CHARGE

Public Chargepoint Flexibility Insight Report

The Charge Project
December 2021

ea technology

PTV GROUP the mind of movement

smarter grid solutions

1.1. Abbreviations

CLM	Customer Load Management scheme
CMC	Centrally Managed Constraint scheme
CPMS	Chargepoint management system
CPO	Chargepoint operator
DER	Distributed energy resource
DG	Distributed generation
DNO	Distribution network operator (includes independent distribution network operator)
DSC	Declared supply capacity
EV	Electric vehicle
GB	Great Britain
LIFO	Last in first off
LMC	Locally Managed Constraint scheme
OEM	Original equipment manufacturer
SCC	Smart Charging Connection
SGS	Smarter Grid Solutions
SPEN	SP Energy Networks
TCC	Timed Capacity Connection scheme

1.2. Definitions

Smart Charging Connection is the term used to describe a flexible connection designed by SP Energy Networks specifically for public chargepoints. The following definitions are also used:

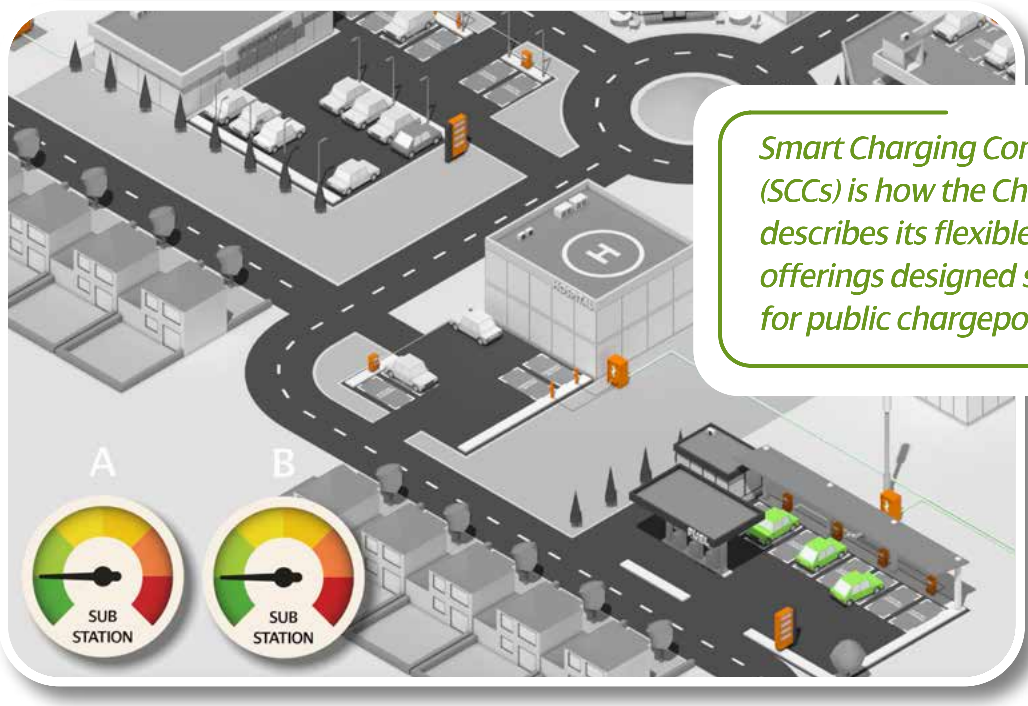
Centrally Managed Constraint Scheme	A **Smart Charging Connection** where multiple network constraint locations are monitored and managed by the distribution network operator.
Connection agreement	A form of agreement based upon acceptance of a **connection offer**, stating the terms under which a **customer** shall be and shall remain connected to the distribution system.
Curtailment	To limit, from time to time, the maximum export/import capacity of a **non-firm** connection. This limits the access to the distribution (and/or transmission) system at the point of connection to avoid breaching network operational limits based on thermal, voltage or fault level constraints.

1.2. Definitions (cont)

Curtailment analysis	A suite of calculations that estimate the expected frequency, duration and kWh/MWh of restricted capacity a **customer** under a **flexible connection** may expect.
Customer	Refers to an organisation, company, etc., connecting to the distribution system.
Customer Load Management scheme	A **Smart Charging Connection** where the **custome**r manages their import/export level within their **connection agreement** via an **import/export limiting device**.
Demand	The electrical load in kW or KVA (or MW or MVA) being consumed by a **customer** or **end user** or group of **customers** or **end users** as the context requires.
End user	EV drivers who use the charging infrastructure.
Flexible connection	A **non-firm** connection (or scheme) whereby network access is managed (often through real-time control) and made available based upon contracted and agreed **principles of access**.
Flexibility services	A connected **customer** can generate revenue by flexibly operating their import/export in alignment with market signals. The provision of flexibility is not essential to their connection agreement.
Import/export limiting device	Automated equipment at the **customer's** substation or point of connection that ensures the **customer's** agreed import/export capacity is not exceeded. This includes the chargepoint itself or a separate controller.
Last in first off (LIFO) network access principle	The allocation of network capacity where a network constraint is resolved by curtailing all participating **customers** in the order in which they applied for connection to the network. The term LIFO stack refers to the ordered list of participating **customers**.
Locally Managed Constraint Scheme	A **Smart Charging Connection** where a single network constraint location is monitored and managed by the distribution network operator.
Non-firm	A connection with capacity constraints.
Offer (connection offer)	As defined within Paragraph 12.3 of the Electricity Distribution Licence.
Principles of access	A methodology or ruleset by which network access shall be granted. It also governs when a **curtailment** instruction is issued or network capacity is released to a **customer** under a **flexible connection**.
Smart chargers	Chargepoints with the ability to communicate with both the EV and the energy network, and to manage how fast and when the EV charges.

1.2. Definitions (cont)

Smart charging	The utilisation of **smart charger** capabilities to manage power consumption to either prevent the customer from exceeding their building's maximum energy capacity or to avoid stressing the wider electricity network.
Smart Charging Connections	**Flexible connections** designed by SP Energy Networks specifically for public chargepoints. The **connection agreement** stipulates that the customer must use their **smart charging** capability under certain network conditions.
Timed Capacity Connection Scheme	A **Smart Charging Connection** where the **customer** manages their import/ export level within a prescribed operating schedule as per their **connection agreement**.
Time-of-use tariff	Designed to incentivise **customers** to use more energy at off-peak times in order to balance demand.



Smart Charging Connections (SCCs) is how the Charge Project describes its flexible connection offerings designed specifically for public chargepoints

2. Executive summary

The mass adoption of electric vehicles (EVs) is imperative if the UK is to reach its 2050 emission commitments and net zero aspirations. Yet, for many drivers, the transition to EVs will be unrealistic without greater access to public charging infrastructure, with approximately 40% of UK homes unsuited for private off-road charging.

As such, UK distribution network operators (DNOs) are looking at a wide range of solutions to enable greater deployment of public chargepoints. These include substantial plans for targeted network reinforcement, the procurement of flexibility services, and the provision of flexible connections dedicated to public charging infrastructure.

Although network reinforcement provides the most enduring solution for the deployment of public chargepoints, it is often prohibitively expensive and/or requires an extended lead time. It is therefore essential that DNOs can provide customers with alternative connection options as either a permanent or temporary solution in lieu of reinforcement.

The report looks in detail at four types of SCC schemes: Timed Capacity Connections, Customer Load Management Schemes, and Locally and Centrally Managed Constraint Schemes

Over the past two years, the Charge Project has engaged with parties including original equipment manufacturers (OEMs), chargepoint operators (CPOs), chargepoint installers, chargepoint owners, and local authorities around the topic of Smart Charging Connections (SCCs), which is how the Charge Project describes its flexible connection offerings designed specifically for public chargepoints.

This engagement process has provided a wealth of insight into the technical, commercial and social challenges; risks and opportunities pertinent to various SCC schemes; their broader adoption; and how they sit alongside the market-driven provision and procurement of flexibility services.

As well as disseminating this insight, the purpose of this report is to examine the different types of SCC scheme and how they could work alongside other connection options. It also looks at the role they could play in accelerating the deployment of public charging infrastructure and developing a more cost-efficient system.

SCCs offer DNOs and customers a number of benefits. They enable DNOs to provide new connection customers with a quick and cost-effective alternative to network reinforcement, while the range and versatility of SCCs ensures a suitable solution is available for all chargepoint locations. SCCs also use readily available hardware, software and telecommunications technology, and maximise existing available network capacity.

