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Electric Vehicles: Impact and Opportunity for the Power Grid

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ABSTRACT

The electricity industry is waking up to the prospect of large-scale deployments of electric vehicles (EVs). As an IoT-enabled connected device, electric vehicles present both opportunities and risks to the electric power industry. They require a power source in order to recharge, but their battery can also function as a source of supply. EV fleets and buses present different opportunities than individually owned cars. There is a complex and competitive ecosystem of stakeholders, some of which will be in direct competition with incumbent energy suppliers; there is little room for monopoly market thinking, even for vertically integrated utilities. Effective use of IoT data will be key to EV market optimization. How utilities build infrastructure today, both for EV charging and for data analytics, can determine their opportunity to capitalize on this unique growth opportunity. This presentation shares the global insights that SAS® and Intel commissioned from Navigant Research in the area of EV readiness in a white paper titled "Charging Ahead with EV Analytics".

INTRODUCTION

Sales of electric vehicles (pure electric plug-ins plus hybrids) in 2018 reached 2.1 million units—an increase of 64% from 2017—and represented 2.2% of the market (Irle). That's an impressive growth rate but it's largely a case of drama in small numbers.

But the growth rate in electric vehicle (EV) sales has not been linear, and future EV growth rates are frequently described as exponential. China alone is expecting sales of over 2 million units in 2019, which is close to last year's total global sales figure. Navigant Research estimates global sales of nearly 14 million units in 2026 in their aggressive growth scenario and a total global EV population that year of between 39 million and 57 million vehicles (Ravens 2018).

There is growing evidence that we've reached a tipping point with EVs. Some of the relevant data points supporting this include the following.

- Government policy. Governments around the world are proposing bans on the sale of internal combustion vehicles (ICVs) within the next 20–30 years. Sweden, Denmark, India, the Netherlands, Ireland, and Israel say they will ban the sale of ICVs after 2030 while Costa Rica, Norway, and South Korea have announced proposed bans that take place before that (Hanley 2019). France and the UK have targeted 2040 and 2050, respectively. China has announced their intention to phase out ICVs but has not set a date.
- Carbon emissions. Signatories to the Paris Climate Accord Agreement have agreed to sharply reduce carbon emissions and the goals can't be met by focusing solely on fossil-fuel power plants. In 2016, carbon emissions from the transportation sector in the US eclipsed those from electric power for the first time. Reducing carbon will require electrification of the transportation sector.
- Consumer attitudes. As the range of electric vehicles continues to increase, carmakers expand their EV model selection, EV prices come down, and public charging

infrastructure ramps up, consumers are more and more likely to consider an EV for their next car.

- Compression of adoption rates. Across all types of technology, the rate at which consumers adopt newly commercialized technology is getting faster. Refrigerators took over 40 years to reach a 50% adoption rate in households while microwave ovens took only 10 years. Social media usage and tablet computers hit 50% adoption in five years (Our World in Data). A Visual Capitalist article titled "The Rising Speed of Technological Adoption" posits that today's consumers are "connected, fast-acting, and not afraid to adopt the new technologies that can quickly impact their lives for the better" (Desjardins 2018).
- Redirection of motor racing budgets. Porsche shocked the motor sports world in 2017 when they announced they would be pulling out of the Le Mans Prototype (LMP1) class of the FIA World Endurance Championship to focus on racing electric cars in Formula E. This was less than a year after a similar announcement by Audi. In 2019, Porsche will join Audi, Nissan, BMW, Mercedes-Benz, and Renault in the fifth year of the Formula E series. Why is this included as an EV tipping point? Popular Mechanics pointed out in a recent article that "…in an era when car companies are pledging to electrify their entire lineups in the 2020s, it shouldn't come as a surprise that those companies want to invest their racing dollars in electric tech. Rather than EVs and hybrids complementing the main business of selling combustion road cars, EVs are to become the main business" (Jancer 2018).

EV GROWTH—OPPORTUNITIES AND THREATS

Transportation is on a path to electrification, and while it's difficult to predict the slope of the curve, it's clear that the future holds an unpreceded opportunity for load growth for the electric utility industry. This is good news for investor-owned utilities who have gone from year-on-year load growth of 2–3% two decades ago to flat or even declining load growth.

The demand for significantly more electricity will drive utility capital investments in generation, transmission, and distribution infrastructure, and in charging infrastructure as well. This will provide regulated utilities who earn a rate of return on assets a welcome opportunity to increase their rate base.

In addition to the opportunities for revenue and earnings growth provided by increased sales of electricity and the accompanying investments in infrastructure, transportation electrification will provide the forward-thinking utility with an opportunity to expand beyond the business of selling electrons into developing and marketing new products and services for the energy consumer of tomorrow. These will be discussed later in this paper in the context of EV business models.

But along with the opportunities created by load growth go threats of strains and overloads on the network. This will be primarily in the low-voltage networks, which were not designed to handle the loads of EV charging. As higher-powered charge points are introduced in the market, this will reduce charge times and make charging more convenient; however, it will exacerbate strain on the network and increase the possibility of overloads.

