What's next for Vehicle-to-Everything?

Learnings from the world's leading program

December 2022

KALUZA

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WORLD'S LARGEST DOMESTIC V2G TRIAL

- $477/£420 average customer savings per year
- 93% customer satisfaction rate
- > 3 million 'free' miles driven
- 2.19 GWh demand shifted
- Potential to save 10% in electricity system infrastructure costs
- 46.8 tons of CO2 saved

BARRIERS TO SCALE (V2X)

Technology
- Cost
- Standardisation
- Accessibility

Policy and Regulation
- Market structures
- Outdated processes
- Adaptability

EV drivers
- Tech learning curve
- Battery health
- Customer centricity vs complexity

KEY TAKEAWAYS

- Engage with auto OEMs early
- Collaborate closely with policymakers and regulators to help them stay ahead and implement frameworks that enable scale
- Build customer confidence from the outset and focus on delivering ease and simplicity

Unplugged potential

A typical electric vehicle (EV) sits parked 90% of the time with a battery capable of storing 40kWh of energy - enough to power an average modern home for two days. By 2030, aggregated EVs around the world could create at least 4 TWh of flexible storage capacity, a volume nearly four times more than the utility-scale battery storage forecasts[1] and enough to power the state of California for an entire week.

Clearly, EVs have the potential to provide a significant flexible resource to the electricity system and, by optimizing charging to occur at times of low demand in response to live signals from the grid, they could enable energy systems to:

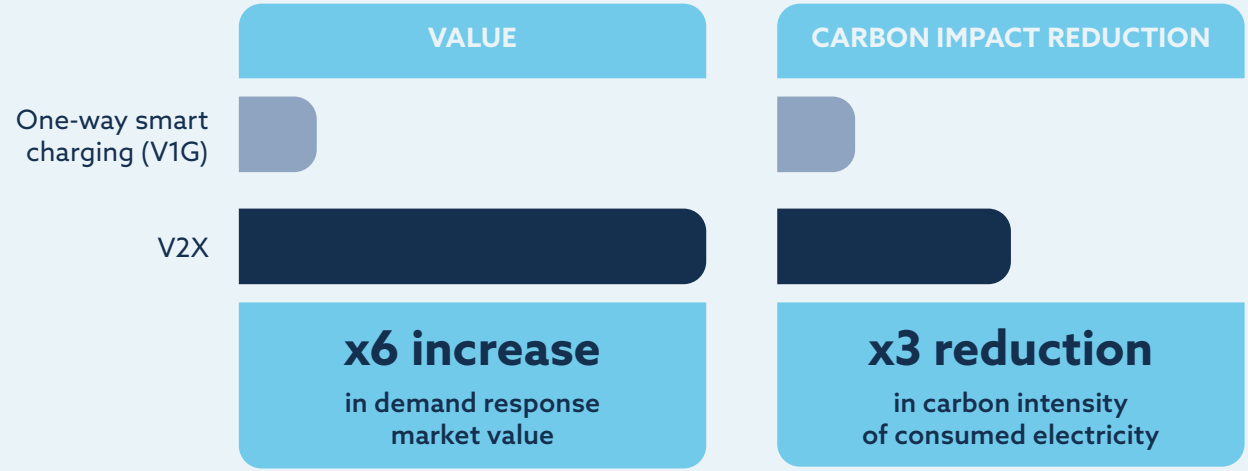
- Utilize more renewable generation
- Save billions in infrastructure reinforcement, and
- Reduce the risk of power outages.

However, one-way smart charging is just the beginning. Through bidirectional charging, EVs can push excess energy back into homes and the grid - unlocking true transformation for consumers, utilities and system operators. This technology is already here and it is known as vehicle-to-everything (V2X).

This paper summarizes the findings of the world's first and largest domestic V2G program, assesses the opportunity for V2X in globally-leading EV markets, identifies key barriers to scale and recommends how these hurdles are overcome.

Note that in this paper we will use 'V2X' as an inclusive term for vehicle-to-home, vehicle-to-grid (V2G) and islanded (e.g. back-up power) operation modes. While the UK trial discussed is presented as V2G, the fundamental learnings gained apply to all types of V2X technology.

Comparing V1G and V2X smart charging



1 BNEF:Global Energy Storage Market to Grow 15-Fold by 2030, October 2022

The world's first and largest V2G program

The world's first and largest residential V2G deployment was launched by OVO, one of the UK's largest energy service providers (ESPs) alongside major auto OEM Nissan and Kaluza, the software provider. The project was an important milestone in proving the performance and value of the technology, as well as evidencing the critical barriers preventing its effective utilization for the electricity system at scale.

The program at a glance

A 36-month real-world demonstrator to develop and deploy 300-400 V2G chargers with OVO customers

Project partners

KALUZA

ovo energy

NISSAN

cenex

INDRA

Project funding

Department of Business, Energy, Industry and Science (BEIS) and Office for Low Emission Vehicles (now OZEV) in partnership with Innovate UK

