NIC Project UKPNEN03 Deliverable D7

Appendix 9
Practical learnings from trial implementation

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Optimise Prime

HITACHI Inspire the Next | Uber | Scottish & Southern Electricity Networks | centrica | Royal Mail | UK Power Networks

Contents

This document is an appendix to Optimise Prime's final report, Deliverable D7, and highlights the main learnings from the practical implementation of the Optimise Prime trials.

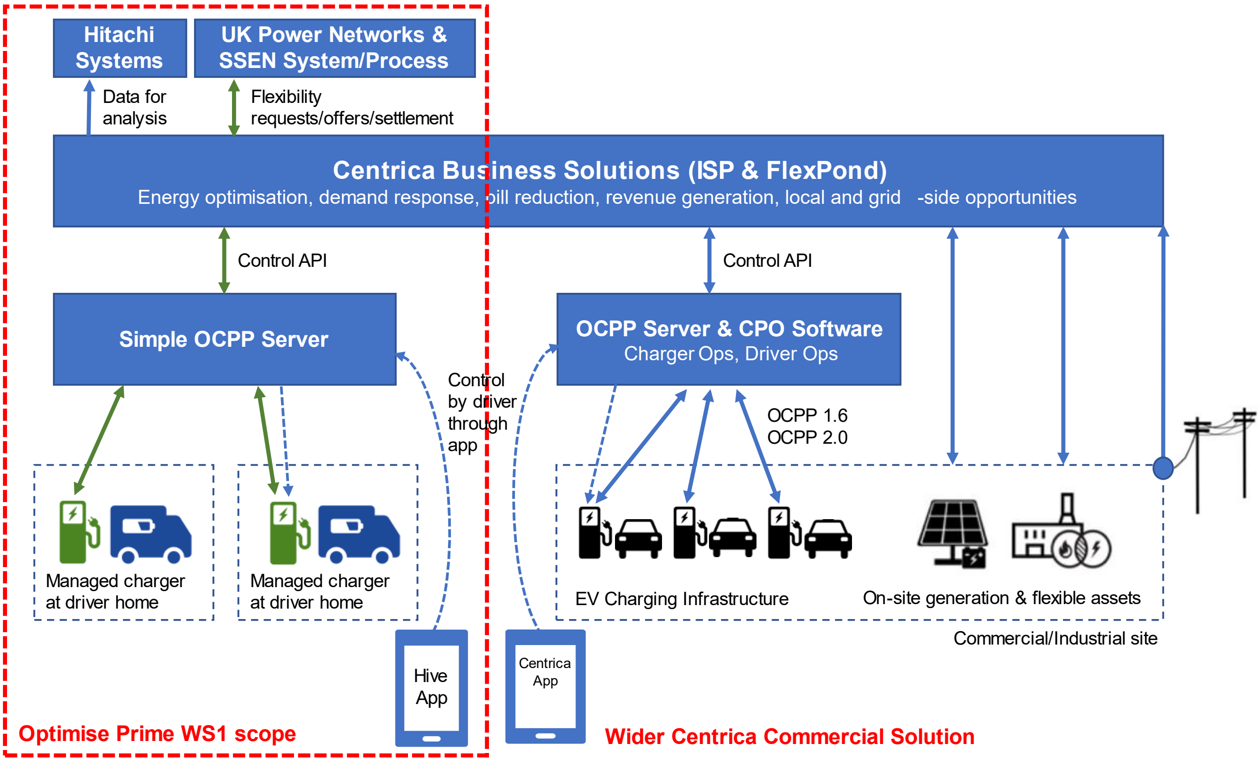
The appendix provides additional context to the recommendations contained within Section 2.3 of the final report, which describes the systems and processes that need to be in place to deliver the project methods. The findings also build on the learnings from the design and build phases of the project presented in Deliverables D2, D3 and D4.

