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Why ICT Systems are Key to Accelerating EV Adoption

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Abstract

When considering how to address anticipated consumer anxiety about the new product, the electric vehicle (EV), automotive manufacturers (OEMs) turned to innovative vehicle **information** and **communication technology** (ICT) systems. EV OEMs correctly surmised that a smart vehicle inter-networked with both ecosystem information and enhanced communicative capabilities would demonstrate the power of right time/right place information to make a market for this new technology product. Moreover, properly implemented vehicle ICT systems would tighten the bond between vehicle and driver, open new methods of customer communication, improve product design cycles, and enhance the automotive brand.

These ICT systems are essential to EVs because they allow owners and drivers to know, to *truly* know their vehicles. EV owners have the ability to track battery use and charging history, activate remote services, and project with a high degree of certainty vehicle range, and alternatives for reaching destinations outside of the current range. For example, an EV driver uses a navigation tool to check a route, which then informs the charging infrastructure along the way of potential demand. If charging is necessary, the ICT system will interact with systems and confirm availability and reserve a charging location convenient to the route. Given the flexibility of modern ICT systems, all actions including authentication and billing could occur in the background, creating smart infrastructures that interact with smart vehicles, and result in a personalized, intuitive driving experience.

With this impressive blend of technologies, a comprehensive ICT approach is clearly essential to optimizing the experience of driving an EV and integrating information from the vehicle and its power source, the current and future, smart grid. Airbiquity will discuss the latest vehicle ICT systems and capabilities, their market entry, growth and consumer and commercial impact, and why EVs and their connected ecosystems are critical to the larger aim of enhancing the transmission and distribution of electrical energy.

Keywords: Smart Grid, EV, V2G

1 Introduction

The electric vehicle (EV) has every appearance to lead a casual observer to believe it is just like every other vehicle. It is not. The EV is a similar vehicle product with decidedly new technology, and as such, has the same market entry challenges as any other new technology product.

Making the transition from new, risky product to established product with a broad and enthusiastic customer base is no simple feat. It is a transition that claimed many companies and products, and is the subject of many books and lectures. To accomplish this transition to established product, the EV is taking advantage of its capabilities to create a truly connected vehicle that keeps the owner informed of vehicle condition and assists the driver in travel planning and roadway operation. The EV uses already established consumer behavior and extends vehicle information and controls to optimize the consumer relationship. As with any product, establishing a tight bond with the consumer has tremendous benefits for brand, product and reputation. The EV

is not only changing our fossil fuel consumption dynamics, it is charting the path forward for integrating vehicles into our connected lifestyles.

The true importance of this integrated approach of machine information and human control will only be determined over time, but hints do exist. A vehicle integrated into connected ecosystems enables a multitude of automated tasks. For example, rather than phoning your child as you arrive at an agreed pickup location, your car would notify your child of your imminent arrival automatically. This simple example demonstrates many features of connected vehicles, like EVs, reducing distracting actions like reaching for a phone and dialing a number, and improving the transportation experience for all.

With corporate average fuel economy (CAFE) standards recently agreed upon in the United States, the role of alternative-fueled vehicles is no longer ambiguous. One representative of a major auto manufacturer stated that at least 10% of the vehicle fleet by 2025 would use battery power as the dominant means of locomotion. The CAFE agreement provides an appropriate timeline for prudent design, capital, and supply planning from the major EV actors. The questions now focus on sustainable operations.

2 The EV Cloud

Why is the EV the first full-time connected vehicle? The maturity of the EV today is akin to the PC in the 1980s. While built with 21st century technology, the EV is an early generation product presenting unique needs as well as new opportunities. First is the need for pro-active energy management – immediate access to vehicle information, such as charge state and range, as well as ancillary information, such as location and availability of charging infrastructure or real-time roadway conditions and weather.