However, the development and introduction of SCCs cannot be done by DNOs alone. As such, a key aim of this report is to gather feedback on the insights the Charge Project has captured so far, in order to fully understand the opportunities that SCCs present, as well as the risks and challenges that will need to be overcome.

The report looks in detail at four types of SCC schemes: Timed Capacity Connections, Customer Load Management Schemes, and Locally and Centrally Managed Constraint Schemes.

The report also looks at where SCC uptake is most likely to initially occur, and concludes that customers with fixed geographic locations – such as workplaces, depots, and leisure and retail outlets – that wish to install a high volume of chargepoints will most likely be early SCC adopters. More broadly, SCCs may also provide a quick, temporary way for chargepoints to be installed ahead of network reinforcement work.

It also looks at SCCs in the context of the principles of access, the flexibility services market, and current smart charger functionality.

In summary, SCCs have huge potential to provide customers with a technically and commercially viable alternative to reinforcement-driven connections. However, DNOs must collaborate with chargepoint owners, installers, manufacturers and end users to deliver the full potential of SCCs and overcome the various risks and challenges faced by their introduction and adoption. In particular, more work and investment are required to standardise SCC functionality, including communication methods between chargepoint management platforms and third-party systems such as DNOs and aggregators.

3. Introduction

3.1. The Charge Project

The Charge Project's purpose is to accelerate the deployment of public chargepoints for electric vehicles (EVs). It aims to do this by providing stakeholders with access to information about where there will be a growing demand for public charging infrastructure and where there is available network capacity. In combination, this information will enable optimal investment locations to be identified.

The Charge Project is developing 'ConnectMore', an industry-leading self-service connection tool that will reduce the time it takes for customers to get a quote for the connection of public chargepoints to the network. ConnectMore empowers customers to choose their own connections, giving them access to combined public charging infrastructure demand and network capacity maps to identify suitable locations. Customers can then select their own connection at a point on the network with available capacity – ConnectMore will automatically generate a corresponding connection cost estimate.

In addition, a key focus of the Charge Project is to provide greater access to network capacity through the introduction of Smart Charging Connections (SCCs). These flexible connections will allow customers to maximise the amount of chargepoints or total rating they can add to new or existing network infrastructure, whilst minimising the delay, cost and disruption of new connections. The option to choose an SCC instead of a conventional connection requiring reinforcement is also built into ConnectMore.

Further information on ConnectMore and Smart Charging Connections can be found on the Charge Project website: www.chargeproject.co.uk.

3.2. The Purpose of the Insight Report

The purpose of this report is to:

1. Raise awareness of the SCC solutions, how they fit alongside other connection options, and the role they can play in accelerating the deployment of public charging infrastructure, plus their contribution to the development of a more cost-efficient system.
2. Disseminate insight that the Charge Project has generated on the flexibility of public charging infrastructure and, where possible, validate these findings through responses.
3. Stimulate and capture feedback to ensure that the SCCs developed and trialled under the Charge Project deliver the maximum value.

From the perspective of a DNO, SCCs have huge potential to provide customers with a technically and commercially viable alternative to reinforcement-driven connections. However, the development and introduction of SCCs cannot be delivered by DNOs alone. Collaboration with chargepoint owners, installers, manufacturers and end users will be essential to deliver their full potential and overcome the various risks and challenges faced by their introduction and adoption.

Over the past two years, the Charge Project has engaged with parties involved in the public charging infrastructure supply chain, including (but not limited to): OEMs, CPOs, chargepoint installers, chargepoint owners and local authorities. Although primarily focused on the recruitment of trial participants, this engagement has provided a wealth of insight into the technical, commercial and social challenges, risks and opportunities pertinent to SCC schemes, along with their broader adoption and how they sit alongside the market-driven provision and procurement of flexibility services.

3.3. Feedback

SCCs have the potential to accelerate the deployment of public charging infrastructure across Great Britain (GB). For example, an initial assessment highlighted that the introduction and adoption of SCCs could deliver up to £666m of benefits to GB by 2050[1].

An initial assessment highlighted that the introduction and adoption of Smart Charging Connections could deliver up to

£666m of benefits to GB by 2050

However, the development and introduction of SCCs cannot be done by DNOs in isolation. A key aim of this report is to gather feedback on the insights that the Charge Project has captured so far, in order to fully understand the opportunities that SCCs present, as well as the risks and challenges that will need to be overcome for their deployment. It is essential that the insights outlined in this report are a true representation of the position of the various stakeholders, technology and commercial arrangements.

1. https://www.ofgem.gov.uk/publications/electricity-nic-submission-sp-energy-networks-charge

As such, once you have read the report, we would greatly value your thoughts on its content, particularly in terms of how SCCs could fit into the current market while accelerating the roll-out of public charging infrastructure.

To do this, we have developed a separate feedback form which can be accessed here.

The feedback generated will be vital in shaping the Charge Project's work, and help to:

1. Refine the SCC definition
2. Tailor different SCC solutions to specific stakeholder types
3. Define the value case of SCCs
4. Understand technology prerequisites for SCCs and development requirements
5. Identify gaps in/challenges to SCC uptake

4. The need for Smart Charging Connections

The decarbonisation of transport is imperative if the UK is to reach its 2050 emission commitments and net zero aspirations. Legislation has been passed prohibiting the sale of petrol- and diesel-fuelled vans and cars by 2030, and hybrids by 2035. For many drivers, this transition is unrealistic without greater access to public charging infrastructure. Approximately 40% of UK homes do not have private off-road parking, which makes home charging impossible. Drivers living in these properties will need to be confident of the availability and accessibility of public chargepoints before they switch to EVs.

The decarbonisation of transport is imperative if the UK is to reach its 2050 emission commitments and net zero aspirations

A recent report from Policy Exchange[2] indicated that around 400,000 public chargepoints would be required by 2030 – nearly a ten-fold increase from the present number of 47,576[3]. The installation of these chargepoints presents a major opportunity for the UK to invest in a green recovery following the COVID-19 pandemic. However, it also poses a significant challenge to the UK's electricity network. There is a risk that the network will not be able to facilitate the additional EV charging load in a cost-effective and timely manner.

UK DNOs are looking at a wide range of solutions to facilitate greater network access for chargepoints. These include substantial plans for targeted reinforcement, the procurement of flexibility services, and the provision of flexible connections dedicated to public charging infrastructure, e.g., SCCs.

2. https://policyexchange.org.uk/wp-content/uploads/Charging-Up.pdf
3. https://www.zap-map.com/statistics

Reinforcement provides the most enduring solution, but the associated costs and long lead times often prohibit chargepoint schemes from progressing. It is therefore essential that DNOs can provide customers with alternative connection options as either a temporary or permanent solution in lieu of reinforcement.

It is expected that the flexibility services market will provide a viable alternative to reinforcement, and there is much focus nationally on the implementation of these schemes to understand their technical and commercial performance. In such a scheme, it is possible to connect chargepoints to a local network because existing customers have their demand curtailed in order to accommodate the connection, for which they receive compensation. However, the ability of this type of scheme to provide a viable solution will be highly dependent on the availability and capability of existing customers to provide a load relief service. This ability will vary significantly from location to location, as will the necessary level of compensation.

SCCs require the new connection customer to curtail their load at times when the network is becoming constrained. Although they will not be compensated for doing so, it will provide the customer with greater access to underlying network capacity, often without the need for reinforcement.

As this report details, there are a range of possible SCCs that vary in complexity and ability to release capacity. They all utilise hardware, software and telecommunication solutions readily available and deployable by the customer and/or the DNO in a shorter timescale and at a lower cost than traditional network reinforcement. Their versatility ensures that they can provide an appropriate solution for all public chargepoint locations.

SCCs are not dependent on other market participants, and thus guarantee that DNOs can always offer customers an alternative option to reinforcement alone. It is feasible that SCCs could be adopted as a temporary solution (as could flexibility services) ahead of reinforcement being delivered. SCCs may not exclude the customer providing flexibility services, but this would need careful consideration on a case-by-case basis.

In some cases, SCCs may endure in the long term as customers mitigate curtailment risks in various ways. Section 9 covers the interactivity between different forms of network and flexibility solutions in greater detail.

