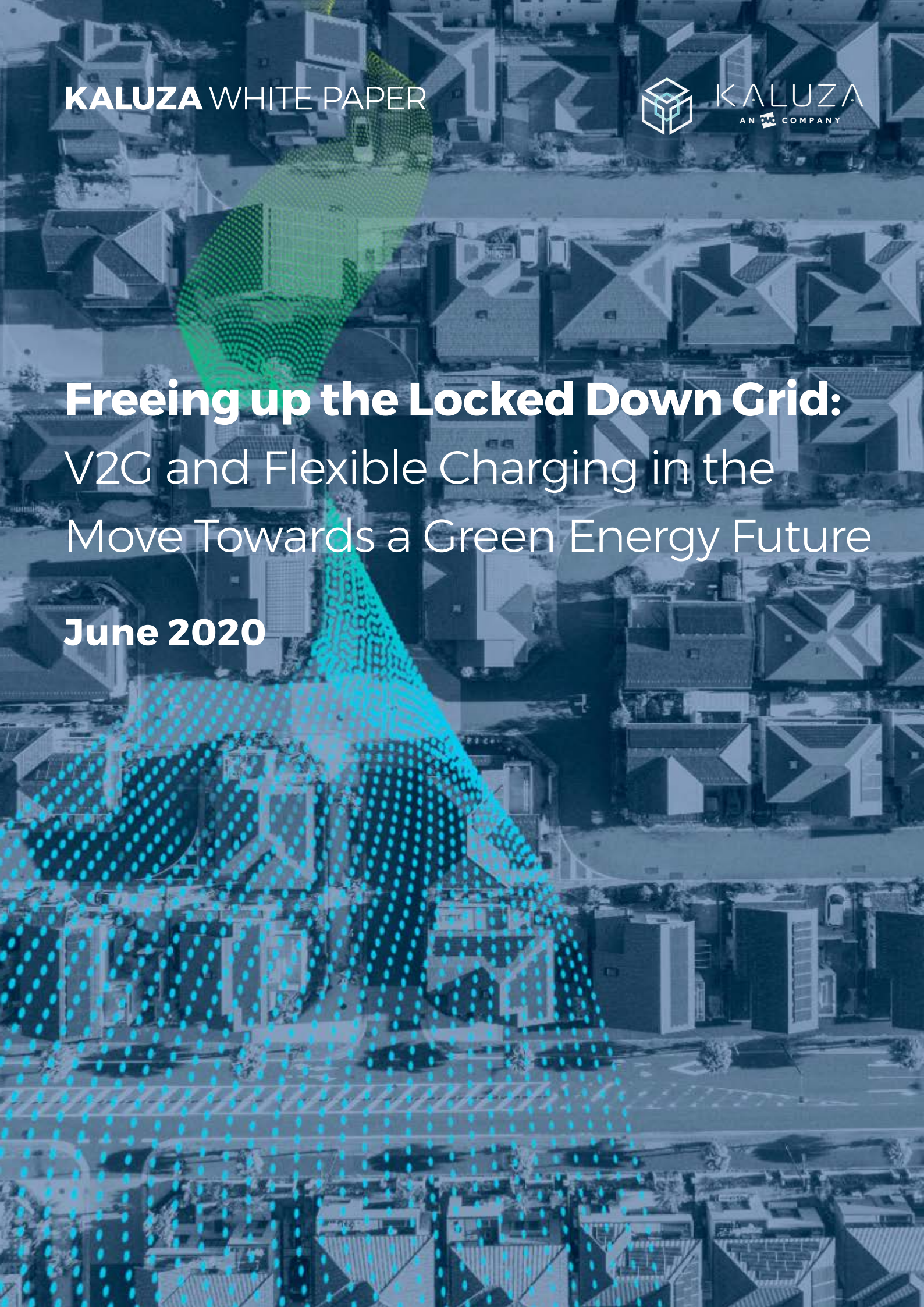

KALUZA WHITE PAPER

KALUZA AN OVO COMPANY

Freeing up the Locked Down Grid:

V2G and Flexible Charging in the Move Towards a Green Energy Future

June 2020

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A Snapshot of the Future

This year, the UK's energy system has endured some of the most extreme grid conditions in modern times. From 90 mph winds and nearly 100 hours of negative energy prices, to the widespread impact of COVID-19, the UK's electricity system is having to evolve, fast. The shift to home working, has meant that people at home are more central than ever in enabling a more decarbonised and resilient energy system. Spring 2020's combination of record-breaking renewable generation and demand changes highlights the need for system flexibility at the domestic level in order to shape a cheaper and greener energy future.

National Grid has taken reactive, short-term measures to avoid system faults in lockdown, such as allowing embedded generation to be cut from the grid, and paying for wind and solar farms to turn off. Despite the immediate efficiency of these actions, the COVID-19 lockdown has highlighted how flexible technologies can help manage the grid, bolster long-term renewable energy penetration and reduce system costs that will ultimately lower customer bills. For example, during the summer of 2019, the cost of balancing the system was approximately £333 million, whereas for the same period in 2020 it is expected to increase by £500 million because of the impact of COVID-19.*

Flexibility is the ability to import and store energy during periods of low electric demand - often corresponding to periods of generation from renewable sources like solar and wind - and thereby reduce the peak demand requirements at a system level. It enables demand to become dynamic as opposed to static, creating valuable opportunities for a smarter, decentralised grid that is powered fully by renewable energy.