1 Solutions implemented to deliver the home charging trial

Centrica was responsible for implementing the system controlling the charging of the British Gas electric vehicles (EVs), alongside the EV charging infrastructure, as shown in Figure 1. This primarily consisted of:

- A single socket EV charge point (CP) at each driver's home, connected by cellular data to a central system for metering and control messages
- A central CP control system
- A driver recharging process, using metering data in order to refund drivers the cost of charging their EV
- A driver app – giving the driver details of the charging process, allowing the driver to opt out of flexibility events or notify the system of the charging of a non-British Gas vehicle.

Figure 1 – Schematic of CP management system installed in workstream 1 (WS1)



UK Power Networks implemented new functionalities within its Active Network Management (ANM) system ANM Strata. This allowed Centrica to bid for flexibility services, the bids to be analysed and the flexibility services dispatched.

Full details of the solution implemented by Centrica and UK Power Networks can be found in Deliverables D2 and D3.

The solutions implemented allowed the Centrica vehicles to take part in the following Optimise Prime trials:

- The monitoring of usage/demand patterns, including implementation of smart charging, to understand the impact of this type of vehicle on the distribution network
- Trial of flexibility services dispatched by the DNO
- Exploring the systems and processes necessary to manage home based charging and refund the driver for electricity used – described further in section 1.2.

1.1 Learnings from implementation and operation

The learnings from the build and test of the solution can be found throughout Deliverables D2, D3 and D4. In general the installation of the infrastructure for WS1 proceeded with few issues, delayed mainly by vehicle availability. However, the following points summarise the key learning points encountered:

Applicability of at-home charging for home-based drivers

At-home charging will not be possible for all drivers that take their vehicle home – even those with a driveway. Limitations were found due to homes where there was already a high electrical load (especially in homes with all-electric heating). The positioning of parking spaces also made installing CPs impractical because of the distance or obstacles to the home's distribution board.

While the initial rollout has been weighted towards drivers with off-street parking, British Gas forecasts that, in the future, up to 60% of its drivers will not be able to charge at home overnight (in the trials, this was 20%).

Technical and communications constraints at homes

The use of cellular communication with CPs is not 100% reliable, but this can be managed as part of an aggregated load (i.e. a more diverse aggregated load allows for better overall control of charging because of the lower overall effect of the loss of control of individual CPs). Use of wired communications would be more reliable, however utilising drivers' existing internet connections would likely introduce other risks, where the connection may be turned off, or changed, by the homeowner and beyond British Gas' control.

1.2 Managing commercial load in residential settings

1.2.1 Separating load

Deliverable D5, Section 6 introduced the methodology that Centrica has followed in order to separate commercial load and domestic load at the homes of their drivers. The solution included a CP installed at the driver's home with metering and control linked back to Centrica's control systems. An app allowed drivers to monitor charging activity, override flexibility events and notify Centrica when non-work EVs are plugged in. Centrica's system was able to make payments to drivers for electricity used through the company payroll.

The following learnings were developed:

Automating the reimbursement of charge-at-home electricity is necessary for larger fleets

If large numbers of vehicles are having their charging reimbursed against different tariffs, there is significant administrative overhead without automation.

Gaining the trust of drivers through clear communication is necessary for the successful implementation of reimbursement solutions

Where the driver is paying the electricity bill and being separately reimbursed by their employer, drivers may have some concerns that they are not being fairly reimbursed. There is also the case of bill shock where there is a timing mismatch between the expense and the bill being received, leading to the perception that the EV is costing the driver more money through increased electricity bills.

There are limitations in what can be achieved through a commercial solution at present, because the driver has to pay the bill and is separately reimbursed

Commercial solutions enabling separate payment of the EV charging cost by the fleet operator directly to the electricity supplier are being explored to address the issue of bill shock.

The fact that drivers are reimbursed correctly and, as far as possible, reimbursed in advance of needing to pay their bill was not sufficient to overcome the issues faced by drivers. The lag between payment by the company and the need to pay the bill could result in the money being spent before the bill is paid. In some cases a different member of the household is responsible for paying the bill to the member who receives the expense reimbursement.

Based on this learning, Centrica has continued to refine their methodology in order to improve the experience of drivers. This has become increasingly necessary where rising electricity prices have meant that drivers' electricity bills have grown substantially during 2022, increasing concern over billing issues.