To meet both the needs of the EV driver and the requirements of the EV manufacturer, the connected EV is spontaneously building an ecosystem of participants that, in many cases, have never previously interacted. Automotive manufacturers, utilities, electric vehicle equipment suppliers, regulators, home automation suppliers, and more are all finding their way in this new market. Many challenges become opportunities for entrepreneurs and engineers, and many opportunities become challenges for road safety and an optimized product experience. To provide scalability and sustainability, the vehicle ICT system is connected to a network of services, customized to each vehicle and driver. This is the EV cloud.

The OEM needs to deliver a class of customer-facing general data services previously unavailable and, in some instances, not even relevant to traditional internal combustion engine (ICE) vehicles. The OEM needs to ensure the driver has the information and services needed to efficiently manage the experience of owning and driving an EV. At the same time the connectivity of the EV enables the OEM to collect rich sets of vehicle data and driver behavior data to influence development efforts for current and future automotive products. The EV cloud normalizes the various capabilities and presents the driver with a dashboard of information and features that maintains concurrency with fast-moving, connected markets globally.

The EV presents the utilities with a class of electronic device that is fixed in neither location nor time, and that would place significant load on the local distribution grid for an extended period. The utilities and the OEMs can collaborate on an information architecture that will address the needs of many parties, while also enabling a better product experience for the EV owner. The EV cloud enables each utility and OEM to create sustainable or ad-hoc data relationships, in support of the multitude of companies with varying plans and market timing. Progressive regions with high EV ownership, like the Pacific Northwest or Southern California, can pioneer information collaboration across both vehicle manufacturer and utility, which requires no difference in equipment or systems than, for example, rural utility providers.

Advanced ICT solutions, like that being deployed for the Ford Focus Electric, present an integrated and open architecture for the dynamic inclusion of services and the transparent but secure distribution of rich and timely data across the network for the benefit of all participants.

Figure1: The connected EV cloud

The EV cloud platform that enables current services will rapidly expand in scope and capabilities, incorporating all integrated vehicle performance and infotainment systems. The ongoing evolution of the smart grid will have an increased relationship with EV energy management, through both the OEM and the EV owner. The development of vehicle-to-grid (V2G) integration, including feed-in-tariffs (FiTs) for EVs, will alter the supply-demand relationship, with benefits impacting the utility (capital offset), the community (smarter energy management and emergency power supply during outages), and the EV owner (income). The EV market is developing alongside the adoption of smart home technologies, as these also require connectivity to deliver remote control, data access and bi-directional communication with the customer.

Today the EV is a connected vehicle. Tomorrow, drivers will expect all EV varieties, from plug-in hybrid to battery-only and anything in between, to be connected and offer a host of services that can be delivered by the cloud seeded with the EV.

3 How ICT Supports the EV Driver

3.1 Anywhere, Anytime Information

The benefits of a rich EV ecosystem are best realized when the EV owner has access to the EV and associated data and services anywhere and anytime. Today for EVs like the Nissan Leaf and the Ford Focus Electric, access is made available via smartphone apps and personal web portals. Through these interfaces to the EV, the driver can obtain live information from the vehicle addressing state of charge, vehicle health, location, and other parameters as supported by the vehicle manufacturer. This data can be presented to the driver or monitored and processed in the cloud, with the driver receiving notifications only when conditions warrant, such as when a scheduled charging session cannot commence because the EV is not plugged in. The ability for the EV to be reached over the embedded Telematics Control Unit (TCU) supporting packet data means the EV can be reached as long as it has a cellular signal.

Figure 2: The connected EV smartphone application

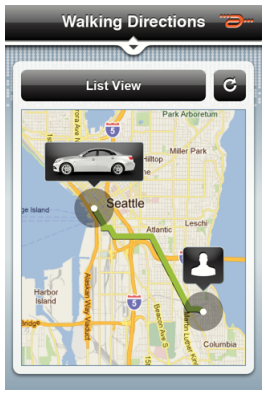

Figure 3: The connected EV smartphone app, routing the driver to his parked vehicle

