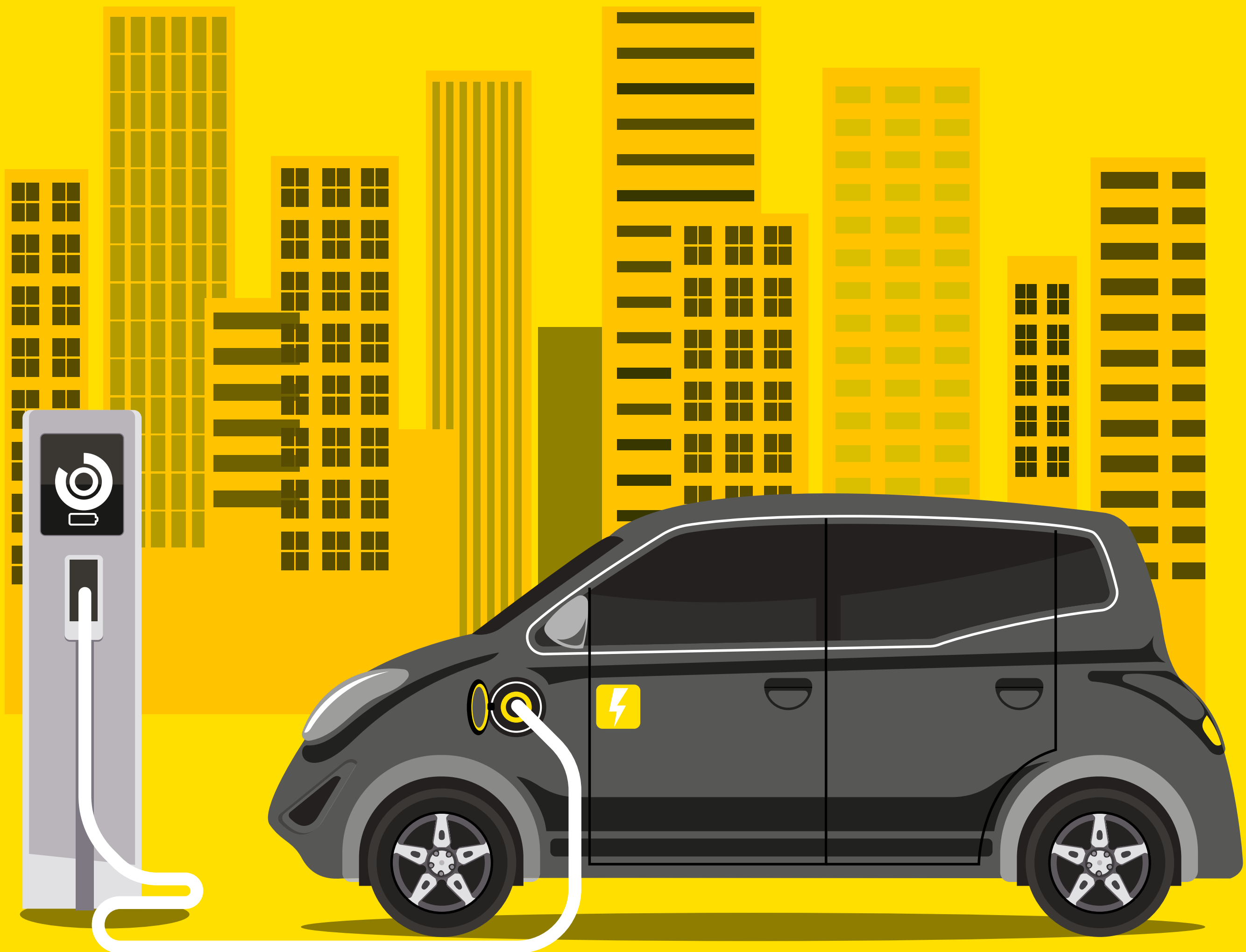
Decentralised Energy Trading Association

Charge point provision in local authority housing

January 2022



Context

Foreword

DETA was set up to facilitate greater flexibility in energy use and generation through deployment of energy storage. In addition to emerging needs like charge point provision across society, regulatory developments like P375 are creating revenue opportunities for more flexible approaches.

Our work on this project looked specifically at charge point provision and I am pleased to introduce our paper on the impact of flexibility technologies on the provision of charge points to residents of local authority developments.

Lord Redesdale

Executive summary

Electric vehicle (EV) ownership will continue to expand driven by a combination of policy and technology improvements that enhance drivers' experience. Today, EV ownership is concentrated in high income demographic groups. This is a different demographic to the tenants in local authority owned housing.

In future this will change as the cost of new EVs continues to fall and the second-hand market becomes better supplied. The implication of this is that there will be an increasing requirement for EV charge point provision in local authority developments to ensure residents can charge cost effectively. Without provision residents would be forced to use public charging network which currently operate tariffs up to four-times the average price paid for a domestic tariff. Therefore in some respects, lack of charge point provision can become a fuel poverty issue.