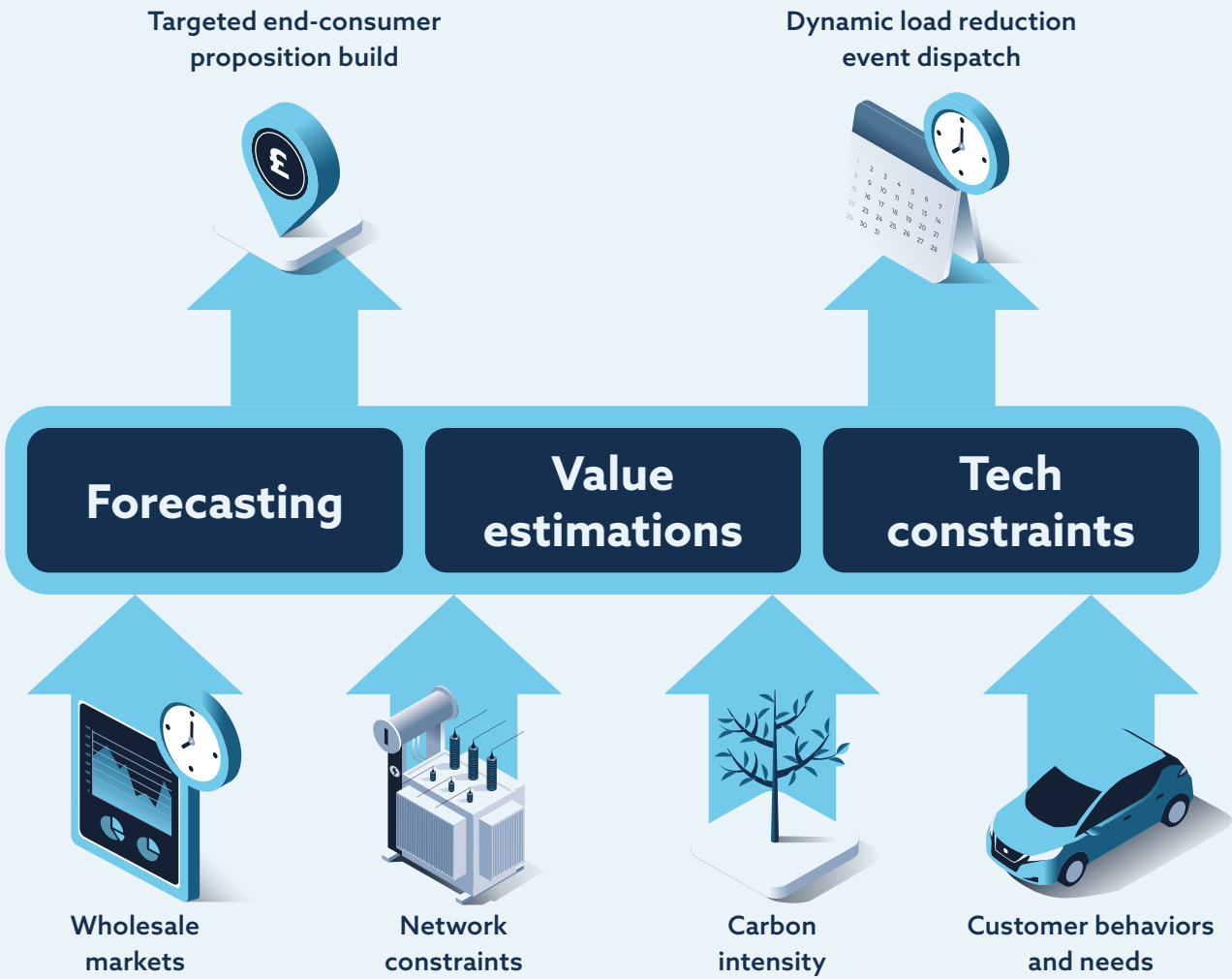
Key achievements

- Bespoke V2G hardware developed and manufactured
- User and installer apps developed
- Bespoke V2G tariff proposition launched
- Onboarded >330 customers
- Analyzed half-hourly data from charger fleet over 12 months
- Insights collected from V2G customers

Software integration and optimization

Leveraging algorithms that combine real-time market signals - such as wholesale electricity price feeds, weather and grid constraint data - Kaluza integrated with the V2G hardware to automatically charge connected vehicles when prices and carbon levels were low, and exported energy from the EVs when the grid was constrained. Kaluza also built capabilities to receive dispatch notifications via local and national grid operators so it could adjust charging patterns, on a minute-by-minute basis, while conserving enough charge to meet each customer's needs.

Optimizing charging for customers and the grid



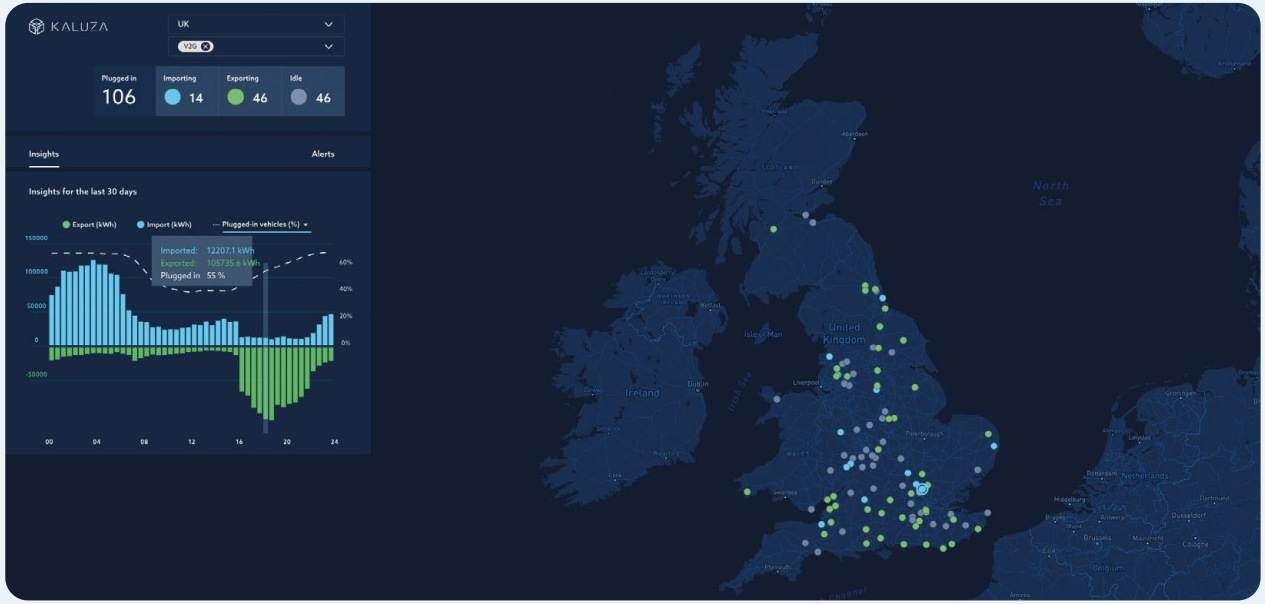
Live Control Room

The Control Room provided a 360-degree live view of all connected EVs and enabled the program leaders to understand the dynamics of V2G charging at a national level. Control strategies such as event dispatch in response to local and national supply shortfall events were executed through this tool and the live reaction of each device could be tracked in real time.

In addition to the portfolio-level view, a granular breakdown of a single device's behavior could be analyzed via the 'Insights Panel' enabling device-to-device comparisons to be made and any operational issues to be identified at speed.

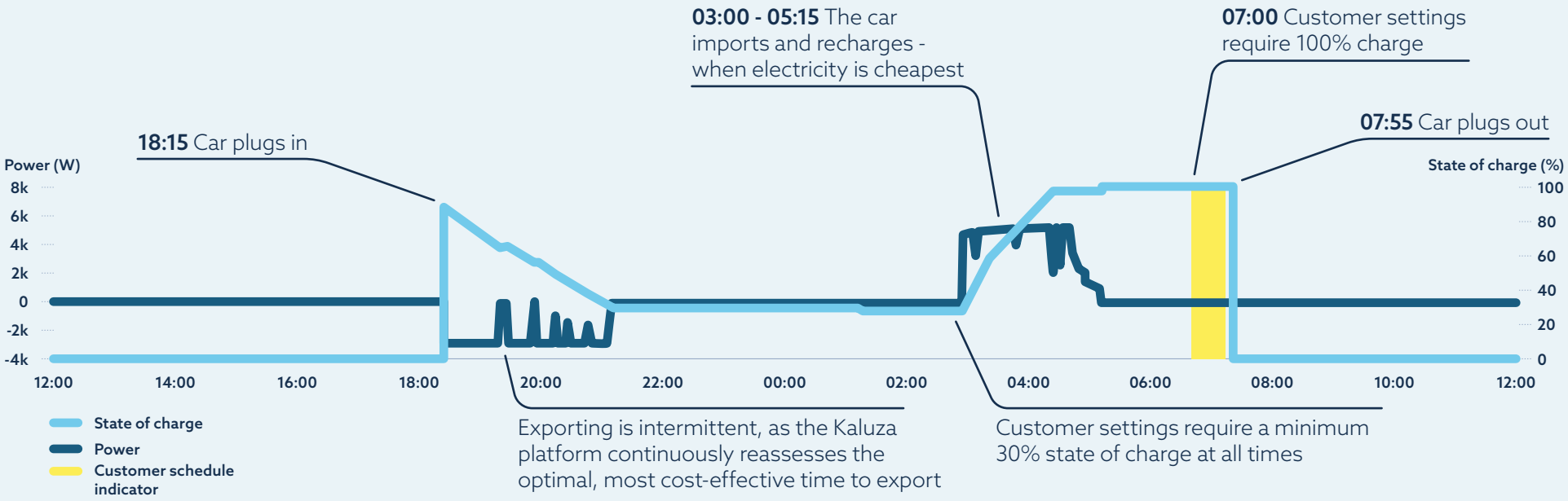
Typically, an EV would be plugged into the V2G charger during the UK's evening peak period (between 17:00 and 21:00). The charger would immediately start exporting surplus energy

