LCPDelta

Smart ReStart

Closedown report

Prepared for SP ENW

Final version

Report written by:	Clarissa Muliawan	Clarissa.Muliawan@lcp.com
Report reviewed by:	Jonny Buzzing Emma Carr	Jonny.Buzzing@lcp.com Emma.Carr@lcp.com

Date of issue: 16/02/2026

Review Date	Checker/Reviewer	Notes
09/02/2026	Clarissa Muliawan	Initial issue of document
11/02/2026	Emma Carr	Initial review
12/02/2026	Emma Carr	Final review

LCP Delta is a leading European research and consultancy company providing insight into the energy transition. Our focussed research services include Connected Home, Electrification of Heat, Electric Vehicles, New Energy Business Models, Digital Customer Engagement and Local Energy Systems. We also provide consultancy for clients including networking companies and policymakers. LCP Delta mission is to help our clients successfully navigate the change from 'old energy' to new energy.

About LCP Delta

LCP Delta is a trading name of Delta Energy & Environment Limited and Lane Clark & Peacock LLP. References in this document to LCP Delta may mean Delta Energy & Environment Limited, or Lane Clark & Peacock LLP, or both, as the context requires.

Delta Energy & Environment Limited is a company registered in Scotland with registered number SC259964 and with its registered office at Argyle House, Lady Lawson Street, Edinburgh, EH3 9DR, UK.

Lane Clark & Peacock LLP is a limited liability partnership registered in England and Wales with registered number OC301436. All partners are members of Lane Clark & Peacock LLP. A list of members' names is available for inspection at 95 Wigmore Street, London, W1U 1DQ, the firm's principal place of business and registered office. Lane Clark & Peacock LLP is authorised and regulated by the Financial Conduct Authority for some insurance mediation activities only and is licensed by the Institute and Faculty of Actuaries for a range of investment business activities.

https://www.lcp.com/en/important-information-about-us-and-the-use-of-our-work contains important information about LCP Delta (including Lane Clark & Peacock LLP's regulatory status and complaints procedure), and about this communication (including limitations as to its use).

Disclaimer and use of our work

Where this report contains projections, these are based on assumptions that are subject to uncertainties and contingencies. Because of the subjective judgements and inherent uncertainties of projections, and because events frequently do not occur as expected, there can be no assurance that the projections contained in this report will be realised and actual events may be difference from projected results. The projections supplied are not to be regarded as firm predictions of the future, but rather as illustrations of what might happen. Parties are advised to base their actions on an awareness of the range of such projections, and to note that the range necessarily broadens in the latter years of the projections.

Executive summary

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.

Desk based research, modelling, and extensive engagement with the DCC, DNOs, suppliers, RECCo, SECCo, manufacturers and wider smart-meter ecosystem stakeholders was undertaken. 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.

As a result, Smart ReStart evolved from a single-function concept to a multi-option “toolkit” approach, recognising that multiple smart meter functionalities would be beneficial 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. Modelling result indicates that this is the most beneficial.
- Switching or proportional control (APC and SAPC)[1] of specific devices such as EV chargers and, where safe and manufacturer-approved, certain heat pumps.

All options have merits but alone do not offer a complete solution. The most credible approach is a hybrid, or “toolkit” approach, depending on the network factors, that combines pre-set randomised offset on auxiliary loads for the first 10–30 minutes of restoration, temporary whole home load limits to stabilise feeders, and, where device functionality allows, selective proportional control.

The optimal mix should be adaptive to feeder topology, LCT penetration, thermal risk and customer acceptance.

Across the work packages:

[1] APC is Auxiliary Proportional Controller and SAPC is Standalone Auxiliary Proportional Controller. APC is built directly into the smart meter. whereas SAPC is a separate device connected via the Home Area Network (HAN).

- WP1 (Technical Review) 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.
- WP2 (Regulatory Review) 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.
- WP3 (Operational Review) 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.
- WP4 (Modelling) 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 can offers significant benefits for the LV network but requires enhanced industry coordinated development across technical, operational and regulatory domains.

Going forward further analysis, testing, validation and stakeholder engagement is required to unlock the benefits of Smart ReStart, including a robust modelling of solution implementation costs and benefits for networks, customers and other impacted stakeholders such as suppliers, DCC, device manufacturers.

Contents

1. Introduction

The project aims to assess whether smart meters can be used to mitigate Cold Load Pick Up (CLPU) within current GB regulatory and technical frameworks and identifies changes needed for future trials and deployment

This report provides a consolidated Smart ReStart project close-down summary. It presents the key findings, outputs, recommendations, risks and next steps across all four work packages, forming the basis for decisions on potential next-phase development and trial design.

1.1. Smart ReStart overview

1.1.1. Project Background

As GB progresses towards Net Zero, the uptake of LCTs such as electric vehicles (EVs) and heat pumps is accelerating. SP ENW Distribution Future Energy Scenarios (DFES 2025) forecasts around 3.5 million EVs and 2 million heat pumps on its network by 2050. This growth presents new operational challenges for network operators, particularly in relation to CLPU events after prolonged outages.

CLPU occurs when many devices restart simultaneously after a power outage, producing a sharp surge in demand that can exceed network design limits. Evidence from the UK Power Networks' Cold Start innovation project shows that, by 2030, peak demand following restoration could more than double, individual customer demand could exceed 4 kW, and low voltage (LV) feeders could face up to 50% overloading. In severe cases, this could cause further outages or require expensive and premature network reinforcement.

Existing black-start procedures manage system-level frequency but do not address reloading of individual distribution substations or LV feeders. There is a growing need for a method to control and gradually ramp up demand after prolonged outages to maintain network stability and reliability and avoid secondary outage risk.

1.1.2. Smart ReStart

The original scope of the project was to leverage the SMETS2 smart meter randomised offset function to mitigate CLPU risk during power restoration events.

