

DELTA-EE

Smart electric vehicle charging with the customer and grid in mind

**A joint whitepaper by Delta-EE, Kaluza and UK
Power Networks**

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Executive summary

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Smart charging is the product of different elements of the energy system working together to provide flexibility and demand management from end customers' electric vehicles.

- Smart charging presents exciting new opportunities to lower the running costs to electric vehicle (EV) customers while reducing the impact of EV uptake on electricity networks.
- UK companies are leading the way in exploring EV flexibility potential on local network levels.
- Flexibility markets are in their infancy and therefore need government leadership to enable its commercial viability. Projects and trials are helping open up the marketplace, but more support will be welcomed by the industry.
- Continued collaboration and active engagement are driving progress towards unlocking the full potential of smart EV charging.
- Residential flexibility from electric vehicles is critical to integrating the increased amount of renewable energy needed on the system to achieve a net zero. This flexibility is on the cusp of widespread adoption, after years of projects like those explored in this paper. Policymakers should consider removing barriers to domestic flexibility accessing different markets. In doing so, smart charging drivers and households can be rewarded for helping the system to be more flexible.
- In June 2020, UK Power Networks became the first network operator in the UK to award contracts for smart charging to provide network flexibility.

Introduction

In this paper, we explore the opportunities, challenges and the potential value of smart EV charging as part of a flexible future energy system.

As the system evolves towards a zero-carbon grid, increased renewable penetration in the generation mix and the electrification of heat and transport will bring challenges to balancing the system. Flexibility plays a key role in facilitating this transition and addressing the main challenges that distribution and transmission system operators will be facing in the future.

The need for flexibility in a zero-carbon world has been illustrated more than ever during the COVID-19 lockdown as the system's demand and generation mix has changed significantly.

This has created new challenges for the system operator around renewable generation spikes and less predictable demand – exposing the system to more frequent occurrences of high imbalances. As a result, additional system balancing costs are expected to reach £500m between May and August 2020.

Intelligent optimisation of household loads can help solve these residential network challenges. The increase in EV uptake presents a significant opportunity for smart charging at the household level, to provide the flexible load needed to balance increasing intermittent generation on the national (TSO) and local (DSO) level.

Although in their infancy, DSO flexibility markets are quickly evolving. In June 2020, UK Power Networks became the first network operator in the UK to award flexibility agreements to smart EV charging providers. To deliver network benefits through smart charging, DNOs need to understand the reliability and level of response that can be achieved, while giving customers control of their charging.

In order to successfully realise the benefits of smart EV charging, end customers must be incentivised through compelling energy propositions and a choice of the latest charging hardware that give them a rewarding and seamless digital experience.

Smart charging explained

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Smart charging can be simplified down to charging your EV at variable charging rates, based on external factors to help manage loads on the grid. However, there are nuances to this.

An Overview

Smart charging is one of the most attractive methods for EVs to provide flexibility and load management services to the electricity system that doesn't necessitate substantial costs to chargers or vehicles. Smart charging:

- can be broadly defined as the intelligent optimisation of the charging of EV batteries, that considers user preferences, external signals (price, availability of solar/other renewables) and demand requirements.
- primarily occurs through a connected charger that determines time of charge and rate of charge to start/stop charging the EV to pre-set requirements whilst also considering the variables above.

Charger-centric smart charging is currently the dominant approach. These chargers are usually connected to a cloud service provider (e.g. Kaluza, Jedlix, ev.energy) that takes external market values and can be paired with local PV (solar) generation, localised load signals to start/stop charging when it would benefit both the customer and the grid.

Home-centric smart charging is a niche, but growing approach – where a centralised home energy management system works as a master controller between different energy sources and consumers within a household to optimise and balance energy flow. This is especially prevalent in homes with PV installations on the roof and where the homeowner owns an EV.

Delta-EE conducted customer research in 2019 for its Electric Vehicle & Electricity Research Service. We surveyed 1000 BEV and PHEV owners across 5 key EU markets, asking for their views on smart charging. Some of the key insights are:

- The more mainstream smart charging becomes, the greater the customer level of understanding will be, which is directly proportional to uptake.
- However, there is still low awareness of smart charging in most markets – more education about the benefits and availability of smart charging approaches is needed.
- Energy suppliers are well positioned to be smart charging providers. They are currently customer's preferred smart charging providers alongside DNOs. Energy suppliers have the capability to bundle savings into the monthly utility bill and can optimise their wholesale trading arrangements for maximum value creation.
- Customers are predominantly driven by the financial aspects of smart charging, with the environmental benefit a close second.