Expanding charge point provision can have significant implications for peak electrical loads in local authority developments. Typical power draws of 7 and 11kW for EV chargers can exceed peak loads in domestic residences.

Working with a combination of publicly available data and development level data supplied by Northampton Partnership Homes, DETA contracted Flexible Power Systems (FPS) to model the impact of charge point provision on peak electrical demand, identify cost impacts and propose mitigation strategies.

The study found that charge point provision had the potential to increase peak loads in development by up to 73%. Meeting this requirement retrospectively could lead to connection and site upgrades running to hundreds of thousands of pounds.

Solar was found to be poorly corelated with likely resident charging patterns, but energy storage showed promise as a tool to peak shave EV charging loads.

Storage remains expensive technology despite the dramatic decreases in cell prices achieved over the last decade. As a result, stacked revenue models incorporating arbitrage, balancing services and connection upgrade avoidance were required to get paybacks into an acceptable range 6-7 years.

The implications of this study are therefore:

- Significant amounts of resident charging should be considered at the design stages in new developments to minimise downstream costs
- Expanded provision at existing developments is likely to be required over the coming years and
- Flexibility technologies like energy storage have the potential to mitigate load growth but require a business case that incorporates other revenue streams.

Background

Current status

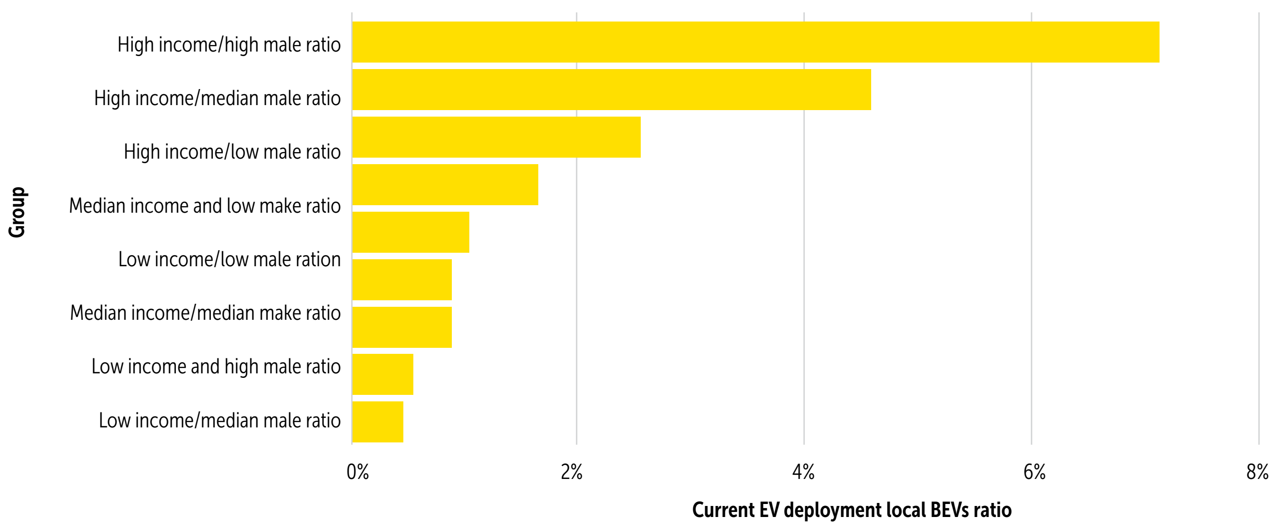
In the UK, while EVs are rising in prominence as manufacturers increase advertising campaigns and government legislation increasingly focuses on transport, progress is still required before a nationwide infrastructure grows to support the decarbonisation transition of transport.

Current legislation regarding provision of charge points at new developments is set at local level often by councils or other authorities, such as the Edinburgh Design Guide 2020 which specifies one in six spaces must have active fast charging provision at residential developments. An even more ambitious target in the London Plan 2021 sets in policy T6.1 the requirement that at residential developments in all 32 London boroughs, at least 20% of bays have "active" and the other 80% have "passive" have point provision. National level legislation is currently undergoing consultation and proposes introducing similar requirements.

In terms of ownership, EVs disproportionally belong to males (89%), within the middle-upper income groups and within urban areas source (see Figure 1).

The existing UK charge point network is in its early stages. A Zap-Map Survey 2020 found that the majority of home chargers are fast 7kW, with the second most popular being 3kW chargers. The study also found that 90% of EV owners also use public charge points, with most using rapid DC and 7kW chargers. However the size of the public network is neither large enough to meet current demand or growing fast enough to meet projected future demand. 43% of UK respondents to the Shell 2021 EV Drivers survey said that increased availability of charge points would improve their driving experience.

