Electric Vehicle (EV) Charging:

The Missing Link for Smart, Sustainable Cities

eBook

October 2022

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Foreword

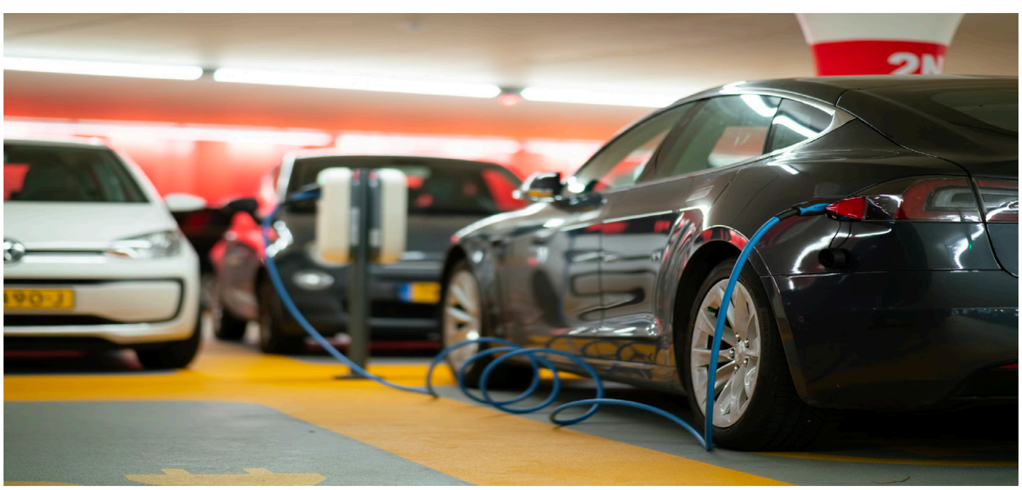
The Electric Vehicle revolution is underway - but is our infrastructure ready to support it?

The future of mobility is electric. With accelerating advances in battery technology, vehicle software, and connectivity, electric vehicles (EVs) promise to improve upon vehicles powered by internal combustion engines (ICE) by providing a safer, cheaper, and more sustainable transportation experience. Crucially , EVs also play a major role in increasing our stewardship of the environment and building a more sustainable future.

Currently, traditional ICE vehicles are a necessity for modern life, but require burning fossil fuels which produces harmful emissions. Therefore, cities and governments around the world have increasingly incentivized the adoption of electric vehicles by providing direct rebates, promoting mining minerals used in EVs like lithium and nickel, and legislating strict emissions targets.

These policy initiatives, coupled with a greater interest in sustainability by consumers, has led to an explosion of EV adoption worldwide. Unfortunately, barriers still remain. For EVs to continue to grow, consumer concerns need to be addressed. Chief among these concerns is "range anxiety"—the average EV range is around 225-250 miles, and while this will increase over time, it remains a major barrier as consumers fear the possibility of running out of fuel during a trip with their EV.

The factors of rapid adoption of EVs and "range anxiety" emphasize the need for more EV charging stations. Unlike gas pumps, EV charging stations refer to equipment that charges electric vehicles by supplying electrical power. It is important to recognize that EV charging technology, like that of EVs, is nascent and still emerging, resulting in many different types and capabilities of available EV charging stations.



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The Rise of EV Charging Station Infrastructure

EV charging stations span three levels

	Level 1	Level 2
Voltage	120v 1-Phase AC	208v or 240v 1-Phase ac
Charging Loads	1.4 to 1.9 kW	2.5 to 19.2 kW (Typ. 7 kW
AMPS	12-16 Amps	12-80 Amps (typ. 32 Amps)
Charging time for Vehicle	3-5 Miles of Range Per Hour	10-20 Miles of Range Per Hour
Deployment Environment	Residential	Public/Commercial
Price Range *(Excluding installation costs)*	$300-$600	$500-$1,200

Voltage	208V or 480 3-Phase AC
Charging Loads	<90 kW (typ. 50 kW)
AMPS	<125 Amps (Typ. 60 Amps)
Charging time for Vehicle	80% Change in 20-30 Minutes
Deployment Environment	Public/Commercial
Price Range *(Excluding installation costs)*	$20,000 - $50,000

The EV charging industry features three major levels of charging with significant differences in price, application complexity and interface quality.

- **Level 1 EV Charging Stations:**
Level 1 EV charging stations utilize common household electrical outlets and can be thought of as a plug or extender since the actual charging occurs on-board the vehicle. These "stations" are inexpensive or provided gratis with an EV purchase and are almost exclusively used for residential charging given their slow speed.

- **Level 2 EV Charging Stations:**
Level 2 EV charging stations are the most common type, but they are typically more expensive than Level 1 chargers. These stations use high-powered outlets (240V) to fully charge vehicles in 6-12 hours, and are mostly found in residential and commercial settings like multi-dwelling units. Unlike Level 1 charging stations, Level 2 chargers may have some remote maintenance, pricing, and load balancing capabilities.

- **Level 3 EV Charging Stations:**
Also known as DC Fast Charging (DCFC), level 3 EV charging stations differ greatly from other levels in that the charging happens fully within the station and it uses DC power, allowing users to fully charge an EV in as little as 30 minutes. These stations must allow for AC/DC power conversion and typically cost between $15-40k, making them unsuitable for residential charging. Found in commercial and public spaces, DCFC stations have the flexibility to incorporate and enable many new applications.

