Are Utilities Ready for Autonomous EV Charging Control?

Tory Neuenschwander, Senior Product Manager
Mike Ting, Senior Product Manager

WHITE PAPER

Have utilities gained enough confidence in Machine Learning Analytics and Artificial Intelligence to adopt autonomous managed Electric Vehicle (EV) charging as a tool in their Demand Response Programs?

PAST APPREHENSION

The world is at the cusp of an Artificial Intelligence revolution. Artificial Intelligence (AI) may become the most disruptive technological development to date creating new opportunities and risks in every aspect of business and life. Technology business leaders such as Elon Musk, Bill Gates and Warren Buffet have all issued apparent, ominous statements on AI:

"Robots will be able to do everything better than us…I am not sure exactly what to do about this. This is really the scariest problem to me."
-Elon Musk, South by Southwest (SXSW) tech conference 2018

The power of artificial intelligence is "so incredible, it will change society in some very deep ways… the world hasn't had that many technologies that are both promising and dangerous…"
– Bill Gates, Co-founder of Microsoft at the 2019 Human-Centered Artificial Intelligence Symposium at Stanford University

"If [self-driving cars] make the world safer, it's going to be a very good thing," Buffett said. "But it won't be a good thing for auto insurers."
-Warren Buffett at Berkshire Hathaway Annual Investors meeting 2017

Scary, huh?

What exactly is Artificial Intelligence then? You've no doubt heard that term thrown about very loosely by technology companies wanting to tout their sophisticated software offerings. Itron's generally accepted definition of AI simply means software developed to mimic aspects of human intelligence.

Artificial Intelligence can be classified in many different ways, but the most relevant way for our purpose is to segment it into three classes (listed here in order from most to least powerful): Artificial Super Intelligence (ASI), Artificial General Intelligence (AGI), and Artificial Narrow Intelligence (ANI). As the name implies, an ASI will be a formidable and truly autonomous machine capable of emotional response, self-directed learning, analysis and decision making to degrees well beyond what a human brain is capable of. Today, however, ASIs are purely theoretical as we lack not only the computing resources required, but also an adequate foundational understanding of autonomous intelligence and emotion to realize such a powerful machine-based application. In contrast to the super-human ASI, AGIs are generally understood to be a replicant of the human mind. Also still theoretical, researchers are looking for practical ways to implement human emotions and other competencies into machines to enable them to act like humans.

In contrast to the prior two classes, ANIs are the only type of artificial intelligence currently achievable in a practical sense. ANIs can consist of expert-systems based on rules and logic but may also be based on machine learning algorithms applied to vast quantities of data or set loose to explore and learn a custom environment (as in the Atari-playing agents). Regardless, an ANI is suited only to the task for which it was built and has limited generalization outside of that task. Understanding AI in the context of these classes will hopefully alleviate some reticence in implementing this technology in the Utilities industry. From this point forward, the use of 'AI' in this paper will always refer to an ANI system.

When deployed as a product offering, an AI is not autonomous in the sense of being free to make decisions outside of its deterministic algorithms; rather it is automated, and the algorithms can be 'black-box' in nature. These characteristics are the source of much of the legitimate concern that people have regarding bias and discrimination present in an AI system. As AI practitioners, we are obligated to be aware of and respond to these concerns and deploy AI in an ethical manner that is not detrimental to the human beings who will be influenced by the results of the AI system. In the strict case of optimizing utility operations, however, the human influence and emotion is minimal. The AI systems automate actions based upon past experiences as learned from historical data and provide the ability to adapt to new circumstances. This is the innovation that modern utilities can feel comfortable leveraging. Overall, the potential benefits of AI make such systems a valuable tool for utilities looking to solve the increasingly complex challenges of grid electrification.

TRANSPORTATION ELECTRIFICATION, UTILITIES, AND AI

The transition towards a highly electrified and decarbonized energy future is well under way. The trends that Nissan, Toyota and Tesla set in motion just a decade ago have now permeated across the entire automobile industry. With battery costs declining, vehicle range steadily increasing, and customer preferences evolving rapidly, nearly all the major auto manufacturers have announced plans to shift to producing all-electric fleets over the next 10-15 years. Electric vehicles (EVs) are now expected to outsell gasoline and diesel vehicles by 2040 with total penetration approaching 40%[1].

At face value, this transition to electrified transportation represents a source of significant growth in total electric load and revenue for utilities. The U.S. DOE's National Renewable Energy Laboratory estimates that load growth from EV charging could lead to sustained load growth of 80 TWh per year in the U.S. alone. Utilities rightly see transportation electrification as their biggest revenue growth opportunity in the last 20 years – as many have faced low-to-zero load growth from increased energy efficiency and adoption of behind-the-meter solar PV systems.

This growth in revenue will not come for free. Indeed, EV charging represents a significant increase in residential and commercial loads on a per-premise basis – so much so that some homeowners must upgrade their electric service just to install EV charging equipment. And because EV adoption is often clustered within a utility distribution network, these sharp local increases in load – when uncontrolled – can strain distribution transformers and other distribution assets in short order, leading to reduced asset life. Even worse, when these new EV charging loads combine with air-conditioning loads on hot days, transformers can quickly overheat and risk catastrophic failure.