Currently, SMETS2 electricity smart meters already include a randomised 0 to 30 minutes offset functionality. This is designed to smooth national demand spikes during Time of Use tariff changes. In practice, any device linked to a meter control switch, such as an Auxiliary Load Control Switch (ALCS) or Home Area Network (HAN)-connected relay, waits for its offset period to expire before responding to a signal.

The DNO would then use the randomised offset feature in SMETS2 meters at re-energisation to stagger reconnection by up to 30 minutes in constrained areas of the network, thereby smoothing the aggregate load ramp and reducing CLPU peaks.

During the project we have discovered additional SMETS2 functionalities that has the potential to support DNOs, including ALCS, HCALCS, proportional control, load limiting, and meter telemetry.

For any smart meter-based CLPU mitigation to work, three conditions must be satisfied:

- Technical: Smart meters must be able to control relevant loads (via ALCS or HAN-connected relays) and apply offsets within defined windows.
- Regulatory: Distribution Network Operators must have the authority to send staggered reconnection commands, either directly via the DCC, through supplier cooperation, or by pre-scheduling the offset in the smart meter configuration.
- Customer: Consent, privacy safeguards, and clear liability arrangements must be in place.

Smart ReStart therefore aims to assess both the technical feasibility and the regulatory requirements for using Smart Meter during a CLPU events. The goal is to determine whether the approach is permissible under current GB arrangements, and what changes or derogations would be required to make it a practical and scalable solution.

1.2. Work-packages structures

The project is divided into several work packages:

- WP1 (Passiv UK): Technical feasibility of SMETS2 for CLPU mitigation
- WP2 (LCP Delta): Regulatory and compliance assessment
- WP3 (LCP Delta): Operational methodology and implementation approaches
- WP4 (LCP Delta): Simulation roadmap, modelling, and recommendations for next steps

1.3. Research methodology

The research combines internal expertise from Passiv UK and LCP Delta, desk-based review of existing literature and codes, and extensive stakeholder engagement across DNOs, suppliers, DCC, ENA, and policy bodies.

The methodology comprises:

- A literature review of CLPU to understand future risk, sensitivities, and drivers
- Stakeholder engagement to validate assumptions and clarify operational realities
- A regulatory review to assess feasibility under current codes and identify required modifications
- A technical assessment of SMETS2 functionalities, constraints, and interoperability
- Development of operational approaches and a modelling roadmap to test effectiveness

2. Literature review of Cold Load Pick up (WP1)

This section summarises the evidence base on CLPU to determine whether it represents a material and growing risk to GB distribution networks.

2.1. Introduction and key questions

This section aims to examine where and when CLPU is likely to emerge, which technologies drive the effect, and the key sensitivities that shape its scale. It draws heavily on the UK Power Networks Cold Start innovation project[2], which provides the most relevant quantitative modelling of post-outage behaviour under increasing electrification. The work package has also reviewed other initiatives and academic research focusing on CLPU.

The key questions examined in this section are:

- Is CLPU likely to become a significant operational problem in GB?
- Where in the network is it most likely to present risks (i.e., LV feeders, constrained substations)?
- When will CLPU begin to exceed acceptable thresholds (e.g., 2030, 2040, 2050)?
- Which technologies and behaviours drive the largest contribution to the peak?
- What sensitivities (temperature, outage duration, LCT mix) most strongly influence CLPU magnitude?

2.2. CLPU risk and sensitivity

Evidence from the UK Power Networks Cold Start project shows that CLPU is not a theoretical future risk but a near-term operational challenge. Modelling of an 11 kV network under varying outage durations and LCT penetration levels demonstrated that, by 2030 and beyond, CLPU could:

- More than double post-restoration peak demand
- Raise individual customer demand above 4 kW
- Overload LV feeders by up to 50%

The modelling found that heating demand was the largest single driver, contributing around 40% of the post-outage surge, closely followed by other background household loads (43%)

[2] https://es.catapult.org.uk/project/uk-power-networks-cold-start/

and EV charging (17%). These proportions highlight that CLPU is not simply an "EV problem"; rather, it is a whole-home, whole-feeder effect, exacerbated by the electrification of heat.

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.

Overall, the literature provides strong evidence that unmanaged CLPU could result in:

- Feeder or transformer overload
- Voltage deviations
- Secondary outages during restoration
- Increased need for reinforcement in constrained areas

2.3. CLPU across broader academic and industry literature

Across the broader academic and industry literature, CLPU is consistently identified as a complex, multi-driver phenomenon that intensifies as electrification increases, and no single mitigation method has yet proven universally effective. Empirical studies of real residential CLPU events show that traditional modelling often underestimates both the initial peak and the total duration of the recovery period, particularly in homes heated by low-temperature heat pumps, highlighting the need for longer-duration and more granular modelling. Other research demonstrates that demand response interventions, especially those that modulate heat pumps, can materially reduce CLPU impacts with minimal loss of comfort, suggesting that managed appliance behaviour is both technically feasible and socially acceptable when designed well.

Reliability-focused studies confirm that CLPU must be explicitly accounted for in restoration planning. Strategies that ignore CLPU perform worse than those that incorporate it, reinforcing the need for proactive demand management. Flexibility focused programmes, although not CLPU specific, show that coordinated control of domestic heat pumps and EV chargers is practical at scale and can support system resilience when appropriate digital and market frameworks are in place.

International research also indicates that integrating smart metering or AMI data into restoration sequencing can significantly enhance power utilisation, improve customer comfort, and reduce recovery times. Finally, optimisation-based approaches, such as two-stage or islanded restoration strategies, demonstrate that intelligent, sequenced reconnection can accelerate recovery while controlling peak loading.

2.4. Conclusion and next step

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.

