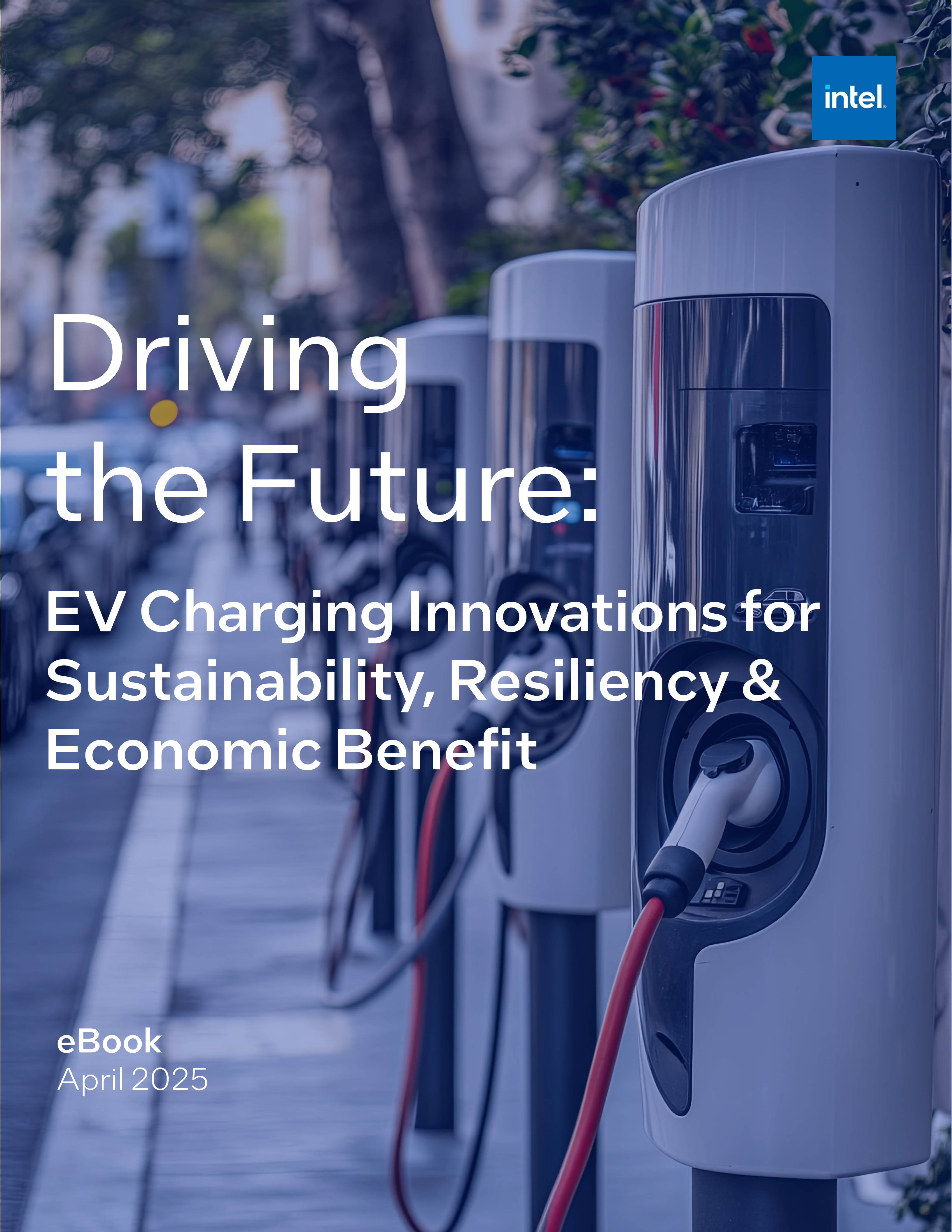


Driving the Future:

EV Charging Innovations for Sustainability, Resiliency & Economic Benefit

eBook

April 2025

What's changed since the last edition?

Since the paper's original publication in 2022, the EV, charging, and broader transportation landscape have evolved significantly, driven by innovations that emphasize sustainability, economic benefit, and resiliency. Breakthroughs in battery technology and renewable energy integration have advanced sustainability by reducing emissions and enabling greener infrastructure.

At the same time, generative AI is enabling innovative economic models—from new revenue streams for smart charging stations to optimized grid management—delivering tangible financial benefits to cities and businesses while improving consumer experience.