The Kaluza Control Room showing V2G connections



EVs importing from the grid **EVs exporting energy via a V2G charger** **EVs not plugged in**

A day in the life of a V2G charger



from the EV back into the grid in response to high demand levels, helping to ease system congestion. The spikes in the 'Power' line above reflect how the EV behavior directly changed in response to live data from the grid.

After the evening peak, most EVs remained idle, neither charging nor discharging but maintaining a state of charge ~30%, a minimum threshold which the customer had set in the event of needing to make an unplanned trip. At 03:00, when the electricity prices and CO2 intensity were lower, gradual charging began in order for a full battery to be obtained by 07:00 when the customer had scheduled their car to be ready by.

Overall, customer plug-in rates peaked between 17:30 and 18:00 and unplugging between 07:30 and 08:00. On an average day, ~61% of the V2G portfolio was available between plug-in and plug-out times, showing the significant system flexibility potential that V2X technology, coupled with a compelling customer proposition, can present at scale. The average battery's state of charge on plugging in was 43% and most customers set their car's maximum state of charge at 90%.

The customer experience

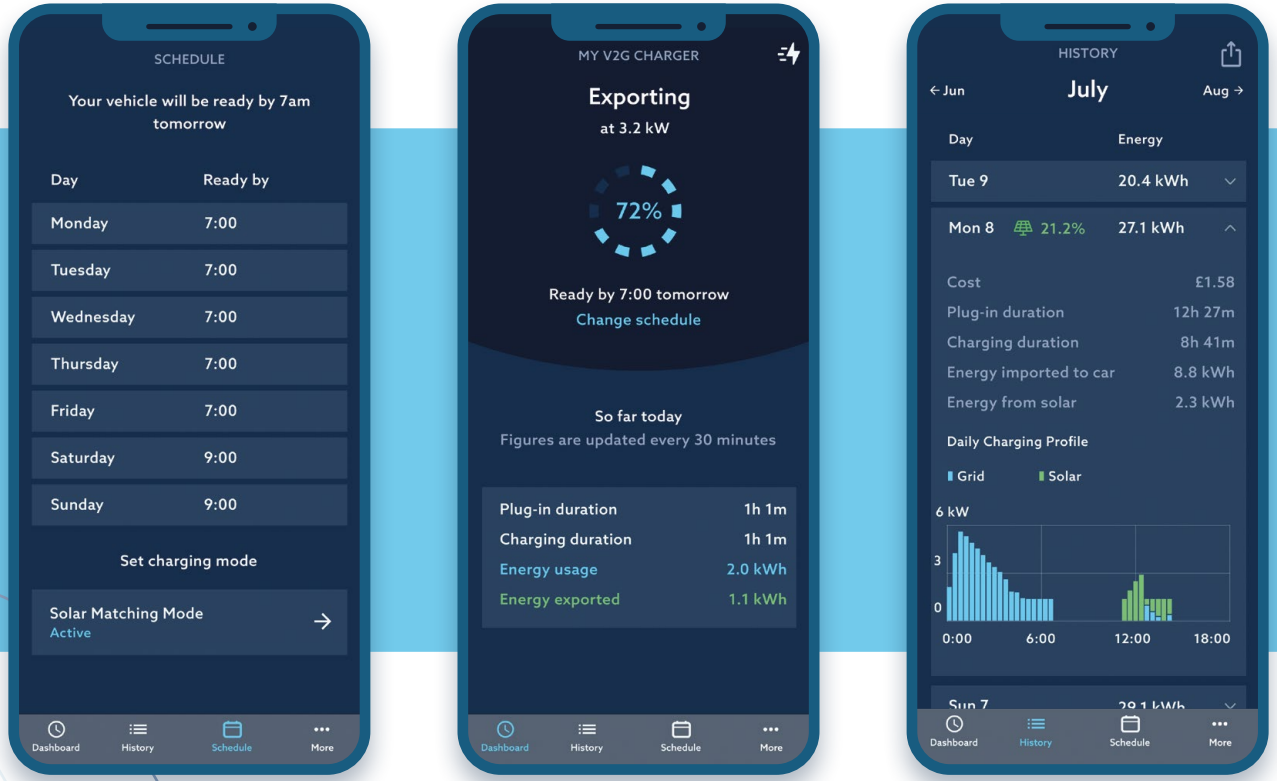
OVO, the energy service provider, received the full value from the load shifting and passed it to their V2G customers through an innovative proposition that credited drivers $0.36/£0.30 per kWh exported to the grid from the meter. V2G credits were then automatically added to the customers' monthly energy bills viewable via their mobile app.

To incentivise the right behaviors, the customer mobile app was built with ease of use and adaptability at the forefront.

From left to right, these app interfaces show how customers scheduled their charging, gained important insights into their vehicle's current behavior and state of charge, and historic imports and exports.

Based on trialist research, a minimum state of charge feature was developed to ensure a baseline of energy was preserved at all times, in case the car was needed in an emergency. This boosted drivers' confidence in the technology as they were reassured that they would always be able to use their vehicle. Customers were also educated on the benefits of a minimum state of charge on battery health, addressing some initial concerns among the cohort (see page 11).

Educating customers and driving value through an engaging user experience



Program findings

$477/£420
Average customer savings per year

93%
Customer satisfaction rate

> 3 million
'Free' miles driven

Average customer charging metrics

Average importing
11.36 kWh/day

Average exporting
6.77 kWh/day

18
Average monthly plug-ins

Average plug-in and plug-out times
17:30 plug-in
08:00 plug-out

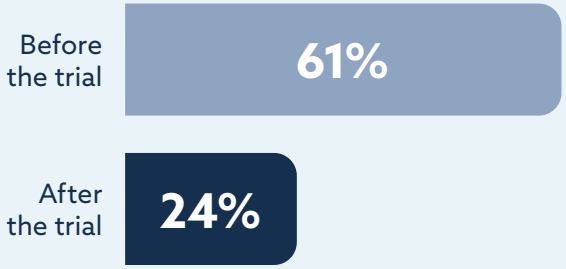
The program garnered rich insights from an operational, technical and customer standpoint, as well as into the macro challenges of V2G, V2X and even one-way smart charging deployment.

Customer benefits

Program participants were often paid double the amount they had originally paid for charging. In most cases, customers received monthly rewards of ~ $41/£35 for their V2X exports enabling them to reduce their monthly energy bill by 40% on average. Some of the more active and engaged participants earned up to $960/£800 a year through V2G and completely eliminated their household energy costs.