A majority of EV charging stations are "slow" chargers - Levels 1 and 2. These types are most suitable for overnight charging in residential homes and buildings. For cities, retailers and fueling stations, charging times that span hours are simply unfeasible for their business models. Therefore, these actors are increasingly turning to Level 3 DCFC stations to allay "range anxiety" and incentivize EV adoption.

EV charging allows for a re-imagining of the vehicle fueling paradigm, in which EV charging can play a central role in smart cities sustainability and infrastructure initiatives. To prepare for the EV charging future, governments and cities around the world are heavily incentivizing the construction of public EV charging stations. Though EV and EV charging adoption varies by country, nearly every region is passing policies that affect EV charging.

Many of these policies are part of larger sustainability initiatives, demonstrating the importance of EVs and EV charging to the future of sustainability. Each major region and country is taking a slightly different approach to how they are subsidizing, legislating or directly funding EV charging infrastructure, which reveals idiosyncrasies in their strategies:

- **North America:**
This year, two major policies were passed in the U.S.: the Bipartisan Infrastructure Law, which introduced the National Electric Vehicle Infrastructure (NEVI) program, and the Inflation Reduction Act (IRA), which provides additional tax credits for EV charging station purchases. NEVI covers up to 80% of the costs for states to deploy EV charging infrastructure as it seeks to encourage a nationwide charging network. In Canada, a new program allocates almost $1 billion for public EV charging station deployment.

- **Europe:**
In Europe, the European Commission's Alternative Fuels Infrastructure Directive sets a framework outlining how each country should invest in EV charging infrastructure, but individual countries are responsible for passing their own programs. Germany, France, the U.K., and others have all passed attractive incentives for EV charging stations.

- **China:**
Compared to other countries, China has taken a strong lead in terms of EV and EV charging station adoption. Through the New Infrastructure Plan and the latest Five-Year Plan, incentives for EV charging stations and battery swapping stations have helped China's installed base of DCFC stations surpass those of other nations.

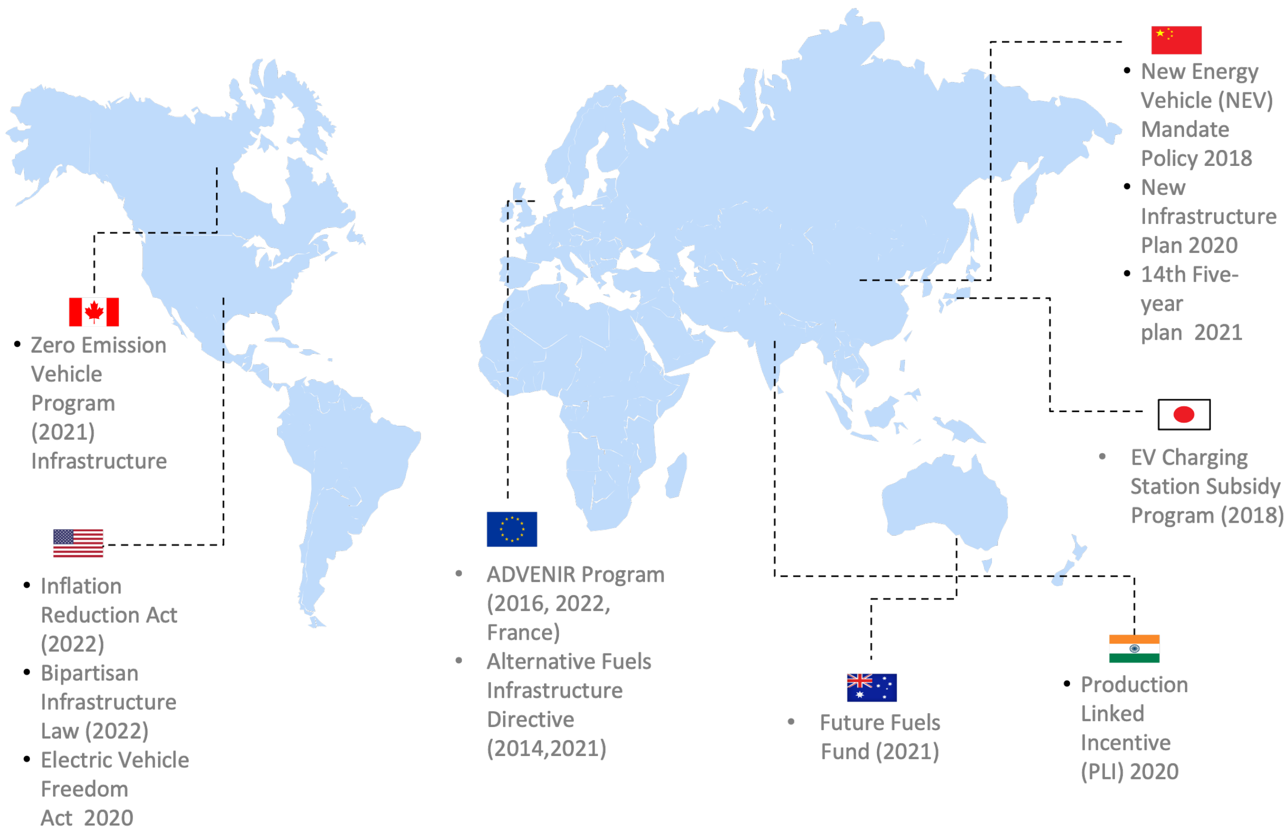
- **Rest of World:**
Other nations have been slower to adopt EVs and EV charging stations, but policies in emerging markets are starting to accelerate. In India, the FAME I & II Acts mandate large cities to have at least one EV charging station in every 3km x 3km grid. The UAE's EV Green Charger Initiative seeks to increase EV adoption in the Middle East, and investment by private utilities like Enel have helped spur EV adoption in South America.