The Advantages of Smart Charging Connections:

- **SCCs guarantee that an alternative to network reinforcement can be offered to a new connection customer, independent of other market participants**
- **SCCs can provide either a permanent or temporary solution to network constraints**
- **The range and versatility of SCCs should ensure there is a suitable solution for all chargepoint locations**
- **SCCs make use of readily available hardware, software and telecommunications technology**
- **SCCs do not preclude customers participating in the flexibility services market**
- **SCCs maximise existing available network capacity**

5. Smart Charging Connection Schemes

5.1. Identification of Smart Charging Connection Schemes

In the initial phase of the Charge Project, SP Energy Networks (SPEN) and Smarter Grid Solutions (SGS) undertook an in-depth review of how chargepoint load could be flexibly accommodated across a wide range of network locations. This comprehensive review considered over 80 combinations of network topography, voltage, connection location, and likely location of network stress points.

For each combination, SPEN and SGS assessed how the resulting network stress could be relieved by a technology-led solution, and identified the minimal viable solution to provide capacity for each. The analysis highlighted that for the 80-plus combinations, a solution could be found from just four SCC schemes. These solutions were equally split between 'customer-led' and 'DNO-led' schemes.

5.2. Customer-Led Smart Charging Connections

Customer-led SCCs are schemes that can be operated using technology owned and operated by the connection customer exclusively.

5.3. DNO-Led Smart Charging Connections

DNO-led SCCs are reliant on a DNO system communicating directly with the customer's chargepoint management system (CPMS). The DNO system directly instructs the CPMS about the available network capacity and the import limit setpoint it should adhere to. The DNO signal does not instruct the individual chargepoints themselves. It is the responsibility of the customer's CPMS to decide how the signal should be implemented. This linkage increases the complexity of the SCC, but provides greater access to wider network capacity, because the DNO is certain of a response to a network constraint signal.

Customer-Led Smart Charging		DNO-Led Smart Charging	
Timed Capacity Connection Schemes	**Customer Load Management Schemes**	**Locally Managed Constraint Schemes**	**Centrally Managed Constraint Schemes**
• Smart chargepoints are programmed by the customer to curtail load at a set level and set time/duration to avoid periods of peak load on the network	• Smart chargepoints are programmed by the customer to ensure their collective demand does not exceed the declared supply capacity of the connection	• A single network constraint location is monitored by the DNO • A local controller calculates and communicates the available capacity to the customer chargepoints, which undertake any necessary constraint action	• Multiple network constraint locations are monitored by the DNO • A central platform coordinates the measurements, then calculates and communicates the available capacity to the customer chargepoints • This scheme offers greater scalability than a Locally Managed Constraint Scheme

Increasing Complexity and Increasing Network Capacity Access

6. Timed Capacity Connections

6.1. Overview

Timed Capacity Connections (TCCs) are the simplest form of SCC. Chargepoints that share the same network connection are programmed by the CPO to curtail their collective demand for a set time period that coincides with peak load on the local DNO network. The time, duration and scale of this curtailment is determined by the DNO via a detailed curtailment analysis.

The ability to set a timed constraint is a common feature of smart chargers, either programmed locally or administered via the CPO's remote CPMS. There is no requirement for a direct link to DNO systems for this type of scheme to function. There is also not usually a requirement for additional hardware, which makes the costs of this type of scheme relatively low. A trade-off of TCCs' simplicity and low cost is that they provide limited access to additional network capacity when compared to other SCC schemes. They also carry an inherent risk that the load profile on the local network may change and the original curtailment may no longer be sufficient to avoid network constraints. The management of this risk needs careful consideration.

View animation

Timed Capacity Connections animation

6.2. Opportunity and application

TCCs offer the lowest cost and simplest SCC option to accommodate chargepoints on a constrained network. They are most applicable in locations where charging demand can be shifted to avoid periods of peak demand on the network. This naturally lends itself to locations where charging can be shifted into evenings and overnight, for example, residential areas and depots. They are less suitable for chargers that provide convenience charging to EV drivers, such as en route rapid chargepoints.

TCCs provide an opportunity to connect public on-street residential chargepoints to the existing network with minimal need for reinforcement. This type of connection is also applicable to fleet/depot chargepoints on congested networks. In both scenarios, the end users of the chargepoints are likely to be regular users who, with familiarity, will be able to adjust their charging behaviour to the timed connection.

ea technology PTV GROUP the mind of movement smarter grid solutions SP ENERGY NETWORKS

A TCC could be considered when, following a standard network assessment, it is found that the requested connection capacity cannot be fully accommodated by the local network. The DNO would then undertake a further and more detailed curtailment assessment of the network, considering the load profile over the course of the day and at different times of the year. A TCC could be proposed by the DNO if this curtailment analysis identifies that the network has a consistent load profile and the fully requested load only poses a risk to the network for a consistent and limited set period. The TCC offer would curtail the connected demand to an acceptable level during this constrained period. For the remainder of the time, the demand would not be curtailed.

Many end users, both domestic and fleet-based, are willing to be flexible with the time of their charging if they receive financial incentives to do so

For example, in the case of residential on-street public chargepoints, the TCC agreement would probably stipulate that the chargepoint load would only require curtailing during the network peak 'teatime' load period, for example, 16:30–18:30, and only in winter months when peak loading is expected to occur. The exact magnitude of the curtailment would be dependent on the load profile analysis and parameters of the local network, but in most cases, it would still facilitate charging.

TCCs could also apply to depot chargepoints on networks with industrial and commercial loads that drop off significantly in the evening and through the night. In these circumstances, it could be possible to provide capacity for a substantial charging hub in the evening/overnight, while heavily curtailing this in the daytime.

Many end users, both domestic and fleet based, are willing to be flexible with the time of their charging if they receive financial incentives to do so. Many already shift their charging into the evening to take advantage of lower-cost energy from their supplier. A TCC will not provide the customer with any compensation for changing the charging behaviour of their end users, but it will result in significantly lower upfront costs. TCC customers can still take advantage of lower energy costs from their supplier that coincide with periods when they are not curtailed. However, the TCC would prevent the customer from responding to dynamic energy price tariffs that promote energy usage during the period they are curtailed.

6.3. Insight

Our initial engagement has provided the following insights into the TCC schemes:

- The simplicity of the TCC scheme is appealing, particularly as it provides greater access to the network without the need to integrate with DNO systems.
- Although this functionality should be increasingly commonplace in smart chargers, it is not uniformly available, and there are few examples of TCC schemes in the UK at present.
- Some customers agree that TCCs are highly applicable to residential on-street locations, but the level (i.e., total capacity being installed) to which these types of chargepoints are currently being deployed does not necessitate an SCC.

- It is anticipated that residential end users will become familiar and accepting of the TCC restrictions on charging, although engagement will be required to raise their awareness.
- This engagement would also explain the benefit of TCCs to the customer, i.e., faster and wider deployment of charging infrastructure with lower cost and reduced disruption.
- Their acceptance would be further enhanced if there were enough chargepoints and load diversity that a limited number of end users could prioritise their charging and effectively 'opt out' of being curtailed – even if this meant paying extra (i.e., scheduled charging). The ability to offer this will depend on the level of curtailment, as in some extreme cases, it could be 0kW.
- The business case for on-street chargepoints is the hardest to justify, as their utilisation is dependent on EV uptake being high in the local area and the revenue from the energy provided is relatively low compared to that from rapid chargepoints. They also need to have minimal impact on the movement of pedestrians. As such, there is presently a high uptake of low-cost chargepoints that have a small footprint and can be deployed with minimal disruption. Often, they are incorporated into existing street furniture, such as street-lighting columns, and provide a 'slow' AC charge (<5kW).
- At present, the trade-off of the reduced cost and size is the intelligence of the chargepoints, which impacts their ability to provide TCC functionality.
- The deployment of on-street residential chargepoints is typically led by local authorities, whose primary aim is to maximise the coverage provided with the limited funding available to them. As such, it is typical that on-street residential schemes will only install two to four AC chargepoints per street. These might be the aforementioned 'slow' (<5kW) or 'fast' (7–22kW) chargepoints. Either way, the typical power consumption is relatively low and can often be accommodated by the existing network. So although the TCC is very applicable for on-street schemes, they will only be required when they are deployed at scale or the necessary charging power increases.
- There are already several examples of TCCs being deployed for large depot charging sites in the UK, including a bus depot in London facilitated by UKPN.
- Engagement with several depot fleet operators highlighted that they all had near-term plans to electrify their fleet of vehicles, with most intending to utilise overnight charging. As such, if a TCC facilitated a faster and/or cheaper connection on the proviso that overnight charging would not be curtailed, fleet operators would be very keen to adopt it.
- Some of the fleet operators went as far as saying they would be willing to adopt a TCC that curtailed their import to almost nothing during the working day if it facilitated several MVA of capacity in the evening.
- There is currently a lot of focus on the development and deployment of solutions that will facilitate the smart charging of depot EVs. Several solutions are now commercially available, with some fleet operators looking to develop their own in-house solutions.