Finally, enhanced resiliency through improved load balancing, smarter energy distribution, and robust digital platforms is ensuring that the transportation ecosystem remains reliable and adaptable amid growing demand. Together, these trends are creating a more sustainable and interconnected ecosystem for electric mobility.

> "Our transportation system is evolving, it is no longer just concrete, asphalt, and steel. Today, our transportation system includes sensors, software, data, and algorithms. In this new era of infrastructure, we will link the physical transportation system with a digital layer, allowing us to gather, transmit, store, analyze, communicate, and share information in real-time, and to use that information to increase safety, reduce congestion, reduce emissions, and enhance mobility for every transportation user."

Laura Chace, President & CEO, ITS America, May 2024

Contents

4 Foreword
5 The Rise EV Charging Station Infrastructure
9 Making EV Charging Stations More Sustainable, Equitable and Profitable
15 EV Charging Stations in the Forecourt of the Future
20 EV Charging Solutions
23 Getting Started & Intel Resources

Author
Anthony Abuta,
Director, Cities & Intelligent Transportation, Intel

Editors
Harry Pascarella, Vice President, Harbor Research, Inc.
Daniel Intolubbe-Chmil, Director, Harbor Research, Inc.

Contributors
Joe Jankosky
Megha Sarang
Yau Wei Yeong
Vibhu Bithar
Gustavo Michel

Executive Sponsor
Prakash Kartha, GM, Transportation Infrastructure, Edge Computing Group, Intel

Foreword

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

The future of mobility is electric. 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.

Also, EVs 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 gasoline, producing harmful emissions and lowering air quality. 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 from consumers in sustainability and the other benefits EVs provide, has led to an explosion in worldwide EV adoption. However, barriers still remain. For EVs to continue to grow, consumer concerns need to be addressed. Chief among these concerns is "range anxiety"—the fear of possibly running out of charge during a trip and not being able to find a convenient charging station. While the average EV range has grown to around 250-300 miles, up from 225-250 miles when this paper was first published in 2022, range can be impacted significantly by weather and driving conditions. Combined with a perceived lack of access to charging stations and the inconvenience of waiting for the battery to charge, EV adoption continues to face headwinds in the market.

These factors—the rapid adoption of EVs and the persistent "range anxiety" — emphasize the need for more, and more advanced, EV charging stations. Like gas pumps, EV charging stations provide the electricity that allows EVs to run. Intermediaries between the electric grid and consumers, these chargers can be found at service stations, retail businesses, and residential buildings and homes. However, EV charging technology, like that of EVs, is nascent and still emerging, resulting in many different types and configurations of EV charging stations.

1

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 Emps (typ. 32 Amps)
Charging time for Vehicle	3-5 Miles of Range Per Hour	10-20 Miles of Range Per Hour
Deployment Environment	Residential	Residential / 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

EV charging systems are categorized into three levels of charging, with major differences in performance and price. Even within levels, differences in price, application complexity, and interface quality persist. EV charging levels are defined as follows:

- **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 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 than other types 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. However, 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.Though a majority of EV charging stations are "slow" chargers, Levels 1-2, 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. However, EV charging allows for a reimaging 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:**
There are two major policies in the U.S. driving investment in EV charging: the Bipartisan Infrastructure Law, which introduced the National Electric Vehicle Infrastructure (NEVI) program, and the Inflation Reduction Act, 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 $1B for public EV charging station deployment.

- **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 and investment plans 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.

- **India:**
The FAME I & II acts mandate large cities to have at least one EV charging station in every 3km x 3km grid, in addition to a broader, nation-wide policy targeting 30% EV adoption in privately-owned vehicles, 70% in commercial vehicles, and 40% in buses, and 80% in two- and three-wheeled vehicles by 2030.

- **Middle East:**
The UAE's EV Green Charger Initiative seeks to increase EV adoption across the its major cities by providing the necessary charging infrastructure. It also has additional policies and targets for the expansion of electric and hybrid vehicles across the country.