35% EV charging station market is projected to witness a CAGR of more than **35%** during 2022-2028

1.1m China has more than **1.1 million** public EV Chargers accounting for 65% of such chargers in the world

$115B Global EV charging station market size & share is expected to hit USD **115 billion** by 2028

24% The number of DCFC ports increased by **24%** from 2020 to 2021 in the US



- IRA'22 provides tax credit of up to $7,500 for businesses and individuals purchasing EV chargers
- NEVI'22 provides $5 billion to states to deploy DC Fast chargers

- NIP'22 will spend $1.4 Trillion on digital infrastructure including new-energy vehicle charging stations and ultra-high voltage transmission

- ADVENIR'2020 (France) allocates €100 million for 45,000 new charging points by the end of 2023

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As policymakers continue to allocate significant funding for EV charging initiatives, the opportunity for EV charging suppliers, manufacturers and customers expands. These players need to carefully consider the future of mobility and design EV infrastructure accordingly.

As range and cost concerns may dissuade customers from purchasing EVs, other concerns may be holding back the EV charging market from achieving its potential.

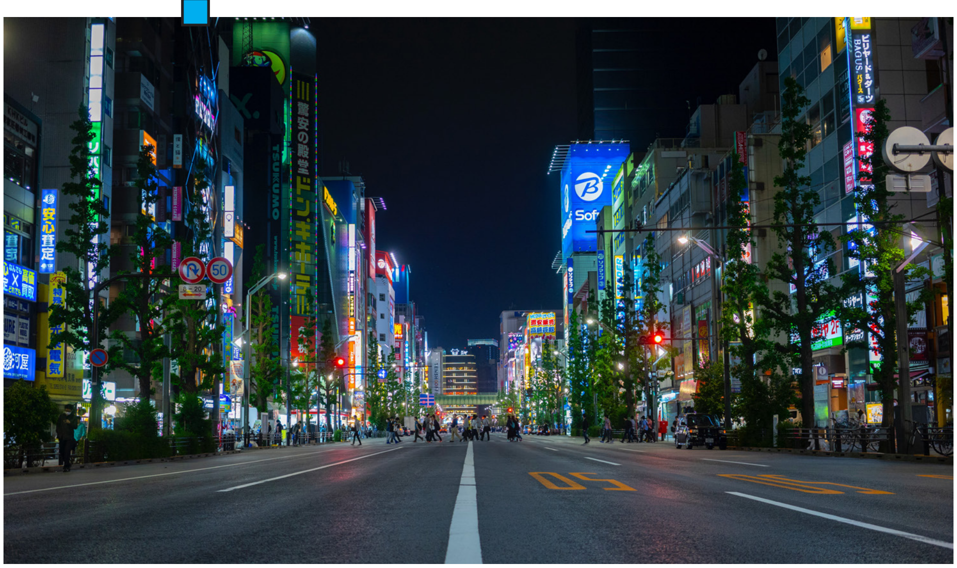
Need for New Business Models: Unlike ICEs, where vehicle fueling only occurs in commercial venues like gas stations, EVs allow for vehicle fueling to occur overnight in someone's place of living, when utility rates are at their cheapest. While great for consumers, this poses challenges to gas stations, who rely on visits and retail revenues in order to break even. EV charging will force these suppliers to change their business models, potentially turning to digital signage and advertising to recoup costs.

EV Charging Station Costs: Advanced DCFC stations can cost in excess of $40,000 to purchase, in addition to maintenance, installation and software costs. Leveraging incentives and subsidies will be critical to justify the expense of DCFC infrastructure, especially for cities with limited budget.

Impact on Utilities Peak Loads: Current electricity transmission and distribution infrastructure is struggling to keep up with the demand that new technologies bring, and the thought of EVs simultaneously charging during peak loads worries some utilities. However, this presents an opportunity for suppliers to implement V2G and bidirectional charging and load balancing to allow EV charging stations to play a key role in the future of energy and electricity.

DCFC Battery Degradation: Fast charging may accelerate the speeds at which EV batteries degrade[1], especially those that opeate in extreme climate conditions. Advanced batter management systems (BMS) and load balancing capabilities in the DCFC station can help reduce this impact, but will likely require edge AI capabilities to ensure constant battery condition

While these barriers will impact adopters, suppliers, and energy providers, they also present opportunities to reimagine the future of EV charging. By augmenting EV charging stations with advanced capabilities, these equipment can play a major role in creating the smart cities of the future.