93% of participants were satisfied or very satisfied with their V2G experience. The level of concern around battery health dropped from 61% at the beginning of the trial to 24% at the end, and worries about cost savings while using V2G decreased from 43% to 28%. With regards to how V2G could be improved, customers expressed a desire for the technology to do more for them, for example, be compatible with their solar PV and be used to deliver back-up power.

Customer concerns about battery health impact



93%

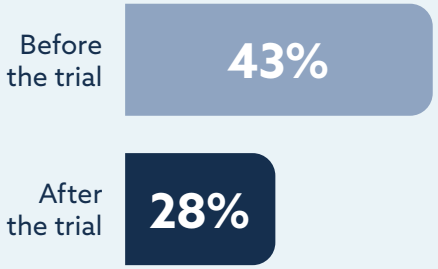
of V2G customers satisfied with their charging experience

"The income from V2G means that my driving miles are free... but now I increasingly think of it as money off my entire energy bill.

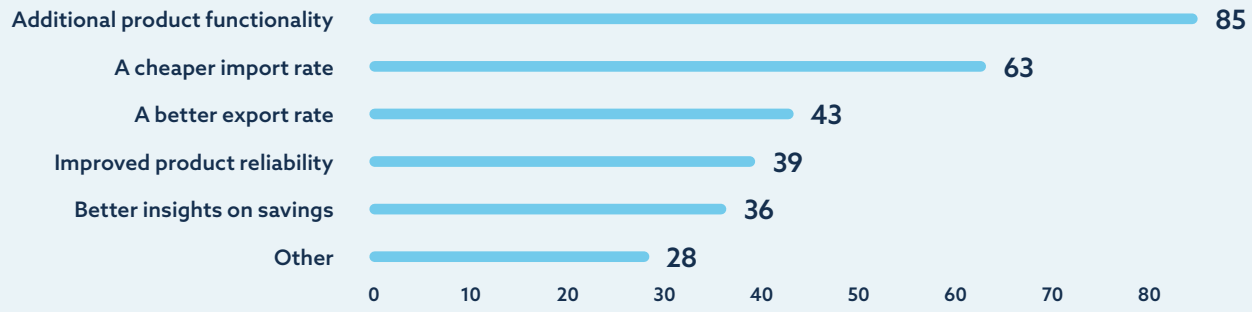
Over the last month, looking at my electricity usage overall, I am actually £7 in credit thanks to V2G."

V2G customer

Customer concerns about savings



Main ways to improve V2G



Grid resilience and decarbonization

Based on data from this deployment, bidirectional EV charging offers almost three times more daily flexibility to the grid than one-way smart charging. The V2G portfolio was deployed in the UK wholesale market as well as within the local (Distributed Network Operator)[2] and national (Energy System Operator)[3] systems to support system balancing during generation shortfalls as well as constraint management zone (CMZ) events in regions of the UK. Through doing so, it became clear that V2G offers deep load-shifting benefits as well as an effective mechanism for mitigating dynamic network constraints in real time. Critically, the flexibility generated from V2G-enabled devices has the potential to accelerate the uptake of renewables.

A fleet of 330 V2G-enabled EVs over **one day** can save **192 kg CO2**

This is a **45% CO2 saving** compared to unmanaged EV charging

And equivalent to the daily CO2 offset from **~7,000 trees**

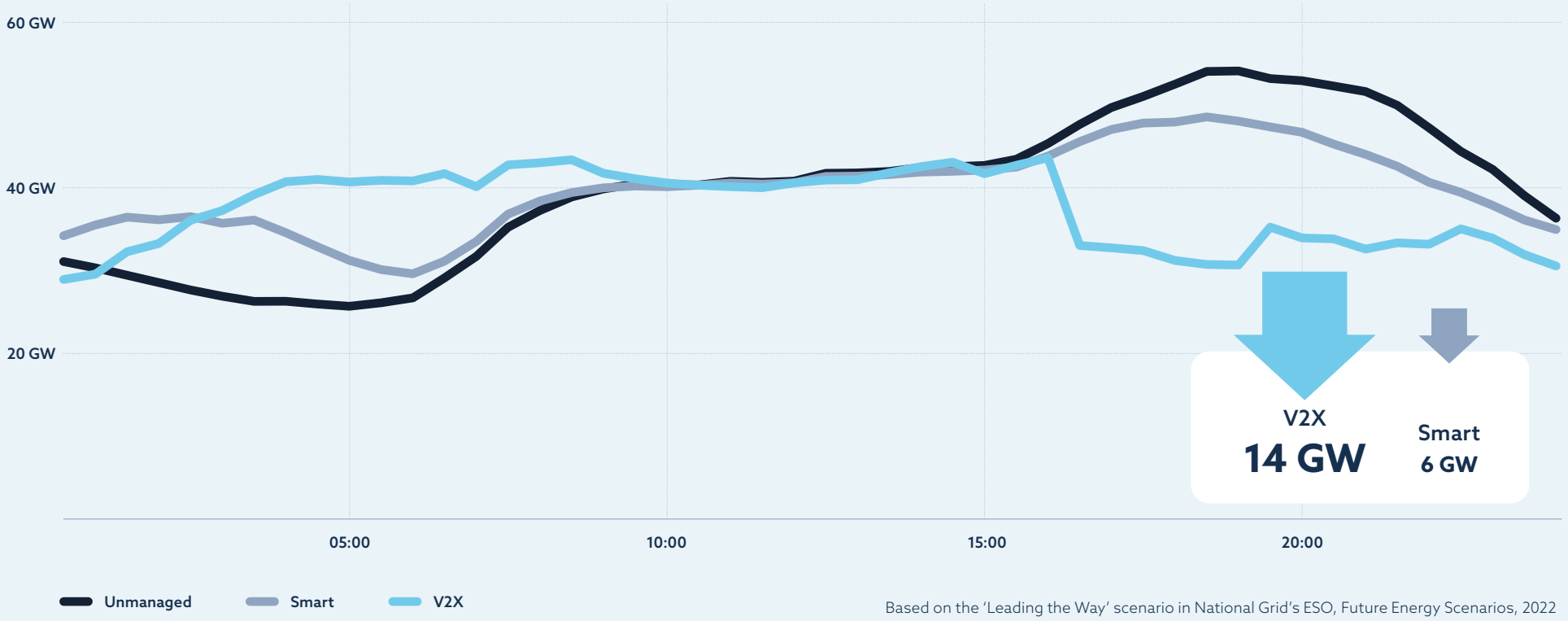
2.19 GWh
of demand shifted

Potential to
save 10%
in electricity system infrastructure costs

46.8 tons
of CO2 saved

2 Kaluza Delivering First Local Grid Constraint Management Service, August 2020
3 Freeing up the Locked Down Grid: V2G and Flexible Charging in the Move Towards a Green Energy Future, September 2020

Future peak load impacts of V2X and smart charging in the UK



Based on the 'Leading the Way' scenario in National Grid's ESO, Future Energy Scenarios, 2022

The international opportunity

Over the last five years, 106 V2X initiatives have been launched across 26 markets, correlating with geographies where EV adoption is accelerating.

