NIA ENWL041

Smart Restart

Closedown Report

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Review

Name	Role	Signature
Andy Howard	Innovation Programme Mgr.	A Howard
Geraldine Paterson	Innovation PMO Manager	G Paterson

Approval

Name	Role	Signature & Date
R Moulton	Head of Innovation	R Moulton – 28 July 2026

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Glossary of terms

Acronym	Description
ALCS	**Auxiliary Load Control Switch** A wired smart meter controlled relay providing binary on/off control for specific circuits such as storage heaters or immersion heaters.
AMI	**Advanced Metering Infrastructure** The full smart metering ecosystem, including meters, communications networks and data systems enabling remote control and data collection.
APC	**Auxiliary Proportional Control** A functionality enabling graded modulation of power for compatible devices (e.g., EV chargers, domestic batteries) via HAN connected controllers.
CLPU	**Cold Load Pick-Up** A surge in demand when devices restart simultaneously after a prolonged outage, potentially exceeding LV network limits.
CLF	**Consumer Led Flexibility** Programmes enabling consumer devices to participate in flexibility services, which may overlap with auxiliary control functions.
DCC	**Data Communications Company** The organisation providing secure national communications infrastructure for GB smart meters.
DCUSA	**Distribution Connection and Use of System Agreement** An industry code governing distribution-network charging arrangements, connection processes, and commercial rules.
DNO	**Distribution Network Operator** Companies responsible for operating, maintaining, and developing the electricity distribution networks.
DUIS	**DCC User Interface Specification** The specification defining how users issue commands and retrieve data from smart meters via the DCC.
ECS38	**Set Randomised Offset Limit** A smart meter configuration command that sets the 0–30 minute randomised offset window for scheduled events.
ENA	**Energy Networks Association** The trade association representing UK and Irish energy networks.
EV	**Electric Vehicle** A vehicle powered fully or partly by an electric battery, contributing to CLPU if charging resumes after outages.
GBCS	**Great Britain Companion Specification** The technical specification defining SMETS2 message formats, behaviours, and device interoperability.
GDPR	**General Data Protection Regulation** Legislation governing the protection and lawful processing of personal data.
GSOP	**Guaranteed Standards of Performance** Regulatory standards defining suppliers' and DNOs' minimum customer-service commitments.
HAN	**Home Area Network** The short-range wireless network allowing smart meters to communicate with in-home devices (e.g., relays, IHDs, controllers).
HCALCS	**High-Capacity Auxiliary Load Control Switch** A HAN-connected relay capable of switching higher-capacity or high-load devices such as EV charging equipment.
HEMS	**Home Energy Management System** Customer-side systems/devices that manage household load and may integrate with smart meter control features.
LCT	**Low-Carbon Technology** Technologies such as heat pumps, EVs, solar PV and batteries that influence network load and CLPU risk.
LL	**Load Limiting** A smart meter functionality that imposes a maximum household power cap for a defined period, useful for CLPU mitigation.
LV	**Low Voltage** The low-voltage part of the electricity distribution network delivering power to homes and small businesses.
RECCo	**Retail Energy Code Company** The organisation responsible for governance and development of the Retail Energy Code (REC).

Acronym	Description
SAPC	**Smart Auxiliary Proportional Control** An advanced version of APC offering more granular proportional control for suitable appliances.
SEC	**Smart Energy Code** The regulatory framework governing smart meter operation, access permissions, technical processes, and data management.
SECCo	**Smart Energy Code Company** The body responsible for administering and maintaining the Smart Energy Code.
SMETS	**Smart Metering Equipment Technical Specifications** The technical standards for GB smart meters; SMETS2 is the current national standard.
Smart ReStart Toolkit	The combined set of smart meter functions (randomised offset, load limiting, auxiliary switching, proportional control) proposed to mitigate CLPU.
SSES	**Smart Secure Electricity Systems** A DESNZ/Ofgem programme developing future regulation for smart, secure, and flexible electricity systems.
WP	**Work Package** A structured component of the Smart ReStart project: WP1 (Technical), WP2 (Regulatory), WP3 (Operational), WP4 (Modelling).