Centrica has shown through the project that it is possible to manage reimbursement of charges for a commercial load through a software solution. Implementation of such a solution saves money for the fleet operator, as the cost of manually reimbursing electricity use would likely be resource intensive and more prone to error.

Centrica has developed functionality to participate in the project's flexibility events and charge according to a lower tariff (where employees are on a British Gas tariff), potentially reducing Centrica's costs further. There is no direct financial impact on the driver, as they are reimbursed for the power at cost. There could potentially be scope for any savings from flexibility or smart charging to be shared with the driver as a further incentive.

It has become clear through the project that an industry solution, with separate metering and billing of commercial load, could provide additional benefits to both parties, for example:

- The driver would not be part of the reimbursement process – the usage would never appear on their bills and the driver would not have to settle the account. This would remove potential worry over household budgeting and ensuring they are being refunded correctly.
- Centrica would be able to choose the tariff for its commercial load. This would make it easier to utilise time-of-use tariffs, allow negotiation of commercial rates with its wholesale arm and simplify the payment process.

1.2.2 Total cost of ownership (TCO) impacts

The project carried out a full TCO analysis for the fleets involved in Optimise Prime, considering the various factors that contribute to the costs faced by fleet operators. This analysis can be found in Appendix 4.

Managing commercial load at homes results in a number of TCO impacts for fleet operators. The key considerations are summarised below:

Cost of Electricity

The vehicle is charged on the driver's home electricity tariff which influences the cost of charging the fleet vehicle. The fleet operator can encourage drivers to choose lower, or time-of-use, tariffs to cut charging costs, but ultimately this is a decision for the driver. In some circumstances a time-of-use tariff may not be advantageous for the driver if this makes their electricity more expensive during the day and may incentivise a private EV to be charged during the cheaper times.

Electricity costs for home charging may be higher than for vehicles charged at depots, where corporate rates can be negotiated.

Home charging is, however, significantly less expensive than using rapid public charging infrastructure to charge. British Gas has shown that a sizeable proportion of drivers that take their vehicle home will still have to charge using public infrastructure, and so this needs to be taken into account when calculating the TCO. This price differential has increased during 2022 as commercial electricity prices have increased, with some providers of rapid charging increasing charges to as much as £1/kWh (compared with 34p/kWh for the current electricity price cap).

Cost of Infrastructure
Infrastructure is a relatively minor part of the cost of electrification and is considered as part of the TCO analysis. In the Centrica case, CPs were given to the drivers as it would not be practical or desirable to remove chargers from driver's properties when they were no longer needed for work purposes.

Cost of Reimbursement and management
Centrica found that there was a cost associated with reimbursing drivers, and the cost of automating this process was lower than the potential cost of carrying out the reconciliation manually, given the number of drivers in the fleet.

Revenue from flexibility services
The ability to provide flexibility services potentially provides a further revenue stream to the fleet operator that would not be possible without the implementation of the infrastructure solution.

2 Solutions implemented to deliver the depot charging trial

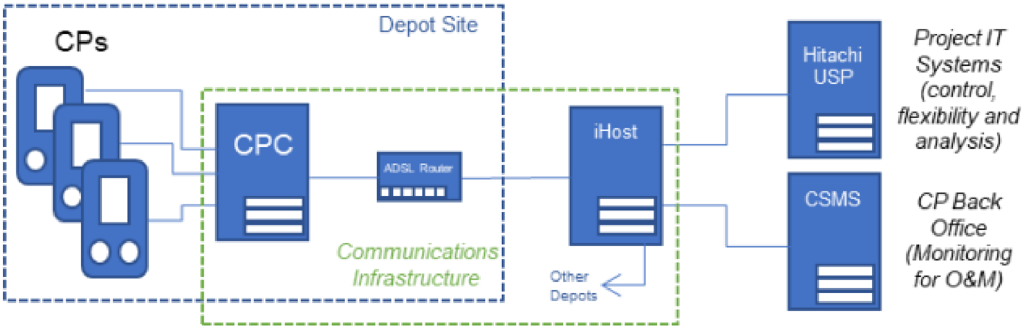
The WS2 charging solution consisted of EV CPs installed at nine Royal Mail depots in and around London. These were controlled either by a hard-wired or an over the air charge point controller (CPC – Figure 2) solution, where control messages were sent from the Hitachi system, to the CPC's iHost system and then via charge point operator's back-office system to the CP. This is illustrated in Figure 3 below.