The findings reinforce the need for new operational tools capable of smoothing demand during restoration. Cold Start recommends exploring approaches that leverage in-home appliance flexibility, identifying high risk network areas, assessing cost benefit trade-offs, and developing supporting policies and standards.

These insights underpin the Smart ReStart project's objective, to evaluate whether smart meter functionality, as an alternative to new physical infrastructure that can provide a scalable, low-cost method for managing CLPU. The remainder of this report builds on the literature by testing technical feasibility, regulatory permissibility, and operational pathways to trial and future deployment.

3. Regulatory Review (WP2)

This section summarises the current Great Britain regulatory framework governing smart meters and assesses whether staggered reconnection for CLPU mitigation is permissible today.

3.1. Introduction and key questions

This review examines the regulatory codes and standards relevant to Smart ReStart and evaluates whether smart meters can be used for CLPU mitigation within the current GB framework. The analysis covers the SMETS2 Technical Specification, the GB Companion Specification, the Smart Energy Code (SEC), the DCC User Interface Specification (DUIS), the Distribution Code, and relevant supplier and DNO licence conditions. It also considers active consultations such as the Smart Secure Electricity Systems (SSES) programme and the forthcoming EV Smart Charging Regulations (2025), to ensure alignment with the most recent policy developments.

The review aims to answer four key questions:

- Is staggered reconnection technically permitted under existing smart-meter rules?
- Do DNOs have the authority to issue reconnection-related commands, or does this sit exclusively with suppliers?
- Would controlled reconnection comply with current DNO licence conditions, including consumer protection, privacy and the Guaranteed Standards of Performance (GSOP)?
- Are there active policy changes that would enable Smart ReStart in the near future?

3.2. Smart meter regulation today

The SEC governs access to all SMETS2 functionality. SMETS2 meters support a limited set of 22 remote commands, known as configuration service requests, that can be changed remotely via the DCC. These include actions such as enabling or disabling supply, setting load control schedules, and adjusting the randomised offset limit. Each of these configurations is clearly defined and heavily regulated under the SEC, which specifies who can use the function, for what purpose, and under which conditions.

Suppliers currently hold the permissions required to trigger commands such as ECS38 (Set Randomised Offset Limit), while DNO access is restricted primarily to data retrieval rather than device control.

Although staggered reconnection functionality technically exists within SMETS2 and GBCS (via ALCS/HCALCS scheduling and configurable offsets), DNOs cannot operationalise these functions today. This means that:

- Smart meters can support staggered reconnection in principle,
- But DNOs lack standing authority to send the required commands, and

- There is no existing industry process governing how reconnection behaviour should be managed after an outage.

3.3. Gap analysis

RAG analysis assess how close Smart ReStart is to compliance today, where the remaining gaps lie, and what actions are needed to move from technical rules to regulatory approval.

Table 1 : Regulatory Gap Analysis

Regulatory Area	RAG Status	Key regulations	Key Gap	Mitigation / Next Step
Smart meter technical capability	Amber/ Green	ECS38 randomised offset and HCALCS control are fully supported in SMETS2, GBCS, and DUIS.	Coverage is not universal: not all meters are fitted with ALCS and HCALCS. There currently are active development with HEM providers and suppliers to look into incorporate HCALCS into their product. [3]	Further engagement with Home Energy Management (HEM) providers and network modelling is required to establish the minimum critical mass needed for effectiveness. If proven critical, next step of the project will involve building case for regulatory changes will be needed for new LCTs to be equipped with randomised offset.
Access and permissions	Amber	Whilst DNO are able to access smart meter data, ECS38 sits within supplier-controlled functions under SEC.	No standing authority for DNO-initiated ECS38 exists. Current rules would force DNOs to rely on supplier cooperation, which is impractical at scale or pre-load functionality that will allow randomisation to be triggered during re-energisation	Demonstrate proof of concept through modelling. Seek an Ofgem derogation for a trial. Develop a multi-supplier operational protocol via ENA. Progress towards a targeted SEC modification that grants DNOs conditional rights to use ECS38 for CLPU events.
Consumer protection & liability	Amber	GSOP, licence conditions, and GDPR protect customers. Short, controlled delays are unlikely to trigger GSOP breaches if managed.	No standard process exists for securing consent for DNO-led ALCS control. Current supplier terms do not specify that ALCS may be used during emergencies, and customers may opt out. Liability is unclear if reconnection fails.	Engage with consumer representatives to test acceptability. Establish an industry-wide consent mechanism and liability framework. Work with suppliers and Ofgem to embed these safeguards into licence conditions or national agreement.

[3] Smart Meter Based Internet of Things Applications: Phase 2 Projects - GOV.UK

Future policy alignment (further detail on next section)	Green / Amber	DESNZ/Ofgem SSES proposals, EV Smart Charging Regulations 2025, and the Clean Flexibility Roadmap all signal a policy shift towards authorised demand control.	These supportive changes are not yet embedded in the SEC or distribution licences. The gap is therefore one of timing and codification rather than direction.	Use trial evidence to influence SEC Panel discussions and SSES implementation. Position Smart ReStart as a low-cost, low-impact flexibility measure that complements national EV and heat pump policy.

3.4. Future policy directions

The wider policy environment is increasingly aligned with Smart ReStart:

- Smart Secure Electricity Systems (SSES) is consulting on licence changes enabling authorised load control by DNOs under defined safeguards.
- EV Smart Charging Regulations (2025) introduce mandated randomised delays and default off-peak behaviours, normalising staggered activation for consumers.
- RIIO-ED3 emphasises resilience and operational tools for managing LV networks during stress events, directly supporting CLPU mitigation measures.
- Proposed SEC modifications (e.g., expanding ALCS roles, improving switching information access) illustrate a gradual shift toward more active smart-meter-based system operation.