- An overwhelmingly common theme is that customers expect their batteries to be charged to a sufficient level by the time the vehicle is needed. A manual override to their charging was seen as a desirable option to maintain peace of mind.

As shown in the Figure 1 below, Kaluza's charger-centric approach to device optimisation involves a core platform which has the capability to integrate multiple streams of network and environmental signals on both a national (TSO, wholesale, grid CO₂), and local level (distribution network and local distributed generators) depending on the individual situation and customer preferences.

These signals, combined with additional customer preferences (e.g. state of charge, ready-by-time), are utilised to deliver required electricity to the individual devices at the lowest possible cost, while also further reducing their EV charging carbon footprint.

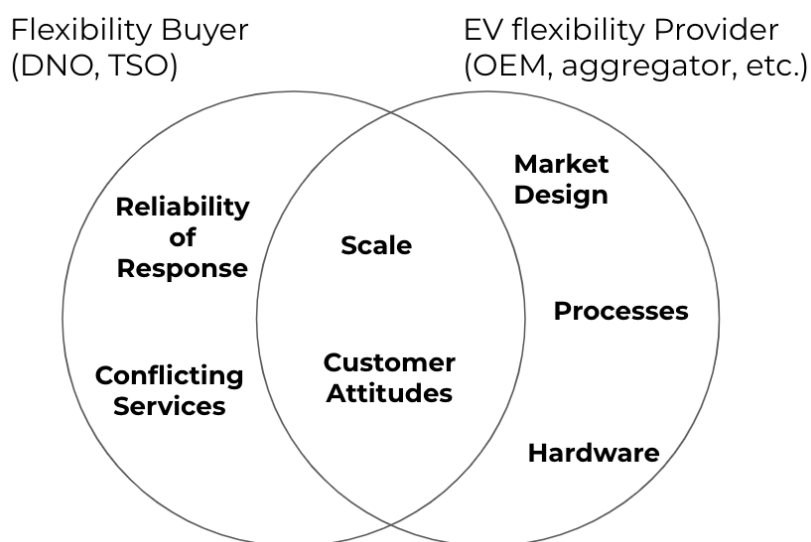


Figure 1 Kaluza's Charger-centric smart charging

The challenges facing smart charging

Enabling smart EV charging requires input, cooperation and investment from different parts of the EV value chain. The key challenges for different players in the smart charging ecosystem varies.

Smart Charging Challenges from Different Perspectives



As the EV market evolves, it is important to note that smart charging is still facing a variety of challenges from both the flexibility buyers and flexibility sellers.

Flexibility Provider Perspective

While domestic level EV smart charging has the potential to present significant flexible capacity to the local and national grid, many of the markets that could utilise this capacity are still out of reach, due to the challenges associated with having the right flexibility capacity available, at scale.

Currently, half-hourly price optimisation and emerging DSO flexibility markets present some opportunities to generate revenue, but several factors prohibit access to many of the major markets or a level playing field against MW scale flexibility assets. These fall into two segments – **market design and processes, hardware mismatch** and the **common challenge** of scale of EV flexibility.

Market design and processes

When considering wholesale electricity markets and network charging, only a small fraction of domestic customers are exposed to half-hourly electricity prices, which is needed for optimisation. Mandatory half-hourly settlements and smart meter penetration, down to the household level, will allow customers to maximise the savings that can be achieved from smart charging. Beyond this, further change is required as part of the current network charging reforms to create more accurate and cost-reflective network charging signals.

When discussing DSO and TSO flexibility markets, further development is needed on flexibility marketplace design to ensure that they:

- Enable simpler and more streamlined onboarding and ongoing participation in these markets via improved IT infrastructure. This would enable easier market access for large portfolios of kW scale devices and large-scale assets.
- Implement baselining methodologies that accurately recognise the flexibility delivered from assets with primary use (including EVs).
- Implement standardised data exchange approaches across all markets and device types.