EV uptake in the residential market is likely to be fairly slow and gradual, and given the ever-increasing analytically driven ability of utilities to predict and prevent overloading, a blown transformer caused by EV charging should be a rare event. However, commercial vehicle charging and electrification of private and municipal fleets pose greater challenges to the utility.

The Tesla semi-truck—announced in November 2017 with hundreds of pre-orders—will require a charger with ten times the power levels of Tesla's current Supercharger. The demand this charger will place on the grid has been compared to the equivalent of as many as 3000–4000 homes (Shrestha 2017).

The electrification of fleets—both private and municipal—will also create nearly immediate pockets of high loads across the network. For example, assume a large food delivery company servicing a city has a fleet of 100 conventional delivery vehicles which they have decided to replace with electric vehicles. In as long as it takes for the vehicles to be delivered—perhaps a few months—the load profile for the facility will change dramatically and peak loads could easily increase by an order of magnitude.

A similar situation will occur when municipalities decide to electrify their vehicle fleets—in some cases in response to commitments to achieve carbon reduction targets. In 2017, the city of Shenzhen, China, announced that they had become the first city in the world to transition to an all-electric bus fleet. With over 16,000 buses, Shenzhen's bus fleet is larger than the fleets of New York City, Los Angeles County, New Jersey Transit, suburban Chicago, and Toronto combined. This required a substantial investment in charging infrastructure with 510 bus charging stations with 8000 charging points (Graham 2018).

E-MOBILITY: UNIQUE AND RAPIDLY EVOLVING DEMANDS

EVs are like nothing else electric utilities have dealt with in the 100+ year history of their industry. They are loads but are also potential sources of supply. They move around and even if the utility has visibility of their location, their movement patterns might be difficult to predict. Navigant Research predicts that "Utilities will have to work with a complex and competitive ecosystem of stakeholders, a diverse customer base with different requirements, and a wide range of technologies that affect the grid in different ways" (Ravens 2018).

This ecosystem will be complex, the customer base will be diverse, and competition between the market participants will be intense.

The term *E-mobility* has come into wide use over the last few years and describes not just vehicles with electric powertrains but also the charging infrastructure, the power grid, and even the regulatory environment associated with these vehicles. E-mobility stakeholders will include utilities; regulators; vehicle manufactures; local, state, and federal governments; technology providers; telecommunications companies; fleet operators; insurance companies; and many more.

The customer base will include not just multiple segments (such as the traditional residential, commercial, and industrial customer classes) but a highly heterogenous infrastructure with numerous types of assets:

- Multiple powertrains (hybrids, plug-in hybrids, and pure electric)
- Multiple vehicle types (cars, bikes, motorcycles, scooters, buses, and trucks) with varying degrees of built-in IoT-based technology and connectivity
- Multiple charge-point types (ranging from residential chargers to the types of chargers that will be required for commercial vehicles such as Class 8 tractors) also with varying degrees of built-in IoT-based technology and connectivity.

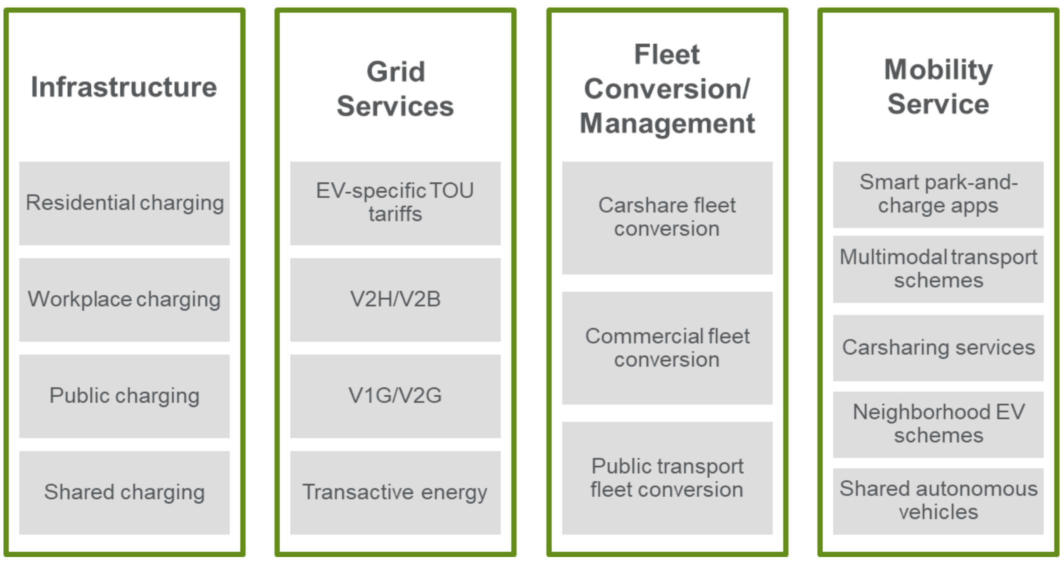
Competition in E-mobility will be fierce with market participants coming from both expected sources (such as distributed energy resource aggregators) as well as unexpected ones.