Figure 1: EV ownership by demographic, FPS



Outlook

Policy

In 2019 the UK, the government passed a law to require the UK to achieve net zero emissions by 2050. This ambitious target will have far reaching implications across the entirety of UK society and the transport decarbonisation revolution already in motion will be accelerated by this and other policies over the coming decades, notably the ban on sales of vehicles without zero emission capability from 2030 and from 2035 a ban on any vehicle that isn't fully zero emission.

Policy covering the entire UK on charge point provision for new build and renovations (https://bills.parliament.uk/bills/2950) is likely to be passed into law soon, marking a change from previous national level guidance which encouraged but did not mandate charge point provision.

EV market

The number of EV models available in the UK increases every year, offering consumers more choice and increasing market competition. Every major OEM now has at least one EV offering.

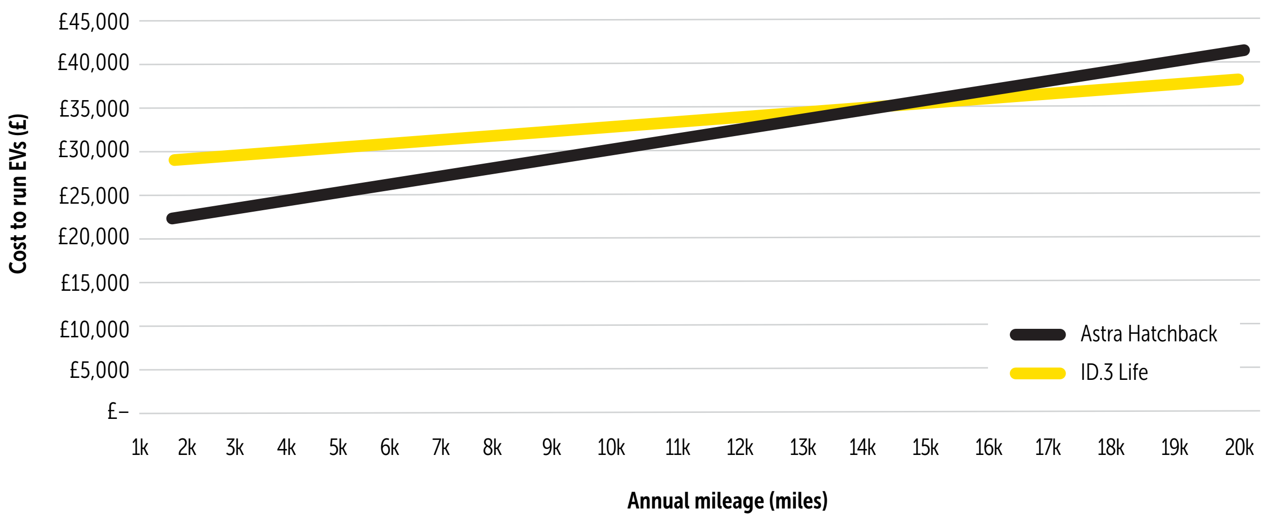
The second-hand EV market is also expanding. While second hand EVs currently command a price premium over their equivalent diesel and petrol models, this is likely to come down in the coming years as increased volume and improved next-generation electric vehicle technology lower the current stock of EV's resale values, crucially making the upfront cost of EVs more affordable for lower income demographics.

EV cost

EV prices continue to fall as production scales up and technology costs such as batteries become cheaper. In 2010 battery costs were £712/kWh but by 2020 had fallen to £107/kWh, equivalent to saving around £30,250 on a 50 kWh EV. These costs are expected to continue dropping over the coming years and decades as production scales up and technology improves.

EVs are now around equal cost to run based on lease models depending on annual mileages. Figure 2 shows the annual cost to own an Astra Hatchback vs and ID.3 Life for a period of 6 year at a 4% interest rate. At around 13.5k annual miles the electric model becomes cheaper to own than the diesel.

Figure 2: Mileage sensitivity analysis



The running costs of EVs are also lower than ICE vehicles. EVs convert roughly 77% of electrical energy from the grid into power at the wheel while ICE equivalents convert 12%-30% of the energy stored in gasoline to power at the wheels. Even if the energy powering the EV comes from a gasoline generator running at 40%-55% efficiency it would consume less gasoline than an ICE equivalent. Due to these thermodynamic efficiencies, once the cost of purchasing or leasing an EV approach that of ICE then there is a fuel poverty argument for adopting EVs making them a realistic choice for more households.

EV uptake

Policy and technology improvement mean that there are likely to be many more EVs in the future, with the National Grid Future Energy Scenarios (FES) predicting there could be over 11 million EVs on UK roads by 2030 and over 30 million by 2040 (up from 0.6 million in 2021).

This will lead to a very significant broadening in the demographic of EV owners and also an even greater requirement for EV charging.