Initiatives such as ENA Open Networks Project are supporting a coordinated approach between electricity networks to address such challenges. The inclusion and award of low voltage (LV) flexibility agreements in UK Power Networks 2020 flexibility tender was a world-first and the reduction of the minimum threshold to 10kW is an encouraging direction of travel.

Hardware mismatch

As the majority of early flexibility markets have been developed around procurement from MW scale assets, requirements for metering hardware have also been focused on industrial scale assets. Uncertainty for the future of smart and flexible assets on a domestic scale (including smart chargers and EVs) comes from there being no explicit standards for the metering hardware on flexible devices connected at a LV level.

Without sufficient communication of this mismatch between value chain participants, it will likely lead to significant capacities of stranded domestic flexibility, therefore locked out of providing cheap balancing services to the network. More direct engagement and collaboration between OEMs (EV service equipment and automotive), service providers and networks needs to take place to address this.

Network operator perspective

The market for domestic flexibility and smart charging is still at a very early stage of development. This means that there are several questions and uncertainties that need to be addressed and resolved to ensure smart charging can play a role in the future flexibility markets.

Networks are making progress to simplify and extend rapidly developing DSO flexibility markets to facilitate participation from all levels of flexibility. However, smart charging propositions for domestic customers are relatively new and offered by a small number of market leaders, which reduces market liquidity.

Reliability of response

To defer network investment through the deployment of smart solutions, such as smart charging, DNOs need to understand the reliability and level of response that can be achieved. More data, such as that being collected through UK Power Network's project, Shift, is needed on market-led smart charging so that DNOs can understand and assess the network impact and value of smart charging. It is important that network operators understand the variability of response, and the degree to which customers override optimisation so they can account for the impact of these on demand, while giving customers the ability to control their charging.

Conflicting services

In addition to reliability of response, further understanding of how different market signals and services may interact and how these should be developed to ensure the network, as a whole, is utilised in the best way possible. Flexibility delivered through smart charging could be utilised for national or local needs. However, a better understanding of how to manage potential conflicting services, while enabling customers to achieve the lowest costs via their smart charger, needs to be developed further.

Common Challenges

Understanding customer attitudes and achieving scale

As the overall number of EVs is still relatively low, scale presents a fundamental challenge in using smart charging capabilities in most flexibility markets on the local or national level. While this will change as significantly more EVs are expected to be on the roads over the next decade, it is important to resolve some of the challenges adhered to above. Ensuring not to continue stifling and limiting the opportunities for smart charging will benefit customers and network operators.

In parallel to this, market players like Kaluza are still learning about the customer attitudes towards smart charging as the market moves from innovators and early adopters to early the majority. Understanding how to best engage different customers in smart charging will be essential in getting the most out of smart charging for the network and the customer.

Automotive OEM perspective

The Automotive OEMs have a vital part to play in smart charging flexibility. As they produce the hardware that is turned up and down, they also own the customer relationship of the single most expensive component in the smart charging value chain. Whilst standards and connectivity are in place to enable charger-centric smart charging, the vehicles themselves are not always fully integrated into the value chain, which asks the question – why not?

While OEMs are beginning to understand the challenge their products bring to the electricity industry, traditionally they not been involved in the supply of energy to their products. The oil & gas industry have always served this purpose. OEMs are now growing more aware of the required interactions with the energy sector, with many providing domestic chargepoints via their retailer networks, under their own name or with strategic partners in certain markets.

Whilst there is an obvious benefit to incorporating the vehicle directly into the smart charging ecosystem to truly enable *car-centric charging*, there are numerous challenges for the manufacturer. Modern cars are designed for the global market, and selecting a strategic partner in each market that can be relied upon to deliver a service to their customers is not an easy integration task. For a market that is immature, with interoperability and chargepoint variation and retail supply challenges, this currently isn't feasible for a car manufacturer to cater to every eventuality.

Whilst OEMs might be tempted to trial services in selected markets, a global standardised solution is unlikely in the near future.

This is one of the reasons why charger-centric smart charging will dominate in the short term. The ability to start and stop charging a vehicle, and vary the rate of charge using the handshake agreements between the charger and vehicle, is enough to provide the same experience and generate value to the consumer.