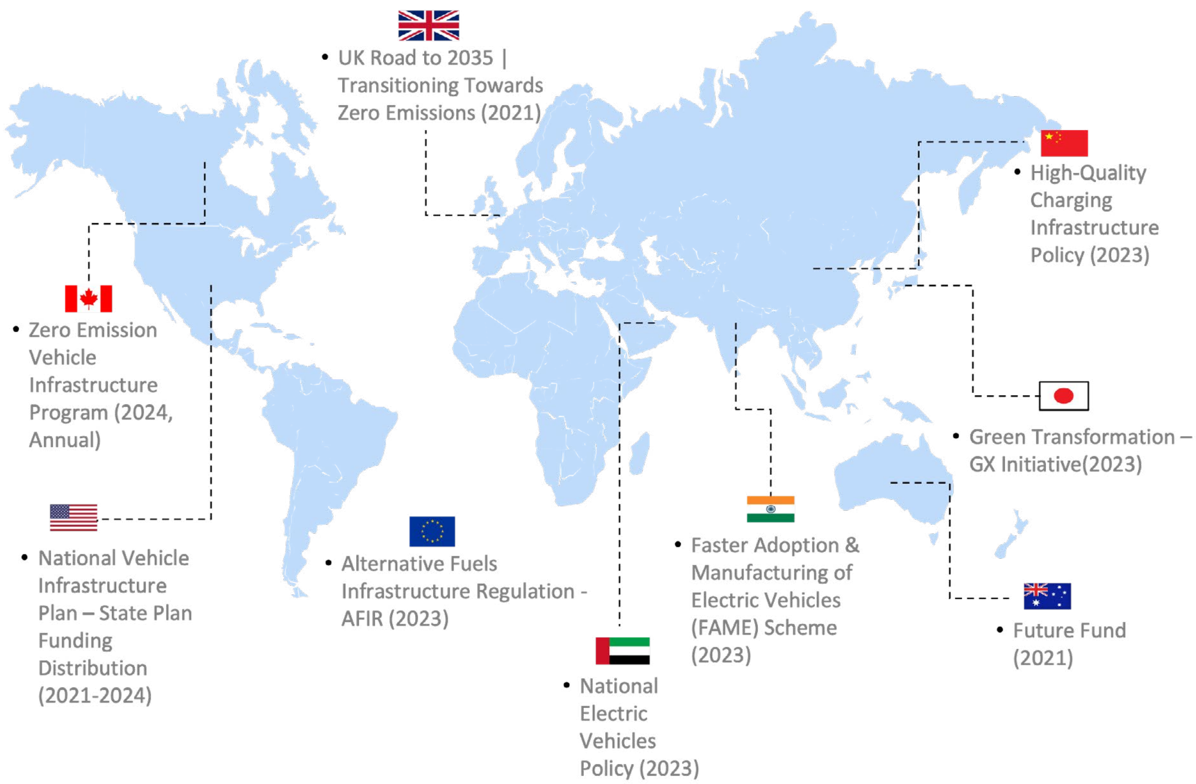
- **Latin America:**
Latin American countries are collaborating to expand EV charging infrastructure, with five planned EV charging corridors spanning South America, Central America and the Caribbean. Additional investment by private utilities like Enel have helped spur EV adoption in South America.

30% EV charging station market is projected to witness a CAGR of more than **30%** during 2024-2032

2.2m China has more than **2.2 million** public EV Chargers accounting for 65% of such chargers in the world

$31B Global EV charging station market size & share is expected to hit USD **31 billion** by 2032

35% The number of DCFC ports increased by **35%** from 2023 to 2024 in the US



IRA'24 provides tax credit of up to **$7,500** for businesses and individuals purchasing EV chargers **NEVI'21** distributed **$2.3 billion** to states to for EV charging stations between 2021-2024

Sinopec allocated **$2.55 Billion** towards EV stations & petrol transitions, with **PetroChina** distributing an estimated **$960 million** towards integrated petrol, EV and hydrogen stations in 2024

AFIF2 (EU) allocates **€298 million** for 5K new charging points for Heavy Duty & Light Commercial vehicles across Europe in 2025

As policymakers continue to allocate significant funding for EV charging initiatives, the opportunity for EV charging suppliers, manufacturers, and customers expands. Ecosystem participants need to carefully consider the future of mobility and design EV infrastructure accordingly, especially as customer concerns persist.