This convergence of policy signals creates a favourable environment for regulatory reform. Stakeholders consulted stress that now is the right time to influence changes, as ongoing smart meter reviews could otherwise lock in standards that do not support CLPU mitigation.

3.5. Stakeholder engagement

Engagements with the DCC, ENA and SSEN, ENWL, and Talan provided insight into the practical and regulatory constraints around using smart meter functionality for CLPU mitigation.

Discussions with the Smart DCC confirmed that ALCS and HCALCS are technically available but not widely installed for LCTs. Control remains with suppliers, and randomised offset is only used for tariff schedules, not restoration. Any change to allow DNO use would require modification of the Smart Energy Code. the DCC can provide data on uptake trajectories for auxiliary switching devices.

ENA and SSEN highlighted that network operators have previously attempted to gain greater smart meter control, but proposals have faced supplier resistance. Today, only suppliers can set randomised offset. Network operators receive outage alerts but cannot influence device behaviour. Stakeholders noted that changes to the SEC or DCUSA would be costly and time consuming.

SP ENW confirmed that CLPU has been suspected to occur during periods of severe system pressure. The risk is highest during one-in-twenty winters when electric heating is widely used. Existing protection relies on fuse settings, which may be insufficient as electrification grows. SP ENW also noted that DNOs do not have direct operational relationships with suppliers, which limits coordinated actions during restoration.

Talan and code governance bodies (RECCo and SECCo) explained the regulatory landscape further. DCUSA and the Retail Energy Code are central for connection and tariff issues, while the SEC governs smart meter control. SEC changes are often slow and contentious. Expanding DNO control would require SEC modification or government intervention, and stakeholders noted significant cost and governance barriers.

Overall, engagement confirmed strong industry awareness of CLPU risks but also highlighted the current limits on DNO control, slow code modification processes and the need for coordinated regulatory change before Smart ReStart can be operationalised.

3.6. Conclusion and next steps

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.

The next step is to generate the evidence base required for regulatory change. WP3 and WP4 support this by:

- Developing operational options for pre-configured staggered reconnection
- Modelling the effectiveness of different approaches
- Engaging with suppliers, the DCC, Ofgem and consumer groups
- Designing a trial, likely under an Ofgem derogation or sandbox

This staged approach will position Smart ReStart for successful code modification and eventual business-as-usual adoption.

4. Technical Review (WP1)

The technical review aims to assess the technical feasibility of using SMETS2 in managing CLPU.

4.1. Introduction and key questions

This analysis evaluates both the technical functionalities of SMETS2 smart meters and the regulatory framework that governs their operation, identifying where smart-meter functionality could contribute to CLPU mitigation and where the existing architecture introduces fundamental constraints.

The assessment draws on SMETS standards, smart-meter equipment technical specifications, manufacturer-approved device functionalities, and relevant distribution operational practices. It also incorporates insights from the Cold Start modelling work.

The technical review focuses on four central questions:

- What smart meter functions exist today that could support staggered reconnection
- How do these functions behave in real restoration conditions, including communications latency and device response
- Which features could meaningfully reduce CLPU and which are insufficient
- What changes to firmware, configuration or standards would be required for effective deployment in future

This assessment draws from SMETS standards, GBCS requirements, device specifications from manufacturers, operational practices in DNOs, and insights from the Cold Start modelling.

4.2. Smart meter capabilities today

GBs smart metering system provides a secure and interoperable communications platform through the DCC. SMETS2 meters support several technical features that could, in principle, influence demand following restoration

However, the system was originally designed for supplier-led functions such as billing, prepayment and consumer engagement. As a result, the architecture does not naturally support rapid, deterministic operational control during outage restoration. Three characteristics of today's system have the greatest impact on feasibility for CLPU mitigation

Three characteristics of today's system significantly influence feasibility for CLPU mitigation:

- **Trigger behaviour**

Smart meters do not apply randomised offsets on power restoration. Offsets are only applied to scheduled calendar events such as tariff switching. This sharply limits the usefulness of randomised offset for CLPU in its current form.

- **Device diversity**

ALCS, HCALCS and proportional controllers are not universally installed. Only a subset of homes have controllable relays or paired appliances, and proportional control is not suitable for heat pumps, which are expected to be the dominant CLPU driver.

- **Communications latency**

DUIS service requests are delivered in waves rather than instantaneously. SMETS1 and SMETS2 devices behave differently. Any strategy based on real-time commands must account for several seconds to minutes of communication and execution delay.

Together, these characteristics mean that some features have limited technical value for CLPU today, while others hold potential but are constrained by system architecture or device coverage.

4.3. Solutions options

Randomised Offset

The randomised delay function can apply a 0 to 30 minute offset to scheduled events. However, it does not activate on power restoration. Even if this limitation were addressed through code changes and firmware updates, the maximum 30 minute window is too short to meaningfully influence the multi-hour CLPU profile modelled in Cold Start. In isolation, randomised offset offers very limited benefit.

ALCS and HCALCS (binary auxiliary switching)

ALCS and HAN-paired relays can turn circuits on or off. They are technically functional but limited because they only provide binary control, rely on specific wiring or paired HAN devices, and would introduce activation delays that depend on signalling latency. Mandating widespread installation could duplicate other regulatory requirements on Consumer Led Flexibility and introduce unnecessary consumer cost.

APC and SAPC (proportional control)

Proportional control offers graded modulation of appliance power and can be suitable for EV chargers and domestic batteries. However, it is unsuitable for heat pumps, which cannot modulate below manufacturer defined thresholds. Penetration of APC and SAPC devices in GB is extremely low, limiting applicability in the short to medium term.

Load Limiting at the Meter (LL)

Load limiting is the most technically promising function. SMETS devices can impose a whole-home power cap for a defined duration, providing a strong means of reducing overload risk when supply is restored. This functionality is technically mature but currently associated with prepayment and debt scenarios. Deployment for CLPU purposes would require regulatory changes and customer safeguards. Nevertheless, its technical potential is significant.