Executive summary

Aims

As GB progresses towards Net Zero, the rapid growth of heat pumps and electric vehicles (EVs) places low voltage (LV) networks at a greater risk of Cold Load Pick-Up (CLPU) following prolonged outages.

CLPU is not yet a widespread operational issue, but evidence from UK innovation projects and future modelling indicates that, by the 2030s, there is a risk that post prolonged outages, restart demand could exceed LV feeder and transformer limits, creating risks of secondary outages and voltage issues.

Smart ReStart explores whether existing smart meter functionalities could offer a scalable, low-cost approach to mitigating future CLPU risk.

Methodology

Desk based research, modelling, and extensive engagement with the Data Communications Company (DCC), Distribution Network Operators (DNOs), suppliers, Retail Energy Code Company (RECCo), Smart Energy Code Company (SECCo), manufacturers and wider smart-meter ecosystem stakeholders was undertaken.

Outcomes

Early expectations focused on using the SMETS2 randomised-offset functionality; however, evidence gathered during the project showed that randomised offset alone is not sufficient to manage CLPU as the deployment of LCTs increases. Its 30-minute cap, firmware constraints and the extended recovery behaviour of heat pumps limit its effectiveness in winter peak conditions.

Key learning

A single-function concept is not possible, and any future CLPU management will need a multi-option "toolkit" approach to enhance network resilience.

Three core technical options emerged:

- Randomised restart of auxiliary-controlled loads which builds on the existing offset functionality through pre-setting or extension.
- Whole home load limiting at the meter.
- Switching or proportional control of specific devices such as EV chargers and, where safe and manufacturer-approved, certain heat pumps.

Conclusions

The project demonstrated that CLPU is a credible future risk. While no single smart meter functionality provides a deployable solution today, several functionalities show potential and could form part of a future toolkit approach, subject to further technical, regulatory and operational development.

Closedown reporting

This project was compliant with Network Innovation Allowance (NIA) governance, and this report has been structured in accordance with those requirements. This report and the associated documents are available via the Energy Networks Association's Smarter Networks learning portal at www.smarternetworks.org or via the Electricity North West website.

1. Project fundamentals

Project title	*Smart ReStart*
Project reference	***NIA_ENWL041***
Funding licensee(s)	**Electricity North West Limited**
Project start date	**August 2025**
Project duration	**7 months**
Nominated project contact(s)	**Elizabeth Wilson**

2. Project background

As GB transitions towards Net Zero, the number of electric vehicles and heat pumps is forecast to increase significantly. Electricity North West's Distribution Future Electricity Scenarios (DFES), published in January 2025, forecasts 3.5 million electric vehicles and 2 million heat pumps by 2050. This expected growth in low carbon technologies exposes networks to increased cold load pickup challenges following prolonged outages (24 hours or more), where the post-restoration demand could exceed current substation and feeder design parameters.

The UKPN innovation project, Cold Start, investigated the impacts of cold load pickup, and clearly highlighted the scale of the challenge. By 2030, peak demand after outages could more than double, individual customer demand could exceed 4 kW, and LV feeders might experience up to 50% overloading. An 8-hour outage could result in loading beyond thermal limits, sustained for nearly 20 minutes after restoration. The project recommended that future work focus on exploring practical mitigation strategies and assessing their cost-effectiveness.

Smart Restart builds directly on this foundation, aiming to identify a scalable, low-cost solution using existing smart meter functionality to help DNOs proactively manage this risk.

Having a method to control and gradually ramp up demand after prolonged outages will allow DNOs to maintain network stability and reliability and avoid the need for additional network reinforcement to manage the high demand associated with cold load pickup.