3.2 Remote Control Drives Interaction and Confidence

For any manufacturer, delivering a solution that addresses present as well as anticipated needs can be very complex. Taking a cue from Apple, if access is simple and the interface intuitive and thoughtfully designed, user adoption will both meet and exceed all expectations. In the 1990s most drivers locked their cars with a physical key. This evolved to the current key fob that remotely, though still at relatively close range, secures the doors. Today, the connected EV has a software remote control with global range. Using the personal web portal or the smartphone app, the EV

driver can remotely control a broad range of OEM-supported vehicle functions. The days of hurried trips through the airport only to be uncertain whether you really did lock the car doors are coming to a close. Anywhere, anytime access to core vehicle systems will be a staple of the EV, and an indicator of how the mass of the automotive market will evolve.

The ICT offers EV remote control for convenience, comfort, and security. Today, remote controls lock and unlock doors, honk the horn, flash the headlights, and prepare the cabin to the drivers' preferences. Remote initiation of EV charging is available for times when you need to override a scheduled charge event.

In the future, the remote control can be extended to adjusting windows, sunroof, unlocking the trunk, turning off the security alarm or any other OEM-supported function.

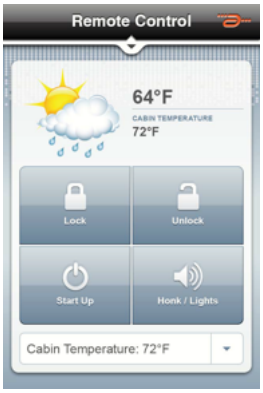

Figure 4: EV remote control in a smartphone app

3.3 Energy Management

The EV of 2012 is currently constrained in vehicle range by the cost and size of today's lithium battery technology. While the effective range of the EV is more than twice the average 29 miles driven daily by U.S. drivers [1], range remains an important metric for the EV driver. According to Mark Perry, director of product planning and strategy for Nissan North America, drivers of the LEAF electric car almost never go more than 37 miles in a single day.

The EV cloud and vehicle ICT systems play a critical role in keeping the driver aware of vehicle charge status and offering information about charging resources via the vehicle head unit, any web-connected device, or smartphone. The EV cloud, by design, quickly and easily integrates any permitted service provider or content partner to provide services for each automotive manufacturer, each vehicle line within a fleet, and for each driver of each vehicle.

Most EV drivers follow a fairly regular charging routine, once they become accustomed to their individual use habits. The EV Project Q4 2011 Report shows that the EV is plugged into the residential EVSE for an average of 11.5 hours per day and the EV is actually charging for 2.2 hours per charging event. The average daily distance traveled was 30 miles with 27.7 miles traveled between charges. [3] As the data builds to a statistically relevant set, the cloud becomes a rich repository of data and these data hold new possibilities.

An example feature using this data rich EV cloud is "Ready to Go." This feature presents the user with a statistically relevant indication of the energy (charge) needed for each day. This prediction is made by mining the historical use of the vehicle by this driver for the day of the week in question, as well as for other comparable EV owners. If the analysis yields the EV will need 14 kWh of energy for a second Thursday of February histogram, and the vehicle has an 18 kWh charge, the vehicle is "Ready to Go." Variables such as the day's weather, updates to traffic, and planned road works, or even the integration of personal calendar data can change the energy outlook for the day. The user is supplied with appropriate notification of anomalies that may modify the predicted energy requirement. "Ready to Go" is just one simple example of utilizing the richness of the data in the EV cloud on a hyper-personalized basis to assist the driver and increase their confidence in EV operation.

Though a simple example of rich information service for the driver, such capabilities might be even more relevant for utility capacity planning. A reliable indication of both demand and location would be invaluable tools for any utility, and the EV cloud provides a means of anonymized data exchanges that do not breach the trust of personally identifiable information (PII).

Charging networks, like Coulomb's Charge Point Network, are integrated as a service within the EV cloud by using the Charge Point Network API and delivering a unique interface on the targeted devices. This live access to critical EV infrastructure presents the user with current

information about the location, type, availability, and pricing of geographically appropriate charging stations. The integration of ecosystem participants permits driver information presentation in the most appropriate and personalized manner. The confluence of this information through a cohesive EV cloud assists the driver to locate, select, and even reserve the charging station that best meets his needs. As is likely self-evident by now, such forward-looking data has high value for many ecosystem participants.