In addition to the range and cost concerns described earlier, other concerns and barriers may dissuade or prevent customers from purchasing EVs. These include:

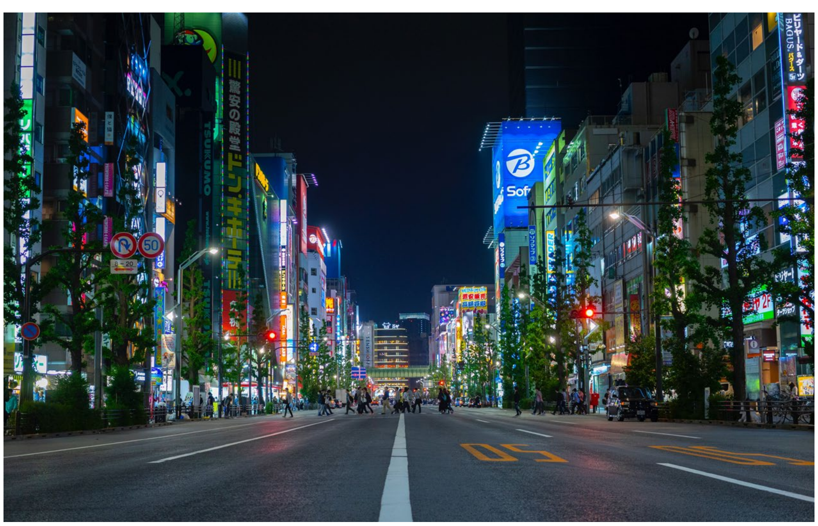
Residential Charging: Unlike ICEs, where vehicle fueling only occurs in commercial venues like gas stations, EVs allow for vehicle fueling to occur overnight in someone's place of living, when utility rates are at their cheapest. While great for consumers, this poses challenges to gas stations, who rely 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 bidirectional charging and load balancing to allow EV charging stations to play a key role in modernizing the electric grid.

DCFC Battery Degradation: Fast charging may accelerate the speeds at which EV batteries degrade, especially those that operate in extreme climate conditions. Advanced battery 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, this equipment can play a major role in creating Smart Cities of the future.



2

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

It is imperative that cities and communities become more sustainable, affordable and resilient. Infrastructure is increasingly seen as a key driver in achieving these goals, along with the overall attractiveness and competitiveness of states and municipalities. With the physical and digital worlds becoming permanently intertwined, investment in New Infrastructure that combines the latest technology innovations like AI and wireless networks with traditional infrastructure projects is can generate profound impacts for citizens and communities alike. When applied to EV charging, New Infrastructure investments can enable advanced energy management, real-time charger management, and personalized experiences, creating a future-proof system that benefits all constituents.

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 capabilities.

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

A combination of high-performance CPUs, GPUs and FPGAs can outfit an EV charger with all the computing required to support efficient power conversion, energy management, human-machine interface (HMI), payment processing, communications, and more. GPUs and CPUs can combine to enable real-time data collection and advanced analytics to support AI-enabled applications, such as energy management, personalized user interface, smart advertising, and video analysis for license plate recognition, security, and similar use cases. These solutions can help improve the user experience by making it more efficient and interactive.

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 (human machine interface) 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 distributed 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

Power Conversion
Market Drivers

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

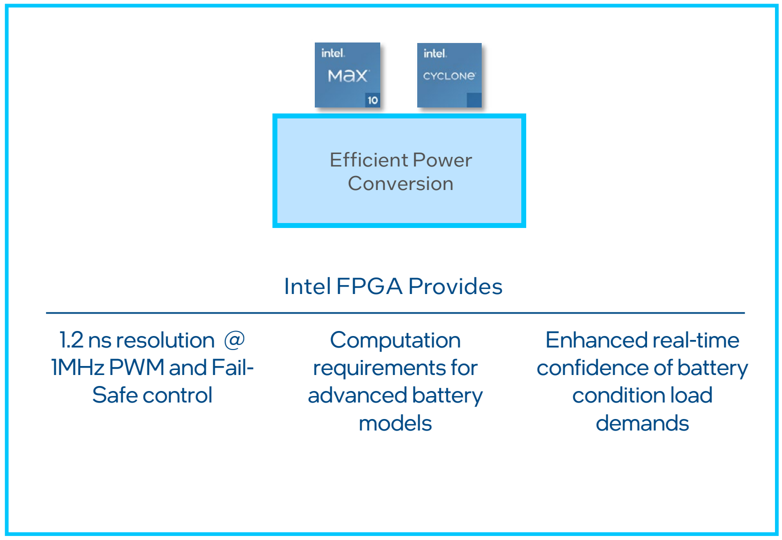
Efficiency
Need higher efficiency power conversion through SiC; need high resolution PWM for efficient power conversion

Battery Management
Market Drivers

Slowing Innovation
Battery cost and density innovation is slowing for large-scale applications, need to enable second life for batteries

V2G
Accelerating V2G applications and DER/ Smart Grid integration to support next generation EVs and grid requirements

Intel EV Charging Infrastructure Model



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 instead used to power the vehicle, resulting in cheaper prices for the customer while reducing the load for utilities. FPGAs can also support batteries and battery management systems (BMS) by providing the compute necessary to evenly distribute loads across cells, reducing the threat of degradation and providing greater longevity to the battery.