Market disruptors might follow the model of Uber and Airbnb and build digital capabilities around the customer rather than own and operate assets.

Navigant Research points out that transport electrification threatens the core business of some of the world's most powerful companies—oil majors (Ravens 2018). It should be no surprise that Shell has been making investments not just in EV charging companies but electric utilities as well. Shell recently made a bold prediction that they believe they can be the largest electricity company in the world by the early 2030s (Crowley 2019).

EV BUSINESS MODELS

Navigant Research categorizes EV-related business opportunities in four groups, and these are shown below in Figure 1.



(Source: Navigant Research)

Figure 1. EV Business Model Categories

INFRASTRUCTURE

Charging infrastructure will play a key role in the acceleration of EV vehicle sales in order to allay the range anxiety that is often cited as an inhibitor to EV purchases. Based on that, many of the utilities wishing to accelerate EV adoption are actively pursuing an EV infrastructure strategy that could be described as "if you build it they will come."

The value that utilities will receive from provisioning charging infrastructure will go far beyond just hardware and installation fees. The data that will be available about the vehicles using the charging points will be invaluable in a multitude of use cases including predicting charging behavior, optimizing charging rates in areas of concentrated high demand, ensuring grid stability, and designing new products and services for the EV owner.

GRID SERVICES

Given the potential negative effects on network reliability—particularly in areas with high penetration of EVs—most of the current grid services business models being tested by utilities focus on maintaining the reliability and stability of the grid. EV-specific time of use (TOU) tariffs could be used to smooth out peak demands and absorb output from renewable sources such as wind when the output exceeds demand.

Vehicle-to-home (V2H) and vehicle-to-business (V2B) grid services leverage the fact that the energy stored in an EV battery can be used to power homes and businesses. The Nissan LEAF was one of the first EVs with vehicle-to-grid (V2G) capability and has been involved in pilot projects all over the world. In October 2018, it became the first V2G-approved electric car in Germany (Kane 2018).

Looking ahead to the future of energy, as transactive energy matures, EVs will most certainly participate as buyers of locally generated solar power as well as grid supply sources during periods of peak demand.

FLEET CONVERSION AND MANAGEMENT

Fleet conversion to EVs was covered briefly earlier in this paper. Navigant Research points out that "Fleet owners will require extensive charging infrastructure that will have exacting requirements—typically, larger batteries to be charged by high capacity charge points, often at specific times of the day—and, as a result, will create unique load curves. Consequently, fleet charging infrastructure will require a concentration of high capacity chargers under a single feeder creating heavy demand on networks, which will require careful management and potential asset upgrades" (Ravens 2018).

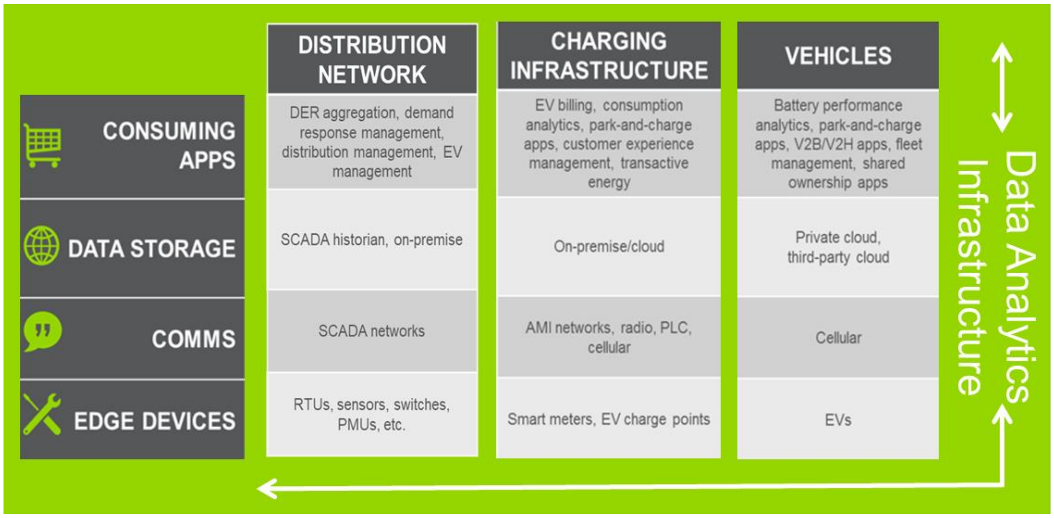
MOBILITY SERVICE

The most exciting, dynamic, and unpredictable area of EV-related business opportunities lies in mobility service models. Navigant Research believes that much of the innovation in this area will be in applications that will rely heavily on access to data from numerous sources and locations, much of which will be generated by IoT devices (Ravens 2018).