Implications for local authorities

While EVs are not owned in significant numbers by the residents of today, the trends of the last decade are expected to continue resulting in much higher levels of ownership over the coming years.

Whilst today there is only modest overlap between the demographics of EV owners and housing service users, this is likely to change in future.

This is likely to put significant pressure on existing local power supply infrastructure. A typical house has an average maximum demand of between 7-8kW, so even a modestly powered 7kW EV charger could double the average maximum load.

Unmanaged charging by many or all residents even with only 1 car per household would significantly increase peak power demand beyond planned connection sizes, which is likely to result in expensive connection size upgrades creating issues for housing trusts.

Managed charging is also important to achieving the lowest cost possible charging. If residents do not have access to smart and overnight charging, they will be forced to pay higher costs at public charge points. As often residents in council owned property are from lower income demographics this would disproportionately affect the less well off in society and contribute to fuel poverty.

Work is being undertaken by operators of on-street public charging to remedy this by providing smart charging options to those without home charging, but ultimately this may not be a scalable solution for all once EVs become too numerous for on-street charging to satisfy demand.

Context and purpose of this paper

DETA wanted to address a perceived lack of quantitative understanding of the impact of charge point provision on council owned development and contracted FPS to explore the issue in more detail through:

- Modelling current load profiles today seen at some real-world developments
- Adding progressively higher penetrations of EV charging to understand the demand impacts and whether there is a problem
- Testing mitigation options from a peak load and cost-benefit perspective

This project is a sub element of the wider Virgin Park and Charge Phase 2 (VPACH2) project funded by Innovate UK. Partners include SMS plc, Connected Kerb, Liberty Charge, Cenex, Virgin Media, Ginger, Loughborough University and Green.TV. A number of local authorities in England and Northern Ireland are also involved in the wider project.

Situation modelled

The developments

With the assistance of Northampton Partnership Homes, FPS modelled a planned development in Northampton Town Centre that consisted of 24 houses and 102 flats.

For the study, the sites were modelled as having a connection capacity of 700kVA based on diversified load calculations for each building type, and a connection power factor of 0.95.

EV charging provision

The current plans for the site are to have 10 7kW chargers in total attached to the landlord supply. The study tested the impact of 4 different growth scenarios:

- A 7kW charger per two households.
- A 7kW charger per household.
- An 11kW charger per two households.
- An 11kW charger per household.

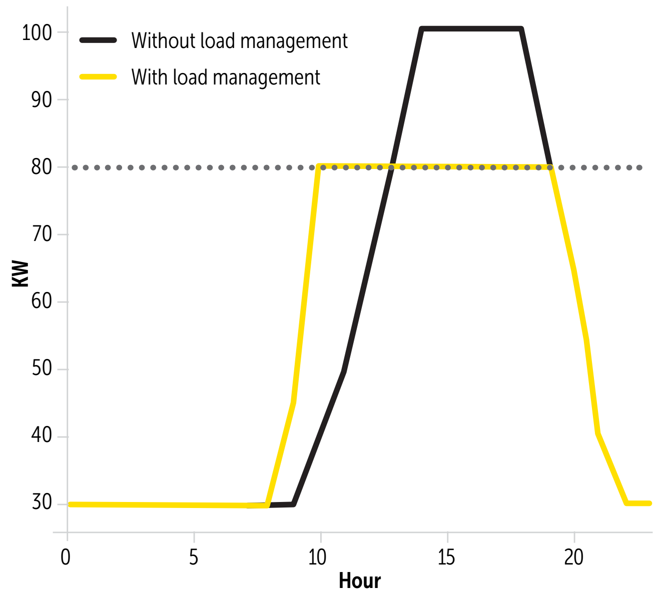
Mitigation options considered

Mitigation options to reduce the impact of this extra charging demand on connection infrastructure were considered. Smart charging was assumed not to be an option without resident consent and due to the shared nature of the charging infrastructure.

The two options considered that could be delivered by the local authority were:

- **Renewable photovoltaic (PV)** – installing PV as behind the meter generation will reduce the net load seen at the connection point when there is solar irradiance. The planned site installation is rated 12.24kWp (peak power output of 12.24kW).
- **Battery storage** – battery storage can be used to charge at times of low-cost electricity/low demand and then discharged at times of high-cost electricity or to perform peak shaving. An example of this is shown in Figure 3 with peak load limited to 80kW.

Figure 3: **Example peak shaving plot**



Modelling results

Baseline

The first part of the model to be developed was the baseline – how the site load profiles would look without any modifications from the planned development.

Figure 4 shows a possible load profile for this baseline load in the week the peak load occurs. The EV loads are attached to the landlord supply.

As can be seen in Table 1, EV charging accounts for about 16% of total energy consumption and 21% of total electricity cost. This is because most charging takes places during the peak tariff cost hours in the evening.