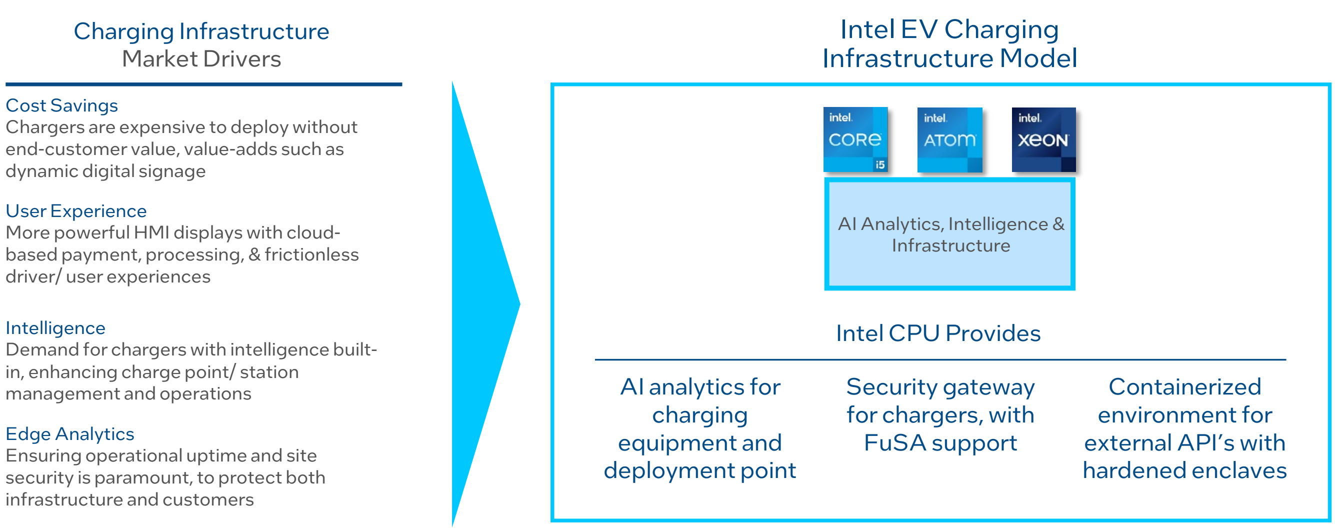
Battery management and efficient power conversion are also important ingredients for vehicle to grid (V2G) and bidirectional charging, or the ability for EVs to provide power back to the grid or a conumer's home through Level 2 and Level 3 EV charging stations. This capability is critical for utilities to reduce peak loads and unlocks new revenue streams for EV owners by allowing them to monetize their excess electricity, turning EVs into distributed energy resources. Consumers can also benefit by optimizing charging in combination with their home energy use to reduce peak time energy bills. Optimizing AC/DC conversion can increase the amount of power offloaded to the grid, and high-performance computing can enable the best real-time energy management systems to facilitate V2G activity.

How artificial intelligence unlocks the future of EV Charging

Artificial intelligence (AI) and machine learning (ML) have created massive amounts of value across industries, but they have traditionally been absent from the vehicle fueling process. However, upgrading DCFC stations with edge AI capabilities can unlock significant value-added applications that improve sustainability, economic benefit and infrastructure resiliency:

Generative AI-based Customer Engagement: LLM-based applications can provide a chat interface for users to interact with, including asking for or receiving recommendations for attractions, restaurants, or sightseeing in the area to pass the time while charging.