THE ROLE OF ANALYTICS

As transportation electrification accelerates, the increasingly complex business models associated with it will provide a wide-ranging variety of use cases that will require every kind of analytic technology including data mining, forecasting, optimization and simulation, and text analytics. Machine learning, deep learning, artificial intelligence, computer vision, and natural language processing will find numerous and various applications as utilities find that EVs sit at the intersection of transportation electrification, digital transformation, and the IoT.

Navigant Research describes the EV technology infrastructure that utilities will create as an IoT ecosystem with pervasive analytics. See Figure 2.



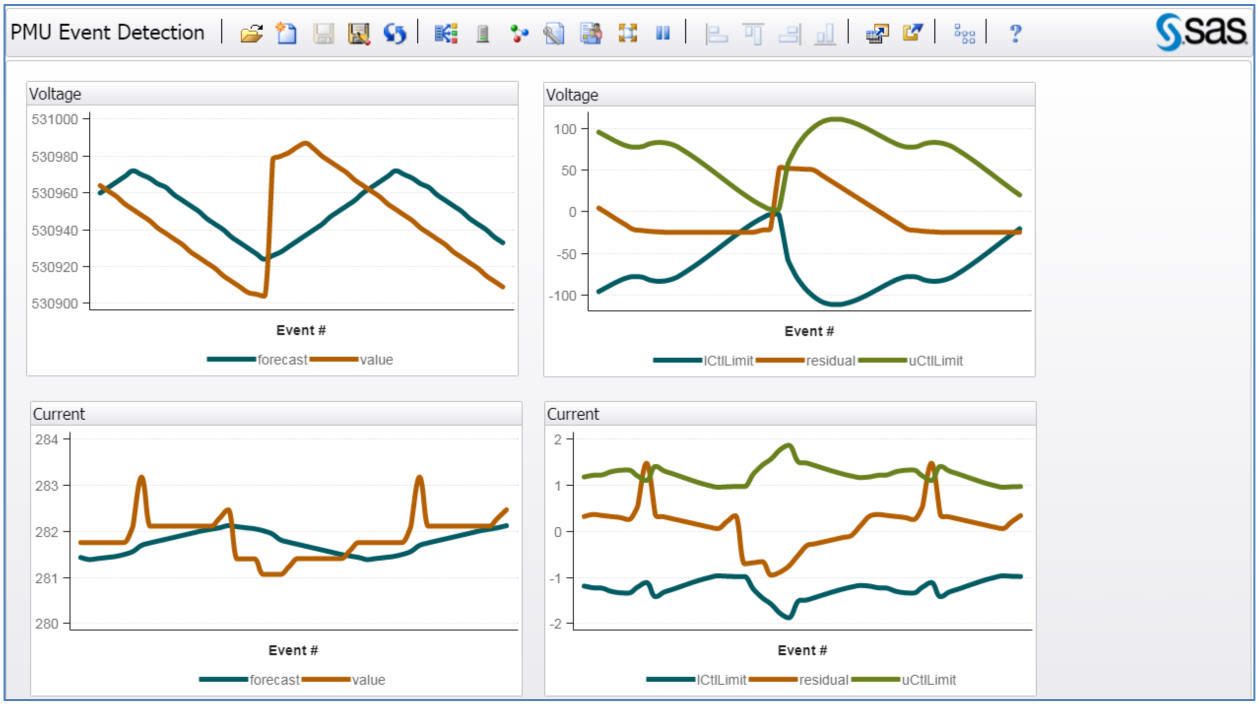
(Source: Navigant Research)

Figure 2. EV Technology Infrastructure Is an IoT Ecosystem with Pervasive Analytics

The interrelated and connected devices in this ecosystem will create data that will be analyzed in multiple locations:

- at the edge where it is created
- in motion (streaming)
- in centralized databases
- in the cloud
- by applications that consume the data

Utilities across the world have been using SAS® to analyze data at rest since 1976. A number of forward-thinking utilities have taken advantage of streaming analytics to analyze data in motion, and edge analytics to analyze data at the edge. For example, SAS worked with Duke Energy and North Carolina State University to test the capability of SAS® Event Stream Processing to analyze large amounts of streaming data generated by synchrophasors. See Display 1.