Figure 4: **Baseline load profile, 22-24/11/19**

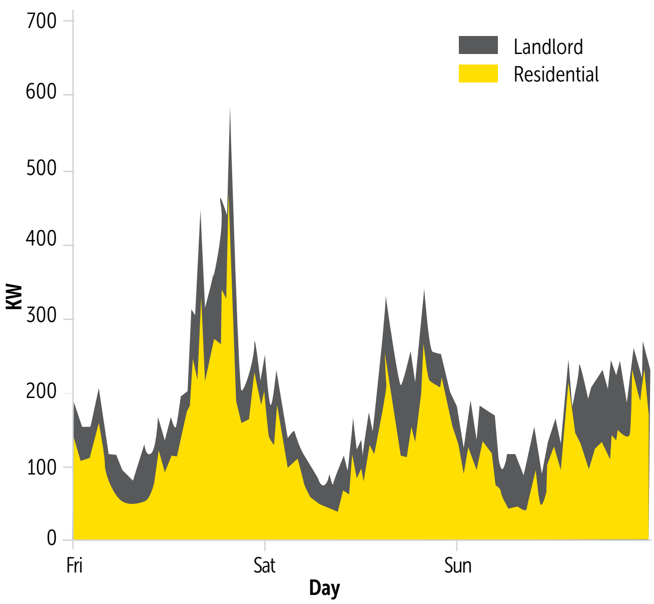


Table 1: Baseline load key metrics

Metric	Total Site	EV Charging
Energy Consumption (kWh/year)	1,341,800	217,800
Energy Cost (£/year)	147,200	30,500
Maximum Load (kW)	627	73.7
Maximum Load Date	22 November, 7:30pm	Most days, between 3pm-8pm

Growth potential

Shown in Figure 5 for the same dates as in Figure 4 are potential load profiles are each the 5 EV charging provision scenarios. As can be seen each case adds increased load with the most noticeable increases being in the evening when residents are plugging in their EVs.

Table 2 demonstrates how charging load and costs increase with electric charge point provision (EVCP) provision.

Figure 5: **EVCP provision scenarios load profiles, 22-24/11/19**

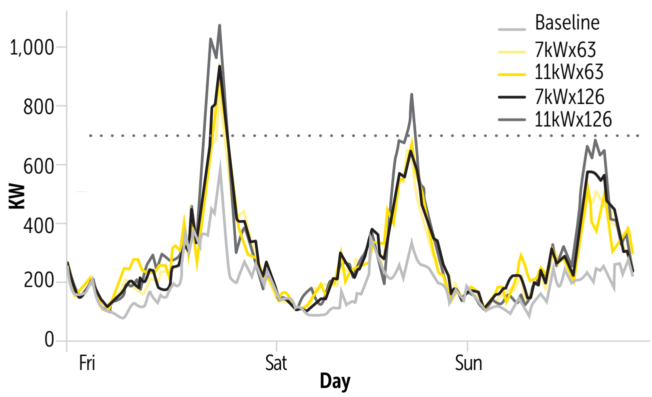


Table 2: EV charging loads and associated costs					
Metric	**Baseline (7kW, 10 chargers)**	**7kW, 63 chargers**	**11kW, 63 chargers**	**7kW, 126 chargers**	**11kW, 126 chargers**
Peak EV Load (kW)	73.7	383	570	540	675
Charging Electricity Cost (£/year)	30,500	112,100	132,200	128,400	152,200

In the sample shown, the baseline agreed supply capacity (ASC) (dashed red line) is being exceeded in all 4 growth scenarios, with other occurrences of this throughout the year this would necessitate upgrading of connections.

In the case where these upgrades are made as the site is being developed costs would be significant, but if retrofitted after completion would be even larger as material site works including the digging up of existing connection cables and relaying new ones would be required.

Table 3: Scenario connection impacts					
Metric	**Baseline (7kW, 10 chargers)**	**7kW, 63 chargers**	**11kW, 63 chargers**	**7kW, 126 chargers**	**11kW, 126 chargers**
Mean Load (kVA)	176	243	257	257	274
Max Load (kVA)	640	893	934	965	1,110
Implied ASC (kVA)	700	1,000	1,100	1,100	1,300
Indicative Connection Cost (£1000s)	140	220	240	240	260
Total Energy (MWh)	1,549	2,132	2,255	2,256	2,404
Total Energy Spend (£1000s)	164	233	254	250	274