3. Project scope

Smart Restart will develop and simulate a methodology for mitigating cold load pickup through smart meter-based load control, reducing the risk of overloading LV networks during re-energisation. Central to this approach is the random offset feature built into smart meters, which can delay the reactivation of devices (such as heat pumps and EV chargers) controlled by a smart meter control switch—e.g., an Auxiliary Control or Consumer Access Device—by anywhere from 0 to 30 minutes. By staggering when each device switches back on, the random offset helps prevent a sudden demand surge that could otherwise cause significant voltage or frequency issues, potentially jeopardising system stability or leading to a partial or total network shutdown.

The project will include both a desktop study of smart meter capabilities and simulations of selected LV networks to test the impact of the proposed load control methodologies. In parallel, the project will develop a roadmap for potential future field trials to validate results of simulation and potential benefits.

The project will deliver benefits to the GB electricity distribution system, including:

Financial:

- Potential deferral of network reinforcement by mitigating peak demand spikes
- Reduced operational and maintenance costs from avoiding overloaded conditions
- Avoided CI/CML penalties by reducing the risk of secondary outages following restoration

Environmental:

- Enabling more reliable integration of LCTs such as EVs and heat pumps
- Supporting the net zero transition through smarter grid operation

Operational:

- Improved LV network resilience and recovery following prolonged outages
- Use of existing infrastructure (smart meters) to deliver new value with minimal cost

4. Objectives

The project aims to:

- Assess the technical feasibility of using smart meter load control features to manage cold load pickup
- Review regulatory and compliance considerations and engage key industry stakeholders
- Develop high-level strategies for staged load reconnection using SMETS functionality
- Define the data and modelling requirements for future simulation and validation
- Provide recommendations and a roadmap for potential future trials and operational deployment

5. Success criteria

The success of the project will be determined by the completion and quality of the following key deliverables:

- Technical Feasibility Report –A review of SMETS smart meter functionality and its potential application for cold load pickup mitigation
- Regulatory and Compliance Review – A report outlining the current regulatory landscape, potential barriers, and stakeholder perspectives on controlled reconnection as well as policy recommendations
- Implementation Methodology Options – Development of high-level operational approaches for staggered reconnection using smart meter features.
- Simulation Roadmap – A plan specifying the modelling requirements, data needs, and proposed approach for simulating cold load scenarios in future work.
- Final Project Report – A consolidated summary of all findings and recommendations across work packages, including next steps for potential field validation.

6. Performance compared to the original project aims, objectives and success criteria

This project adopted both technical and commercial methodologies, combining desktop research, simulation-based modelling, and stakeholder engagement to assess how smart meter-based load control can mitigate cold load pickup events following prolonged outages. The core focus was to evaluate the feasibility and system impact of using SMETS meter functionality—specifically staggered reconnection and random offset features—to reduce peak network demand during restoration.

The method was delivered through four interrelated work packages:

Work Package 1: Technical Feasibility Assessment

- A desktop review of SMETS smart meter functionality, with a focus on demand control features such as staggered reconnection and random offset timers.
- This work package confirmed that several SMETS2 functions could support CLPU mitigation but highlighted key constraints and further considerations including latency, device diversity, and non-restoration-triggered offsets. Load limiting emerged as the strongest technical option.

Work Package 2: Regulatory and Compliance Review

- Assessment of the current regulatory landscape, including Distribution Code compliance and potential future changes. Engagement with key stakeholders (e.g. Ofgem, DESNZ, suppliers, DCC) to understand constraints and opportunities.
- This work package found that the smart metering framework does not prohibit the use of smart meter functionality for resilience or CLPU purposes. However, DNOs

currently lack authority to issue key commands (e.g., ECS38), and customer-consent, liability and governance mechanisms are not yet in place.

Work Package 3: Implementation Methodology Design

- Development of high-level operational strategies for staged load restoration, including prioritisation rules, randomisation windows, and load type-specific approaches (e.g. for EV chargers and heat pumps).
- This work package highlighted that low-voltage restoration is currently designed to restore supply without differentiated control of individual customer devices. Consequently, Smart ReStart would need to rely on pre-configured reconnection behaviour rather than real-time control. Adoption would require additional processes, supplier engagement, and improved visibility of low-carbon technologies.