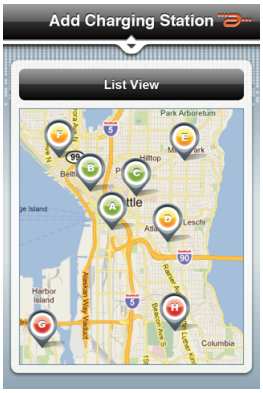

Figure 5: Charging location station display

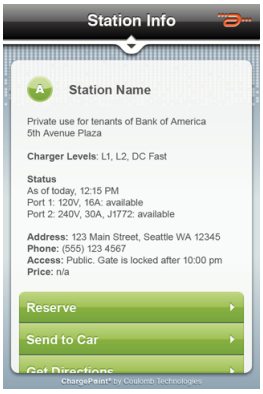

Figure 6: Live charging station information

3.4 Destination Awareness

Perhaps the most intriguing development from an integrated EV ecosystem comes from the driver. Data relevant to the driving task has its highest value when in the context of a ***destination***. Culturally, many owners jump into their cars and drive off. It is highly likely, perhaps even inevitable, that each driver knows his or her destination prior to departure. The vehicle ICT systems and EV clouds remain unaware, however, until informed.

Destination data entry is an anticipated and seismic shift in driver behavior, much like seat belts. One simple change, that of taking the extra few seconds to secure driver and passengers to the vehicle through tension belts has saved countless lives. Nearly every trip in any vehicle has a known endpoint. Each day the vehicle reflects the routines and schedules each driver has built across time. Informing the EV cloud of a trip's destination, as routinely as buckling the seat belt, would yield tremendous benefits across all facets of the transportation industry.

When destination and time of travel data are known to the EV cloud, real-time data for the state of charge, routing, terrain, weather, road conditions, and traffic enhance the driving experience, making it very personalized. The EV cloud can resent the driver with recommended charging stations along the route and present routing options to extend the range of the EV. Live traffic data can be applied to show the impact of changing a departure time to avoid traffic or the benefits of taking an alternative route.

In the case where the driver is running errands on a weekend, the EV cloud services can determine if and when the driver is approaching a pre-set range threshold. The driver is notified well before a safe return to the home charging unit is not possible. If the driver continues the journey, recommended charging stations will be made available along with the required charging time and cost. The choice is, inevitably, the driver's to make, but the choices are now much better informed. Location based services can be applied that note a Peet's Coffee & Tea is at the charging location to help pass the time and re-energize the driver. Coupons are supplied from Peet's, loyalty programs for charging providers record the activity, the route navigation amends the expected time of arrival, and notifications are sent to family or friends of the updated schedule.

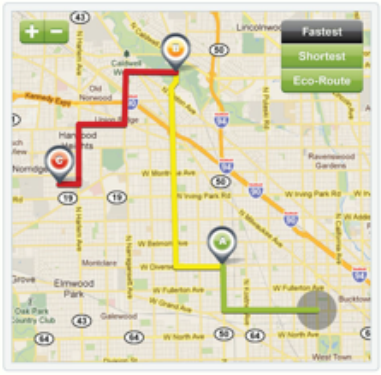

Figure 7: EV routing map illustrating the state of charge for each destination; yellow indicates charging is recommended, red indicates charging is needed

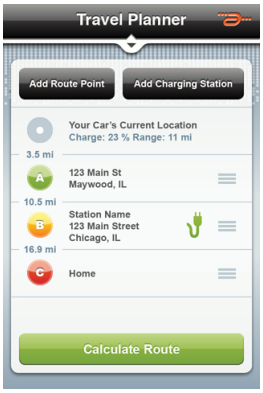

Figure 8: Smartphone app trip planning with charging station

3.5 Personalized Driver Information

Driving has always been a personal experience, with unique styles that can vary by vehicle. The driver's style in acceleration, cornering and braking directly impact EV energy efficiency. The EV cloud is able to collect vehicle performance data for each driver of an EV. The data is analyzed and presented to the driver to show them how his current driving style influences the performance and energy efficiency of the EV. Driving an EV is different than an ICE, with regenerative braking, multiple drive profiles (Sporty, Eco, Eco Pro) influencing how the EV performs. If the driver wants to enjoy the enhanced torque of the EV as he carves the curves of the backcountry roads, he will now understand the energy cost.