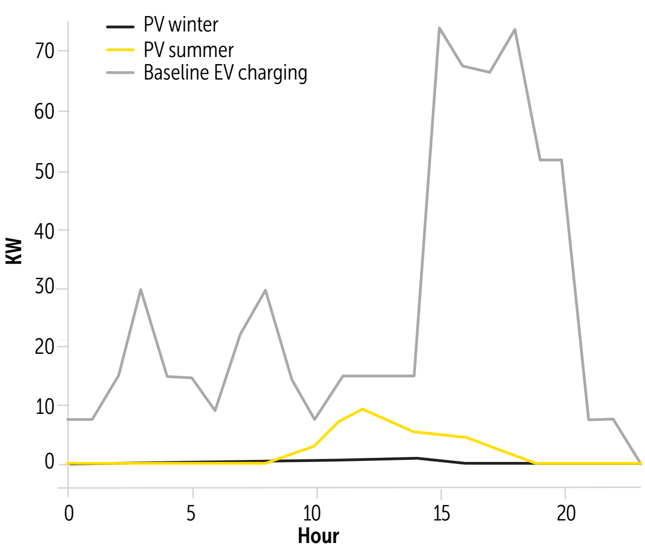
The results in table 3 for the baseline and growth scenarios show that without mitigation the peak load could well exceed the 700kVa required for the baseline resulting in expensive connection upgrades. It is assumed in each growth scenario that there is an initial installation cost for the 700kVa and a later upgrade to meet the required demand.

Mitigations

In the scenarios investigated, the solar provision described the plan of 12.24kWp is not effective to mitigate the power demands of the electric vehicle charging. The reasons for this are threefold:

- The rated output is small compared to the peak charging demand. Even at peak output the generated power doesn't exceed the power draw of 2 7kW chargers and only just of 1 11kW charger, however in all scenarios modelled at peak charging time far more residents are charging their cars at once.
- Peak solar output occurs during the middle of the day and is trailing off by the peak charging hours in the evening (see Figure 6).
- PV output is correlated to climatic conditions and so cannot always be relied upon to produce the same (or even a moderate) level of output. This means that especially during the winter other options should be considered (see Figure 6).

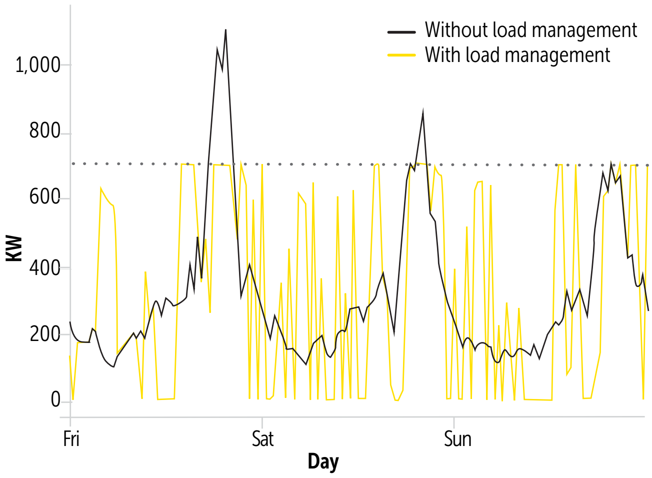
Figure 6: PV Output Vs Charging Demand



In the modelling, storage capacity and discharge rate for each growth scenario was sized so that no load suppression (e.g. reducing the power supplied to chargers) was required to keep the net load below a target ASC of 700kVa based on the baseline.

Figure 7 shows an example of the load management undertaken by the storage device in the highest EV charging demand scenario.

Figure 7: 126x11kW Load Management



Each of these ratings is shown in Table 4. While storage in each scenario effectively avoids any connection upgrades, the upfront cost of the batteries is significant and up to £729k in the largest case well exceeding the one-time connection costs avoided. Hence to make storage an attractive proposition and achieve acceptable paybacks, a revenue stack has to be developed from three different components:

- **Energy savings** – this is the cost avoided (or "profit") from charging the battery at times of lower electricity pricing such as during the night and discharging during the peak pricing times, such as red band periods typically occurring between 4pm-7pm.
- **Balancing services** – these are sold to National Grid to help balance the grid at times of high demand and/or low generation. Aggregators like Grid Beyond and literature energy storage stacks typically assign a value to these services equivalent to about 15% of energy trading savings but also come with stringent compliance rules.
- **Capacity market** – part of the UK government's Electricity Market Reform package designed to ensure security of supply and provides payments for reliable sources of capacity. In the last T4 last auction, payments cleared at £18/kW.

These annual revenues can also be seen in Table 4.