For each smart charging service provider to create an application that runs on a car manufacturer's specific platform would be daunting. But common platforms (e.g. an evolution of Android Auto / Apple Car Play / the App store approach to features) may enable plug and play functionality – with the service provider responsible for managing customer expectations. Whilst this approach will need further development by both the vehicle OEM and energy service aggregator, this has the potential to be a common method for delivering vehicle integrated solutions, which will empower the customer – giving them more choice and control.

What is the potential of smart charging?

Smart EV charging can provide solutions to the challenge of flexibility reserves and demand management for the electricity grid, with the potential to provide a CAPEX light solution in certain areas, when compared to traditional reinforcement for demand growth.

Studies have shown the potential benefits of active (demand side flexibility or response) versus passive (network investment) approaches to demand management.

Passive approaches represent the greatest upfront CAPEX investment required and includes expanding generation and network capacity increases. This business as usual approach is still appropriate in a wide variety of circumstances, but active approaches (smart and flexible) should be used to optimise the use of existing network capacity to reduce network investments.

An active approach to accommodating additional demand (EVs, PV, heat pumps etc) could result in system cost savings if it can demonstrate the same level of reliability as traditional approaches to network operators. The estimated savings vary from £3bn to £6bn per annum by 2050¹, which can be delivered by strategic application of stationary storage at a domestic or grid level. A study by Carbon Trust and Imperial College London on behalf of the Government, showed a potential saving of up to £8bn per annum by 2030².

A portion of this saved cost could be reflected in the customer's monthly bill, as system costs are included in the £/kWh value a customer would pay. The value would vary between each individual customer, but the saving on infrastructure and capital expenditure could be reflected in bills.

It is also expected that active flexible approaches to electricity system management could reduce the generation capacity required by 20TWh - 35TWh/year by 2050¹, maximising renewable and zero carbon infrastructure and assets.

When looking at the additional system balancing costs that have occurred throughout the COVID-19 lockdown in mid-2020, caused by reducing predictable demand and 'higher than usual' renewable generation costs on the UK network, Kaluza analysis shows that each EV with

¹ The range specified here represents the majority of estimates across a number of different studies and sources

- Delta-EE Flexibility & Energy Storage Research Services
- Piclo, Element Energy, Graham Oakes, UKRI April 2020 <https://piclo.energy/publications/Value+of+Flexibility.pdf>
- Aurora Energy Research May 2018 <https://www.nic.org.uk/wp-content/uploads/Power-sector-modelling-final-report-1-Aurora-Energy-Research.pdf>

² Imperial College, Carbon Trust Nov 2016

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

the right intelligence implemented could save the system and end-customer £20 from the additional balancing costs occurred over the 4 month period. In a net-zero world, this could enable annual system savings of at least £0.5bn from utilisation of smart EV charging to support just the system foot room as more intermittent renewables are connected to the grid.

A DNO perspective on smart charging – UK Power Networks

UK Power Networks have been one of the UK's leading DNOs with a strategy to be an enabler of the electric vehicle revolution while maintaining its position as the UK's lowest-cost DNO. This is being achieved by placing the customer at the forefront. Enabling easy and hassle-free network connection to the customers on the network is key. Their aim is to enable everyone to be able to charge where they want, at an affordable cost, whether this is at home, on the street, en-route to or at work. To facilitate this, they are working across many different charging and customer segments across the whole transport space to understand the infrastructure requirements, consumer behaviours and preferences that are driving this revolution.

As one of the early movers in the EV space, UK Power Networks' strategy for EVs was first formalised back in 2017, with updates being announced since then³. Their approach is to deliver the transition to net zero at the lowest cost to customers by:

- **Forecasting** – Using UK's leading network operator EV forecasts to inform network planning to understand where the uptake will be and when it will occur
- **Monitoring** – Increasing visibility of what is happening on networks utilising a variety of available data
- **Deploying smart** – Optimising network use through innovative technical and commercial solutions including smart charging and V2G. UK Power Networks were the first DNO to adopt a "flexibility first" approach and to champion market-led smart charging.
- **Investing strategically** – Flexibility should be maximised first to reduce investment required, but networks should also invest where it is the best value option to provide capacity and meet our customers' needs

Value of smart charging to a DNO

Smart charging presents a significant opportunity to manage the impact of EV uptake on the network by shifting EV charging away from times of peak demand. Typically, domestic demand peaks in the evening when people get home and drops to a minimum overnight. Smart charging gives customers the ability to shift their EV charging to times when prices are lower or there is less demand for electricity, which can improve the use of the existing network capacity by flattening peaks. On some networks, shifting flexible demand, such as EV charging, may be able to reduce or delay investment in the network. In combination with other smart solutions, network visibility and investment, this will enable DNOs to facilitate EV uptake and meet customers electricity needs.