- The development and trial of solutions to facilitate flexible connections for depot EVs is a major component of the Optimise Prime NIC project being undertaken by UKPN and its partners[4].
- Unlike the on-street schemes, there appears to be a more near-term uptake of SCCs with depots. The simplicity of non-curtailment during the required charging period of fleets makes TCCs a very attractive option to customers and end users.
- The Optimise Prime project also looks at the provision of Profile Capacity Constraints. This is a variant of TCC that utilises forecasting to assign the half-hourly curtailment limits a day ahead. This increased level of sophistication provides further access to available network capacity.
- Although a TCC scheme could be used to manage constraints on a customer's local network, most customers would opt for a Customer Load Management Scheme, as this would provide them with greater capacity access. (See Section 7.)
- The major risk to both the DNO and chargepoint owner is that the status quo of the network loading changes and the defined curtailment period and scale is no longer sufficient to mitigate the risk of a network constraint. In this eventuality, there will be a requirement for either the conditions of the TCC to be revised or the network reinforcement to be undertaken. Transparency on this issue and an agreement on the responsibilities of each party will be required upfront, ahead of any connection taking place.
- For DNOs, the risk is in being reliant on the customer operating and maintaining the TCC to ensure the network remains within its operational limits. The question was raised regarding what level of risk would be allowed before the DNO would insist on the inclusion of monitoring or a form of back-up protection/inter-trip to guard against non-compliance.
- For the chargepoint owner, the risk is related to end-user acceptance and commercial performance of the TCC. Until it is operational, it will be difficult for the true impact of the curtailment to be ascertained.

6.4. Challenges

There are no major barriers to the provision and adoption of TCCs. However, customers, CPOs, installers and DNOs require more practical experience of their implementation in order to facilitate the necessary changes to existing policies and processes, inform technical requirements, and generate appropriate messaging to raise awareness of them.

4. https://www.optimise-prime.com

Commercial Challenges	Technical Challenges	Societal Challenges
• **Economic** - At present, there isn't a detailed understanding of the business case for TCCs vs conventional reinforcement connections in terms of cheaper connection costs vs lost revenue from curtailment. • **Legal** - There is limited scope within existing connection offers to facilitate TCCs - new contracts will have to be established that highlight responsibilities and recourse for non-compliance. • **Policy & Process** - Present DNO policies and processes do not include provision of TCCs.	• **Performance** - It is not currently understood whether smart chargers can provide the necessary requirements to reliably operate a TCC. • **Curtailment Assessment** - No established process is in place to assess network suitability to accommodate a TCC and the curtailment required. • **Network Security** - Little experience of long-term reliability (i) Can the CPO provide sufficient fail-safe capability, or does this need to be established by the DNO? (ii) How can the long-term compliance of the TCC be monitored by the DNO?	• **Customer & End-User Acceptance** - Will TCCs provide the required charging to meet the needs of end users? • **Awareness** - To gain traction, there needs to be greater awareness of TCCs across the supply chain.

6.5. Proposed approach of the Charge Project

There is an emerging role for TCCs in accelerating the deployment of public chargepoints, but the awareness of customers, readiness of the technology, and internal processes of DNOs need to improve to facilitate them. As such, the Charge Project is looking to:

- Undertake extensive desktop analysis of the performance of TCCs across several network connection scenarios to identify how their business case compares to conventional reinforcement connections over a suitable period, utilising real-world charging profiles and network load data wherever possible. Also, assess the cost of lost revenue through curtailment against the lower connection cost.
- Raise customer awareness of the role of TCCs, their applicability, their benefits and downsides, and their performance alongside traditional reinforcements.
- Raise awareness of TCCs and their requirements across the supply chain deploying chargepoints.
- Provide customers with guidance on their requirements to adopt a TCC.
- Provide guidance to installers on the implications of adopting a TCC, including any technical considerations and any requirements for commissioning.
- Develop SPEN's internal processes to facilitate TCCs, sharing the changes with other UK DNOs to promote a standard approach.
- Include the necessary changes to connection offers to highlight the roles and responsibilities of the DNO and the customer, and the recourse for non-compliance.
- Develop a process for our design engineers to follow in order to undertake a curtailment analysis sufficient to assess whether a TCC is an appropriate connection option. This could be in the form of a standard design template incorporated into the DNO's design manuals.
- Develop a strategy for ensuring the enduring performance of the TCC schemes does not compromise the network. This will consider such things as the deployment of network monitoring, periodic reviews of performance and the encroachment on network operating limits, the building of TCC locations into load-related expenditure plans, and the development of a process for non-compliance. All of this relies on an efficient management system to record and maintain details of TCCs that have been approved on the network.

7. Customer Load Management Schemes

7.1. Overview

Customer Load Management Schemes (CLMs) are another relatively simple form of SCC, used exclusively to prevent chargepoints from causing customers to exceed their declared supply capacity (DSC). Chargepoints on the customer network are programmed by the CPO to ensure their collective demand never exceeds either a static or dynamic limit.

A CLM with a **static limit** will have a fixed 'kVA' limit (programmed into the CPMS) which the chargepoints collectively will not breach via CPMS coordination. The static limit is lower than the aggregated full load of the chargepoints. This type of scheme takes no consideration of any other loads on the customer's network.

A CLM with a **dynamic limit** considers additional loads on the customer's network and calculates the headroom available for the chargepoints to utilise without the DSC being compromised.

Assuming the customer has a connection with a suitable DSC, there are no requirements for additional DNO network studies to accommodate a CLM. It would be the responsibility of the customer/installer to assess the viability of the CLM and ensure it would not jeopardise the security of the site supply or the DNO network by exceeding the DSC.

The ability to operate a CLM with a static and dynamic limit is becoming more common among smart chargers, but there are significant variances between how readily available they are between CPOs. As with the TCC scheme, the CLM can be either programmed locally or administered by a remote CPMS. There is no requirement for a direct link to DNO systems and, in some cases, there is no need for additional hardware, which makes the complexity and costs of the scheme also relatively low.

View animation

Customer Load Management Scheme animation

7.2. Opportunity and application

CLMs offer a major opportunity for existing customers to accommodate EV charging while utilising their existing connection capacity. For many customers, this would allow them to provide access to chargepoints while minimising delay, disruption and expenditure. A CLM can provide a suitable stop-gap solution until the customer can justify increasing its DSC or complete any required reinforcement work.

The development of smart chargers and their trajectory to providing static and dynamic CLMs means that, for many customers, this solution could be provided with minimal need for additional technology, particularly with AC chargepoints.

Many EV drivers who already use AC chargepoints have grown accustomed to their power output varying between 7, 11 and 22kW dependent on the number of EVs charging at a site. As long as they can receive a guaranteed minimal charge rate, they are likely to accept the solution.

CLMs are applicable where the customer wants to add chargepoints to its connection without increasing its DSC. The reluctance to increase the DSC could be due to a wide range of factors, such as disruption, cost and time – assuming that it triggers reinforcement on the customer's network or the DNO network. A higher DSC will result in a higher capacity charge, which the customer might also want to avoid.

The development of smart chargers and their trajectory to providing static and dynamic CLMs means that, for many customers, this solution could be provided with minimal need for additional technology, particularly with AC chargepoints

The site curtailment assessment ultimately sits with the customer and any parties working on its behalf. The assessment needs to identify how likely un-curtailed chargepoints are to breach the site DSC, and thus the level to which they need to be curtailed to prevent this from happening. The customer then needs to decide if the frequency, duration and scale of these curtailments will be acceptable to it and the EVs it is looking to charge. To undertake this curtailment analysis, the customer needs to know its DSC, the likely charging demand profile and, if it is considering a dynamic scheme, the profile of the residual site load. With both the chargepoint and site load profiles, datasets of higher granularity will lead to more representative studies.