How various drive train modes and regenerative braking influence the energy consumption of EVs is not immediately obvious. The connected EV makes it obvious. Informing the driver of his braking score trip-by-trip or across any given period of time. With permission, the EV cloud can use any recorded trip and graphically define EV performance point by point, right on a map. The EV cloud can present information and recommendations on how to handle corners, accelerate and brake, as well as the impact of traffic or changing road elevation. All of this data is readily available and can be presented to the driver in new ways when he wants it to improve his EV experience.

3.6 Social Networks

Bill Frykman, Ford Motor Company business and product development manager, noted in a press release: "We are offering a new way of sharing your driving experiences to create a cool factor with the goal of educating new Focus Electric drivers on the perks that come with an electric vehicle lifestyle."

The ability to compete and win awards, badges or trophies takes on a game-like quality that can motivate and reward drivers. Fine tuning Eco driving style and drivers can achieve the greatest range on a single full charge this week in a region, state, country, or the world. By being a part of the EV community drivers see how they are contributing to the overall EV miles driven, fuel saved, gas stations not visited and CO_2 not released in to the environment.

Also of note, drivers who achieve the highest braking score recover the most energy back to the batteries while decelerating, all the while not wearing the brake pads, yet another savings.

This new EV lifestyle is what EV owners want to experience and share while expressing their pride and achievements. Connected EVs also represent a contest of sorts, often referred to as "gamification." Simply presenting a comparison of a household's energy consumption to that of a neighbor's and the most efficient near-by households has driven household energy consumption down by 1.5%. [4] "Where do I stand?" is a very powerful human motivator and one that instigates positive change even where the environmental benefit is not a core interest of the participant. The effect of this comparative competition is even greater when there is shared interest and an achievable goal – the best EV performance.

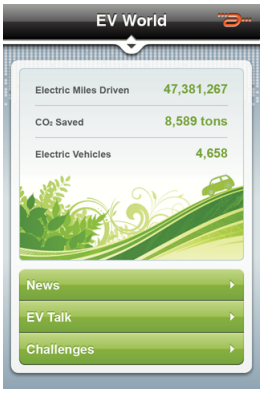

Figure 9: Smartphone app presentation of EV community shared ecosystem impact

4 Ecosystem Benefits

The EV, as a unit or a fleet, cannot create an ecosystem. Too many end points in any networked construct create inordinate complexity. An EV connecting to an EV cloud, however, creates endless possibilities. The EV cloud acts as a normalization layer, customized to vehicles and fleets, personalized to owners and drivers, and inclusive of different actors and motivations. A loosely-coupled architecture is flexible to meet the demands of data contribution and information transparency, logarithmically expanding the potential benefits for all ecosystem participants.

Automotive manufacturers are embracing the reality that the automobile is not just a product comprised of steel, plastic, and rubber. Automobiles are now part of the consumer electronics ecosystem, and the connected EV represents the riches and broadest example of the integration of mobile and Internet technologies as part of the automotive experience. This revolution brings with it a new set of consumer expectations for connectivity, integration with consumer electronics, data and services as well as the ability for the vehicle to be updated over the cloud.

Utilities are also embracing the EV for reasons both altruistic and market-driven. The EV as a portable power device represents intriguing potential opportunities that could shave millions from capital planning while delivering tailored services to EV owners.