Kaluza's flexibility platform is able to connect and control millions of smart devices across people's homes - such as electric vehicle smart chargers, heaters and batteries - helping reduce pressure on the grid at peak times and lower energy costs and carbon for customers. Collaborating with major energy retail partners, OVO Energy and EDF, Distributed Network Operators, UK Power Networks and Western Power Distribution, and a number of leading hardware manufacturers, Kaluza's technology is helping lay the foundations for a more flexible and consumer-centric energy future.

This white paper will assess the bilateral impact of the UK lockdown's unprecedented demand patterns, coupled with an increased reliance on renewable generation, in creating complex challenges for balancing the electricity grid. It will also demonstrate how smart, flexible home technologies, with a focus on Kaluza-connected Vehicle-to-Grid electric vehicle chargers, have dynamically reacted to these changes.

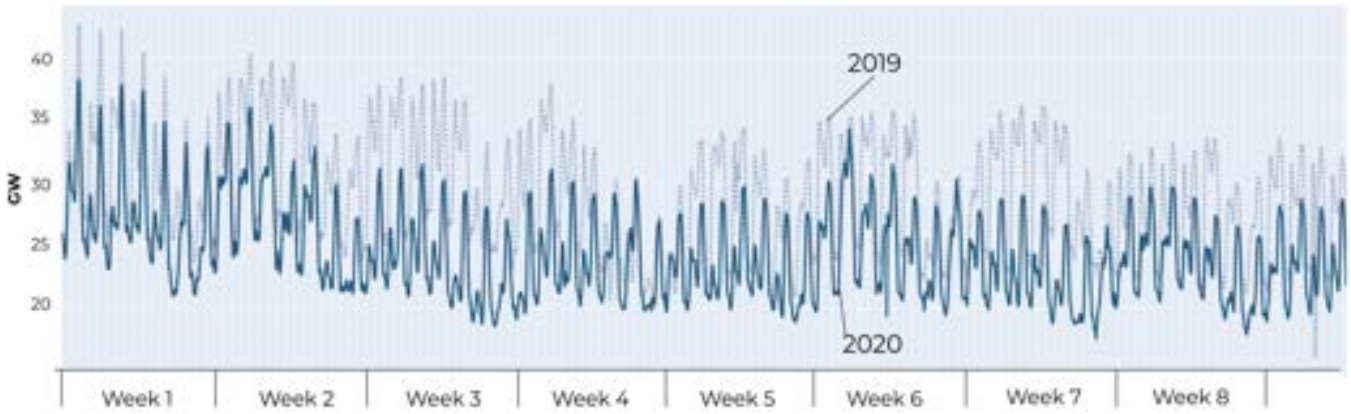
*ESO BSUoS Forecast Update, National Grid ESO, 21st May 2020

Shifting Demand

The total electricity demand on the UK energy system has dropped to new daytime lows. In comparison to system peak demand data from April and May last year, overall electricity demand has fallen by ~17%, a daily decrease of approximately 0.11 TWh. These significant shifts are mainly due to a number of energy intensive commercial and industrial (C&I) businesses ceasing operations as a result of the COVID-19 lockdown measures. It is therefore reasonable to assume that most or all of this demand will gradually resume on exiting the lockdown.

FIGURE 1

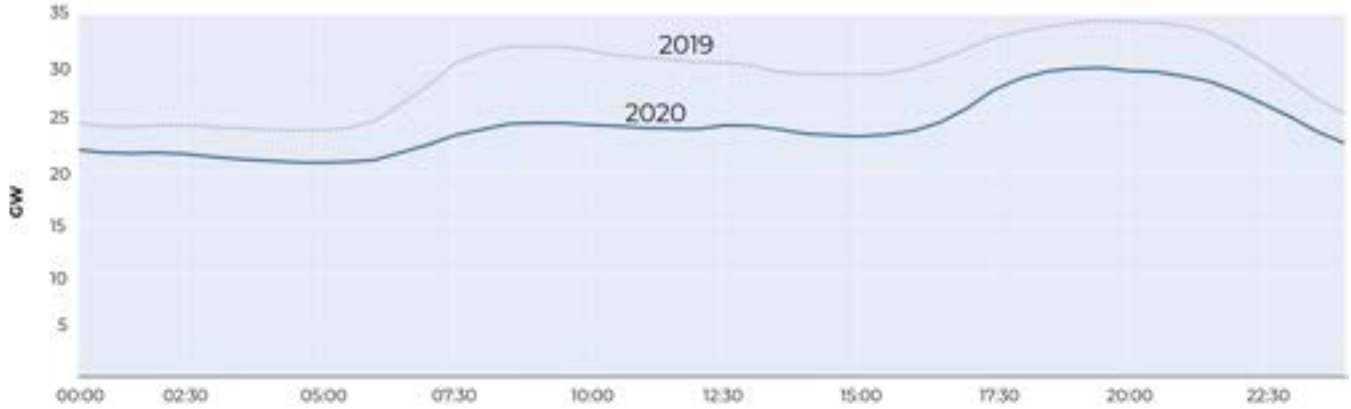
Total Half-Hourly Demand - Weeks of lockdown period (starting 23/03 to 22/05) vs same time last year



Source: Elexon BMRS and National Grid Data Portal

FIGURE 2

Average Daily Demand Profile - Weeks of lockdown period (starting 23/03 to 22/05) vs same time last year