There is a wide range of applications for CLMs, predominantly for sites with an existing connection that cannot be increased without excessive cost, delay or disruption. This is equally applicable to a wide range of chargepoint locations, such as workplaces and leisure and retail destinations. However, a CLM will only be as good as the available headroom. If the site is already operating close to its DSC limit, it is unlikely that the level of curtailment introduced by the CLM would be acceptable.

The suitability of dynamic CLMs will also be dependent on the responsiveness of the scheme and the volatility of the residual load of the site. The capacity limit of the dynamic CLM will have to be reduced to mitigate the risk of exceeding the DSC should a large, disruptive load be switched on. If the scale of these disruptive loads is too high, the capacity limit might result in a level of curtailment that is unacceptable to the customer.

A CLM can also be applied to new connections, whether they are exclusively for chargepoints or a mix of non-EV site loads and chargepoints. Customers may assess the acceptability of a CLM in cases when the DNO identifies a practical reduction to the requested DSC that would prevent the need for reinforcement, potentially saving the customer time, money and disruption.

Customer load management appears to be predominately available for the AC chargepoint market at present. In general, DC chargepoints are designed to provide a rapid charge – a service that end users pay a premium for. For this reason, on-site load management solutions for DC chargepoints are not as common and require additional hardware. (Such solutions are generally tailored for large 'charging hubs' for which the reduction in electricity costs is appealing to the CPO).

7.3. Insight

Our initial engagement has provided the following insights on CLM schemes:

- The ability to operate CLMs is becoming more commonplace in the smart chargers being deployed in the UK. However, the functionality available varies significantly by OEM and CPO.
- It is typical that AC chargepoints at the same physical location and same electrical circuit can provide the CLM functionality with minimal need for additional technology. The chargepoints would typically have the ability to communicate among themselves to adhere to either a static or dynamic setpoint.
- The coordination of AC chargepoints spread out over several circuits and locations would necessitate a separate controller to orchestrate the adherence to a setpoint.
- Similarly, it is more likely that DC chargepoints would require a separate controller to provide the CLM functionality.
- The introduction of a dedicated controller for AC and/or DC chargepoints also provides additional performance benefits and functionality, including scheduling of charging, integration of distributed energy resources (DERs) and further fail-safe options. As such, it is increasingly common for them to be installed at large charging hubs and depots.
- Static limit CLM functionality is increasingly available from smart chargers. The functionality is often utilised by chargepoint owners to avoid standing charges for half-hourly metering by ensuring the total demand of their chargepoints does not exceed 69kW. This is particularly commonplace for EV charging locations that offer both 50kW DC and 22/43kW AC charging.
- Static limit CLMs often utilise a satellite and hub configuration to communicate between themselves and manage their collective energy demand. Every chargepoint can function as the 'hub', which makes the scheme resilient to the loss of communication from any of the chargepoints.
- Dynamic limit CLMs require a hardwired signal to be passed from a meter to the hub chargepoint. These are often not at the same location, and installation is typically not possible without undesirable disruption.

- Dynamic limit CLMs also utilise a satellite and hub configuration, but require a dedicated hub chargepoint to integrate with the signal from the site's electricity meter. Because of this, the scheme has lower resilience compared to static limit schemes.
- Sites operating both AC and DC chargepoints would often only look to deploy the CLM to the AC units, while providing the DC units with unconstrained access.

- For **customers** looking to adopt a CLM, there are several risks that need to be carefully considered and managed:
  - Will the CLM provide sufficient capacity for the chargepoints to meet the requirements of their end users, and will the capacity be available at the times it is required? This is especially important in relation to paying end users, as opposed to the charging of staff or fleet vehicles.
  - The failure of a CLM could result in both financial penalties for breaching the DSC and the loss of the site supply, risking the security of supply to the site's other loads. It is therefore essential that the CLM has suitable fail-safe measures integrated in and alongside it to prevent its failure from causing wider issues.
  - Where the failure of a CLM could lead to issues on the wider network, there might be additional requirements from the DNO to ensure appropriate fail-safe measures are in place.
  - The selection of the smart charger must be in parallel with, or after, the decision is made to adopt a static or dynamic CLM. The suitability and readiness of the smart chargers to provide this functionality varies significantly. In many cases, it will be impossible to retrofit this functionality once the chargepoints have been installed.
  - There is potential that smart charging cables could, by proxy, provide this functionality retrospectively. However, these will come at an additional cost.
  - The adoption of a dynamic CLM might also cause unacceptable disruption to the customer, as it often requires a hardwired link between a meter measuring the live total site demand and the chargepoints.

- For **DNOs**:
  - There is a risk of being reliant on the customer operating and maintaining the CLM to ensure that the customer stays within its DSC. Excursions beyond the DSC could pose a threat to the network's operational limits, especially if multiplied across several sites in the same network area.
  - The widespread adoption of CLMs could result in a masked load growth and the erosion of load diversity on the network.
  - There is also an inherent risk that customers could install CLMs without informing the DNO.

7.4. Challenges

As with TCCs, there are no major barriers to the provision and adoption of CLMs. However, customers, CPOs, installers and DNOs require more practical experience of them. Doing so will facilitate the necessary changes to existing policies and processes, inform technical requirements, and generate appropriate messaging to raise awareness of them.

Commercial Challenges

- **Economic** - At present, there isn't a detailed understanding of the business case for CLMs vs conventional reinforcement connections in relation to cheaper connection costs vs lost revenue from curtailment.
- **Legal** - There is limited scope within existing connection offers to facilitate CLMs - new contracts will have to be established that highlight responsibilities and recourse for non-compliance.
- **Policy & Process** - Present DNO policies and processes do not include provision of CLMs. Should DNOs introduce a 'Connect and Notify' policy?

Technical Challenges

- **Performance** - It is not currently understood if smart chargers can provide the necessary requirements to reliably operate a CLM. It is also not clearly understood if smart chargers and the associated CPMS can provide close to real-time control where site security is critical.
- **Curtailment Assessment** - The responsibility sits with the customer/installer, both of which might not be equipped to carry this out, and may need guidance/support. The implications of getting it wrong could be significant.
- **Network Security** - Little experience of long-term reliability.

(i) Can the CPOs provide sufficient fail-safe capability, and what standards should be put in place?

(ii) How can the long-term compliance of the CLMs be monitored by the DNO?

(iii) Should DNOs develop a Type Test Register of CLM solutions to avoid the requirement for witness testing or functionality testing?

Societal Challenges

- **Customer & End-User Acceptance** - Will CLMs provide the required charging to meet the needs of end-users?
- **Awareness** - To gain traction, there needs to be greater awareness of CLMs across the supply chain.

7.5. Proposed approach of the Charge Project

As with the TCC scheme, there is an emerging role for CLMs in accelerating the deployment of public chargepoints, but the awareness of customers, readiness of the technology, and internal processes of DNOs need to improve to facilitate them. As such, the Charge Project is looking to:

- Undertake extensive desktop analysis of the performance of CLMs across several network connection scenarios and customer connections to identify how their business case compares to conventional reinforcement connections over a suitable period, utilising real-world charging profile and network load data wherever possible. Assess the cost of lost revenue through curtailment against the lower connection cost.
- Work with a customer or customers looking to deploy a CLM in the SP Manweb licence area, if the opportunity arises.
- Raise customer and end-user awareness of the role of CLMs, their applicability, their benefits and downsides, and their performance alongside traditional reinforcements.
- Raise awareness of CLMs and their requirements across the supply chain deploying chargepoints.
- Provide customers and installers with guidance on the implications of adopting a CLM and their requirements.
- Provide guidance on how to undertake curtailment analysis for both static and dynamic CLMs.
- Develop SPEN's internal processes to facilitate CLMs, sharing the changes with other UK DNOs to promote a standard approach.
- Include the necessary changes to connection offers to highlight the roles and responsibilities of the DNO and the customer, and the recourse for non-compliance.
- Develop a strategy for ensuring that the enduring performance of the CLMs does not compromise the network. This will consider such things as the deployment of network monitoring, periodic reviews of performance and the encroachment on network operating limits, the building of CLM locations into load-related expenditure plans, and the development of a process for non-compliance.
- Make recommendations for the establishment of a national Type Test Register for CLM solutions.