Work Package 4: Simulation Roadmap

- Definition of the data, network models, and software requirements (e.g. PowerFactory) to enable future simulation and validation of proposed methodologies.
- This work package showed that staggered reconnection and load limiting can significantly reduce peak demand and improve voltage performance in many scenarios, though effectiveness varies by network topology, LCT uptake and the timing of the restoration event i.e. peak hours or non-peak etc.

The project concludes that smart meter based CLPU mitigation could offer benefits for the LV network but requires enhanced industry coordinated development across technical, operational, and regulatory domains.

7. Required modifications to the planned approach during the course of the project

No formal changes were required to the project scope. However, findings from the research broadened the focus from the original randomised offset concept to a wider assessment of smart meter functionalities capable of supporting CLPU mitigation.

8. Project costs

Item	Category	Estimated costs (£k)	Final costs (£k)	Variance
1	Labour	55	33	22
2	Contractors	210	210	0
	Total	**265**	**243**	**22**

The budget included more time for subject matter experts to review the project than was needed, and so the Labour costs were below forecast.

9. Lessons learned for future projects

The Project identified a number of lessons for future projects. These include starting engagement with smart meter governance bodies earlier, so that any regulatory barriers are flagged at the start of the Project. This type engagement could possibly be considered pre-project to help define the required outputs for future projects. The project also discovered that smart meter functionality should not be assessed in isolation from operational and regulatory constraints. Future innovation projects should engage suppliers and device manufacturers from project inception to ensure that any specific limitations are considered. Future CLPU studies would also benefit from access to higher-resolution network and customer demand data. Network resilience solutions are likely to require a portfolio approach rather than reliance on a single technology, so any future projects will need to balance a number of elements.

10. The Outcomes of the project

The Smart ReStart project investigated whether existing smart meter functionality could mitigate Cold Load Pick-Up (CLPU), an emerging risk linked to the electrification of heat and transport. The work combined literature review, regulatory assessment, technical evaluation, and operational analysis.

Overall, the project finds that CLPU is a credible and increasing potential risk but also demonstrates that existing smart meter capabilities are not sufficient to provide a clear or deliverable solution at present. While some technical options show partial promise, limitations across regulation, system design, operational feasibility, and device coverage mean that no defined pathway to implementation has been established.

10.1. Literature review of Cold Load Pick Up

The literature review indicates that CLPU is likely to become more pronounced as low-carbon technologies (LCTs), particularly heat pumps and electric vehicles (EVs), increase. Modelling suggests that under certain scenarios:

- Post-outage demand could rise significantly above normal levels
- LV feeders could face overloading under high electrification conditions
- Household demand could increase materially during recovery

However, these projections are subject to uncertainty. Outcomes depend heavily on assumptions around behaviour, weather, and technology performance, meaning the scale, timing and location of impacts remain uncertain.

CLPU is a whole-system effect, driven by combined demand across heating, background load and EV charging. Electrified heating appears particularly important due to sustained recovery behaviour, although further modelling may be needed to quantify this impact.

The persistence of the CLPU spike is also important. The Cold Start analysis indicates that elevated demand can last well beyond the initial reconnection period, meaning that short, manual interventions or simple reconnection sequencing are unlikely to be sufficient in an electrified system.

The literature clearly demonstrates that CLPU is a real and increasing network risk, driven by the accelerating uptake of heat pumps and EVs. Without intervention, or significant LV network upgrade, post-outage demand could exceed network design limits in multiple GB regions by 2030.

10.2. Regulatory Review (WP2)

The regulatory framework does not explicitly prevent the use of smart meter functionality for resilience purposes, but it does create substantial barriers.

The most significant constraint is that DNOs lack authority to control smart meter functions, with permissions held by suppliers under the Smart Energy Code. There is no established mechanism for coordinated use during restoration.