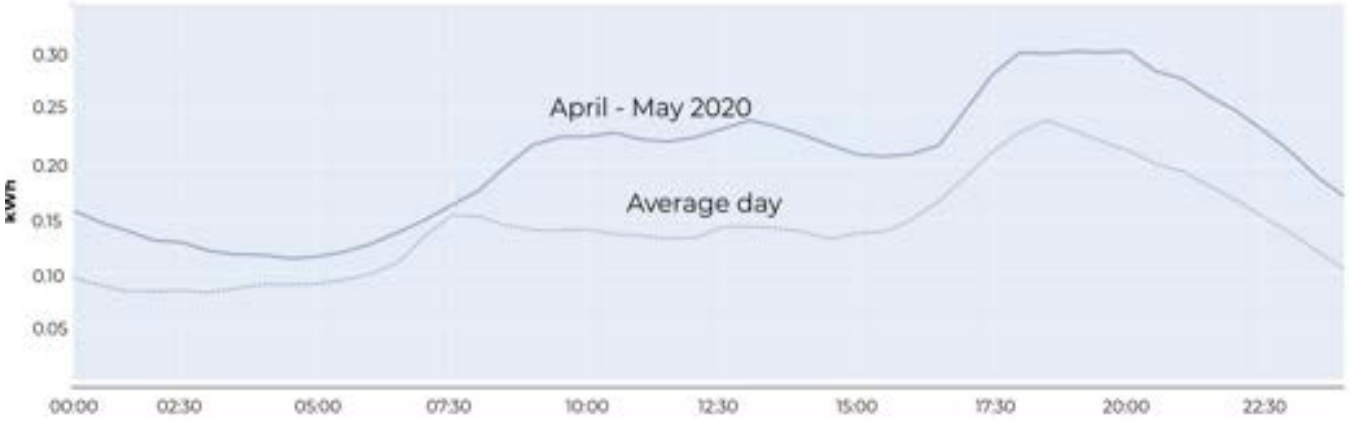


Source: Elexon BMRS and National Grid Data Portal

At the residential level, demand has increased by 15%-20% and, in contrast to C&I demand reductions, this trend could be sustained for longer depending on new behavioural changes that emerge post-lockdown. Beyond overall consumption, changes have also occurred in regards to how and when electricity is being consumed throughout the day. The effects can be explained predominantly by increases in home working and much of the population cooking at home, using electrical tools to refurbish their properties, and streaming video content at different times to normal.

FIGURE 3

Average Household Demand profile - Weeks of lockdown period (starting 23/03 to 22/05) vs average day



Source: Kaluza platform data

Renewable Generation on the up

Compounding the unprecedented changes in the demand for electricity, the volume of renewable generation in the UK's energy mix has increased substantially. While conventional, fossil fuel-based generation (including coal and CCGT) dropped by around 12% in lockdown compared to the same time last year. Electricity generation from clean, renewable sources has increased by ~10% due to highly windy and sunny weather throughout April and May and achieved one whole month powered by coal-free generation.

FIGURE 4

Source: Elexon BMRS and National Grid Data Portal

Network Visibility and Balancing

The combined trends of lower and newly-evolving demand patterns, and hikes in renewable generation, have created complex challenges for grid balancing at a national and local level. The lack of visibility on the domestic network, including new user norms and supply data from distributed renewable generation sites, for example, community-owned turbines, has deepened the complexity of achieving system balance.

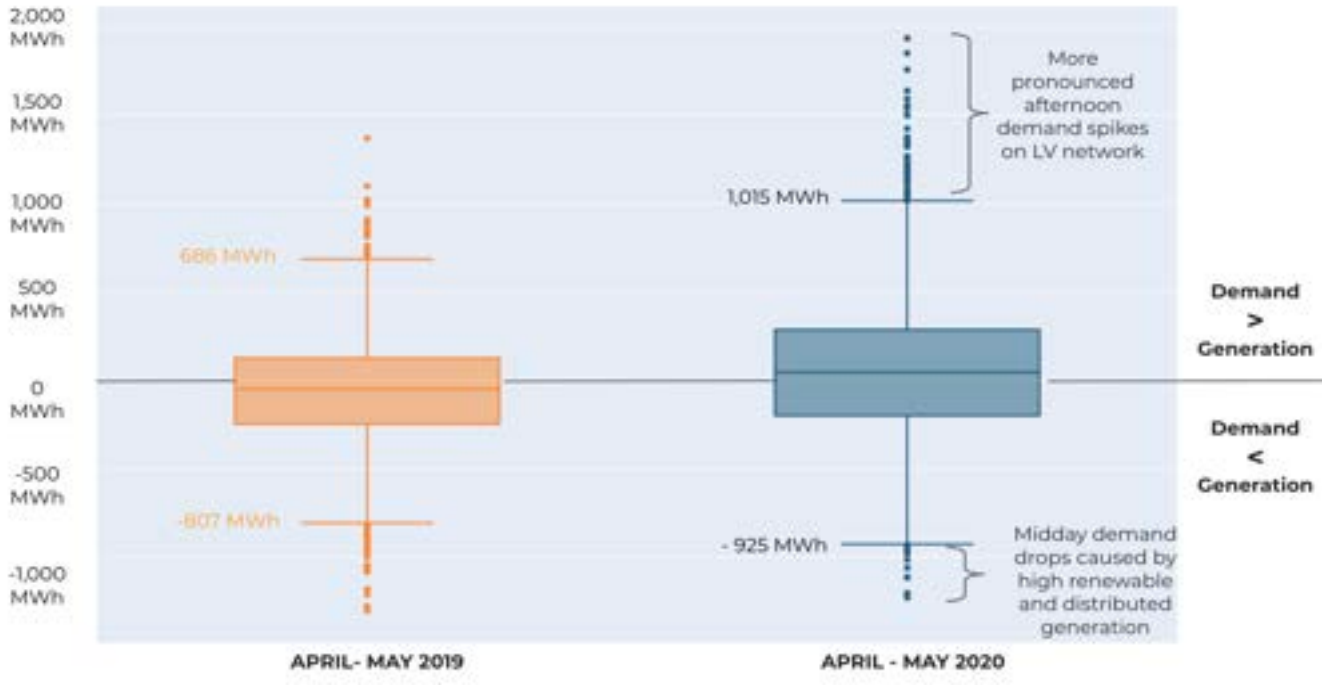
Whilst most of the UK's C&I premises have relatively granular demand monitoring, there is an absence of insight into conditions at the household level. Although smart meters will help gather more data on domestic demand and usage, only ~30%* of homes across the UK have the devices installed. There has thus been an inability to holistically understand the true extent of the decrease in C&I demand and the increase in residential demand caused by lockdown.