8. Locally and Centrally Managed Constraint Schemes

8.1. Overview

These schemes are commercially and technically more complex because they require the integration of DNO systems with those of the CPO. The trade-off to this increased complexity is greater access to the available network capacity and greater certainty for the DNO that they are developing, as well as managing a secure and efficient network for CPOs and other customers.

Both schemes rely on network monitoring at locations that could be potentially stressed by the connection of the new chargepoint load. These network measurements are assessed to identify the network capacity available, and to derive a dynamic setpoint for the chargepoints to adhere to. This setpoint is communicated directly to the customer-owned CPMS, which, in turn, identifies what corrective action is required to ensure the total demand does not exceed the setpoint.

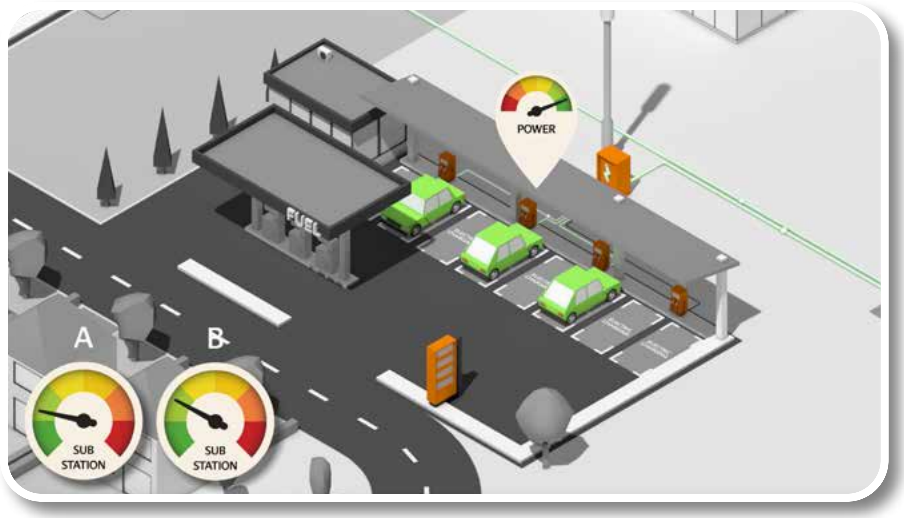
Locally Managed Constraint Schemes (LMCs) can be deployed where the chargepoint load is only likely to stress a single location on the network. As such, there is an opportunity to include the control functionality, which derives and communicates the setpoint to the customer, in the monitoring solution.

Centrally Managed Constraint Schemes (CMCs) can be deployed where the chargepoint load has the potential to stress multiple locations on the DNO network. As such, a central platform is required to coordinate and assess multiple measurements from the network and derive and communicate a resulting setpoint to the customer. It is likely that the central platform would take the form of a distributed energy resource management system (DERMS); these are used by DNOs for flexible distributed generation (DG) connections (of the active network management type).

Given that the failure of the customer to respond to the instructed setpoint could result in the DNO network becoming stressed and impact the security and quality of supply to other customers, a key consideration of both schemes is the fail-to-safe provision.

View animation

Locally Managed Constraint Scheme animation



View animation

Centrally Managed Constraint Scheme animation

8.2. Opportunities and applicability

DNO-led SCCs have the potential to release the greatest amount of capacity for chargepoint connections. They provide the customer with the maximum amount of capacity available, exploiting real-time latent capacity across the network. These schemes have the potential to provide either a temporary or a permanent alternative to network reinforcement.

Locally Managed Constraint Schemes (LMCs) can be deployed where the chargepoint load is only likely to stress a single location on the network

The impact of a curtailment setpoint signal from the DNO can be mitigated through the management of energy to and from on-site DER and/or storage.

The direct link between the DNO and the CPMS could provide additional benefits, such as the communication of flexibility service signals, should they come from the DNO.

An LMC or CMC could be considered when the requested capacity is perceived to be predominantly available on the DNO network but, under certain loading conditions or running arrangements, cannot be fully accommodated and would require curtailment.

To identify whether the local network is suitable for these schemes, the DNO will undertake a detailed curtailment analysis, considering the loading over a period long enough to determine the availability of the requested capacity. This curtailment analysis would look to identify and quantify, for example:

- The maximum level of capacity curtailment required.
- The percentage of time the full requested capacity is available.
- The frequency and duration of common network constraints and resulting customer curtailment.
- The probability of various levels of curtailment being applied.

This DNO curtailment analysis on its own will only identify the impact the schemes would have on the availability of the fully requested load. It would not consider the coincidence of the network constraint with the load profile of the chargepoints. This more detailed curtailment analysis would need to be undertaken by the customer. This analysis will ultimately drive the customer's commercial decision to accept or reject the SCC.

In theory, there is a wide range of applications for both LMCs and CMCs, but given their relative complexity, it is likely they would be most applicable where they would enable the avoidance of substantial reinforcement costs and/or major delays

In theory, there is a wide range of applications for both LMCs and CMCs, but given their relative complexity, it is likely they would be most applicable where they would enable the avoidance of substantial reinforcement costs and/or major delays. As such, it is more likely they will be most appropriate for larger-capacity charging locations connected to higher-voltage networks in the immediate future. However, deployment at lower voltages could prove effective once DNOs have established low voltage network control and a central DERMS platform capable of integration with most common CPMSs.

Once established, the central DERMS platform could also provide additional SCC functionality, such as capturing monitoring data, providing policing, mitigating the risks of simpler SCC schemes, and enabling more sophisticated customer arrangements with on-site DER.

8.3. Insight

Our initial engagement has provided the following insights into the LMC and CMC (DNO-led) schemes:

- There is little experience or trials of DNO and CPO systems for public chargepoints being integrated in the UK. No immediate examples outside of the endeavours of the Charge Project and Optimise Prime project could be cited.
- The closest example is the trials undertaken to control domestic chargepoints under Western Power Distribution's Electric Nation project.
- Although some customers could see the value of having the option of DNO-led SCC schemes available to them in the long term, they do not have an immediate need for them. At present and in cases in which network access is limited, the connection customer would opt to shift its focus to an alternative site or tailor its demand to meet the available capacity. In time, customers' ability to select sites on this basis will reduce, and their interest in DNO-led SCC schemes will increase accordingly.
- The integration of DNO and CPO systems will require additional investment and resources from the CPO. Given that this is not an immediate area of concern, this development is not presently a priority of CPOs.
- In general, there is reticence amongst customers (and CPOs especially) with establishing the required system integration and giving DNOs any level of control over their assets. This concern is focused primarily on how the DNO signals could interfere with their commercial proposition to end users or impact the charging of essential fleet vehicles.

- This reticence diminished slightly with the realisation that they were in full control of how their chargepoints responded to the DNO setpoint signal, i.e., the DNO would not control individual chargepoints and decide which would be curtailed. This would solely be done by the CPMS, configured to meet the needs of the CPO and its end users.
- A major risk/concern for customers is that they have less certainty and control over the occurrence of a curtailment signal. Unlike the TCC, which provides a fixed but uniformly applied constraint window, and the CLM, which is largely driven by its own load, the LMC/CMC curtailment signals could be impacted by faults, temporary running arrangements, or increased external network loads, with all of these factors beyond the customer's visibility or control. There is an inherent risk that the DNO curtailment signal coincides with peak charging and has an unacceptable impact on paying end users or fleet EVs.
- Discussions on DNO-to-CPO integration have highlighted that the method will vary significantly by CPO. For some, it would likely be a direct link to a 'hub' chargepoint capable of interpreting the setpoint and controlling the adjacent 'satellite' chargepoints. Other CPOs will require integration with a physical onsite CPMS, particularly common at large charging sites. Lastly, and increasingly common, would be the integration of the DNO signals with a CPO cloud-hosted CPMS, which may prove to be the simplest, cheapest and most extensible option, but have less robust on-site fail-to-safes.
- Questions remain of the reliability, latency and responsiveness that can be expected by all of the different integration methods, particularly when sending signals over a cellular network or the internet.
- At present, there is not a standard protocol for the communication between the DNO and CPO. However, discussions with customers highlighted several protocols that had been developed to allow this communication pathway, which will be covered in greater detail in section 8.5. The main protocols to be mentioned are:
    - **OpenADR** (Automatic Demand Response)
    - **OSCP** (Open Smart Charging Protocol)
    - **OCPI** (Open Chargepoint Interface)
    - **OPC UA** (Open Platform Communications Unified Architecture)
- The ability to operate the chargepoints in a DNO-led SCC is predominantly dictated by the CPO's CPMS, rather than the hardware itself. There are, however, some exceptions to this, and it is essential that the chargepoint hardware can communicate externally.
- Because of the reticence of some customers to adopt a DNO-led scheme and tackle the development challenges, the scale of the benefit delivered needs to be suitably large in terms of cost or reduction in time to connect. A good example of this would be the facilitation of a connection at a lower voltage, e.g., at 11kV as opposed to 33kV.
- The acceptability of a DNO-led SCC would also be higher where the site includes integral DER that could backfill the energy required in the event of an external network constraint.