This is why UK Power Networks has been one of the DNOs broadening the market for domestic customers to participate in flexibility. In June 2020, they became the first network operator in the UK to award contracts to smart EV charging providers to provide network flexibility. The inclusion of LV flexibility zones was a world first and had a minimum threshold of 10kW for

³ <https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2019/11/UK-Power-Networks-Electric-Vehicle-Strategy-November-19.pdf>

participation, making this product more accessible to smaller or distributed sources of flexibility like EVs.

Through [Shift](#), they are exploring ways to incentivise market-led smart charging via network price signals as well as through flexibility markets, which will provide widespread opportunities for flexibility as well as more targeted solutions. There are a number of considerations when evaluating the material impact of smart charging on the network.

- Flexibility will be an important tool to increase utilisation of the network at times where capacity is available.
- The proportion of EV customers on a local network and the level of smart charging participation will impact the effect of smart charging at a local level.
- Synergies with other sources of load growth, such as electric heating, must be considered when evaluating network solutions.
- As flexibility increases, visibility of network conditions will be increasingly important to monitor network utilisation and ensure security of supply.

Smart charging will not enable distribution networks to mitigate all constraints, but it is an important tool to help utilise existing network capacity and manage the impact of electric vehicles.

Investing in EV Innovation

UK Power Networks approach to supporting the electrification of transport has been built on the evidence and experience gathered through EV innovation portfolio and projects dating back to Low Carbon London which started in 2010 through to projects like Smart CAR, Black Cab Green, Recharge the Future and Optimise Prime.

Shift is the testament of UK Power Networks' commitment to facilitate the emerging market of EV flexibility and enable the transition to electric vehicles at the lowest possible costs to end-customers. Working with Kaluza, Octopus Energy and ev.energy they are trialling different mechanisms to incentives smart charging with over 900 EV customers to measure impact on consumer charging behaviour.

UK Power Networks has also set up [TransPower](#) to assess the potential for vehicle-to-grid (V2G) to support the network through bi-directional charging. This includes partnering with 20+ organisations including OEMs, suppliers, technology providers and academics on V2G trials with domestic customers, commercial fleets and double-decker buses. With over 80 V2G charge points installed as part of the TransPower trials, UK Power Networks are leading the industry in developing connections processes and flexibility products. A handy link to knowing about the numerous V2G projects underway is, [V2G Hub](#).

UK Power Networks are also working with commercial fleets, Private Hire Vehicle operators and a technology provider to develop practical solutions through [Optimise Prime](#), their own large-scale trial of commercial EVs. It seeks to understand and minimise the impact that the electrification of commercial vehicles will have on distribution networks, including smart charging trials.

Insights from Kaluza Smart Charging trial in project Shift.

Since September 2019, Kaluza has been running a pilot-scale smart charging trial for 311 smart chargers across London and the South East of the UK, as part of UK Power Networks' project Shift.

Through Kaluza's intelligent flexibility platform, the connected EVs are optimised in real time against localised half-hourly pricing signals. In this pilot, the Kaluza platform receives live wholesale electricity pricing data and combines this with a time of use network price feed from UK Power Networks (the Distribution Network Use of System charge, DUoS), together with existing UK-wide Transmission Network Use of System charges (TNUoS). Aggregated, these price signals are reflective of both the demand on the local distribution networks and the transmission system constraints on a national level.