Telemetry and readback functions

Read Supply Status and similar commands could provide situational awareness for staged reconnection. However, DNOs have limited access to granular telemetry. Governance changes would be required before this information could support controlled restoration.

Communications constraints

Latency and retry cycles across the DCC network guarantee that control actions will occur over a window of time, not simultaneously. Any CLPU mitigation strategy must be designed around these progressive delivery patterns rather than instantaneous instructions.

4.4. Gap analysis

A qualitative RAG assessment of key smart-metering functionalities indicates that most available mechanisms currently fall into the Red or Amber categories for post-outage CLPU mitigation. Load limiting is assessed as Green from a purely technical perspective, but becomes Amber/Red once regulatory, consumer-protection and governance constraints are considered.

Table 2: Technical gap analysis

Function / Capability	RAG	Key Considerations
ALCS – ESME wired auxiliary switching	Amber	▪ Binary ON/OFF only ▪ Limited to wired second circuits (e.g., storage/immersion heaters) ▪ High dependency on comms latency for timing accuracy. ▪ Requires consumer-protection safeguards
HCALCS – HAN-connected auxiliary switching	Amber	▪ Binary ON/OFF only ▪ Potential duplication/conflict with CLF mandates for ESAs ▪ Dependent on HAN stability and communications latency ▪ Device–HAN pairing introduces operational complexity
APC / SAPC – Auxiliary proportional control	Amber	▪ Proportional control restricted by heat-pump minimum operating thresholds (risk of damage or voiding warranties) ▪ Requires HAN-connected controllers at additional cost ▪ Not widely deployed ▪ High communications dependency for granular control ▪ More applicable to EVs/batteries than heat pumps
Randomised Offset (current DUIS command)	Red	▪ Only applies to scheduled calendar events (not triggered by power restoration) ▪ Maximum delay ~30 minutes (1,799 seconds) ▪ Insufficient for multi-hour (up to 10h) CLPU behaviour of heat pumps and EVs ▪ Provides a limited /uncertain operational effect on the immediate post-outage demand
Randomised Offset (hypothetical firmware update)	Red	▪ Not a defined SMETS/DUIS functionality today ▪ Would require significant regulatory changes ▪ Would require broad manufacturer firmware updates ▪ Complex to apply consistently across device classes ▪ High implementation and testing burden for uncertain operational benefit
Load Limiting – Meter-level power cap	Amber	▪ Offers whole-home demand suppression, making it one of the highest-impact CLPU tools ▪ Restricted by strong consumer-protection provisions ▪ DNO use would require ESRN-based regulatory exceptions ▪ Latency/communication dependencies affect the precision of activation windows ▪ Requires careful safeguarding of vulnerable customers and medical dependencies
Telemetry / Readback (DUIS Read	Green	▪ Enables closed-loop orchestration, verification of reconnection progress and cohort staging ▪ Valuable for checking whether load-limiting or ALCS commands have taken effect

Supply Status)		▪ DNO access to granular telemetry requires regulatory change • Provides situational awareness but does not itself mitigate load

4.5. Conclusion and next steps

The technical review concludes that the SMETS2 contains several functions that could contribute to mitigating CLPU. However, none of them can provide a complete or immediately deployable solution on their own.

Randomised offset is not triggered at restoration. ALCS and APC have limited coverage or suitability. Proportional control is not compatible with heat pumps. Telemetry access is restricted. Communications delay makes real-time orchestration difficult.

Load limiting stands out as the most effective functionality capability, but its use outside prepayment contexts is not currently permitted.

Unlocking the potential of smart meters for CLPU mitigation will require:

- Development of pre-configured reconnection settings
- Targeted SEC and DUIS modifications
- Clarification of roles and permissions for DNOs
- Evaluation of firmware change pathways
- Modelling evidence to validate effectiveness
- Investigation of interoperability across devices and meter types

Subsequent work packages assess the operational process design, engage with stakeholder and network modelling to test how smart meter functionality could be implemented safely, and effectively.

5. Operational Review (WP3)

This section defines the operational methodology and roadmap for transitioning Smart ReStart from trial to potential Business-as-Usual adoption.

5.1. Introduction and key questions

The operational review aims to assess current outage restoration procedures, identifies the operational changes required to implement staggered reconnection, and evaluates the feasibility of different operational options. It also highlights the operational challenges that arise from multi-supplier environments, limited visibility of LCTs, customer expectations, and the need for clear governance.

The objective is to understand what would need to change for Smart ReStart to function reliably during real post-outage events. The operational assessment focuses on four central questions:

- How is power restoration carried out today on the low-voltage network
- What operational constraints and practical realities affect the use of smart meter functions during CLPU events
- What operational scenarios or methods could support staggered reconnection
- What organisational, process and governance changes would be required for a trial and for future business-as-usual delivery

These questions guide the evaluation of how Smart ReStart could be implemented across DNO operations.

5.2. Outage procedure today

Today's LV restoration process is based on established engineering practices. When a fault is resolved and a circuit is re-energised, customer devices simply return to their prior state. There is no coordination across appliances or between suppliers, DNOs and the DCC. This means that EV chargers, heat pumps and other high-demand devices can all restart at once.

Operational constraints include:

- DNOs receive outage and restoration notifications with a delay because of comms hub behaviour
- DUIS commands cannot be relied upon for real-time orchestration because delivery occurs in waves and execution time varies across devices
- There is no existing procedure to pre-configure reconnection behaviour for restoration events
- Suppliers and DNOs operate independently during restoration, and multi-supplier feeders add complexity

- DNOs have limited visibility of which homes contain EV chargers, heat pumps or other significant loads

This means Smart ReStart must rely on pre-configuration rather than real-time control, and it must operate within a multi-party environment where DNOs do not currently hold full operational authority.