- For customers and DNOs alike, there is a security risk associated with the integration of their systems.
- For DNOs, there is a reliance on the customer responding to constraint signals to maintain the quality and security of the network supply. It is essential that there is an automated process to fail-safe and remove non-compliant chargepoints from the network before they cause disruption to surrounding customers on the network. As DNOs have nothing they can directly control on the customer's side of the connection, a fail-safe scheme will ultimately trip off the customer's incoming supply to secure the wider network. Obviously, this is a major risk for the customer that could result in lost revenue, disruption to the charging of fleet vehicles, and a reliance on staff to manually re-energise the site. As such, it is clear that agreed mechanisms are required for monitoring and remediating chargepoint response.
- DNOs will also have to consider how future network programmes impact the schemes and ensure that the proposition to the customer is not detrimental to future network development. This is applicable to all SCCs in different ways, although the LMC and CMC methods have the benefit of being actively managed and, therefore, can be adapted and extended over time.
- As with the other schemes, the selection of the smart charger must be in parallel with, or after, the decision to adopt an LMC or CMC. The suitability and readiness of the smart chargers to provide this functionality varies significantly. In many cases, it will be impossible to retrofit this functionality once the chargepoints have been installed.
- The investment in a DERMS platform and its ongoing operation will only be cost-effective if deployed at scale and if the reuse/extension of DERMS for SCC implementation can be factored into ongoing DNO DERMS programmes.

There is a growing trend to electrify vehicles that charge at a depot location – for example, delivery vans, bin lorries, buses, taxis

ea technology

PTV GROUP the mind of movement

smarter grid solutions

SP ENERGY NETWORKS

8.4. Challenges

DNO-led SCCs are unavoidably more complex and challenging to deliver than their customer-led counterparts, but they should provide the greatest access to the available capacity on the network.

Commercial Challenges

- **Economic** - At present, there isn't a detailed understanding of the business case for DNO-led SCCs vs conventional reinforcement connections. The business case, especially at low voltage, needs to be fully understood due to the complexity of the DNO-led schemes and level of integration required between DNO and CPO systems (which is currently not mainstream).
- **Legal** - There is limited scope within existing connection offers to facilitate DNO-led SCCs - new contracts will have to be established that highlight responsibilities and recourse for non-compliance. Contractually, it is more complicated where non-compliance affects network security/other customers. In cases in which multiple CPOs operate within the boundaries of the same network constraint(s), contractual agreement over who gets curtailed first, and by how much, must be established.
- **Policy & Process** - Present DNO policies and processes do not include provision of DNO-led SCCs.

Technical Challenges

- **Performance** - It is not currently understood whether smart chargers can provide the necessary requirements to reliably operate a DNO-led SCC.

i) Integration of DNO and CPO systems requires development and no stardardised method has been established,

ii) It is not clearly understood whether smart chargers and the associated CPMSs can provide close to real-time control where site/network security is critical.

- **Curtailment Assessment** - No established process is in place to assess network suitability to accomodate DNO-led SCCs and the curtailment required.
- **Network Security** - Little experience of long-term reliability.

i) Can the CPO provide sufficient fail-safe capability, or does this need to be established by the DNO

ii) How can the long-term compliance of the DNO-led SCC be monitored by the DNO? (iii) Robust security measures need to be in place when integrating with critical DNO systems.

Societal Challenges

- **Customer & End User Acceptance** -

i) Current lack of acceptance from CPOs to receive and comply with a DNO signal.

ii) Will DNO-led SCCs provide the required charging to meet the needs of end users?

Awareness - To gain traction, there needs to be greater awareness of DNO-led SCCs across the supply chain.

8.5. Proposed approach of the Charge Project

In the latter half of 2021, the Charge Project will undertake a virtual trial of the DNO-led SCCs. The trials will evaluate the value of LMCs and CMCs under varying deployment scenarios and assess the performance of the DERMS platform in an open-loop configuration, managing several different SCCs in parallel.

(The Charge Project's original intention was to undertake several physical trials of LMC and CMC solutions with willing CPOs and customers. This would have provided the experience of integrating with a host of CPMSs and assessing the performance of the schemes' impact on charging demand.)

A key consideration for DNO-led SCCs is the secure method of communication between DNO and CPO. As previously mentioned, a number of protocols have been highlighted as providing such a pathway.

EV Charging Standards and Electricity Demand Protocols:

- **OpenADR** (Automatic Demand Response), an American protocol, is being gradually adopted worldwide. OpenADR facilitates common information exchange between electricity service providers, aggregators, and end users.

  Examples of its use:

  1. Sending price and load control signals, which can be used for decreasing or increasing the power consumption of individual devices.
  2. Sending reports - in the EV context, this can be standardised metering data from a chargepoint (for example, for monitoring and validating performance) and use times for forecasts, etc.)

- **OSCP** (Open Smart Charging Protocol) is an open communication protocol between the CPMS and DNO. The protocol can be used to communicate a time interval prediction of the local available network capacity to the CPO, which can fit the charging profiles of the EVs within the boundaries of the available network capacity.
- **OCPI** (Open Chargepoint Interface) is an open standard that provides a mechanism for exchange of data, primarily intended for EV roaming support between CPOs and e-Mobility service providers (eMSP) to provide roaming customer billing. A smart charging profile can be issued to control the charging rate of an individual chargepoint EV charging session.

General Communication Protocols:

- REST API (Representation State Transfer Application and Programming Interface). RESTful web services utilise the OpenAPI standard and use an HTTP-based protocol to exchange information. Data is exchanged via a client/server architecture via exposed API endpoint addresses. REST APIs are widely used today in web services and provide support for authentication and encryption. This is a general web standard for communication. The OSCP and OCPI protocols incorporate a REST API architecture as the means of communication.
- OPC UA (Open Platform Communications Unified Architecture) is a widely used industrial controls protocol open standard for communication from machine to machine (M2M) and from machine to the cloud. Proven security mechanisms such as authentication, authorisation and encryption guarantee a secure connection.

When considering the most suitable protocol for the Charge Project trials, the main use case involves the Charge Project's system defining a setpoint for a group of devices, which are then managed by a separate CPO system.

There are several protocols applicable for CPOs to manage the individual devices and the charging/payment process. As the Charge Project is not addressing individual chargepoints, OCPI is not suitable for the main use case.

OpenADR can be implemented at the CPMS level and provide a single demand signal for the EV site as a whole, so this is suitable for the main use case. However, none of the CPOs engaged with the project can provide OpenADR support at this time.

It is important to retain flexibility in the delivery solution and there is currently no clear market leader, as this field is still in development

OSCP has been deemed a good fit for the Charge Project. It has good depth of coverage and can provide the facility to send schedule data with real-time updates where required. However, none of the CPOs engaged with the project can provide OSCP support at this time.

It is important to retain flexibility in the delivery solution and there is currently no clear market leader, as this field is still in development. At present, none of the CPOs engaged with the project can provide external protocol support between DNO and CPMS, so this is an area that would require future development at both ends to support communications (development of which is beyond current scope).

Therefore, for the purpose of the trials, the Charge Project will investigate the feasibility of the existing communication options, as well as the specification of a new standardised REST API design template. This will involve defining a model of an interface for a proposed CPMS REST API server endpoint that will receive site-wide dynamic smart charging signals issued from the DNO.

9. Further Insights

While not attributable to any one specific SCC, the following topics were routinely discussed and given consideration by the Charge Project team, as well as the customers engaged. The following sections highlight the preliminary thoughts arising from these discussions.

9.1. When will the need for Smart Charging Connections become prevalent?

As highlighted previously, the underlying response from our customers has been that they can see the benefit of SCCs and would want them available as an option. However, the scale of their present deployments and ability to be selective over locations means SCCs are not an option they would immediately consider.