The pressure for increased system flexibility is rising as capacity margins during winter and summer peaks are narrowing. This trend is materializing in many markets globally, for example:

- California is facing blackouts amid recent heat waves[4]
- Texas' grid is struggling to manage extreme weather as high AC and electric heating loads threaten capacity reserve[5]
- France is looking to expand its 'load shedding' options in the coming winter[6]

V2X potential across Europe and the US in 2030

40 m EVs
52 GW of flexible capacity

8.2 m EVs
10.6 GW of flexible capacity

26 m EVs
34 GW of flexible capacity

7.5 m EVs
9.7 GW of flexible capacity

OPPORTUNITIES

- Facilitate more renewable generation
- Manage network constraints in a net-zero system
- Reduce costs
- Back-up power in extreme weather events

In Europe, 40 million EVs are predicted to be on the road which would generate 52 GW of flexible storage capacity via V2X. This would displace nearly one third of the gas generation currently powering the continent.

In the US, more than 26 million EVs are expected to be on the roads which equates to ~34 GW of flexible storage capacity. This volume would have a significant effect on grid constraint management during extreme weather events and general system resilience.

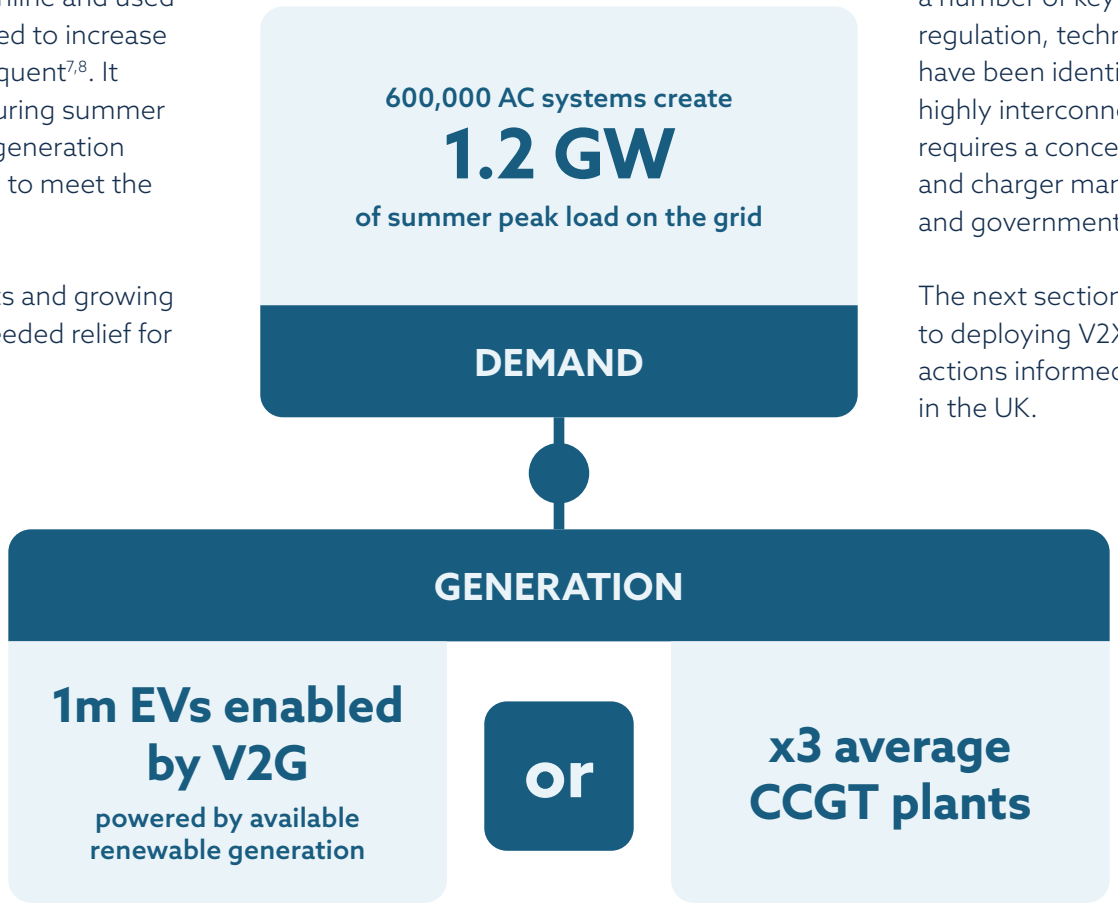
4 The new EV charging tech bolstering the Californian grid, October 2022
5 Why Everyone Is Talking About Texas Electric Grid, Forbes, July 2022
6 French Government Prepares For Power Shedding, October 2022

The demand from cooling

This analysis demonstrates the potential of V2X in balancing the energy system when more air conditioning units are brought online and used more intensively, a trend expected to increase as heat waves become more frequent[7,8]. It shows the increased flexibility during summer peaks and equivalent fossil fuel generation that would otherwise be needed to meet the increased demand.

Reflecting on these recent events and growing trends, V2X could offer much-needed relief for global energy systems.

V2X can help manage the additional load needed for cooling



What's preventing the rapid expansion of V2X?

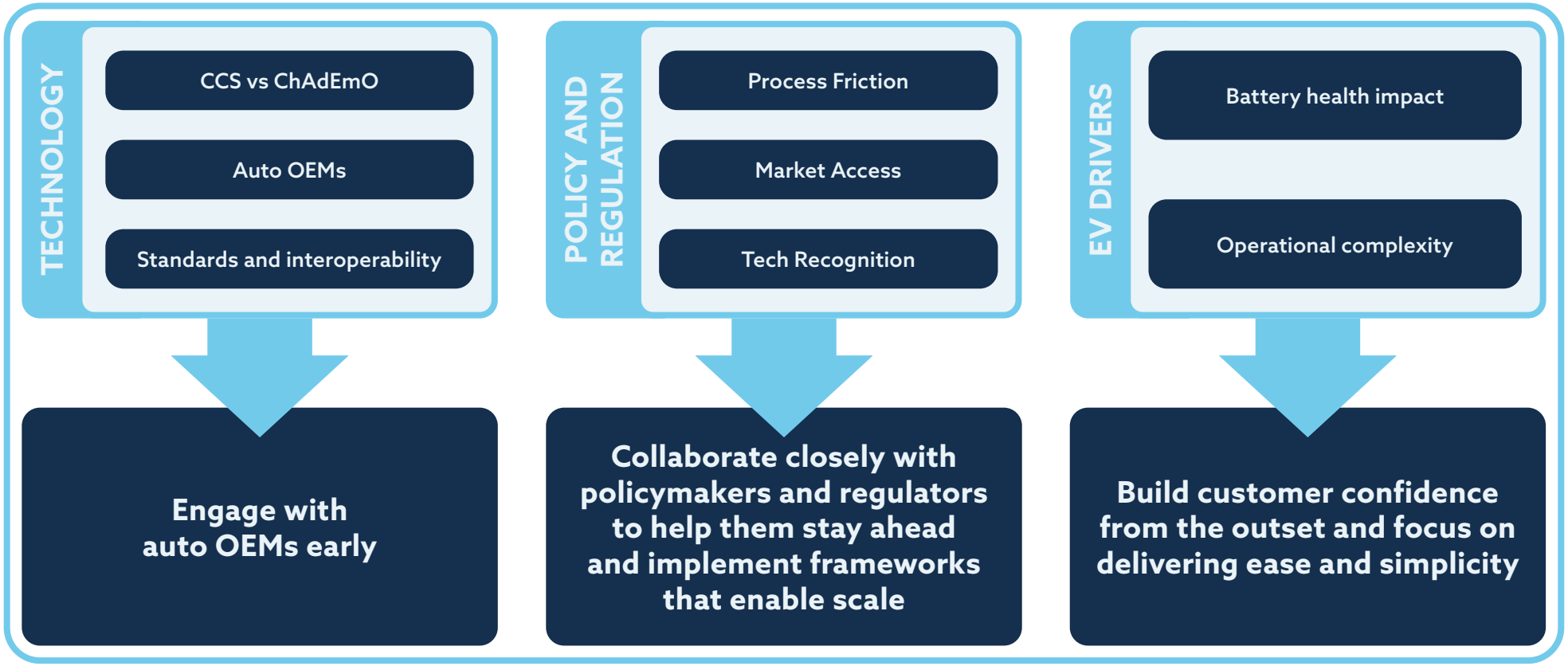
Through the world-leading UK V2G program a number of key barriers across policy and regulation, technology and consumer behavior have been identified. These challenges are highly interconnected and addressing them requires a concerted effort across ESPs, EV and charger manufacturers, software providers and governments.