Additionally, there has been a comparatively high amount of distributed renewable generation (small wind and solar) on the energy system, due to the UK's sunny and breezy weather over the lockdown period. A large part of these generation assets are not monitored as intensely as large generation plants, meaning the network operators are unable to accurately track or predict how much extra capacity is being integrated onto the system.

Impacts of these factors can be observed in the system's net imbalance volume fluctuations and system prices when compared to April and May 2019. Historically, most of the system balancing (from Response/Reserve Products to Balancing Mechanism) has required procuring sufficient generation to meet the demand at any given moment (headroom). However, over the course of May 2020, there have been a number of instances where support has been requested to absorb the high levels of unpredicted excess renewable generation (footroom).

FIGURE 5

HH Net Imbalance Volume Distribution (April-May 2019 vs April-May 2020)



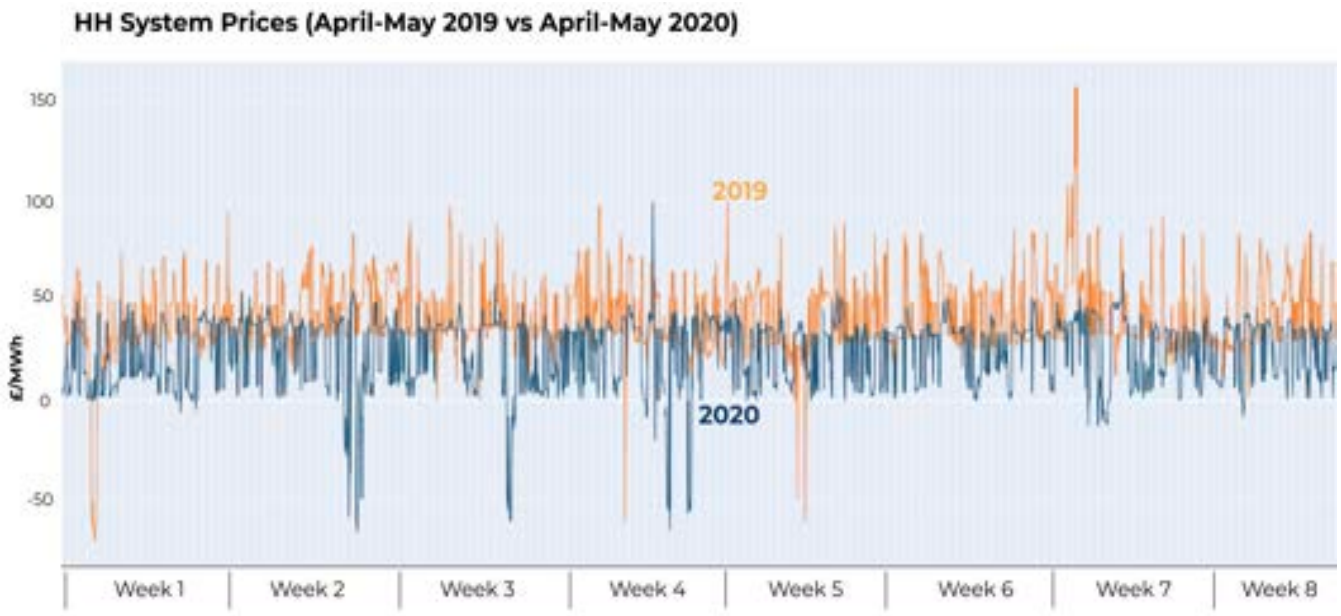
Source: Elexon BMRS and National Grid Data Portal

*Smart Meter Statistics in Great Britain: Quarterly Report to end March 2020, BEIS, 28 May 2020

To further mitigate the footroom concerns, National Grid ESO have also launched a new flexibility product (Optional Downward Flexibility Management), aiming to procure demand turn-up or generation turn-down from flexible assets currently not participating in Balancing Mechanism or any other NG ESO balancing services.