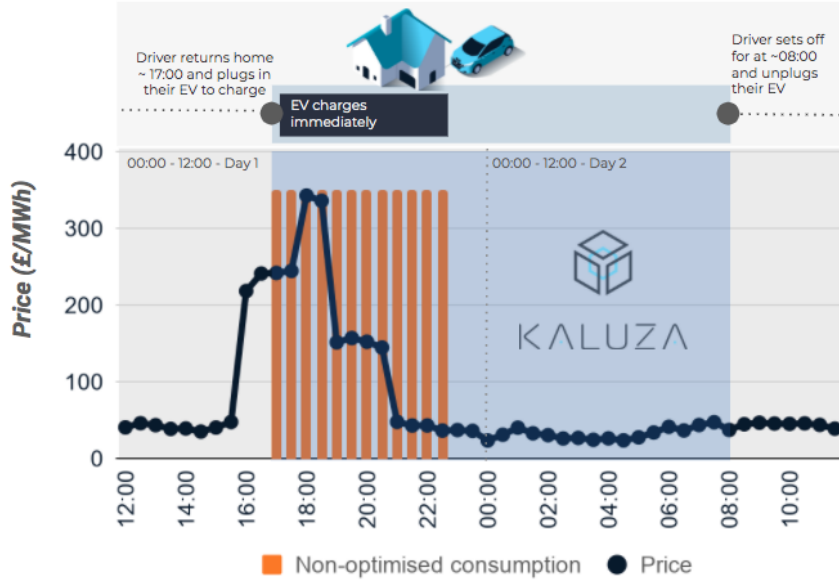
These price signals seek to incentivise flexibility. On a minute-by-minute basis, Kaluza's optimisation algorithms dynamically manage the unique charging profile of each vehicle in the portfolio against a half-hourly price stack. Kaluza shifts consumption away from times when prices are high — or equivalently, times of peak constraint on the network.

In addition to price-optimisation, Kaluza ensures customers' mobility needs are met. Within the customer's smart charging app, drivers can set their desired "ready-by time" for when they want their EV charged by. Users can also choose to override a smart charging session, such that their EV charges immediately. The price optimisation is illustrated in Figure 2, which highlights an unmanaged EV that charges as soon as it plugs in, and a managed EV that is smart-charging to avoid peak prices whilst ensuring it is charged and ready by 8am.

Figure 2. Illustration of how optimisation against price signals can be used to manage EV consumption - highlighted both an unmanaged EV, and an EV with a smart charger.

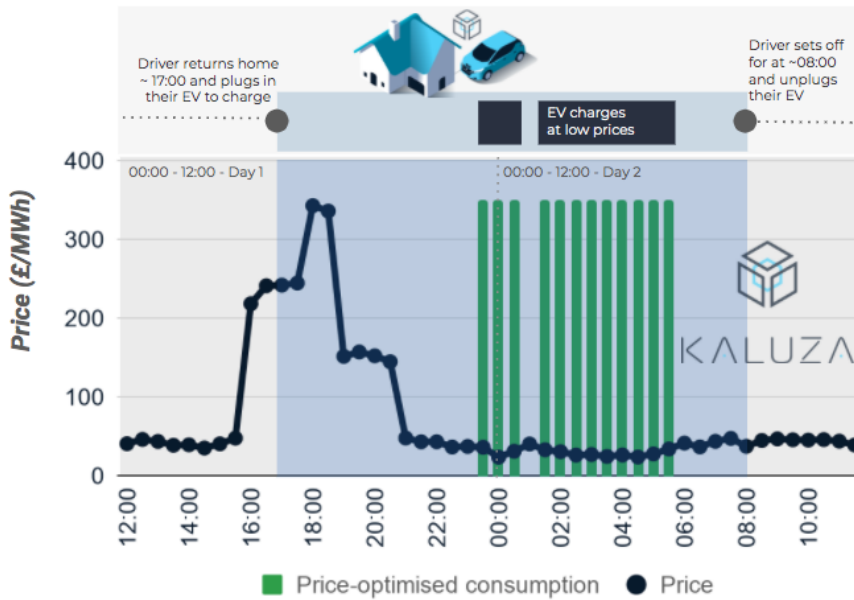
(A) Illustration of consumption for unmanaged EVs

— charging begins as soon as they plug in (often during times of peak network constraint)



(B) Illustration of consumption for smart charging EVs

— charging begins once actioned by optimisation algorithms (at the times of cheapest prices, and equivalently - low constraint on the network)



The trial seeks to demonstrate the efficacy of a time of use network pricing mechanism for optimising the use of existing network capacity through EV smart charging. In particular, it aims to quantify:

- the ability to reduce EV demand at peak times
- the impact of smart charging on EV charging diversity
- and the scalability and cost savings potential for both grid operators and end customers.

