers to purchase an EV. Examples include; financial incentives to charge vehicles during off-peak hours, and paying to utilize the EV batteries to increase the capacity of the grid. Additionally, installation of smart meters and vehicle to grid (V2G) systems would allow EVs to add capacity to the grid during peak usage hours without having to make new investment in power plants. While this technology is still in its infancy, it offers promise and highlights the type of innovation needed to push EVs forward.

Show me the money

Now, onto the broader issue of funding and developing a modernized infrastructure. Funding is a highly debated topic, as many worry that EVs will be slowed by a “chicken or the egg” scenario due to the current lack of infrastructure and the high cost to develop. The top response to who should bear the primary cost burden was “all of the above” (35.3%), which includes government, utilities, local municipalities, private interests and others. At least initially, it appears this is exactly what is happening. There have been numerous announcements of joint partnerships between automakers, utility and charging companies, entrepreneurs, government agencies, and so on.

Nineteen percent of those surveyed indicated that government should bear the primary burden of developing and funding an EV infrastructure or a smart grid. In fact, this is already a reality as the federal government has offered billions of dollars in the form of loans, grants, and rebates through various stimulus programs (i.e., ARRA, ATVM)², which has offered incentive to private industry to invest in the effort.

Figure 4: U.S. Net Generation by Energy Source (All Sectors)



Source: U.S. Energy Information Administration (EIA)

In addition, utility companies are installing smart meters in homes, municipalities are modifying their planning to include charging stations, and private investors continue to work on development of quick charge and battery swap systems for residential, commercial and industrial applications. While this initial “all in” effort is extremely encouraging, continued collaboration is necessary to expedite the development of a high tech EV infrastructure. Key stakeholders must also understand that it will take years, perhaps decades, to fully mature and be capable of supporting EVs as a mainstream and viable automotive option.

² The American Recovery and Reinvestment Act of 2009 (ARRA) and the Department of Energy’s Advanced Technology Vehicle Manufacturing (ATVM) Section 136 of the Energy Independence and Security Act of 2007.

Energizing EVs in 2020

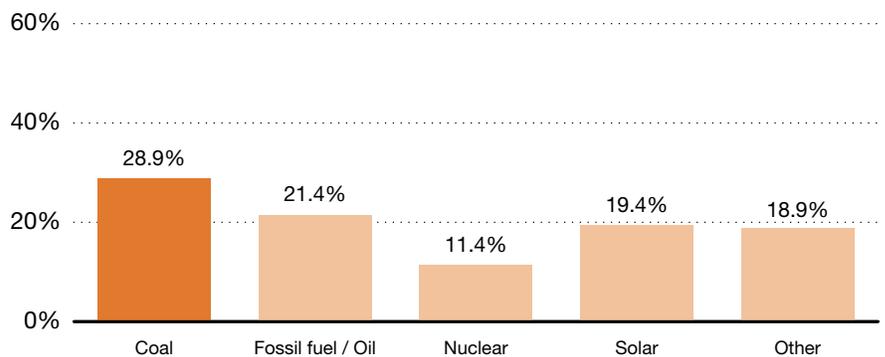
As demand for EVs grows, what energy sources will be used to provide power to them? From a sustainability standpoint, determining the ideal energy sources is critical. Many have argued that EVs don't actually reduce emissions if the power sources they are receiving electricity from further pollute the environment (i.e., coal, oil). Of those surveyed, 16.2% felt the lack of clean energy sources to supply energy is the primary roadblock preventing the power grid from supporting a large number of EVs.

The emissions tradeoffs between ICE vehicles and EVs powered by “dirty electricity” is and will remain an issue of concern, and the need to shift the nation’s grid to cleaner, renewable energy sources is clear. Today, almost 50 percent of U.S. electricity generation is provided by coal. However, nearly one-third (28.9%) of respondents felt that by 2020 it would still be the primary energy source. This furthers the argument that while significant investment is being made, fundamental changes to the grid and the energy sources that power it will still take time to implement

Shifting from fossil fuels will take time, but incremental progress is still a step in the right direction. New developments in renewable energy sources like solar and wind offer optimism for a continued shift to clean energy.

Figure 5: Respondents predict that coal will remain primary energy source for EVs in 2020

Q. What type of energy will be the primary source of power for EVs in 2020?



Source: PwC Charging Forward Survey

Pros and cons

Positive Indicators for EVs

- Government Support – Financial and legislative support continues in the form of tax credits, low interest loans, grants, and environmental legislation that steers the industry toward cleaner, sustainable energy solutions
- Infrastructure – Heavy investment from both public and private sources to build an easily accessible network of battery swap and recharging stations. “Quick charge” stations are readily available, allowing for an 80% charge in ~30 minutes. Additionally, a universal standard is developed for the hardware used to recharge EVs
- R&D / Technology – Technological breakthrough is realized, resulting in lower cost per kWh (\$200-\$400), along with significantly longer battery ranges through the use of innovative materials and chemical reactions
- China effect – The Chinese government recently announced a pilot program to offer EV & hybrid incentives (up to \$8,800) in its metropolitan hubs, which has the potential to rapidly increase consumption of alternative fuel vehicles in China. Autodata is forecasting production to eclipse 27 million units by 2017.