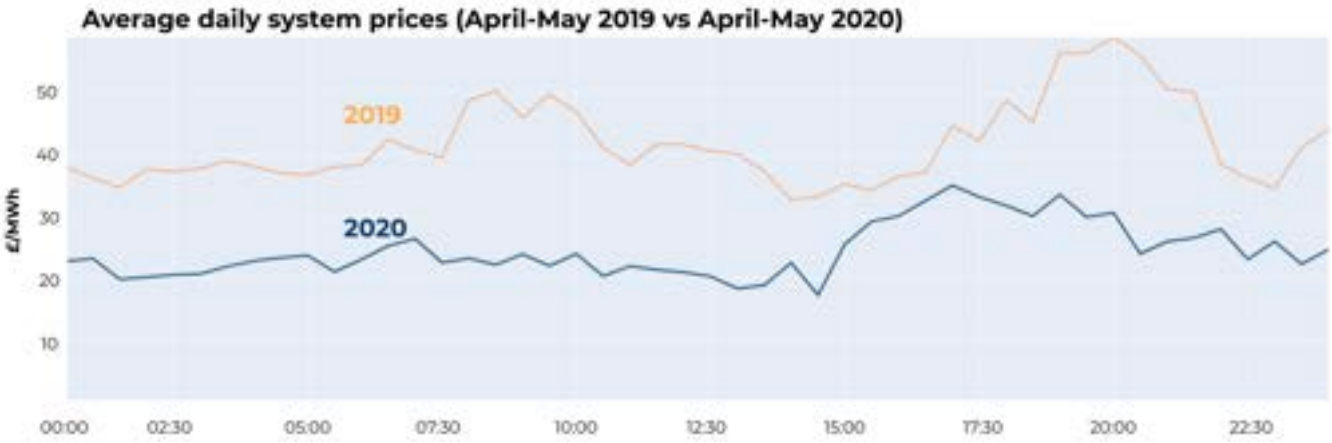
By analysing April - May's net imbalance volume data, in comparison to the same time last year, we can see that changes on the electricity system have led to higher fluctuations in the half-hourly system imbalance. Imbalance has been pushed both positive and negative as a direct result of the increase in unpredictable demand and generation. The high contribution of renewable generation is also reflected on the daily system prices which, on average, have been ~70% lower than the same time last year and multiple instances of half-hourly prices dropping below 0. This means the grid would be willing to pay for the consumption of excess energy on the system at the local network level.

FIGURE 6



Source: Elexon BMRS and National Grid Data Portal

FIGURE 7



Source: Elexon BMRS and National Grid Data Portal

The Role of Domestic Flexibility for the Future Grid

The widespread proliferation of electric vehicles (EVs), batteries and smart electric heating in people's homes will introduce a huge reserve of flexible energy storage capacity distributed all through the network.

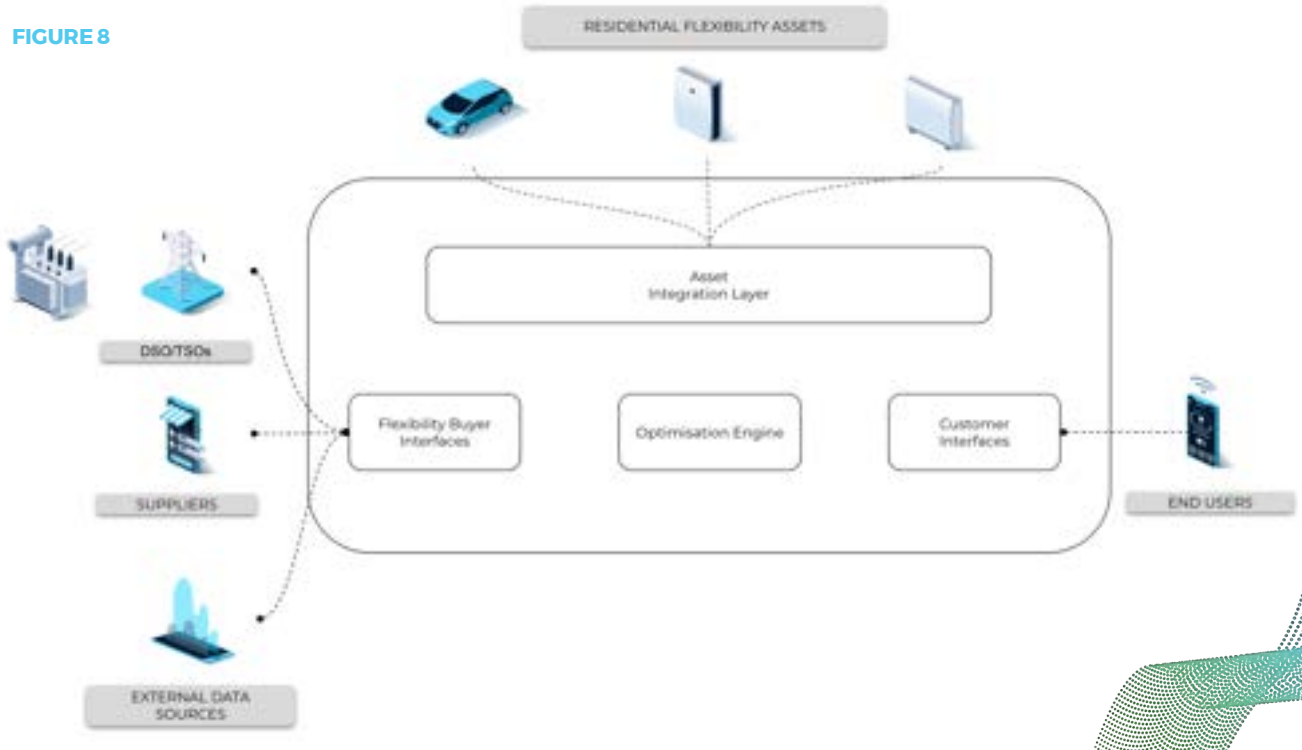
Intelligently managed at scale via technology platforms such as Kaluza's, domestic flexibility can significantly reduce system costs, strengthen grid resilience and its ability to use more renewable generation, as well as benefit device owners. A 2018 study conducted by OVO Group and Imperial College London*, estimated that residential flexibility could result in whole system cost savings of £6.9bn in delivering the energy transition by reducing the requirement to invest in traditional network infrastructure, and integrating higher levels of cheaper renewables like wind and solar.