The next section explores the main challenges to deploying V2X at scale and recommends actions informed by first-hand experience in the UK.

7 WMO warns of frequent heatwaves in decades ahead, July 2022

8 Extreme heat waves may be our new normal, thanks to climate change. Is the globe prepared?, August 2022

Scaling V2X: Barriers, guidance and key takeaways



Technology

Hardware and charging standards

V2X is still a nascent technology, with only a handful of hardware manufacturers offering chargers capable of bidirectional charging and even fewer auto OEMs making V2X-enabled EVs. At the point of writing, CHAdeMO remains the most developed charging standard, yet its prevalence is limited. Currently few vehicles, including the Nissan Leaf and Mitsubishi Outlander, are compatible with CHAdeMO and allow for V2X charging without a risk to battery warranty.

UK market data suggests that more than 75% of all charging happens via Combined Charging System (CCS) chargers (including Tesla's proprietary solution) while only 25% utilize CHAdeMO. The US market is similar, with installed CCS DC fast charge points outnumbering CHAdeMO since 2020. The popularity of CCS is expected to grow further while CHAdeMO will be phased out, as indicated by Nissan's announcement to end the production of its Leaf[9] by the middle of the decade in order to make way for new models with CCS compatibility. With limited scale, cost remains a fundamental issue. Today, a V2X-enabled charger can cost 10 times more than a standard charge point, preventing growth in customer demand.

Positively, there has been significant progress in the auto OEM and charging standards space over the last 12 months:

- Ford has announced V2X compatibility for the Ford F-150[10] and automakers like VW, Hyundai and Stellantis are commiting to manufacturing V2X-compatible EVs in the near future[11,12,13]. In total, seven auto OEMs have announced that they will deliver V2X-compatible EVs by the end of 2022[14].
- There is a growing number of charge point manufacturers who are launching V2X-enabled CCS chargers and seeking the relevant accreditations, for example, the Underwriters Laboratories (UL) certification which is required in California.

However, the market is facing mounting scalability challenges associated with new hardware standardization and development speed, particularly in light of the fact that the only established V2X charging standard and real-world V2X-enabled EVs are being phased out without replacements in the near-term.

Ultimately, auto OEMs hold the key to V2X commercialization and the next few years will be pivotal. As a customer's first point of contact in their journey to owning an EV, auto OEMs have the ability to make or break the V2X opportunity. True scale will only be reached when multiple auto OEMs bring V2X-enabled EV models to the market, become comfortable with the technology and have clarity around the business case. Close technical and commercial collaboration between the players across the value chain (ESP, software provider, auto OEM and charger OEM) is essential from the outset to encourage confidence and trust.

An example of where this close-knit ecosystem created key progress in the UK program was around the warranty of the participants' Nissan

9 Report: Nissan LEAF To Be Phased Out, July 2022
10 F-150 lightning power play: first electric truck to enhance your home energy independence, February, 2022
11 Volkswagen Plans To Offer V2G And Plug & Charge Technology In 2022, December 2021
12 Hyundai to include V2G capabilities for their EVs, April 2022
13 Stellantis: Driving Toward A New Era Of Sustainable Mobility, April 2022
14 Key developments in bi-directional charging, EVMarketReports, November 2022

Leaf. By using a 'tried and tested' V2X charger, and through close collaboration with Nissan, the partners were able to clearly define the optimization parameters (charging cycles, state of charge etc.) of the vehicles to protect battery health while enabling drivers to be rewarded. It meant the warranty could be maintained throughout the program with minimal operational issues and enabled OVO to assure participants that the availability and health of their vehicles would not be affected in any way.

KEY TAKEAWAY
Engage with auto OEMs early

"The industry should now focus on improving the market conditions that will drive consumer adoption. The top barriers to scale adoption include the high cost of V2X equipment across the value chain (EV/EVSE/Home/Grid), and safety regulations and communications standards that are incompatible with this new reality. The latter is particularly important.

Interconnection standards differ across regions, and standards bodies responsible for the various components of the value chain (ex. SAE, UL, and IEEE) have yet to come together, resulting in inflated costs to develop, install, and manage the hardware and software needed to transform an EV battery pack into an active grid energy management device."

Linda Farinaccio
Market Channels and Partnerships, dcbel

Policy and regulation

As is often the case, policy and regulatory change tends to lag behind technological innovation, and the same is true in the case of V2X. The technology introduces a multitude of requirements at the low voltage, demand side of the grid that it was simply not built to support.