1. Geotab, 2020. (Link)

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How Edge Computing, AI and Connectivity Make EV Charging Sustainable, Equitable and Profitable

By future-proofing Level 3 DCFC stations, cities and retailers have the opportunity to implement a more sustainable infrastructure solution. However, DCFC stations have unique requirements compared to Level 1 and 2 chargers, such as the power conversion process from AC to DC power and the need for integrated payment processing and connectivity.

To help effectively manage the power conversion process while supporting applications that provide value to customers and solution providers, these stations require high-compute silicon—no ordinary solution will do. Though this might add to the upfront costs, emerging applications like a multi-interface UI and digital signage with targeted advertisements will quickly demonstrate their value.

A specialized type of high-compute silicon is the field-programmable gate array (FPGA). As implied in its name, this integrated circuit can be configured after manufacturing to fit the specific needs of its application. Specifically, FPGAs have proven capable at optimizing the AC/DC power conversion process, so that the power lost in the conversion is minimized and can be used to power the vehicle, resulting in cheaper prices for the customer while reducing the load for utilities.

FPGAs also support battery management. Unlike charging with AC power, DC fast charging risks overloading EV batteries, which could contribute to their decay, or loss of range over time. FPGAs support batteries and BMS by providing the compute necessary to evenly distribute loads across cells, eliminating the threat of decay and providing greater longevity to the battery.

Battery management and efficient power conversion are also important ingredients for vehicle to grid (V2G) charging, or the ability for EVs to provide power to the grid through EV charging stations. This allows utilities to reduce peak loads and unlocks new revenue streams for EV owners by allowing them to monetize excess electricity. Optimizing AC/DC conversion increases the amount of power to offload to the grid, turning EVs into distributed energy resources.

Anatomy of a Level 3 DCFC Station

Energy Management And Load Balancing
Detect the type of vehicle and optimal charging regimen; power allocation and load balancing algorithms amongst charging station end-points

HMI/Infotainment
User friendly HMI paired with video animation and real-time responsive elements that enables easy interaction between EVs and EV charging station

Payment Facilitation
Bluetooth and NFC radios for effortless, touchless payment transactions, paired with access control software to improve user experience

Dynamic Advertisements and Digital Signage
Marketing capabilities and customer experience focused use-cases such as targeted advertisements enable the sales journey to start in the parking lot

High Power Levels
High power levels drive higher power losses; minimal power losses are critical in DCFC applications for both operators & customers

Efficiency
Optimize the AC to DC power conversion process by minimizing power loss, saving money for both users and utilities operators

Battery Management
Provides computation requirements, density improvements for advanced battery models enabling second life for batteries

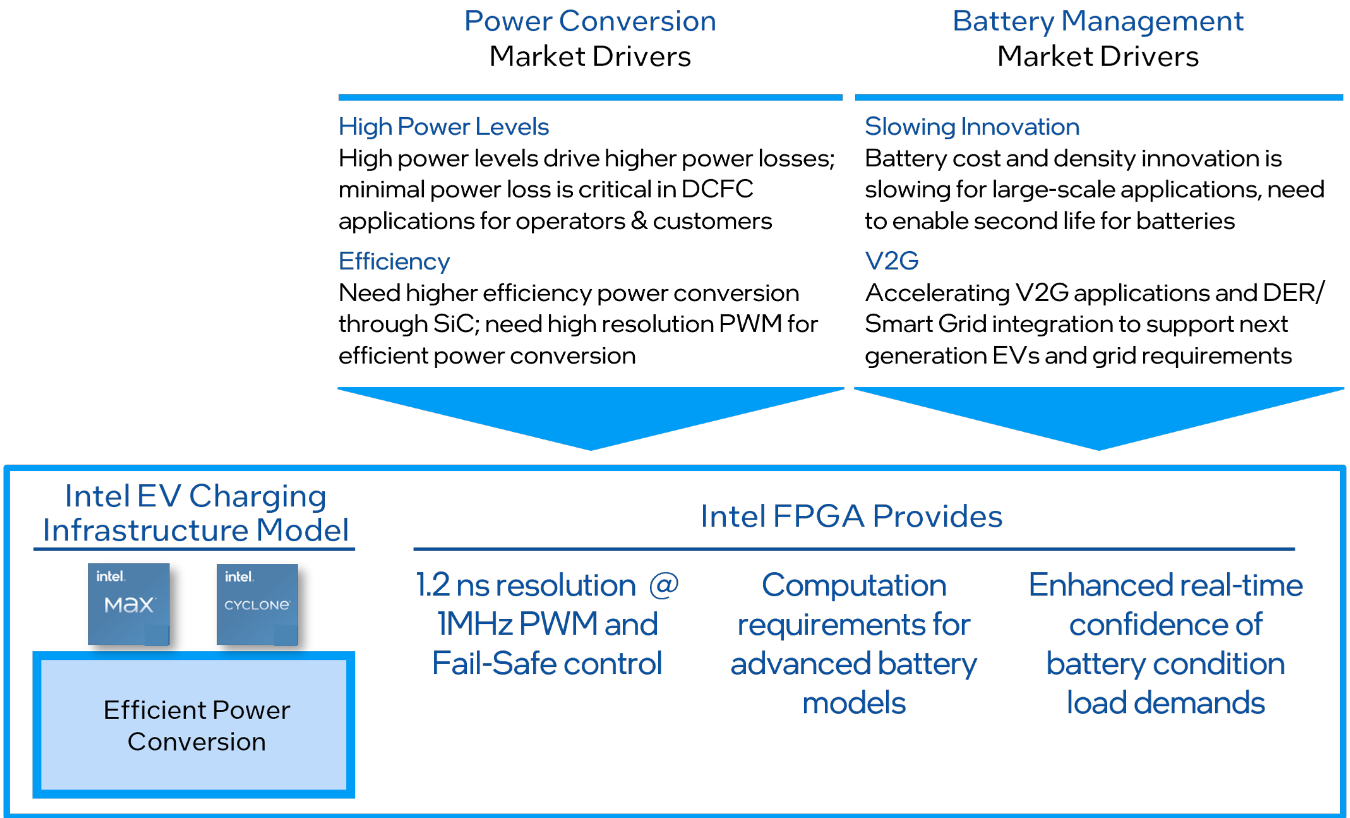
V2G (Bidirectional Charging)
EV Charging Stations that enable vehicle-to-grid communication allow DCFC Stations to function as distribute energy resources, powering the grid during off-peak hours