Optimising Smart, Flexible Devices at Scale

Kaluza's flexibility platform is able to connect and control millions of smart devices across people's homes, such as electric vehicle chargers, electric heaters and batteries. The platform uses AI to optimise device charging patterns so they use energy when costs and carbon levels are lower and when there is abundant green energy on the grid. The domestic flexibility created is served to the grid to facilitate balancing.

Customers with platform-connected devices benefit too. Kaluza ascertains information about the end customer's need for an individual asset through a mobile web app and combines it with data received from various flexibility buyers, such as distribution system operators and retail energy suppliers. The platform then requests a charging path that is able to simultaneously deliver the needs of the end customer, for example, their electric vehicle is fully charged by a defined time the following day, and, simultaneously, dynamic flexibility to the system buyers. As the flexibility provided by Kaluza's devices shifts demand away from peaks, when energy prices and carbon levels on the system are higher, cost savings are created for energy retailers. These are then passed back to the customer in the form of reduced energy bills.

FIGURE 8

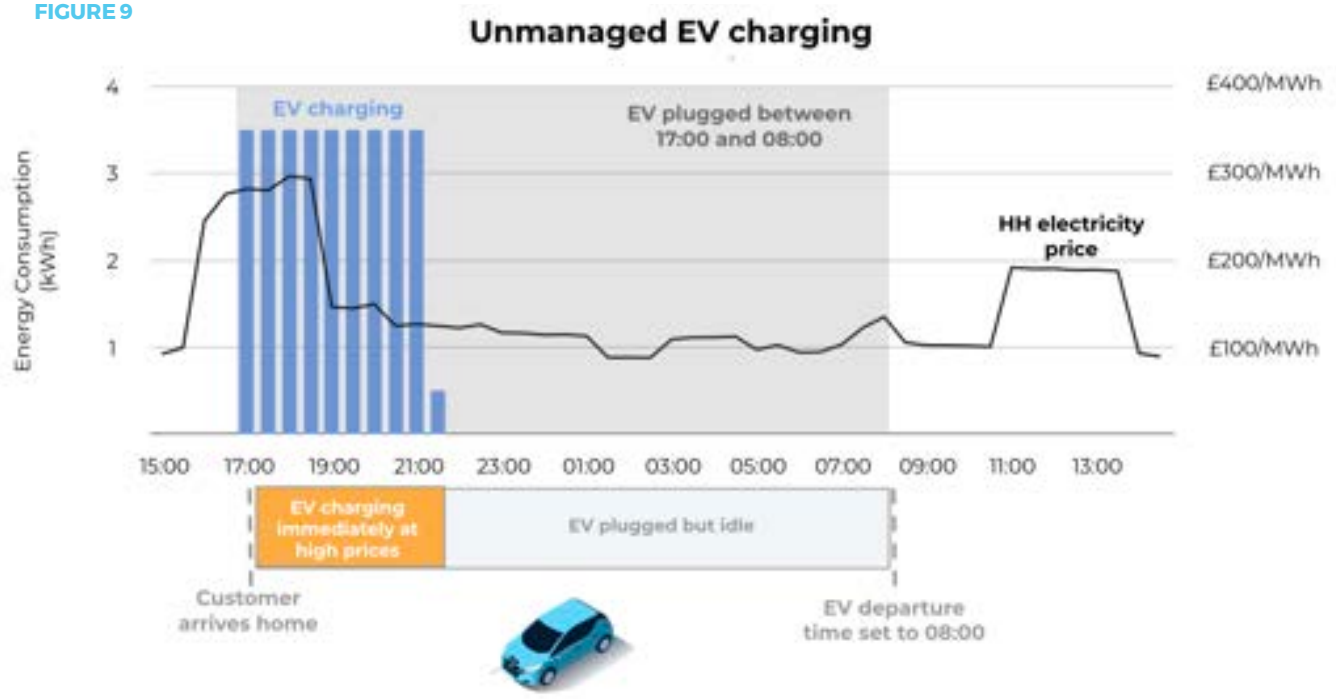


* Blueprint for a post-carbon society, September 2018, OVO Energy & Imperial College London

Kaluza Optimisation in Action

To illustrate how this works in the real world, consider a typical EV user who arrives home at 5pm, plugs their car into their EV charger and needs to use it again for their commute at 8am. A conventional EV charger, without smart charging capability, would start charging the car at full power immediately after it is plugged in until the EV battery reached full capacity. This often corresponds to times of peak demand in the system, of which the "HH electricity price" in *Figure 9* is an indicator. The car remains plugged in until 8am when it is actually needed, and yet it is charged in a way that increases peak demand on the grid.