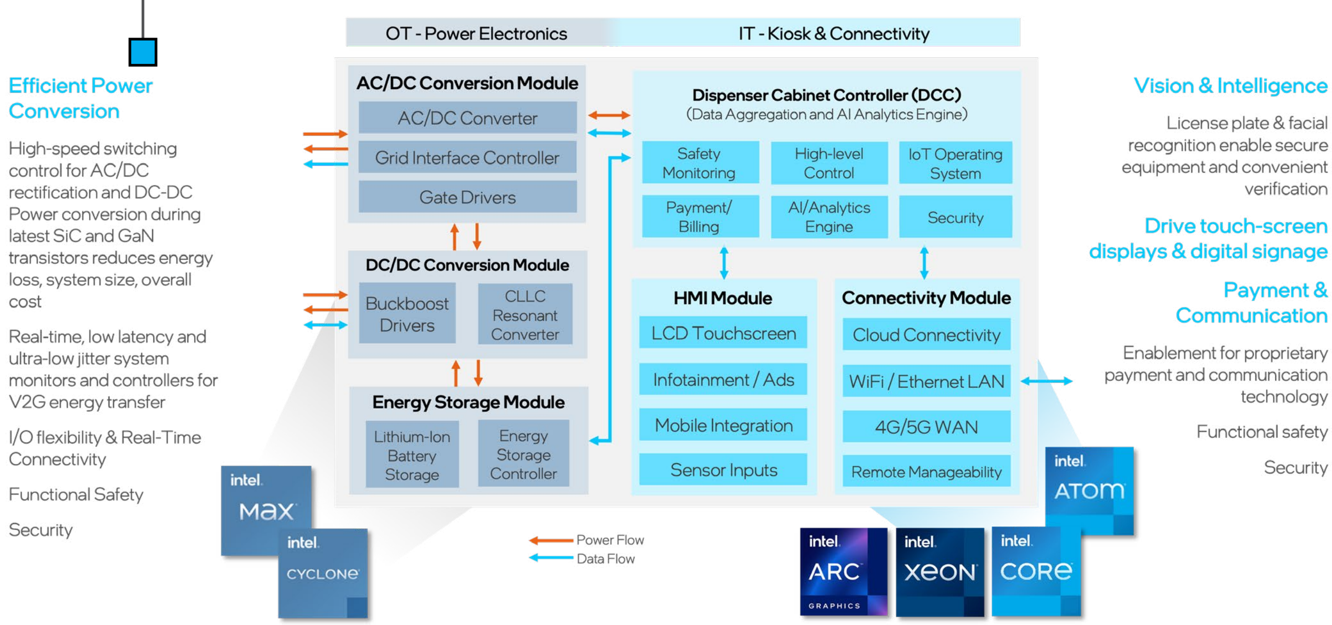
Personalized Advertising: One way that suppliers can offset DCFC implementation and maintenance costs is by using the charger's HMI as a digital signage application. By providing personalized advertisements or infotainment to satisfy users during the longer charging period, adopters can unlock new revenue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



Automated and Adaptive 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/inverters, the station can optimize the use of renewable loads during peaks. Charging stations can also engage in adaptive load balancing between a group of charging stations to ensure many vehicles charging at once in the same area do not overload the grid.

Charger Management, Fault Detection & Predictive Maintenance: Analysis of charger usage and function data can be analyzed in real-time to provide insight on the overall health and performance of the charger and its subsystems, alerting owners and operators to functional issues and maintenance needs.

Energy Management: Monitoring when and how chargers are used, in combination with data coming from the grid, nearby buildings, or a consumer's home can enable advanced energy management to help users, operators and utilities reduce costs and optimize energy usage.



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.

Smart Parking & Road Infrastructure: The data collected and produced 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 the need for automatically detecting and predicting occupancy status, while charging data can be used to predict traffic patterns, helping city management systems reduce congestion.

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. However, consumers are increasingly demanding new personalized, digital experiences powered by advanced technologies, and those same advanced technologies can provide new value and cost savings for cities and businesses alike. To prepare for this future, EV charging suppliers and adopters should build flexibility into 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, and 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 and vehicle-to-grid technology (V2G), consumers can realize new revenue streams from charging, turning vehicle fueling from a cost into a revenue stream for drivers. Although vehicles will still likely be expensive, charging can help drivers recoup EV costs, regardless of their income, helping create a more equitable transportation future for all. Also, gas stations are often placed in low-income environments, and EV charging can reduce our reliance on these polluting gas stations. EV charging stations with connectivity can 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. However, the changes that EV charging promises present opportunities to implement a new vision for consumer experiences in parking lots, shopping complexes, rest stops and more.