The trial is still underway and is expected to finish in November 2020. Early results from the first few months of the trial have, however, already begun to demonstrate how effective such network price signals can be in shifting load away from periods of peak demand.

Figure 3 showcases the average daily load profile across the Shift portfolio from the first four months of the trial. The average load profile is shown for both the baseline unmanaged charging scenario (in which the EV starts charging as soon as it is plugged in), and the managed scenario (in which charging is optimised by Kaluza against the trial's real-time price signals). Both scenarios are mapped against the colour-banded network demand levels experienced on weekdays by distribution networks in the UK; the "red" hours of peak network demand, the "amber" hours of medium demand, and the "green" hours off-peak network demand.

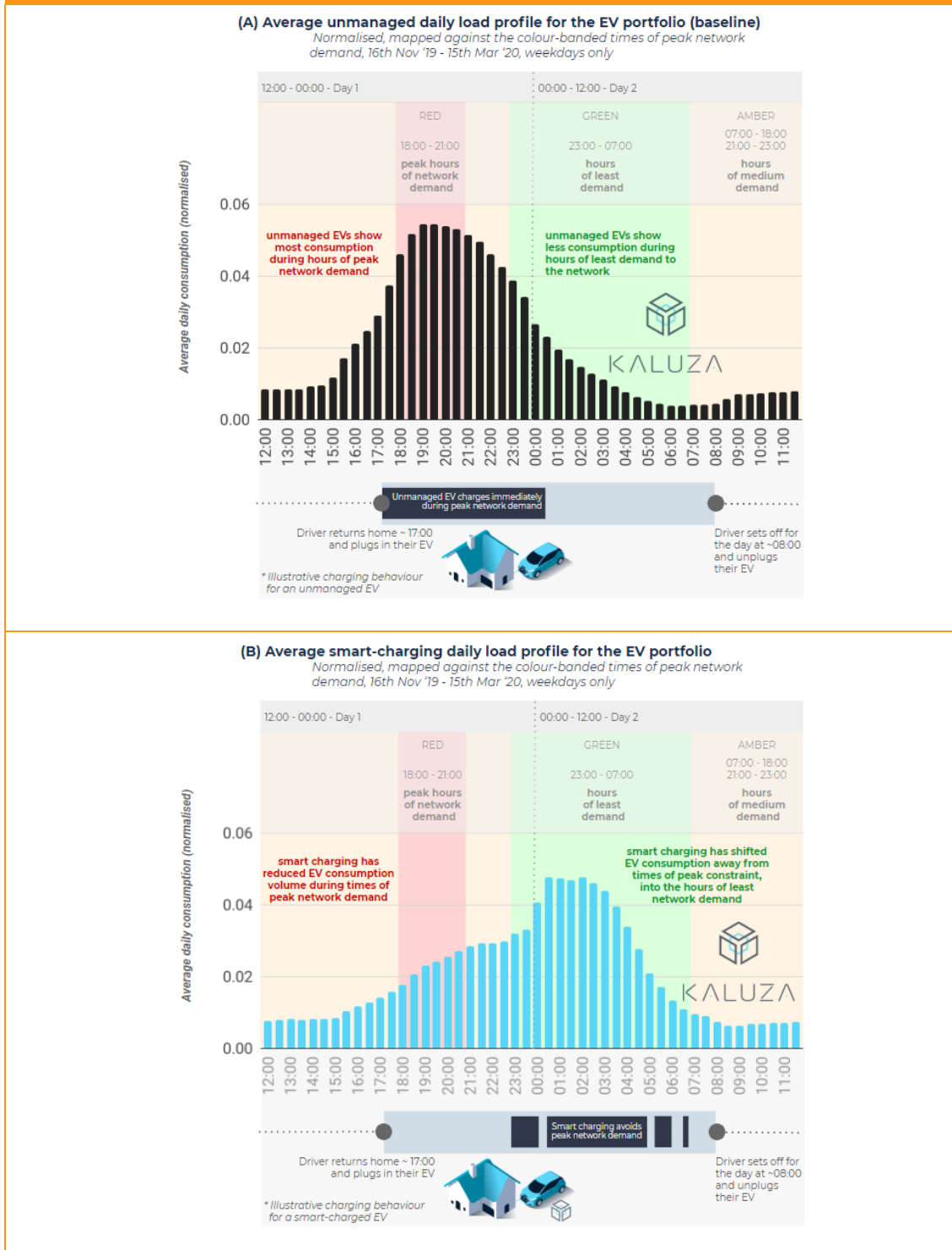
This snapshot of early trial data begins to demonstrate how smart charging against network price signals can direct consumption away from times of network demand. This helps optimise use of existing network capacity, which may prevent or delay the need for network investment. In this example, shifting EV consumption away from the peak "red" and "amber" times of the Shift trial's DUoS signal, and into the least-constrained early hours of the morning.