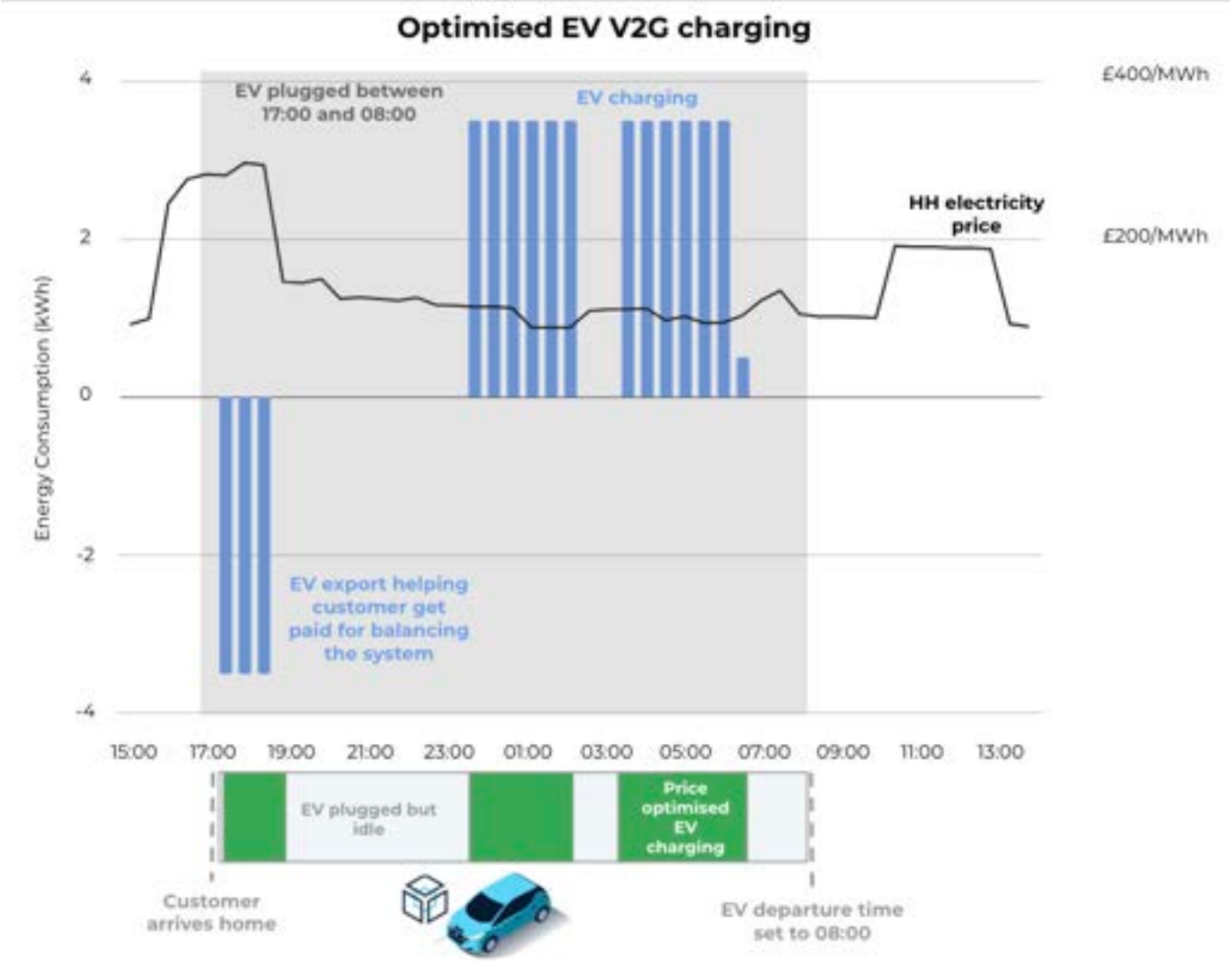
FIGURE 9



Source: Kaluza platform data

Unlike a conventional EV charger, a Vehicle-to-Grid charger (V2G) is able to both import power from the grid to charge the EV battery and also export power from the EV battery into the customer's home and the grid if requested, see *Figure 10*. A customer with a Kaluza-connected system involving such a Vehicle-to-Grid charger uses a web app to specify at what time they need their car ready. During periods of high system prices or peak demand (4pm to 7pm), the Kaluza system then commands the vehicle to export power from the EV battery into the grid - thus reducing peak grid demand.
Then, during the overnight hours when system prices and demand are low (often corresponding to periods of renewable generation), the Kaluza system commands the vehicle to import power from the grid into the battery so as to get the car ready by the customer specified time of 8am. Thus, Kaluza is able to service the needs of the system while also ensuring that end customer needs are met.