The traditional approach to accommodating load growth in the distribution network is to simply add more transformers to the distribution network or replace existing transformers with larger-capacity units. However, considering that a typical utility operates tens or even hundreds of thousands of distribution transformers, continuing that approach will erode much of the revenue growth from EV charging.

Today, a utility with 1.4 million residential customers faces annual distribution system CAPEX and OPEX of roughly $300 million and $200 million, respectively. To accommodate a highly electrified transportation system, utilities will inevitably have to increase their distribution CAPEX spend from today's levels – perhaps substantially. The primary challenge for utilities, therefore, is how to minimize the CAPEX needed to accommodate growth in EVs, while maintaining the reliability and safety of the distribution network.

Protecting vulnerable transformers – and in turn minimizing the CAPEX spend – requires controlling EV charging in a distinctly different fashion than how other consumer loads have been controlled in the past for utility demand response programs. Historically, utilities used centralized control platforms to dispatch demand response resources to serve a single system-level need such as peak-shaving. Protecting distribution transformers requires defining the "need" of each transformer individually as each transformer will have a different combination of EVs and EV charging technology, customer charging behavior, non-EV loads, transformer capacity, age, and even varied weather conditions. Considering that a mid-sized utility may have hundreds or even thousands of vulnerable transformers, the amount and frequency of analysis and decision-making required to support this use case quickly exceeds the limits of what humans and the legacy control platforms are capable of.

Itron firmly believes that delivering transformer protection through controlling EV charging will require a significant level of autonomous control driven by Artificial Intelligence. In this application, an AI-driven system super-charges the transformer-specific analytics by learning patterns and optimal solutions that may be outside the capabilities of human analysts either due to sheer scale or the complexities of the data. Further, AI-driven system can either automatically deploy actions or recommend actions directly to the human analyst. For example, such a system may operate by predicting transformer load, detecting new EVs, and optimizing EV charging load for targeted distribution segments or by time-of-use (TOU) rate class for targeted segments. Analytics help utilities understand and prepare, but AI helps them act.

[1]Source: BloombergNEF, Electric Vehicle Outlook 2021

HOW DO UTILITIES CONTROL AI?

AIs require new oversight paradigms, such as human/machine collaboration in decision-making processes and clear rules of engagement. For Itron, it is important that we build failsafe operations into Distributed Energy Resource (DER) Analytics AI software that protect the utility as much as possible from triggering unwarranted events.

In general, it is important for utilities and technology companies like Itron to incorporate as many controls as possible into an AI system. On Feb. 11, 2019, President Donald J. Trump issued the Executive Order on Maintaining American Leadership in Artificial Intelligence. The executive order specifically directs the National Institute of Standards and Technology (NIST) to create "a plan for Federal engagement in the development of technical standards and related tools in support of reliable, robust, and trustworthy systems that use AI technologies." However, such a plan has not yet been published, so it remains the responsibility of utilities and technology companies to implement AI in a responsible manner. The following generalized list of key controls is not mandated but is useful in this effort:

1. Artificial Intelligence ethics and model governance
2. Data and model management, governance and privacy standards
3. Understanding the human-machine integration, interactions, decision-support and outcome for audit trails
4. Cybersecurity vulnerability, risk management and business continuity plans

Itron uses specific controls in AI systems. When these systems are running in production and important decisions are based on its recommendations, we use the following methods to ensure validation and produce an audit trail should errors occur:

» Structured and logged data acquisition and curation

» Structured and logged data pipeline processes

» Logging of versions and metrics of models

» Logging of model predictions

» Active monitoring of data and models for continued suitability

» Identification of the team or team(s) responsible for developing and maintaining the system

The above practices consider the AI system as a whole, not just the associated analytical models. A model is only going to be as good as the data collection, data processing and other elements of the system. The audit trail should extend to the collection, cleansing and storing of data as well. This is important especially if models are going to be automatically retrained on a pre-determined basis.

In addition to the ability to audit an AI system, there must also be an allowance for manual overrides. Whether it is the utility on an aggregate scale or an EV owner, autonomous charging must have a failsafe. We need to be able to say that the AI has "preferences" for when EVs can be controlled, but ultimately the EV owner can override that preference if they need their EV charged right away.

Feedback from many sources is required to report undesired behavior produced by an AI system. Both utilities and end users are provided mechanisms to notify Itron when they see something atypical. This feedback loop is necessary and will help ensure Itron's AI system continues to serve all customers as accurately and efficiently as possible.

CONCLUSION

AI systems are powerful tools for the utilities sector, especially in light of increasing grid complexity caused by the proliferation of Distributed Energy Resources. AIs can enable more informed and efficient planning, better decision making, and even take actions that may otherwise be impossible to help ensure a smooth and cost-effective transition to a rapidly expanding DER world. However, the complexity and power of AI systems also creates new challenges. As a greater amount of analysis and decision making is delegated to machines, it is important that all resulting actions are traceable through the system that produced them. This means a rigorous AI-specific auditing structure needs to be in place in addition to the traditional software and product quality assurance protocols. As you consider implementing advanced Distributed Energy Management Systems or are looking for enhanced systems with the ability to provide detailed analysis on EV specific load, ensure that the system of choice provides the safety mechanisms and audit integrity that allows you to comfortably use AI.

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To learn more visit **itron.com**

CORPORATE HQ

2111 North Molter Road
Liberty Lake, WA 99019 USA

Phone: 1.800.635.5461
Fax: 1.509.891.3355