5.3. Solution options – operational review

The assessment has identified several operational pathways, each with distinct benefits and constraints.

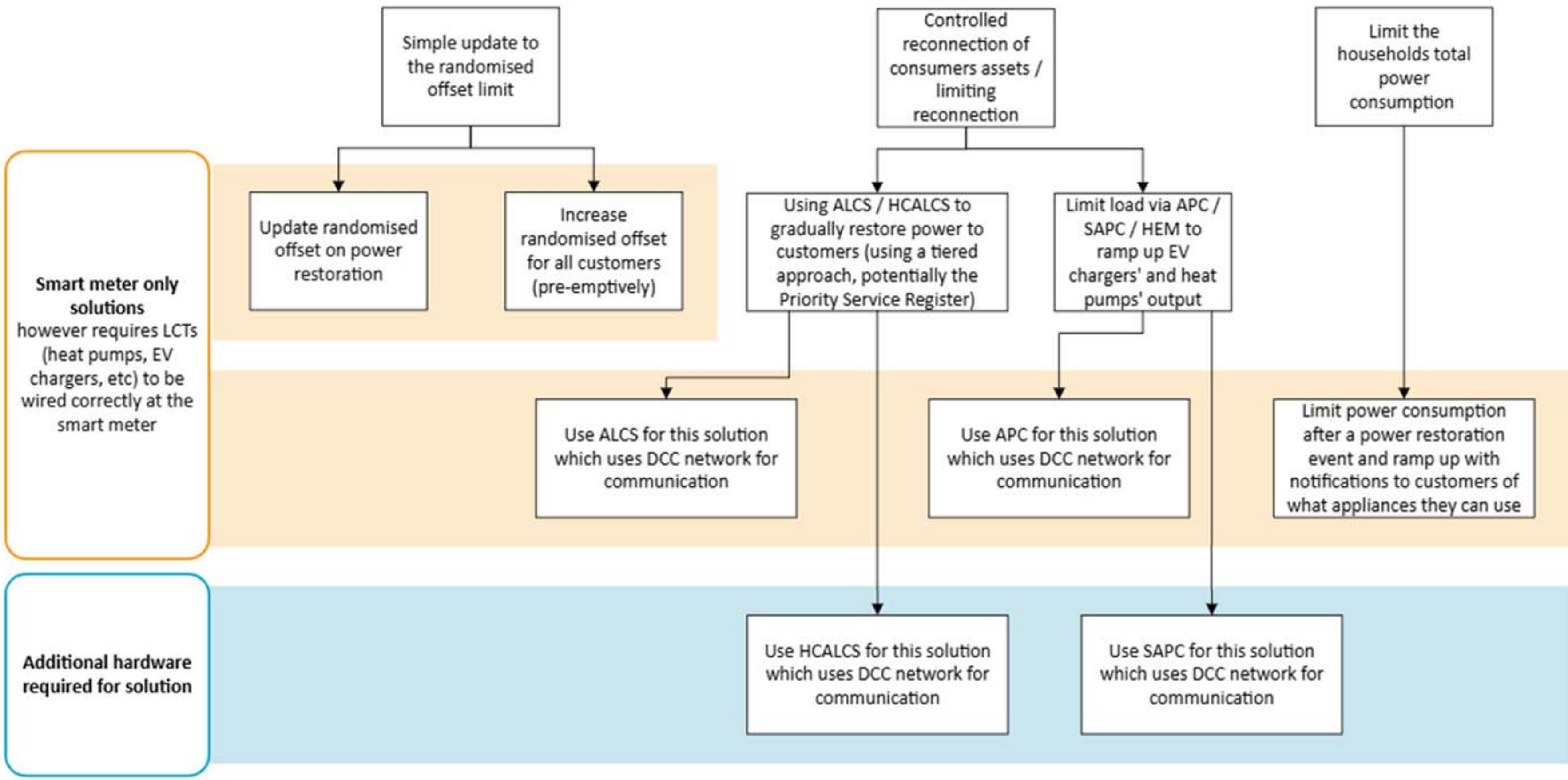

Figure 1 : Operational pathways of Smart ReStart options

1. Pre-set randomised offset: Randomised delays which stagger customer reconnection following restoration

This is the most practical near-term option. The reconnection delay would be configured in advance and stored on the meter so that, when power is restored, devices reconnect gradually rather than immediately.

- This approach uses existing SMETS2 functionality but would require:
- An SEC modification to allow offsets to apply on power restoration
- Supplier-led firmware updates across affected meter populations

It offers a simple, predictable restoration profile without relying on real-time signalling.

2. Proportional load management (via APC and SAPC): gradual demand recovery following restoration

Proportional control allows devices such as EV chargers or domestic batteries to reduce demand in a graded way. This option is more future-focused because device penetration is currently very low. It depends on:

- Wider rollout of APC and SAPC-capable appliances
- Customer participation and opt-in mechanisms
- Clear communication about the impact on charging or appliance operation

This option could complement other measures in the long term.

3. Household load limitation: Temporary power limitation per household following restoration

Load limiting is the most powerful technical tool for controlling CLPU. It can cap total household demand for a defined period after restoration, significantly reducing the risk of secondary outages.

However:

- Only suppliers can use this function today
- It has never been used operationally for network restoration
- Governance and customer communication requirements are significant

Enabling DNO access would require regulatory and process change but offers strong operational value.

5.4. Implementation considerations

A comparative assessment of the proposed solutions evaluates their ease of implementation, where a higher score indicates a more straightforward pathway to BaU adoption. Six metrics were used and analysis results are detailed in Figure 2 below:

- Code changes required
- Operational changes required
- New register requirements
- Ability to adopt existing assets
- Security considerations

- Level of control provided

In the near term, solutions relying solely on existing SMETS2 hardware are favoured, as they avoid the need for new in-home devices. The figure below compares the options across these six metrics.