Table 4: Storage mitigation sizing, revenue and costs

Scenario	Discharge (kW)	Capacity (kWh)	ASC (kVA)	Battery cost (£1000s)	Connection savings (£1000s)	Annual revenue (£1000s)
Baseline	140	280	700	213	0	30
7kWx63	280	560	700	425	80	57
11kWx63	320	640	700	486	100	64
7kWx126	340	680	700	516	100	67
11kWx126	480	960	700	729	120	87

Figure 8: Annual storage revenue stack

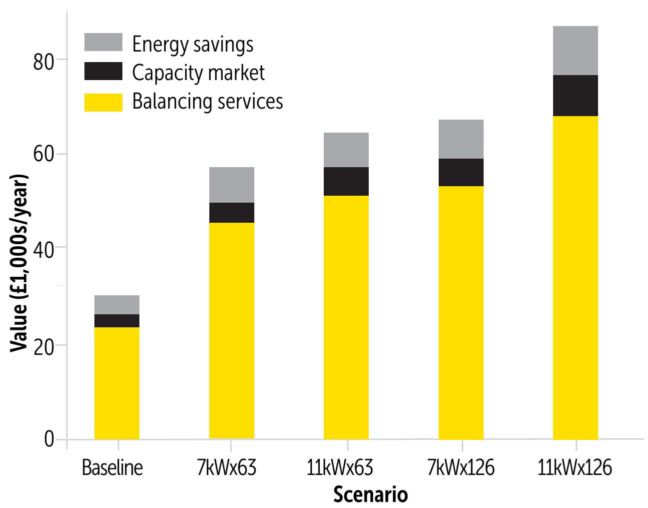


Figure 9: Seven year storage revenue stack

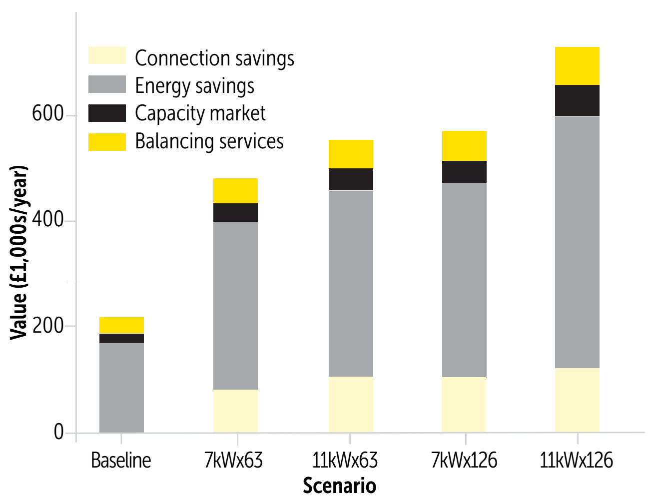


Figure 9 shows the relative size of each of these components of the annual revenue stack. As can be seen, in all cases the majority is made up of the energy cost savings however both the capacity market and balancing service revenues are not negligible and when looked at as part of the 7-year savings are comparable to connection cost savings.

By combining these with the revenue streams available it is possible to compute simple paybacks for the batteries. Table 5 shows paybacks based on:

- Energy savings (A)
- Energy savings + connection upgrade avoidance (B)

Table 5: Revenue stack effects on payback							
Scenario	Discharge (kW)	Capacity (kWh)	ASC (kVA)	Battery cost (£1000s)	Payback (years) (A)	Payback (years) (B)	Payback (years) (C)
Baseline	140	280	700	213	8.9	8.9	7.1
7kWx63	280	560	700	425	9.4	7.7	6.1
11kWx63	320	640	700	486	9.5	7.6	6.0
7kWx126	340	680	700	516	9.7	7.8	6.2
11kWx126	480	960	700	729	10.7	9.0	7.0

Stacking revenue streams and benefits improves the system paybacks by between 2 and 3 years vs. only energy cost savings revenue. In all scenarios, payback can be brought to or under 7 years, which is close to being fundable without recourse to vary high value services like dynamic containment.

This modelling was undertaken using the Octopus energy half-hourly tariff (2019), however at the time of writing rising gas prices driven by resumption of industry activity as economies reopen after the COVID-19 pandemic have sent electricity prices soaring. Unpredictable events such as this highlight the benefits of storage, as inflated prices also increase the energy price differential leading to greater savings for operators of storage and reduced time to payback.

Conclusions

New developments should consider EV charge point provision as is being mandated by policy. In the future many more residents will own EVs than currently and the cost of planning for this in the initial development through passive charge point provision and correctly sizing grid connection infrastructure will in the long term save significant retrofit costs which would otherwise be incurred as EV penetrations increase.

As EV ownership continues to grow, soon it will be worth considering charger provision at existing developments too. By analysing headroom levels as done in the Northampton development study, mitigation solutions such as energy storage or smart charging where feasible can be deployed which will avoid the need to retrofit grid connection infrastructure and while meeting acceptable payback targets. We expect the business case for flexibility technologies like storage to continue to improve as more domestic loads like heat pumps are added to the distribution network.