FIGURE 10



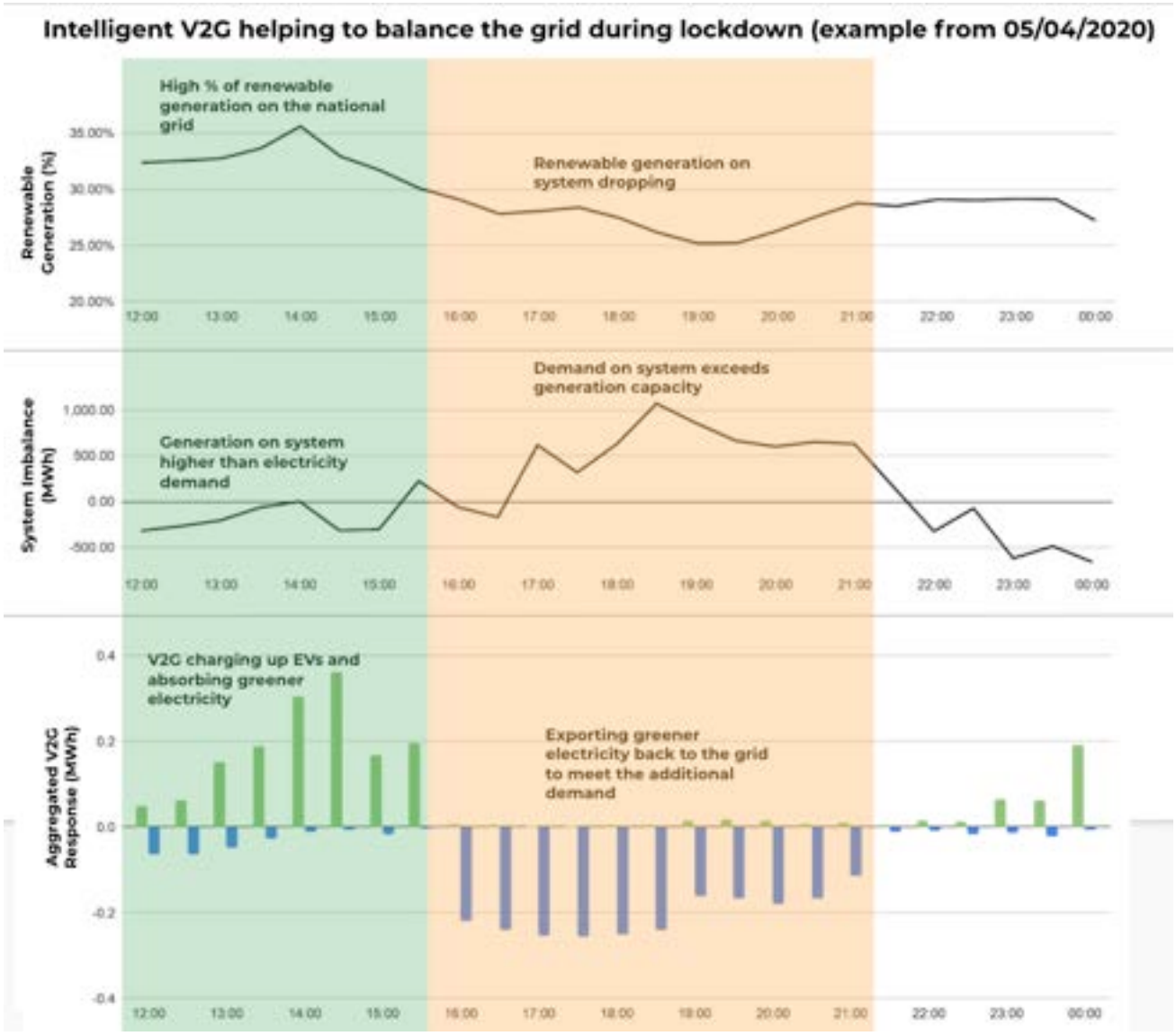
Source: Kaluza platform data

Smart V2G Charging in Lockdown

Although other assets on Kaluza's platform have contributed to domestic flexibility on the grid during lockdown, V2G chargers have provided the highest volumes. The graph below shows how Kaluza's platform has been able to support the network by optimising the V2G devices to absorb abundant renewable generation from the grid, and export it back when additional capacity is needed to meet the afternoon peak demand. During the first week of lockdown, the chargers exported almost 50% more than the previous week. In fact, Kaluza-optimised devices continued to export at this increased rate throughout the whole of April.

Figure 11 shows how a group of Kaluza-connected V2Gs responded to market signals and helped to balance the system during lockdown in a 12-hour period. Between 12pm and 4pm, the connected EVs were used to charge as the overall grid had a high percentage of renewable generation and negative system imbalance requiring additional load. Between 4pm and 9pm, renewable generation capacity on the system dropped below 30%, and system imbalance indicated that additional capacity was needed to supplement the additional load. In response to this change on the system, the V2Gs were further utilised to support the system with additional capacity from export. This is just one of many examples throughout the lockdown period where Kaluza V2Gs have helped the system deal with rapid changes in demand and generation.

FIGURE 11



Source: Kaluza platform data

From Lockdown to Zero Carbon

The UK energy system's response to the COVID-19 lockdown, has shone a light on key areas of improvement and opportunity that could facilitate our transition to a highly distributed and renewably-powered energy system of the future. The shift in demand behaviours and unprecedented levels of renewable generation are introducing new complexity and challenges for grid operations. However, as presented in this paper, flexible, AI-optimised home devices are proving their ability to support the underpinnings of a more resilient, agile system. The assessment of Kaluza-connected V2G charging behaviours alone during the lockdown period shows how domestic devices can automatically respond to fast evolving grid events, and increase renewable generation utility.

A zero carbon energy system will require more renewable generation capacity and increasing electrification across heat and transport. Although renewable penetration will need to hit a constant of 100%, the lockdown experience is providing rich insights into managing large volumes of intermittent wind and solar generation on the system. In addition, the demand changes that have been occurring during lockdown are analogous to the shift in how and where electricity will need to be consumed in future.

The impact of the UK's lockdown highlights the need to develop two key areas of the energy system to facilitate the transition to zero carbon:

- Increased data and visibility at all levels.
- Domestic flexibility that can help bridge the gap between high renewable generation and increases in electrification of heat and transport.

Kaluza's flexibility platform has the potential to empower people at home to participate in a democratic and cleaner energy system by unlocking the full potential of smart home technology. Recognising the important role domestic flexibility has to play, and shaping a market that will realise that value, will be critical in the transition to an intelligent, zero carbon system.

A Kaluza-optimised Indra V2G device at an OVO Energy customer's home.

OUR TECHNOLOGY PLATFORM ECOSYSTEM

Kaluza is OVO Group's technology platform ecosystem that is driving the transition to a zero carbon grid. Its software platforms enable energy suppliers to empower their customers with unique digital experiences and smart, low carbon technologies that not only reduce energy bills, but lay the foundations for a more flexible energy system.

Streaming real-time data from customers to the grid, Kaluza creates new visibility into household energy enabling retailers to innovate new offerings and augment their operations. Connecting to industry-leading hardware, Kaluza optimises car charging, home heating and energy storage so that devices consume energy when it is less carbon intensive and costly, benefiting customers, suppliers and the grid.

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