4.1 ICT Yields Rich Data

The rich and timely data from the EV cloud optimizes the EV experience and eases the transition from ICE to EV in many ways. These EV vehicle and driver histograms represent new and valuable data for the manufacturer regarding product performance, usage patterns, as well as customer/driver behavior. Analysis of aggregated, anonymized data may yield improvements in everything from traffic flows to power flows, from product development to user experience, as well as create relationships between supplier and consumer where none previously existed.

Such symbiotic and interdependent relationships are novel for many of the market actors, so progress will be mitigated by ecosystem participant psychology, perhaps even more so than technology development. The value may be in the data, but the challenge will be creating win/win/win situations within the ecosystem. By providing transparency and neutral broker services as a hub, the EV cloud is imperative for EV market success.

4.2 Automotive Manufacturers

The actor with the most at stake, clearly, is the EV manufacturer. Not only is a new and brand-impacting product entering the market, but comparisons to similar products can mis-categorize the market conversation. Moreover, the amount of personally identifiable information (PII) accumulated by the manufacturer creates opportunity *and* risk.

The opportunity represents a level of customer intimacy that has long eluded automotive manufacturers. Gone will be the days of an expensive product driving off the lot with feedback reserved only for those who visit an authorized service center. The OEM will soon know real-time product performance for the entire fleet, with benefits in warranty management and a better informed product development process. Moreover, the behavior of drivers relative to product yields a very rich data set that leads to an understanding of customer experience. This same rich data, though, represents risk in data security and personal privacy. The benefits will only accrue to the OEM if they respect the customer relationship, which means respecting and protecting their customer data.

4.3 Utilities

The utility has much to gain from the deployment of EVs across their respective territories. The EV represents the largest increase in potential demand since the air conditioner. While it may be some time before any broad market impact is evident, the geographic clustering of EV owners is likely to create some near-term energy distribution challenges, especially at the local or neighborhood level. Creating the processes and systems for EVs to become known to the utility before it creates any local service disruptions is imperative for managing both the customer experience and the market conversation.

The introduction of EVs that can also feed energy back into the grid has many positive attributes. The opportunity for EVs parked in urban cores or even high schools to reduce peak demand and offset capital investment by utilities remains a long-term objective for many ecosystem participants. This requires significant process and systems integration across many parties and, therefore, may develop slowly. A more near-term opportunity would view the EV as a backup generator for residential power outages. Just a few stories of an energy interruption from a severe windstorm offset by the EV feeding energy back to the home would do wonders for the market conversation. The concurrent benefits to the utility and OEM brands should not be underestimated.

4.4 Social Networks

The same social networks used by the EV driver to share with the EV community, and implemented as part of the anywhere, anytime ITC system, permits the automotive manufacture and authorized partners the means to directly engage with the EV community on a individual, group, regional or global basis. The automotive manufacture can send a wide range of EV news and information to the EV community directly with the ability for the community to talk back. Broad, timely, and deep communication with the EV community can be realized. Likewise the EV community can have their own discussion boards for sharing EV tips and experiences. Local groups can be formed and events planned.

A future part of this closer relationship between the owner and manufacturer will be seen with the integration of the service department. After purchase of the EV the only face-to-face relationship is with the service department. Now via the ICT, vehicle health data can be analyzed by an ICT cloud service and appropriate communication and action can be initiated between the service department and the vehicle owner.

4.5 Law of Unintended Consequences

Most exciting about the introduction and global productizing of electric vehicles is the myriad suspicions and hunches that we just won't know from this vantage point. EVs can represent a step function change in the cost of transport, if electric bits can maintain a significant cost and sustainability advantage to fossil fuels. For many fleets, fuel accounts for approximately 30% of operational cost. Saving 10% on fuel drops nearly 3% to net income, which is material for an industry where baseline is 4-5% net operating margin. Will manufacturers be responsive to unique fleet needs, where EVs might have a substantial impact? Will services be available? Will actors in the fleet industry sanction open platforms for asset homologation and management? The EV as a product might need a significant leap in battery technology to reach any parity with fossil fuel vehicles, but, as a catalyst, may just reset the table for transportation management.

Acknowledgments

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