Figure 2 – WS2 Charge point controller

Hitachi developed and operated the IT system that managed charging at the sites. This system:

- Captured charge point meter data, vehicle telematics data and building load data for real time charging optimisation and data analysis
- Allowed the setting of dynamic connection limits – either firm or profiled – for each site
- Managed the charging of connected electric vehicles in order to prevent breaches of the connection limit set for each site
- Allowed the setting of optimisation profiles that could prioritise charging vehicles with lower state of charge, over those with a higher state of charge
- Allowed the setting of optimisation profiles to reduce charging at times of high power costs
- Allowed charging events to be created and bids to be made for the Optimise Prime flexibility products
- On receipt of dispatch requests (Product A) or schedules (Product B) from the DNO, reduces CP load to deliver flexibility services.

Figure 3 – Schematic for CP control at Royal Mail sites



Deliverables D2 and D3 explained in depth the solutions installed at the depots in order to deliver the WS2 trials.

2.1 Learnings for implementation and operation

As the project progressed, Optimise Prime developed further learnings regarding the trial infrastructure. Key findings included:

Zero-Amp Setpoint

In the original design of the control system, it was specified that vehicles would always be permitted to charge at a minimum level. Due to the capabilities of the CPs, this was set at 6A/~1.4kW). This was specified for several reasons:

- To protect Royal Mail's operations from risk during the trials, given that at 6A, vehicles would still be sufficiently charged overnight, even in the event of malfunction of the optimisation system or on-site communications systems
- Testing highlighted issues where one type of CP exhibited unexpected behaviour when power was reduced to zero amps. The CP would not always reactivate a session when sent a higher setpoint and the charging cable would not release from the socket if the vehicle needed to be moved while the charger is at zero
- The potential for confusion from drivers, who need a clear indication that the vehicle has been plugged in correctly. Drivers usually rely on waiting to see the charging indication but would be faced with a waiting for power status.
- Optimisation became complicated because CPs could charge at 0 or 6A but not at points in between. Different CPs would either ignore such signals or treat them as 0. At sites with limited capacity, this could result in CPs being turned down to 0 unnecessarily for longer periods of time.

The flexibility trials indicated that being able to turn charging down to zero would result in achieving flexibility targets more reliably. As a result, a process was developed to turn CP down to zero amps in line with a flexibility period, ensuring that EVs plugged in during the period were also capped at zero amps, and then returned to optimisation at the end of the period. This proved successful and was implemented across several events in the final round of flexibility trials.

Set Point Time Intervals

In order to adjust the rate at which EVs charge, the Optimise Prime system generated set points which it distributed to the sockets on the CPs. These set points controlled the current value (in amps) that each socket delivers to the connected EV. The maximum set point that Royal Mail installed CPs can enact is 32A per socket. With some exceptions, the minimum set point is 6A, as noted above.

During set point testing it was found that the interval between set points sent to CPs had an impact on the reliability of the CP to enact the set points. Specifically, if multiple set points were sent to the same charger in quick succession then the CP would occasionally fail to enact all of the set points. This was particularly evident when sending set points to both sockets on the same CP in succession. Testing at various time intervals was able to determine an optimum set point interval rate at which CPs were able to reliably enact the succession of set points received. The following set point interval rules were therefore applied to the trials:

Interval between a series of set points

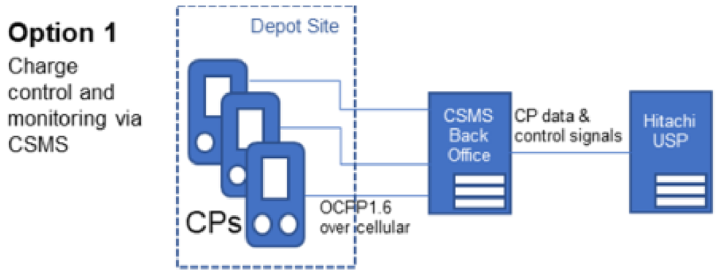
This was set to five minutes. The term series relates to the group of set points (current values) sent to all the active chargers at a depot. At Royal Mail, the number of set points generated related directly to the number of sockets at the depot. The largest Royal Mail depot (Mount Pleasant) contained 87 sockets, whereas the smallest depots (such as Bexleyheath) contained six sockets. This five minute interval therefore relates to the elapsed time from when the first set point is sent to the first charger socket at a given depot, and when that same charger socket will receive the next set point. The five minute interval ensures that there is sufficient time for each socket at the site to receive and enact a set point before the next series of set points are generated and distributed.

Interval between individual set points in the same series
This was set to two seconds for Alfen CPs and 10 seconds for Swarco CPs. This interval relates to the elapsed time gap between when each individual set point were sent to an individual socket at the same site. It provided a time delay that enabled each charger to receive and enact the new set point. This interval therefore defined the duration of a series of set points. For example, at Mount Pleasant with 87 Alfen sockets, the elapsed time from the first and last set point for a series of set points is 87 (sockets) x two seconds (set point interval) = 174 seconds.

Over the Air CP control

As introduced in Deliverable D3, and further explained in Deliverable D4, the project tested an alternate methodology for CP control at additional sites: over the air control utilising the charge point operator's (CPO's) back-office system and wireless communication, as shown in Figure 4. The results of the trial were mixed. While control of the CPs was generally reliable through this platform, the capture of data was less consistent. Some CPs would not report when charging sessions ended, and gave the impression that they were still charging, at the last reported level, until the vehicle was unplugged. This behaviour was intermittent and, while it was possible to rectify data after the event, it caused issues in real-time optimisation. The project was unable to rectify this issue fully due to the reliance on cooperation with the CPO to resolve the issue. As a result two of the smaller depots were omitted from some trials of flexibility and profiled connections.

Figure 4 – Configuration of over the air CP control



While over the air control created savings during implementation (because there is no on site infrastructure required), it required a close working relationship with the CPO, and may not be suitable for environments where there are a range of different charge point operators and vendors.

CP control and implementation of OCPP

The complexity of implementing CP controls should not be underestimated, especially with mixed estates of CP hardware. A significant amount of testing was required to understand how different CPs behaved in different scenarios. While CPs follow standards, such as Open Charge Point Protocol (OCPP) 1.6, for their control, differences were found in the implementation of OCPP and capabilities of devices. Some specific examples included:

- The ability of charge points to process frequent changes of setpoint
- Response to low setpoint levels below 6A (as mentioned above)
- Whether real power (instantaneous load) is reported or needs to be derived from energy metering data.

Requirement for constant change management due to external changes

Implementation of the Optimise Prime solution with a mixture of new and existing infrastructure at depots was particularly challenging. Multiple providers were involved in providing the data and control necessary for the solution, including two charge point operators, three telematics providers, a building load monitoring system provider, and Royal Mail's site and IT contractors. While the challenge integrating these providers can be planned for, the project also found that there was continual change that had to be managed as providers updated their systems – e.g. changing the specification of telematics data streams, updating CP equipment firmware or changing back office CP technology providers. All of these factors impacted the running of the overall solution and changes often occurred with little or no warning.

The over-riding recommendation is to reduce complexity by having smart charging solutions designed in from the outset. However, where it is necessary to implement a solution of this nature it is essential to ensure there is sufficient monitoring in place to detect errors in operations and resources in place to rectify them.

Importance of piloting and testing

The project implemented a pilot test site at Novuna Vehicle Solutions' Trowbridge offices featuring one of each of the CPs installed at Royal Mail sites together with the CPC infrastructure (Figure 5), and the CPC solution.