Negative Indicators for EVs

- Government Support – Global government support is not realized, rather EVs gain only regional support, while others focus on existing core competencies (traditional hybrids, diesels, advancement of traditional ICE)
- Infrastructure – Limited future investment due to high cost and marginal success of various pilot programs. Consumers deterred by price premiums, lack of access to charging stations in urban centers, extended charging times and other associated ownership costs
- R&D / Technology – R&D progress begins to level off, due to decreased funding and/or emergence of competing
- Material cost – Despite recent discoveries of reserves, a lack of infrastructure to extract the material combined with high demand across multiple sectors has resulted in continued price increases for lithium. Additionally, the continued high cost of the cathode in lithium-ion systems and uncertainty over reliable, safe, and cost-effective alternatives to cobalt oxide remain a concern

Considerations for success

Today, successful companies acknowledge the importance of proactively engaging in the dialog and providing a viewpoint that will reshape the automotive industry and infrastructure of tomorrow.

As new opportunities and challenges continue to emerge, it remains important to continue to closely monitor the progress being made in each of the key areas discussed in the survey. Collaboration remains a key element of addressing those challenges, as multiple sectors (automotive, energy, utilities and cleantech) unite to forge a new and exciting path with the opportunity to fundamentally change the world in which we live.

Given the perpetual concerns related to fossil fuel use, few doubt the inevitably bright future for EVs. But like all great advancements, sufficient time, resources and policies are critical of alternative fuel vehicles in China. Autofacts is forecasting production to eclipse 27 million units by 2017. Today's investments are expected to pave the way for future EV success on a global scale, but in the interim, the automotive industry must continue charging forward.

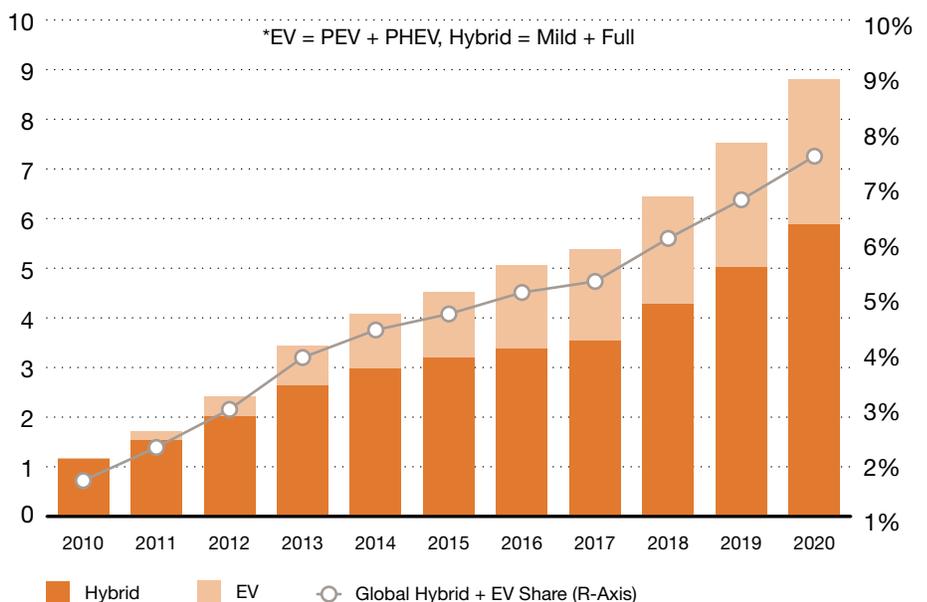
In terms of the assembly outlook for hybrids and EVs, Autofacts is forecasting that annual production will reach approximately nine million units by 2020, representing roughly 9 percent of global market share. Of that, three million units will be plug-in and pure electric vehicles.

The PwC EV survey: *Charging Forward* results highlight several key issues and questions industry participants should “ask and consider”.

- What are the key recently passed and pending regulatory issues that you should be concerned with, and what are the potential impacts on your business and sector?
- What type of public/private investment support is available?
- Who should you reach out to if you're interested in cross-sector collaboration?
- What are some of the best practices to follow in order to maximize your potential for success?
- What are you doing to differentiate yourself in this fast paced and highly competitive segment?
- What are the key sets of knowledge and resources needs to address the unique challenge that this sector presents?

Figure 6: Global: Hybrid + EV Assembly Forecast*

2010 – 2020 (Millions)



Source: Autofacts Analysis

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