Intel Compute

- Connectivity
- AI and Analytics
- HMI/ Infotainment

Intel FPGA

- Power Conversion
- System Monitoring
- Charging Infrastructure



How artificial intelligence unlocks the future of EV Charging

Artificial intelligence (AI) and machine learning (ML) have created massive amounts of value across industries, although they have traditionally been absent from the vehicle fueling process. Upgrading DCFC stations with edge AI capabilities can unlock significant value-added applications:

AI-Based Security: Using computer vision and integrated camera systems, EV charging stations can detect and authenticate a user based on their license plate number and automatically begin the charging process. This can also be used to detect potential fraud events and integrate with site surveillance systems to deter vandalism and theft.

Automated Load Balancing: With integrated smart meters, DCFC stations can monitor the fluctuating price of electricity in real-time to optimize the price of EV charging. As DCFC stations increasingly integrate with renewable energy generation and storage systems like solar panels and inverters, the station can optimize the use of renewable loads during peaks.

Personalized/Targeted Advertising: One way that customers can offset DCFC implementation and maintenance costs is by using the charger's HMI as a digital signage application. By providing personalized advertisements or infotainment to satisfy users during the longer charging period, adopters can unlock new revenue streams.

Smart Parking & Road Infrastructure: The data collected by DCFC charging can be invaluable to supporting emerging smart city ecosystems, like smart parking and traffic management. Repurposing parking spaces as charging stations unlocks applications to detect and predict occupancy status, while charging data can be used to predict traffic patterns, helping city management systems reduce congestion.

Charging Infrastructure
Market Drivers

Cost Savings Chargers are expensive to deploy without end-customer value, value-adds such as dynamic digital signage	**Intelligence** Demand for chargers with intelligence built-in, enhancing charge point/ station management and operations
User Experience More powerful HMI displays with cloud-based payment, processing, & frictionless driver/ user experiences	**Edge Analytics** Ensuring operational uptime and site security is paramount, to protect both infrastructure and customers

Intel EV Charging Infrastructure Model

intel CORE | intel ATOM | intel XEON

AI Analytics, Intelligence & Infrastructure

Intel CPU Provides

AI analytics for charging equipment and deployment point	Security gateway for chargers, with FuSA support	Containerized environment for external API's with hardened enclaves

As innovators continue to develop new AI transportation applications, the data collected and produced by DCFC stations will be increasingly valuable. Preparing these stations for the future of AI will help to future-proof EV charging infrastructure.

For cities and retailers with limited budgets and funding, the cost of a technical refresh can be prohibitive. Consumers are increasingly demanding new personalized, digital experiences powered by advanced technologies. To prepare for this future, EV charging suppliers and adopters should build-in flexibility to DCFC stations to handle the workload demands of future applications.

To accomplish this, workload convergence helps unify compute workloads on a single platform, providing application and compute scalability. Additionally, a Cloud connection can offload increasing data volumes. Suppliers should focus on building stations with longevity in mind.

Altogether, these applications may require a larger capital expenditure, but they are important for reimagining the role of EV charging stations. With bidirectional charging/V2G, consumers can realize new revenue streams from charging, turning vehicle fueling from a cost into a revenue stream for drivers. Vehicles will likely remain expensive, so charging can help drivers recoup EV costs, regardless of their income. This helps create a more equitable transportation future for all. In addition, EV charging can reduce our reliance on these polluting gas stations, which are often placed in low-income environments. EV charging stations with connectivity can also bring WiFi or private networks to more communities.

3

EV Charging Stations in the Forecourt of the Future

The forecourt of the future concept turns the current filling station format on its head, unlocking new value for retailers and cities

With high-compute DCFC stations, cities and retailers will have made significant progress in enabling the future of smart cities. EV charging promises opportunities to implement a new vision for evolving consumer experiences.

EV charging's longer fueling times, as well as its potential to unlock new applications, makes it a perfect candidate to participate in and augment the retail and smart cities experience.

The Forecourt of the Future concept can more directly integrate EV charging into daily life, while using the DCFC station to directly power and support retail and urban road infrastructure applications.

For example, a DCFC station using AI-powered license plate or vehicle make and model recognition can quickly identify a customer and integrate with a retailer's rewards and loyalty programs. The retailer could then offer a discount for customers who both charge vehicles and make retail purchases.