Appendix

Modelling approach

Overall workflow

Baseline System	Add Storage	Sensitivity Analysis	Business Models
Domestic Consumption Profiles Planned Solar Installation Output Profiles Planned EV Charger Profiles Tariffs	Energy Storage Despatch Schedules Distributed and Centralised Energy Storage	Optimise storage specification (energy/power) Optimise storage distribution	Tenant energy cost reduction Landlord energy cost reduction Developer for energy services with or without P375

Storage despatch algorithm objective function

Total Electricity Cost = **Electricity Price** x [Electricity Use + EV Charge − Solar Output − Battery Discharge]

Landlord loads model

Load profiles for landlord supplies have been constructed incorporating:

- Constant loads for the small power, access control and boosted water consistent with their diversified loads.
- Internal and external lights operating on a timed basis consistent with sunrise and sunset.
- Lifts modelled on the basis of randomised events at high frequency and low frequency
- High frequency periods 6-10am and 5-10pm
- Low frequency periods in other hours.
- EV loads have been modelled in a similar manner but are a key sensitivity variable so are discussed in more detail in subsequent slides

Domestic loads model

Sampled from a 2013 smart meter data set from a UK Power Networks (UKPN) smart meter trial. Sampling adjusted for data completeness, diversified peak load assumptions from planning docs and socio-economic group.

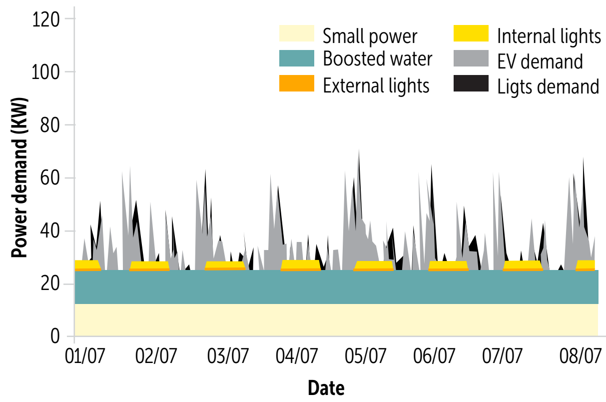
PV generation model

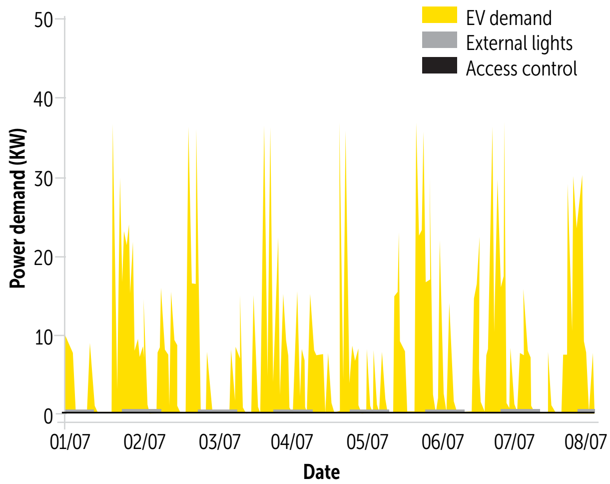
Solar output modelled based on local historic insolation data sized for 12.24kWp system described in planning docs.

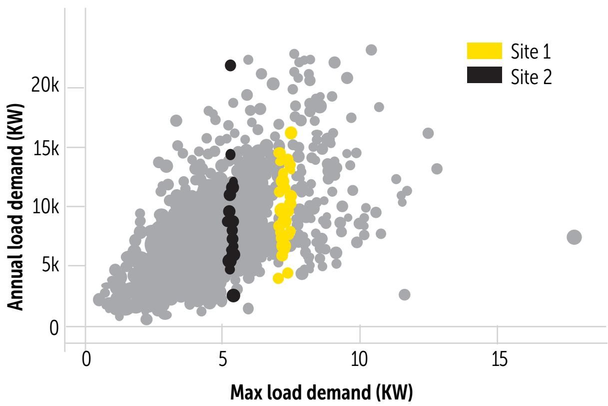
EVCP model

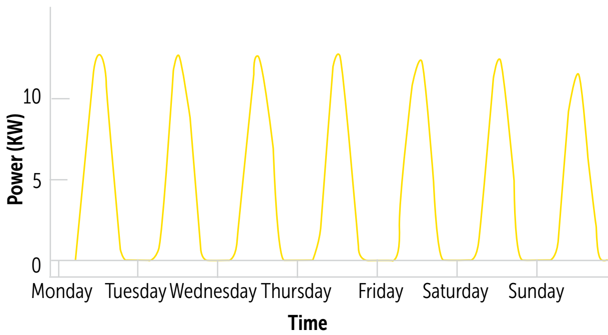
EV charging events are captured through a model that has several steps:

- Vehicle arrivals are modelled through a Poisson distribution.
- Arrivals are converted to charging events on the basis of a charge point being available.
- A normally distributed set of arrival states of charge determines the initial vehicle state of charge for each charging sessions.
- Charging sessions are modelled as lasting for a maximum of 2 hrs for low charge point provision levels.
- Charge rates are determined by battery charge level at the start of the HH charging period and charger picked.









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