Additional challenges include:

- No standard approach to customer consent or acceptable use
- Unclear liability arrangements
- Limited precedent for network-led control
- Lengthy and complex code modification processes

Although policy developments (e.g. Smart Secure Electricity Systems (SSES), EV smart charging regulations, RIIO-ED3) indicate a shift toward demand-side control, these are not yet sufficiently defined to enable implementation. Regulatory change remains a key dependency with uncertain timelines.

The regulatory review concludes that Smart ReStart is feasible within the existing GB smart-metering architecture, but cannot be implemented today without changes to permissions, consent mechanisms, and industry governance.

10.3. Technical Review (WP1)

Smart Meter Capabilities Today

The GB smart metering system provides a secure and interoperable communications platform through the Data Communications Company (DCC). SMETS2 meters support a range of functionalities that, in principle, could influence electricity demand following the restoration of supply after an outage. Although these functionalities were primarily designed to support supplier-led activities such as billing, prepayment and tariff management, some may also have potential applications in mitigating Cold Load Pick-Up (CLPU).

However, the current smart metering architecture was not developed specifically for operational network restoration. Consequently, several characteristics of the existing framework affect the extent to which smart meter functionality can be used to manage CLPU events.

Trigger Behaviour

SMETS2 meters include a randomised offset capability that introduces a delay before a control action is executed. The purpose of this functionality is to avoid large numbers of devices responding simultaneously to scheduled events, such as tariff changes. From a CLPU perspective, a similar approach could potentially reduce the rate at which demand returns following restoration by staggering the reconnection of controllable loads. However, under current arrangements, randomised offsets are only applied to scheduled events and are not triggered by power restoration. This limits their applicability as a CLPU mitigation measure in their current form.

Device Availability and Diversity

A number of smart-meter-enabled control technologies exist, although their deployment is not universal.

Auxiliary Load Control Switches (ALCS) are meter-connected switching devices that provide remote on/off control of dedicated electrical circuits, such as storage heaters or immersion heaters. Home Area Network Connected Auxiliary Load Control Switches (HCALCS) provide a similar capability for devices connected through the smart meter Home Area Network (HAN), potentially including technologies such as EV chargers. These technologies could contribute to CLPU mitigation by delaying or sequencing the reconnection of selected loads following restoration. However, their deployment remains limited, and their operation is restricted to binary control, whereby devices are either energised or de-energised.

SMETS2 also supports Auxiliary Proportional Control (APC) and Smart Auxiliary Proportional Control (SAPC). Unlike ALCS and HCALCS, these functionalities enable compatible devices to operate at varying power levels rather than simply switching on or off. In principle, this could facilitate a more gradual recovery of demand following restoration. However, current deployment levels are low, and the functionality is not readily applicable to several technologies expected to contribute significantly to future CLPU, including many heat pump installations.

Communications Characteristics

Communications between authorised users and smart meters are managed through the DCC using processes defined within the DCC User Interface Specification (DUIS). DUIS specifies the service requests used to exchange information and issue commands to smart metering devices. Commands are not delivered instantaneously and may be affected by communications latency, batching processes and retry mechanisms. As a result, smart meter actions occur over a period of time rather than at a precisely defined moment. Any operational approach that relies on smart meter communications must therefore account for these delivery characteristics.

Taken together, these characteristics indicate that while several SMETS2 functionalities may have relevance for CLPU mitigation, their effectiveness is influenced by factors including deployment levels, communications architecture and the intended design of the existing smart metering framework.

Assessment of Relevant Functionalities

The technical review considered a number of SMETS2 functionalities that could potentially support the management of post-restoration demand.

Randomised Offset introduces a delay before a control action is carried out. If applied during restoration, it could reduce coincident demand by staggering the reconnection of controllable loads across a customer population. However, the functionality is not currently triggered by restoration events and is limited to a maximum delay of approximately 30 minutes. Given that CLPU effects may persist for several hours, particularly where electric heating and EV charging are present, the potential contribution of randomised offset is likely to be limited if deployed in isolation.