This ability to be selective is due to the nature of current deployments. At present, many of the chargepoint installations have been made by CPOs and local authorities. The CPOs are looking to establish sites that can generate sustainable revenue, which has often precluded the installation of high volumes of chargepoints during the infancy of EV uptake. These installations are not tied geographically to any specific location. Similarly, local authorities are looking to establish a high level of coverage of public chargepoints, rather than high volumes of chargepoints at hubs. They also have the benefit of the flexibility to choose from multiple locations where they own the land, where there is network capacity, and where there are no planning objections. Given the immediate choice between offering an SCC or opting for a reduced capacity or an alternative site, both CPOs and local authorities would opt for the two latter options.

The underlying response from our customers has been that they can see the benefit of SCCs and would want them available as an option

Depot charging hubs are an exception to this. There is a growing trend to electrify vehicles that charge at a depot location – for example, delivery vans, bin lorries, buses, taxis. These depots tend to be bound to a geographic location, so there is little option to move the charging hub to a location with more abundant capacity. As such, it is very likely that the immediate uptake and utilisation of SCCs will be predominantly at depot locations. As highlighted in Section 6, at present most of these fleets are operational during the day. It is therefore expected that overnight charging will be predominantly utilised, thus making TCC schemes a perfect fit for this application.

The initial uptake of SCCs is therefore likely be when customers with fixed geographic locations, such as workplace, leisure and retail locations, look to install a high volume of chargepoints. This will be driven by their customers' i.e., end users', adoption of EVs.

9.2. Smart Charging Connections and the Principles of Access

An important theme for discussion regarding SCC schemes is the impact of how curtailment could change as a result of changes to the demand profile or new connections to the wider network.

For CLMs, the customer has a DSC that it can operate up to regardless of what's happening on the surrounding network. If more customers connect, or demand increases or decreases on the local network that supplies them, it will not impact their ability to operate up to their DSC. However, an increased load on the surrounding network could impact the customer's ability to increase its DSC. Saturation of network capacity with contracted CLM demand also provides a strong first-comer advantage that does not scale well to a wider customer base. However, saturation would most likely trigger load-related reinforcement, which would release additional capacity.

TCCs and DNO-led SCCs (LMCs and CMCs) seek to utilise the remaining capacity on the network to supply the chargepoints. The addition of new connections to the same network would only be possible if they had no detrimental impact on the level of curtailment encountered. This would only likely be possible via reinforcement, which would ultimately increase the capacity available and reduce the curtailment.

The principles of access for TCCs and DNO-led SCCs become more complicated when the load of existing customers connected prior to the chargepoints increases or changes profile. Commercially, these customers have the right to increase or change their demand profile as long as they do not exceed their DSC. Curtailment levels for TCCs, LMCs and CMCs would remain a risk and require monitoring and possibly mitigating. It is likely that for the immediate future, DNOs will continue to operate access on the last in first off (LIFO) principle, which is used for other flexible connections such as those for distributed generation. It should be noted that market-based capacity access and curtailment trading are currently being explored by several DNOs.

The customer needs to fully understand the commercial implications of adopting an SCC and ensure this understanding is not lost through change of ownership (of the assets)

For TCCs specifically, a change to the surrounding load would not be apparent to the customer. The DNO would need to remain vigilant through monitoring to ensure that the TCC curtailment level was still appropriate. If it was found that the TCC was increasingly unlikely to prevent a network constraint, the DNO would likely prioritise the network for load-related reinforcement, as opposed to changing the TCC curtailment level or curtailment period.

A change to the surrounding load for DNO-led SCCs would be apparent to the connection customer because the frequency and scale of curtailments would increase. The implications of load growth should be considered at the DNO curtailment analysis stage, looking to understand the sensitivity of estimated constraint to changes in underlying load profile.

It is important to emphasise that over time, changes to the network load are inevitable. For this reason, SCCs are more likely to be an interim solution ahead of network reinforcement. The offering of SCCs requires transparency to the customer. The customer needs to fully understand the commercial implications of adopting an SCC and ensure this understanding is not lost through change of ownership (of the assets). The offering of SCCs requires the DNO to be vigilant, to not only protect the needs of the customer, but also the security of the network. DNO monitoring of the network, applying conservatism to the curtailment analysis, periodic reviews of network load growth and, lastly, load-related reinforcement may all be necessary to effectively manage change.

9.3. Interaction of Smart Charging Connections and the Flexibility Services Market

There has been a strong interest from customers in discussing the potential opportunities for their chargepoints to generate income via the provision of flexibility services. Customers were keen to discuss the potential impact that SCC adoption could have on this opportunity.

At present, there are no established policies that define the acceptable interactivity of flexible connections and the provision of flexibility services. Logic suggests that it would not be in the interests of UK customers if the connecting customer were to be compensated for providing a flexibility service that was necessary to facilitate its own connection. Likewise, it should not be compensated for providing a flexibility service that is mandated by its flexible connection.

There is an underlying reticence from CPOs to consider a DNO-led solution at present, which will slow down their development and deployment

CLMs only prevent a constraint on the customer's network or exceedance of its DSC. Should there be a request for local or national network load relief flexibility service, there is no apparent barrier to the customer applying.

Customers with TCCs and DNO-led SCCs are already benefiting from a flexible connection that reduces their own connection cost and/or shortens connection timescales, while alleviating the increased risk of the local network being constrained. The SCC customer has already benefited from a non-firm connection and will be constrained during periods of high loading on the network. DNO evaluation of flexibility requirements must consider the non-compensated curtailment of SCCs prior to identification of the need for compensated flexibility services from other sources. This is a balance that is currently not captured in regulation or connections policies.

Our discussions highlighted that the biggest challenge for CPOs looking to provide flexibility services would be their ability to demonstrate the consistency of load reduction delivery on demand. The present level of chargepoint utilisation would not naturally lend itself to demand reduction being readily available because the baseline demand before a flexibility service activation event might be zero if no EV was connected and charging.

None of the SCCs would prevent the customer from adopting a time-of-use tariff as long as it did not result in the customer contravening its curtailment obligation.

9.4. Readiness of Smart Chargers and Chargepoint Operators

The ability to provide SCC functionality is neither uniform nor standardised across the current smart charger market. Smart chargers' ability to adhere to dynamic limits, whether generated internally or externally, needs further development. Significant technical development is required by CPOs and OEMs for the chargepoints to provide this functionality. The development of SCC functionality is competing for resources within these organisations that are currently engaged with developing e-mobility functionality. As such, SCC-readiness capabilities are not presently the highest priority for CPOs and OEMs.

There is an underlying reticence from CPOs to consider a DNO-led solution at present, which will slow down their development and deployment. This is a barrier that will need to be overcome if SCCs are to be an effective tool in enabling maximum network capacity access and greater breadth of connection options for customers.

The development of a standard protocol and a standard set of interface signals for DNO-to-CPO communications would be a major enabler for the provision of flexible connections. At present, CPO systems do not widely include the functionality to accept external smart charging-related signals, either locally at the physical chargepoint level or centrally at the CPMS level. There is a need for a preferred industry-standard communication technology and corresponding preferred protocol to be adopted within the industry.

The ability to quickly and safely isolate CPO sites in response to safety-related DNO trip requests, following detection of DNO network overload conditions, is also an aspect that CPOs must develop and implement accordingly to ensure site safety. It is important that CPOs are sufficiently aware of the wider DNO safety aspects and prepared for the DNO-led safety actions and financial implications of lost charging during periods of site isolation.

Access to highly granular chargepoint data is currently limited (or simply not available). This impacts on the current level of understanding of EV charging demand profiles for various charging types. To facilitate the uptake of all SCCs (particularly in assessing their suitability and curtailment requirements), sharing of detailed datasets should be encouraged.

10. What happens next?

Now that you have read this report, we would greatly value your thoughts on its content, particularly in terms of how SCCs could fit into the current market while accelerating the roll-out of a public charging infrastructure. In particular, we would be grateful for any comments or insight you might have on the following topics/questions:

- The opportunity and applications highlighted for each SCC scheme
- The key challenges presented for each SCC scheme
- The insights generated so far by the Charge Project
- Are there any other aspects of SCCs you strongly agree or disagree with?
- Are there any other factors relating to SCCs that need to be considered?

To comment on the report, we have developed a separate feedback form, which can be accessed here.

The feedback generated will be vital in shaping the Charge Project's work going forward.