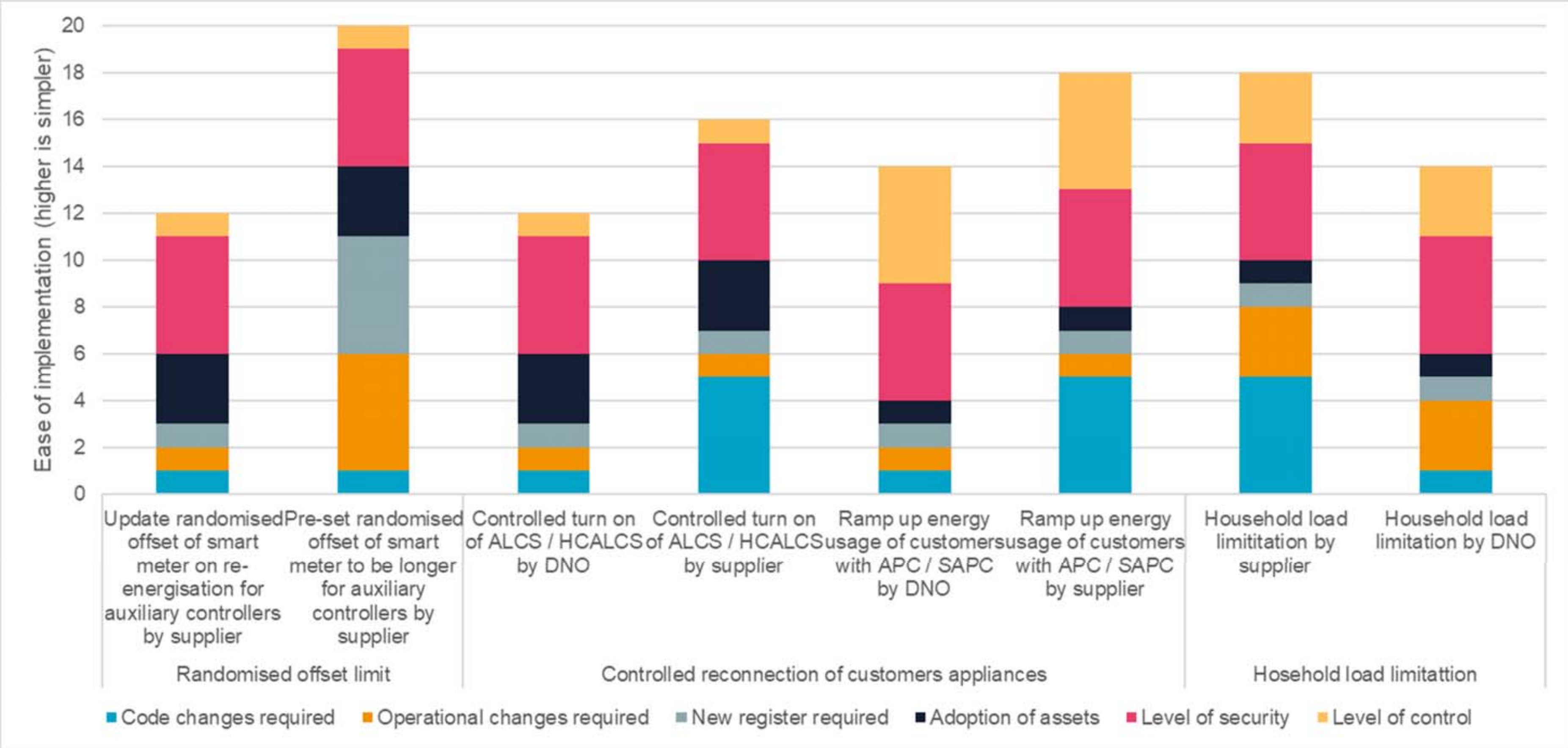

Figure 2: Implementation considerations of Smart ReStart options

5.5. Conclusion and next steps

The analysis has identified actions needed to progress Smart ReStart:

- Engage Ofgem and SEC governance to establish a pathway for the required code changes and firmware updates.
- Develop interim operational processes for identifying constrained areas, selecting appropriate reconnection strategies and coordinating with suppliers.
- Explore customer communication, incentives and acceptance strategies.
- Work with suppliers, DCC, ENA and consumer organisations to define roles, responsibilities and safeguards.
- Use modelling outputs from WP4 to validate reconnection strategies and quantify expected benefits.

Smart ReStart should ultimately form part of the DNO operational toolkit for managing LV networks under stress conditions following outages. The pathway to business-as-usual involves staged development: evidence from modelling, followed by a structured trial under a regulatory derogation, and then a codified industry procedure.

6. Simulation roadmap (WP4)

This section evaluates how different smart-meter functionalities can support network resilience through power-flow analysis. It also considers the extent to which the proposed Smart ReStart options address the underlying CLPU problem.

6.1. Key questions

The modelling aims to assess the impact of CLPU and increasing penetration of LCTs across different physical network configurations. Three representative LV distribution network topologies provided by SP ENW were modelled. These topologies reflect common GB distribution arrangements, including both pole-mounted and ground-mounted distribution transformers.

Using multiple topologies enables assessment of how network layout, asset configuration, and transformer installation type influence:

- thermal loading
- voltage performance
- overall LV network resilience

under both normal operation and cold-start condition and are modelled using consistent assumptions for:

- household load definitions
- transformer representation
- cable ratings and parameters

6.2. Conclusion and next steps

The modelling results demonstrate that smart meter enabled control functionalities are beneficial in supporting network performance during CLPU events. The effectiveness of these functionalities, however, is highly scenario dependent. Factors such as the underlying network topology, the level of LCTs uptake, particularly electric vehicles and heat pumps and the timing of the cold start relative to daily demand patterns, all have a significant influence on the extent to which smart meter interventions can mitigate adverse impacts.