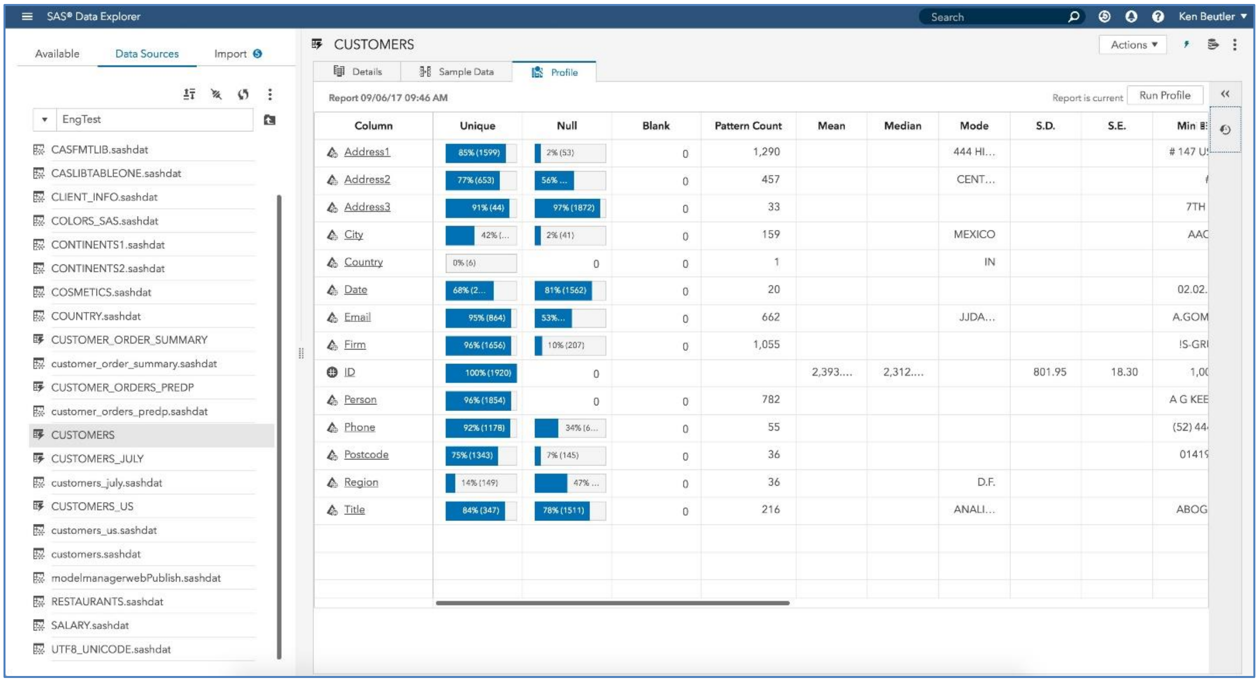


Display 1. Real-Time Synchrophasor Analytics Using SAS® Event Stream Processing

Where the analyses will take place is just one of the dimensions of EV analytics. As noted earlier, the use cases generated by transportation electrification will span all disciplines in analytics. An exponential growth in data, users, and models will create an acute need for governance to ensure data legitimacy, analytical integrity, and trust. Navigant Research states that "The most successful utilities will be those that adopt a platform-based approach, where there is a fundamental recognition in the value of making data available to all interested parties" (Ravens 2018). The SAS® Analytics Platform is well positioned to support the EV strategies and ecosystems of utilities by accelerating the analytics life cycle from data to discovery to deployment.

DATA

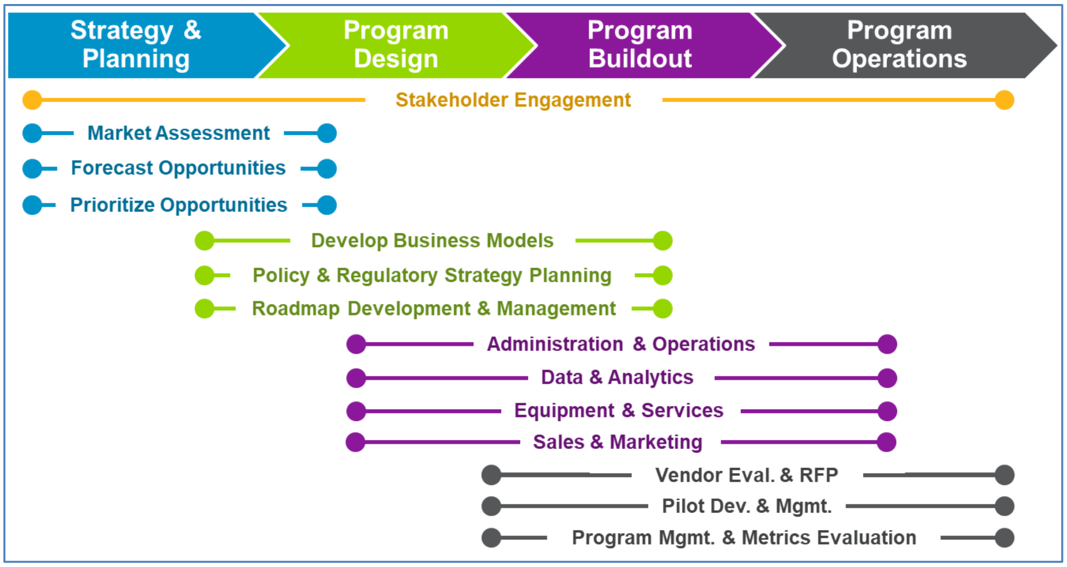
Navigant Research believes that EV data and analytics requirements highlight the need for a Chief Data Officer (CDO) role (Ravens 2018). CDOs must ensure that data is at the core of all strategic initiatives to improve operational efficiency, reduce risks, and increase revenue. Embedded data management and analytics capabilities ensure that applications and processes will work in an appropriately governed environment and within the organization's compliance and data privacy framework. With SAS® Data Management, utilities will be able to effectively access, integrate, cleanse, and govern all types of EV-related data and create a trusted data foundation that drives insights across the organization. See Display 2.