Figure 3 shows that in this data excerpt, not all demand is moved away to times of peak network demand. This is attributed either to customers overriding their charging sessions to charge immediately, or to charging which is forced to start immediately to meet a customer's ready-by-time. With the latter, this could happen if an EV plugs in close to their programmed ready-by-time, or if they have an EV with a large battery capacity that requires a long time to charge.

Despite not achieving a 100% reduction of consumption during peak hours, this is an encouraging penetration of managed charging hours for such a nascent technology. Kaluza expect this is likely to further reduce consumption as customers become more familiar and comfortable with automated smart charging technologies, and the smart charging experience is further optimised. Beyond Shift, Kaluza are conducting several research streams that are exploring what motivates customers to smart charge, what is driving them to override today, and how customer propositions can be designed to incentivise smart charging behaviour that create grid and customer benefits.

Figure 3. Normalised daily electric vehicle consumption across the Shift trial EV portfolio. (a) unmanaged consumption with a “dumb” charger, (b) Kaluza-optimised consumption against price signals.

Data collected from 16th November 2019 - 15th March 2020 (prior to wide onset of COVID-19 restrictions in the UK). Period of peak network demand (18:00 - 21:00) highlighted in red, medium demand (07:00-18:00 and 21:00 - 23:00) highlighted in amber, and off-peak demand (23:00 - 07:00) in green.



The impact of smart charging goes beyond shifting each individual EV charging profile, however. At scale, smart charging could be used to shift flexible domestic load to reduce overall peaks in demand on the local network. The extent to which smart charging can provide value to networks will be explored once data capture from the Shift trial is complete. This will build on and validate early trial insights, assess the consistency in response over time, and provide an enhanced understanding of the relationship between DSO and other market signals.

As well as the immediate learnings, the Shift trial's market-led approach to smart charging could be reflective of our future energy system – a distributed, smart grid in which network capacity signals are used to intelligently deploy flexibility at a domestic level.

Beyond the Shift trial, Kaluza optimises a wide portfolio of home batteries, storage heaters, EVs with smart chargers and vehicle-to-grid EVs. These are optimised against real-time price signals in the existing UK market, including wholesale prices, DUoS charges, TNUoS charges, and other costs of supply. Some of these assets are used to participate in DSO flexibility markets and are exploring flexibility opportunities in the National Grid's balancing and ancillary service markets.

The Kaluza smart charging approach and technology is entirely scalable and represents a template for future EV charging approaches. Smart charging against price signals that account for network conditions provide DNOs with an opportunity to utilise existing network capacity before reinforcing to facilitate the uptake of EVs; it also enables energy suppliers to unlock new pools of revenue through flexibility markets or by avoiding peak network charges. This can be augmented through participation in DSO flexibility markets to manage any outstanding constraints. In turn, this presents end consumers with reduced energy bills through compelling, novel propositions.

What next?

There are still opportunities to unlock greater value, innovate and optimise the system.

The UK energy market is still a way off from being a mass adopter of domestic flexibility and unlocking this is the key to achieving net zero emissions by 2050. Crucially, this can only be enabled through:

- Key developments in policy and regulation such as prioritising domestic flexibility to meet reliability needs and more granular pricing at the network level
- Continued co-operation within different sectors of the smart charging value stream

Residential flexibility from electric vehicles is critical to integrating the increased amount of renewable energy needed on the system to achieve a net zero. This flexibility is on the cusp of widespread adoption, after years of projects like those referenced in this paper.

Positive action from policymakers at all levels to help remove barriers to domestic flexibility would be welcome to truly unlock innovation. In doing so, smart charging drivers and households can be rewarded for helping the system to be more flexible, and reducing network costs.