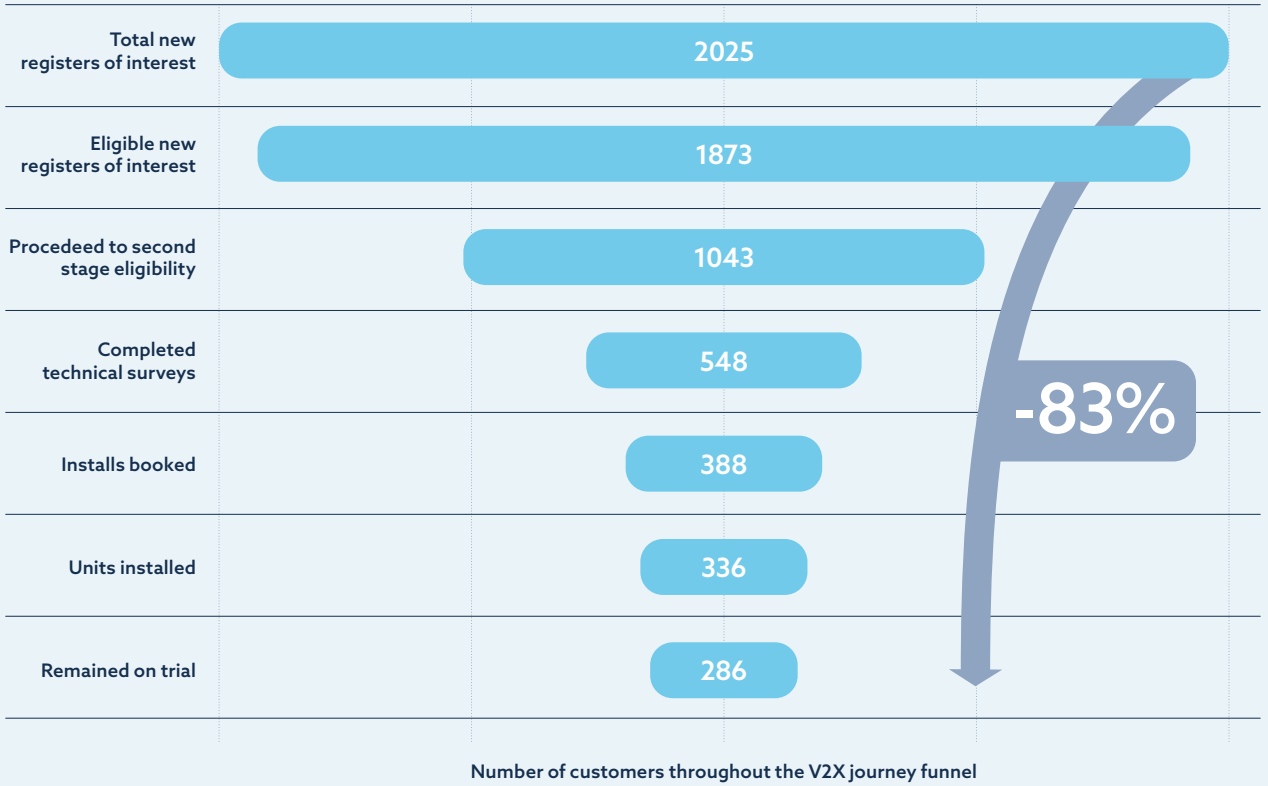
On a technical level, bidirectional EV charging connects new export loads at the very edges of the grid, disrupting the centralized, top-down electricity system model established around the world. These infrastructural restrictions limit the amount of value each customer can create and their ability to become active participants in decarbonization.

Partners in the UK program experienced a high degree of friction across V2X installation, connection and utilization in potential ancillary markets and load reduction programs. Many of these obstacles required new or amended policies and frameworks that recognize EVs (including bidirectional) as demand response assets akin to large-scale batteries at the higher-voltage levels.

For example:

1. The development of new installation approval standards to allow V2X charger installation in customer homes. These were produced in the UK program in close collaboration with local network operators and improved the visibility of locations where potential household export could reach 6kW (the volume required for V2X)

The journey to a V2X install is full of friction



and where limitations were likely.

2. Revised ancillary market designs that support small-scale flexibility participation and clearer metering standards. These measures would make a substantial difference to how much system value could be generated through V2X.

While operational models that focus on site 'islanding' or limiting operations to only V2H (vehicle-to-home) can overcome some of these blockers early on, these modes of operation do not reflect the full potential of operations in V2G mode.

Policymakers and regulators need to recognize the value of V2X in meeting growing electrical demand and play a more active role in supporting its deployment as part of the roadmap for a decarbonized energy system. Again, close collaboration across the main stakeholders in the industry (charger and EV OEMs, installers, software providers) and the regulator early on is key to accelerate learnings from V2X programs and encourage efficient market development.

KEY TAKEAWAY

Collaborate closely with policymakers & regulators to help them stay ahead and implement frameworks that enable scale

"We don't need to reinvent the wheel on this. Identify the bidirectional EV charging use cases that can be addressed with existing process, rules, and policies, and treat them the same as existing technology such as behind-the-meter storage and residential backup generators."

Garrett Fitzgerald
Senior Director, SEPA

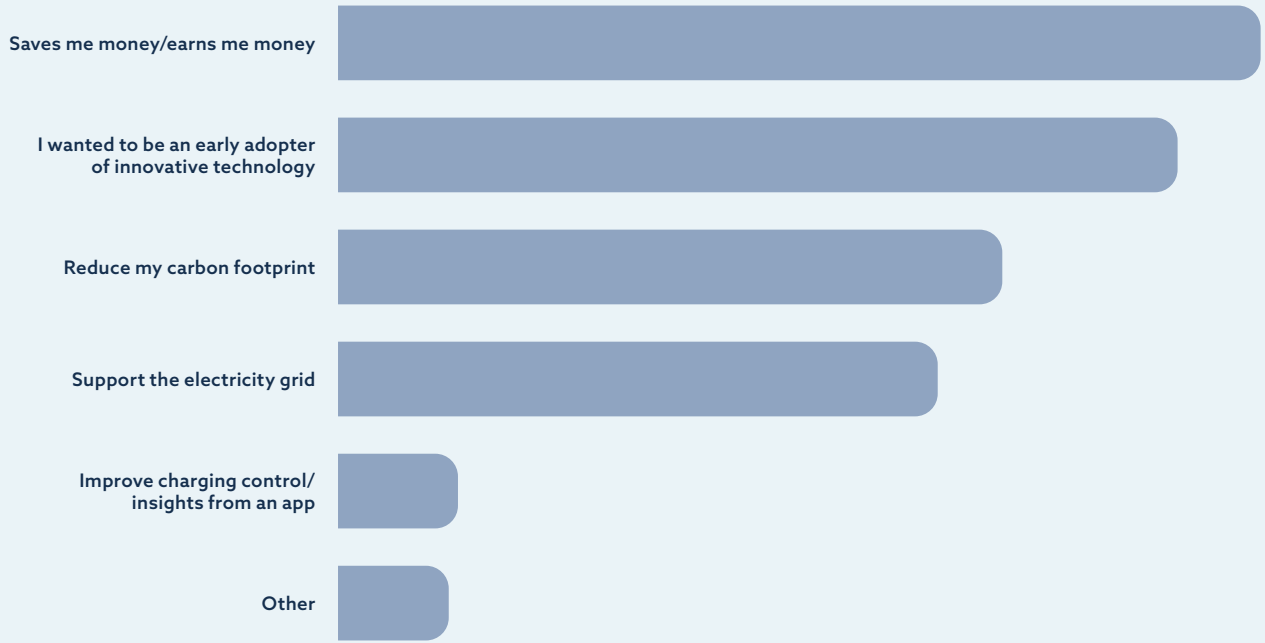
EV drivers

The concept of using the battery in your electric vehicle to power your home or sell electricity back into the grid is still unknown to most EV drivers and the wider population. Awareness is growing in the auto and utility sectors but more work needs to be done to educate these stakeholders too. Demystifying the 'what?' and 'why?' questions about this new technology is crucial and, if done correctly, will enable new levels of customer engagement and 'stickiness' for utilities and auto OEMs.

Different methods of customer engagement and proposition type can directly affect the amount of flexible value and cost savings created. Overlooking 'customer centricity' when designing any type of intelligent EV charging service is an approach doomed to fail. Therefore, finding the most effective way to delight the customer with a focus on ease and simplicity, in addition to financial reward, will maximize the program success.