Display 2. Profiling Customer Data with SAS® Data Management Helps Transform, Integrate, Govern, and Secure Data while Improving Its Overall Quality and Reliability

DISCOVERY

The data generated by the EV IoT ecosystem—and the complex, dynamic, and continually evolving business models associated with EVs—will drive analytic use cases in every part of the utility's business. Figure 3 below from Navigant Research shows a small but representative subset of these use cases categorized by where they would fit in a project life cycle methodology.

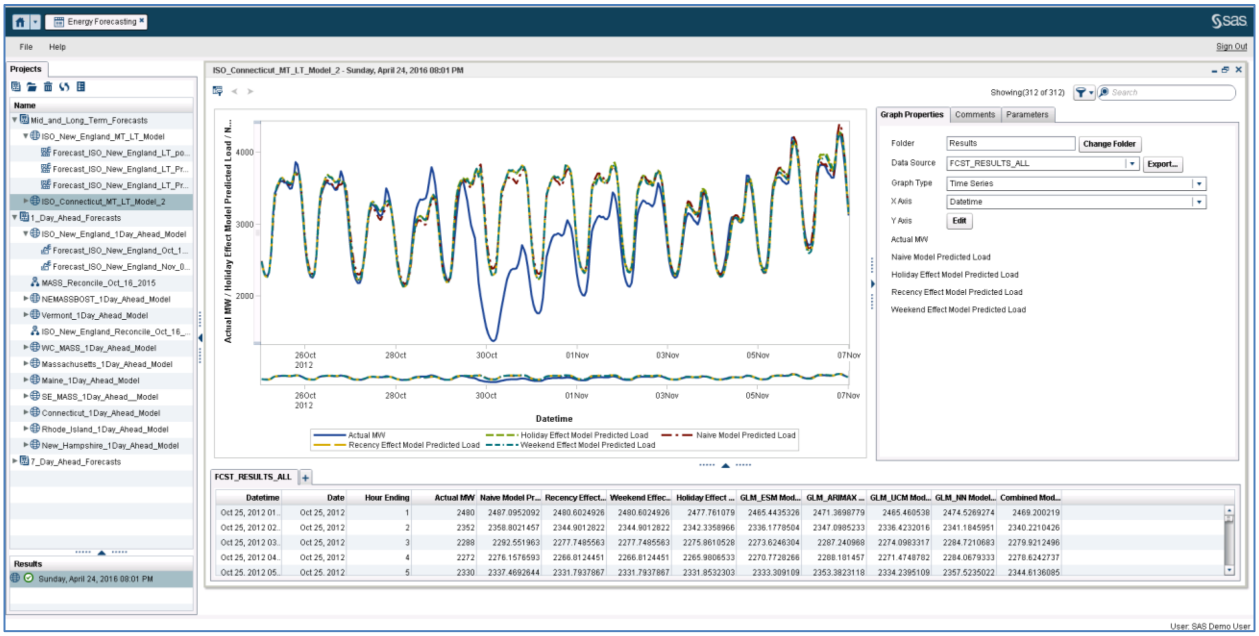


(Source: Navigant Research)