ALCS and HCALCS (Auxiliary Switching) provide remote switching of specific loads or devices. These functionalities could support restoration strategies by delaying the reconnection of selected appliances during the initial stages of demand recovery. Their effectiveness is constrained by relatively low deployment levels, dependence on compatible equipment and the binary nature of the control they provide.

APC and SAPC (Proportional Control) provide a more flexible form of control by enabling compatible devices to operate at reduced power levels. This could support a more gradual restoration of demand and potentially reduce peak loading following an outage. However, deployment remains limited and the application of proportional control to heat pumps may be restricted by technical operating requirements and manufacturer constraints.

Load Limiting (LL) enables a temporary cap to be placed on total household demand at the meter. Unlike device-specific control mechanisms, load limiting acts at the whole-property level and is therefore independent of the types of appliances connected within the home. As a result, it offers a potentially effective means of constraining post-restoration demand and reducing loading on feeders and transformers. Nevertheless, the functionality is currently associated primarily with prepayment arrangements, and wider use for network resilience purposes would require regulatory approval, governance arrangements and appropriate customer protection measures.

Telemetry and Readback Functions enable information to be retrieved from smart meters regarding supply status and device operation. While these functions do not directly reduce demand, they could improve visibility of restoration progress and support the coordination of staged restoration strategies. Their value for operational use is currently constrained by limitations on DNO access to detailed smart meter data.

Communications Constraints were also considered as an overarching factor affecting all smart-meter-based approaches. Latency and retry cycles within the DCC communications architecture mean that instructions are delivered progressively rather than simultaneously. While this limits the scope for highly time-sensitive control, it may also introduce some natural diversity in the timing of customer demand restoration.

Conclusion

The technical review indicates that SMETS2 incorporates a number of functionalities that could contribute to the mitigation of CLPU. However, each functionality is associated with technical, operational or regulatory limitations that restrict its effectiveness as a standalone solution. Load limiting appears to offer the most direct mechanism for constraining post-restoration demand at the household level, whilst randomised offset, auxiliary switching and proportional control could provide complementary benefits under appropriate circumstances.

Overall, the findings suggest that CLPU mitigation is unlikely to be achieved through any single smart meter functionality. Rather, the evidence supports the development of a broader portfolio of complementary measures, with the most appropriate combination likely to depend on network characteristics, customer technology uptake and the operational context of the restoration event.

10.4. Operational Review (WP3)

The operational review examined current low-voltage (LV) network restoration processes, the practical constraints associated with using smart meter functionality during outage events, and the operational changes that would be required to implement Smart ReStart. The review drew on stakeholder engagement with Distribution Network Operators (DNOs), suppliers, the Data Communications Company (DCC) and industry code bodies, alongside an assessment of existing restoration practices and smart metering operational processes.

Current LV restoration procedures are based on established engineering practices. Once a fault has been resolved and supply is restored, customers' appliances typically return automatically to their pre-outage operating state. There is currently no coordinated mechanism for controlling how individual devices reconnect, nor is there a defined operational process linking DNOs, suppliers and the DCC during restoration. As a result, heat pumps, EV chargers and other high-demand appliances may resume operation simultaneously, contributing to CLPU risk.

The review also identified a number of operational constraints that influence the feasibility of Smart ReStart. These include limited visibility of low-carbon technologies connected to individual properties, the absence of real-time control capabilities within current restoration processes, communications latency across the smart metering ecosystem and the fact that DNOs do not currently possess direct authority to control relevant smart meter functions. Consequently, any future Smart ReStart solution is likely to depend on pre-configured behaviours and agreed operational processes rather than real-time intervention during an outage event.