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THE FORECOURT OF THE FUTURE

ENERGY MANAGEMENT

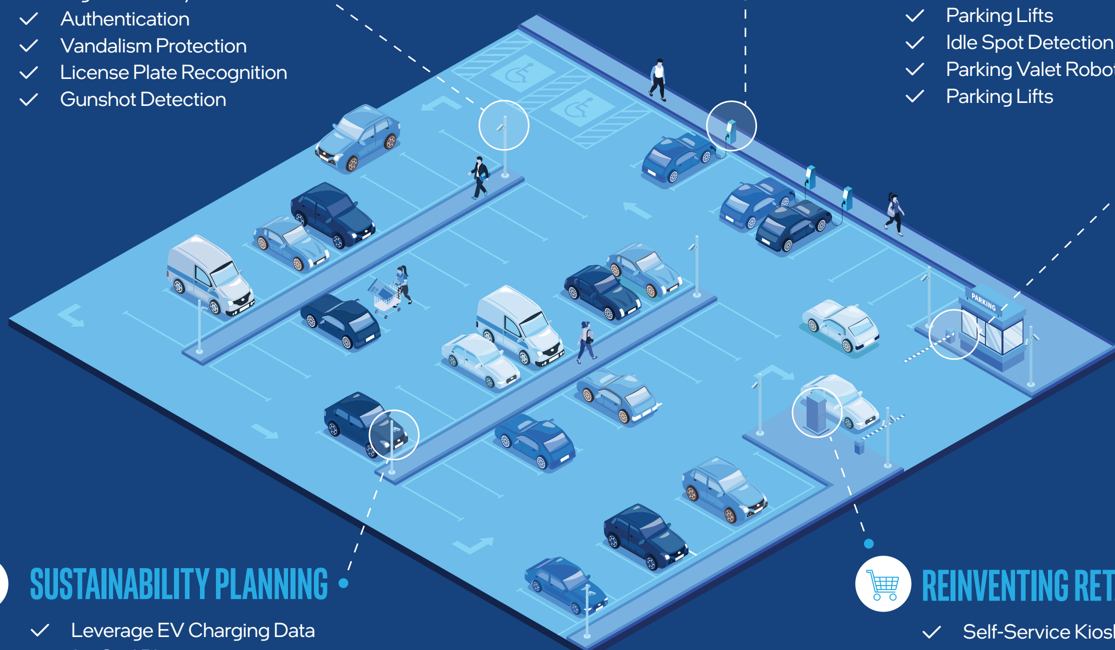
- V2G & Bidirectional Charging
- Integrated Smart Meters
- Automated Load Balancing
- Energy Storage

SAFETY & SECURITY

- Digital Security
- Authentication
- Vandalism Protection
- License Plate Recognition
- Gunshot Detection

TRAFFIC MANAGEMENT

- Pedestrian Safety
- Route Optimization
- Parking Lifts
- Idle Spot Detection
- Parking Valet Robots
- Parking Lifts



SUSTAINABILITY PLANNING

- Leverage EV Charging Data for Grid Planning
- Smart Street Lighting
- Energy Usage Optimization

REINVENTING RETAIL

- Self-Service Kiosks
- Digital Signage
- Point of Sale Integration
- Personalized & Targeted Advertising
- Loyalty & Rewards

In retail environments – like apparel stores, hotels and resorts, or even fast-casual restaurants, the EV charging station can play a key role in enabling emerging retail applications. As customers park their vehicles into integrated charging spaces, the charging station can automatically authenticate the user, understand their purchase history to recommend items to their taste, and validate their rewards membership to promote discounts.

In addition to retail and commercial venues, DCFC stations are often deployed in public spaces within cities. They can therefore play a key role in enabling the smart city of the future. Connected to the central utilities grid infrastructure of cities, EV charging stations could represent key interface points that optimize the consumption of electrical power while enabling V2G and bidirectional charging, allowing for a more sustainable power infrastructure, as well as other applications:

Self-Service Kiosks: The EV charging station's HMI can also function as a self-service kiosk in retail venues. For example, as someone charges their vehicle in a quick-serve restaurant, they can place a food order directly from the charging station's interface. If they choose to eat at the restaurant, they may exceed their necessary charging time, but with load balancing, the EV charging station can optimize the price of charging over that time.

Digital Signage: Digital signage on EV charging stations in retail apparel venues can promote and recommend targeted products based upon a user's customer profile and purchase history, even integrating payment directly on the charging interface.

Point-of-Sale (POS): The EV charging station features payment processing capabilities to fulfill the charging experience. In retail venues this could be bundled with the retail payment, leveraging the charging station's POS and potentially offering bundles or discounts for combining EV charging with retail purchases.

Digital Security: EV charging stations could help authenticate retail customers. In additon, cameras integrated with these systems can help detect and deter theft, fraud and vandalism activities, helping to enable a safer retail experience.

Transportation: Within transportation venues like airports and rail stations, EV charging stations allow users to charge their cars while traveling. For long trips, vehicles in these venues will likely remain idle—however, they could function as batteries where EV energy is used to power urban transportation systems during peak loads, helping to reduce the strain of electricity generation and distribution.