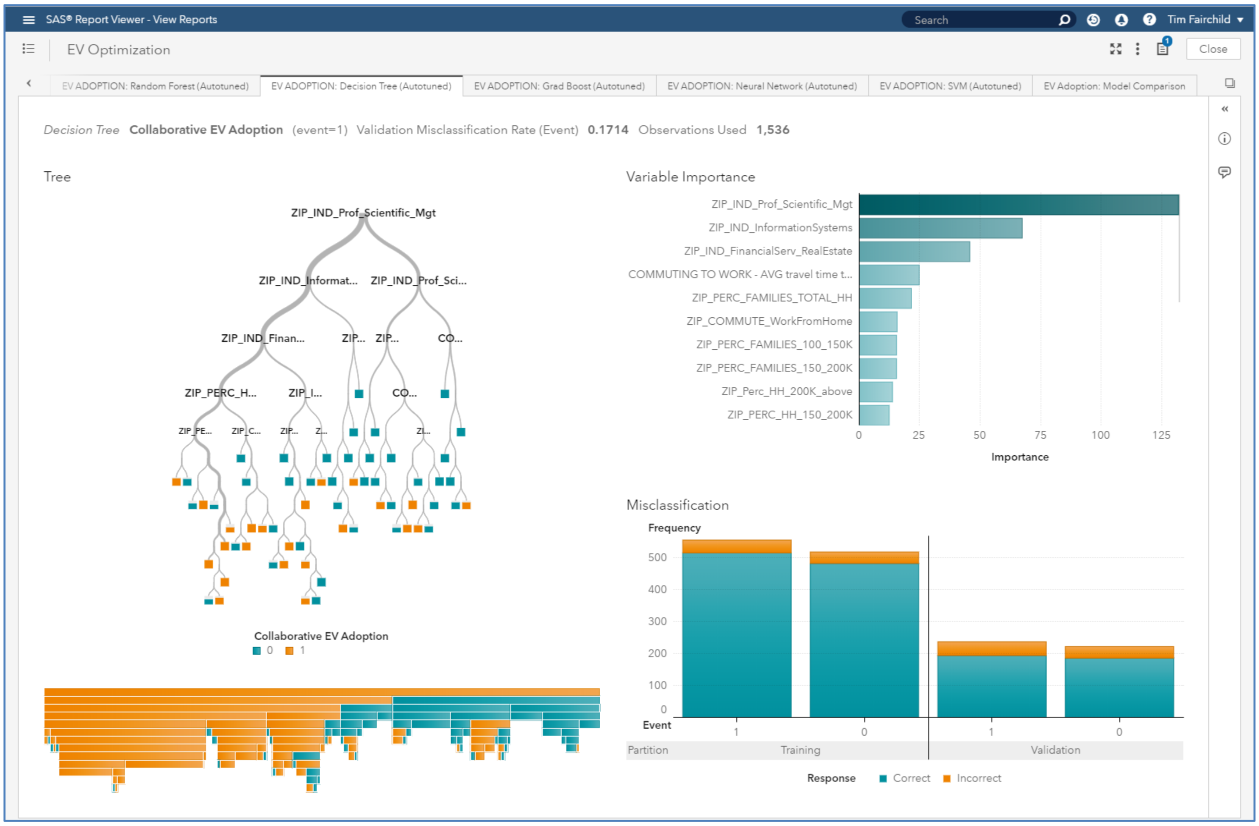
Figure 3. EV IoT Use Cases and Life Cycle

Network utilities will need to forecast distribution loads by identifying the geographical areas most likely to be affected by EVs. This will call for a combination of analytic technologies and techniques including customer segmentation (Display 3), load forecasting (Display 4), EV adoption forecasting (Display 5), and predictive asset maintenance (Display 6).

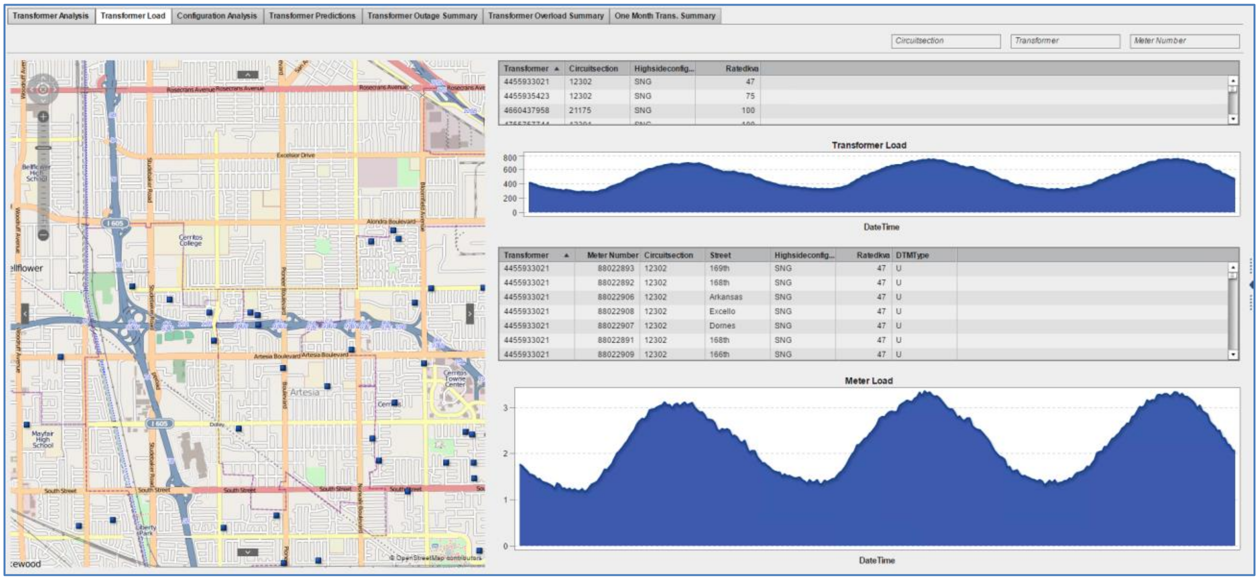
Display 3. Using SAS® Visual Data Mining and Machine Learning to Cluster Customers



Display 4. The Forecasts Results Workspace in SAS® Energy Forecasting Showing Forecasted versus Actual Loads



Display 5. Predicting EV Adoption Rates Using SAS® Visual Data Mining and Machine Learning