Based on the findings of the review, several areas for further development were identified:

- **Regulatory and code development:** Further engagement with Ofgem, SEC governance bodies and industry stakeholders will be required to assess the changes necessary to support Smart ReStart functionality. This may include modifications to permissions governing smart meter controls, changes to operational processes and consideration of any firmware updates required to support restoration-related functionality.
- **Operational procedures:** Additional work is required to develop practical processes for identifying constrained network areas, selecting appropriate restoration strategies and defining how DNOs, suppliers and the DCC would coordinate during a restoration event.
- **Customer engagement and protections:** Future development should consider customer communications, acceptance, consent arrangements and the safeguards required to protect vulnerable consumers.
- **Industry governance:** Roles, responsibilities and liability arrangements would need to be clarified across DNOs, suppliers, the DCC, the Energy Networks Association (ENA) and consumer representatives before operational deployment could be considered.
- **Modelling and validation:** The network modelling undertaken within WP4 demonstrated that approaches such as staggered reconnection, temporary load limiting and managed demand recovery can reduce peak demand and network

loading under certain scenarios. Further modelling and validation would be required to assess their effectiveness across different network topologies, restoration conditions and levels of low-carbon technology uptake.

The findings indicate that Smart ReStart has the potential to form part of a future DNO operational toolkit for managing LV networks during restoration events. However, implementation would require a phased approach. This is likely to involve further modelling and analysis, followed by controlled trials under an appropriate regulatory framework, before progressing towards a standardised industry process and wider deployment.

Further detail on the operational review methodology, findings and recommendations is provided in the full WP3 report on the SP ENW website here.

11. Data access & quality details

The project did not require access to customer-level, commercially sensitive or personally identifiable data. The work was based primarily on literature reviews, stakeholder engagement, smart metering specifications and representative network modelling. No material data quality issues were identified that affected project outcomes.

Anonymised data can be made available in line with our innovation data sharing policy, which can be found on our website.

12. Foreground IPR

No foreground IPR has been developed.

13. Planned implementation, recommendations, or next steps

13.1. Key Findings

As the project progressed, it became clear that Smart ReStart could not rely solely on the SMETS2 randomised-offset function. Engagement with technical experts, smart-meter ecosystem stakeholders and colleagues within SP Electricity North West showed that randomised offset is insufficient to manage CLPU under future scenarios with higher levels of electric vehicles, heat pumps and clustered low-carbon demand. The existing 30-minute limit, firmware constraints and long recovery behaviour of heat pumps resulted in it being inadequate.

This reinforced the need for a broader “toolkit” to manage CLPU that could combine complementary functionalities such as extended or pre-set offsets, whole-home load limiting and potential device-level switching or proportional control, each of which offer different strengths, constraints and regulatory requirements.

The Smart ReStart project demonstrates that smart-meter functionality offers a promising foundation for mitigating CLPU, as electrification increases across GB networks. Evidence from the literature, technical assessments and modelling confirms that CLPU risk is more likely by the 2030s, particularly due to the rising uptake of heat pumps and EVs.

Smart meter functionalities can play an important role in managing this risk, with several functions showing network benefit potential to smooth post-outage demand and improve resilience.

The review shows that while no single function is sufficient on its own, several complementary smart meter functionalities can contribute to an effective CLPU-mitigation toolkit.

- Pre-set randomised offset provides a useful starting point, particularly when extended or pre-configured. With this, ALCS/HCALCS offer binary control, where installed.
- Proportional load management (via APC and SAPC) presents longer-term opportunities as device availability increases.
- Household load limitation, although not yet available to DNOs for restoration purposes, demonstrates the strongest technical potential for suppressing post-outage demand peaks.

The regulatory review confirms that the current smart metering framework does not explicitly prohibit the use of smart meter functions for outage management or resilience purposes. However, DNOs do not currently hold the authority to trigger key functions such as the Set Randomised Offset Limit command (ECS38), which enables the configuration of smart meter randomisation settings, and there is no established customer consent, liability, or governance framework for network-led reconnection control.

Technical and operational assessments demonstrate that smart meter-enabled interventions can be integrated into future restoration processes, provided they are pre-configured rather than delivered in real time, and supported by appropriate industry governance.