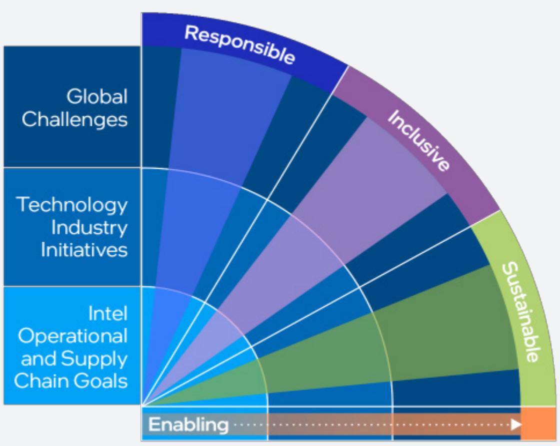
Smart Lighting: EV charging stations can also function as smart lighting systems, allowing excess EV energy to sustainably power smart city lighting. Occupancy data collected from EV charging stations could help optimize lighting patterns.

Traffic Management: EV charging stations help enable smart parking and traffic management systems in cities. As stations fluctuate in their usage and occupancy, this data allows city stakeholders to better predict traffic patterns, helping route drivers accordingly or directing them to an optimal parking and charging space.

For this future to be realized, cities need to invest in upgrading their data management and analysis infrastructure. Over time, EV charging stations can fully integrate into smart cities power and road infrastructure ecosystems, adding value to city stakeholders and drivers alike.

A central value proposition of EV charging stations is that they are networked together, or integrated in one, potentially nationwide EV charging network. Unlike individual, disparate gas pumps, EV charging stations all fit into the same electrical power grid and can communicate their energy needs across great distances. This will enable a more resilient, sustainable renewable energy future by allowing for better utilities planning, consumption and renewable power generation.

Intel's RISE Strategy



Intel's RISE strategy is a corporate initiative to increase collaboration with others to create a more responsible, inclusive and sustainable world, enabled through technology and collection actions. In addition to Intel's own operational and supply chain goals, Intel has made a commitment to net zero greenhouse gas emissions in its operations by 2040. Intel is addressing global sustainability challenges with external technology initiatives, including EV charging. For example, Intel's Mobileye technology is enabling automotive safety around the world, in addition to major healthcare and industrial initiatives to promote sustainability in major industries. Only together can we make a difference.

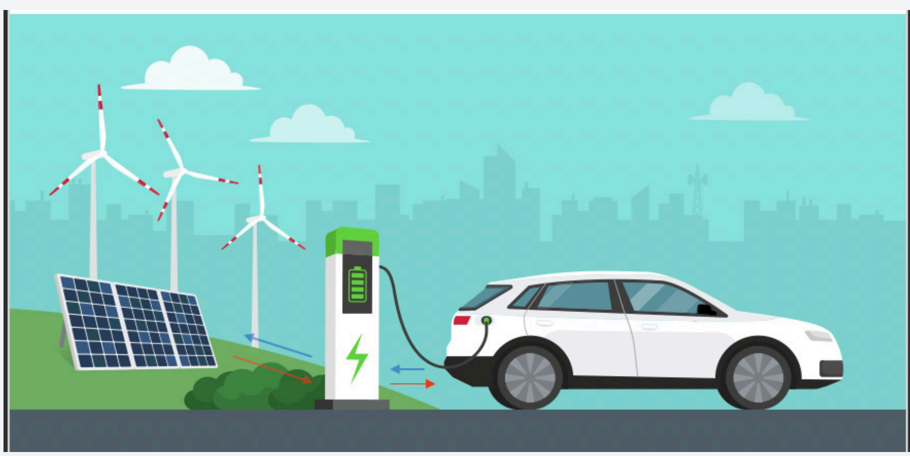
Sustainability Planning: Currently, utilities are working closely with EV charging station manufacturers to leverage EV charging data for better grid planning. By using occupancy data and predicting energy demand, utilities can better prepare for the future of EVs by making better-informed grid infrastructure investments.

Energy Usage Optimization: Load balancing at the point of charging can help optimize the consumption of electricity and reduce its usage during peak loads, allowing utilities to meet greater energy demand with fewer generation and transmission infrastructure investments.

Renewable Generation & Storage: Over time, EV charging stations may include on-site renewable energy generation systems, such as solar panels, along with energy storage systems, such as batteries. These upgrades, combined with software-defined load balancing, can enable EV charging stations to automatically use renewable loads during peak times and otherwise offset renewable power back to the grid, replacing the need for power plants.

With these capabilities, EV charging stations can play a major role in enabling more sustainable cities. However, it will take collaboration and data sharing by suppliers and consumers alike to create a world that is more responsible, inclusive, sustainable and enabled through technology.

EVs Support End-to-End Utilities Infrastructure



With FPGAs and communication capabilities with utilities infrastructure, EV charging stations can facilitate the transfer of power from the EV to the grid, not just vice-versa. This allows EVs to be directly integrated into our utilities infrastructure, functioning somewhat as batteries where they charge the grid during peak times, reducing overall energy consumption and peak loads.

4

EV Charging Solutions

The solution spotlights that follow are available now or will become available in the near future. This is not intended to be a comprehensive catalog of all products or product-categories in existence, but rather, these are illustrative possibilities to demonstrate the breadth of solutions that are available.