In the UK program, participants were surveyed in order to understand their motivations for taking part. As per the visual below, the financial incentive was the biggest driver, followed in close second by the desire to be an early adopter and thirdly, to reduce their carbon footprint. This insight helped to shape the customer proposition and development of the app as the trial progressed, and contributed strongly to the high satisfaction score that was achieved.

Customers' reasons for getting V2G



Importantly, a successful program must help a customer to achieve something they want or need and be designed to incentivize the 'target behavior' that will create most value from the technology. An example of this in the UK program was in the development of the 'charge path feature' allowing participants to see how their vehicle would be charging in the upcoming minutes and hours, giving them more reason to trust the software optimization. As a result of this feature, the number of hours in which customers allowed the software to optimize charging increased by 40%. Further, by educating customers on what the software was doing and the consequences of overriding it, the number of flexible charging hours increased by 141%, enabling more flexible value and cost savings to be generated.

Over the three-year period of running the UK V2G program, the partners constantly tested and revised the proposition and messaging based on customer feedback.

This iterative feedback process helped strengthen the UK program's approach to customer acquisition and experience.

Customer feedback from the UK V2G program

"Our main concern is the battery because it's the most important part"

"I care about my EV range over time and know what happens to phone batteries. How would this (V2X) affect me?"

Two key focuses came out of the feedback:

1. **Make rewards simple and engaging:** Communicating the rewards structure effectively for diverse customer segments is critical especially when it comes to a relatively complex technology. Customer research plays an important role in this and as V2X technology scales, investment in customer research should not be understated.

2. **Invest in educating customers:** this is key to addressing concerns and misconceptions around the technology and builds trust so that drivers can get the most out of their EV for as long as possible. Enabling customers to easily set their V2X charging settings for optimum battery performance is a crucial part of making V2X adoption scalable.

Striking the right balance between educating customers about what they need and want to know, versus overinforming them with the complexity of behind-scenes-operations, will maximize customer acquisition and help retain engagement for longer.

A simple and seamless customer experience

Central to the success of any demand response program is a seamless user experience (UX), that allows drivers to incorporate the technology in their day-to-day lives. Currently, the complexity of the EV ecosystem makes EV acquisition and ownership overwhelming for many customers.

Today, an average customer needs to interact with at least six different parties in order to receive the full EV experience.

It is imperative that the transport and energy sectors come together to simplify this experience for customers to maximize the rewards from EV adoption and managed charging, for all.

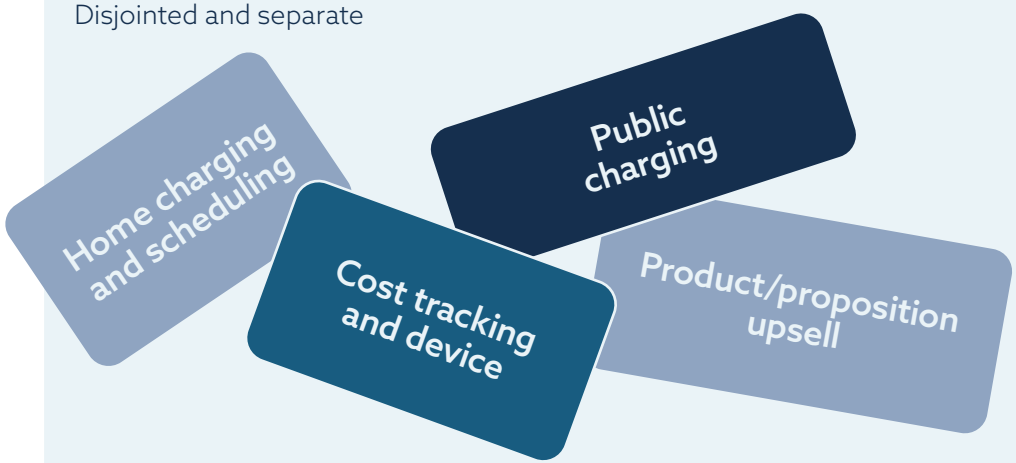
KEY TAKEAWAY

Build customer confidence from the outset and focus on delivering ease and simplicity

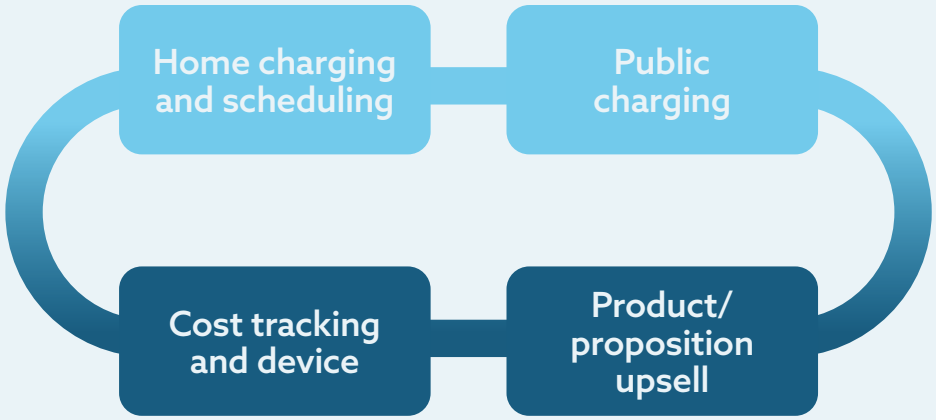
The customer journey in the EV space is too confusing

Customer centricity is key in engaging customers with V2X and smart charging

Disjointed and separate



Lilnked and seamlessly sequential



"We were the first UK energy supplier to offer our customers V2G charging to help the energy sector solve huge challenges. Our partnership with Kaluza has enabled households to reduce their electricity bills, thousands of EV batteries to help balance the grid in times of peak demand, and more renewable energy to come onto the system.

As more and more consumers choose EVs there is a huge potential to reinvent how they engage with their energy use. With energy grids globally facing capacity crunches, V2G technology is a vital tool that will empower consumers to mobilize and to become active participants in the energy transition."

Raman Bhatia
CEO, OVO Energy

Conclusion

Rolling out V2X at scale is no easy feat. It involves creating a new energy ecosystem where auto OEMs, charging hardware players, utilities, software providers and regulators come together to untangle the end-to-end complexity, evolve energy market operations and focus on customer needs. Succeeding in this will not only benefit customers with free driving miles, cheaper household energy bills and lower carbon footprints but enable a more affordable and resilient energy transition.

The way in which the automotive and energy sectors converge in the next few years has the power to make or break the ability to scale V2X in global markets. Close collaboration across the value chain is essential to build greater awareness around the technology and lobby for the changes needed to unlock its full value.

About Kaluza

Kaluza is a leading software platform powering the future of energy. From revolutionising billing to smart electric vehicle charging, Kaluza's SaaS technology is empowering some of the biggest energy suppliers to better serve millions of customers. Its live data platform transforms supplier operations, reducing cost to serve and boosting customer engagement. Powered by Kaluza, suppliers can invest in innovating for tomorrow's customers and drive decarbonisation with smart, low carbon technologies that not only reduce energy bills, but lay the foundations for a more flexible energy system.

www.kaluza.com

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