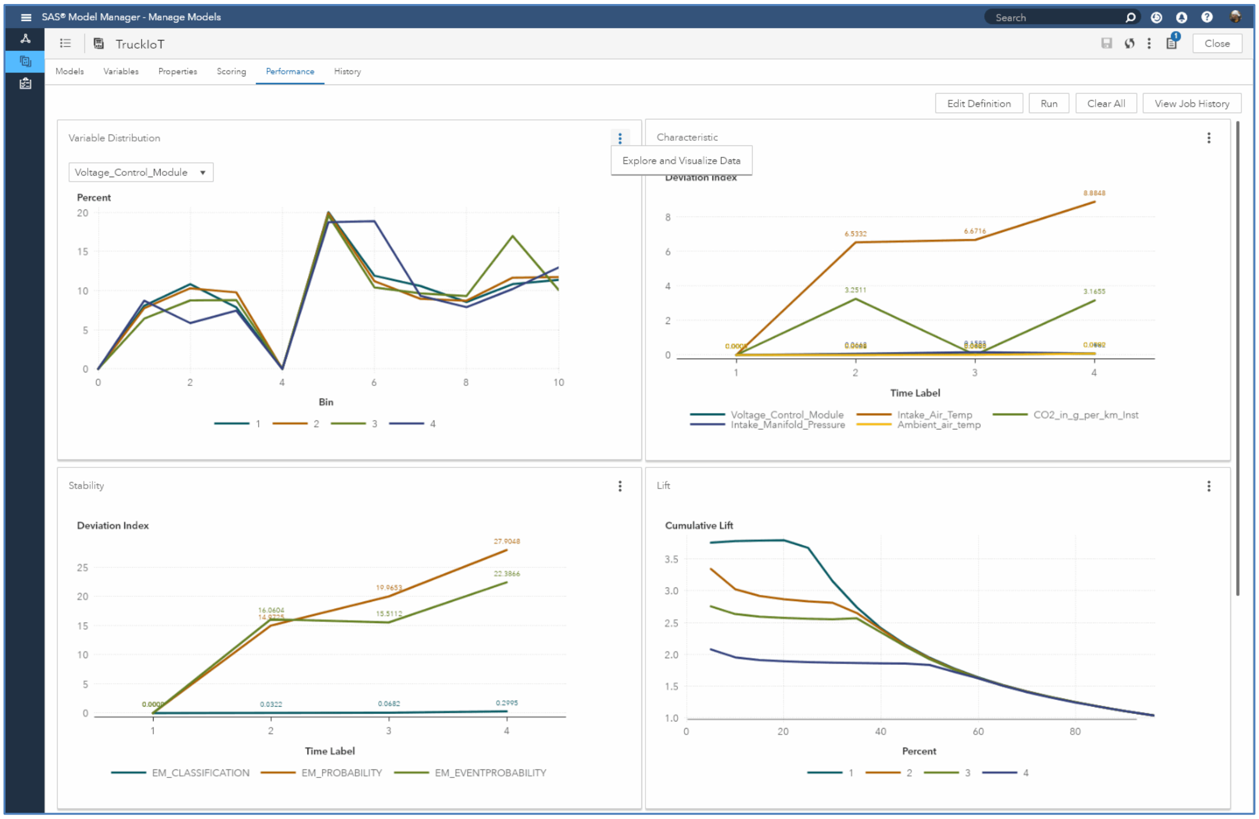


Display 6. Geospatial Transformer Load Analysis

DEPLOYMENT

It's not uncommon today for utilities with millions of customers to have tens of thousands of analytic models related to these customers. Organizations face a lot of challenges in managing analytical model collections. For many, it's an inefficient manual process that takes too long, especially when there are more models than ever. Model decay from underlying market or behavioral changes diminishes model effectiveness and can lead to poor decisions.

For the reasons set forth in this paper, the number of analytic models driven by mainstream adoption of EVs and the electrification of transportation will cause a dramatic increase in the number of analytic models requiring management in this phase of the analytics life cycle. See Display 7.



Display 7. Visually Examining Model Performance Results with User-Defined Performance Data

CONCLUSION

Driven by multiple factors—including planned policy-making by governments throughout the world—electric vehicles have reached a tipping point. While this presents an unprecedented opportunity for load and revenue growth for utilities, it also poses serious challenges to the operation of the electric grid.

E-mobility business models will evolve rapidly and will combine a complex and competitive ecosystem of stakeholders with an infrastructure consisting of an IoT ecosystem. This will create opportunities for the application of every kind of analytic technology including data mining, forecasting, optimization and simulation, and text analytics. Machine learning, deep learning, artificial intelligence, computer vision, and natural language processing will be front and center.

The electrification of transport is also the digitization of transportation. As Navigant Research points out, “The increasing complexity of business models will require more data from more sources, IT-OT convergence (merging the assets, people, and processes of traditionally disparate information and operations technology), and a sophisticated data and analytics platform” (Ravens 2018).

EVs sit at the intersection of transportation electrification, digital transformation, and the IoT and will provide one of the greatest varieties of use cases for the application of advanced analytics over the next 10-20 years. Analytics will play a key role as an essential enabler of transportation electrification and in achieving a low-carbon future.

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