Imagen Energy + SECO AI EV Charging Station

Solution Overview

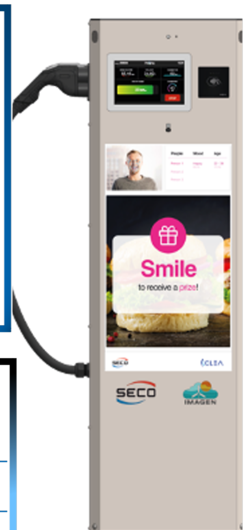
SECO and Imagen Energy's AI EV Charging Station, powered by Intel compute and FPGA, is five times smaller than traditional DCFC solutions and leverages off-the-shelf software tools and applications for fleet charging

Value Proposition

- Allows system integrators and customers to quickly field a fleet of EV Chargers and manage quality services for customers
- Provides contactless payment, predictive maintenance, digital signage, and security

Solution Components

- Intel FPGA
- CLEA Hardware Development Kit
- IMAGEN EV-100



Solution Summary

Use:	EV Fleet Charging
Company:	Imagen Energy + SECO
Product:	CLEA AI Charging Station

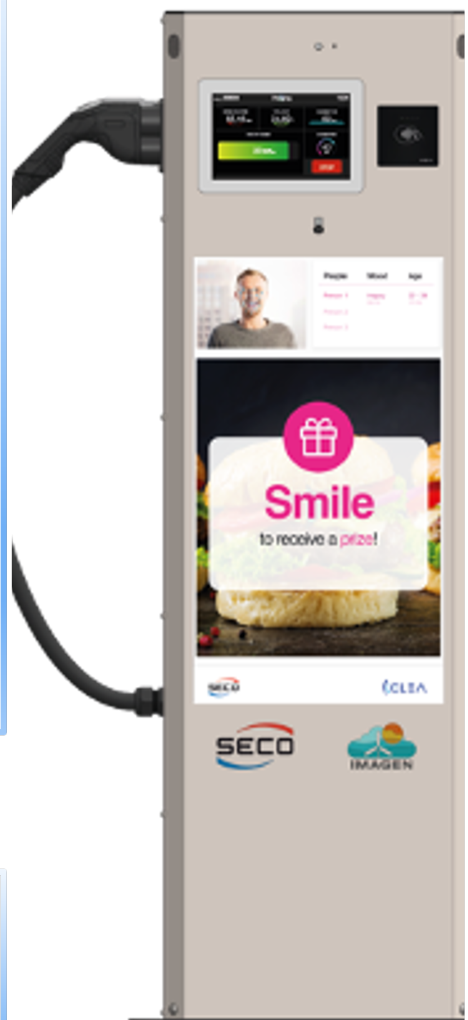
SECO CLEA AI EV Charging Station

Solution Overview

SECO and Imagen Energy's AI EV charging station, powered by Intel compute and FPGA, is five times smaller than traditional DCFC solutions and leverages off-the-shelf software tools and applications for fleet charging, including dynamic advertisements

Value Proposition

- Allows system integrators and customers to quickly field a fleet of EV Chargers
- Provides contactless payment, predictive maintenance, and security
- Edge AI-powered dynamic advertisements



Solution Components

- Intel Atom X Series Processors
- CLEA CORE software, based on Intel OpenVINO for people tracking, vehicle recognition, and other applications
- IMAGEN EV-100 (with Intel Cyclone V FPGA/SOC)

Solution Summary

Use:	EV Fleet Charging
Company:	SECO S.p.a
Product:	CLEA AI EV Charging Station

EOS LINX

EOS Linx EV Charging Station

Solution Overview

EOS Linx EV charging stations incorporate layers of technology into each charging station to enhance the driver experience and provide immediate value to every charging location, as well as high visibility engagement opportunities for advertisers,

Value Proposition

- Integrated renewable energy to reduce energy costs
- Compatibility with all EVs
- Hyper-local targeting and ability to daypart advertisements
- Easy-to-use, UL certified system
- Voice analysis, motion detection, and thermal tracking

Solution Components

- Intel vPro Platform powered by Intel Core i5 Processors
- Intel OpenVINO Toolkit
- 75" Digital Display
- EOS Security Component

Solution Summary

Use:	EV Charging for Drivers & Smart Cities
Company:	EOS Linx
Product:	EOS Linx EV Charging Station

Getting Started

The EV Charging future is still being written, providing us an opportunity to shape it together.

EV Charging promises to drastically alter the vehicle fueling paradigm. Cities, suppliers and retailers should view this change not as a challenge, but as a major opportunity. By rethinking how vehicle fueling fits into broader retail, energy utilities and urban transportation infrastructure, stakeholders can take advantage of these solutions to usher in a new era of technology-enabled sustainability and mobility.

The time to act is now—these stations are still being specified, and the recent influx of funding and subsidies will likely lead to an explosion in adoption of EV charging stations in the near future. Together we can work to promote the value of future-proof EV Charging Stations that provide a better charging experience for all. This will require close collaboration though all stages of the transportation value chain, as well as aligning on open data sharing and infrastructure standards.

Intel is committed to improving the lives of citizens everywhere through technology. We look forward to working together to unlock the full potential of EV charging and the once-in-a-generation opportunity it represents.

Get in Touch

The following industry experts are available to help you identify Intel technology solution partners for your specific situation and needs:

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October 2022

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