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. This idea—the Forecourt of the Future—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, extending sustainability, economic benefit, and resiliency values to adjacent infrastructure and 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 the retailer's rewards and loyalty programs, potentially offering a discount for customers who both charge vehicles and make retail purchases.

THE FORECOURT OF THE FUTURE

ENERGY MANAGEMENT

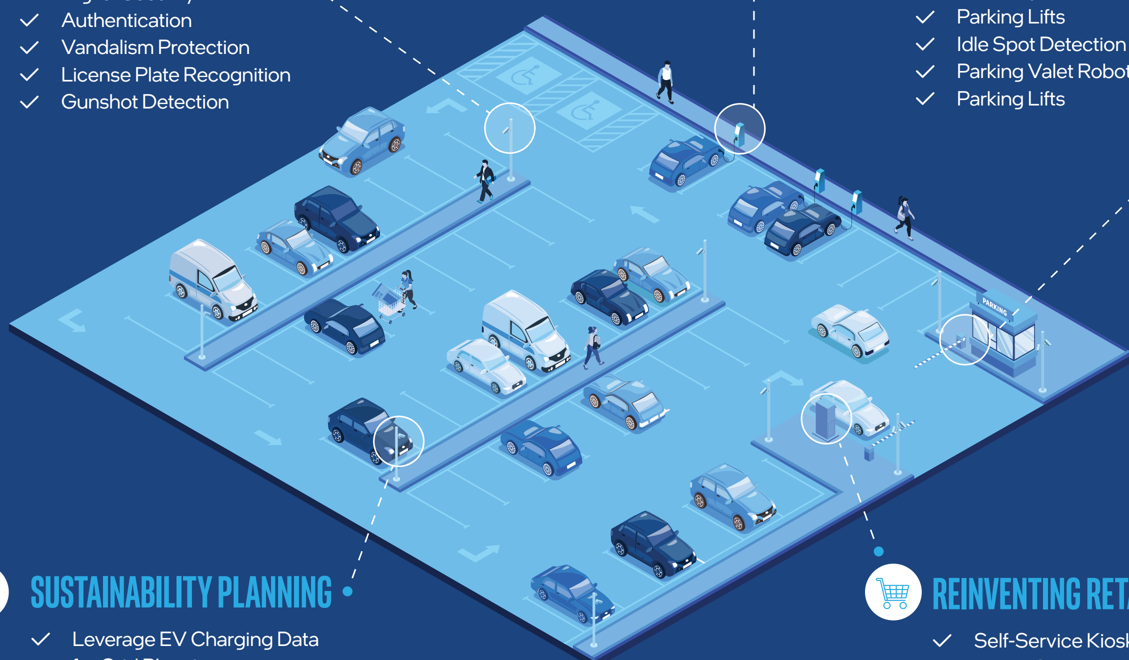
- V2G & Bidirectional Charging
- Integrated Smart Meters
- Automated Load Balancing
- Energy Storage

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 of 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. Therefore, they can also 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 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. Also, 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, in which EV energy is used to power urban transportation systems during peak loads, helping reduce the strain of electricity generation and distribution.

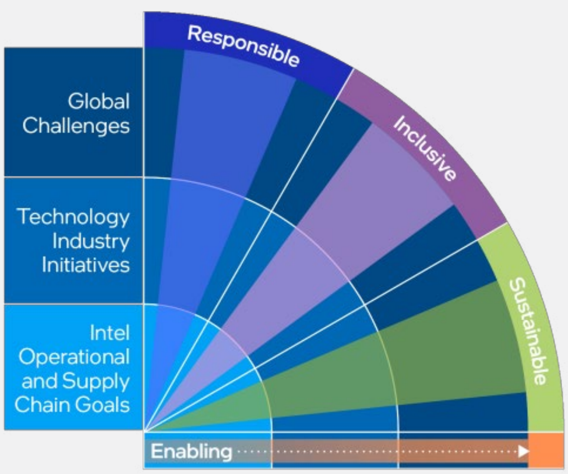
Smart Lighting: EV charging stations can also function as Smart Lighting systems, allowing excess EV energy to sustainably power Smart City lighting. In addition, occupancy data collected from EV charging stations could help optimize lighting patterns.

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 help them to find 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, including 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 Over time, EV charging stations may include onsite 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 off-peak times, reducing overall energy consumption and peak loads.

4

EV Charging Solutions In Action

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.