Figure 5 – Pilot site at Novuna offices

This proved essential when implementing the trial systems, as it allowed the project to ensure that charging control worked reliably before it was rolled out to operational sites where disruptions to charging could impact upon Royal Mail's ability to deliver. The pilot site also allowed the robust regression testing of updates to CP firmware before it was rolled out to site, ensuring that the CPs were kept up to date, while disruptions to the optimisation and control systems were avoided.

While most issues could be resolved at the pilot site, it was also necessary to carry out extensive testing at each of the depots (Figure 6), involving the actual Royal Mail vehicles, to ensure that there were no further issues caused by local infrastructure.

Figure 6 – Testing at a Royal Mail depot

3 Solutions implemented to deliver the mixed charging trial

The WS3 solution involved data capture and analysis. Data was sent from Uber to Hitachi on a monthly basis, detailing all journeys made by Uber EVs, together with data on vehicle type. Additionally, UK Power Networks and SSEN provided data on substation capacity across the areas where the vehicles operated.

Hitachi designed models to infer or predict the times and locations of demand, the requirement for charging infrastructure, and the impact that this would have on the distribution network.

Inferred charging behaviour

Each driver's home location (to LSOA level) was estimated based on frequent day start and end locations, allowing the project to quantify on and off-shift charging. This was split between home and on street using data on the availability of off-street parking.

Gaps (e.g. Uber App off or App Open) between fare-paying journeys were identified and analysed for whether drivers:

- **Should charge:** Assuming an 80% starting SoC, a machine learning probability model was built based on their current inferred state of charge and the relative demand in their borough during their shift. For each of these on-route charge events the most optimal charge point was identified for that driver.
- **Could charge**: Then it was decide whether or not a driver could have charged, based on whether it was possible to drive along the road network using the shortest path (at the average road network speed) to the CP that would have given them the most charge in the time available during either an offline or open event (where charging could have taken place) before returning to the next event in the Uber trip data. (i.e. the driver could travel from their start point to a CP, in the time available, and have time to for a meaningful charge).
- **Did charge:** A probability score is then assigned, using another machine learning model, for whether or not the driver did charge based on whether or not they should have charged, and could have charged.

Simulating full electrification

Once current trip data was analysed, the data was extrapolated to account for a situation when all Uber vehicles are EVs. A full explanation of this work can be found, together with the analysis in Appendix 2, section 3.

Network impact of electric PHVs

The available headroom in each LSOA (using the secondary substation with the most available capacity) was compared against the predicted demand from Uber EVs in the current and future scenarios, in order to create heatmaps of areas of the network according to available capacity.

Full details of the modelling techniques used in WS3 can be found in Deliverable D4.

3.1 Learnings from implementation and operations

The initial learnings from the WS3 trials were reported in Deliverables D2 and D3.

The trials were completed successfully, with few issues encountered.

Growth of dataset over trial duration

At the outset of the project, it was anticipated that each trial would reach 1,000 vehicles. However, the Uber trial reached over 7,000 vehicles as a result of the extended project duration and the faster pace of electrification in this segment. This created some challenges for the project, where the volume of data greatly exceeded original expectations. The analysis models had to be updated and analysis of journeys had to be broken down into months in order to be successfully processed. Data processing capacity also had to be expanded.

The growth of the Uber fleet, in comparison to the other fleets, was driven by several factors including the:

- Greater availability and choice of cars
- Lower price variance between ICE and EV
- Availability of near home charging was a key issue for drivers without home charging.

Additionally, to tackle operational and financial barriers to EVs, Uber introduced a range of incentives for its drivers under their Clean Air Plan. These include:

- Discounts on buying or leasing an EV from dedicated partners (including Nissan, Hyundai, Kia, Otto and WeFlex) through the Uber Green Scheme
- Discounted charging at BP Pulse’s public charging network
- Dedicated CPs at rapid charging hubs in London
- Discounts on home chargers
- Higher trip rates for EV drivers (through Uber Green).