Operational analysis highlights that low-voltage restoration is currently designed to restore supply without differentiated control of individual customer devices. As a result, Smart ReStart would rely on pre-configured settings and would require additional enabling processes, supplier engagement, and improved visibility of low-carbon technologies.

Modelling results confirm the value of this approach, staggered reconnection, temporary load limiting, and managed recovery profiles can reduce peak demand, improve voltage stability, and lower thermal loading, although performance varies depending on feeder topology, LCT penetration and the timing of restoration.

These findings support the view that the most effective approach to managing CLPU would be to develop a flexible toolkit, adapted to local network characteristics rather than use a single prescribed mechanism.

Although the project did not identify an immediately deployable smart-meter-based solution for CLPU mitigation, it has delivered significant value by reducing uncertainty in an area of growing importance to electricity networks. The project established a clearer understanding of the scale and timing of future CLPU risks, assessed the capabilities and limitations of existing smart meter functionality, and identified the key technical, operational and regulatory barriers that would need to be addressed before implementation could be considered. The project has also provided an evidence base to inform future innovation activities, regulatory discussions and network planning decisions, enabling future investment and development efforts to be targeted more effectively.

13.2. Risk

The main risks relate to regulatory uncertainty, dependency on supplier-controlled functions, and the availability of compatible devices, such as HCALCS and SAPC, during the early stages of deployment.

SEC and licence modifications may be slow to progress or face opposition from market participants. Customer protection requirements, including consent, vulnerability safeguards and liability frameworks, must be carefully designed to avoid unintended consequences.

Technical risks include communication latency via the DCC, interoperability constraints across meter types and Home Area Network (HAN) devices, and the potential for inconsistent performance across mixed technology estates. Operational risks arise from multi-supplier coordination challenges and limited visibility of customer LCTs.

Residual modelling uncertainty, particularly around heat-pump behaviour, extreme weather scenarios and customer response patterns, can be mitigated through further validation. Incorporating real outage data in future work will help improve accuracy and reliability.

13.3. Recommendations and Next steps

The Smart ReStart project has demonstrated that, while several smart meter functionalities may contribute to the management of Cold Load Pick-Up (CLPU), no single functionality currently provides a complete solution. The findings also indicate that CLPU is likely to become a more significant operational challenge as the uptake of low-carbon technologies increases, with impacts potentially emerging on some networks during the 2030s.

Irrespective of the specific technical solution adopted, continued engagement with Ofgem, the Smart Energy Code (SEC) Panel, suppliers and the Data Communications Company (DCC) is likely to be necessary to clarify roles, permissions and governance arrangements, and to establish appropriate customer-consent and liability frameworks. Engagement with device manufacturers would also support a better understanding of firmware constraints, interoperability requirements and acceptable operating ranges, particularly for heat pumps and other technologies expected to be significant contributors to future CLPU demand. Any future deployment would also require a clear customer communication strategy to support understanding and acceptance of proposed approaches.

There is potential to develop a follow-on project using secondary substation data, smart meter data and wider network data from areas with higher levels of low-carbon technology uptake. Such a project could support the development of a more granular bottom-up CLPU model, providing greater insight into the magnitude, duration and location of future CLPU impacts, while also enabling a more robust assessment of potential mitigation measures and their effectiveness across different network conditions.

The recommended next step is not immediate deployment, but targeted investigation of CLPU impacts in areas with higher uptake of heat pumps and electric vehicles, supported by enhanced modelling and continued engagement with regulatory and industry stakeholders.

14. Other comments

No additional comments.

15. Standards documents

Not applicable.

16. Net Benefits Statement

The project did not identify a single smart-meter-based solution that could be directly implemented to mitigate Cold Load Pick-Up. However, the project delivered significant learning regarding the technical, regulatory and operational barriers associated with smart-meter-enabled restoration strategies. The findings provide an evidence base for future innovation activity, support improved understanding of future CLPU risks, and have identified several potential mitigation approaches that warrant further investigation. While direct deployment is not currently recommended, the project has reduced uncertainty and informed future decision-making regarding network resilience in highly electrified energy systems.