DFI

Solution Overview

DFI offers an EV charging solution that combines the charge with a retail digital kiosk. The solution runs Mistral 7B LLM and Intel's Arc GPU's XMX AI Engine for fast AI inference, and consolidates multiple workloads like EV charge controller, digital signage, payment transaction, and interactive kiosk.

Value Proposition

- Provides AI-driven insights for advertising and revenue generation
- Improves LLM response time
- Consolidates workloads to enable a complete EV charging solution
- Enables over-the-air updates for reliable maintenance

Solution Components

- Intel Core i9-13900TE
- Intel Arc GPU XMX AI Engine
- OpenVino toolkit

Solution Summary

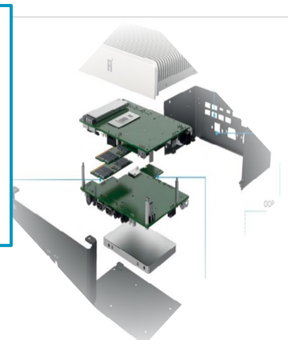
Use Case	AI-enabled EV Charging & Retail Kiosk
Company	DFI
Product	AI Smart Energy-Efficient Charging Station

More Info

Link

Foreward
The Rise of EVs
Anatomy of an EV Charging Station
EV Charging in the Future
EV Charging Solutions
Getting Started & Contact

innodisk



Solution Overview

Innodisk's iGreengo AI Electric Vehicle Charging Network Management System offers AI-driven optimization of charging networks. It manages charging piles by incorporating suburban area support, efficient maintenance, and plate recognition.

Value Proposition

- Optimizes charging infrastructure management to reduce downtime
- Provides real-time charging station availability information
- Enables predictive maintenance of charging infrastructure
- Offers real-time environment monitoring

Solution Components

- Intel Core x i5-1245UE
- OpenVino toolkit

Solution Summary

Use Case EV Charging Network Management

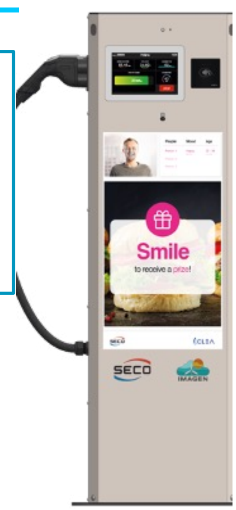
Company Innodisk

Product iGreengo AI Electric Vehicle Charging Network Management System

More Info

Link

SECO



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
- OpenVino toolkit
- Intel Cyclone V FPGA/SOC
- CLEA CORE Software

Solution Summary

Use Case EV Fleet Charging

Company SECO S.p.a.

Product CLEA AI EV Charging Station

More Info

Link

SINTRONES

Solution Overview

Sintrones has developed advanced industrial edge computing solution for EV charging stations that aims to create a convenient operational experience for users. The solution integrates high-quality displays & HMI technology to providing an intuitive, information-rich interactions for users throughout the charging process.

Value Proposition

- Provides information around charging status & progress and space availability
- Multimedia platform for promotional advertising & entertainment
- Intelligent control & remote monitoring enabled by edge computing, AI & web-based graphics interface
- Diverse deployment model from homes to commercial parking structures

Solution Components

- Intel Core i7 Processors
- Intel Celeron Processor
- Intel Pentium Processor
- Intel Atom Quad-core
- Intel HD Graphics

Solution Summary

Use Case	EV Charging
Company	Sintrones
Product	SBOX Industrial IoT Embedded Computers

More Info

Link

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. However, cities, suppliers, and retailers should view this change not as a challenge, but as a major opportunity. By rethinking of how vehicle fueling fist 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, 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 link is available to help you identify Intel technology solutions and strategic alliances for your specific situation and needs:

transportation.us@intel.com

NOTICE & DISCLAIMER

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. Performance varies by use, configuration and other factors. Results may vary. Learn more at www.Intel.com/PerformanceIndex.
Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

No product or component can be absolutely secure.
Intel technologies may require enabled hardware, software, or service activation. Your costs and results may vary.

Statements in this document that refer to future plans or expectations are forward-looking statements. These statements are based on current expectations and involve many risks and uncertainties that could cause actual results to differ materially from those expressed or implied in such statements. For more information on the factors that could cause actual results to differ materially, see our most recent earnings release and SEC filings at www.intc.com.

0425/PDF3

Intel creates world-changing technology that enriches the lives of every person on Earth