In some scenarios, strategies such as staggered reconnection, temporary demand limiting, and gradual demand recovery were effective in reducing peak demand, alleviating thermal loading, and improving voltage stability.

In other cases, particularly under high LCT penetration or during restoration at peak demand periods, the benefits were more limited and required tighter control or combined measures to achieve meaningful improvements. Smart meter functionalities should not be considered as a one-size-fits-all solution, but rather as flexible tools whose value depends on careful coordination with network characteristics and operating conditions.

Overall, the results show positive outcomes for each solution and targeted and context aware deployment of smart meter-based controls could enhance the resilience of distribution networks during cold restart events.

Further analysis would enhance the understanding and robustness of Smart ReStart and the network benefits. Several next steps have been recommended which include

1. Incorporating real outage events to validate the modelling assumptions and provide a stronger basis for operational planning and decision making
2. Expanding the scenario framework to account for greater variation in LCT deployment, behind the meter generation assets (e.g. battery storage and solar PV) and customer behaviour
3. Estimating the risk of secondary outages and extending the modelling framework to identify critical network areas.

7. Next Steps – Technical scoping (WP1)

This section defines the high-level technical requirements, feasibility considerations and next-phase questions for Smart ReStart.

7.1. Introduction

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 SP Energy Networks 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 Smart ReStart "toolkit" that combines complementary functionalities such as extended or pre-set offsets, whole-home load limiting and potential device-level switching or proportional control, each offering different strengths, constraints and regulatory requirements.

The technical scoping focuses on developing a multi-option framework rather than a single solution. This document summarises the technical requirements for each option, highlights the operational and regulatory questions, feasibility and functional gaps that must be addressed in the future. It also sets out the dependencies between technical functionality, customer experience, communications latency, device-safety constraints and regulatory permissions, and identifies areas where further modelling, manufacturer engagement and DCC/supplier coordination are required to confirm viability.

7.2. Overarching questions to be answered in the next phase

As Smart ReStart progresses toward its next phase, a set of cross-cutting questions has emerged that are relevant for all options. These questions reflect the key uncertainties that must be resolved to determine which Smart ReStart functionalities are technically viable, operationally deliverable, and regulatory-compliant at national scale.

Theme	Overarching Questions
Technical	• What combinations of smart-meter functions (extended offsets, ALCS holds, whole-home load limits, proportional control) are technically viable given mixed meter populations and communication latency? • What safe modulation limits exist for heat pumps, and can they be used without violating manufacturer warranty or safety protections? • What minimum penetration of controllable devices (EV chargers, batteries, heat pumps) is needed for meaningful CLPU mitigation?

	• Which devices can safely support switching or proportional control, and what firmware or controller updates are required? • What are the manufacturer constraints and warranty considerations associated with throttling heat pumps or EV chargers?
Regulatory	• What is the most viable pathway for granting DNOs conditional, emergency-only control rights (e.g., SEC modification, Ofgem derogation, sandbox)? • What standardised consent, liability, and customer-protection framework is required for emergency-time load management? • What are realistic timelines for necessary firmware updates, code changes, or DUIS amendments?
Operational	• How should constrained areas be identified and triggered in real operational workflows? • How should offset durations, load-limit profiles, and device-specific control priorities vary by feeder topology and LCT penetration? • What customer communication processes are needed before, during, and after emergency events? • How reliably can multi-supplier feeders coordinate CLPU mitigation actions?
Modelling	• What CLPU parameters (surge magnitude, decay curves, heat-pump recovery) are credible for different outage durations and seasons? • How should modelling incorporate clustered LCT uptake, feeder-level constraints, and SPEN-specific LV network diversity? • For which scenarios do the current 30-minute randomised offset remain sufficient, and where is extension required?
CBA	• What are the realistic system-wide costs of implementing each Smart ReStart functionality (firmware, supplier processes, DCC changes, customer communications)? • Under what conditions does Smart ReStart provide greater value than reinforcement, and how sensitive is this to outage frequency and LCT adoption?

7.3. Next phase

Smart ReStart has demonstrated strong feasibility, future value, and robust industry interest. With coordinated development across the value, impact and implementation of recommended solutions, it can become a core LV resilience tool supporting the transition to a highly electrified energy system.

8. Overall conclusion

This section summarises the core insights from the Smart ReStart project, outlines the recommended direction for future development, and identifies the key risks and next steps required to progress towards a viable trial and potential business-as-usual adoption.

8.1. Key findings

The Smart ReStart project demonstrates that smart-meter functionality offers a credible and 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 ECS38, 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 reinforce the need for Smart ReStart to function as a flexible toolkit, adapted to local network characteristics rather than as a single prescribed mechanism.

8.2. 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 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.

8.3. Recommendations and Next steps

Smart ReStart should progress to a structured next phase focused on developing, testing and validating a multi-option control framework.

Pre-configured offsets and whole home load limiting should be prioritised, as these offer the strongest near-term feasibility. A refined modelling framework should be developed to quantify benefits across multiple outage and LCT penetration scenarios, enabling robust comparison.

Parallel engagement with Ofgem, the SEC Panel, suppliers and the DCC will be essential to shape the regulatory pathway, define roles and permissions, and develop the required customer-consent and liability arrangements. Engagement with device manufacturers is needed to clarify firmware constraints and acceptable operating ranges, particularly for heat pumps. Communication planning should be developed early to ensure customer understanding and acceptance.

If successfully developed, Smart ReStart has the potential to become a core LV network resilience tool, providing a low cost, scalable complement to reinforcement and helping DNOs manage the increasing risk of CLPU in a highly electrified future.

Glossary

Term / Acronym	Definition
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.
HEM – 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).
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).